CHAPTER THREE

RESULTS

3.1 RAINFALL AND HYDROLOGY

According to land precipitation data obtained from the Drainage and Irrigation Department (D.I.D.), Kuala Lumpur, there were two rainfall peaks during a year, the biggest of which was in November and the smaller one was in April (Fig. 2). These peaks coincided with the two intermonsoon periods of the Northeast and Southwest monsoons prevailing from November – April and May – October, respectively.

3.2 WATER PARAMETERS

3.2.1 Temperature

During the study period the surface water temperatures were found to fluctuate between 26.9 °C, as recorded at Station 9 in December 1996, to 31.3°C, as recorded at Station 12 in April 1998 (Appendix 5). The bottom temperature was not to much different from the surface temperature, the difference being less than 1 °C. Mean temperature and standard deviation (S.D) readings at each station are shown in Figure 3 and Table 1.

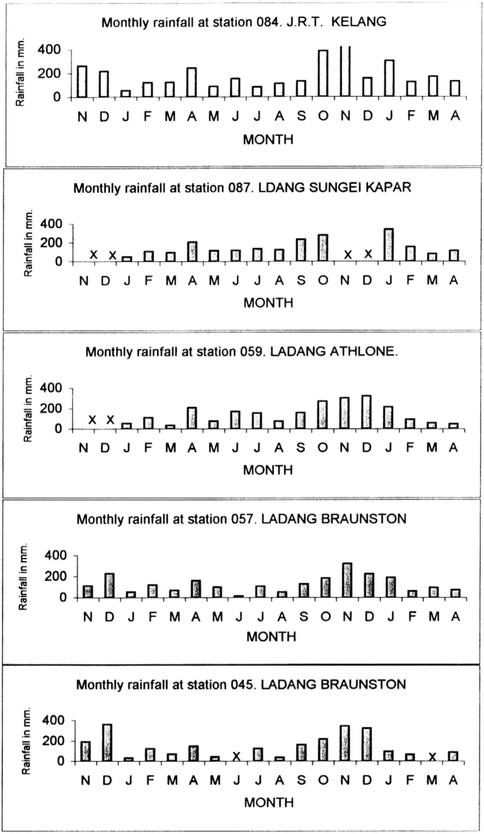


Figure 2. Monthly rainfall at five stations along the coast of Selangor from port Klang to Kuala Selangor (1996-1998).

X = Data not available

3.2.2 Salinity

During the study period, water salinity was found to range from a minimum of 25.3 ppt. recorded at Station 1 in February1998, to a maximum of 32.9 ppt. recorded at Stations 5, 6 and 15 in November 1996, November 1996, and April, 1997, respectively (see Appendix 5). Variations in the salinity values at each station at the time of the study are as indicated in Figure 4 and Table 1.

3.2.3 Turbidity

Turbidity of water recorded during the study ranged from a minimum of 3.75 ntu, at Station 1 in August.1997, to a maximum 270 ntu, at station 2 in February 1997 (see Appendix 5). These fluctuations in turbidity at all the stations are summarised in Figure 5 and Table 1.

3.2.4 Dissolved Oxygen

The maximum value of 8.34 mg/l for dissolved oxygen was recorded at Station 11 in December 1996, and the minimum of 3.44 mg/l was found in Station 6 in March 1997. Both readings were measured at the same depth of 5 meters (see Appendix 5). The mean dissolved oxygen readings at all stations during the study period are shown in Fig. 6 and Table 1.

3.2.5 pH

Results of pH measurements, during the study period showed the maximum of 8.61, recorded at Stations 9, 11 and 12 in Jun 1998, Jun 1997 and April 1998, respectively. The minimum of 7.92 was recorded at Station 6 in March 1997 (see Appendix 5). Furthermore, all pH readings were quite close, in the range 8.20-8.44, as shown in Figure 7 and Table 1.

3.2.6 Depth

The depth range at all stations covered during this study time was 2 to 14.2 meters recorded at stations 2, 9 and 13 respectively (See Appendix 5). There were some differences in station depth as shown in Figure 8 and Table 1.

3.3 BOTTOM AND SEDIMENT CHARACTERISTICS

3.3.1 Comparison between Coulter particle sizing method and Hydrometer method

X^2 tests of the results obtained from the Coulter particle size method and the Hydrometer methods show no significant differences ($p > 0.9$) between the tow methods for sand, silt and clay components (Table 2).

Table1. The mean and Standard deviation of the abiotic factors of the water parameters of all stations during the study period.

Factor	Depth (m)		Turbidity (Ntu)		pH		Dissolved oxygen (mg/l)		Salinity (ppt)		Temperature (^oC)	
Station no	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	3.50	0.2	79.94	56.79	8.23	0.13	5.47	0.74	30.4	2.89	29.8	0.66
2	5.57	6.2	131.80	117.80	8.30	0.05	5.53	1.02	30.6	2.93	30.0	0.65
4	7.05	2.4	48.75	45.17	8.35	0.09	5.50	0.92	31.7	0.76	29.8	0.32
5	4.29	1.8	40.75	24.86	8.24	0.12	5.23	1.12	31.0	2.13	29.9	0.56
6	4.68	1.1	24.50	17.62	8.24	0.26	4.84	1.16	31.3	1.54	29.7	0.30
8	3.76	1.3	11.00	6.53	8.44	0.35	6.63	0.38	32.3	0.22	29.6	0.72
9	3.34	1.5	13.75	8.63	8.38	0.21	6.62	0.50	32.1	0.22	29.4	1.42
10	8.47	3.8	28.75	34.46	8.32	0.18	5.59	0.46	32.2	0.57	29.5	1.00
11	4.65	2.2	16.80	10.66	8.39	0.17	6.40	1.42	31.7	0.50	29.5	0.91
12	12.38	2.2	26.68	21.73	8.23	0.29	5.31	0.25	31.8	0.42	30.2	0.81
13	11.61	3.1	46.00	24.25	8.20	0.11	5.62	0.72	31.9	0.62	30.1	0.76
14	4.03	1.3	61.25	25.57	8.33	0.18	6.76	1.04	32.1	0.35	29.8	0.99
15	3.83	0.9	51.00	23.58	8.33	0.15	6.39	0.64	32.5	0.44	29.7	0.75

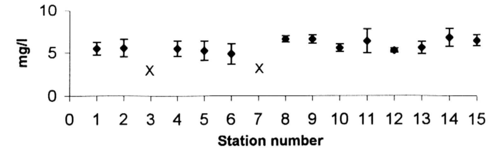


Fig. 6.The mean and standard deviation of dissolved oxygen per station during study period.

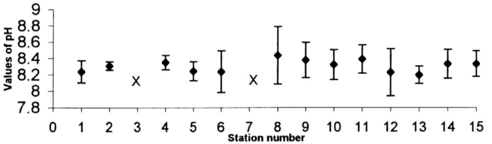


Fig. 7.The mean and standard deviation of water pH per station during study period

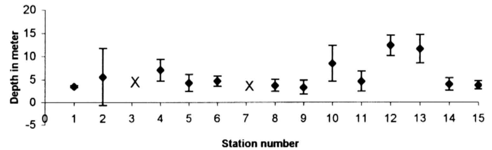


Fig. 8.The mean and standard deviation of depth per station during study time

Note: X = Data not available

Table 2. A comparative assessment of sediment texture by the Coulter counter method and hydrometer method (Bouyoncos, 1951),

Sample no.	Sand %		Silt %		Clay %	
	Coulter	Hydrometer	Coulter	Hydrometer	Coulter	Hydrometer
	n_1	n_2	n_3	n_4	n_5	n_6
1	74	75	3	2	23	23
2	31.12	30	8.54	8	60.34	62
3	6.1	8	77.67	74	16.23	18
4	75.896	74	21.48	24	2.624	2
5	82.23	78	14.55	18	3.224	4
6	63.88	64	32.08	32	4.04	4
7	48.52	52	43.88	42	5.65	6
8	4.13	8	86.85	84	9.02	8
9	77.56	81	18.1	16	4.34	3
10	66.13	69	30.61	29	2.26	2

	Sand	Silt	Clay
$\chi 2$	**3.15507**	**2.15507**	**1.34693**
df	**9**	**9**	**9**
Probability	**p> 0.9578**	**p> 0.9881**	**p> 0.9981**

Since, the p values of the X^2 test for the different classes of sediments (sand , silt and clay) were grater than 0.958, 0.988 and 0.988 respectively, therefore there were no significant difference between the results obtained by the coulter counter and Hydrometer methods.

3.3.2 Sediment texture and characteristics

Parameters of the bottom sediments from the study area are recorded in Table 3. The texture of the Klang Strait sediments ranged from sand to clay, and would have 6 classes if the USDA classification scheme (Soil survey staff, 1975) is adopted. The majority of the sediment samples fell into either silt loam or sandy loam classes (Appendix 6). The bottom sediments were generally greyish-colored and extremely soft in texture. Clay content was low; the percentage of clay ranged from 1.03 % at Station 9 (located offshore) to 10.25 % at Station 1 (located at the mouth of the Selangor river) (see Fig. 9). Percentages of silt within the study area ranged from 4.82 - 87.22 %, the lowest and highest at Station 8 and Station 4 respectively. More stations recorded a higher percentage of silt content which decreased in the offshore direction (Fig. 10).

Sand distribution in the Klang Strait is given in Figure 11. The sand component which was divided into 4 categories, namely, "very fine", "fine", "medium" and "coarse" sand, ranged from 1.66 – 57.94%, 0.04 – 66.76%, 0 – 18.30 and 0 – 24.69% (Table 4). The highest values of these categories occurred at stations 14, 8, 11 and 5 respectively. According to the distribution of sand texture classes, it is clear from the results that the percentage of "sand" classes decreased towards stations located near or at the shore (Fig. 11). The mean percentages of all sediment texture classes of all stations in the study area are summarized in Table 4.

The results indicate clearly that the bottom sediments of the inshore study sites composed mostly of mud, while the more offshore sites had coarser deposits dominated by sand. Sediment deposits of the study sites were mainly of terrestrial origin. The high mud content indicates the large sediment loads released during the rainy seasons by erosional processes on land that were transported seawards by the rivers. The percentages of sediment classes were recorded at each station in Klang Strait is shown in Appendix 6.

3.3.3 Sediments Parameters

During the study period sediment pH, temperature, redox potential and organic matter content were measured. The minimum sediment pH of 6.1 was recorded at Station 1 in February 1997, and the maximum of 9.8 was recorded at Station 14 in December 1997. However, the pH value mostly lie between 7.0 – 8.0 (see Table 3 and Figure 12).

The minimum and maximum temperatures of the sediment during the study period ranged from 27.3 C° to 31.8 °C, which were recorded at Stations 2 and 14 in February 1998 and December 1997 respectively. The mean sediment temperature was 29°C (Table 3 and Figure 13). The sediment redox potentials ranged from -160 mV (Station 14 in December 1997) to 44 mV (Stations 8 and 9 in March 1997 and Station 8 in June 1997 (see Table 3 and Appendix 7).

The percentages of organic matter (by weight) in the sediment samples ranged from 2.08% to 11.1%; these were recorded at Station 14 in December 1997 and Station 4 in August 1997, respectively (Table 3). The distribution of the organic matter content in the study area (Figure 4) illustrates that the percentage of organic matter content was

Table 3: The mean reading of all sediment classes and parameters per station during the study period (There were no data collected for stations 3 and 7 because of unsuitable conditions such as the depth and boat traffic) .

Staion	Clay %	Slit %	V.F.S. %	F.S. %	M.S. %	C.S. %	pH	Redox.P.	Temperature	Organic matter
1	7.35	58.94	15.28	10.52	4.72	2.87	7.42	-43.40	28.56	7.93
2	5.22	46.37	22.83	14.81	4.85	5.47	7.43	-7.20	29.44	7.22
4	6.45	66.17	10.19	11.78	3.40	1.65	7.44	-25.80	28.74	6.89
5	11.90	67.60	7.66	4.01	3.39	5.58	7.43	-32.00	29.38	9.78
6	6.80	69.11	10.91	7.39	3.88	1.90	7.21	-12.00	28.36	8.65
8	4.04	32.08	25.42	30.70	3.79	4.02	7.23	-5.60	29.02	3.60
9	3.44	23.79	44.20	26.44	1.08	1.05	7.43	-20.80	29.12	2.24
10	5.53	61.51	8.83	13.73	5.92	5.26	7.67	-33.00	29.34	5.11
11	4.65	31.02	9.20	36.37	10.66	8.10	7.80	-38.80	29.12	4.44
12	8.01	73.45	10.13	5.17	1.50	1.75	7.91	-31.10	29.73	9.31
13	2.98	19.89	34.94	40.06	1.24	0.89	8.11	-58.00	29.90	5.49
14	2.30	14.66	54.46	23.77	3.66	1.15	8.90	-73.20	30.58	4.41
15	4.52	40.50	32.75	16.19	4.38	1.65	8.35	-46.40	29.82	3.47

V. F.S = Very fine sand,F.S = Fine sand, M.S = Medium sand, C.S = Coarse sand.

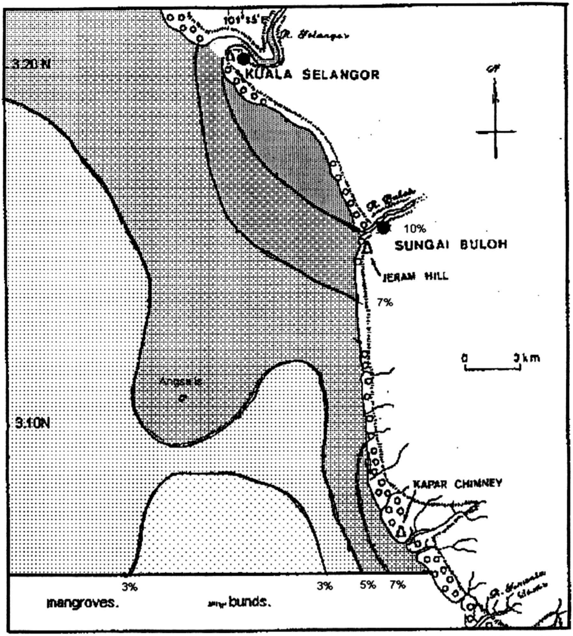


Fig.9: The distribution of clay content in the bottom sediments of Klang Strait (1996-1998). <3%, 3%-5%, 5%-7%, 7%-10% and > 10-18.7% of clay.

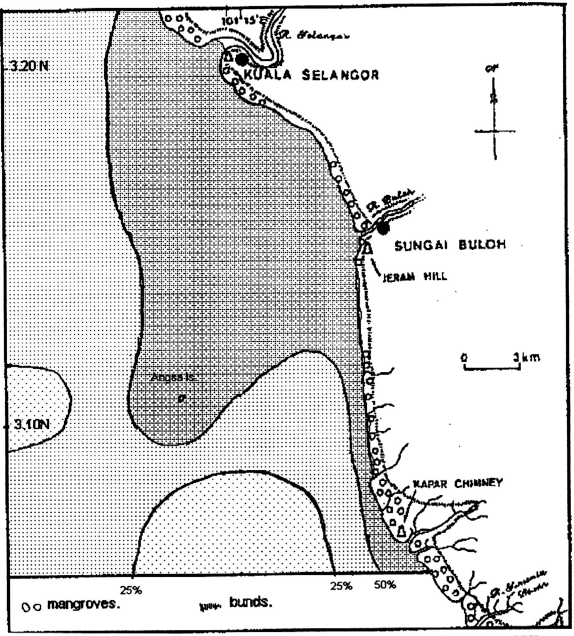


Fig. 10: The distribution of silt content in the bottom sediments of Klang Strait (1996-1998). <25%, 25-50% and > 50-87.2 % of silt.

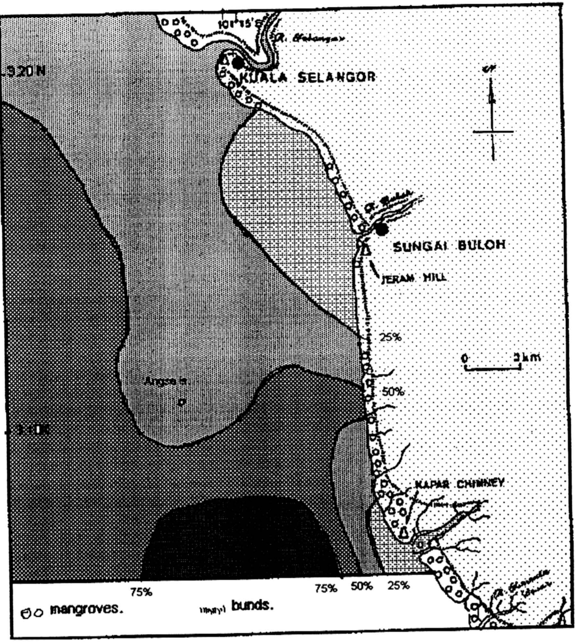


Fig. 11: The distribution of sand content in bottom sediments of the Klang Strait (1996-1998). <25, 25-50%, 50-75%and >75 - 83.1 % of sand.

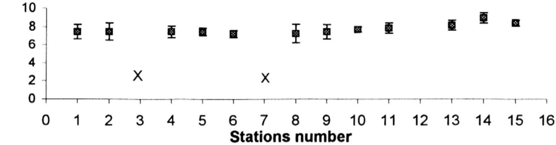


Fig.12. The mean and standard deviation of sediment pH during study period

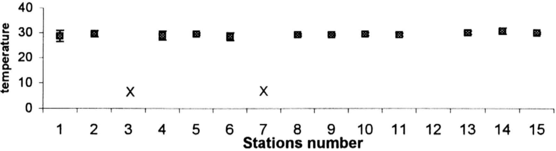


Fig. 13. The mean and standard deviation of sediment temperature during study period

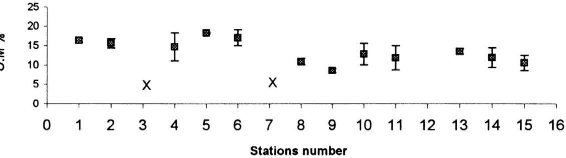


Fig. 14. The mean percentages and standard deviation of organic matter in sediment during study period

te: X = Data not available

high for stations located near the mouth of the river and close to mangrove sites. The percentages of organic matter in the sediment decreased in the offshore direction (Figure 15). Sediment parameters recorded at each station are shown in Appendix 7.

