

Distribution, Abundance and Composition of Zooplankton in the South China Sea, Area I :Gulf of Thailand and East Coast of Peninsular Malaysia

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ABSTRACT

The sample of 81 stations in the Gulf of Thailand and the East Coast of Peninsular Malaysia were collected by M.V.SEAFFDEC on 4 September - 4 October 1995 for the pre northeast monsoon period and on 23 April - 23 May 1996 for the post-northeast monsoon period. 34 groups of zooplankton were found in this study. Copepod was the most abundant in both period followed by Chaetognatha in pre-monsoon and Ostracod in post-monsoon. Biomass and abundance vary from 0.069 - 20.172 ml/m³ and 36 - 3,413 no/m³ in pre-monsoon and 0.18 - 2.589 ml/m³ and 91-1,514 no/m³ in post-monsoon respectively. There was significant difference for abundance between pre and post-monsoon period (at 95 % level). But there was no significant difference between biomass for both period.

Key words: zooplankton, the Gulf of Thailand, Peninsular Malaysia

Introduction

Marine zooplankton serve a key role in the food chains of the sea as they transfer energy from the phytoplankton to higher trophic levels. In the context of fisheries biology, the transfer of energy to the fish stocks is of particular interest, especially during the first weeks in the life of the fish, as the survival of the larvae. Previous investigations of zooplankton in the Gulf of Thailand have been done since 1926. Many papers concerned the seasonal abundance and distribution of zooplankton in the Gulf of Thailand were based on the results of the NAGA Expedition during 1959-1961 (Brinton 1963, Suvapepun, 1977; Suwanrumpha, 1980^a and Suvapepun, 1980). Few studies have been made on copepod (Suvapepun and Suwanrumpha, 1969; Suwanrumpha, 1980^b), salps (Suwanrumpha, 1995), fish larvae (Chayakul, 1990), shrimp larvae (Tubtimsang, 1981^a) and invertebrate larvae (Tubtimsang, 1981^b). However, at least 238 species of zooplankton have been record in this region (Suvapepun, 1981).

The propose of the present investigation is to describe the zooplankton community in the gulf of Thailand and Malaysia, and provide an estimation of abundance, composition, biomass and their distribution.

Methods

The sample of 81 stations in the Gulf of Thailand and the East Coast of Peninsular Malaysia were collected by M.V.SEAFFDEC on 4 September - 4 October 1995 for the pre monsoon period and on 23 April - 23 May 1996 for the post-monsoon period. Station no. 27 was omitted (Table 1 and Figure 1). The oblique tow was made from the surface to ~5 m above the bottom with 0.03 mm bongo net fitted with the mouth flow-meter. The sampling time was approximately 30 minutes with the ship speed was about 2 knots. The samples were preserved in 10 % buffered formalin-seawater immediately. In the laboratory, the displacement volume of total zooplankton was measured after large gelatinous zooplankton had been removed. The samples were sub-sampled with Folsom Plankton Splitter and then counted to taxon. Data on biomass and abundance were standardized per cubic meter.

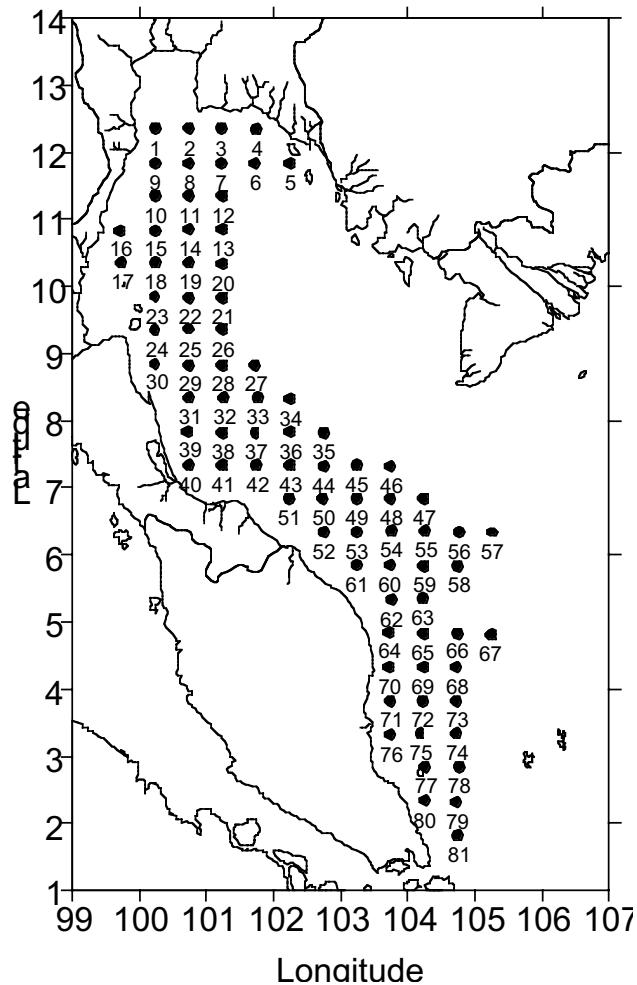


Fig. 1. Area and stations of collaborative research survey in the Gulf of Thailand and the east coast of Peninsular Malaysia

Results

Biomass and abundance of total zooplankton

Pre-monsoon period

Biomass and abundance of total zooplankton were showed in Fig. 2 and 4. Biomass vary from 0.069-20.172 ml/m³ which station 42 (near Pattani bay) has the highest biomass. Abundance vary from 36 - 3,413 no/m³ which station 42 (near Pattani bay) has the highest abundance.

Post-monsoon period

Biomass and abundance of total zooplankton were showed in Fig. 3 and 5. Biomass vary from 0.18 - 2.589 ml/m³ which station 24 (near Ko Samui) has the highest biomass. Abundance vary from 91 - 1514 no/m³ which station 2 (near Amphor Sattahip) has the highest abundance. It is obvious that the abundance was high in the upper part of the Gulf of Thailand, near Ko Samui and the lower part of Peninsular Malaysia.

In post-monsoon period, there were 49 stations (61.25 %) which increase in biomass while 29 stations (36.25 %) were decrease and 2 stations (2.5 %) were constant (Table 2 and 4). For abundance, in post-monsoon period, there were 60 stations (75 %) which increase in abundance while 11 stations (13.75 %) were decrease and 9 stations (11.25 %) were constant (Table 3 and 4).

T-test (Table 5) shows the significant difference for abundance between pre and post-monsoon

Table 1. Information of the stations in the study areas.

Stn. No.	Pre-NE monsoon		Post-NE monsoon		Position		Depth (m)
	Date	Time	Date	Time	Latitude	Longitude	
1	5/9/95	0609-0617	24/4/96	0810-0823	12-20 N	100-15 E	31
2	5/9/95	1048-1055	24/4/96	1149-1210	12-20 N	100-45 E	29
3	5/9/95	1511-1526	24/4/96	1616-1628	12-20 N	101-15 E	31
4	5/9/95	1912-1228	24/4/96	2100-2125	12-20 N	101-45 E	27
5	6/9/95	0559-0617	25/4/96	0600-0628	11-50 N	102-15 E	30
6	6/9/95	1026-1047	25/4/96	1023-1052	11-50 N	101-45 E	47
7	6/9/95	1436-1458	25/4/96	1507-1538	11-50 N	101-15 E	45
8	6/9/95	1840-1859	25/4/96	1933-2000	11-50 N	100-45 E	40
9	7/9/95	0606-0627	26/4/96	0557-0622	11-50 N	100-15 E	37
10	7/9/95	1022-1043	26/4/96	1026-1056	11-20 N	100-15 E	50
11	7/9/95	1425-1453	26/4/96	1456-1524	11-20 N	100-45 E	52
12	7/9/95	1837-1858	26/4/96	1926-1955	11-20 N	101-15 E	60
13	8/9/95	0559-0632	27/4/96	0623-0632	10-50 N	101-15 E	65
14	8/9/95	1228-1157	27/4/96	1042-1112	10-50 N	100-45 E	60
15	8/9/95	1631-1700	27/4/96	1532-1603	10-50 N	100-15 E	55
16	8/9/95	2051-2118	27/4/96	2002-2032	10-50 N	099-45 E	50
17	9/9/95	0555-0628	28/4/96	0557-0626	10-20 N	099-45 E	48
18	9/9/95	1116-1143	28/4/96	1010-1040	10-20 N	100-15 E	55
19	9/9/95	1557-1620	28/4/96	1439-1507	10-20 N	100-45 E	60
20	9/9/95	2015-2042	28/4/96	1853-1922	10-20 N	101-15 E	65
21	10/9/95	0557-0625	29/4/96	0557-0628	09-50 N	101-15 E	70
22	10/9/95	1010-1038	29/4/96	1021-1050	09-50 N	100-45 E	60
23	10/9/95	1431-1455	29/4/96	1436-1504	09-50 N	100-15 E	35
24	10/9/95	1847-1909	29/4/96	1842-1913	09-20 N	100-15 E	30
25	12/9/95	0600-0625	1/5/96	0555-0623	09-20 N	100-45 E	37
26	12/9/95	1036-1110	1/5/96	1028-1057	09-20 N	101-15 E	65
27	-	-	2/5/96	2145-2215	08-50 N	101-45 E	75
28	12/09/95	1517-1550	1/5/96	1508-1532	08-50 N	101-15 E	59
29	12/09/95	1950-2015	1/5/96	2027-2057	08-50 N	100-45 E	32
30	13/9/95	0557-0613	2/5/96	0555-0624	08-50 N	100-15 E	25
31	13/9/95	1139-1201	2/5/96	1116-1145	08-20 N	100-45 E	29
32	13/9/95	1539-1604	2/5/96	1519-1547	08-20 N	101-15 E	55
33	13/9/95	2002-2027	3/5/96	0551-0622	08-20 N	101-45 E	70
34	14/9/95	0548-0622	3/5/96	1014-1043	08-20 N	102-15 E	78
35	14/9/95	1207-1240	3/5/96	1558-1625	07-50 N	102-45 E	72
36	14/9/95	1651-1717	3/5/96	2006-2035	07-50 N	102-15 E	73
37	14/9/95	2116-2143	4/5/96	0553-0622	07-50 N	101-45 E	57
38	15/9/95	0600-0626	4/5/96	1017-1046	07-50 N	101-15 E	50
39	15/9/95	1022-1034	4/5/96	1427-1451	07-50 N	100-45 E	28
40	15/9/95	1419-1438	4/5/96	1835-1853	07-20 N	100-45 E	22
41	15/9/95	1823-1852	6/5/96	0542-0611	07-20 N	101-15 E	42
42	17/9/95	0903-0930	6/5/96	1001-1030	07-20 N	101-45 E	50
43	17/9/95	1329-1357	6/5/96	1423-1441	07-20 N	102-15 E	52
44	17/9/95	1744-1816	6/5/96	1835-1905	07-20 N	102-45 E	55
45	18/9/95	0600-0625	7/5/96	0541-0611	07-20 N	103-15 E	56
46	18/9/95	1046-1113	7/5/96	1010-1039	07-20 N	103-15 E	53
47	18/9/95	1622-1648	7/5/96	1530-1600	06-50 N	104-15 E	58
48	18/9/95	2249-2318	7/5/96	1952-2020	06-50 N	103-45 E	57
49	19/9/95	0554-0623	8/5/96	0540-0608	06-50 N	103-15 E	55
50	19/9/95	1047-1109	8/5/96	1030-1100	06-50 N	102-45 E	51
51	19/9/95	1502-1528	8/5/96	1451-1521	06-50 N	102-15 E	49
52	19/9/95	2044-2107	8/5/96	2025-2055	06-20 N	102-45 E	39
53	20/9/95	0558-0625	9/5/96	0540-0610	06-20 N	103-15 E	35
54	20/9/95	1028-1056	9/5/96	0959-1027	06-20 N	103-45 E	62
55	20/9/95	1458-1528	9/5/96	1417-1446	06-20 N	104-15 E	62
56	20/9/95	1925-1958	9/5/96	1836-1904	06-20 N	104-45 E	61
57	21/9/95	0545-0613	10/5/96	0529-0600	06-20 N	105-15 E	60
58	21/9/95	1119-1147	10/5/96	1107-1135	05-50 N	104-45 E	62
59	21/9/95	1543-1611	10/5/96	1523-1551	05-50 N	104-15 E	66
60	21/9/95	2016-2043	10/5/96	1953-2022	05-50 N	103-45 E	57
61	23/9/95	0552-0617	12/5/96	0607-0637	05-50 N	103-15 E	50
62	23/9/95	1208-1234	12/5/96	1142-1211	05-20 N	103-45 E	61
63	23/9/95	1627-1654	12/5/96	1609-1638	05-20 N	104-15 E	65
64	23/9/95	2221-2245	12/5/96	2152-2222	04-50 N	103-45 E	60
65	24/9/95	0849-0918	13/5/96	0925-0955	04-50 N	104-15 E	65
66	24/9/95	1314-1444	13/5/96	1338-1408	04-50 N	104-45 E	72
67	24/9/95	1742-1813	13/5/96	1752-1822	04-50 N	105-15 E	76
68	25/9/95	0548-0618	14/5/96	0544-0612	04-20 N	104-45 E	73
69	25/9/95	1019-1046	14/5/96	1025-1053	04-20 N	104-15 E	67
70	25/9/95	1436-1501	14/5/96	1445-1513	04-20 N	103-45 E	40
71	25/9/95	1915-1930	14/5/96	1904-1932	03-50 N	103-45 E	34
72	26/9/95	0544-0611	15/5/96	0539-0609	03-50 N	104-15 E	53
73	26/9/95	1014-1044	15/5/96	0952-1021	03-50 N	104-45 E	73
74	26/9/95	1433-1502	15/5/96	1416-1444	03-20 N	104-45 E	68
75	26/9/95	1849-1915	15/5/96	1827-1854	03-20 N	104-15 E	53
76	27/9/95	0545-0602	16/5/96	0541-0603	03-20 N	103-45 E	27
77	27/9/95	1054-1120	16/5/96	1139-1209	02-50 N	104-15 E	46
78	27/9/95	1511-1534	16/5/96	1557-1627	02-50 N	104-45 E	65
79	27/9/95	1934-2000	16/5/96	2018-2047	02-20 N	104-45 E	60
80	28/9/95	0515-0542	17/5/96	0535-0604	02-20 N	104-15 E	34
81	28/9/95	1043-1104	17/5/96	1123-1151	01-50 N	104-45 E	54

Table 2. Biomass of zooplankton (ml./m³) in the Gulf of Thailand and the East Coast of Peninsular Malaysia: pre = pre-monsoon post = post-monsoon

Station	pre	post	Station	pre	post	Station	pre	post
1	0.58	0.89	29	1.31	0.88	56	0.43	0.79
2	0.56	2.08	30	1.46	1.63	57	0.21	0.61
3	0.52	1.16	31	0.51	0.90	58	0.35	0.66
4	0.27	1.17	32	0.59	0.37	59	0.36	0.92
5	0.36	0.43	33	1.56	0.60	60	0.42	0.19
6	0.83	1.13	34	1.63	0.65	61	1.21	0.27
7	0.27	1.03	35	2.60	0.46	62	0.53	0.63
8	0.26	0.98	36	1.17	0.34	63	0.50	0.79
9	0.60	0.82	37	0.70	0.61	64	0.78	0.46
10	0.32	1.16	38	0.18	0.44	65	0.24	0.61
11	2.12	0.87	39	0.82	0.69	66	0.09	0.18
12	0.35	0.72	40	0.83	0.74	67	0.23	0.41
13	0.07	0.42	41	0.68	0.49	68	0.18	0.45
14	0.16	0.33	42	20.17	0.45	69	0.15	0.64
15	0.16	0.70	43	1.71	0.48	70	0.60	0.79
16	0.47	1.06	44	1.89	0.5	71	0.52	0.8
17	0.41	1.10	45	0.66	0.42	72	0.49	0.86
18	0.90	0.66	46	0.27	1.71	73	0.37	0.53
19	0.51	0.37	47	0.21	0.19	74	0.2	0.58
20	0.64	0.34	48	0.36	0.38	75	0.28	0.49
21	0.22	0.31	49	0.38	0.57	76	1.76	0.67
22	0.29	0.41	50	0.47	0.33	77	0.35	1.07
23	0.87	0.81	51	0.80	0.31	78	0.31	0.77
24	0.95	2.59	52	1.23	0.61	79	0.45	0.84
25	0.86	0.99	53	0.78	0.40	80	0.92	0.65
26	0.11	0.50	54	0.53	0.48	81	0.79	0.44
28	0.37	0.21	55	0.21	0.54			

Table 3. Total abundance of zooplankton (ml./m³) in the Gulf of Thailand and the East Coast of Peninsular Malaysia: pre = pre-NE monsoon, post = post-NE monsoon

Station	pre	post	Station	pre	post	Station	pre	post
1	253	924	29	735	242	56	153	367
2	272	1,514	30	752	509	57	110	343
3	186	828	31	284	833	58	108	301
4	256	568	32	157	779	59	170	219
5	168	290	33	483	497	60	188	351
6	530	942	34	201	657	61	188	134
7	275	766	35	477	561	62	195	209
8	193	663	36	298	379	63	161	433
9	594	561	37	230	275	64	319	240
10	210	769	38	91	603	65	159	453
11	834	1,361	39	489	481	66	70	288
12	153	528	40	1,036	528	67	95	91
13	73	352	41	693	506	68	111	178
14	69	234	42	3,413	361	69	98	135
15	61	536	43	1,390	458	70	328	563
16	252	756	44	296	353	71	328	742
17	333	909	45	223	429	72	212	620
18	377	518	46	134	199	73	159	860
19	237	410	47	83	466	74	90	427
20	196	372	48	36	213	75	167	410
21	155	369	49	192	214	76	1,624	456
22	134	310	50	278	334	77	588	851
23	453	856	51	762	352	78	250	565
24	709	1,234	52	837	438	79	227	724
25	621	780	53	495	646	80	974	842
26	63	452	54	142	224	81	296	961
28	170	428	55	105	228			

Table 4. Differences of total abundance and biomass of zooplankton from the Gulf of Thailand and the East Coast of Peninsular Malaysia in the pre- and post-northeast monsoon periods.

