CHAPTER III

RESULTS

Environmental Factors

1. Temperature

During the study period, surface temperature at the PMBC pier were shown in Fig. 6a. Temperature ranged from 26.5 ^{o}C in September 1990 to 31.8 ^{o}C in April 1991. High peaks of temperature were shown during March and May (Table 2). It is to be noted that during July to September the temperature at the PMBC pier was about 2 ^{o}C higher in 1991 than in 1990.

2. Rainfall

The amount of monthly rainfall during August 1990 to July 1991 showed the long period of wet season, eight months between August-November 1990 and between April-July 1991 (Fig. 6b). The average monthly rainfall during the wet season was 240.4 millimeters while during the dry season was only 52.6 millimeters.

4. Chlorophyll Concentration

In analysis of the chlorophyll concentration, the >1 micrometer fractions (GF/C glass filter paper) and >8 micrometers (membrane filter) showed sign of seasonal variation by having two peaks in February and July, both in 1990 and 1991 (Fig. 6c). The >1 micrometer fraction ranged between 286.63-1233.88 microgram per cubic meter of water with the average of 596.93 microgram per cubic meter of water. The >8 micrometer fraction ranged between 59.99-828.50 microgram per cubic meter of water and the average was 254.10 microgram per cubic meter of water (Table 2).

5. Primary Production

Primary production at the PMBC pier during the first half of the study period, July-December 1990, with the average of 44.87 milligram carbon per cubic meter of water per day, was lower than during the second, January-July 1991, with the average of 87.03 milligram carbon per cubic meter of water per day (Fig. 6d). The primary production ranged between 19.17 and 156.85 milligram carbon per cubic meter of water per day with the average of 69.09 milligram carbon per cubic meter of water per day (Table 2).

Relationship between temperature and chlorophyll concentration and primary production were presented in Fig. 7 which only primary production that showed positive correlated to temperature, Fig. 7c, $r^2 = 0.5$, $p < 0.05$.

Table 2 Primary production, chlorophyll concentration and temperature at PMBC pier during July 1990 to August 1991.

Date	Primary Production (mgC/m^3/d)	Chlorophyll GF/C (ug/m^3)	Chlorophyll 8 u (ug/m^3)	Temperature (oC)
23 Jul 90	66.11	1203.88	727.88	27.0
30	72.90	666.25	538.13	26.9
06 Aug 90	47.13	473.13	193.75	27.0
13	42.10	505.13	167.13	27.5
20	57.79	569.88	93.38	27.2
23	59.05	615.75	200.63	27.3
28	28.65	431.63	109.88	27.0
03 Sep 90	46.64	500.38	59.88	26.5
10	53.89	715.00	200.00	26.9
24	-	725.13	271.50	27.2
01 Oct 90	36.17	459.13	75.13	27.0
05	59.95	606.00	156.00	27.7
11	32.77	353.75	129.50	28.3
24	26.03	491.00	154.75	27.7
29	30.02	557.63	174.00	27.8
05 Nov 90	19.17	702.63	265.50	27.0
13	23.81	393.25	146.25	28.3
26	64.39	513.13	272.38	27.6
11 Dec 90	49.28	286.63	73.75	27.9
17	43.92	491.00	147.00	28.3
25	37.71	363.88	137.50	28.8
02 Jan 91	61.20	517.38	346.50	27.9
07	93.40	778.25	269.63	28.2
14	31.41	513.13	205.38	28.2
21	112.33	692.63	422.88	28.3
28	41.67	405.13	191.25	29.1
11 Feb 91	120.00	579.13	318.75	28.3
18	156.85	1186.50	828.50	28.1
25	55.15	466.00	248.38	29.0
04 Mar 91	60.73	596.63	234.75	29.8
11	21.37	313.88	69.25	30.0
19	63.83	706.50	179.75	29.7
20	81.44	628.63	315.50	30.1
26	80.79	598.00	347.00	30.6
09 Apr 91	98.94	533.50	272.88	30.5
15	137.15	701.13	101.50	31.0
22	59.91	369.63	178.38	31.8
29	75.35	499.75	334.25	31.0
06 May 91	122.13	506.87	303.00	31.5
13	94.17	599.63	426.88	30.9
20	85.08	822.75	339.63	30.8
27	115.89	863.38	194.38	30.5
10 Jun 91	92.96	316.50	479.63	30.0
17	141.07	962.00	357.63	28.0
24	122.33	749.88	123.75	30.3
01 Jul 91	90.26	468.75	177.50	29.1
09	90.42	493.13	217.25	29.2
15	44.04	977.13	166.38	29.2
22	-	458.38	598.63	29.0
29	-	1233.88	151.88	29.2
06 Aug 91	-	414.25	264.13	29.4
13	-	662.75	-	29.0
20	-	-	-	28.7