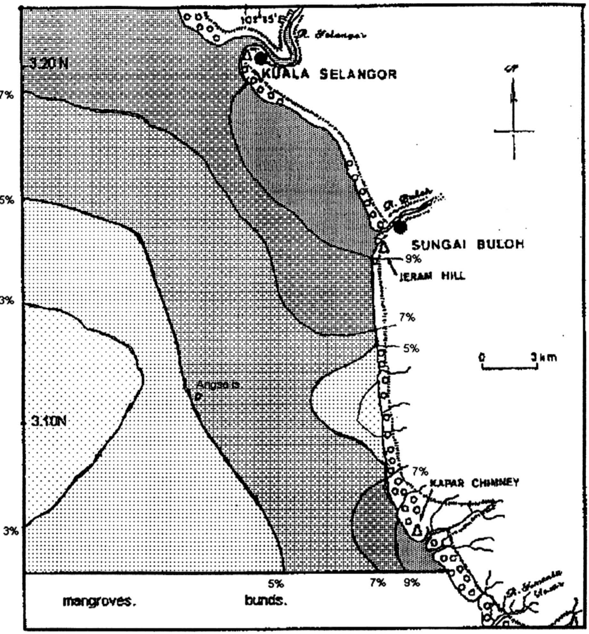
3.4 MULTIVARIATE ANALYSIS

3.4.1 Sediment and water parameters

Principal component analysis (PCA) of the various water and sediment characteristics, namely, turbidity, water pH, salinity, dissolved oxygen, percentage clay, silt, very fine sand, fine sand, medium sand and coarse sand content, sediment pH, redox potential and organic matter content were performed after arcsine transformation of the percentage data.

The PCA extracted the first 3 principal components which explained a total of 80% of the observed variability or variance. The first principal component explained 47.7%, the second 19.8% and the third 12.9% of the total variances (Table 4). The factor loadings of the first 3 components are also shown in Table 4, and plotted in Figure 16. Factor scores for each station are plotted in Figure 17.

As indicated by these figures, nearshore stations 1, 2, 4, 5, 6 and 12, which were clustered together, were characterized by high clay, silt and organic matter. Among these stations, Stations 1, 2, 4 and 5 had relatively turbid waters. Stations 1, 2, 4, 5 and 6 were stations located just off the mouth of the River Selangor estuary. Stations 8, 9, 10 and 11 formed another cluster characterized by very fine to fine sand as



15: The distribution of organic matter percentages in Klang Strait during the study d. <3%, 3%-5%, 5%-7%, 7%-9% and >9 - 11.1 % of organic matter.

Table 4. Eigenvalues and factor loadings of the first three principal components obtained from PCA analysis of environmental variables measured at 13 stations in the Klang Strait.

STAT. FACTOR ANALYSIS	Eigenvalues (pca.sta) Extraction: Principal components			
Value	Eigenval	% total Variance	Cumul. Eigenval	Cumul. %
1	6.19789	47.6761	6.19789	47.67606
2	2.56966	19.7666	8.76754	67.44265
3	1.6753	12.8869	10.4428	80.32956

STAT. FACTOR ANALYSIS	Factor Loadings (Unrotated) (pca.Sta) Extraction: Principal components (Marked Loadings are >.700000)		
Variable	Factor **1**	Factor **2**	Factor **3**
Turb.	0.24551	0.20058	0.72069
WpH	-0.5332	-0.7473	-0.1055
WO_2	-0.89582	-0.2881	0.07027
Sal.	-0.70922	-0.0421	-0.4699
Clay	0.92098	-0.0221	-0.0932
Silt	0.92192	-0.003	-0.2093
Vfs	-0.83359	0.35245	0.07441
Fs	-0.8181	-0.2363	0.10252
Ms	0.11492	-0.6783	0.58467
Cs	0.35911	-0.7602	0.40247
SpH	-0.59679	0.49466	0.38679
Sredox	0.42957	-0.5708	-0.4226
Org	0.89592	0.31178	0.13599
Expl.Var	6.19789	2.56966	1.6753
Prp.Totl	0.47676	0.19767	0.12887

Note: Turbidity (Turb.), Water pH (WpH), Dissolved oxygen (WO2), Salinity (Sal), Clay (Cla), Silt (Silt), Very fine sand (Vfs), Fine sand (Fs), Medium sand (Ms), Coarse sand (Cs), Sediment pH (SpH), Sediment redox (Sredox) and Organic matter content (Org).

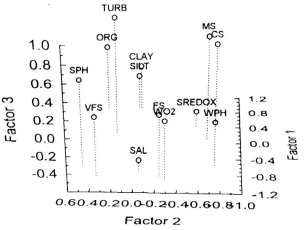


Figure 16. Factor loadings of sediment and water parameters measured at 13 stations for first, second and third factors (principal components) (see Table 4 for details)

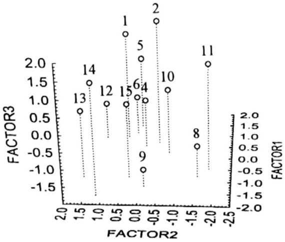


Figure 17. Spatial distribution of sampling stations with respect to sediment and water characteristics as measured by first, second and third principal components.

substrate and high sediment pH, high dissolved oxygen and salinity. The third cluster comprising Stations 13, 14 and 15 were situated further offshore. These stations were characterised by sandy substrates and high salinity water.

Table 5 summarises the results of the PCA analysis as interpreted above.

3.5 DISTRIBUTION AND ABUNDANCE OF FISH AND MACROBENTHOS

During the study period, a total of 22,376 fish and macroinvertebrates specimens were examined. A total of 162 species belonging to 73 families were recorded from 65 trawl samples, sampled during November 1996 - April 1998 (Table 6). These species comprised 119 fish and 43 invertebrate species belonging to 55 and 18 families, respectively.

3.5.1 Fish

A total of 119 fish species belonging to 55 families were divided into two broad classes: pelagic and demersal fish, of which there were 29 and 90 species belonging to 10 and 45 families respectively (Table 7).

Distribution of mean fish density in Klang Strait shows the highest fish density in the coastal mudflats stretching from the Kapar power station to the estuary of the Selangor River, and on the southern shoal of Angsa Bank where the water depth is shallow (Fig. 18a). Fish density as well as biomass (Fig. 18b) decreased more

Table 5. Summary of the PCA analysis results(Stations distribution according to water and sediment characteristics)

High clay, silt and organic matter	Low clay and silt High fine and very fine sand High salinity High dissolved oxygen	Higher medium and coarse sand	
1, 2, 4, 5 and 6	13, 14 and 15		Turbidity higher
12	9	8, 10 and 11	Lower turbidity

rapidly in the deep than in the less deep offshore water. Low densities of fish were obtained in deep water at the northwestern entrance of the strait.

3.5.1.1 Demersal fish

Density contours of demersal fish in the Klang Strait show the highest densities in estuaries and the coastal mudflats, which decreased rapidly in the offshore direction (Figures. 19a & b). The lowest densities were obtained from deep water at the northwestern entrance of the strait and in the shallow western and southern regions of Angsa Bank.

A total of 90 species belonging to 45 families were recorded from 9,269 specimens examined (Table 7). The number of species per station ranged from 24 to 45 species; these being recorded at Station 12 and Station 10 respectively. The mean density of all the demersal fish species ranged from 85.2 individuals (ind.) ha^{-1} to 772.6 ind.ha^{-1} . The lowest and highest densities were recorded at Station 9 (located offshore) and Station 5 (located nearshore) respectively (Table 8). The maximum mean biomass of all demersal fish species was 40.1 kg ha^{-1} (Station 5) and the minimum was 1.3 kg ha^{-1} (Station 9) [see Table 9]. The presence or absence of the demersal fish species at each station, during the study period, is shown in Appendix 8.

The families of demersal fish in order of importance were Sciaenidae, Leiognathidae, Ariidae, Trichiuridae, Teraponidae, Sillaginidae, Cynoglossidae and Platycephalidae (Table 12).

e 6: Checklist of fish and macroinvertebrate species in Klang Strait (1996 to 1998).

SPECIES	Code	Authority	FAMILY
Arius caelatus	Aricae	(Valenciennes, 1840)	Ariidae
Arius maculatus	Arimac	(Thunberg, 1792)	Ariidae
Arius sagor	Arisag	(Hamilton - Buchanan, 1822)	Ariidae
Arius venosus	Ariven	(Valenciennes, 1840)	Ariidae
Osteogeneiosus militaris	Ostmil	(Linnaeus, 1758)	Ariidae
Pseudorhombus malayanus	Psemal	Bleeker, 1866	Bothidae
Paramonacanthus choircephalus	Parchi	(Bleeker)	Aluteridae
Apogon ellioti	Apoell	Day	Apogonidae
Apogon quadrifasciatus	Apoqua	Cuvier, 1830	Apogonidae
Ambassis commersoni	Ambcom	(Cuvier, 1829)	Ambassidae
Batrachus grunniens	Batgru	(Linnaeus, 1758)	Bathydraconidae
Callionymus sagitta	Calsag	Pallas	Callionymidae
Alectis indicus	Aleind	(Ruppell, 1828)	Carangidae
Atropus atropus	Atratr	(Bloch & Schneider, 1801)	Carangidae
Alepes djeddaba	Aledje	(Forsskal, 1775)	Carangidae
Carangoides armatus	Cararm	(Ruppell)	Carangidae
Carangoides malabaricus	Carmal	(Bloch & Schneider, 1801)	Carangidae
Scomberoides commersonianus	Scocom	Lacepede, 1802	Carangidae
Megalaspis cordyla	Megcor	(Linnaeus, 1758)	Carangidae
Scoliodon sorrakowah	Scosor	(Cuvier, 1829)	Carcharinidae
Chirocentrus dorab	Chidor	(Forsskal, 1775)	Chirocentridae
Escualosa thoracata	Esctho	(Valenciennes, 1840)	Clupeidae
Illisha elongata	Illelo	(Bennett, 1830)	Clupeidae
Sardinella fimbriata	Sarfim	(Valenciennes, 1847)	Clupeidae
Herklotsichthys punctatus	Herpun	(Ruppell, 1837)	Clupeidae
Hilsa toli	Hiltol	(Valenciennes. 1847)	Clupeidae
Cynoglossus macrolepidotus	Cynmac	(Bleeker, 1851)	Cynoglossidae
Cynoglossus lingua	Cymlin	(Hamilton - Buchanan, 1822)	Cynoglossidae
Anodontostoma chacunda	Anocha	(Hamilton - Buchanan, 1822)	Dorosomidae
Drepane longimana	Drelon	(Bloch & Schneider, 1801)	Drepanidae
Drepane punctata	Drepun	(Linnaeus, 1758)	Drepanidae
Coilia dussumieri	Coidus	Valenciennes, 1848	Engraulidae
Setipinna taty	Settat	(Valenciennes, 1848)	Engraulidae
Stolephorus baganensis	Stobag	(Hardenberg, 1933)	Engraulidae
Thryssa dussumieri	Thrdus	(Valenciennes, 1848)	Engraulidae
Thryssa hamiltonii	Thrham	(Gray, 1835)	Engraulidae
Thryssa kammalensis	Thrkam	(Bleeker,1866)	Engraulidae
Ephippus orbis	Ephorb	(Bloch,1787)	Ephippidae
Gerres abbreviatus	Gerabb	Bleeker, 1850	Gerridae

SPECIES	Code	Authority	FAMILY
Gerres filamentosus	Gerfil	(Cuvier)	Gerridae
Acentrogobius caninus	Acecan	(Valenciennes, 1848)	Gobiidae
Aulopareia atripinnatus	Aulatr	Koumans, 1953	Gobiidae
Aulopareia sp.	Aulsp.	(Koumans, 1953)	Gobiidae
Butis koilomatodon	Butkoi	Koumans, 1953	Eleotrididae
Parachaeturichthys polynema	Parpol	(Andriashev, 1965)	Bathydraconidae
Harpadon nehereus	Harneh	(Hamilton - Buchanan, 1822)	Harpadontidae
Kurtus indicus	Kurind	Bloch,1787	Kurtidae
Halichoeres bicolor	Halbic	(Bloch & Schneider, 1801)	Labridae
Gastrophysus lunaris	Gaslun	(Bloch,1787)	Lagocephalidae
Torquigener oblongus	Torobl	(Bloch,1787)	Lagocephalidae
Leiognathus brevirostris	leibre	(Valenciennes, 1835)	Leiognathidae
Leiognathus bindus	leibin	(Valenciennes, 1835)	Leiognathidae
Leiognathus daura	leidau	(Cuvier, 1829)	Leiognathidae
Leiognathus elongatus	leielo	(Gunther)	Leiognathidae
Leiognathus equulus	leiequ	(Forsskal, 1775)	Leiognathidae
Gazza minute	Gazmin	(Bloch)	Leiognathidae
Secutor insidiator	Secins	(Bloch, 1787)	Leiognathidae
Lutjanus johni	Lutjoh	(Blach,1792)	Lutjanidae
Lutjanus russelli	Lutrus	(Bleeker, 1849)	Lutjanidae
Stephanolepis auratus	Steaur	(Castlenau)	Monacanthidae
Valamugil cunnesius	Valcun	(Valenciennes, 1836)	Mugilidae
Upeneus sulphureus	Upesul	(Cuvier, 1829)	Mullidae
Upeneus tragula	Upetra	(Richardson)	Mullidae
Muraenesox cinereus	Murcin	(Forsskal, 1775)	Muraenesocidae
Gymnothorax tile	Gymtil	(Hamilton, 1822)	Muraenidae
Nemipterus hexodon	Nemhex	(Quoy & Gaimard, 1824)	Nemipteridae
Chiloscyllium indicum	Chiind	(Gmelin)	Orectolobidae
Platycephalus indicus	Plaind	(Linnaeus, 1758)	Platycephalidae
Platycephalus scaber	Plasca	(Linnaeus, 1758)	Platycephalidae
Platax teira	Platei	(Forsskal, 1775)	Platacidae
Plotosus anguillaris	Ploang	(Bloch)	Plotosidae
Eleutheronema tetradactylus	Eletet	(Shaw, 1804)	Polynemidae
Polynemus indicus	Polind	Shaw, 1804	Polynemidae
Polynemus sextarius	Polsex	Bloch & Schneider, 1801	Polynemidae
Pomadasys hasta	Pomhas	(Bloch, 1790)	Pomadasyidae
Pomadasys maculatus	Pommac	(Bloch, 1797)	Pomadasyidae
Scatophagus argus	Scaarg	(Linnaeus, 1758)	Scatophagidae
Chrysochir aureus	Chraur	(Richardson, 1846)	Sciaenidae
Dendrophysa russelli	Denrus	Cuvier, 1830	Sciaenidae
Johnius belangerii	Johbel	(Cuvier, 1830)	Sciaenidae

SPECIES	Code	Author	FAMILY
Johnius carouna	Johcar	Cuvier, 1830	Sciaenidae
Johnius carutta	Johcau	Bloch, 1793	Sciaenidae
Johnius dussumieri	Johdus	(Valenciennes, 1833)	Sciaenidae
Johnieops vogleri	Johvog	(Bleeker, 1853)	Sciaenidae
Johnieops weberi	Johweb	Hardenberg, 1836	Sciaenidae
Johnius trachycephalus	Johtra	(Bleeker, 1850)	Sciaenidae
Otolithes ruber	Otorub	(Schneider, 1801)	Sciaenidae
Panna microdon	Panmic	(Bleeker, 1849)	Sciaenidae
Nibea soldado	Nibsol	(Lacepede, 1802)	Sciaenidae
Pennahia macropthalmus	Penmac	(Bleeker, 1850)	Sciaenidae
Rastrelliger kanagurta	Raskan	(Cuvier, 1816)	Scombridae
Indocyblum guttatus	Indgut	(Bloch & Schneider, 1801)	Scomberomoridae
Polycaulus uranoscopus	Polura	(Bloch & Schneider, 1801)	Scorpaenidae
Vespicula trachinoides	Vestra	(Cuvier, 1829)	Scorpaenidae
Siganus javus	Sigjav	(Linnaeus, 1766)	Siganidae
Siganus canaliculatus	Sigcan	(Park, 1797)	Siganidae
Sillago sihama	Silsih	(Forsskal, 1775)	Sillaginidae
Solea ovata	Solova	Richardson	Soleidae
Synaptura commersoniana	Syncom	(Lacepede, 1802)	Soleidae
Zebrias quagga	Zebqua	(Bloch)	Soleidae
Psettodes erumei	Pseeru	(Schneider, 1801)	Psettodidae
Sphyraena jello	Sphjel	Cuvier, 1829	Sphyraenidae
Pampus argenteus	Pamarg	(Euphrasen, 1788)	Stromateidae
Pampus chinensis	Pamchi	(Euphrasen, 1788)	Stromateidae
Parastromateus niger	Parnig	(Bloch, 1795)	Stromateidae
Saurida tumbil	Sautum	(Bloch, 1795)	Synodontidae
Saurida undosquamis	Sauund	(Richardson, 1848)	Synodontidae
Therapon jarbua	Thejar	(Forsskal, 1775)	Teraponidae
Therapon theraps	Thethe	Cuvier, 1829	Teraponidae
Trichiurus lepturus	Trilep	Linnaeus, 1758	Trichiuridae
Dasyatis imbricatus	Dasimb	(Schneider, 1801)	Dasyatidae
Dasyatis kuhlii	Daskuh	(Muller & Henle)	Dasyatidae
Dasyatis uarnak	Dasuar	(Forsskal, 1775)	Dasyatidae
Dasyatis zugei	Daszug	(Muller & Henle)	Dasyatidae
Trypauchen vagina	Tryvag	(Bloch & Schneider, 1801)	Trypauchenidae
Pseudotriacanthus strigilifer	Psestr	(Cantor)	Triacanthidae
Triacanthus brevirostris	Tribre	Schlegel	Triacanthidae
Triacanthus biaculeatus	Tribia	(Bloch, 1795)	Triacanthidae
Tetraodon nigroviridis	Tetnig	de Proce	Tetraodontidae