	Abundance		Biomass	
	No. of station	Percentage	No. of station	Percentage
Increase	60	75	49	61.25
Decrease	11	13.75	29	36.25
Constant	9	11.25	2	2.5

Table 5. Probability (p) of null hypothesis (significant $p < 0.05$) from t-test for comparing biomass and abundance at pre- and post-northeast monsoon period.

	P
Biomass	0.9189
Abundance	0.0080

Table 6. Taxonomic list of zooplankton found in the Gulf of Thailand and the East Coast of Peninsular Malaysia. The average abundance of zooplankton:

+++ = very common (>10 no./m³)

++ = common (6-10 no./m³)

+ = rare (0-5 no./m³).

pre = pre-NE monsoon period (4 September - 4 October 1995)

post = post-NE monsoon period (23 April - 23 May 1996)

Taxon	Abundance		Taxon	Abundance	
	pre	post		pre	post
Medusae	+	+	Phyllosoma larvae	+	+
Siphonophora	+++	+++	Shrimp larvae	++	++
Ctenophora	+	+	Anomura larvae	+	+++
Nemertinea	+	+	Brachyura larvae	+	+
Cyphonautes larvae	+	+	Stomatopod larvae	+	+
Actinotroch larvae	+	+	Heteropoda	+	+
Chaetognatha	+++	+++	Pteropoda	++	+++
Polychaeta	+	+	Cephalopoda	+	+
Cladocera	+	++	Gastropod larvae	+++	+++
Ostracoda	+++	+++	Bivalve larvae	++	++
Copepoda	+++	+++	Echinodermata larvae	+	+
Cirripedia larvae	-	+	Larvacean	+++	+++
Amphipoda	+	+++	Thaliacea	+	++
Isopoda	+	-	Brachiopod larvae	+	+
Mysidacea	+	+	Crustacean nauplii	+	+
Cumacea	+	+	Fish eggs	+	+
Euphausiacea	+	-	Fish larvae	+	+
Lucifer spp.	+++	+			

period (at 95 % level). But there is no significant difference between biomass for both period.

Taxonomic composition

34 groups of zooplankton were found in this study (Table 6 and 7). Copepod dominated the zooplankton community with average 208 and 229 no/m³ (55.99 % and 43.9 % composition) in the pre-monsoon and the post-monsoon respectively. Followed by Chaetognatha (average 30 no/m³ with 8.02 % composition) in pre-monsoon and Ostracod (average 93 no/m³ with 17.8 % composition) in post-monsoon (Table 8).

Distribution of individual taxa

Medusae

In pre-monsoon period, the medusae were found to be very common. Large number were observed in station 53 and 80 (13 and 10 no/m³ respectively) which were in the east coast of Peninsular Malaysia. But in post-monsoon period, Large number were observed in station 8 (77 no/m³) which were in the Gulf of Thailand. Furthermore, the number of individual of medusae was higher in post-monsoon period than in pre monsoon period in the great number of the stations. However, most of medusae distributed near shore rather than offshore (Fig. 6 and 7).

Siphonophora

Siphonophora were observed to be very common in both area. The amount of siphonophora was increase in post-monsoon period for 1.5 - 100 times in every stations (except station no. 42). Nevertheless, there were more abundant in nearshore samples for both period (Fig. 8 and 9).

Ctenophora

Ctenophora found to be rare in this investigation. The percent occurrence was 26.25 % in pre-monsoon and 23.75 % in post-monsoon. The greatest number were 4 no/m³ at station no. 24 (near Ko Samui) in pre-monsoon period and 4 no/m³ at station 2 (near Amphor Sattahip). Most of them were found in the Gulf of Thailand. However, there were more abundant in nearshore samples for both period (Fig. 10 and 11).

Nemertinea

Nemertinea were rare in pre-monsoon period (8.75 % occurrence) but quite common in post-monsoon period (73.75 % occurrence). The abundance was high in post-monsoon period and the distribution were similar in patterns for both of samples taken at nearshore and offshore(Fig. 12 and 13).

Cyphonautes larvae

Cyphonautes larvae were common in pre-monsoon period (70% occurrence) but rare in post-monsoon period (10% occurrence). The abundance was high in pre-monsoon period (Fig. 14 and 15).

Actinotroch larvae

For both period, Actinotroch larvae were quite rare and abundance were occurrence (Fig. 16).

Chaetognatha

Chaetognatha were the second most abundant component in pre-monsoon period but were the forth abundant component in post-monsoon period. Station 42 (near Pattani Bay) and station 11 (near Prachuap Khiri Khan) had the highest abundance in pre-monsoon period. While station 2 had the highest abundance in post-monsoon period. The patterns of distribution were similar for the near

Table 7. Taxonomic list of zooplankton found in the Gulf of Thailand and the East Coast of Peninsular Malaysia. Frequency of occurrence is shown as;

R = Rare

C = Common

VC = Very Common.

pre = pre-NE monsoon period (4 September - 4 October 1995)

post = post-NE monsoon period (23 April - 23 May 1996)

Taxon	Frequency		Taxon	Frequency	
	pre	post		pre	post
Medusae	VC	VC	Phyllosoma larvae	C	C
Siphonophora	VC	VC	Shrimp larvae	VC	VC
Ctenophora	R	R	Anomura larvae	VC	VC
Nemertinea	R	VC	Brachyura larvae	VC	VC
Cyphonautes larvae	VC	R	Stomatopod larvae	VC	VC
Actinotroch larvae	R	R	Heteropoda	VC	VC
Chaetognatha	VC	VC	Pteropoda	VC	VC
Polychaeta	VC	VC	Cephalopoda	C	C
Cladocera	VC	VC	Gastropod larvae	VC	VC
Ostracoda	VC	VC	Bivalve larvae	VC	VC
Copepoda	VC	VC	Echinodermata larvae	VC	VC
Cirripedia larvae	-	R	Larvacean	VC	VC
Amphipoda	VC	VC	Thaliacea	VC	VC
Isopoda	R	-	Brachiopod larvae	R	R
Mysidacea	VC	VC	Crustacean nauplii	VC	VC
Cumacea	R	R	Fish eggs	VC	VC
Euphausiacea	R	-	Fish larvae	VC	VC
Lucifer spp.	VC	VC			

Table 8. Percent composition of some zooplankton in the Gulf of Thailand and the East coast of Peninsular Malaysia in the pre-and post-northeast monsoon periods.

Rank	Pre-monsoon		Post-monsoon	
	Taxon	Per cent composition	Taxon	Per cent composition
1	Copepoda	55.99	Copepoda	43.9
2	Chaetognatha	8.02	Ostracoda	17.8
3	Ostracoda	5.47	Siphonophora	6.3
4	Siphonophora	3.61	Chaetognatha	5.4
5	Gastropod larvae	3.17	Gastropod larvae	4.4
6	Lucifer spp.	3.17	Amphipoda	3.2
7	Laevacean	2.78	Pteropod	3.0
8	Shrimp larvae	2.67	Laevacean	2.1
9	Pteropod	2.57	Shrimp larvae	1.9
10	Bivalve larvae	2.25	Anomura larvae	1.8

shore and offshore stations in post-monsoon period. But in pre-monsoon period, the number of chaetognatha taken from the near shore stations were higher than the offshore stations (Fig. 17 and 18).

Polychaeta

Polychaet larvae were observed to be fairly common even though the number of them were not so high. However, the number of organisms were higher in pre-monsoon than post-monsoon period. Higher abundance occurred near shore than offshore for both period. In the post-monsoon period, polychaet were absent in the east coast of Peninsular Malaysia (Fig. 19 and 20).

Cladocera

Cladocera were the regular component in the samples in this investigation. Station 17 (near Chumphon) had the highest abundance in pre-monsoon period. While station 1 and station 17 had the highest abundance in post-monsoon period. Higher abundance occurred near shore than offshore for both period especially in the Gulf of Thailand (Fig. 21 and 22).

Ostracoda

Ostracoda were the third most abundant in pre-monsoon period and the second most abundant in post-monsoon period. They were observed to be common in this study area. In post-monsoon showed higher abundance than in pre-monsoon period. However, in pre-monsoon period the ostracoda distributed near shore rather than off shore while in the post-monsoon period the patterns of distribution were similar (Fig. 23 and 24).

Copepoda

Copepoda dominated the zooplankton in this investigation in both season. They consisted 55.4% and 43.9% of zooplankton population in pre and post-monsoon respectively. Number of copepod were increase in post-monsoon period in most of the stations. There were higher abundance at near shore than offshore stations in both period (Fig. 25 and 26).

Cirripedia larvae

Cirripedia larvae were very rare in this study. They found only 0-5 no./m³ during post-monsoon and none in pre-monsoon (Fig. 27)

Amphipoda

Amphipoda were very common. High number of abundance occurred near shore in both period. There are no differences in number between pre and post-monsoon period (Fig. 28 and 29).

Isopoda

Isopoda were very rare in this study. The percentage of occurrence was 10 in pre-monsoon and 0 in post-monsoon period (Fig. 12).

Mysidacea

The per cent occurrence of mysidacea was quite high for both period. They were abundant from the lower part of the Gulf of Thailand along the east coast of Peninsular Malaysia. Most of them distributed off shore rather than near shore. However, the abundance in post-monsoon was higher than in pre-monsoon (Fig. 30 and 31).

Cumacea

Cumacea were occasionally present in zooplankton samples especially along the east coast of

Peninsular Malaysia. The average abundance in both period were not difference. Cumacea number were high at near shore stations in pre-monsoon period but there were similar in post-monsoon period (Fig. 32 and 33).

Euphausiacea

Euphausiacea were very rare in this study. They found only 10 per cent occurrence in pre-monsoon period and none in post-monsoon period (Fig. 12).

***Lucifer* spp.**

Lucifer spp. were very common. They were abundant in the upper part of Gulf of Thailand, Pattani Bay and near shore along the east coast of Peninsular Malaysia in pre-monsoon period. Although they found to be most abundant in the upper part of Gulf of Thailand, near Ko Samui and the lower part of Peninsular Malaysia in post-monsoon period. The distribution pattern were similar for both nearshore and offshore stations (Fig. 34 and 35).

Phyllosoma larvae

Phyllosoma larvae were found to be irregular in this area. The largest number in post-monsoon was found near Ko Samui. However, The average abundance showed no differences between both period (Fig. 36 and 37).

Shrimp larvae

Shrimp larvae were the regular component in the zooplankton population. The great number were found near shore in both season especially at Pattani Bay in pre-monsoon period (81 no/m³) and in the upper part of the Gulf of Thailand in post-monsoon period (126 no/m³). The average abundance showed no differences between both period (Fig. 38 and 39).

Anomura larvae

Anomura larvae were common organisms. The average abundance was higher in post-monsoon period (10 no/m³) than in pre-monsoon period (1 no/m³). The distribution was dispersed nearshore and offshore (Fig. 40 and 41).

Brachyura larvae

Brachyura larvae occurred regularly in the zooplankton samples. They found most abundant at Pattani Bay and nearshore stations in pre-monsoon period. The post-monsoon period showed the same pattern of distribution but the great number was 27 no/m³ near Ko Samui (station 24). The average abundance of brachyura larvae was higher in pre-monsoon (4 no/m³) than in post-monsoon period (2 no/m³) (Fig. 42 and 43).

Stomatopod larvae

Stomatopod larvae were very common. The average abundant in both season showed no differences. The distribution was scattered throughout the study area (Fig. 44 and 45).

Heteropoda

Heteropoda were very common. In pre-monsoon period, the abundance was high near shore along the east coast of Peninsular Malaysia whereas in post-monsoon they were scattered throughout the study areas. However the average abundance in both season showed no differences (Fig. 46 and 47).

Pteropoda

Pteropoda were very common. The average abundant of them was a little bit higher in post-

monsoon (15.6 no/m³ than in pre-monsoon period (9.57 no/m³). Pteropods number were high at nearshore stations (Fig. 48 and 49).

Cephalopoda larvae

Cephalopoda larvae were quite seldom in this study. The average number for both period was no differences. Anyway, they dispersed throughout the study area (Fig. 50 and 51).

Gastropod larvae

Gastropod larvae were very common. They occurred in considerable number during pre and post monsoon period. However, the abundance of gastropod in post-monsoon was a little bit higher than in pre-monsoon. They found high number near Pattani Bay and along the lower part of Peninsular Malaysia in pre-monsoon while along the middle through the lower part part of the Gulf of Thailand in post-monsoon period (Fig. 52 and 53).

Bivalve larvae

Bivalve larvae were observed to be very common but not in large number. There was no differences in both period. The distribution was scattered (Fig. 54 and 55).

Echinodermata larvae

Echinodermata larvae consisted of asteroidea (star fish larvae), holothuroidea (sea cucumber larvae), echinoidea (sea urchin larvae), ophiuroidea (brittle star larvae) and crinoidea (feather star larvae). They were the regular component in the plankton samples in this study but not in large number. The result showed no differences between both period. Most of the echinodermata larvae dispersed nearshore in pre-monsoon and scattered in post-monsoon period (Fig. 56 and 57).

Larvacean

Larvacean were very common but found in small number. The number increased in post-monsoon period. The abundance of larvacean occurred nearshore. The highest number was station 42 (near Pattani Bay) and station 80 in Peninsular Malaysia in pre-monsoon while the upper part of the Gulf of Thailand and near Ko Samui were rich in Larvacean number in post-monsoon period (Fig. 58 and 59).

Thaliacea

Thaliacea (tunicates or salps) were observed to be very common. The number of thaliacea was increased in post-monsoon period in most of the stations. Thaliacea number were high at nearshore stations especially in the middle part of the Gulf of Thailand in post-monsoon (Fig. 60 and 61).

Brachiopod larvae

Brachiopod larvae were occasionally present in low number. In pre-monsoon the abundance were found at around Battani Bay and the end of Peninsular Malaysia but in post-monsoon there were found at the upper gulf of Thailand and the end of Peninsular Malaysia. There were no differences in number in both period (Fig. 62 and 63).

Crustacean Nauplii

Crustacean Nauplii occurred regularly in the plankton samples but not in high number. The number were increased in post-monsoon period. However, the abundance occurred in the nearshore stations in both period (Fig. 64 and 65).

Fish eggs and Fish larvae

This important component of the meroplankton appeared in considerable number during pre and post monsoon period. The abundance of fish larvae and fish eggs in pre-monsoon occurred near Ko Samui, Battani Bay and station 80. In post-monsoon period, the abundant of fish larvae was near Ko Samui but fish eggs was around Prachuap Khiri Khan Bay. The number of fish larvae and fish eggs increased in post-monsoon period in some area (Fig. 66 - 69).