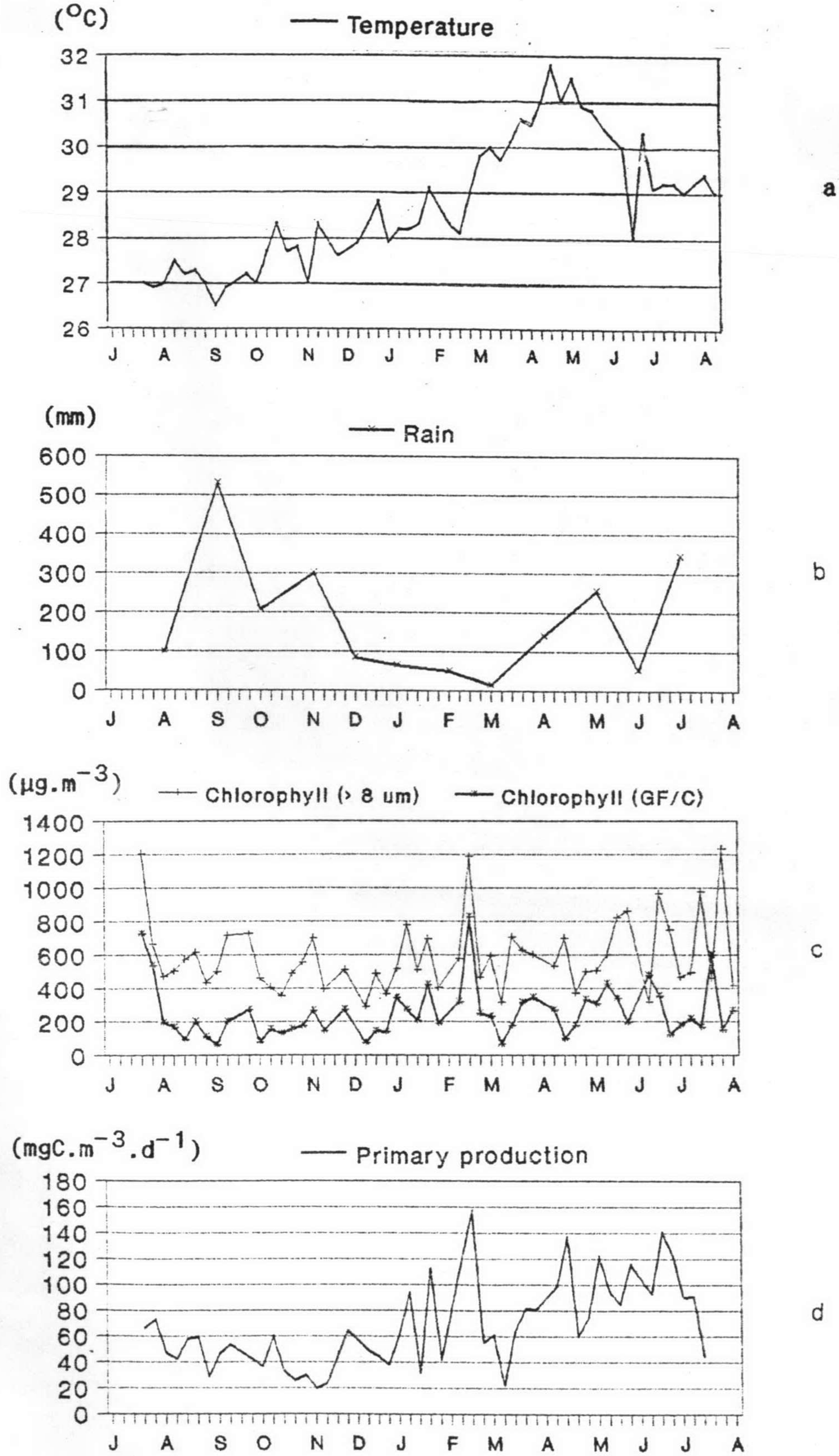

Fig. 6 Seasonal variation of a) temperature and salinity, b) monthly rainfall, c) chlorophyll concentration and d) primary production at the PMBC pier during July 1990 to July 1991.

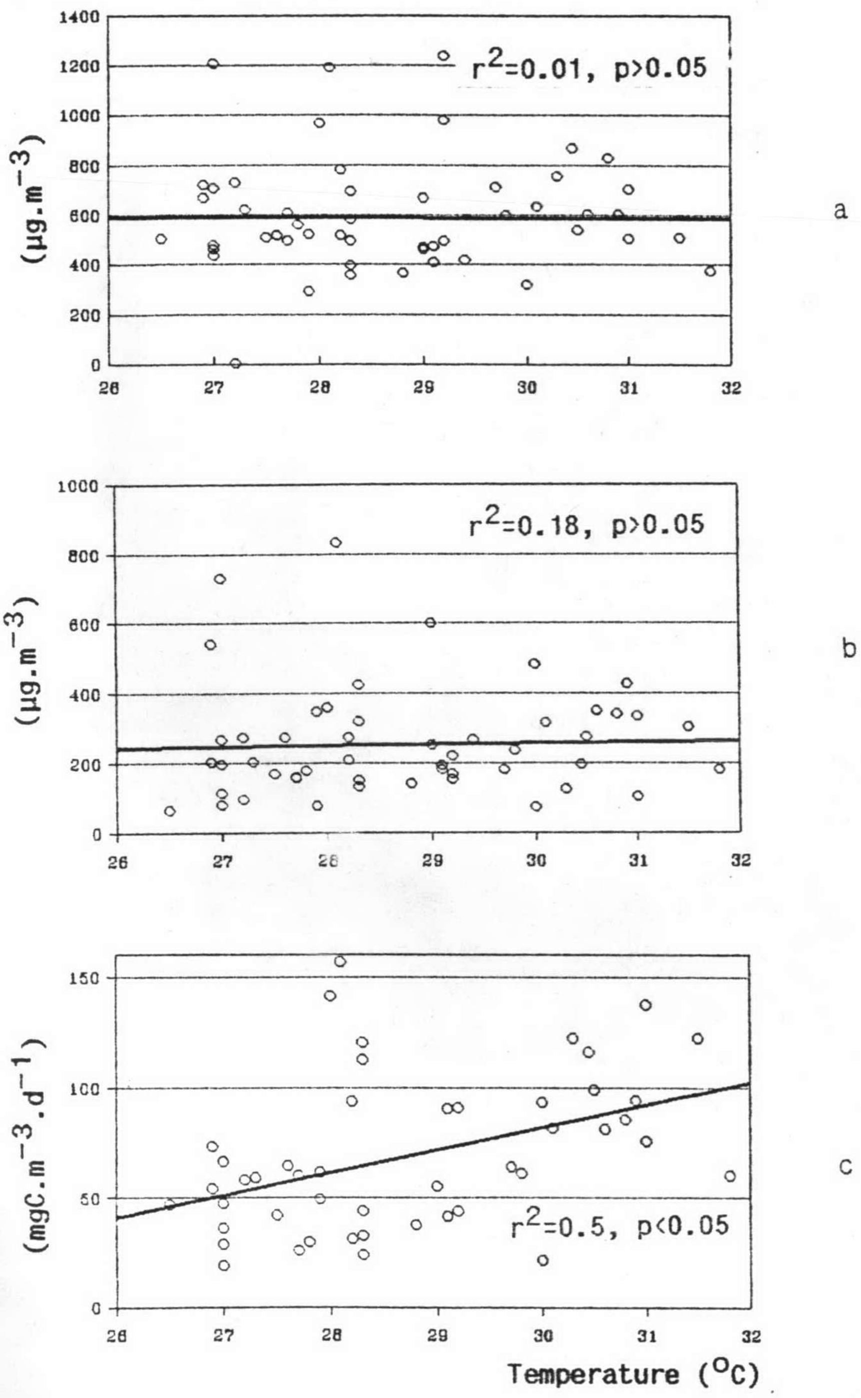

Fig. 7 Relationship between temperature and a) chlorophyll concentration (> 1 µm), b) chlorophyll concentration (> 8 µm) and c) primary production.

Copepod Culture

The experiments in cultivation of *A. gibber* in the laboratory were carried on without success for six months during July to December 1991 as the animals could not reached the next generation. The animals from the culture could only once develop to stage copepodite 1, but in most experiments they were died before that.

The water quality was expected to be an important problem since a lot of bacteria were found in the culture within only a few days after started incubation. Various treatments had been tried to clean the culture seawater such as heated to 80 ^{o}C, boiled in oven or autoclaved, but the animals still could not grow more than ever. Since juvenile stages of animals are sensitive to changes of environments, especially temperature and the laboratory at PMBC does not have the temperature controlled system, so, temperature might be another one important factor in this experiment.

Carbon Content Analysis

Average size of eggs gained from females incubation in the laboratory was 88.9 micrometers (n = 270) and the average weight of eggs is 0.089 microgram carbon. Size ranges of copepodite and adult female sampled from the PMBC pier employed for carbon analysis were 535.7-789.6 micrometers (n = 405). Their weight ranged from 2.32 to 6.53 microgram carbon (Table 3). Length-weight regression (Fig. 8) for those animals was gained as the equation :

$$W = (1.188 \times 10^{-9})\ L^{(3.359)},\ r^2 = 0.89$$

where, W = weight in microgram carbon of *A. gibber*

L = prosome length in micrometer of *A. gibber*

a = 1.188×10^{-9}

b = 3.359

Table 3 Body length (micrometer) and weight in microgram carbon of *Acrocalanus gibber*, copepodid stages and adult females sampled from the PMBC pier.