SPECIES	Code	Authority	FAMILY
CROINVERTEBRATES			
Metapenaeus affinis	Metaff	(H.Milne Edwards, 1837)	Penaeidae
Metapenaeus brevicornis	Metbre	(H.Milne Edwards, 1837)	Penaeidae
Metapenaeus dobsoni	Metdob	(Miers, 1878)	Penaeidae
Metapenaeus lysianassa	Metlys	(De Man, 1888)	Penaeidae
Parapenaeopsis coromandelica	Parcor	Alcock, 1906	Penaeidae
Parapenaeopsis gracillima	Pargra	(Hall, 1962)	Penaeidae
Parapenaeopsis hardwickii	Parhar	(Miers, 1878)	Penaeidae
Parapenaeopsis hungerfordi	Parhun	(Alcock, 1905)	Penaeidae
Parapenaeopsis sculptilis	Parscu	(Heller, 1862)	Penaeidae
Parapenaeopsis maxillipedo	Parmax	Alcock, 1905	Penaeidae
Penaeus merguiensis	Penmer	De Man, 1988	Penaeidae
Penaeus japonicus	Penjap	Bate, 1888	Penaeidae
Penaeus monodon	Penmon	Fabricius, 1798	Penaeidae
Solenocera subnuda	Solsub	(Hall, 1962)	Penaeidae
Alpheus sp.	Alpsp	(de Man, 1911)	Alpheidae
Synalpheus sp.	Synsp	(de Man, 1911)	Alpheidae
Mimocaris sp.	Mimsp	Nobili, 1903	Hippolytidae
Octopus sp.	Octsp		Octopodidae
Sepia esculenta	Sepesc	Hoyle	Sepiidae
Loligo edulis	Loledu	Hoyle	Loliginidae
Matuta sp.	Matsp		Calappidae
Heikea japonica	Heijap	(Von Siebold, 1824)	Dorippidae
Neodorippe callida	Neocal	(Shen, 1932)	Dorippidae
Doclea canalifera	Doccan	Stimpson, 1857	Majidae
Doclea ovis	Docovi	(Herbst, 1788)	Majidae
Charybdis feriata	Chafer	(Linnaeus, 1938)	Portunidae
Charybdis callianassa	Chacal	(Leene, 1938)	Portunidae
Charybdis natator	Chanat	(Herbst, 1794)	Portunidae
Charybdis variegata	Chavar	(Fabricius, 1798)	Portunidae
Portunus pelagicus	Porpel	(Linnaeus, 1758)	Portunidae
Scylla serrata	Scyser	(Forsskal, 1775)	Portunidae
Thalamita crenata	Thacre	(Latreille, 1829)	Portunidae
Parapanope singaporensis	Parsin	De Man, 1895	Xanthidae
Harpiosquilla harpax	Harhar	(de Haan, 1844)	Squillidae
Oratosquilla interrupta	Oraint	(Kemp, 1911)	Squillidae
Oratosquilla perpensa	Oraper	(Kemp, 1911)	Squillidae
Carcinoscorpius rotundicauda	Carrot	(Latreille, 1829)	Merostomata
Tachypleus gigas	Tacgig	(Muller)	Merostomata
Lovenia elongata	Lovelo	(Gray)	Spatangidae
Ophiotrichoides nereidina	Ophner	(Lamarck)	Ophiotrichidae
Salmacis dussumieri	Saldus	(Agassiz and Desor)	Temopleuridae
Luidia penangensis	Luipen	de Loriol	Luidiidae
Malpodinae sp.A	Malspa	(Lampert)	Holothuriidae

DEMERSAL FISH														
	Number of species	36	28	41	36	36	39	31	45	32	24	28	31	34	90
	Number of families	21	17	24	21	23	26	23	28	21	12	19	25	24	45
	Number of individuals	792	657	541	1417	891	460	510	911	840	458	329	568	895	9269
PELAGIC FISH															
	Number of species	14	16	13	16	10	13	17	15	11	13	9	17	15	29
	Number of families	9	9	9	9	7	8	9	8	7	7	5	7	9	10
	Number of individuals	1274	437	105	261	904	416	566	124	234	206	127	593	1812	7059
PRAWN															
	Number of species	9	9	8	8	5	6	4	4	7	6	7	5	6	17
	Number of families	1	2	2	2	2	2	2	2	1	1	1	1	2	3
	Number of individuals	422	287	87	155	93	277	258	27	64	93	58	57	500	2378
CEPHALOPODA															
	Number of species	2	2	3	3	3	3	3	3	3	2	3	3	3	3
	Number of families	2	2	3	3	3	3	3	3	3	3	3	3	3	3
	Number of individuals	50	87	94	78	112	61	43	39	80	40	30	30	99	843
CRABS															
	Number of species	10	9	7	9	9	7	10	9	8	7	9	9	9	15
	Number of families	5	4	4	4	4	4	6	4	4	3	4	3	5	6
	Number of individuals	163	155	130	131	157	46	166	34	106	78	42	206	104	1518
STOMATOPODA															
	Number of species	2	2	3	2	3	1	3	1	3	3	2	2	3	3
	Number of families	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Number of individuals	12	32	38	6	33	17	81	3	23	18	8	37	78	386
ECHINODERMATA															
	Number of species	4	2	4	4	3	3	2	3	3	3	2	1	1	5
	Number of families	4	2	4	4	3	3	2	3	3	3	2	1	1	5
	Number of individuals	120	142	319	180	64	29	5	14	10	15	19	3	3	923
Total individuals		2833	1797	1314	2228	2254	1306	1629	1152	1357	908	613	1491	3491	22376
											Total no. of Species				162
											Total no. of Families				75

Table 8: The mean abundance (ind/ha) per major taxonomical group at the stations during the study period.

GROUPS\ STATION	1	2	4	5	6	8	9	10	11	12	13	14	15	Mean of whol area
FISH														
DEMERSAL FISH	432.4	274.2	164.3	772.6	378.3	175.3	85.2	428.5	317.0	420.7	283.9	173.4	205.1	316.2
PELAGIC FISH	410.8	207.7	29.4	114.7	328.7	252.7	87.0	51.1	73.1	209.3	102.4	133.4	495.5	192.0
Total Fish	**432.4**	**274.2**	**164.3**	**772.6**	**378.3**	**175.3**	**85.2**	**428.5**	**317.0**	**420.7**	**283.9**	**173.4**	**205.1**	**316.2**
MACROINVERTEBRATES														
PRAWNS	192.4	162.1	24.3	72.1	26.9	132.4	104.2	13.7	22.9	85.6	49.6	23.8	105.8	78.2
CEPHALOPODA	20.2	30.5	24.0	24.7	39.2	22.6	7.0	16.7	21.6	38.6	21.9	11.2	34.8	24.1
CRABS	88.3	33.5	24.3	73.3	53.1	19.1	66.2	18.3	46.0	73.5	41.3	113.3	36.4	52.8
STOMATOPODA	5.7	11.2	11.4	2.7	7.4	7.9	27.4	1.9	5.3	20.5	7.1	20.1	17.5	11.2
ECHINODERMATA	63.6	71.8	45.0	99.4	24.0	12.7	0.6	3.5	3.6	15.4	10.2	1.8	1.1	27.1
Total Macroinvertebrates	**370.1**	**309.0**	**129.0**	**272.3**	**150.7**	**194.7**	**205.5**	**54.2**	**99.4**	**233.7**	**130.0**	**170.2**	**195.6**	**193.4**
Fish and Macroinvertebrates	**802.5**	**583.1**	**293.3**	**1044.9**	**529.0**	**370.1**	**290.7**	**482.7**	**416.4**	**654.4**	**413.9**	**343.6**	**400.7**	**509.6**

Table 9: The mean biomass (kg/ha) per major taxonomical group at the stations during the study period.

GROUPS\ STATION	1	2	4	5	6	8	9	10	11	12	13	14	15	Mean of whol area
FISH														
DEMERSAL FISH	4.39	1.70	4.28	40.09	5.21	2.89	1.25	11.90	5.35	15.90	9.35	2.87	2.52	**8.28**
PELAGIC FISH	1.60	0.71	0.54	0.77	0.72	1.49	0.40	0.97	0.53	4.42	1.20	0.29	0.49	**1.09**
Total fish	**4.39**	**1.70**	**4.28**	**40.09**	**5.21**	**2.89**	**1.25**	**11.90**	**5.35**	**15.90**	**9.35**	**2.87**	**2.52**	**8.28**
MACROINVERTEBRATES														
PRAWNS	1.53	0.46	0.25	0.55	0.19	0.30	0.05	0.02	0.17	0.53	0.31	0.19	0.34	**0.38**
CEPHALOPODA	0.42	0.63	0.64	0.71	0.90	0.30	0.14	0.42	0.77	0.54	0.67	0.31	0.64	**0.55**
CRABS	1.25	1.12	0.61	0.93	1.01	0.45	0.14	1.19	1.15	0.85	0.87	1.65	0.33	**0.89**
STOMATOPODA	0.16	0.24	0.22	0.04	0.22	0.04	0.09	0.02	0.09	0.11	0.10	0.20	0.29	**0.14**
ECHINODERMATA	0.80	0.13	0.31	2.06	0.24	0.15	0.04	0.30	0.05	0.57	0.22	0.02	0.02	**0.38**
Total Macroinvertebrates	**4.16**	**2.57**	**2.04**	**4.30**	**2.55**	**1.24**	**0.46**	**1.95**	**2.24**	**2.61**	**2.17**	**2.37**	**1.62**	**2.33**
Fish and Macroinvertebrates	**8.55**	**4.27**	**6.32**	**44.39**	**7.76**	**4.12**	**1.72**	**13.84**	**7.58**	**18.50**	**11.52**	**5.24**	**4.14**	**10.61**

LEGEND TO FIGURES

18-20, 22, 24, 26-40, 42, 44, 46-48, 50, 52-54 (for both a & b)

Distribution contours of fish and macroinvertebrate abundance and biomass in Klang Strait (Straits of Malacca)

Density in individuals / ha (ind/ha) and biomass in kg/ha. Sampling stations are referred by station numbers which are positioned according to an unscaled grid (see Figure 1 for details)

Fig.18a: Density distribution of all fish species in Klang Strait

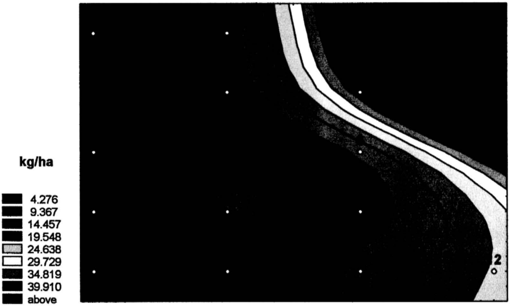


Fig.18b: Biomass distribution of all fish species in Klang Strait

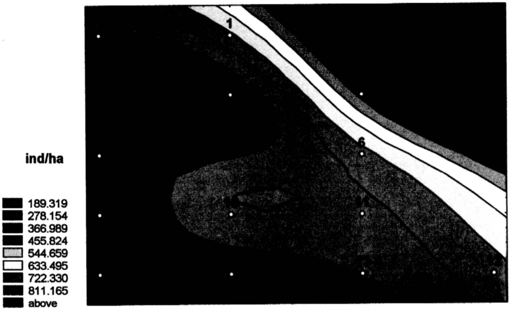


Fig.19a: Density distribution of demersal fish species in Klang Strait

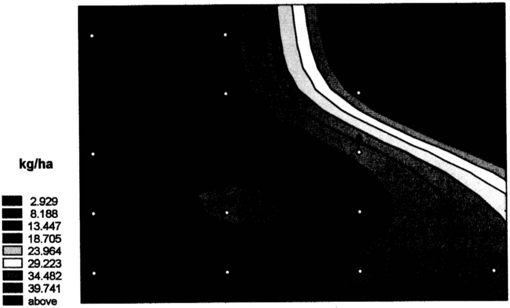


Fig.19b: Biomass distribution of demersal fish species in Klang Strait

The distribution and abundance of the most common families of the demersal fish are further described as follows:

3.5.1.1.1 Sciaenidae

Density contours of sciaenids in the Klang Strait indicate their highest abundance in estuaries and coastal mudflats, which decreased gradually in the offshore direction. These contours appear as a distinct 'density plume', from the mudflats between Kampong Sungai Janggut and Sungai Buloh towards Pulau Angsa and the Angsa Bank (Figure 20a), which may suggest off shore migration. The sciaenid populations were generally more abundant in the southern waters where reasonably high populations were encountered as far as Pulau Angsa. The biomass contours indicate generally larger sciaenids or individuals inhabiting the mudflats to the south (Figure 20b).

A total of 12 species belonging to 7 genera was recorded in the family Sciaenidae. Both Figures 21a & 21b show dendrograms resulting from cluster analyses of Sciaenidae species (case) grouped by similarity of their presence in stations (variable) [Species grouping, left dendrogram], and stations (case) grouped by similarity of sciaenid species (variable) [Station grouping, top dendrogram].

Stations 1, 5 and 2 were grouped together, having almost similar species *Johnius trachycephalus*, *Nibea soldado*, *Johnius dussumieri*, *Dendrophysa russelli*, *Johnius weberi*, *Panna microdon*, *Otolithes ruber*, *Johnius belangeri*, *Johnius carouna* and *Pennahia macropthalmus*. In the PCA (Section 3.3), these stations were

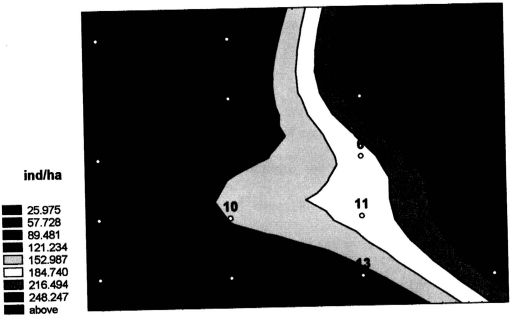


Fig.20a: Density distribution of Sciaenidae species in Klang Strait

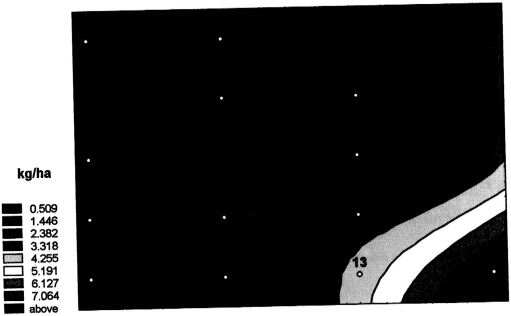


Fig.20b: Biomass distribution of Sciaenidae species in Klang Strait

characterized by sediments relatively higher in clay and silt, richer in organic content and more turbid water. *J. trachycephalus* and *N. soldado* were found only in Stations 1 and 2 (Figure 21a), and together with *J. dussumieri* and *D. russelli* appeared to prefer or tolerant of these conditions (see Table 10).

Stations 8, 9, 13, 14 and 15 were grouped together, by having few but rather similar species in *Pennahia macropthalmus, Johnius carouna* and *Johnius belangerii*. These species were however also caught in all other stations, and appeared ubiquitous in the Klang Strait. Stations 8, 9, 13, 14 and 15 were characterised by sediment with relatively higher content of fine and very fine sand and water of higher salinity and DO. *Chrysochir aureus* found only at Station 13 may be the only sciaenid species preferring or tolerant of such conditions.

Another cluster of stations which grouped Stations 6, 10, 4, 12 and 11 was a mixture of both clayey silt and sandy bottom stations, with turbid to less turbid waters. Presumably such species as *J. weberi* and *P. microdon*, although frequenting coarser sand bottoms in clearer water, are also tolerant of muddy substrates in turbid waters.

The highest mean density of sciaenid fishes by species and in order of magnitude is as follows: *J. dussumieri* (159.8 ind.ha^{-1}, at Station 5), *J. belangerii* (104.4 ind.ha^{-1}, at Station 10), *P. macropthalmus* (84.61 ind.ha^{-1}, at Station 5), *J. carouna* (79.4 ind.ha^{-1}, at Station 11), *J. carutta* (78.1 ind.ha^{-1}, at Station 12), *J. weberi* (50.6 ind.ha^{-1}, at Station 11), *O. ruber* (26.96 ind.ha^{-1}, at Station 12), *P. microdon* (24.5 ind.ha^{-1}, at Station 1), *J. vogleri* (18.13 ind.ha^{-1}, at Station 11), *J. trachycephalus* (16.7 ind.ha^{-1}, at

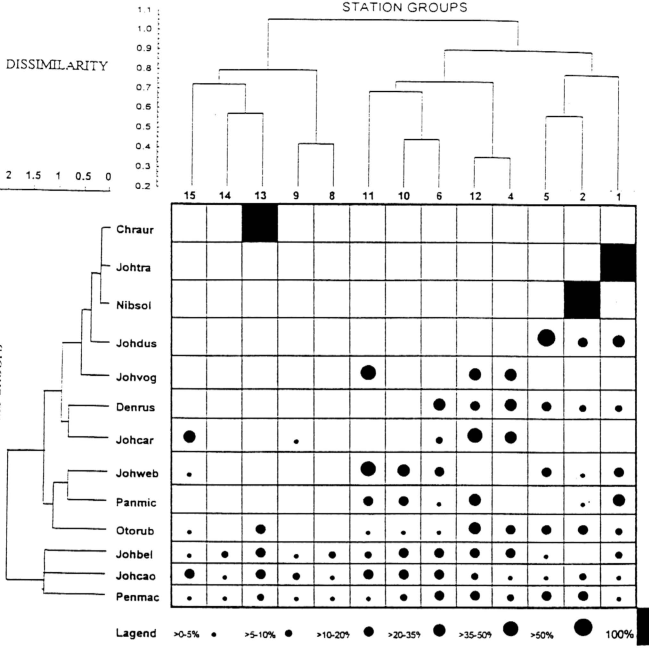


Fig. 21a: Summary of the cluster analysis results for the Sciaenidae species in Klang Strait with emphasis on the distribution of the Sciaenidae species among the stations group. The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. See Table 6 for species code.

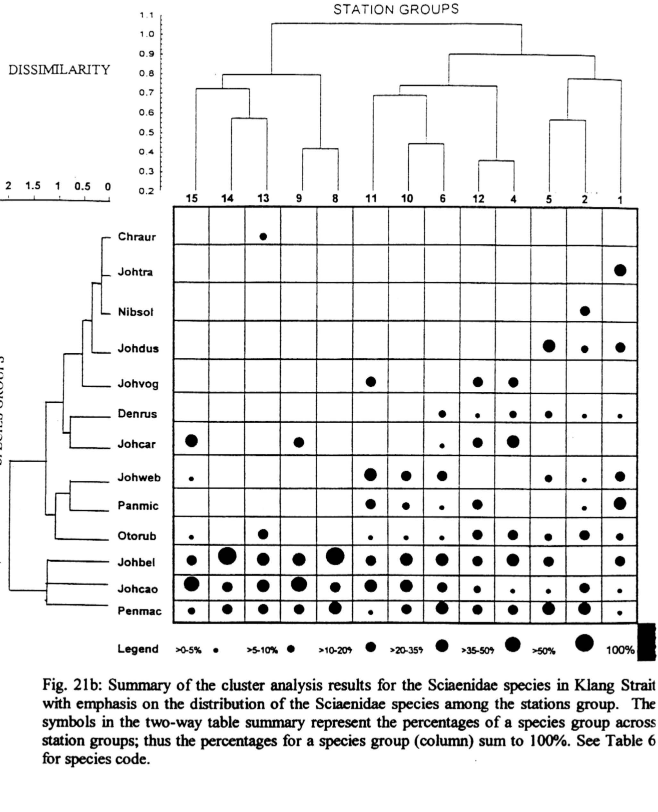


Fig. 21b: Summary of the cluster analysis results for the Sciaenidae species in Klang Strait with emphasis on the distribution of the Sciaenidae species among the stations group. The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

Station 1), *P. macrocephalus* (4.96 ind.ha^{-1}, at Station 2) and *D. russelli* (1.73 ind.ha^{-1}, at Station 4) [see Table 11].