Discussion

The biomass of zooplankton in the Gulf of Thailand in this study was higher than the pass which had range from 14.28 to 33.14 ml/100 m³ in 1979 (Suvapepan, 1980). In general, the plankton biomass off the east coast of the Gulf of Thailand was lower than that in the Inner Gulf and Upper western coast. Highest plankton density in the Inner Gulf was 155.3 ml/100m³ in December (Suvapepan, 1977). The mean abundance of zooplankton in the Gulf of Thailand was slightly increased from 1976-1994 and the patterns of zooplankton distribution were unchanged (Sribyatta, 1996). The present observation showed that zooplankton collected comprises a great variety of organisms and copepod was the main group. The result agree with various workers who reported that copepod was the most important groups and widely distributed in the Inner Gulf and the western coast of the Gulf of Thailand (Suvapepan, 1979; Suwanrumpha, 1980; Sudara and Udomkit, 1984 and Temiyavanich, 1984).

It is obvious that the monsoon affect the zooplankton abundance and their distribution. In post-monsoon period , many organisms were increased in number such as Siphonophora, Cladocera, Ostracoda, Amphipoda, Mysidacea, Anomura larvae Pteropoda and Gastropod larvae. Some organisms were decreased such as Polychaet and *Lucifer* spp. Sribyatta (1996) also found higher number of zooplankton in the northeast monsoon and southwest monsoon. According to Suvapepan (1980) and Suwanrumpha (1980) they concluded that in the Inner Gulf of Thailand periods of high and low zooplankton number coincided with the periods of the two monsoons: with minimum density occurred during the intermonsoons in April and October and that seasonal distribution of different zooplanktonic groups and the species composition are effected by prevailing hydrographical condition induced by the monsoons.

Overall on the shelf, nutrients, phytoplankton and zooplankton show significant positive covariance (Hopcroft and Roff, 1990). This is true also in the Inner Gulf of Thailand whereas Sudara and Udomkit (1984) found that major factor influencing the distribution of zooplankton seems to be the amount of nutrients available. Besides, Tamiyavanich (1984) found the zooplankton abundance had significant correlation to the phytoplankton. Salinity also acts as the major factor determining the variability of zooplankton abundance (Sribyatta, 1996) while temperature is the minor factor (Suwanrumpha, 1978).

Acknowledgements

Appreciation is extended to the Southeast Asian Fisheries Development Center for supporting this research. Thanks are extened to Captain, crews and scientists on the M.V. SEAFDEC for their help in the sampling. Ms. Penjan Rochana-anawat, Ms. Suvimon Sae-Koe and Ms. Siriporn Seurungreong are thanked for preparing the manuscripts. Finally, I wish to thank Mr. Boonlert Phasuk for constructive criticism of the manuscript.

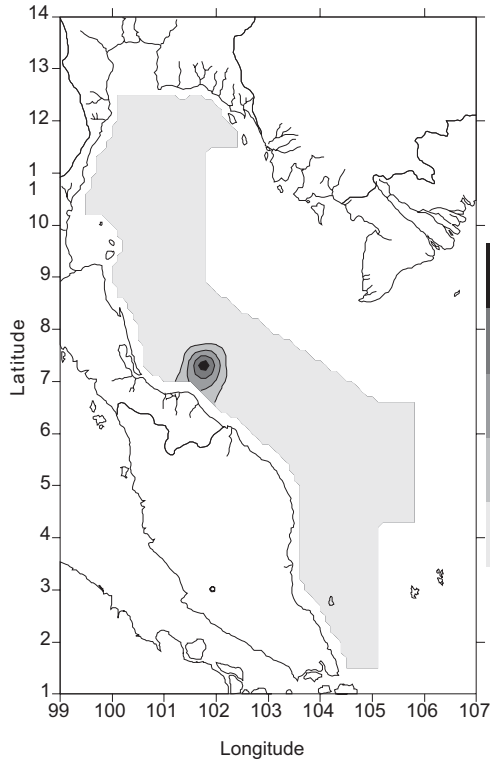


Fig. 2. Biomass of total zooplankton (ml/m^3) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

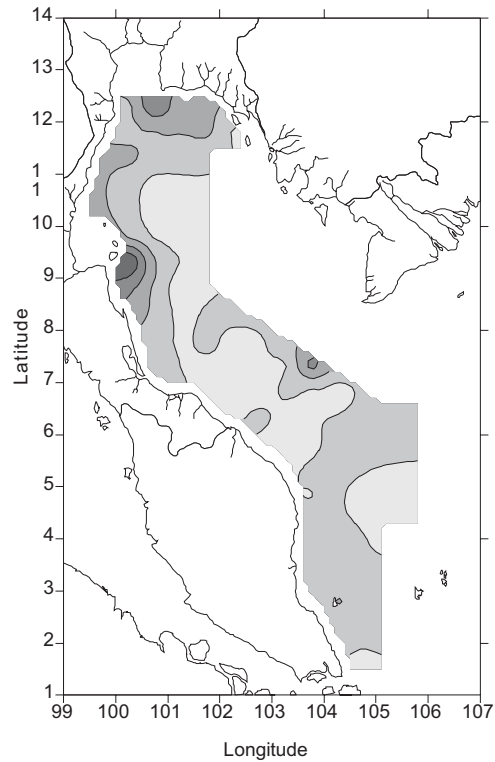


Fig. 3. Biomass of total zooplankton (ml/m^3) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

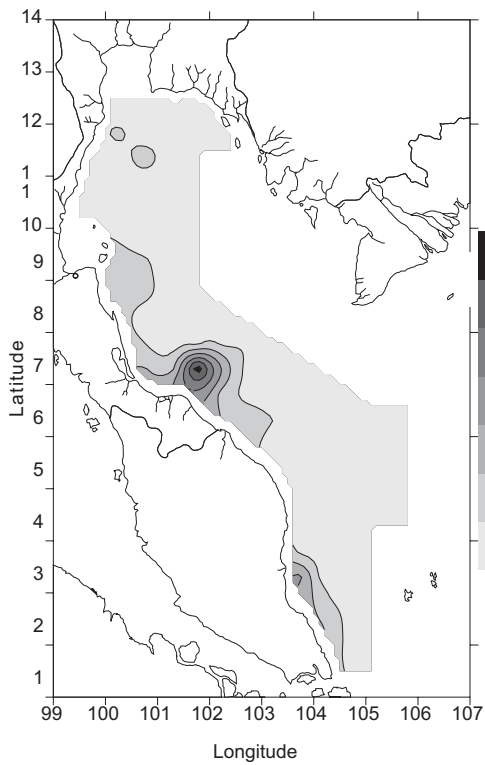


Fig. 4. Abundance of total zooplankton (no/m^3) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

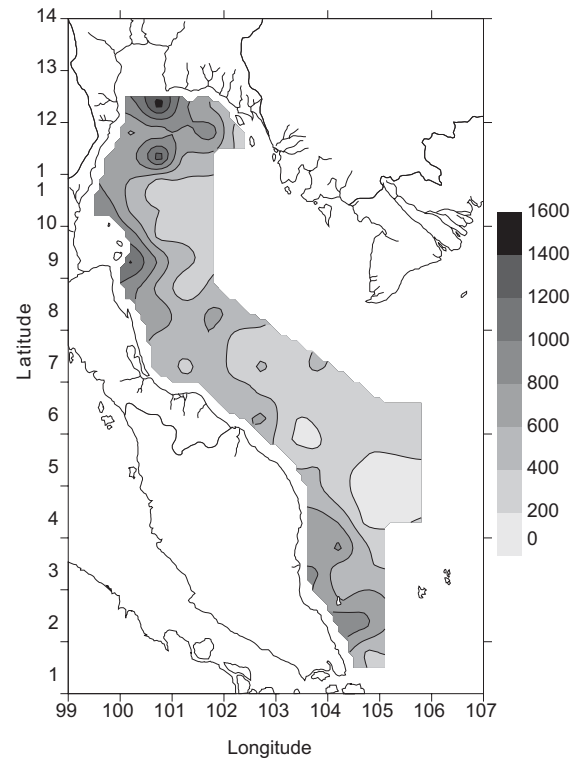


Fig. 5. Abundance of total zooplankton (no/m^3) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

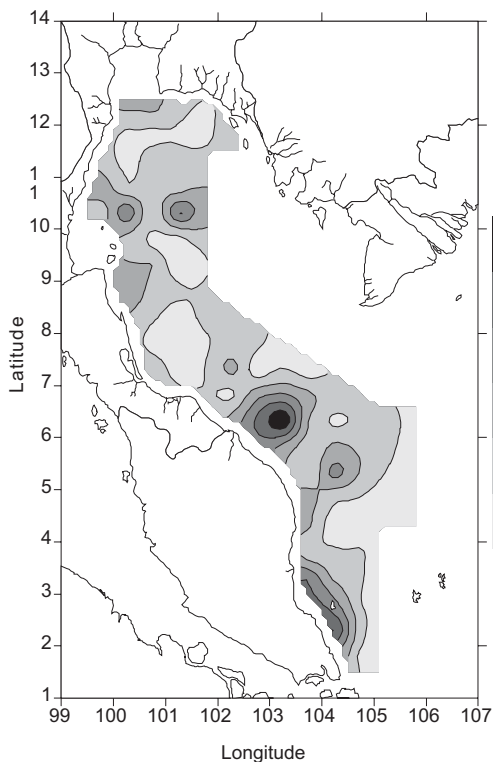


Fig. 6. Distribution of Medusae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

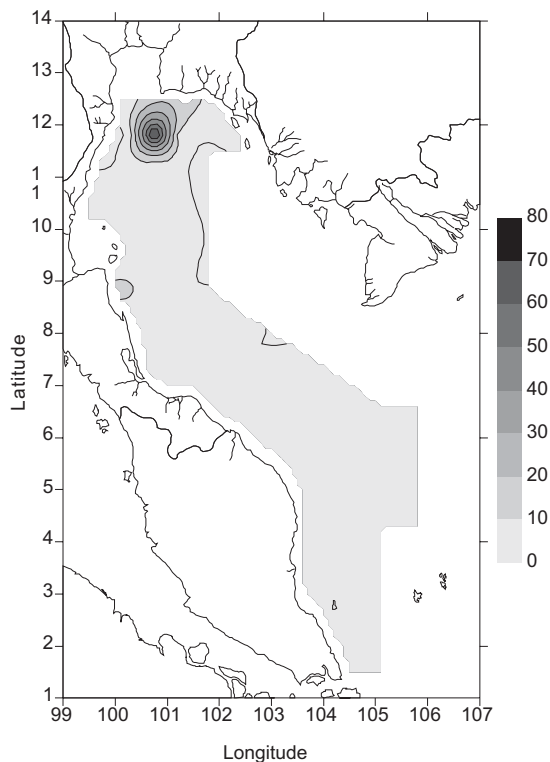


Fig. 7. Distribution of Medusae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

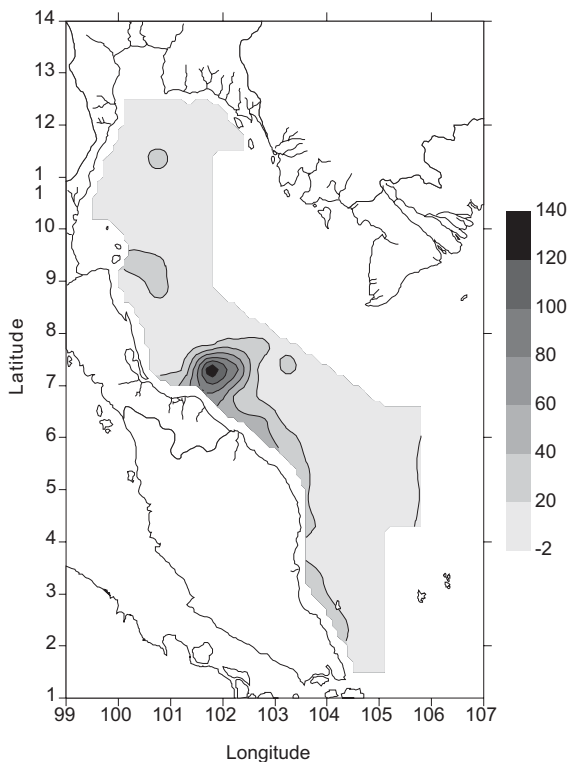


Fig. 8. Distribution of Siphonophora (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

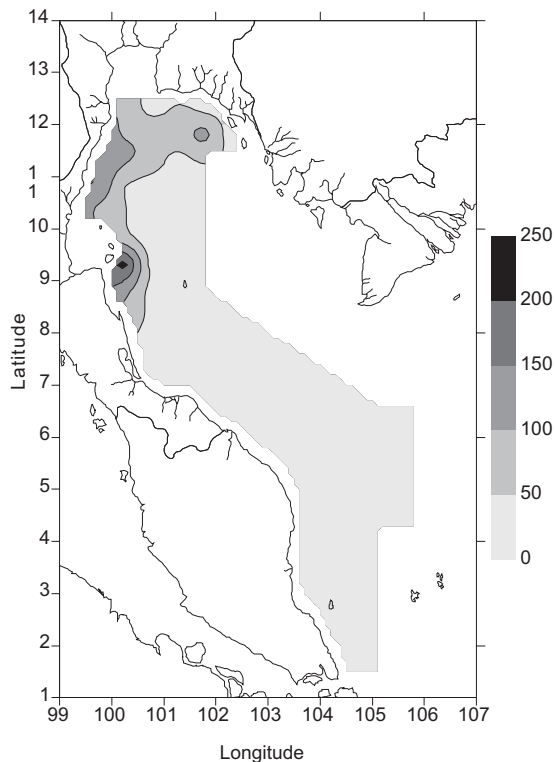


Fig. 9. Distribution of Siphonophora (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

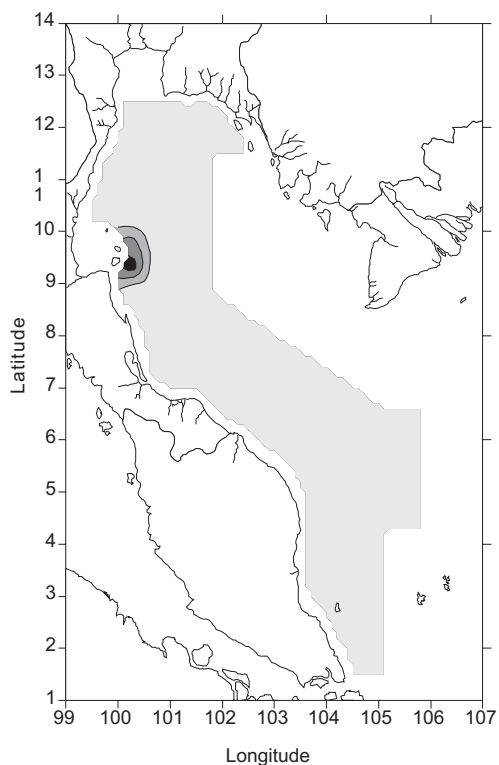


Fig. 10. Distribution of Ctenophora (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

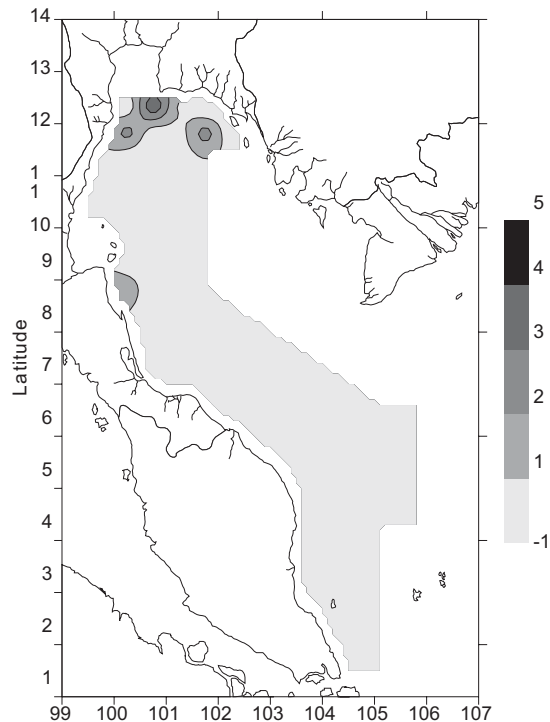


Fig. 11. Distribution of Ctenophora (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