Prosome length (μm)	Weight (μgC)
535.7	2.32
541.7	1.38
582.4	2.27
590.9	1.91
598.0	3.00
602.5	2.72
607.0	2.63
626.3	3.03
640.8	3.38
642.7	3.33
645.2	3.26
757.3	6.53
770.8	5.28
778.0	7.22
789.2	5.14
789.6	6.45

Field Works

1. Abundance of *Acrocalanus gibber*

Seasonal variation in abundance of *A. gibber*, total copepods and zooplankton during the study period were plotted as in Fig. 9a which showed that all of them followed similar pattern of variation. Abundance for all groups were low in December and July to September.

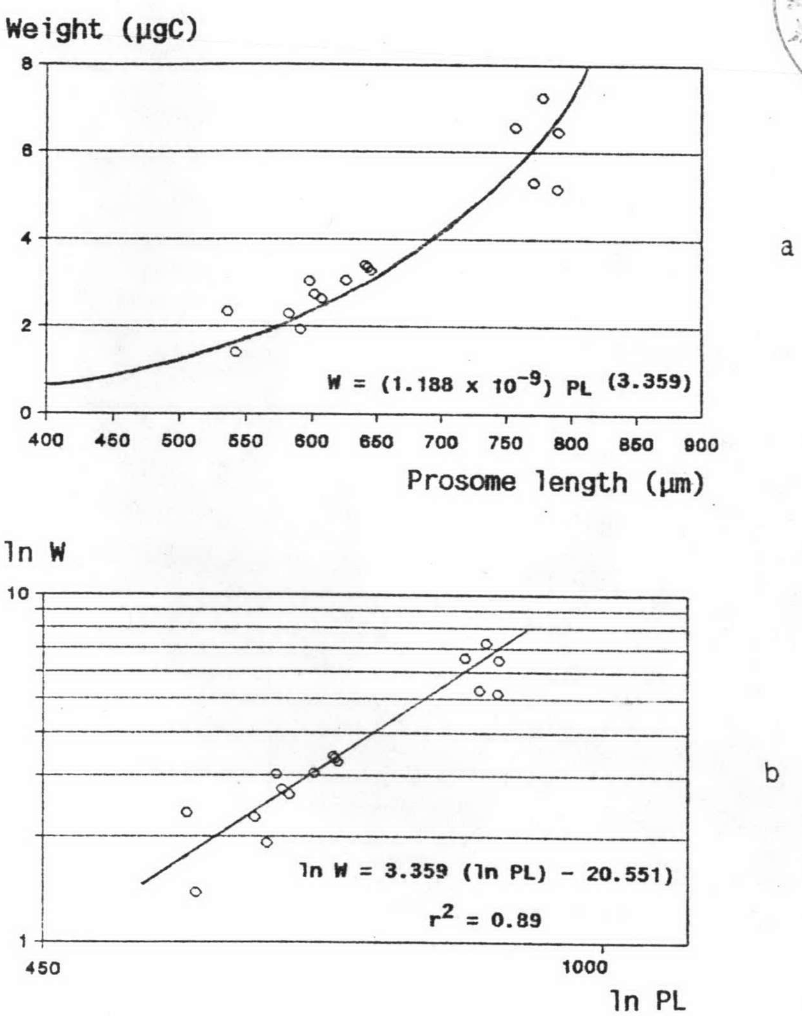

Fig. 8 Length-weight relationship of *Acrocalanus gibber*.
a) allometric relationship
b) linearized relationship

Three peaks of their abundance appeared in October, February and March (Table 4, Fig. 9a). *A. gibber* abundance ranged between 18-227 individuals per cubic meter of water, copepods ranged between 980-4,493 individuals per cubic meter of water while total zooplankton ranged between 1,280-8,102 individuals per cubic meter of water. The average percentage of *A. gibber* related to total number of zooplankton was about 2% and to total copepods was about 6%, while copepods contributed about 58% to the total zooplankton. The prosome length of *A. gibber* varied between 380-900 micrometers.

Table 4 Abundance of zooplankton, copepods and *Acrocalanus gibber* at the PMBC pier during October 1990 to September 1991.

Date	Abundance (no./m^3)		
	Zooplankton (x 100)	Copepods (x 100)	A. gibber (x 100)
October 1990	52.31	28.03	1.60
November 1990	42.84	27.26	0.48
December 1990	18.40	10.61	0.43
January 1991	56.97	25.09	0.46
February 1991	81.02	44.93	2.27
March 1991	41.69	26.37	1.04
April 1991	41.67	30.80	0.79
May 1991	84.35	40.42	1.48
June 1991	46.42	27.73	1.08
July 1991	14.58	9.80	0.18
August 1991	12.80	10.26	0.20
September 1991	18.86	16.39	0.36

2. Biomass

Weekly biomass of *A. gibber* were calculated by using length-weight equation retrived from the carbon analysis :

$$W = (1.188 \times 10^{-9})\ L^{(3.359)}$$

where, W = weight in microgram carbon of *A. gibber*

L = prosome length (micrometer) of *A. gibber*

Biomass of *A. gibber* at PMBC pier between October 1990 and September 1991 ranged between 35.10-448.75 microgram carbon per cubic meter of water with peaks in October, February and May and the average of 159.39 microgram carbon per cubic meter of water.

Zooplankton biomass recorded was in the range of 9.34-52.00 milligram ash-free dry weight per cubic meter of water with the average of 24.36 milligram AFDW per cubic meter of water. Three peaks of high zooplankton biomass were observed in December, March-May and September (Fig. 9b).

3. Egg production and specific egg production rate

Experiment for egg production rate of *A. gibber* was carried out weekly for one year between July 1990 and June 1991. The average size, prosome length of experimental females, was 763 micrometers (N=440, SD = ±1.01), and the carbon content was 9.1 microgram carbon per female. The average diameter of eggs produced in the laboratory was 89 micrometers (N=70, SD= ±0.08). The carbon content of eggs was 0.089 microgram carbon per egg.

Rate of egg production in unit of number of eggs produced per female per day shown in Table 5, ranged from 6.2 to 52.0 eggs per female per day. The annual average was 16.19 eggs per female per day. The pattern of egg production over time of *A. gibber* was shown with two peaks in August 1990 and May 1991, similar to the pattern of their biomass (Fig. 9c).

Relationships between *A. gibber* egg production rate and environmental variables (temperature, concentration of chlorophyll and primary production) were shown by Spearman rank correlation (Fig. 10a-d).

Egg production rate was positively corrrelated to both size fractions of chlorophyll concentration, for >1 micrometer fraction : $r^2=0.54$, $p<0.01$; >8 micrometers fraction : $r^2=0.56$, $p<0.01$). This result suggests that *A. gibber* tend to be limited in egg production by food availability (Fig. 10b,c). Egg production rate was also showed the positive correlation to pelagic primary production (Fig. 10d, $r^2=0.41$, $p<0.01$).

The calculated specific egg production rate which represented the female specific growth rate in terms of carbon content of eggs produced per day in relation to female carbon content. It ranged from 0.09 to 0.51 per day and the average was 0.25 per day.

4. Secondary production of *Acrocalanus gibber* and Total Zooplankton

Secondary production of *A. gibber* was estimated from weekly biomass and specific egg production rate. *A. gibber* showed two peaks in February and May. Secondary production ranged between 4.62-187.54 microgram carbon per cubic meter per day with the average of 44.99 microgram carbon per cubic meter per day.

Variation of zooplankton secondary production showed distinct two peaks in December and May, Fig. 9e, with ranged between 1.30-8.78 milligram carbon per cubic meter per day and the average was 3.46 milligram carbonper cubic meter per day.