The highest mean biomass of the Sciaenidae species in order of magnitude was as follows: *J. belangerii* (3.1 kg ha^{-1}, at Station 10), *O.ruber* (3.1 kg ha^{-1}, at Station 12), *J. carouna* (1.7 kg ha^{-1}, at Station 11), *J. carutta* (1.1 kg ha^{-1}, at Station 11), *J. dussumieri* (0.65 kg ha^{-1}, at Station 5), *P. microdon* (0.35 kg ha^{-1}, at Station 12), *P. macropthalmus* (0.25 kg ha^{-1}, at Station 5), *N. soldado* (0.03 kg ha^{-1}, at Station 2), *J. vogleri* (0.18 kg ha^{-1}, at Station 12), *J. weberi* (0.14 kg ha^{-1}, at Station 1), *D. russelli* (0.09 kg ha^{-1}, at Station 12), and *J. trachycephalus* (0.02 kg ha^{-1}, at Station 1) [see Table 11]. Generally, species that were very abundant but with low biomass indicate that they comprised mainly young juveniles.

3.5.1.1.2 Leiognathidae

The Leiognathidae were most abundant over shallow mudflat areas, particularly in the region between the estuaries of River Buloh and River Selangor (Figures. 22a & b) Their numbers decreased quickly off the shore. Another area of comparatively high densities of leiognathids was in the very shallow eastern region of Angsa Bank (west of Pulau Angsa).

There were 7 species belonging to 3 genera in the family Leiognathidae.. *Leiognathus brevirostris* and *Secutor insidiator* were recorded in all stations (Figure 23a). They were the two most dominant leiognathids (Figure 23b), tolerant of all water and sediment conditions in the Klang Strait. *Leiognathus bindus* were present

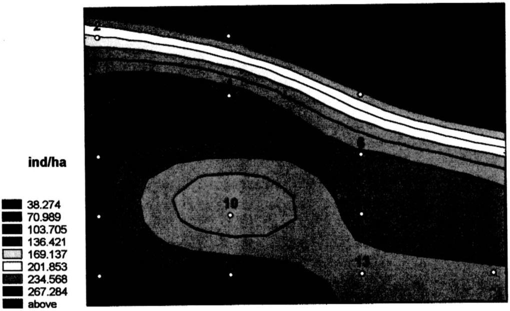


Fig.22a: Density distribution of Leiognathidae species in Klang Strait

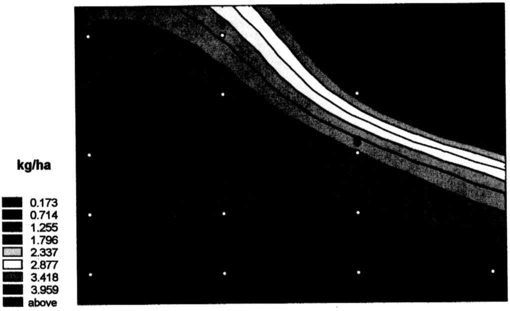
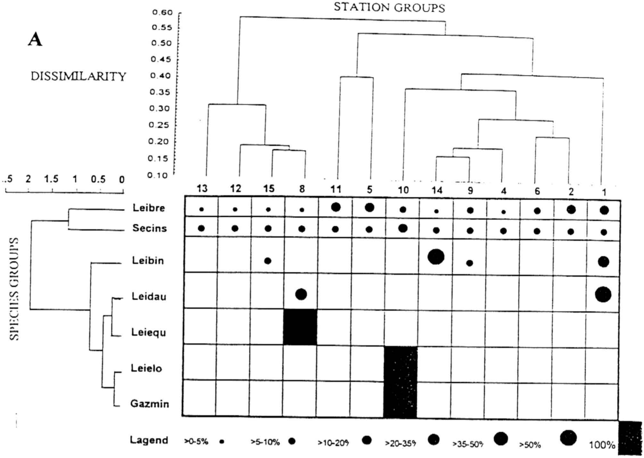


Fig.22b: Biomass distribution of Leiognathidae species in Klang Strait



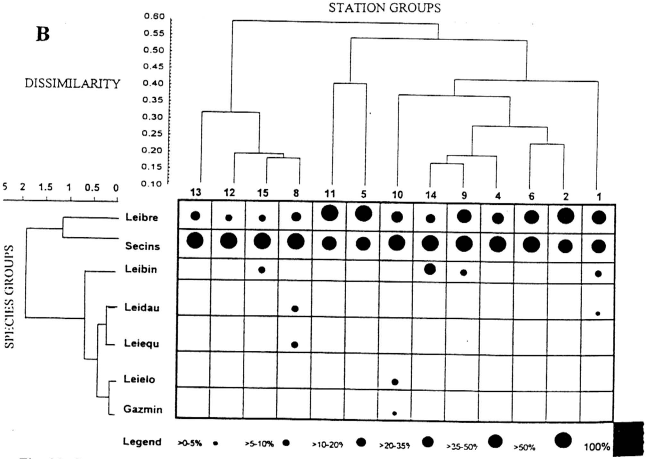


Fig. 23: Summary of the cluster analysis results for the Leiognathidae species in Klang Strait., with emphasis on the distribution of the Leiognathidae species among the stations group. (A) The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. (B) symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

in only four stations: Stations 1, 9, 14 and 15, but apparently preferred fine sand substrates and water with higher DO [Table 10]. *Leiognathus daura* was recorded in Stations 1 and 8. Both *Leiognathus elongatus* and *Gazza minute* were recorded only at Station 10. Together with *L. equulus* which, occurred in Station 8 only, these 3 species apparently preferred coarser sandy substrates and less turbid water (see Table 10).

The highest mean density was observed for *L. brevirostris* (184.6 ind.ha^{-1}), followed by *S. insidiator* (167.4 ind.ha^{-1}); these species were the most common leiognathids. Others were *L. elongatus* (0.5 ind.ha^{-1}), *L. equulus* (0.25 ind.ha^{-1}) and *G. minute* (0.25 ind.ha^{-1}) [see Table 11]. The highest mean biomass was observed for L. *brevirostris* (3.68 kg ha^{-1}), followed by *S. insidiator* (0.43 kg ha^{-1}), *L. bindus* (0.09 kg ha^{-1}), *L. daura* (0.03 kg ha^{-1}), *L. equulus* (0.004 kg ha^{-1}), *L. elongatus* and *G. minute* (0.0004 kg ha^{-1}) [Table 11].

3.5.1.1.3 Ariidae

The Ariidae were largely confined to nearshore waters (Figure 24a). Highest density was observed near the shore, particularly in the mudflat region north and south of the estuary of River Buloh. Ariid density decreased gradually offshore, to as much as 80% of their observed density over coastal mudflats in the southern region of Angsa Bank. The biomass contour shows a distinct 'plume' from the Buloh estuary towards Angsa Bank, suggesting the offshore movement of larger ariids or larger individuals (Figure 24b).

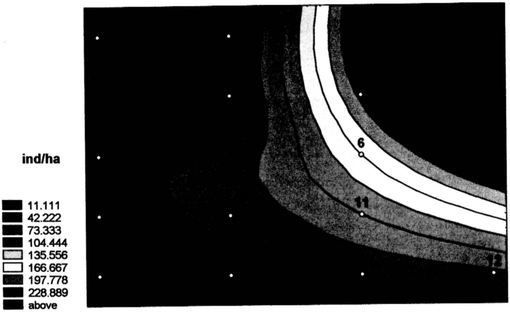


Fig.24a: Density distribution of Ariidae species in Klang Strait

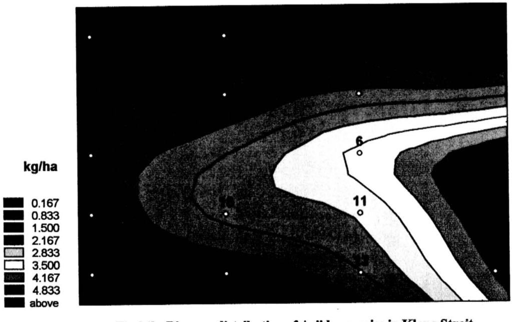


Fig.24b: Biomass distribution of Ariidae species in Klang Strait

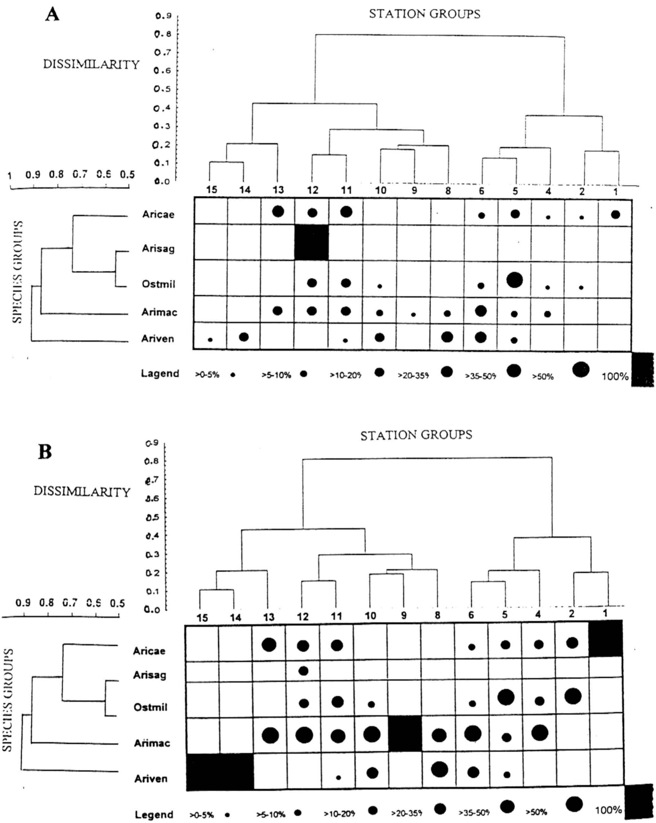


Fig. 25: Summary of the cluster analysis results for the Ariidae species in Klang Strait., with emphasis on the distribution of the Ariidae species among the stations group. (A) The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. (B) symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

There were 5 species of ariids (*Arius caelatus, Arius maculatus, Arius sagor, Arius venosus* and *Osteogeneiosus militaris*), occurring in the Klang Strait waters.

Cluster analysis essentially divide the ariids into 2 main groups, one comprising those which were confined to nearshore waters near estuaries (Stations 1, 2, 4, 5 and 6; right cluster), namely, *A. caelatus, A. sagor* and *O. militaris,* and the second comprising *A. maculatus* and *A. venosus* (Stations 15, 14, 13, 12, 11, 10, 9 and 8; left cluster), which were found nearshore as well as further offshore (Fig. 25). Those inhabiting the nearshore stations, apparently preferred the clayey, silty and high organic substrates, where the water was characteristically turbid. *A. caelatus* was found in all nearshore stations. *A. sagor* was sampled only in Station 12.

The highest mean density was observed for *O. militaris* (205.2 ind.ha^{-1}), recorded at Station 5, followed by *A. maculatus* (124.6 ind.ha^{-1}), recorded at Station 6. Densities of other species in decreasing order were *A. caelatus* (9.29 ind.ha^{-1}), *A. venosus* (6.77 ind.ha^{-1}), and *A. sagor* (1.06 ind.ha^{-1}).

Mean biomass was highest for *A. maculatus* (3.32 kg ha^{-1}) at Station 6, followed by *A. sagor* (1.68 kg ha^{-1}) at Station 12. Biomasses of other ariids in decreasing order were *O. militaris* (0.68 kg ha^{-1}), *A. caelatus* (0.37 kg ha^{-1}) and *A. venosus* (0.18 kg ha^{-1}) [Table 11]. Captured *Arius sagor* were large specimens as shown by their large biomass but low density.

3.5.1.1.4 Dasyatidae

The distribution of the Dasyatidae shows their greater abundance in the southern Klang Strait, particularily at the mudflats off the Kapar power plant (Kapar chimney in Figure 1) and the deltaic islands of Pulau Klang and Pulau Ketam (Figure 26a). The observed density plume towards the Pulau Angsa waters as well as their biomass distribution (Fig. 26b) may indicate the offshore migration of larger or maturing stingrays

There are 4 species belonging to the single genus, *Dasyatis*. *Dasyatis zugei* was the most common stingray caught, being recorded in most stations (Table 11). This species appeared to prefer the coastal mud flats stretching from the River Buloh to River Kapar. *Dasyatis kuhlii* was recorded at only three stations, viz. Stations 8, 10 and 12, and appeared to prefer more sandy substrates *Dasyatis imbricatus* and *Dasyatis uarnak* were caught only once at Station 8 and Station 4, respectively (Table 11).

The mean density (biomass) of *D. zugei* and *D. kuhlii* were estimated at 8.63 ind.ha^{-1}(1.50 kg ha^{-1}) and 5.27 ind.ha^{-1} (1.78 kg ha^{-1}), respectively. *D. imbricatus* and *D. uarnak* had the same density of 0.25 ind.ha^{-1}, while their mean biomass were 0.08 kg ha^{-1} and 0.15 kg ha^{-1}, respectively.

Fig.26a: Density distribution of Dasyatidae species in Klang Strait

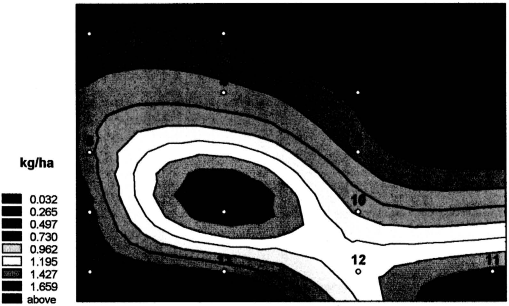


Fig.26b: Biomass distribution of Dasyatidae species in Klang Strait

3.5.1.1.5 Cynoglossidae

Tongue soles show two distinct areas of abundance, one just off the mudflats north of the deltaic islands and the other some 3- 5 km south of the mouth of the Selangor River (Figures 27a & b).

A total of two species belonging to one genus (*Cynoglossus*) were recorded from the family Cynoglossidae. *Cynoglossus lingua* was the most common species being recorded from all stations. Its maximum density of 16.9 ind.ha^{-1} was recorded at Station 13, whereas its maximum mean biomass of 0.44 kg ha^{-1}) was obtained from Station 12 (Tables 11 & 15). *Cynoglossus macrolepidotus* was recorded only once during the study period, at Station 4 with a mean density and biomass of 6.96 ind.ha^{-1} and 0.23kg ha^{-1}, respectively.

3.5.1.1.6 Gerridae

The Gerridae shows a distinctive offshore presence particularly in the Angsa Bank (Figures 28a & b).

Only two species were identified under this family. *Gerres abbreviatus* was present in 8 of 13 stations (Table 11), with highest mean density and biomass of 4.85 ind.ha^{-1} and 0.08 kg ha^{-1} respectively. *Gerres filamentosus* was recorded in Stations 8 and 10 only, with maximum mean density and biomass of 1.24 ind.ha^{-1} and 0.03kg ha^{-1}, respectively. The latter probably prefers sandy substrates.

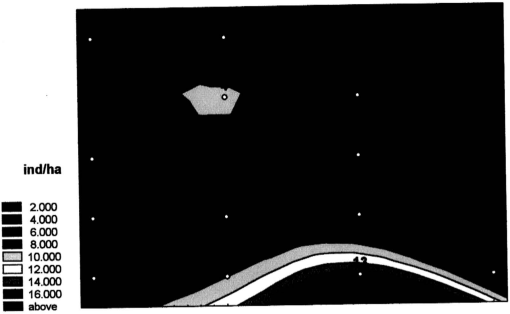


Fig.27a: Density distribution of Cynoglossidae species in Klang Strait

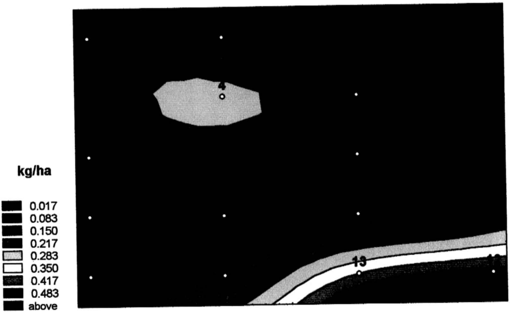


Fig.27b: Biomass distribution of Cynoglossidae species in Klang Strait

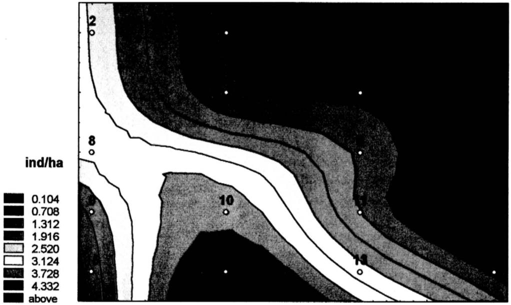


Fig.28a: Density distribution of Gerridae species in Klang Strait

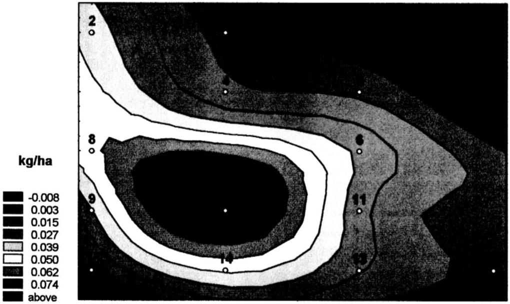


Fig.28b: Biomass distribution of Gerridae species in Klang Strait

3.5.1.1.7 Mullidae

Mullids of the Klang Strait were most abundant in the Angsa Bank, particularly off the mudflats to the north of Pulau Ketam, and in lesser abundance off the mudflat just north of the Buloh River estuary (Figures 29 a & b). Their numbers decreased rapidly in deep waters.

Two species were identified under this family. *Upeneus sulphereus* was recorded in all stations except Stations 1, 4 and 12, with highest mean density and biomass (9.16 ind.ha^{-1} and 0.08 kg ha^{-1}) at Station 14. *Upeneus tragula* was recorded only at Station 10 with mean density and biomass of 0.37 ind.ha^{-1} and 0.003kg ha^{-1} respectively. These mullids, particularly the latter, prefer more sandy substrates.

3.5.1.1.8 Platycephalidae

Platycephalidae or flatheads were abundant in coastal mudflats (Figure 30a), but their biomass were highest a few km south of the River Selangor's mouth as well as off the Kapar River's mouth in deeper waters (Figure 30b).