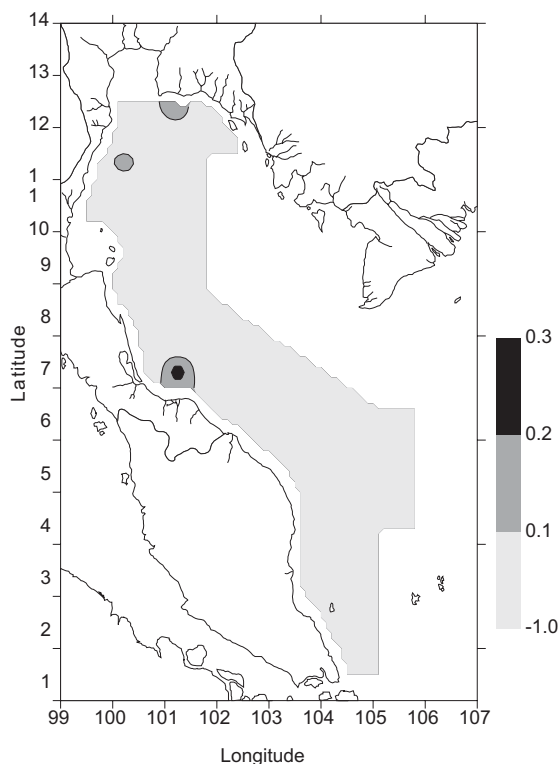


Fig. 12. Distribution of Nemertinea (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

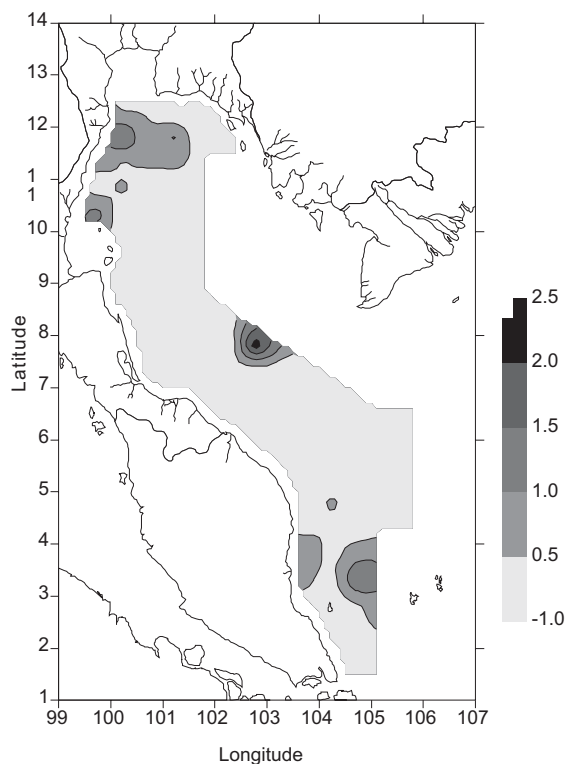


Fig. 13. Distribution of Nemertinea (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

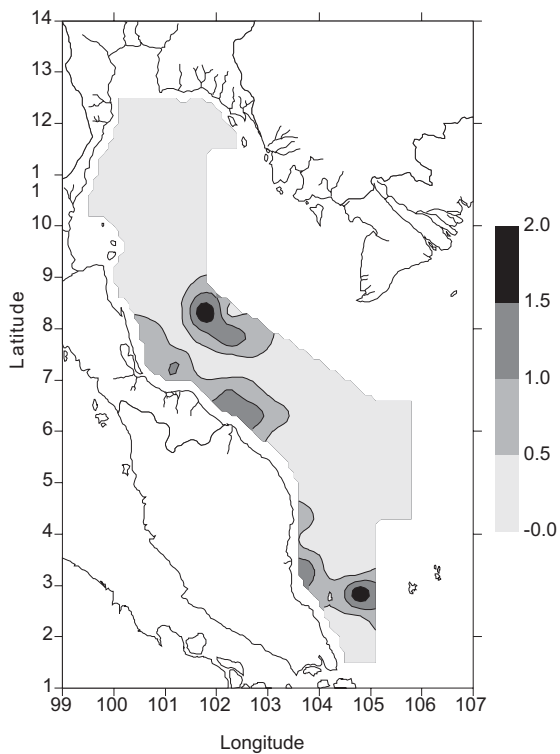


Fig. 14. Distribution of *Cyphonautes* larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

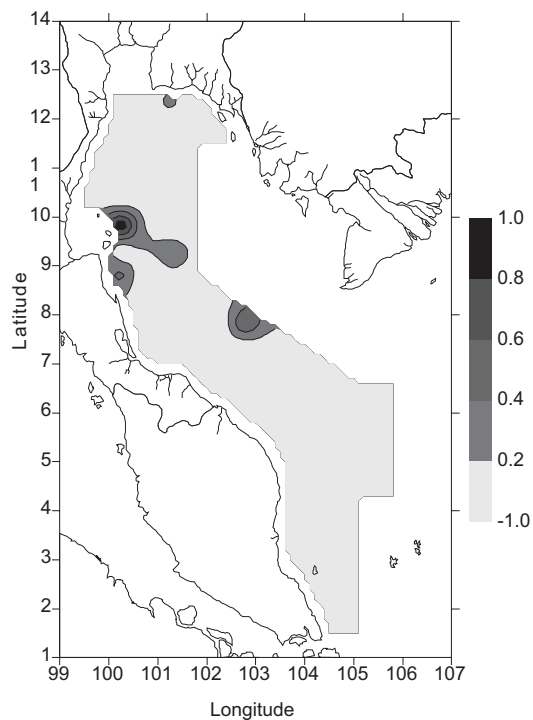


Fig. 15. Distribution of *Cyphonautes* larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

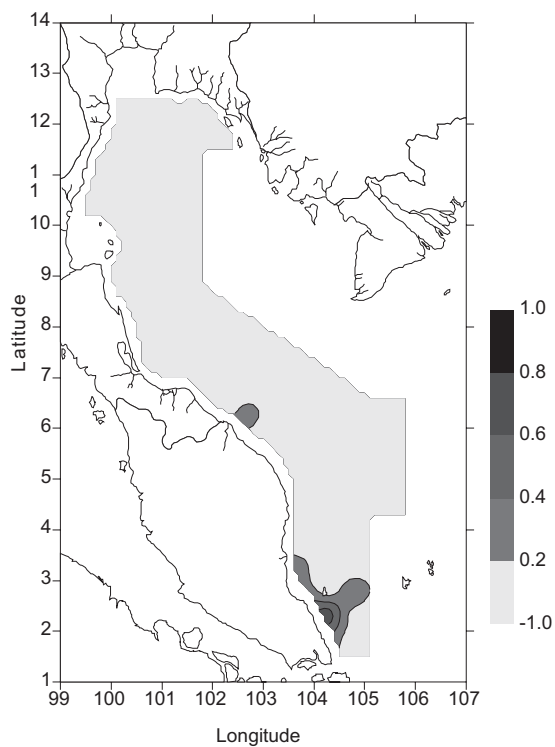


Fig. 16. Distribution of *Actinotrocha* (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

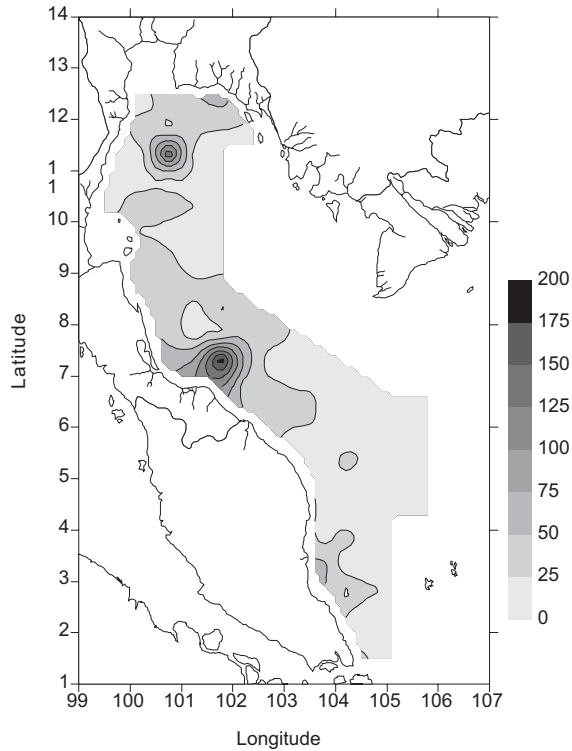


Fig. 17. Distribution of *Chaetognatha* (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

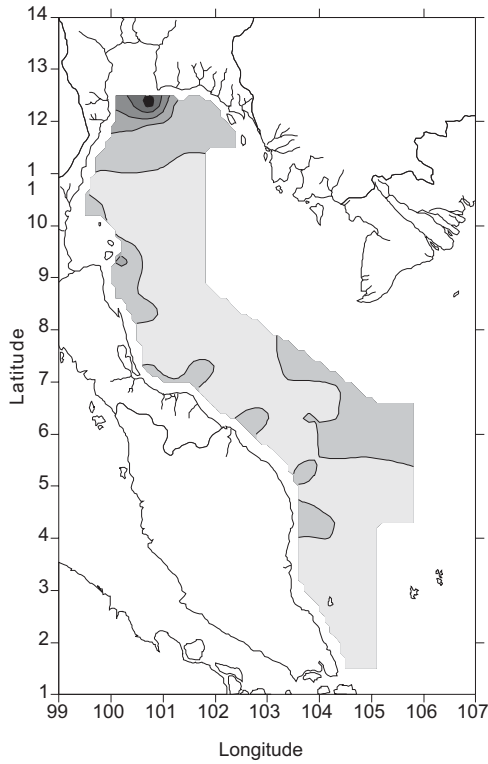


Fig. 18. Distribution of Chaetognatha (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

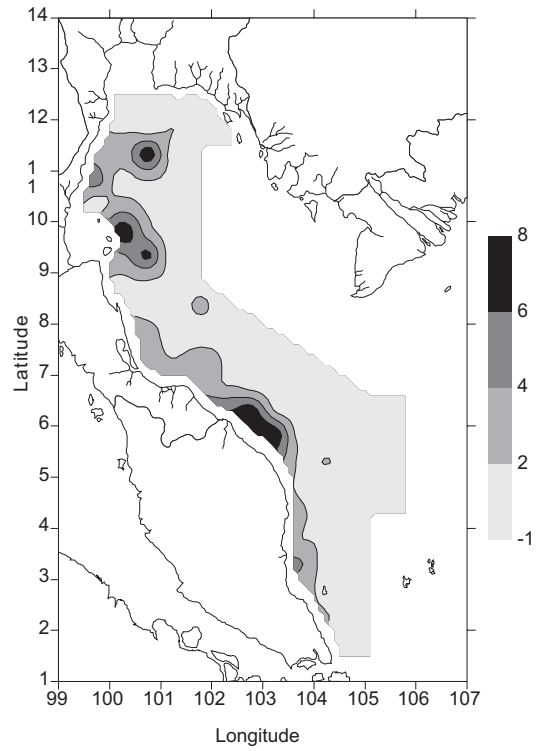


Fig. 19. Distribution of Polychaeta (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

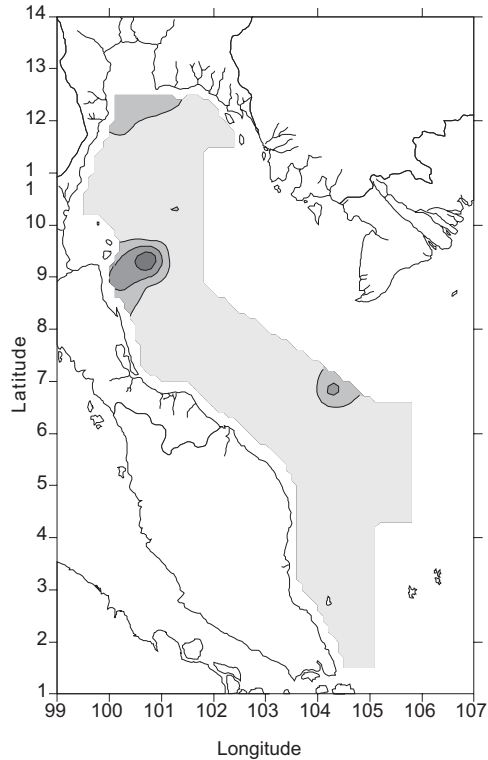


Fig. 20. Distribution of Polychaeta (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

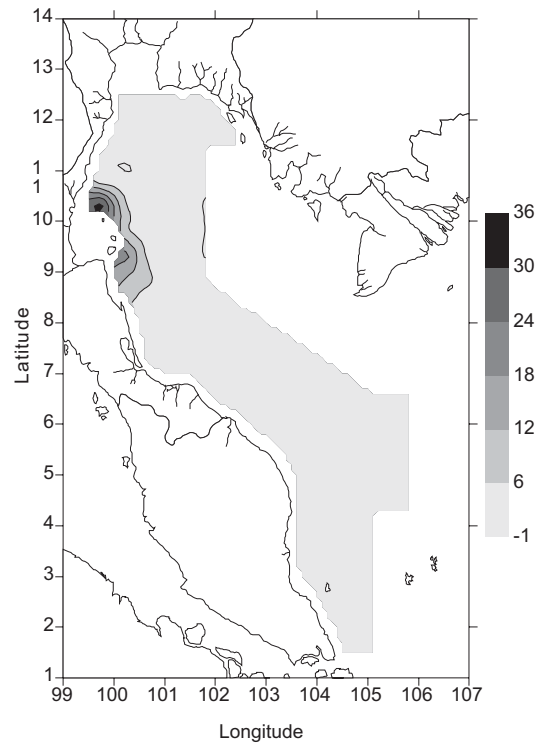


Fig. 21. Distribution of Cladocera (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

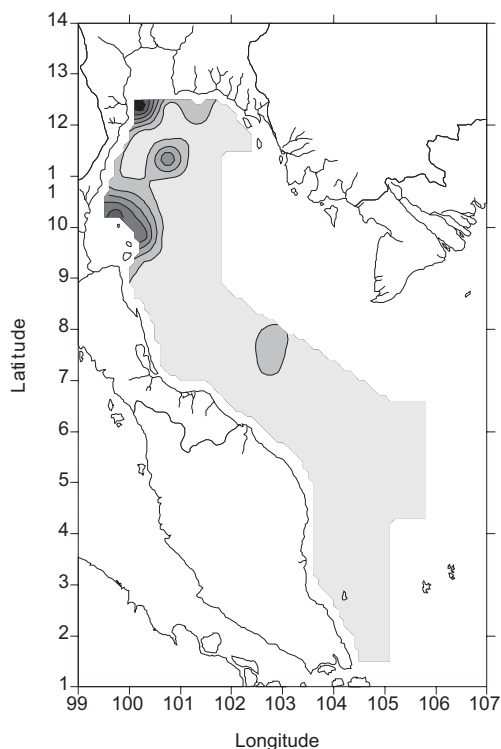


Fig. 22. Distribution of Cladocera (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

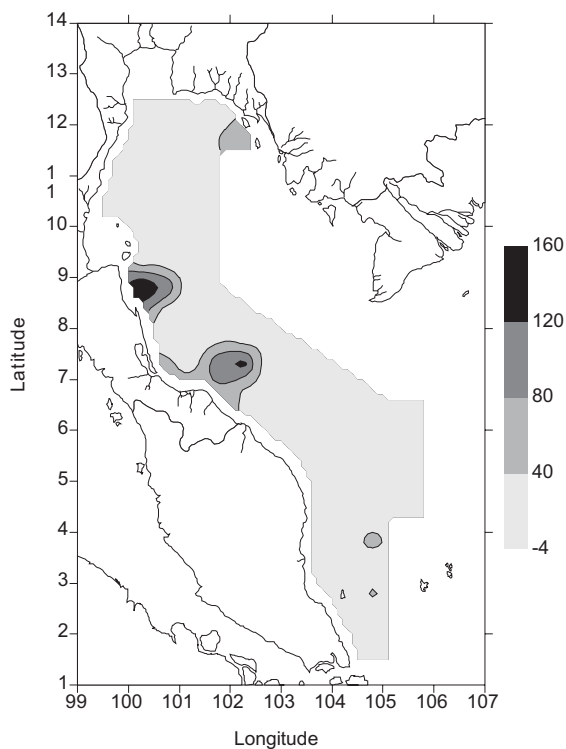


Fig. 23. Distribution of Ostracoda (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