Secondary production of *A. gibber* was significantly correlated to both primary production and chlorophyll >8 µm (chlorophyll : r^2=0.49, p<0.05, Fig. 11c ; primary production : r^2=0.40, p<0.05, Fig. 11d). But the production was independent on >1 µm fraction of chlorophyll, Fig. 11b). Correlation between zooplankton secondary production to neither chlorophyll nor primary production were significant. Secondary production of both *A. gibber* and zooplankton were independent on temperature.

Table 5 One year data of egg production, copepod (*Acrocalanus gibber*), production and zooplankton production at PMBC pier.

Date	egg/female/day	Specific egg production rate (per day)	Copepod biomass (ugC/m^3)	Copepod production (ugC/m^3/d)	Zooplakton biomass (mg afdw/m^3)	Zooplankton production (mgC/m^3/d)
11 Jul 90	26.20	0.39	-	-	-	-
16	23.40	0.35	-	-	-	-
18	15.30	0.23	-	-	-	-
23	28.40	0.42	-	-	-	-
30	20.80	0.31	-	-	-	-
06 Aug 90	19.80	0.29	-	-	-	-
13	13.60	0.20	-	-	-	-
20	52.00	0.77	-	-	-	-
23	14.30	0.21	-	-	-	-
28	13.97	0.21	-	-	-	-
03 Sep 90	6.81	0.10	-	-	-	-
10	14.32	0.21	-	-	-	-
24	19.78	0.29	-	-	-	-
01 Oct 90	9.47	0.14	250.70	-	-	-
05	11.15	0.16	372.93	61.45	20.76	1.71
11	10.00	0.15	296.47	43.81	-	-
24	10.60	0.16	219.86	34.44	-	-
29	6.30	0.09	57.15	5.32	-	-
05 Nov 90	25.30	0.37	196.50	73.47	-	-
13	8.02	0.12	88.86	10.53	32.14	1.90
26	19.70	0.29	185.03	53.87	-	-
11 Dec 90	16.30	0.24	179.55	43.25	52.00	6.26
17	7.00	0.10	77.68	8.04	-	-
25	7.80	0.12	73.70	8.50	-	-
02 Jan 91	13.70	0.20	56.89	11.52	-	-
07	14.60	0.22	110.77	23.90	12.94	1.40
14	7.10	0.10	62.11	6.52	-	-
21	19.60	0.29	143.93	41.69	-	-
28	8.90	0.13	35.10	4.62	-	-
11 Feb 91	25.70	0.38	448.75	170.43	16.58	3.15
18	22.10	0.33	198.58	64.85	-	-
25	9.30	0.14	184.30	25.33	-	-
04 Mar 91	12.60	0.19	315.83	58.81	30.40	2.83
11	10.50	0.16	72.41	11.24	-	-
19	24.30	0.36	-	-	-	-
20	27.50	0.41	-	-	-	-
26	-	-	-	-	-	-
09 Apr 91	6.18	0.09	171.74	15.68	28.52	1.30
15	11.42	0.17	146.04	24.65	-	-
22	-	-	117.98	-	-	-
29	12.87	0.19	201.61	38.35	-	-
06 May 91	11.48	0.17	93.32	15.83	-	-
13	35.02	0.52	362.39	187.54	33.92	8.78
20	29.76	0.44	161.75	71.14	25.04	5.51
27	18.23	0.27	-	-	-	-
10 Jun 91	20.05	0.30	333.97	98.95	11.83	1.75
17	-	-	72.31	-	25.05	-
24	23.76	0.35	-	-	-	-
01 Jul 91	12.37	0.18	-	-	-	-
09	-	-	88.45	-	11.14	-
15	-	-	-	-	-	-
22	-	-	-	-	9.34	-
29	-	-	-	-	-	-
06 Aug 91	-	-	-	-	-	-
13	-	-	91.00	-	23.49	-
20	-	-	-	-	-	-
27	-	-	61.41	-	21.71	-
03 Sep 91	-	-	43.97	-	-	-
10	-	-	86.72	-	15.75	-
21	-	-	78.09	-	43.59	-

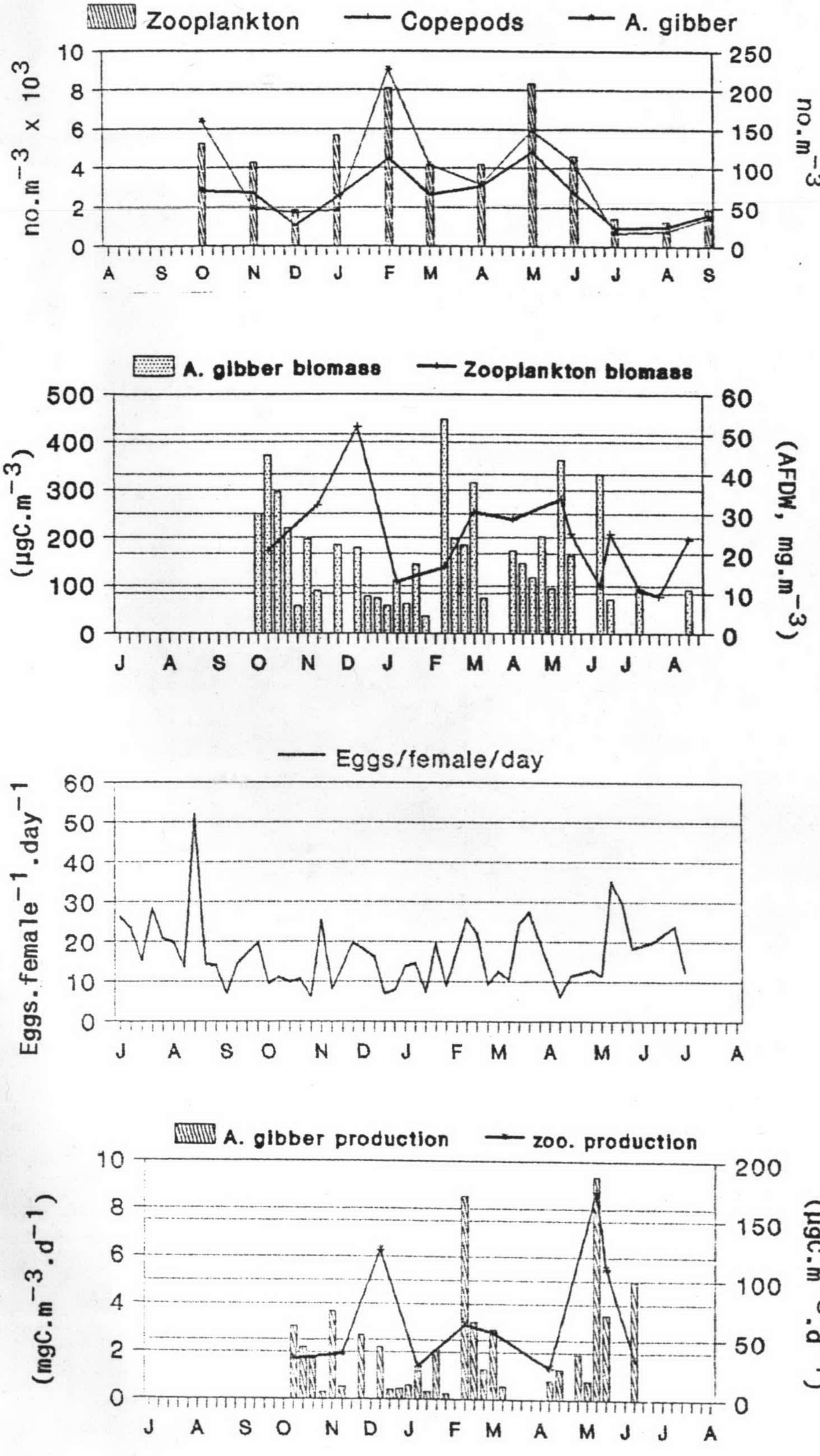

Fig. 9 Seasonal variation of a) abundance of *Acrocalanus gibber*, copepods and total zooplankton, b) biomass of *A. gibber* and total zooplankton, c) egg production rate of *A. gibber* and d) secondary production of *A. gibber* and total zooplankton.