Platycephalus scaber and *Platycephalus indicus* were the two representative species. *P. scaber* was present in all stations with maximum mean density and biomass of 12.56 ind.ha^{-1} (at Station 5) and 0.07 kg ha^{-1} (at Station 12), respectively. This species was most abundant in shallow waters between the estuaries of River Selangor and River Buloh, apparently preferring turbid waters over clayey-silt substrates. *P. indicus* was recorded in all the stations except Stations 8 and 11, with highest mean

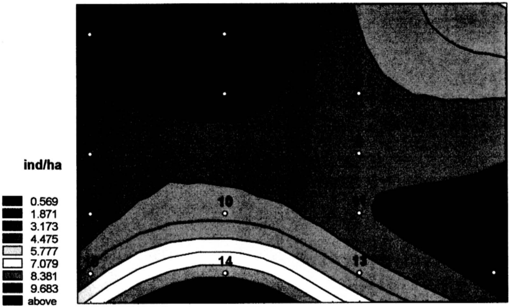


Fig.29a: Density distribution of Mullidae species in Klang Strait

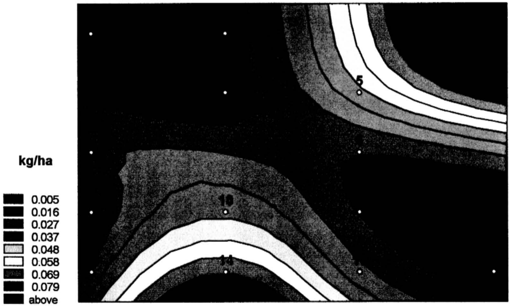


Fig.29b: Biomass distribution of Mullidae species in Klang Strait

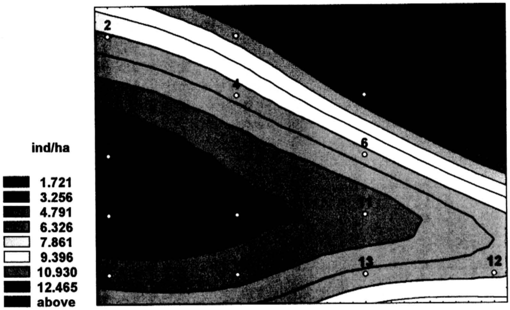


Fig.30a: Density distribution of Platycephalidae species in Klang Strait

Fig.30b: Biomass distribution of Platycephalidae species in Klang Starit

density and biomass of 5.7 ind.ha^{-1} (at Station 2) and 0.28 kg ha^{-1} (at Station 4), respectively.

3.5.1.1.9 Pomadasyidae

The distribution of Pomadasyidae or grunters in Klang Strait appears to be largely confined to offshore shallow waters in Angsa Bank (Figures 31a & b).

Two species of the Pomadasyidae were recorded. *Pomadasys maculatus* was caught from 8 out of 15 stations sampled (Table 11), with the highest mean density and biomass of 13.52 ind.ha^{-1} and 0.24 kg ha^{-1} , respectively (at station 10). This species appeared to prefer sandy bottoms in more saline (offshore) waters. *Pomadasys hasta* was recorded from only two stations: Stations 1 and 8, where the highest mean density and biomass were 0.99 ind.ha^{-1} and 0.07 kg ha^{-1}, respectively.

3.5.1.1.10 Siganidae

Siganids or rabbit fishes were very poor in Klang Strait, being observed off the mudflats between Sungai Buloh and Kuala Selangor; larger individuals were caught off Kampong Sungai Janggut (Figures 32a & b).

There were two species recorded in this family. *Siganus javus* was recorded only in Station 4 with mean density and biomass of 0.6 ind.ha^{-1} and 0.003 kg ha^{-1}

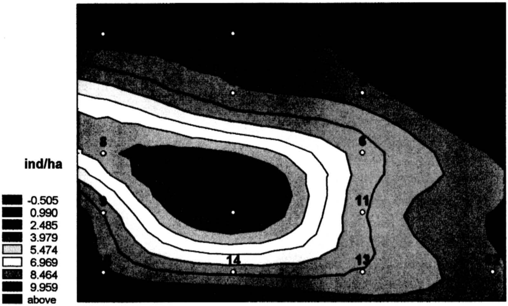


Fig.31a: Density distribution of Pomadasyidae species in Klang Strait

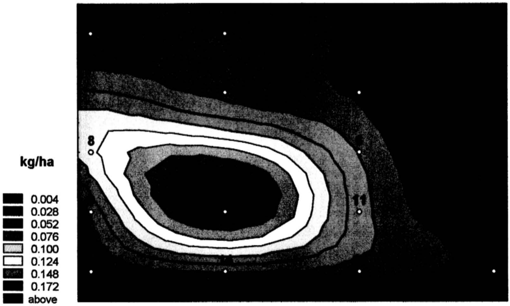


Fig.31b Biomass distribution of Pomadasyidae species in Klang Starit

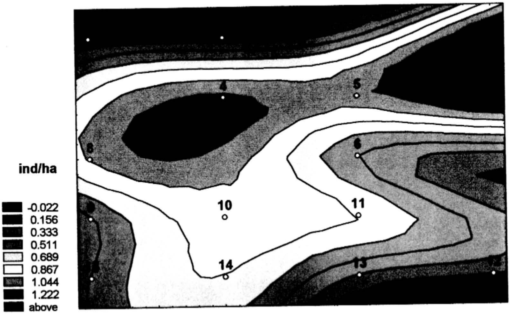


Fig.32a: Density distribution of Siganidae species in Klang Strait

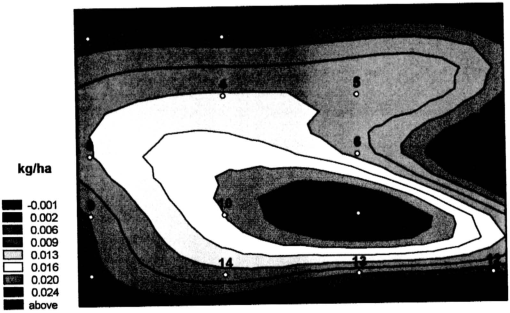


Fig.32b: Biomass distribution of Siganidae species in Klang Strait

respectively. *Siganus canaliculatus* was however recorded in more stations (8), with the highest mean density and biomass of 1.11 $ind.ha^{-1}$ (at Station 5) and 0.04 kg ha^{-1} (at station 11), respectively.

3.5.1.1.11 Ambassidae

Ambassids or glass perchlets were mainly caught over the mudflat north of Sungai Buloh to Kuala Selangor (Figure 33a). However, the larger individuals were observed in deeper waters off the mudflat (Figure 33b).

Only *Ambassis commersoni* species was recorded in all the stations except Stations 6 and 12. The highest mean density and biomass were 18.93 $ind.ha^{-1}$ (at Station 1) and 0.011kg ha^{-1} (at Station 4) respectively. The species prefers estuarine water.

3.5.1.1.12 Dorosomidae

Dorosomidae or gizzard shads were observed mainly off the River Buloh estuary and in Angsa Bank (west of Pulau Angsa) [Figure 34a], but larger individuals were caught at the River Selangor estuary (Figure 34b).

Anodontostoma chacunda was the only species recorded in most stations except Stations 2, 10, 12, 13 and 14, with maximum mean density and biomass of 2.73 $ind.ha^{-1}$ (at Stations 6) and 0.29 kg ha^{-1} (at station 1) respectively. The species shows preference for shallow water.

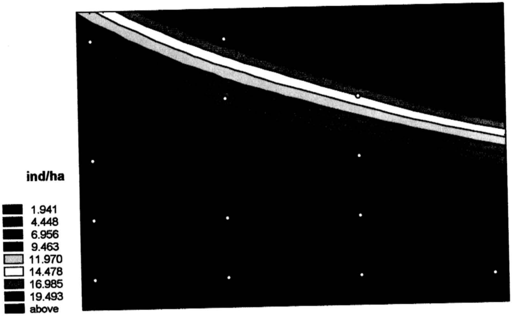


Fig.33a: Density distribution of Ambassidae species in Klang Strait

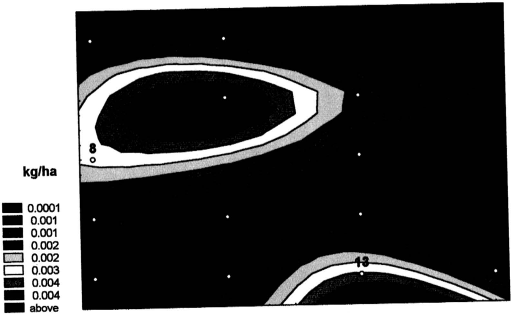


Fig.33b: Biomass distribution of Ambassidae species in Klang Strait

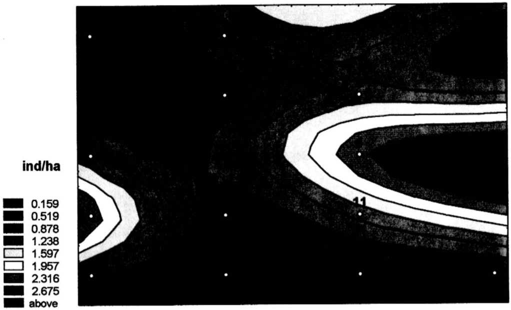


Fig.34a: Density distribution of Dorosomidae species in Klang Starit

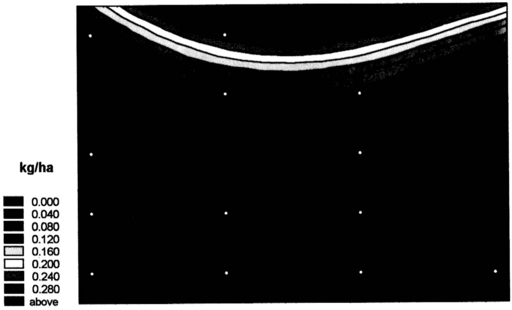


Fig.34b: Biomass distribution of Dorosmidae species in Klang Strait

3.5.1.1.13 Sillaginidae

Sillaginids or sillagos show the highest density in the Angsa Bank (Figure 35a), although large individuals were observed off the estuary of River Buloh in deeper waters (Figure 35b).

Only one species, *Sillago sihama,* was recorded in 8 out of the 13 stations (Table 11). The highest mean density and biomass were 9.39 ind.ha^{-1} (at Station 15) and 0.15 kg ha^{-1} (at Station 4) respectively. This species apparently preferred the more offshore stations, particularly over the Angsa Bank where bottom substrates were sandy.

3.5.1.1.14 Trichuridae

Trichuridae or ribbon fish were most abundant in coastal waters, particularly the southern waters, but their abundance were low in Angsa Bank (Figures 36a & b).

Trichiurus lepturus was the only species recorded under this family, and was found at all stations. The highest mean density and biomass were 15.54 ind.ha^{-1} (at Station 13) and 0.29 kg ha^{-1} (at station 12), respectively.

3.5.1.1.15 Teraponidae

The distribution of Teraponidae shows their highest numbers at the River Buloh estuary and off the mudflats north of Pulau Ketam and Pulau Klang (Figures 37a & b).

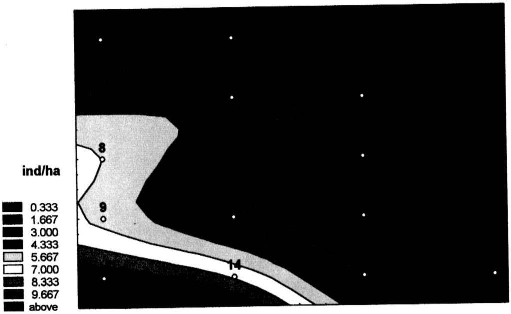


Fig.35a: Density distribution of Sillaginidae in Kalng Starit

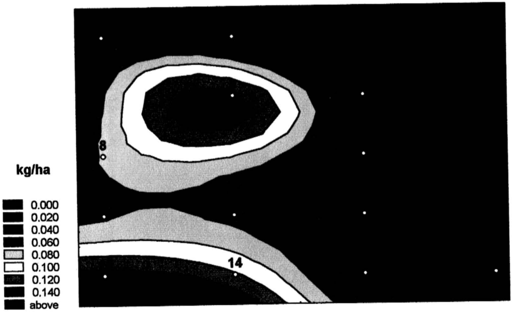


Fig.35b: Biomass distribution of Sillaginidae species in Klang Strait

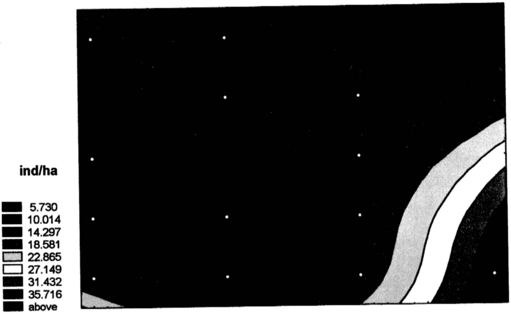


Fig.36: Density distribution of Trichuridae species in Klang Starit

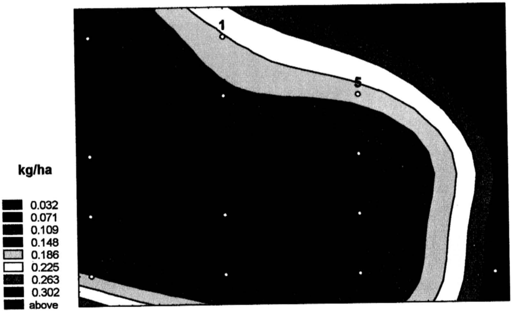


Fig.36b: Biomass distribution of Trichuridae species in Klang Strait

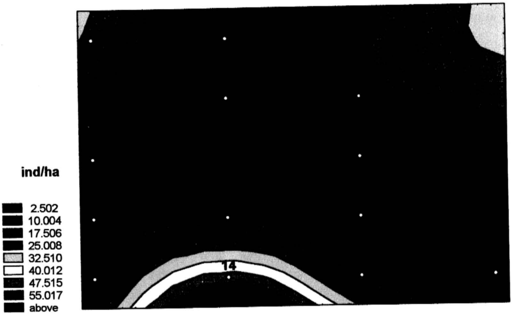


Fig.37a: Density distributin of Teraponidae species in Klang Strait

Fig.37b: Biomass distribution of Teraponidae species in Klang Strait

Terapon theraps and *T. jarbua* were the only two species observed. The former was present in all the stations, except Stations 1, 4 and 12, apparently preferring more sandy substrates and higher salinity. Its highest mean density and biomass were 54.43 ind.ha^{-1} (at Station 14) and 0.21kg ha^{-1} (at Station 13) respectively. On the other hand, *T. jarbua* may prefer substrates from fine silt to fine sand, with a greater tolerance of turbid estuarine water (Tables 10 & 11).

3.5.1.1.16 Trypauchenidae

Blind gobies of the Trypauchenidae were mainly observed in the River Selangor estuary and just off the mudflat to the north of the estuary (Figures 38 a & b).

One species, *Trypauchen vagina*, was recorded at about half the stations examined during the study period (Table 11). *T. vagina* had the highest mean density and biomass of 8.1 ind.ha^{-1} and 0.14 kg ha^{-1} (at Station 1), respectively. Its distribution indicates that the burrowing blind goby prefers substrates of soft mud or very fine sand.

3.5.1.2 Pelagic fish

Pelagic fish caught by the bottom trawl were those that frequented shallow waters or species that occassionally make feeding forays to the sea bottom. Pelagic fish species were particularly abundant in the estuaries of the Selangor River and Buloh River and their vicinities, and offshore at the southwestern margins of Angsa Bank (Figure 39 a & b). These were shallow water areas where the trawl net could sample at the sea bottom as well as the water column. Therefore, the low abundance of pelagic species

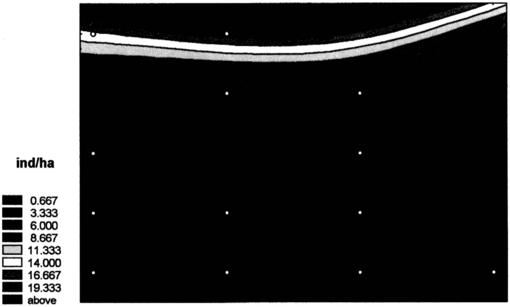


Fig.38a: Density distribution of Trypauchenidae species in Klang Strait

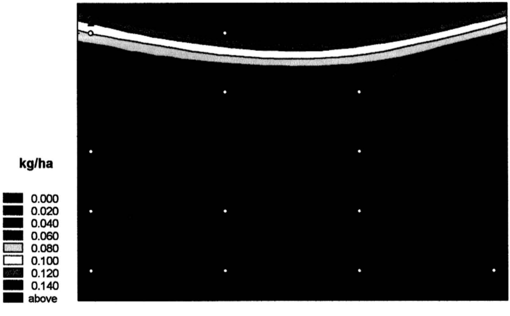


Fig.38b: Biomass distribution of Trypauchenidae species in Klang Strait

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Ariidae	*Arius caelatus*	2.226	0.188	0.247	2.474	0.675	0	0	0	9.286	3.479	9.81	0	0
	Arius maculatus	0	0	4.082	2.474	124.6	3.229	0.967	15.66	58.3	30.15	10.16	0	0
	Arius sagor	0	0	0	0	0	0	0	0	0	1.055	0	0	0
	Arius venosus	0	0	0	0.866	6.766	3.874	0	1.593	0.371	0	0	1.102	0.367
	Osteogeneiosus militaris	0	0.495	0.371	205.2	0.88	0	0	0.496	4.595	2.226	0	0	0
Bothidae	*Pseudorhombus malayanus*	0	0	0	0	0	0.495	0	0.866	0	0	0.703	0.596	0
Aluteridae	*Paramonacanthus choircephalus*	0	0	0	0	0	0.247	0	0	0	0	0	0	0
Apogonidae	*Apogon ellioti*	0	0	0.989	0	0	0	0.12	0	0	0	0	0	0
	Apogon quadrifasciatus	0	0	0	0	0	0.247	0.12	0	0	0	1.055	0	0
Ambassidae	*Ambassis commersoni*	18.93	5.37	5.355	14.75	0	0.126	0.124	0.371	0.124	0	0.919	3.092	1.102
Batracholdidae	*Batrachus grunniens*	0.247	0	2.048	0.989	0.378	1.508	0	2.939	0	0	0	0	0
Callionymidae	*Callionymus sagitta*	9.03	0	0.278	0.551	0.371	2.811	0	0	0	0	0	0.742	0
Carcharinidae	*Scoliodon sorrakowah*	0	0	0	0	0	0	0	0	0	5.728	0	0	0
Cynoglossidae	*Cynoglossus macrolepidotus*	0	0	6.959	0	0	0	0	0	0	0	0	0	0
	Cynoglossus lingua	5.01	4.235	2.314	4.362	1.406	3.367	3.695	2.944	2.669	2.296	16.9	6.42	4.295
Dorosomidae	*Anodontostoma chacunda*	0.858	0	0.247	0.786	2.732	0.646	2.85	0	0.937	0	0	0	0.469
Drepanidae	*Drepane longimana*	1.299	0	0	0	0	0	0	0.124	0.551	0	0.352	0.189	0.75
	Drepane punctata	0	0	0	0	0	0.62	0.131	0.247	0.495	0	0	0.596	0
Gerridae	*Gerres abbreviatus*	0	2.45	0	0	0.84	2.747	1.214	2.507	0	0	1.837	4.848	0.937
	Gerres filamentosus	0	0	0	0	0	0.247	0	1.237	0	0	0	0	0
Gobiidae	*Acentrogobius caninus*	0	0	0.487	0	0	0	0	0	0	0	0	0.596	0
	Aulopareia atripinnatus	0	0	0	0	0.937	0	0	0	0	0	0	0	0
	Aulopareia sp.	0	0	0	0	0	0.469	0	0	0	0	0	0	0
Eleotrididae	*Butis koilomatodon*	0	0	0	0	0	0	0.469	0.124	0	0	0	0	1.47
Bathydraconidae	*Parachaeturichthys polynema*	0	0	0.239	0	0	0	0	0	0	0	0	0	0
Harpadontidae	*Harpadon nehereus*	0.239	1.979	0.989	0	0.371	32.33	2.811	0	1.653	0	0	6.803	62.01
Kurtidae	*Kurtus indicus*	0	0.099	0	0	0	0	0	0	0	0	0	0	0
Labridae	*Halichoeres bicolor*	0	0	0	0	0	0	0	0.509	0	0	0	0	0
Lagocephalidae	*Gastrophysus lunaris*	1.422	0	0.487	5.438	10.62	38.18	21.19	31.42	3.19	0	2.813	10.74	2.119
	Torquigener oblongus	1.538	0	5.953	0	2.181	0	0	0	0.922	5.705	0.919	0	0.367