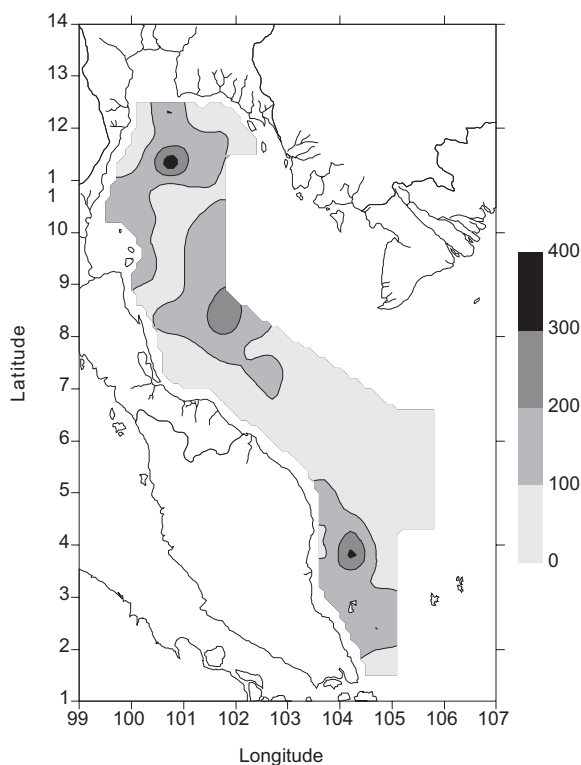


Fig. 24. Distribution of Ostracoda (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

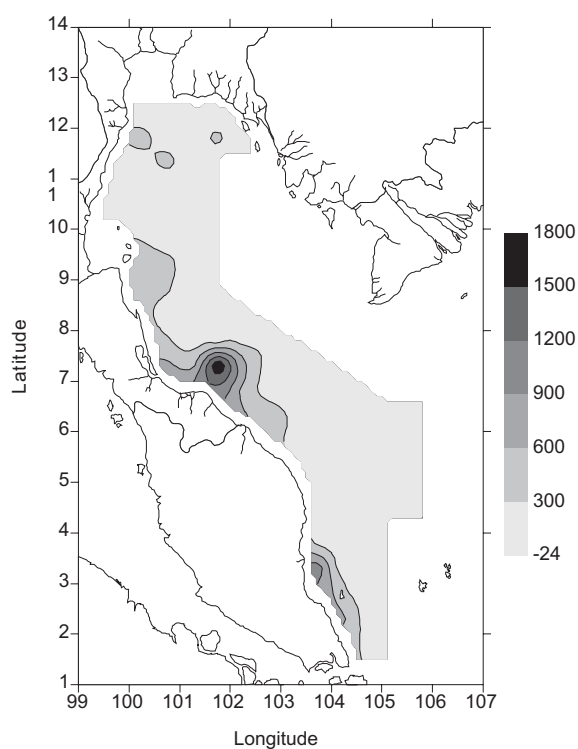


Fig. 25. Distribution of Copepoda (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

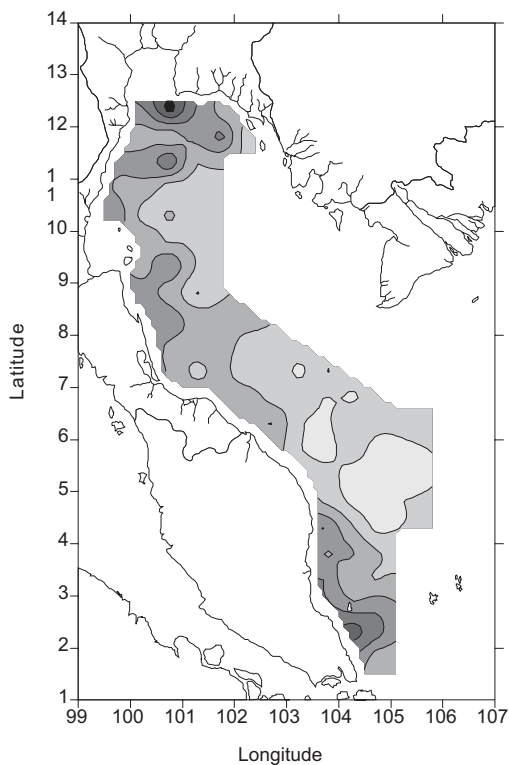


Fig. 26. Distribution of Copepoda (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

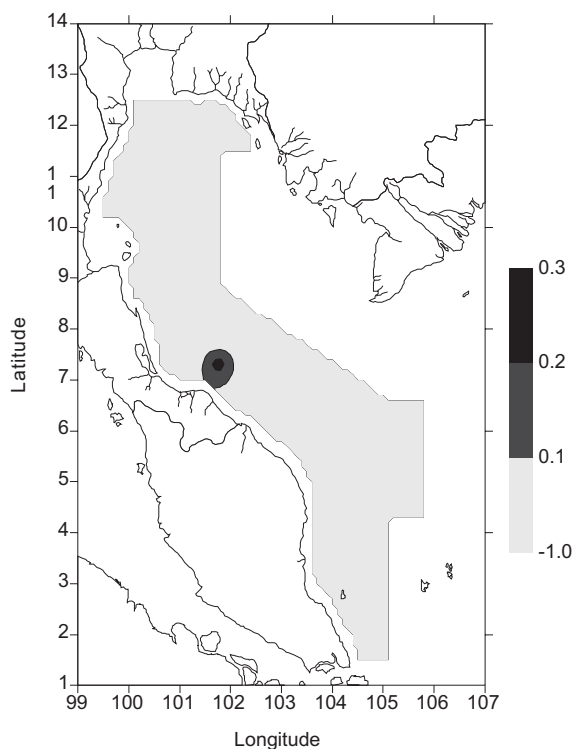


Fig. 27. Distribution of Cirripedia Larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

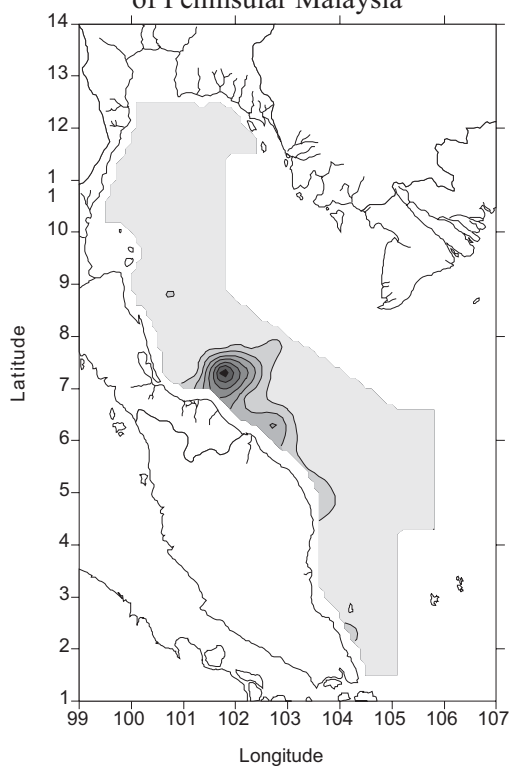


Fig. 28. Distribution of Amphipoda (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

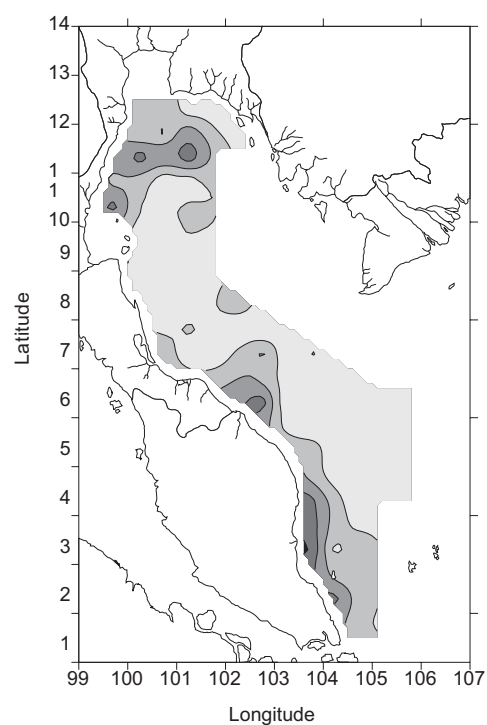


Fig. 29. Distribution of Amphipoda (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

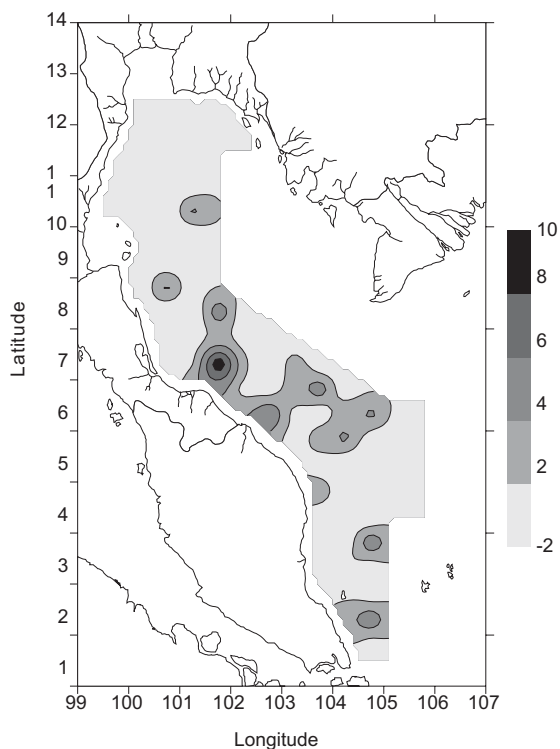


Fig. 30. Distribution of Mysidacea (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

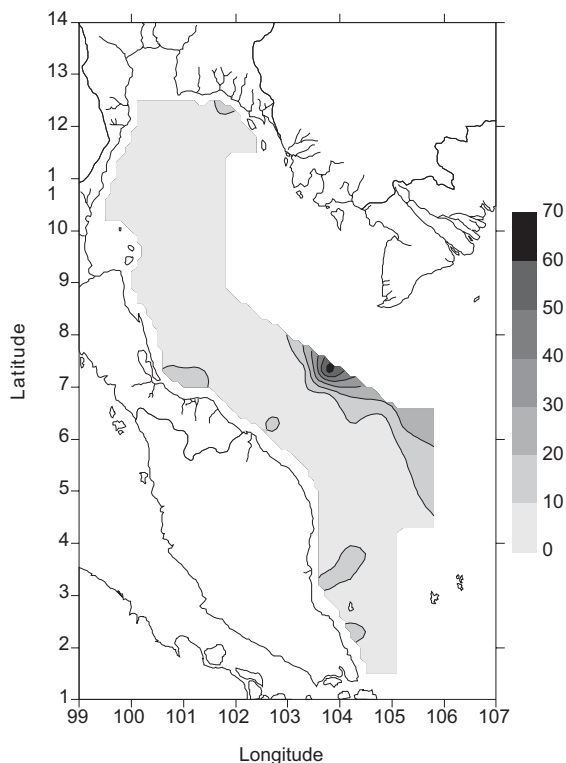


Fig. 31. Distribution of Mysidacea (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

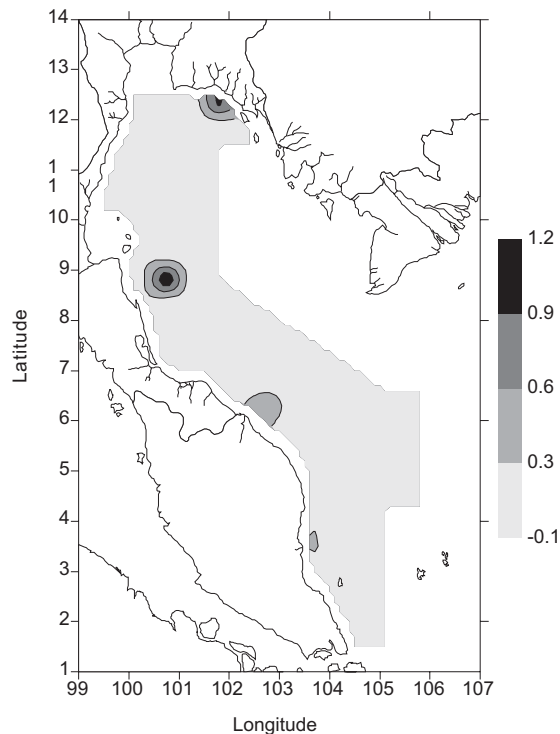


Fig. 32. Distribution of Cumercea (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

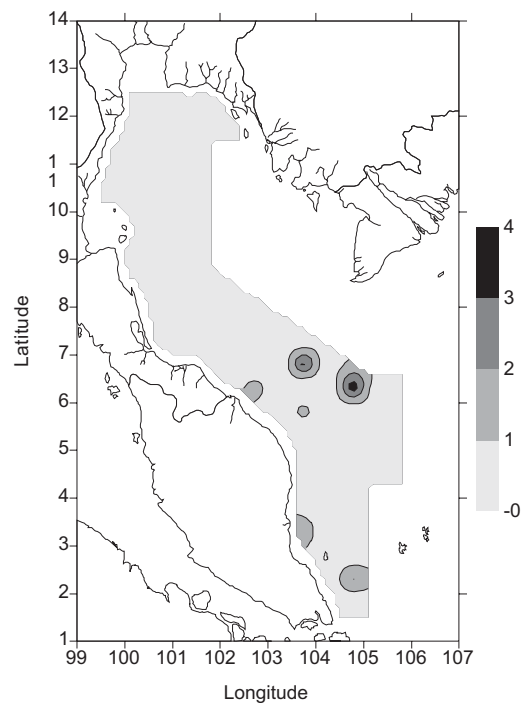


Fig. 33. Distribution of Cumacea (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

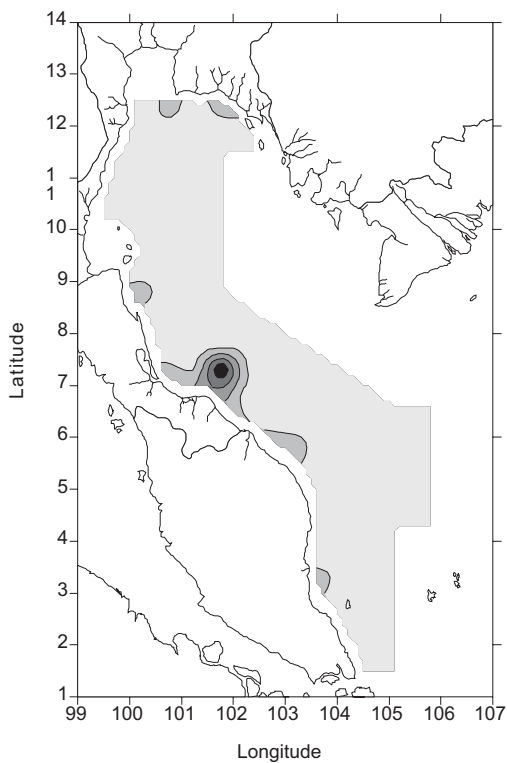


Fig. 34. Distribution of *Lucifer* spp. (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

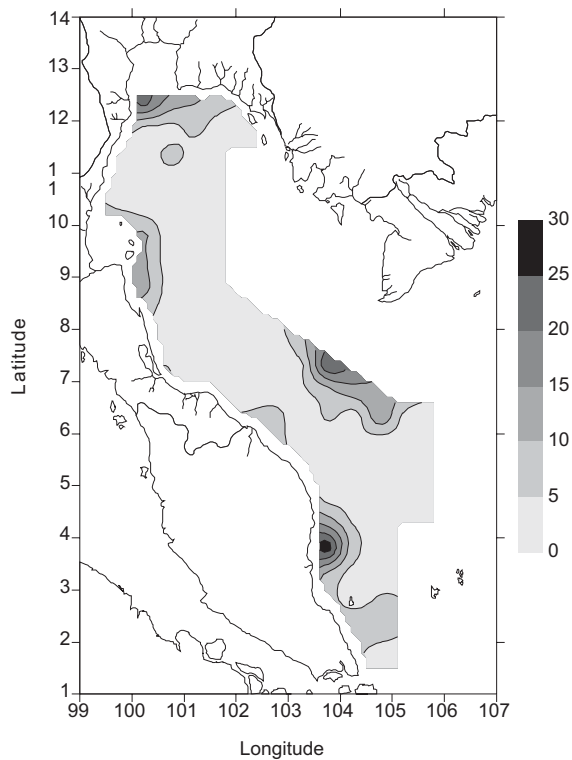


Fig. 35. Distribution of *Lucifer* spp. (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