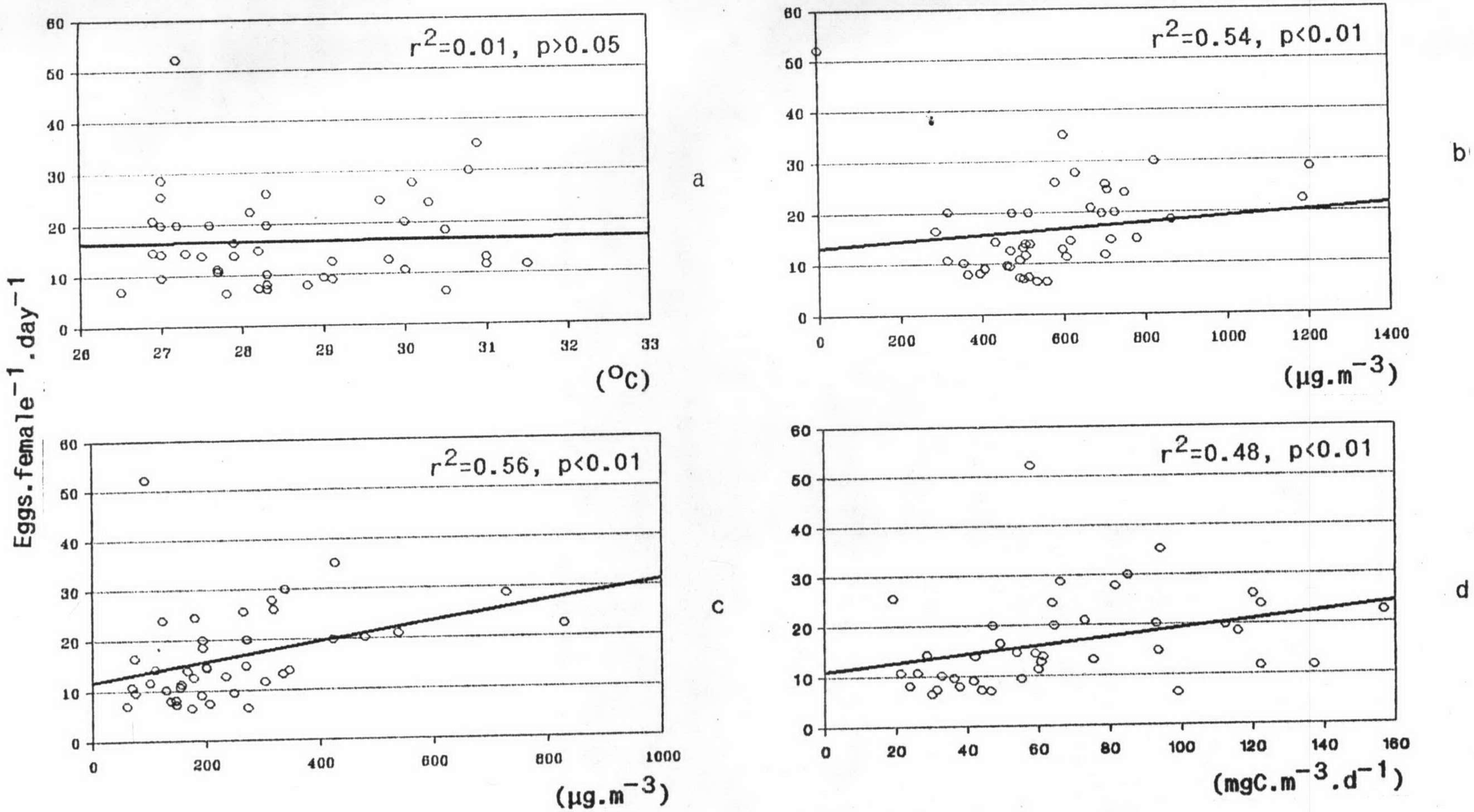

Fig. 10 Relationship between egg production rate of *Acrocalanus gibber* and a) temperature, b) chlorophyll concentration (>1 µm), c) chlorophyll concentration (>8 µm) and d) primary production.