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Leiognathidae	*Leiognathus brevirostris*	170.6	114.8	2.543	184.6	16.34	0.744	7.718	5.64	27.88	0.586	1.758	1.287	0.282
	Leiognathus bindus	1.855	0	0	0	0	0	0.239	0	0	0	0	4.918	0.282
	Leiognathus daura	0.618	0	0	0	0	0.251	0	0	0	0	0	0	0
	Leiognathus elongatus	0	0	0	0	0	0	0	0.495	0	0	0	0	0
	Leiognathus equulus	0	0	0	0	0	0.247	0	0	0	0	0	0	0
	Gazza minute	0	0	0	0	0	0	0	0.247	0	0	0	0	0
	Secutor insidiator	94.87	45.35	20.08	43.61	27.41	25.55	13.17	167.4	10.88	77.86	86.1	13.13	27.67
Lutjanidae	*Lutjanus johni*	3.19	0	0	0	0	0	0	0	0	0	0	0	0
	Lutjanus russelli	0	0	3.001	1.113	0	0.247	0	1.019	0	0	0	1.192	0
Monacanthidae	*Stephanolepis auratus*	0	0	0	0	0	0	12.21	0	0	0	0.919	0	0.367
Mullidae	*Upeneus sulphureus*	0	0.188	0	1.448	1.855	1.912	0.509	1.848	0.247	0	1.973	9.158	3.674
	Upeneus tragula	0	0	0	0	0	0	0	0.371	0	0	0	0	0
Muraenesocidae	*Muraenesox cinereus*	0.796	0.807	0.84	0	0.255	0	0	0	0	0	0	0.72	0
Muraenidae	*Gymnothorax tile*	0	0	0	1.102	0	1.417	0.247	0.937	0	0	0	0.247	0.282
Nemipteridae	*Nemipterus hexodon*	0	0	0.278	0	0	0	0	0	0	0	0	0	0
Orectolobidae	*Chiloscyllium indicum*	0	1.17	0.84	0	0.124	0	0	1.713	0	0.586	3.244	0	0
Platycephalidae	*Platycephalus indicus*	3.278	5.711	1.763	0.124	1.398	0	0.469	1.406	0	3.75	2.11	1.698	2.119
	Platycephalus scaber	6.742	0.377	3.597	12.56	4.216	0.495	0.124	0.371	1.046	2.203	3.674	0.551	0.367
Platacidae	*Platax teira*	0.618	0	0	0	0	0.495	0	0	0	0	0	0	0
Plotosidae	*Plotosus anguillaris*	0.718	0	0	0	0	0	0	0	0	3.351	0	0	0
Pomadasyidae	*Pomadasys hasta*	0.618	0	0	0	0	0.989	0	0	0	0	0	0	0
	Pomadasys maculatus	0	0	0.247	0	3.858	7.916	0.239	13.52	0	0	2.325	1.92	1.228
Scatophagidae	*Scatophagus argus*	12.8	1.358	0.724	0.495	0	0	0.498	0	1.293	0	0	0.937	0
Sciaenidae	*Chrysochir aureus*	0	0	0	0	0	0	0	0	0	0	1.837	0	0
	Dendrophysa russelli	0.618	0.377	1.732	1.448	3.28	0	0	0	0	1.055	0	0	0
	Johnius belangerii	5.107	0	34.35	3.958	92.64	10.98	1.068	104.7	7.91	76.47	53.89	24.72	1.947
	Johnius carouna	0.742	6.117	0.247	0.551	20.95	0.937	3.748	30.92	79.42	3.49	42.6	0.798	24.61
	Johnius carutta	0	0	21.77	0	0.937	0	0.495	0	0	78.07	0	0	8.646
	Johnius dussumieri	6.124	1.653	0	159.8	0	0	0	0	0	0	0	0	0
	Johnieops vogleri	0	0	7.916	0	0	0	0	0	18.13	10.44	0	0	0

		1	2	3	4	5	6	7	8	9	10	11	12	13
Sciaenidae	*Johnieops weberi*	3.34	0.049	0	2.204	4.409	0	0	10.31	50.6	0	0	0	0.247
	Johnius trachycephalus	16.7	0	0	0	0	0	0	0	0	0	0	0	0
	Otolithes ruber	1.051	3.652	3.301	3.056	0.495	0	0	0.124	0.371	26.96	3.165	0	0.298
	Panna microdon	24.49	0.495	0	0	0.551	0	0	2.811	6.402	16.21	0	0	0
	Nibea soldado	0	4.96	0	0	0	0	0	0	0	0	0	0	0
	Pennahia macropthalmus	0.495	15.31	6.3	84.61	27.72	1.406	0.599	3.601	0.866	19.5	5.626	1.315	0.596
Scorpaenidae	*Polyculus uranoscopus*	0.618	0	0.239	1.046	0	0	0	0	0	0	0	0	0
	Vespicaula trachinoides	0	0	0	6.613	0	0	0	0	0	0	0	0	0
Siganidae	*Siganus javus*	0	0	0.6	0	0	0	0	0	0	0	0	0	0
	Siganus canaliculatus	0	0	0.6	1.113	0	0.989	0.12	0.757	0.937	0	0	0.785	0.367
Sillaginidae	*Sillago sihama*	0	0	3.618	0	0	6.195	4.426	1.871	0.371	0	1.27	7.419	9.392
Soleidae	*Solea ovata*	0	0	0.247	0	0	0	0	0	0	0	0	0	0
	Synaptura commersoniana	0	0	0	0	0	0	0.967	1.47	6.392	0	0	2.035	2.486
	Zebrias quagga	0	0	0.247	0	0	0	0	0	0	0	0	2.383	0
Psettodidae	*Psettodes erumei*	0	0	0	0	0	0	0	0.124	0	0	0	0	0
Sphyraenidae	*Sphyraena jello*	0	0	0	0	0.255	0	0	0	0	0	0	0	0
Synodontidae	*Saurida tumbil*	0	0	0	0.551	0.255	1.114	0.12	0.495	0	0	1.758	0	0.282
	Saurida undosquamis	0.239	0	0	0	0	0	0	0	0	0	0	0	0
Theraponidae	*Therapon jarbua*	2.466	5.993	0	2.204	0	0	0	0.247	1.102	0	0	0	25.72
	Therapon theraps	0	22.88	0	7.05	2.414	10.46	2.983	2.335	0.371	0	3.107	54.43	4.208
Trichiuridae	*Trichiurus lepturus*	14.9	14.86	17.37	11.37	12.44	4.441	1.593	2.599	14.84	35.61	15.54	8.022	14.65
Dasyatidae	*Dasyatis imbricatus*	0	0	0	0	0	0.247	0	0	0	0	0	0	0
	Dasyatis kuhlii	0	0	0	0	0	1.732	0	5.093	0	5.271	0	0	0
	Dasyatis uarnak	0	0	0.247	0	0	0	0	0	0	0	0	0	0
	Dasyatis zugei	0	0.188	0.6	0	2.08	0.247	0	0.62	4.367	8.626	7.542	0	1.102
Trypauchenidae	*Trypauchen vagina*	18.05	13.06	0	0.618	1.192	0	0	2.343	0.469	0	0	0	0.371
Triacanthidae	*Pseudotriacanthus strigilifer*	0	0	0	0.495	0	5.195	0	0	0	0	0	0	0
	Triacanthus brevirostris	0	0	0	2.35	0	0	0	1.528	0	0	0	0	0
	Triacanthus biaculeatus	0	0	0	0	0.551	0	0	0.496	0	0	0	0	0
Tetraodontidae	*Tetraodon nigroviridis*	0	0	0	0.618	0	0	0	0	0	0	0	0	0
	Total	434.4	278.2	172.3	782.6	390.3	191.3	103.2	448.5	339	444.7	309.9	201.4	235.1

		1	2	4	5	6	8	9	10	11	12	13	14	15
Ariidae	*Arius caelatus*	0.001	0.008	0.016	0.002	0.111	0	0	0	0.136	0.172	0.374	0	0
	Arius maculatus	0	0	0.12	0.02	3.316	0.165	0.018	1.952	1.611	2.281	1.064	0	0
	Arius sagor	0	0	0	0	0	0	0	0	0	1.681	0	0	0
	Arius venosus	0	0	0	0.108	0.067	0.176	0	0.152	0.01	0	0	0.066	0.01
	Osteogeneiosus militaris	0	0.006	0.003	0.681	0.062	0	0	0.007	0.018	0.155	0	0	0
Bothidae	*Pseudorhombus malayanus*	0	0	0	0	0	0.035	0	0.054	0	0	0.035	0.003	0
Aluteridae	*Paramonacanthus choircephalus*	0	0	0	0	0	0.003	0	0	0	0	0	0	0
Apogonidae	*Apogon ellioti*	0	0	0.002	0	0	0	4E-04	0	0	0	0	0	0
	Apogon quadrifasciatus	0	0	0	0	0	0.004	3E-04	0	0	0	0.004	0	0
Ambassidae	*Ambassis commersoni*	6E-04	3E-04	0.005	0.002	0	0.003	0	0	0	0	0	0.001	0
Batracholdidae	*Batrachus grunniens*	0.021	0.004	0	0	0	0	0.003	0.08	0	0	0.059	0.01	0
Callionymidae	*Callionymus sagitta*	0	0.008	0	8E-04	0	0	3E-07	9E-08	0.001	0	0	0.027	0.388
Carcharinidae	*Scoliodon sorrakowah*	0.247	0.007	0	0.003	0.085	0	0.088	0.051	0.002	0	0	0.215	0.08
Cynoglossidae	*Cynoglossus macrolepidotus*	0	0	0.233	0	0	0	0	0	0	0	0	0	0
	Cynoglossus lingua	0.028	0.059	0.073	0.078	7E-06	0.031	0.009	0.049	0.026	0.443	0.386	0.074	0.041
Dorosomidae	*Anodontostoma chacunda*	0.286	0	0.01	0.014	4E-07	0.033	0.008	0	0.003	0	0.068	0.008	0
Drepanidae	*Drepane longimana*	0.044	0.148	0	0.004	0	0	0	0	7E-04	0.019	0	0.063	0.01
	Drepane punctata	0	0	0.007	0	0	0.059	0	0.271	0	0	0	0	0
Gerridae	*Gerres abbreviatus*	0	0.033	0	0	1E-03	0.048	0.02	0.075	0	0	0.01	0.041	8E-07
	Gerres filamentosus	0	0	0	0	0	0.002	0	0.026	0	0	0	0	0
Gobiidae	*Acentrogobius caninus*	0	0	0.004	0	0	0	0	0	0	0	0	0.004	0
	Aulopareia atripinnatus	0	0	0	0	3E-07	0	0	0	0	0	0	0	0
	Aulopareia sp.	0	0	0	0	0	1E-07	0	0	0	0	0	0	0
Eleotrididae	*Butis koilomatodon*	0	0	0	0	0	0	9E-08	2E-04	0	0	0	0	0.005
Bathydraconidae	*Parachaeturichthys polynema*	0	0	0.002	0	0	0	0	0	0	0	0	0	0
Harpadontidae	*Harpadon nehereus*	0.002	0.075	0.001	0	0.004	1E-05	6E-06	0	0.028	0	0	0.01	0.417
Kurtidae	*Kurtus indicus*	0	0.002	0	0	0	0	0	0	0	0	0	0	0
Labridae	*Halichoeres bicolor*	0	0	0	0	0	0	0	0.002	0	0	0	0	0
Lagocephalidae	*Gastrophysus lunaris*	0.044	0	0.014	0.115	0.207	0.974	0.425	1.629	0.021	0	0.028	0.184	0.018
	Torquigener oblongus	0.423	0	0.818	0	0.214	0	0	0	0.016	0.895	0.169	0	0.003

Family	Species	1	2	4	5	6	8	9	10	11	12	13	14	15
Leiognathidae	*Leiognathus brevirostris*	0.756	0.528	0.005	36.76	0.095	0.003	0.047	0.012	0.099	5E-07	0.004	0.004	0.001
	Leiognathus bindus	0.088	0	0	0	0	0	8E-04	0	0	0	0	0.004	2E-04
	Leiognathus daura	0.028	0	0	0	0	0.001	0	0	0	0	0	0	0
	Leiognathus elongatus	0	0	0	0	0	0	0	6E-04	0	0	0	0	0
	Leiognathus equulus	0	0	0	0	0	0.004	0	0	0	0	0	0	0
	Gazza minute	0	0	0	0	0	0	0	5E-04	0	0	0	0	0
	Secutor insidiator	0.428	0.069	0.08	0.275	0.109	0.059	0.065	0.374	0.062	0.007	0.155	0.031	0.067
Lutjanidae	*Lutjanus johni*	0	0	0.06	0.031	0	0.003	0	0.346	0	0	0	0.022	0
	Lutjanus russelli	0	0	0	0	0	0	0.085	0	0	0	0.004	0	0.001
Monacanthidae	*Stephanolepis auratus*	0.05	0.083	0.004	0.063	0.12	0	0.14	2E-06	0.196	4E-05	0	0	0
Mullidae	*Upeneus sulphureus*	0	4E-04	0	0.037	0.003	0.016	0.001	0.032	7E-04	0	0.009	0.079	0.018
	Upeneus tragula	0	0	0	0	0	0	0	0.003	0	0	0	0	0
Muraenesocidae	*Muraenesox cinereus*	0.003	0.029	0.146	0	0.024	0	0	0	0	0	0	0	0
Muraenidae	*Gymnothorax tile*	0	0	0	0.007	0	0.116	0.036	1E-05	0	0	0	0.047	0
Nemipteridae	*Nemipterus hexodon*	0	0	0.003	0	0	0	0	0	0	0	0	0.016	0.003
Orectolobidae	*Chiloscyllium indicum*	0	0.074	0.176	0	0.027	0	0	0.456	0	1E-05	0.944	0	0
Platycephalidae	*Platycephalus indicus*	0.163	0.046	0.279	0.002	0.015	0	6E-07	1E-05	0	0.211	0.065	0.018	0.004
	Platycephalus scaber	0.166	0.003	0.122	0.298	0.19	0.018	0.006	0.026	0.012	0.275	0.168	0.002	0.003
Platacidae	*Platax teira*	0	0	0	0	0.003	0	0	0.257	0	0.048	0	0	0
Plotosidae	*Plotosus anguillaris*	0	0.02	0.004	0.07	0.033	0	5E-07	0	0	0	0.067	0.009	3E-06
Pomadasyidae	*Pomadasys hasta*	0.021	0	0	0	0	0.068	0	0	0	0	0	0	0
	Pomadasys maculatus	0	0	0.003	0	0.024	0.037	0.002	0.242	0	0	0.008	0.014	0.002
Scatophagidae	*Scatophagus argus*	0.938	0.06	0.053	0.017	0	0	0.031	0	0.036	0	0	3E-06	0
Sciaenidae	*Chrysochir aureus*	0	0	0	0	0	0	0	0	0	0	0.469	0	0
	Dendrophysa russelli	0.011	0.007	0.045	0.052	5E-06	0	0	0	0	0.09	0	0	0
	Johnius belangerii	0.068	0	0.644	0.085	0.077	0.11	0.003	3.078	0.294	2.24	1.46	0.758	0.009
	Johnius carouna	0.006	0.026	0.013	0.014	0.067	6E-07	9E-06	5E-06	1.683	0.137	1.423	0.023	0.393
	Johnius carutta	0	0	0.183	0	5E-06	0	0.011	0	0	1.096	0	0	0.047
	Johnius dussumieri	0.006	0.006	0	0.646	0	0	0	0	0	0	0	0	0
	Johnieops vogleri	0	0	0.075	0	0	0	0	0	0.058	0.18	0	0	0