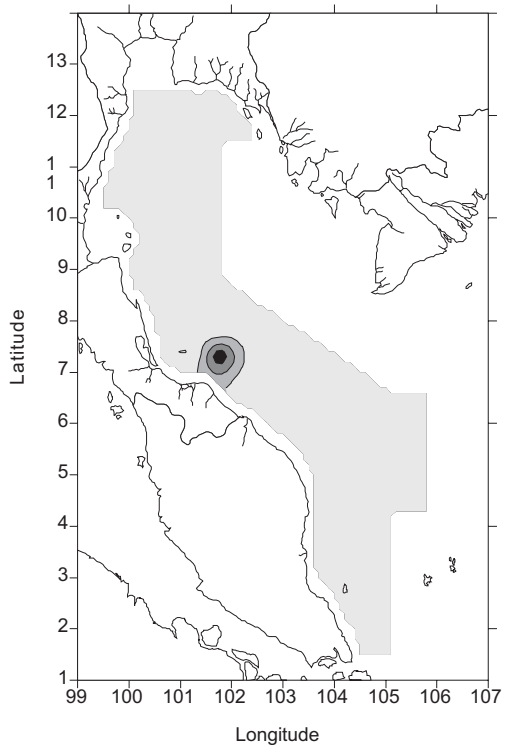


Fig. 36. Distribution of *Phyllosoma* larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

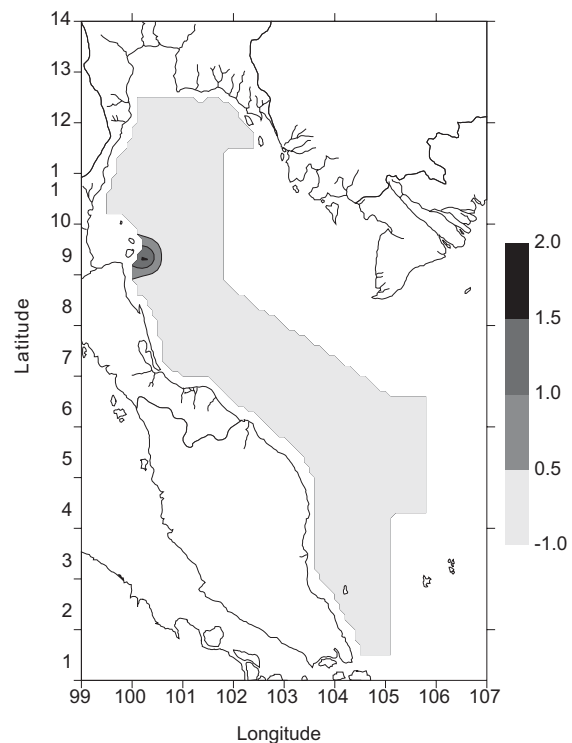


Fig. 37. Distribution of *Phyllosoma* larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

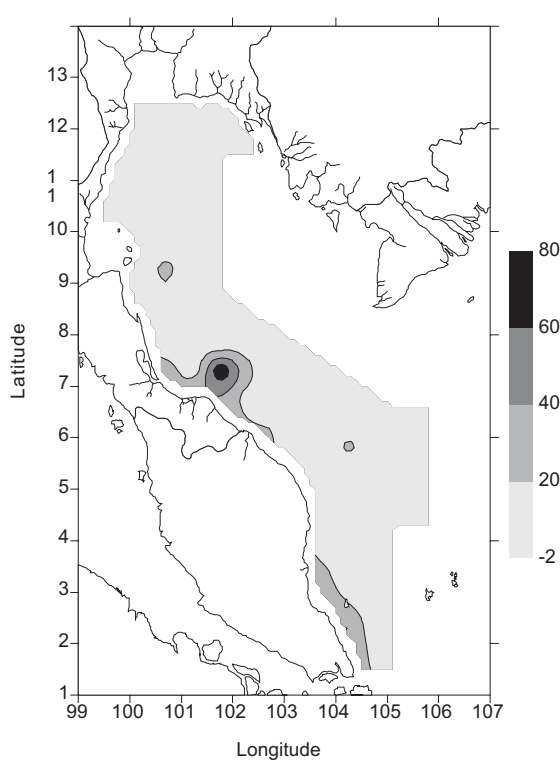


Fig. 38. Distribution of Shrimp larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

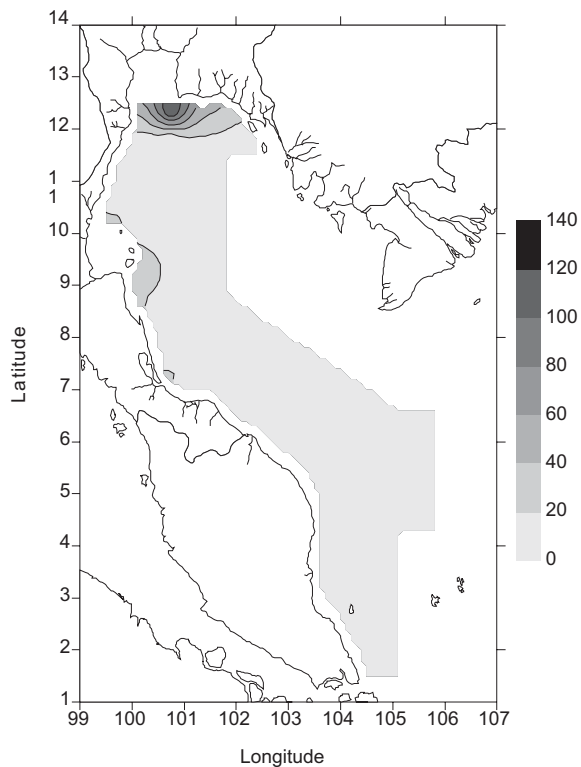


Fig. 39. Distribution of Shrimp larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

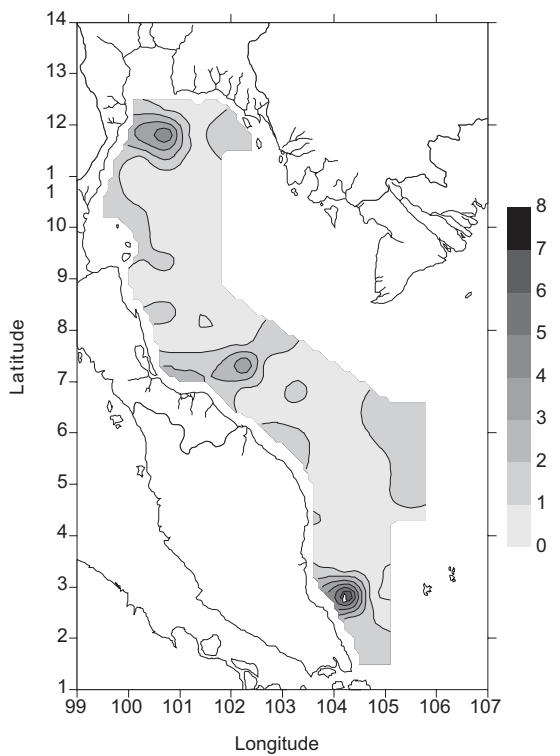


Fig. 40. Distribution of Anomura larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

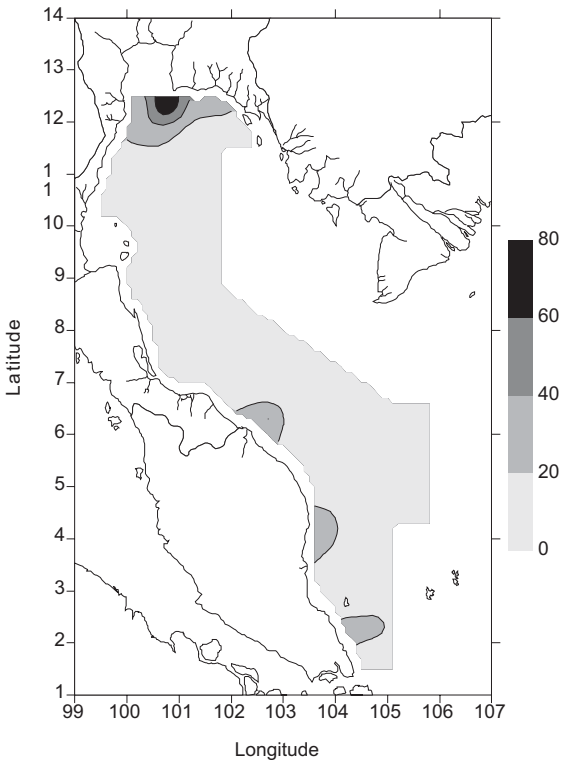


Fig. 41. Distribution of Anomura larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

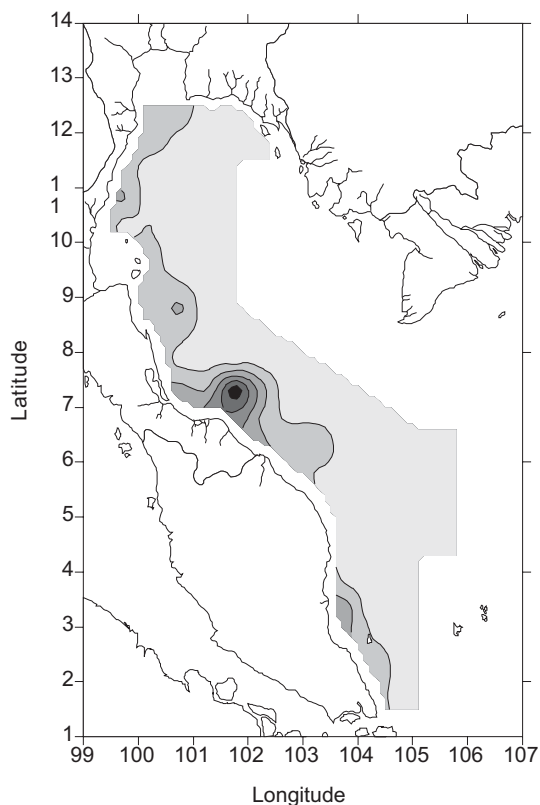


Fig. 42. Distribution of Brachyura larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

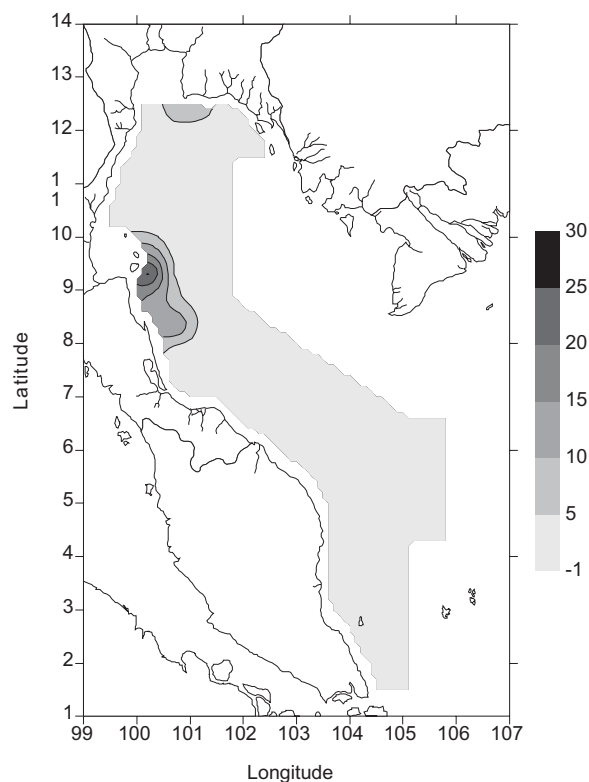


Fig. 43. Distribution of Brachyura larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

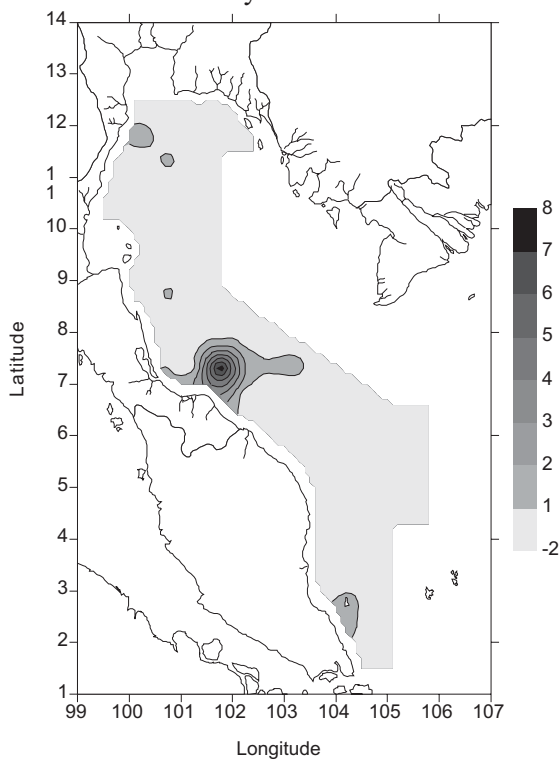


Fig. 44. Distribution of Stomatopod larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

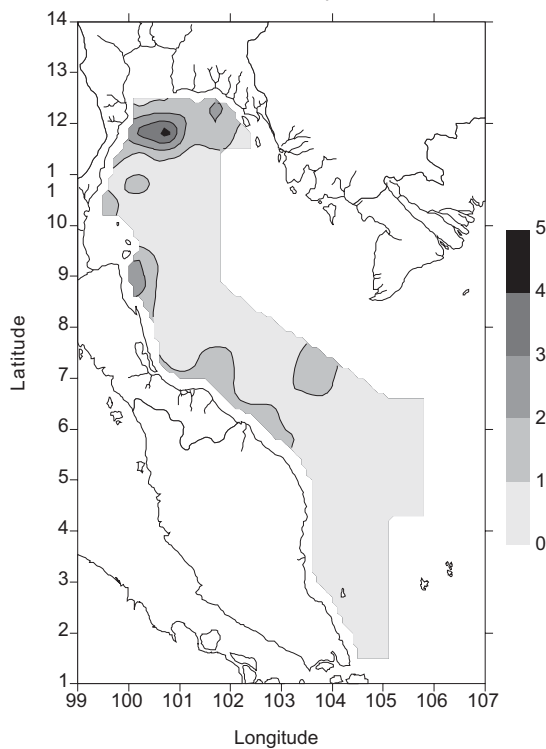


Fig. 45. Distribution of Stomatopod larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

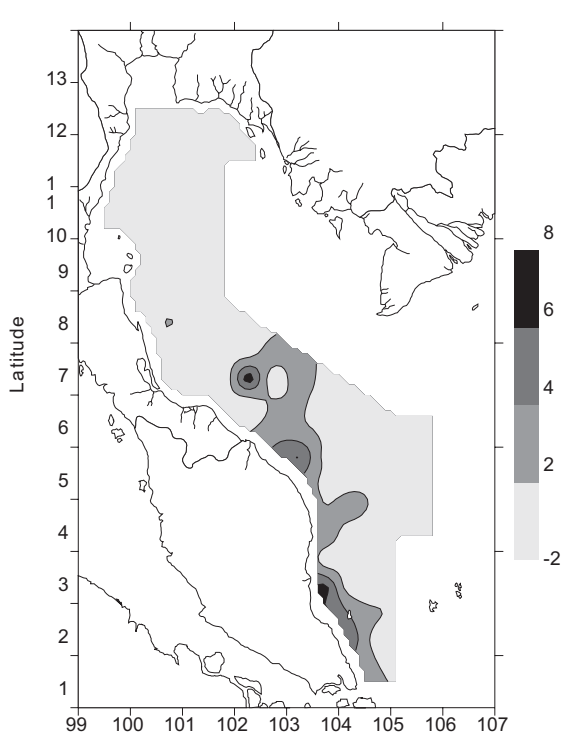


Fig. 46. Distribution of Heteropoda (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