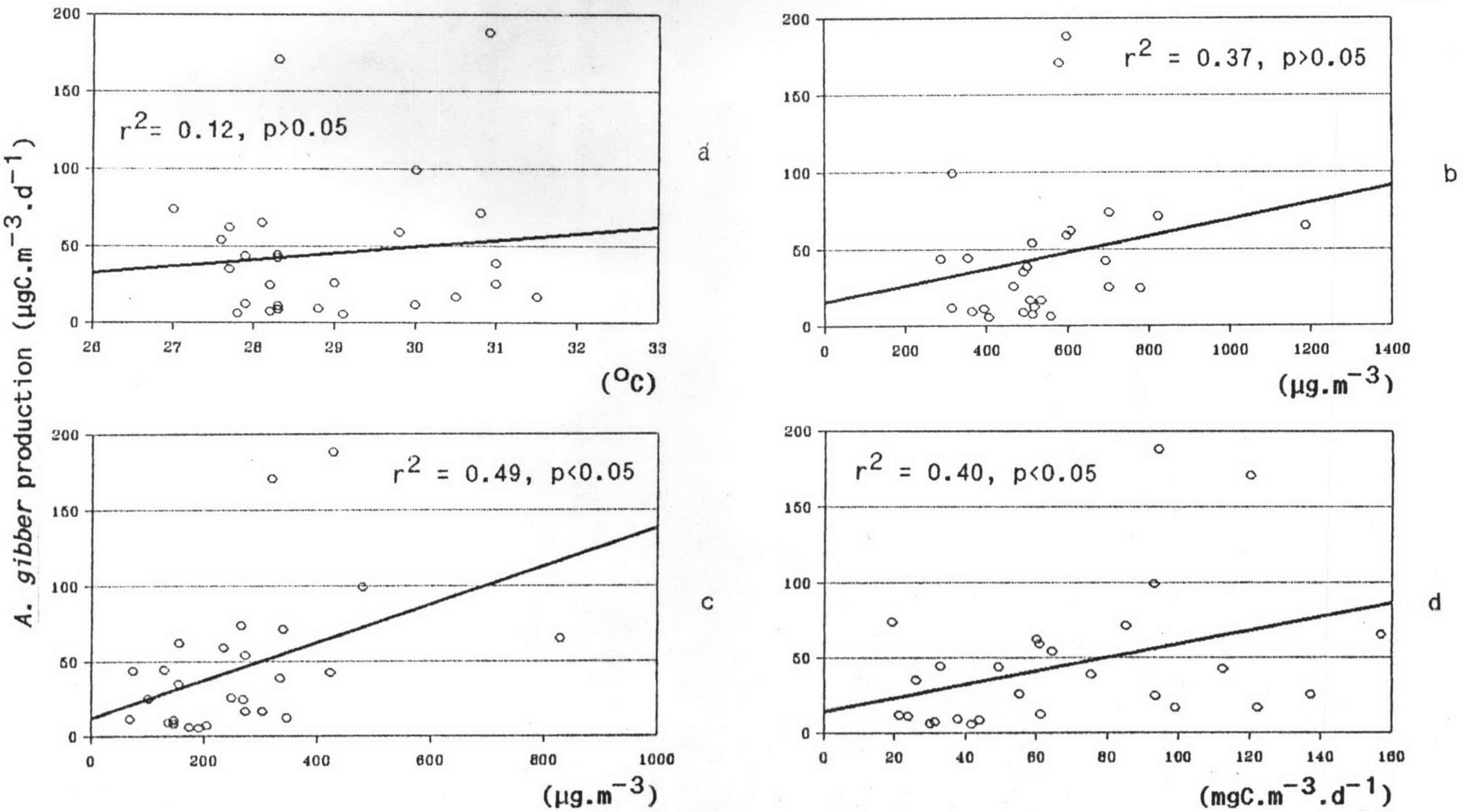

Fig. 11 Relationship between secondary production of *Acrocalanus gibber* and a) temperature, b) chlorophyll concentration (>1 µm), c) chlorohyll concentration (>8 µm) and d) primary production.

Roles of *Acrocalanus gibber* in Pelagic Marine Food Web

1. Ingestion rate

The sizes of phytoplankton cells in stock culture differed somewhat between experiments. The average size was about 14 micrometers in the experiments 4-6, and in experiments 1-3 it was about 16 micrometers in diameter but still in the size range of food that suitable for adult copepods. Approximated carbon content of *Tetraselmis* sp. estimated from equation of Strathmann (1967), was 1.58×10^{-4} and 2.36×10^{-4} microgram carbon per cell for the size 14 and 16 micrometers, respectively.

The filtering rate, average cell concentration and ingestion rate of *A. gibber*, adult females, are shown in Table 6. The average filtering rate for one female ranged from the minimum of 0.6×10^{-4} liter per day to the maximum of 49.2×10^{-3} liter per day. The ingestion rate increased almost linearly with food density and there was still no sign of saturating response (Fig. 12). The ingestion rate averaged for one female ranged from the minimum of 1.98 microgram carbon per day to the maximum of 13.08 microgram carbon per day.

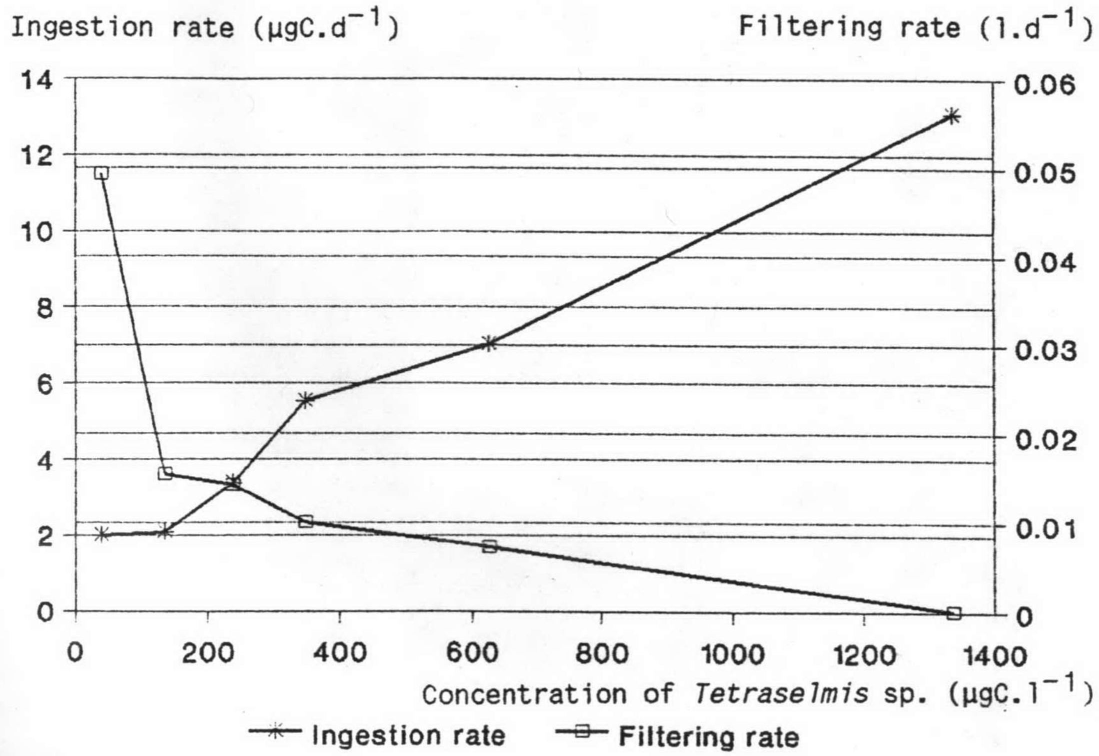

Fig. 12 Filtering and ingestion rate of *Acrocalanus gibber*, adult females at 6 levels of food, *Tetraselmis* sp., concentration.

Table 6 Filtering rate, average phytoplankton concentration and ingestion rate of Acrocalanus gibber, adult females.

	Phytoplankton concentration ($\mu gC.l^{-1}$)					
	50	100	200	400	800	1500
Filtering rate ($\times 10^{-3}$ $l.d^{-1}$)	49.20	15.46	14.21	10.03	7.26	0.06
Ave. concentration ($\mu gC.l^{-1}$)	40.38	135.30	237.58	347.60	626.48	1336.63
Ingestion rate ($\mu gC.d^{-1}$)	1.98	2.09	3.37	5.52	7.03	13.08

2. Stomach content analysis of fishes at the PMBC pier

Only 36 fish species out of the total 136 species of fish recorded from this area, were examined for their stomach content of *A. gibber*, other copepods and also other zooplankton. Altogether 157 guts were examined for *A.gibber*, other coepods and zooplankton. Table 7 showed the fish species composition sampling during daytime in different occasions. Data on their gut contents were shown in Table 8.

Altogether of 13 species were found to consume large amount of copepods and other zooplankton. Among these, 5 species from 2 families contained *A. gibber* in their guts. Those species were 1) *Abudefduf vaigiensis*, 2) *Amblyglyphidodon leucogroter*, 3) *Chromis cinerascens* 4) *Neopomacenthus anabatoides*, which are plankton feeders belonging to the Family Pomacentridae, and 5) *Chaetodon octofasciatus*, which bahaves as a benthic feeder in the Family Chaetodontidae. All species of fishes in Family Caesionidae and Pomacentridae that consumed zooplankton, Table 9, were noticed during field collection that all of them usually formed an aggregated in large schools. They, moreover, were found to be a major component amongst other species found in the study area.

Size ranges of fishes and average number of food items contained in their stomachs were presented in Table 9. Fishes feeding on *A. gibber* were ranged between 6.4-10.0 centimeters in total length while the larger sizes (9.3-12.9) of caesionids were observed to consume other zooplankton rather than *A. gibber*.