		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	0	0	0	0.007
	Johnius trachycephalus	0.018	0	0	0	0	0	0	0	0	0	0	0	0
	Otolithes ruber	0.03	0.025	0.257	0.066	0.061	0	0	0.013	0.011	3.102	0.279	0	0.015
	Panna microdon	0.003	0.055	0.175	0.349	0.177	3E-07	2E-04	0.041	0.014	0.246	0.074	0.006	0.002
	Nibea soldado	0	0	0	0.033	0	0	0	0	0	0	0	0	0
	Pennahia macropthalmus	0.028	0	0	0	0	0.059	0	0	0.223	0.246	0	0	3E-06
Scorpaenidae	*Polyculus uranoscopus*	0.012	0	0.003	0.017	0	0	0	0	0	0	0	0	0
	Vespicaula trachinoides	0	0	0	0.027	0	0	0	0	0	0	0	0	0
Siganidae	*Siganus javus*	0	0	0.003	0	0	0	0	0	0	0	0	0	0
	Siganus canaliculatus	0	0	0.007	0.011	0	0.01	5E-05	0.015	0.039	0	0	0.009	0.001
Sillaginidae	*Sillago sihama*	0	0	0.145	0	0	0.067	0.043	0.05	0.017	0	0.012	0.11	0.132
Soleidae	*Solea ovata*	0	0	0.006	0	0	0	0	0	0	0	0	0	0
	Synaptura commersoniana	0	0	0	0	0	0	0.046	0.102	0.303	0	0	0.098	0.129
	Zebrias quagga	0.075	0.039	0.147	0.024	0	0.04	0.095	0.029	0.024	0.616	0.569	0.735	0.448
Psettodidae	*Psettodes erumei*	0	0	0	0.02	0	0	0.049	5E-06	0	0.168	0	0	2E-05
Sphyraenidae	*Sphyraena jello*	0.093	0	0	0	0	0	0	0	0	0	0.133	1E-06	0
Synodontidae	*Saurida tumbil*	0	0	0	6E-04	2E-04	0.036	0.005	0.025	0	0	0.052	0	0.002
	Saurida undosquamis	6E-04	0	0	0	0	0	0	0	0	0	0	0	0
Theraponidae	*Therapon jarbua*	0.01	0.027	0	0.018	0	0	0	0.01	0.004	0	0	0	0.071
	Therapon theraps	0	0.077	0	0.06	0.033	0.083	0.011	0.051	5E-04	0	0.209	0.09	0.014
Trichiuridae	*Trichiurus lepturus*	0.182	0.044	0.149	0.171	0.056	0.023	0.01	0.002	0.065	0.288	0.062	0.085	0.151
Dasyatidae	*Dasyatis imbricatus*	0	0	0	0	0	0.083	0	0	0	0	0	0	0
	Dasyatis kuhlii	0	0	0	0	0	0.33	0	1.782	0	8E-05	0	0	0
	Dasyatis uarnak	0	0	0.154	0	0	0	0	0	0	0	0	0	0
Trypauchenidae	*Dasyatis zugei*	0	0.052	0.153	0	0.085	0.064	0	0.411	0.346	1.498	1.156	0	0.034
Triacanthidae	*Trypauchen vagina*	0.141	0.077	0	0.011	9E-04	0	0	3E-06	1E-06	0	0	0	8E-04
	Pseudotriacanthus strigilifer	0	0	0	0.005	0	0.14	0	0	0	0	0	0	0
	Triacanthus brevirostris	0	0	0	0.016	0	0	0	0.152	0	0	0	0	0
Tetraodontidae	*Triacanthus biaculeatus*	0	0	0	0	9E-04	0	0	0.06	0	0	0	0	0
90	*Tetraodon nigroviridis*	0	0	0	0.141	0	0	0	0	0	0	0	0	0
	Total	6.5607	5.7031	12.4	50.391	17.398	18.903	19.259	31.921	27.359	40.095	35.517	30.869	32.526

Table 12: The common families of demersal and pelagic fish according to their abundance

Common families of demersal fish	Common families of pelagic fish
1. Sciaenidae	1. Engroulididae
2. Liognathidae	2. Clupeidae
3. Ariidae	3. Stromatidae
4. Trichiuridae	4. Carangidae
5. Teraponidae	5. Polynemidae
6. Sillaginidae	
7. Cynoglossidae	
8. Platycephalidae	
9. Ambassidae	
10. Trypauchenidae	
11. Dasyatidae	
12. Pomadasyatidae	
13. Mullidae	
14. Gerridae	
15. Dorosomidae	
16. Siganidae	

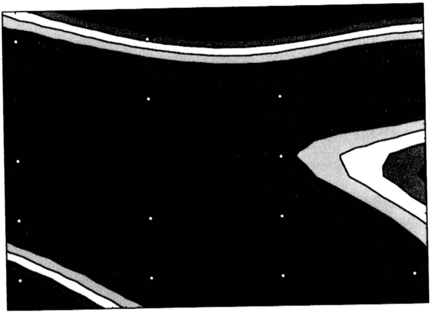


Fig.39a: Density distribution of pelagic fish species in Klang Strait

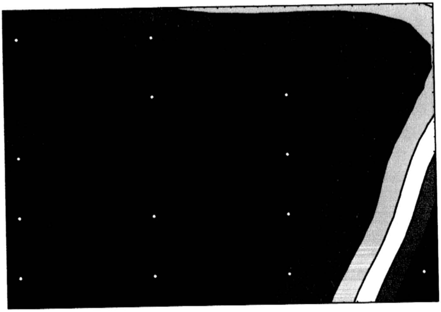


Fig.39b: Biomass distribution of pelagic fish species in Klang Strait

as observed in the deeper region of the strait could be due mainly, to lower fish captures by the bottom trawl.

A total of 7,059 specimens of pelagic fish were examined. Twenty-nine species belonging to 10 families were recorded. The most abundant fish were Carangidae, Engraulididae, Clupeidae, Stromatidae and Polynemidae. The distribution of pelagic fish species at each station during the study period is shown in Appendix 8.
In general the mean density values of pelagic fish ranged from 29.4 numbers (no.) ha^{-1} (Station 15) to 495.5 no. ha^{-1} (Station 4) (Table 8). Relatively high fish densities of fish were located at the mouths of River Selangor (Station1), River Buloh (Station 6) and River Kapar (Station 12) [Table 6]. The maximum of the mean biomass values of the pelagic fish (4.42 kg ha^{-1}) was recorded at Station 12, located near shore close to the mangroves. The minimum value of 0.54 kg ha^{-1} was obtained at Station 4, located 3-5 km off the mouth of the River Selangor (Table 9).

The most important families of pelagic fish species in order of importance by density were Engroulididae, Clupeidae, Stromatidae, Carangidae and Polynemidae.

The distribution and abundance of the most common families are described as follows:

3.5.1.2.1 Carangidae

Carangid fish as sampled by the trawl net were most abundant over the shallow mudflats, particularly off the estuaries at Kuala Selangor and Sg. Buloh, but fish density decreased rapidly offshore in the deepest parts of the strait (Figure 40a). The biomass contours in Figure 40a however show larger concentrations in the estuary of River Selangor and in Angsa Bank, the latter indicative of larger individuals or species (Figure 40 b).

Seven species belonging to 6 genera were recorded from the family Carangidae. *Alepes djeddaba* was the most frequently occurring species, being recorded at all stations except Station 13. Three common carangids, viz. *A. djedabba*, *S. commersianianus* and *C. malabaricus*, characterised Stations 1, 4, 2 and 5 which were grouped together by cluster analysis (Figures 41a & 41b). These 4 stations were also characterised by turbid water and clayey silt substrates (Table 10). *A. indicus* and *A. atropus* may prefer well-oxygenated water over sandy substrates.

A. djeddaba had the highest mean density (35.5 no.ha^{-1}) and biomass (0.01 kg ha^{-1}) at Station 1 (Tables 13 and 14). *Scomberoides commersonianus*, *Atropus atropus* and *Carangoides malabaricus* occurred with mean density (biomass) of 1.91 no.ha^{-1}, (0.33 kg ha^{-1}), 0.73 no.ha^{-1} (0.02 kg ha^{-1}) and 5.62 no.ha^{-1} (0.39 kg ha^{-1}), respectively. *Megalaspis cordyla* and *Alectis indicus* were recorded in only three stations, with maximum mean density (biomass) of 3.31 no.ha^{-1}(0.05 kg ha^{-1}) and 0.94 no.ha^{-1}(0.072kg ha^{-1}), respectively. *Carangoides armatus* was recorded at Station 8 only, with mean density and biomass of 0.99 ind.ha^{-1} and 0.002 kg ha^{-1} respectively (Tables 13 and 14, Figure 41).

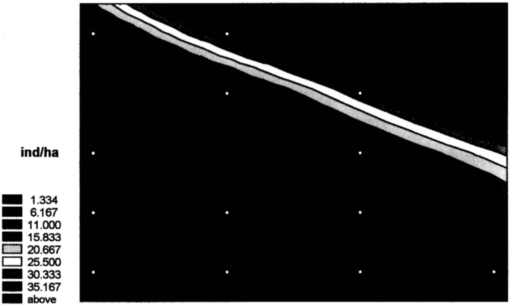


Fig.40a: Density distribution of Carangidae species in Klang Strait

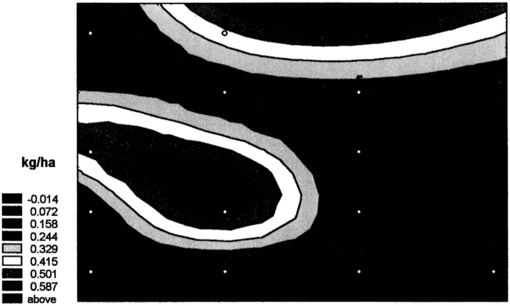


Fig.40b: Biomass distribution of Carangidae species in Klang Strait

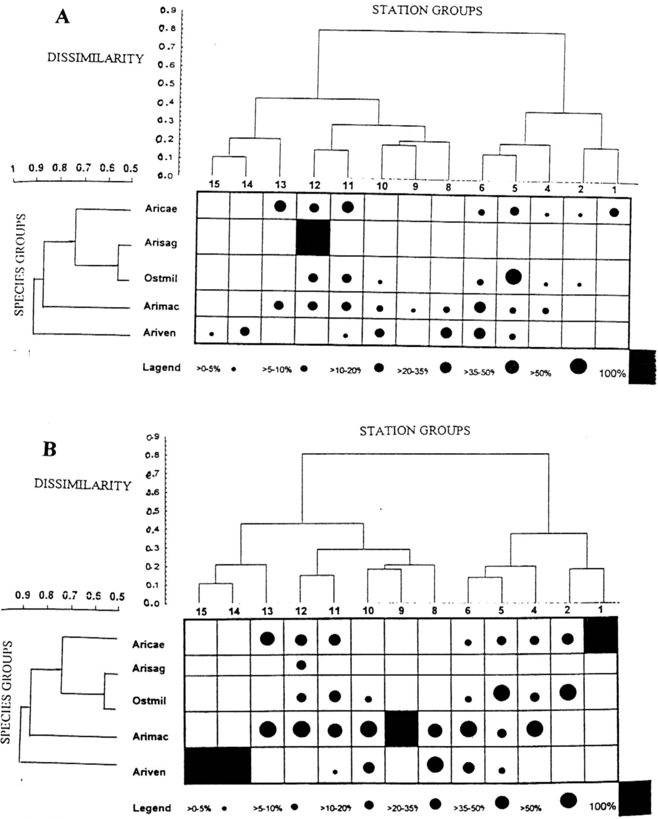


Fig. 41: Summary of the cluster analysis results for the Carangidae species in Klang Strait., with emphasis on the distribution of the Carangidae species among the stations group. (A) The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. (B) symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

3.5.1.2.2 Engraulididae

Engraulididae or anchovy distribution in the Klang Strait shows highest densities in and near the major river mouths of the Selangor River and Buloh River (Figure 42 a & b). Anchovy populations also occurred in shallow waters west of Angsa Island

A total of 6 species belonging to 4 genera was recorded in Klang Strait. These genera were *Coilia, Setipinna, Stolephorus and Thryssa.* *Stolephorus baganensis* and *Setipinna taty* were the most frequently encountered species, being recorded at all the stations. Cluster analysis shows no clear pattern in the distribution of the anchovies. All species show a wide distribution from nearshore to offshore waters (Figure 43). Their distribution however indicates at least 4 species were found together in or near estuaries, for instance, at Stations 1, 5, 6, 11 and 12. *Thryssa dussumieri* was caught only at Station 2 which was a nearshore shallow station, characterised by high turbidity; however, this species was not an abundant species (Figure 43).

Stolephorus baganensis and *Setipinna taty* had mean density (biomass) of 227.7 ind.ha^{-1} (0.03 kg ha^{-1}, at Station 8) and 162.5 ind.ha^{-1} (0.002 kg ha^{-1}, at Station 1) respectively. *Thryssa hamiltonii, Coilia dussumieri, Thryssa kammalensis* and *Thryssa dussumieri* had mean density (biomass) of 77.9 ind.ha^{-1} (1.59 kg ha^{-1}), 33.8 ind.ha^{-1} (0.11 kg ha^{-1}), 31.2 ind.ha^{-1} (0.59 kg ha^{-1}) and 0.84 ind.ha^{-1} (0.21 kg ha^{-1}), respectively.

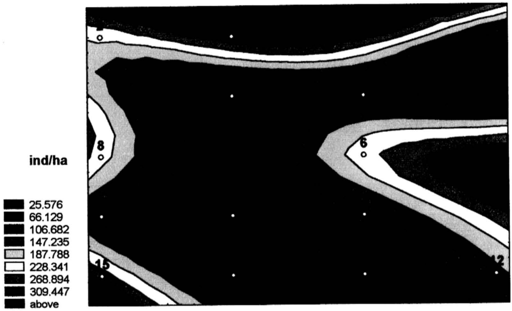


Fig.42a: Density distribution of Engraulididae species in Klang Strait

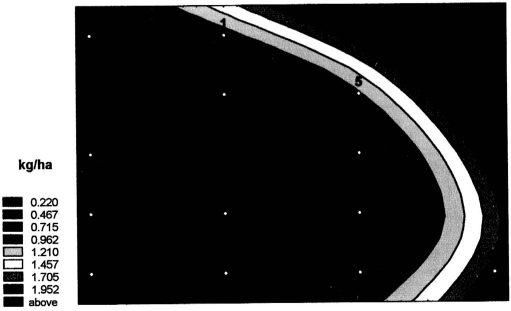
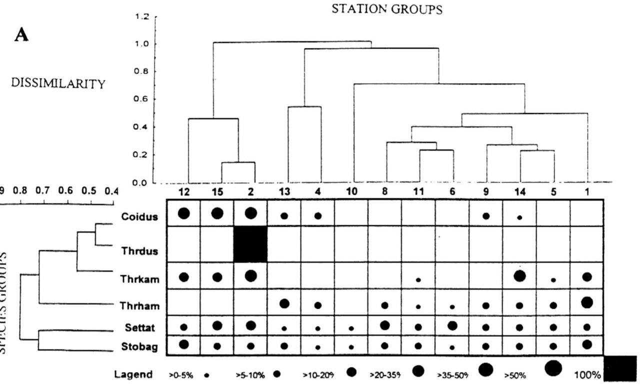


Fig.42b: Biomass distribution of Engrulididae species in Klang Strait

A



B

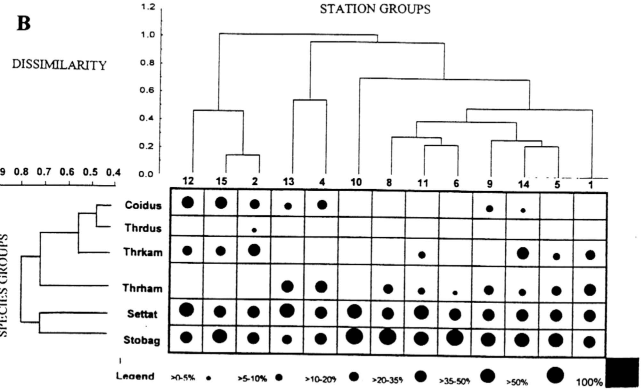


Fig. 43: Summary of the cluster analysis results for the Engraulididae species in Klang Strait., with emphasis on the distribution of the Engraulididae species among the stations group. (A) The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. (B) symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

5.1.2.3 Clupeidae

upeid distribution contours indicate highest densities in shallow waters, near the ore and particularly southwest of Pulau Angsa in the Angsa Bank (Figure 44 a). eir densities decreased towards deep waters although the reason for this could be cause they were not caught by the trawl gear which essentially is a demersal fishing ar. Biomass was highest off the Kapar power station and north of Pulau Klang and lau Ketam.

ere were five species belonging to five different genera. *Ilisha elongata* had an nost ubiquitous distribution, while *Hilsa toli* was generally distributed in shallow ters (Figure 45). *Herklotsichthys punctatus* appeared to prefer more saline water, ce they were not common in or near estuaries. On the other hand, *Escualosa racata* apparently preferred the shallow nearshore, less saline and turbid waters er muddy substrates; it occurred in Stations 4 and 5 only. *Sardinella frimbriata* s found in near shore to offshore waters of Angsa Bank.

order of magnitude, the mean density (biomass) of *Herklotsichthys punctatus, sha elongata*, and *Hilsa toli* were 118.3 ind.ha^{-1} (0.003 kg ha^{-1}), 60.3 ind. ha^{-1} (0.66 ha^{-1}) and 39.3 ind. ha^{-1} (0.42 kg ha^{-1}), respectively (Figure 45, Tables 13 and 14). *dinella fimbriata* had the highest mean density of 2.5 ind.ha^{-1} and biomass of 1kg ha^{-1}. *Escualosa thoracata* had a maximum mean density of 1.24 ind.ha^{-1} and omass 0.04kg ha^{-1}.

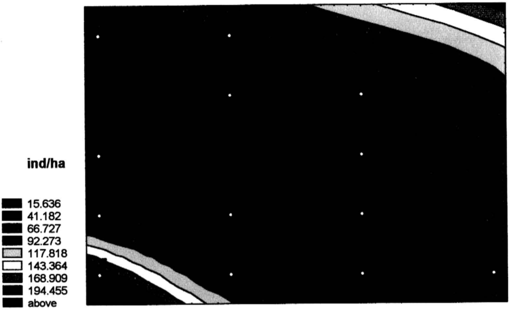


Fig.44a: Density distribution of Clupeidae species in Klang Strait

Fig.44b: Biomass disrtibution of Clupeidae species in Klang Strait

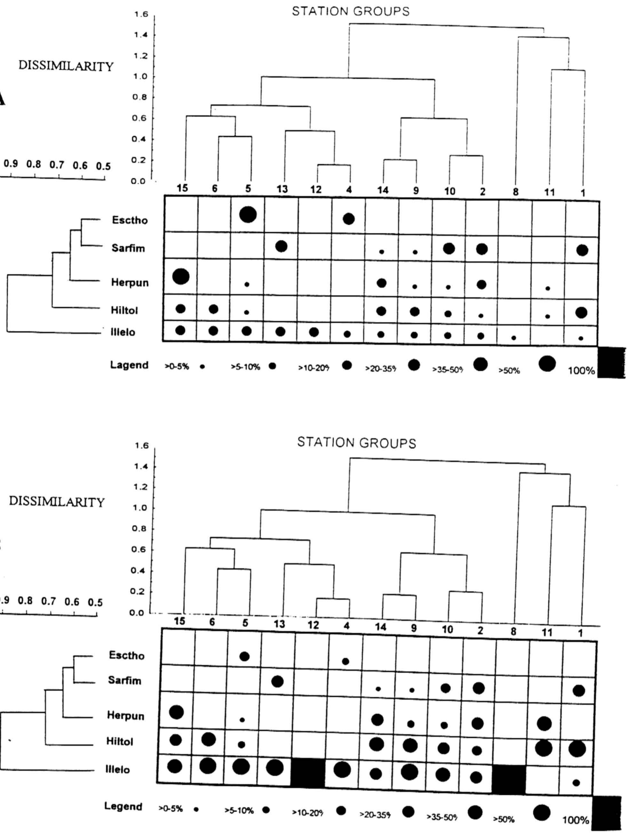


Fig. 45: Summary of the cluster analysis results for the Clupeidae species in Klang Strait., with emphasis on the distribution of the Clupeidae species among the stations group. (A) The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. (B) symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

3.5.1.2.4 Stromatidae

Stromatids or pomfrets were captured mainly in the southern waters, north of the deltaic islands of Pulau Ketam and Pulau Kelang (Figure 46a). Larger individuals which contributed to the higher biomass was observed in the vicinity of Angsa Bank (Fig. 46 b).