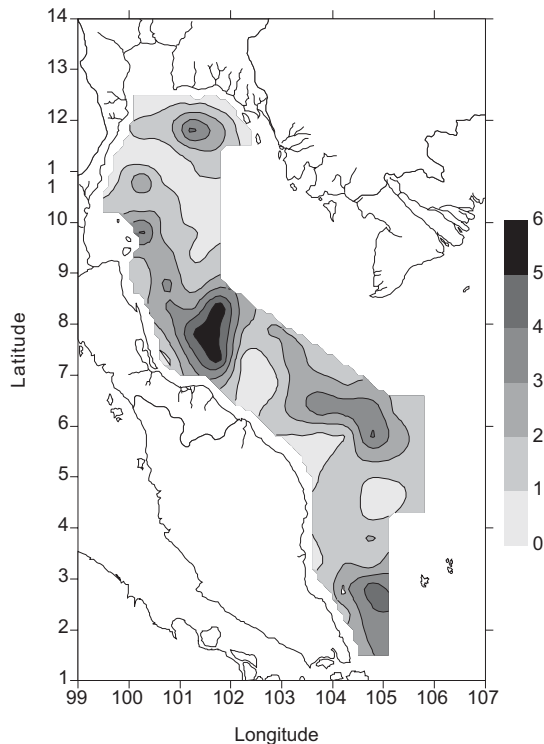


Fig. 47. Distribution of Heteropoda (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

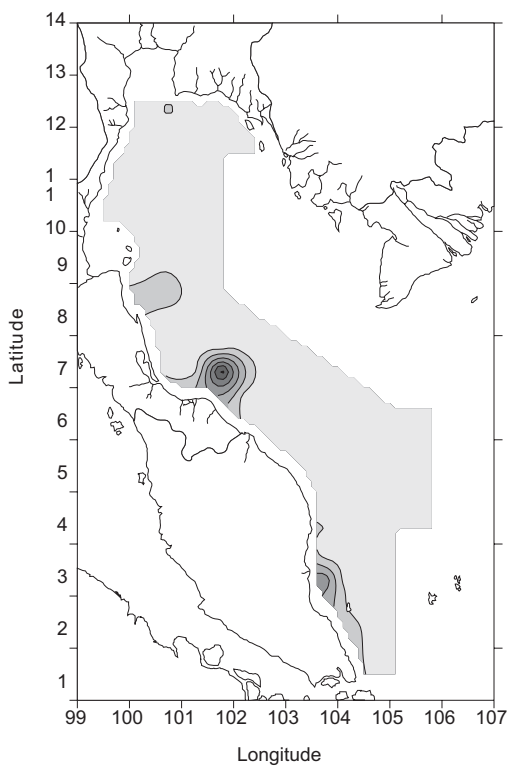


Fig. 48. Distribution of Pteropoda (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

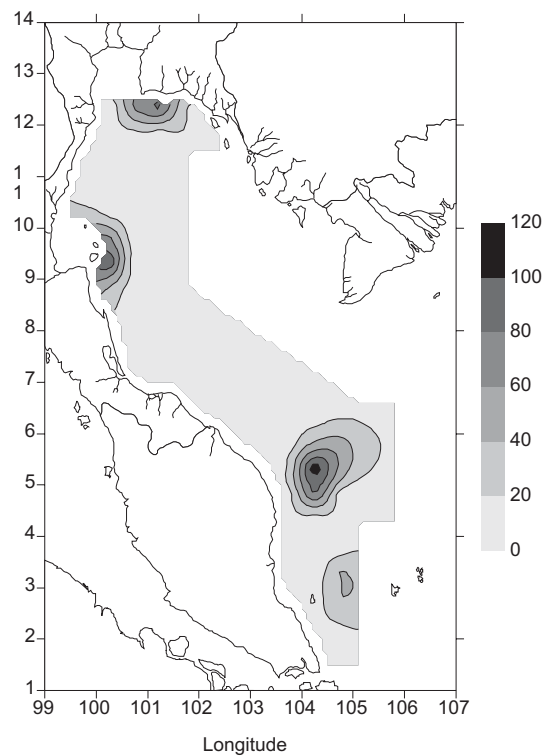


Fig. 49. Distribution of Pteropoda (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

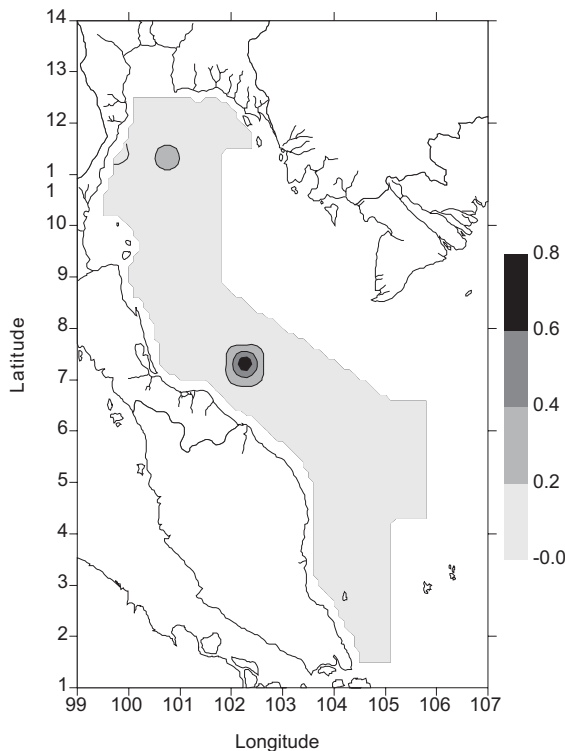


Fig. 50. Distribution of Cephelopoda (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

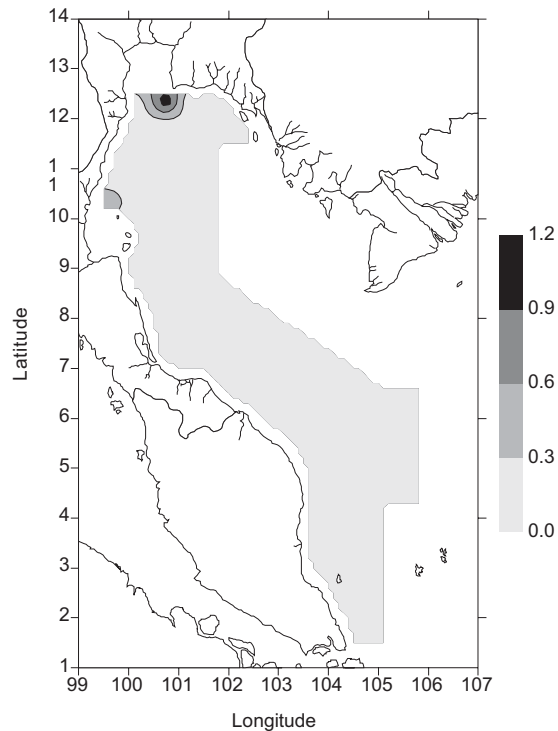


Fig. 51. Distribution of Cephelopoda (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

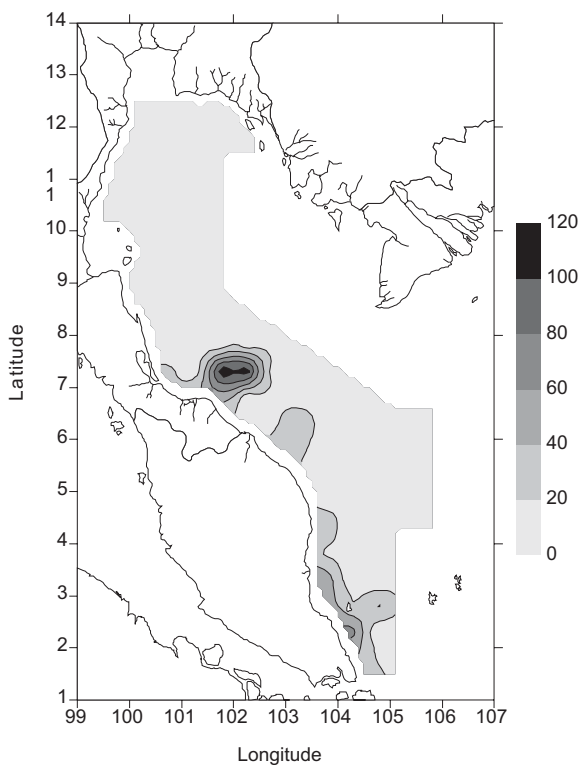


Fig. 52. Distribution of Gastropod larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

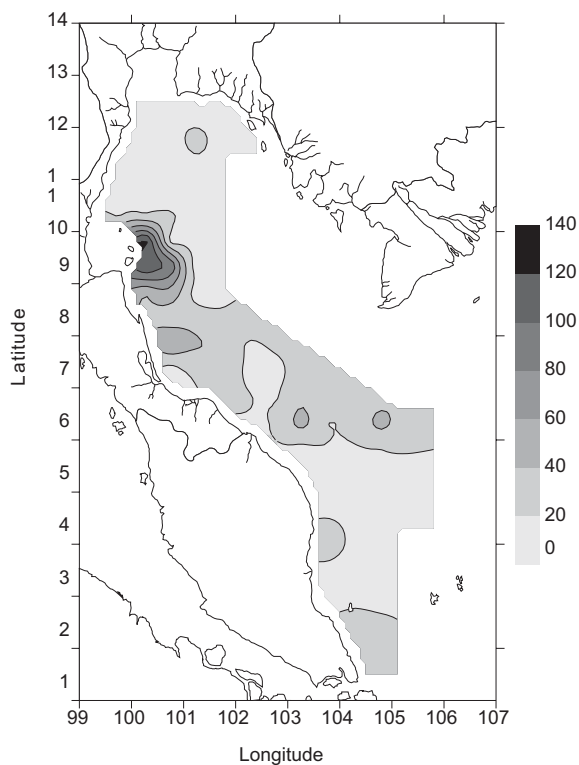


Fig. 53. Distribution of Gastropod larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

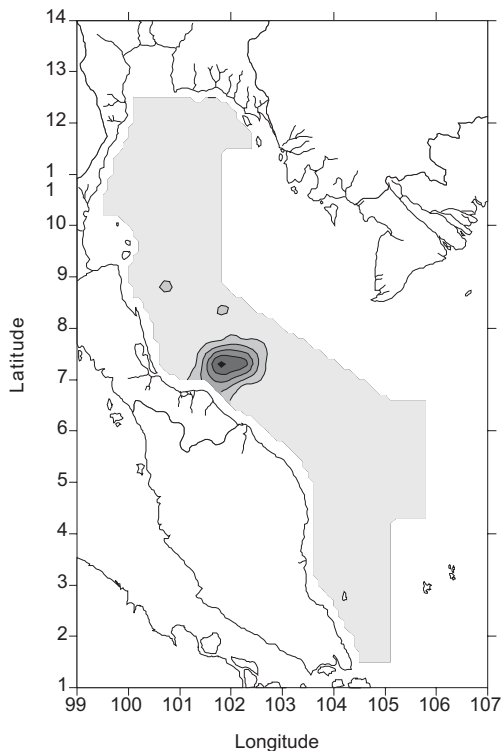


Fig. 54. Distribution of Bivalve larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

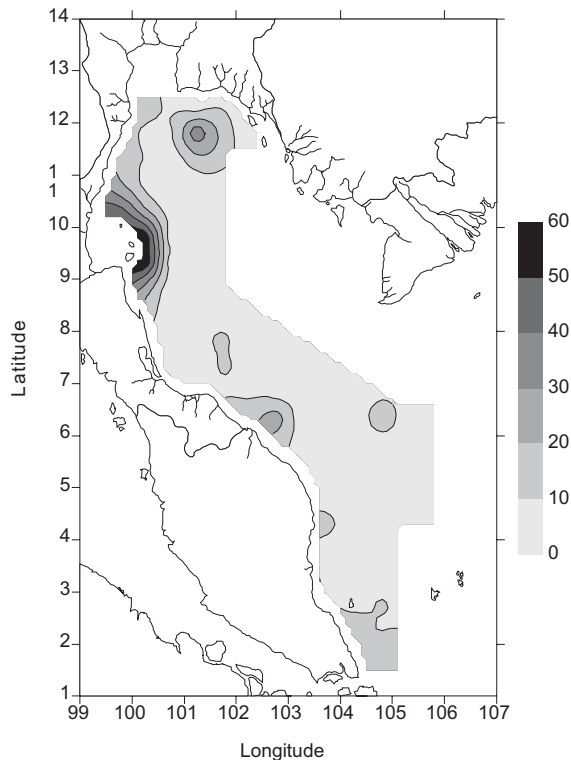


Fig. 55. Distribution of Bivalve larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

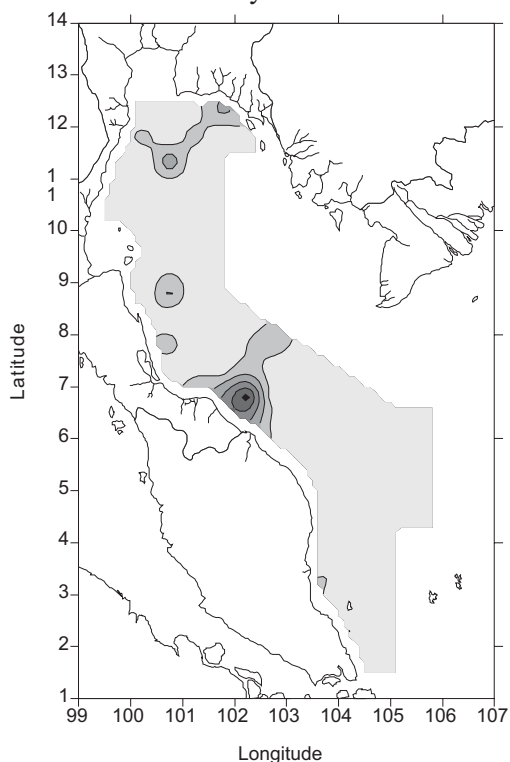


Fig. 56. Distribution of Echinodermata larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

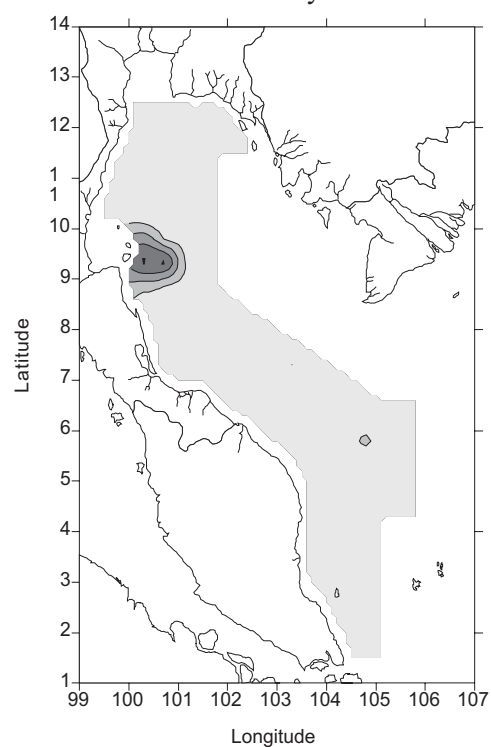


Fig. 57. Distribution of Echinodermata larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

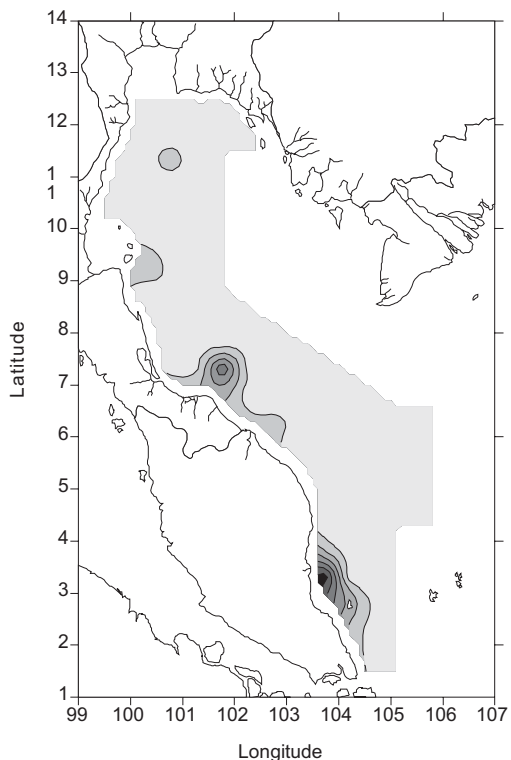


Fig. 58. Distribution of Larvacean (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