3. Zooplankton community

Zooplankton collected at The PMBC pier during October 1990 to September 1991 were shown in Table 10. Cluster analysis was used to determine similarity in appearance and density between zooplankton of each taxa within one year period. Dendrogram in Fig. 13 presented per cent similarity within 16 groups of zooplankton. The zooplankton were separated into two big groups. The first group, which occurred in lower density, composed of shrimp larvae, fish larvae, Brachyura larvae, Ostracods, *A. gibber*, Medusae, Siphonophores and Ctenophores. The second group, the dominant and higher density, were other copepods, Echinoderm larvae, Cerripedea larvae, Larvacea, Mollusc larvae, *Lucifer* spp., Chaetognaths and Polychaetes. *A. gibber* was closest related to

Table 7 Number and species of fish caught at PMBC pier for stomach analysis.

Species	15 Oct	12 Nov	19 Dec	30 Dec(#)
I. Apogonidae				
Archamia fucata	-	-	-	1
Cheilodipterus quinquelineatus	-	-	-	1
II. Caesionidae				
Caesio caerulaurea	-	-	4	-
C. cuning	3	-	8	-
C. lunaris	4	-	4	-
Pterocaesio chrysozona	-	-	2	-
III. Chaetodontidae				
Chaetodon octofasciatus	1	1	-	-
IV. Gobiidae				
Cryptocentrus caeruleomaculatus	-	-	-	1
C. leptocephalus	-	-	-	1
C. strigilliceps	-	-	-	1
Exyrius bellissimus	-	-	-	1
V. Labridae				
Chelinus chlorourus	1	-	-	-
C. digrammus	1	-	-	-
Halichoeres hortulanus	-	2	-	-
H. marginatus	1	-	1	-
H. melanurus	1	1	2	-
Stethojulis trilineatus	2	-	5	-
Thalassoma lunare	1	1	-	-
VI. Lutjanidae				
Lutjanus biguttatus	-	-	3	-
VII. Monacanthidae				
Oxymonacanthus longirostris	-	-	1	-
VIII. Nemipteridae				
Scolopsis vosmeri	-	1	-	-
IX. Pomacentridae				
Abudefduf vaigiensis	1	-	2	-
Amblyglyphidodon leucogaster	20	35	-	-
Amphiprion ocellaris	-	2	-	-
Chromis cinerascens	-	4	-	-
Neoglyphidodon melas	-	-	1	-
Neopomacenthus anabatoides	1	4	-	-
Plectoglyphidodon lacrymatus	-	-	1	-
Pomacenthus adelus	4	1	4	-
P. chrysurus	1	-	-	-
P. molluccensis	-	3	-	-
P. polyspinus	-	-	1	-
Stegastes nigricans	1	-	-	-
X. Scaridae				
Scarus sordidus	-	-	1	-
Scarus sp.(juvenile)	5	2	3	-
XI. Siganidae				
Siganus canaliculatus	3	-	-	-

Table 8 Gut content of fishes collected at PMBC pier.

Fish species	A. gibber	copepods	zoopl.	benthos	algae	sediment	debris
I. Apogonidae							
Archamia fucata	-	-	-	-	-	-	-
Cheliodipterus quinquelineatus	-	-	-	-	-	-	-
II. Caesionidae							
Caesio caerulaurea	-	x	x	x	-	-	-
C. cuning	-	x	x	-	x	-	x
C. lunaris	-	x	x	-	-	-	x
Pterocaesio chrysozona	-	x	x	x	-	-	-
III. Chaetodontidae							
Chaetodon octofasciatus	x	x	x	-	-	x	x
IV. Gobiidae							
Cryptocentrus caeruleomaculatus	-	-	-	x	x	x	-
C. leptocephalus	-	-	-	x	-	x	-
C. strigilliceps	-	-	-	x	x	x	-
Exyrius bellissimus	-	-	-	x	x	x	-
V. Labridae							
Chelinus chlorourus	-	-	-	-	-	x	x
C. digrammus	-	-	-	-	-	-	x
Halichoeres hortulanus	-	-	-	-	-	-	x
H. marginatus	-	-	-	x	-	x	x
H. melanurus	-	-	-	x	x	x	x
Stethojulis trilineatus	-	x	x	x	x	x	x
Thallassoma lunare	-	-	-	-	x	x	-
VI. Lutjanidae							
Lutjanus biguttatus	-	-	x	-	-	-	-
VII. Monacathidae							
Oxymonacanthus longirostris	-	-	-	-	x	-	-
VIII. Nemipteridae							
Scolopsis vosmeri	-	-	-	-	-	-	-
IX. Pomacentridae							
Abudefduf vaigiensis	x	x	x	-	x	-	-
Amblyglyphidodon leucogaster	x	x	x	x	-	-	-
Amphiprion ocellaris	-	x	-	-	x	-	-
Chromis cinerascens	x	x	x	-	-	-	-
Neoglyphidodon melas	-	-	-	x	x	-	-
Neopomacenthus anabatoides	x	x	x	x	-	-	-
Plectroglyphidodon lacrymatus	-	-	x	-	-	-	-
Pomacenthus adelus	-	-	-	x	x	x	-
P. chrysurus	-	-	-	-	x	x	-
P. molluccensis	-	-	-	x	x	-	-
P. polyspinus	-	-	-	-	x	-	-
Stegastes nigricans	-	-	-	-	-	x	-
X. Scaridae							
Scarus sordidus	-	-	-	x	x	-	x
Scarus sp. (juvenile)	-	-	-	-	-	x	-
XI. Siganidae							
Siganus canaliculatus	-	-	-	-	x	x	-

Table 9 Average number of *Acrocalanus gibber*, other copepods and total zooplankton in fish stomachs.

Fish species	Total length (cm)	Number of fishes	Number of zooplankton consumed			
			A. gibber	Copepods	Other zooplankton	Total
Family Caesionidae						
Caesio caerulaurea	11.7-14.0	4	-	120.7	690.0	810.7
C. cuning	9.3-19.9	11	-	100.8	402.6	503.4
C. lunaris	12.2-14.5	8	-	111.3	572.6	683.9
Pterocaesio chrysozona	12.0-12.7	2	-	109.5	113.0	222.5
Family Chaetodontidae						
Chaetodon octofasciatus	6.4-7.3	2	3.0	41.0	10.0	54.0
Family Labridae						
Stethojulis trilineatus	9.8-13.0	7	-	116.7	726.8	834.5
Family Lutjanidae						
Lutjanus biguttatus	12.8-13.0	3	-	-	17.0	17.0
Family Pomacentridae						
Abudefduf vaigiensis	6.7-9.0	3	5.5	571.3	52.2	629.0
Amblyglyphidodon leucogaster	7.4-10.0	55	10.0	209.5	88.8	308.3
Amphiprion ocellaris	6.5-7.1	2	-	37.0	-	37.0
Chromis cinerascens	8.7-9.2	4	9.3	225.3	143.9	378.5
Neopomacenthus anabatoides	7.4-8.6	5	8.3	586.2	77.9	672.4
Plectroglyphidodon lacrymatus	7.2	1	-	-	32.0	32.0

Ostracods at 69.29% level, and they were related to Medusae at 58.97% level.