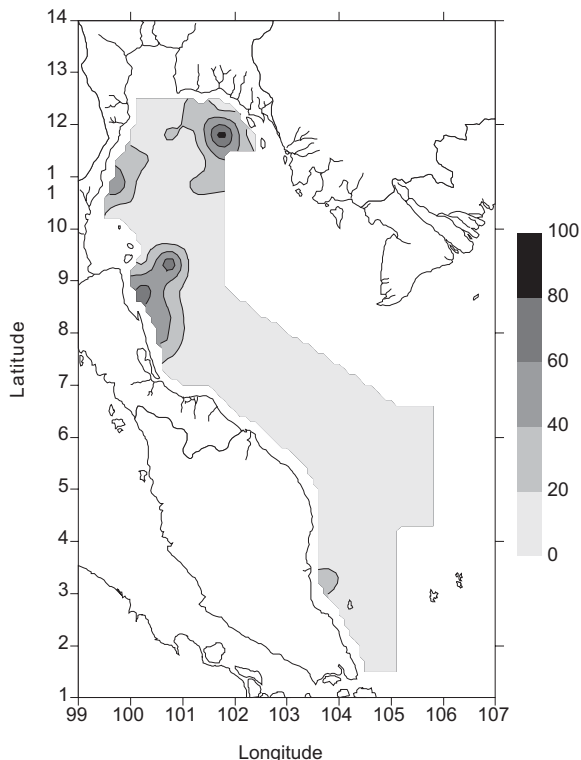


Fig. 59. Distribution of Larvacean (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

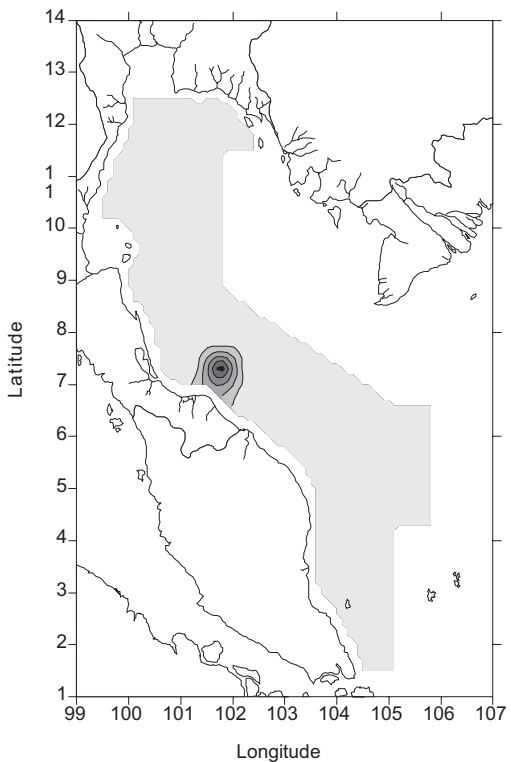


Fig. 60. Distribution of Thaliacea (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

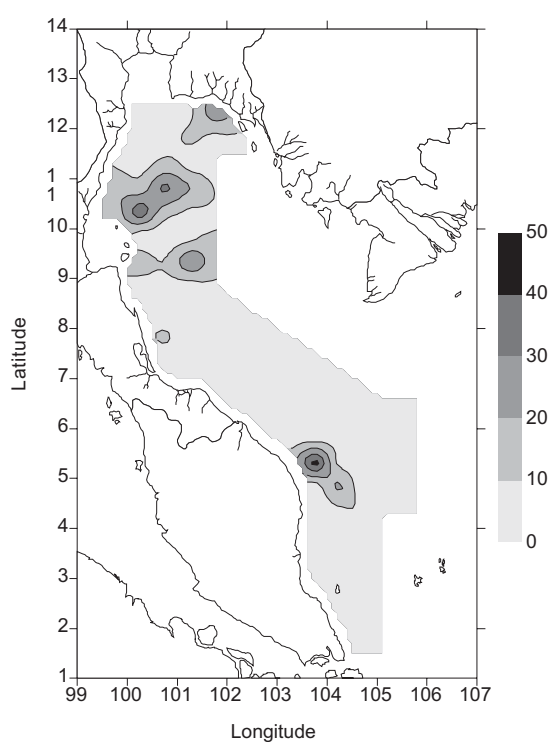


Fig. 61. Distribution of Thaliacea (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

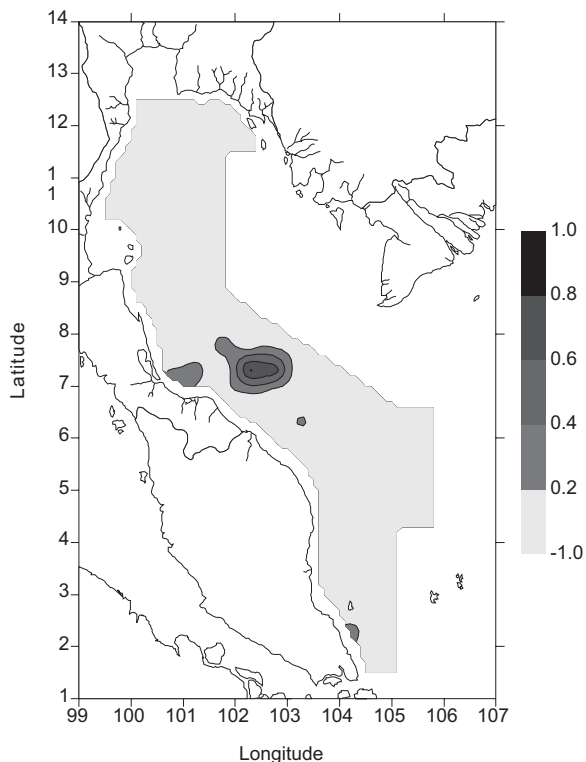


Fig. 62. Distribution of Brachiopoda larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

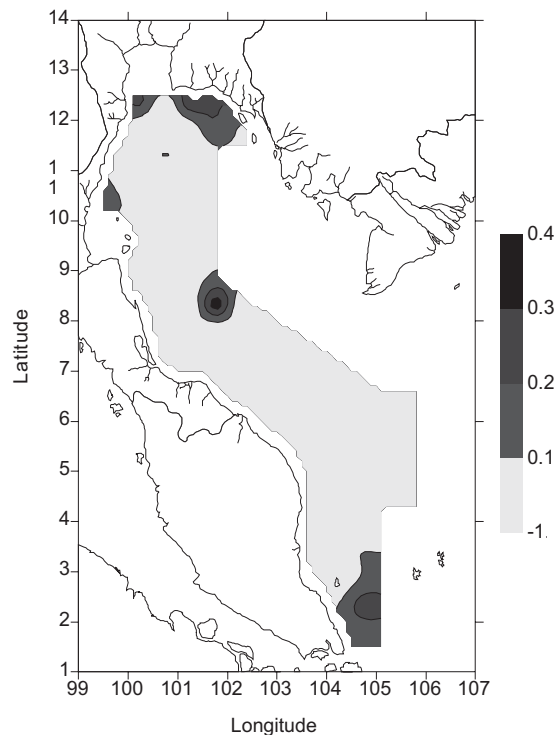


Fig. 63. Distribution of Brachiopoda larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

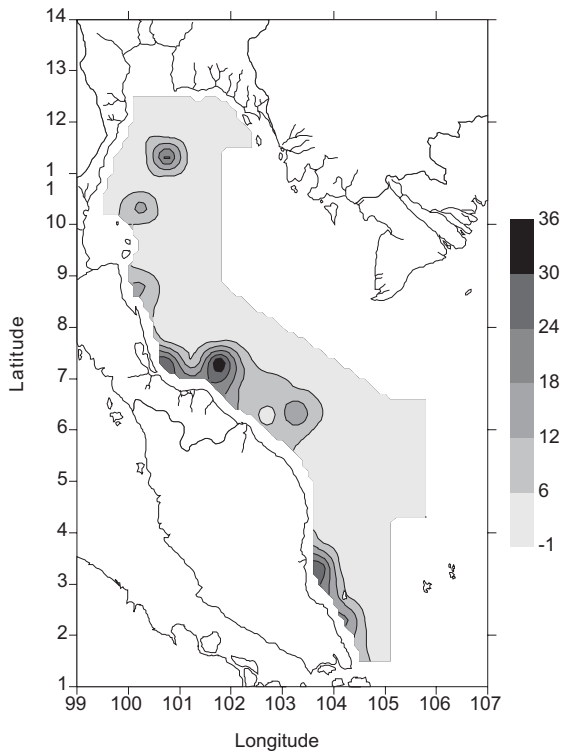


Fig. 64. Distribution of Crustacean Nauplii (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

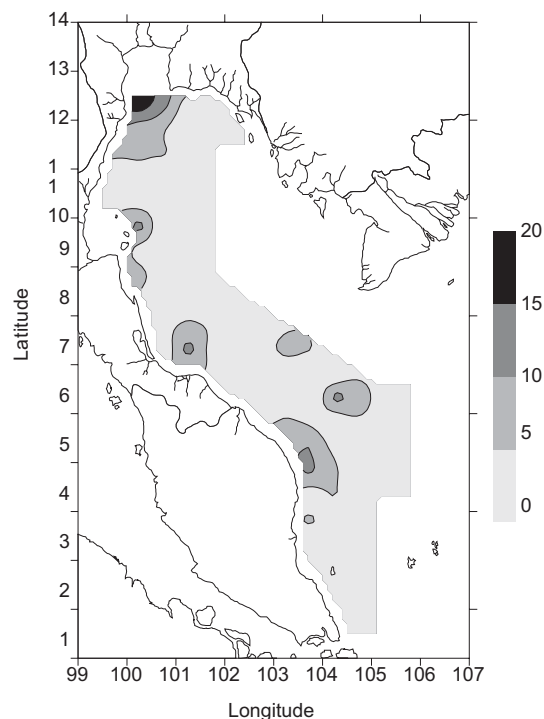


Fig. 65. Distribution of Crustacean Nauplii (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

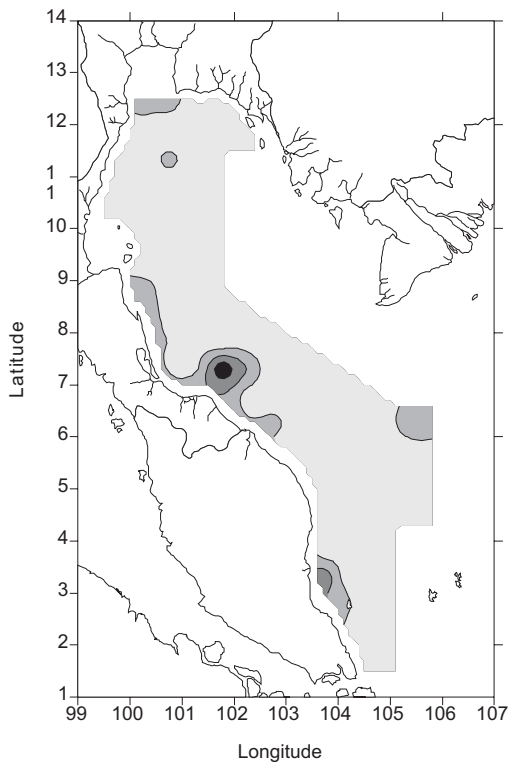


Fig. 66. Distribution of Fish eggs (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

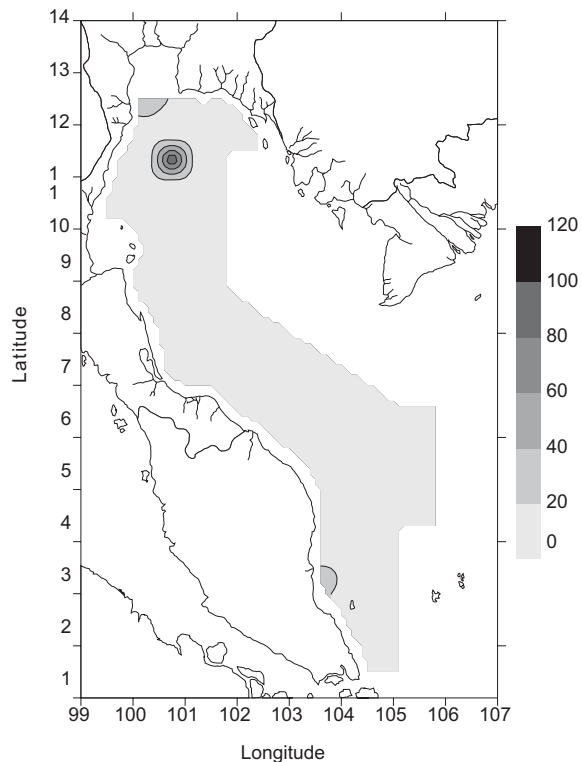


Fig. 67. Distribution of Fish eggs (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

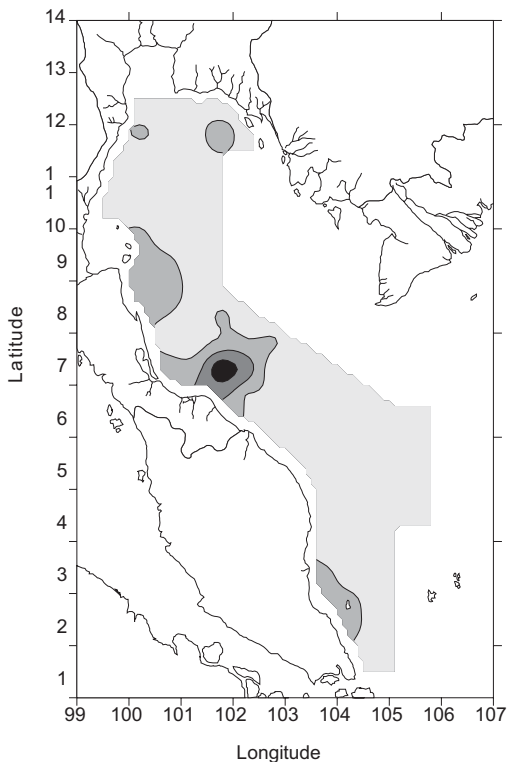


Fig. 68. Distribution of Fish larvae (no/m³) during pre-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

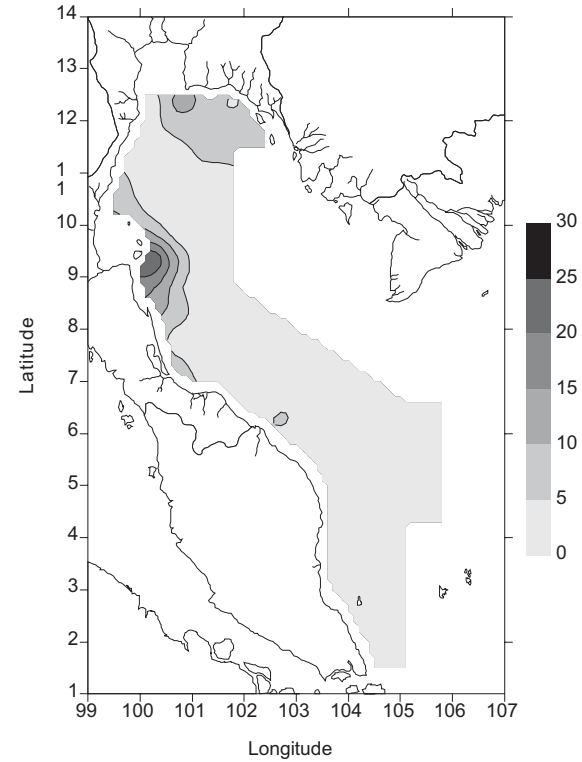


Fig. 69. Distribution of Fish larvae (no/m³) during post-monsoon period in the Gulf of Thailand and the east coast of Peninsular Malaysia

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