Correlation between zooplankton groups within the zooplankton community were shown by Spearman Rank Coefficients, Table 11, which resulted that *A. gibber* is positively related to six groups of zooplankton coexisted in the same period. Those groups of zooplankton were polychaete larvae, shrimp larvae, brachyura larvae, mollusc larvae, ostracods and other copepods.

Table 11 Zooplankton composition at PMBC pier during October 1990 to September 1991.

Organism list	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Medusae	100	92	40	136	28	40	28	76	92	24	4	4
Siphonophora	16	16	4	0	12	20	0	16	0	0	0	0
Ctenophora	0	12	0	20	0	0	0	0	4	0	0	0
Platyhelminthes	0	0	0	4	0	0	0	0	0	0	0	0
Polychaeta	132	144	56	156	540	192	68	276	88	72	4	16
Cladocera	8	0	0	0	0	0	0	0	4	0	0	0
Ostracoda	124	64	28	60	140	140	68	132	68	12	16	12
Cirripedea	176	476	316	384	1500	200	452	3036	1084	56	108	124
Amphipoda	12	4	0	0	0	0	4	0	0	0	0	0
Isopoda	8	0	0	8	4	0	0	4	0	0	0	0
Mysidacea	0	0	0	4	8	0	0	0	0	8	0	0
Shrimp larvae	28	48	8	60	76	40	24	20	12	8	4	0
Luciferidae	68	472	148	96	196	128	144	224	216	52	0	24
Acetes	0	4	0	12	0	0	4	12	0	0	0	0
Anomura	4	4	0	4	0	16	0	0	0	0	0	0
Brachyura	120	28	0	40	20	60	8	28	12	8	8	8
Gastropoda	888	508	128	88	1184	524	212	246	268	80	56	32
Pelecypoda	1040	332	176	48	348	188	108	160	176	92	108	84
Heteropoda	16	0	0	0	0	0	0	0	0	0	0	0
Pteropoda	696	4	0	0	24	0	12	12	20	8	0	4
Cyphonautes	4	0	0	4	0	0	0	0	0	0	0	0
Branchiopoda	8	0	8	0	0	0	0	4	4	0	0	0
Chaetognatha	120	464	168	304	524	476	324	400	192	148	20	8
Echinodermata	40	48	24	2552	24	36	0	36	16	12	0	0
Larvacea	180	388	112	952	1060	324	232	800	672	132	72	72
Thaliacea	0	8	0	4	0	0	0	4	0	0	0	0
Fish larvae	28	48	8	20	8	38	20	16	0	4	0	4
Others	0	0	0	24	4	0	0	4	8	36	0	0
Total	8220	6736	2892	8952	12760	6566	6548	13114	7294	2292	2012	2964

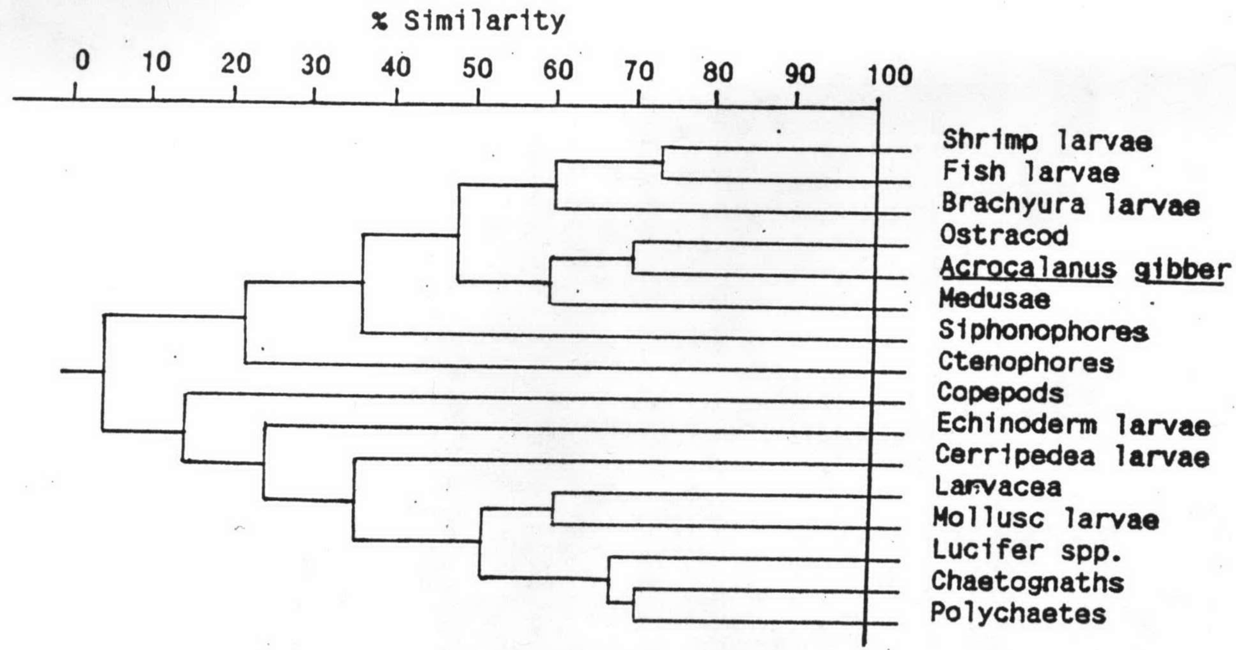

Fig. 13 Dendrogram for cluster analysis of the zooplankton groups at the PMBC pier during one year period.

Table 12 Spearman Rank Correlation between zooplankton groups.

a = Medusae b = Siphonophores c = Ctenophores d = Polychaete larvae
e = Ostracods f = Copepods g = *A. gibber* h = Cirripedea larvae
i = Shrimp larvae j = *Lucifer* spp. k = Brachyura larvae l = Mollusc larvae
m = Chaetognaths n = Echinoderm larvae o = Larvacea p = Fish larvae

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	1															
B	0.38	1														
C	0.66	-0.15	1													
D	0.53	0.64	0.22	1												
E	0.41	0.70	-0.08	0.79	1											
F	0.39	0.41	-0.05	0.67	0.85	1										
G	0.50	0.58	-0.01	0.73	0.92	0.92	1									
H	0.46	0.31	0.33	0.65	0.65	0.78	0.71	1								
I	0.60	0.49	0.41	0.83	0.69	0.56	0.63	0.55	1							
J	0.50	0.46	0.37	0.58	0.55	0.55	0.57	0.90	0.49	1						
K	0.70	0.64	0.32	0.74	0.65	0.50	0.62	0.26	0.71	0.21	1					
L	0.43	0.74	-0.03	0.60	0.79	0.59	0.81	0.46	0.61	0.56	0.57	1				
M	0.31	0.56	0.20	0.82	0.76	0.59	0.59	0.73	0.80	0.73	0.42	0.57	1			
N	0.86	0.62	0.54	0.70	0.43	0.27	0.42	0.36	0.72	0.44	0.79	0.45	0.46	1		
O	0.59	0.30	0.49	0.89	0.68	0.69	0.68	0.82	0.82	0.68	0.57	0.46	0.80	0.59	1	
P	0.55	0.70	0.20	0.52	0.49	0.35	0.38	0.23	0.69	0.35	0.67	0.50	0.55	0.71	0.34	1

The underlined data show significant correlation at 97.5% level.