The three species recorded belonged to two genera, *Pampus* and *Parastromateus*. *Pampus argentus* was recorded at all stations except Station 6, with the highest mean density of 32.41 ind.ha^{-1} and biomass of 0.004 kg ha^{-1}. This species was abundant at Stations 12, 13, 14 and 15 at the southern Klang Strait, which were characterised by well-oxygenated, higher salinity water over sandy substrates. *Pampus chinensis* was recorded in 5 stations, which were characterised by less turbid water over generally sandy substrates. Its maximum mean density was 2.32 ind.ha^{-1} with a biomass of 0.07 kg.ha^{-1}. *Parastromatens niger* was recorded only in Stations 1, 13 and 14, with maximum mean density of 1.24 ind.ha^{-1} and biomass of 0.01 kg ha^{-1}.

3.5.1.2.5 Polynemidae

Most polynemids or threadfins were captured outside but in the vicinity of the estuary of River Selangor and River Buloh (Figures 47 a & b).

There were 3 recorded species belonging to two genera, *Eleutheronema* and *Polynemus*. *Polynemus sextarius* was present in 8 of the 13 stations, with highest mean density of 4.52 ind.ha^{-1} and biomass of 0.32 kg ha^{-1}. Their distribution from

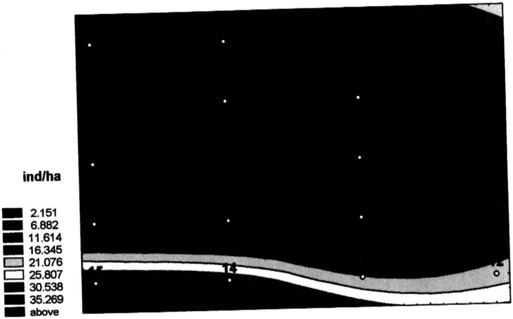


Fig.46a: Density distribution of Stromatidae species in Klang Strait

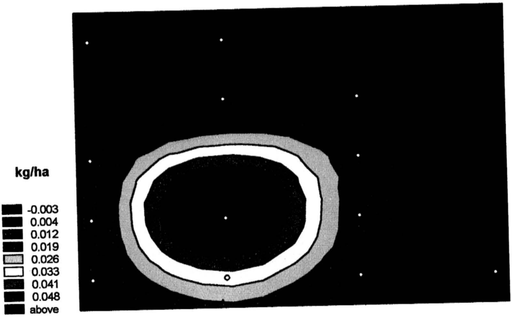


Fig.46b: Biomass distribution of Stromatidae species in Klang Strait

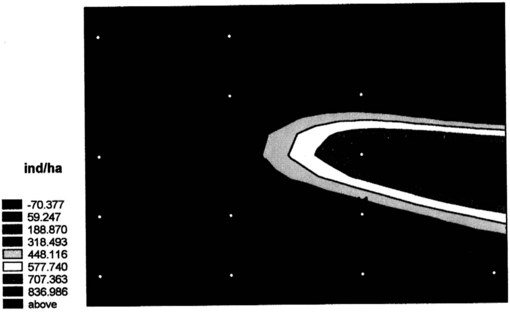


Fig.47b: Density distribution of Polynemidae species in Klang Strait

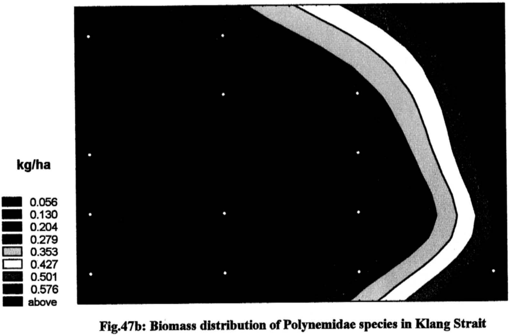


Fig.47b: Biomass distribution of Polynemidae species in Klang Strait

[illegible]	[illegible]	0	0	0	0.124	0	0	0.131	0	0	0	0	0.937	0
	Atropus atropus	0	0	0	0	0	0.367	0.838	0.992	0.937	0	0	2.129	5.622
	Alepes djeddaba	35.51	1.802	0.479	13.69	0.255	2.583	0.12	2.488	0.469	4.65	0	1.784	0.735
	Carangoides armatus	0	0	0	0	0	0.989	0	0	0	0	0	0	0
	Carangoides malabaricus	0.239	0.188	0.734	0.415	0	0.716	0	0	0	0	0	0.378	0
	Scomberoides commersonianus	1.237	0.807	0.239	0.415	0	1.912	0.359	0.496	0	0	0	0	0.469
	Megalaspis cordyla	0	0.049	0	0	3.307	0	0	0.495	0	0	0	0	0
Chirocentridae	*Chirocentrus dorab*	0	0	0	0	0	1.937	0.124	0	0	1.16	0	1.406	0.367
Clupeidae	*Escualosa thoracata*	0	0	0.247	1.237	0	0	0	0	0	0	0	0	0
	Illisha elongata	0.618	4.619	16.11	32.48	27.66	3.229	20.27	22.62	0	40.01	39.46	6.461	60.27
	Sardinella fimbriata	1.915	2.474	0	0	0	0	0.124	2.226	0	0	1.622	0.189	0
	Herklotsichthys punctatus	0	2.845	0	0.124	0	0	0.469	0.469	0.495	0	0	3.783	118.3
	Hilsa toli	39.33	0.942	0	0.551	10.84	0	9.081	5.144	0.922	0	0	30.86	15.06
Engraulididae	*Coilia dussumieri*	0	9.029	0.848	0	0	0	0.937	0	0	33.83	0.919	0.495	15.46
	Setipinna taty	162.5	26.9	3.579	14.35	5.416	7.496	11.14	3.201	19.3	78.75	29.54	7.308	25.91
	Stolephorus baganensis	76.14	117.3	2.172	39.77	277	227.7	33.88	4.669	40.18	17.27	1.837	34.73	215.9
	Thryssa dussumieri	0	0.841	0	0	0	0	0	0	0	0	0	0	0
	Thryssa hamiltonii	77.92	0	2.048	2.597	0.469	2.583	2.05	0	0.742	0	13.01	1.064	0
	Thryssa kammalensis	7.421	31.17	0	0.551	0	0	0	0	0.495	2.916	0	9.771	3.071
Ephippidae	*Ephippus orbis*	0	0	0.247	0	0	1.883	0	5.905	0	0	0	0	0
Mugilidae	*Valamugil cunnesius*	1.716	2.609	0.124	1.863	2.736	0	3.263	0.469	4.472	7.613	0	0	0
Polynemidae	*Eleutheronema tetradactylus*	0	0	0	0	0	0	0	0	0	1.148	0	0	0
	Polynemus indicus	0	0	0	0	0.124	0	0	0.735	0	1.148	0	0	0
	Polynemus sextarius	0	4.517	0.124	4.329	0.922	0	1.406	0	0	0	1.837	0.596	0.469
Scombridae	*Rastrelliger kanagurta*	0	0	0	0.989	0	0	0	0	0	0	0	0	0
Scomberomoridae	*Indocyblum guttatus*	3.351	0	0	0	0	0.646	0	0	0.551	2.296	0	0	0.469
Stromateidae	*Pampus argenteus*	1.732	1.604	2.481	0.618	0	0.646	2.35	0.735	4.498	16.18	13.27	31	32.41
	Pampus chinensis	0	0	0	0.618	0	0	0.495	0.469	0	2.319	0	0	0.937
	Parastromateus niger	1.237	0	0	0	0	0	0	0	0	0	0.919	0.469	0
	Total	410.8	207.7	29.43	114.7	328.7	252.7	87.04	51.11	73.06	209.3	102.4	133.4	495.5

Family	Species	1	2	4	5	6	8	9	10	11	12	13	14	15
Carangidae	*Alectis indicus*	0.0715	0.016	0.022	0.055	0	6E-04	3E-04	0.001	1E-04	0	0.001	0.02	0.001
	Atropus atropus	0.006	0	0.093	0.082	0.024	0.392	0	0.613	0	0	0	0	0
	Alepes djeddaba	0.0103	0	6E-04	9E-04	9E-04	7E-07	0	0	0	0	0	9E-04	0
	Carangoides armatus	0	0	0	0.002	0	0	0.004	0	0	0	0	3E-06	0
	Carangoides malabaricus	0	0	0	0	0	0.015	0.005	0.019	0.003	0	0	0.016	2E-06
	Scomberoides commersonianus	0.3254	0.004	0.016	0.062	2E-04	0.047	3E-04	0.056	0.001	0.102	0	3E-04	0.011
	Megalaspis cordyla	0	0	0	0	0	0.05	0	0	0	0	0	0	0
Chirocentridae	*Chirocentrus dorab*	0.0487	0.014	0.007	0.006	0	0.118	0.011	0.038	0	0	0	0	2E-06
Clupeidae	*Escualosa thoracata*	0	0.002	0	0	0.044	0	0	0.009	0	0	0	0	0
	Illisha elongata	0.0133	0.023	0.286	0.246	0.153	0.082	0.082	0.123	0	0.662	0.312	0.057	0.1
	Sardinella fimbriata	0.2597	0.11	0	0	0	0	0.015	0	0	0.151	0	8E-06	0.023
	Herklotsichthys punctatus	0	0	0.003	0.002	0	0	0	0	0	0	0	0	0
	Hilsa toli	0.0106	0.019	0.234	0.232	0.122	0.066	0.066	0.099	0	0.419	0.416	0.045	0.08
Engraulididae	*Coilia dussumieri*	0.0239	0	0.004	0.01	0.049	0.032	0.107	0	0.014	0	0	0	2E-06
	Setipinna taty	0.0015	0	0	0	0	0	0	0.011	6E-04	0	8E-04	5E-04	4E-04
	Stolephorus baganensis	0	0	0	0	0	0.026	0.002	0.013	0.001	0	0	0.003	0
	Thryssa dussumieri	0	0.022	0.006	0	0	0	3E-07	0	0	0.209	0.005	0.002	0.063
	Thryssa hamiltonii	0.6078	0.061	0.044	0.022	0.01	2E-05	8E-04	0.002	0.046	1.587	0.535	0.079	0.105
	Thryssa kammalensis	0.2238	0.174	0.011	0.061	0.264	0.585	0.183	0.019	0.046	0.034	0.018	0.095	0.203
Ephippidae	*Ephippus orbis*	0	0.059	0	0	0	0	0	0	0	0	0	0	0
Mugilidae	*Valamugil cunnesius*	0.0071	0.038	0.005	0.079	0.15	0	0.176	0.026	0.245	0.365	0	0	0
Polynemidae	*Eleutheronema tetradactylus*	0	0	0	0	0	0	0	0	0	0.076	0	0	0
	Polynemus indicus	0	0	0	0	0.034	0	0	0.321	0	0.048	0	0	0
	Polynemus sextarius	0	0.012	0.005	0.032	0.041	0	0.316	0	0	0	0.05	0.011	0.01
Scombridae	*Rastrelliger kanagurta*	0	0	0	0.035	0	0	0	0	0	0	0	0	0
Scomberomoridae	*Indocyblum guttatus*	0.294	0	0	0	0	0.007	0	0	0.006	0.235	0	0	0.005
Stromateidae	*Pampus argenteus*	0.21	0.049	0.184	0.03	0	0.05	0.119	0.036	0.031	0.617	0.427	0.919	0.561
	Pampus chinensis	0	0	0	0.03	0	0	0.061	0.069	0	0.168	0	0	0.127
	Parastromateus niger	0.9936	0	0	0	0	0	0	0	0	0	0.1	0.054	0
	Total	3.1071	0.604	0.9195	0.9871	0.8925	1.4702	1.1462	1.4558	0.3942	4.6739	1.8651	1.3015	1.2909

inshore waters characterised by muddy substrates to offshore waters characterised by more saline water and sandy substrates indicate their migratory behaviour. *Polynemus indicus* recorded in only three stations (Stations 6,10 and 12) had maximum mean density and biomass of 1.15 ind.ha^{-1} and 0.05 kg ha^{-1}, respectively. *Eleutheronema tetradactylus* was only recorded in the deep-water Station 12, with mean density and biomass of 1.15 ind.ha^{-1} and 0.28 kg ha^{-1} respectively.

3.5.2 Macroinvertebrates

A total of 43 species of macroinvertebrates belonging to 18 families were recorded in the Klang Strait, based on a study of 6,048 specimens (Table 7). The number of invertebrate species per station ranged from 27 in Station 1 to 20 each in Stations 8, 10 and 14. The highest mean density of 370.1 ind.ha^{-1} was recorded in Station 1, which was located nearshore just off of the River Selangor estuary. The lowest mean density of 54.21 ind.ha^{-1} was recorded in Station 10, which was located offshore. (Table 8). The highest mean biomass value of 4.3 kg ha^{-1} was recorded in Station 5, a station located between the estuaries of River Selangor and River Buloh. The lowest mean biomass of 0.46kg ha^{-1} was recorded in Station 9 which was located offshore in Angsa Bank (Table 9). The distribution and abundance of main taxa groups are as follows:

3.5.2.1 Prawns

The density distribution contours of penaeid prawns show that the major areas of prawn abundance were the more extensive mudflats lying north of River Buloh

(Figure 48a). Biomass distribution indicates larger prawn biomass in the same areas and also in the sandy mud shoal west of Pulau Angsa where larger individuals were observed (Figure 48b). The latter prawns were maturing and adult migrants enroute to their spawning grounds (Chong *et al.* 1990).

A total of 17 species of prawns belonging to three different families were recorded. Fourteen species belonged to the Penaeidae, two species belonged to the Alpheidae, and one species belonged to the Hippolytidae.

Penaeid species came from 7 genera (Table 6). Three species, *Parapenaeopsis sculptilis, Parapenaeopsis maxillipedo* and *Penaeus merguiensis,* were caught in all stations. Six species, *Metapenaeus affinis, Metapenaeus brevicornis, Metapenaeus lysianassa, Parapenaeopsis coromandelica, Parapenaeopsis hardwickii* and *Solenocera subnuda* were widely distributed and were found in many of the stations (Figures 49a and b). Three penaeids, *Metapenaeus dobsoni, Penaeus japonicus* and *Penaeus monodon* and one alpheid, *Synalpheus sp*., were caught only once in Stations 11, 13, 11 and 6 respectively. Two other penaeids, *Parapenaeopsis gracillima* and *Parapenaeopsis hungerfordi,* one alpheid, *Alpheus sp.* and one hippolytid, *Mimocaris sp*., occurred in three or four stations (Figure 49a and b) (see also Appendix 8).

Results of the cluster analysis shown in Figures 49a & b show the clustering of nearshore stations (Stations 1, 2, 4, 6, 5, 12 and 11) with almost similar species. These prawn were caught in stations with common characteristics of silty sediments with high organic content and highly turbid waters. The dominant species preferring such

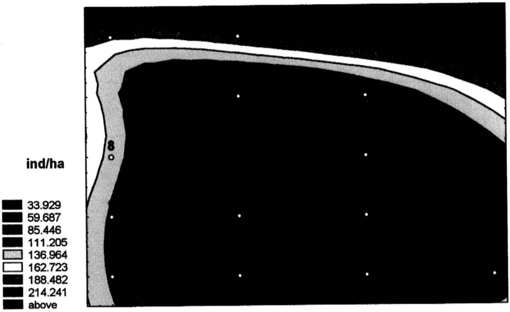


Fig.48a: Density distribution of prawn species in Klang Strait

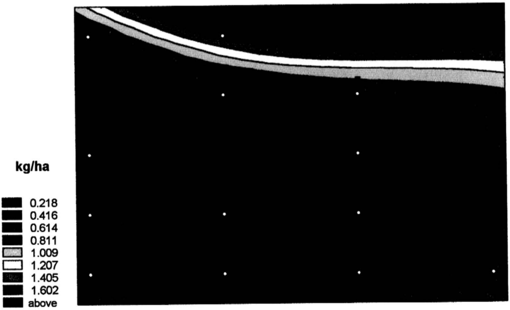


Fig.48b: Biomass distribution of prawn species in Klang Strait

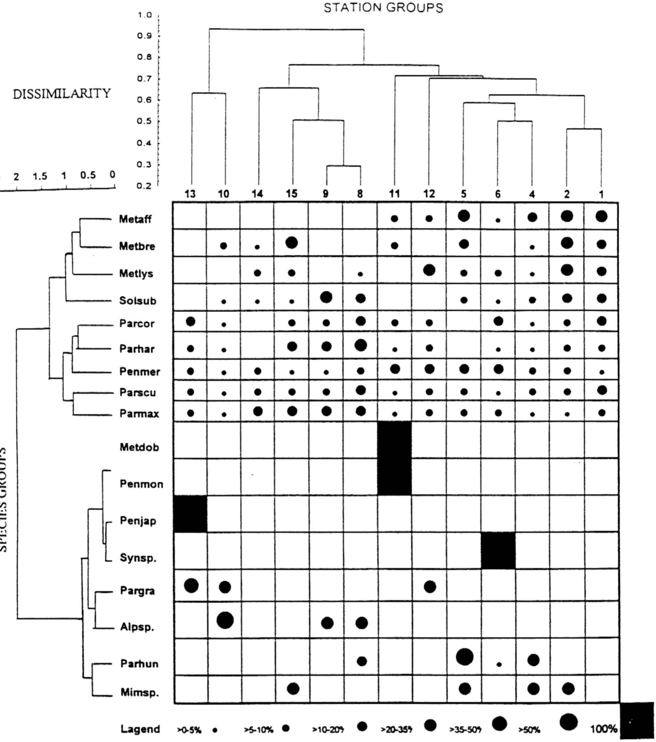


Fig. 49a: Summary of the cluster analysis results for the Prawns species in Klang Strait., with emphasis on the distribution of the Prawns species among the stations group. The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. See Table 6 for species code.

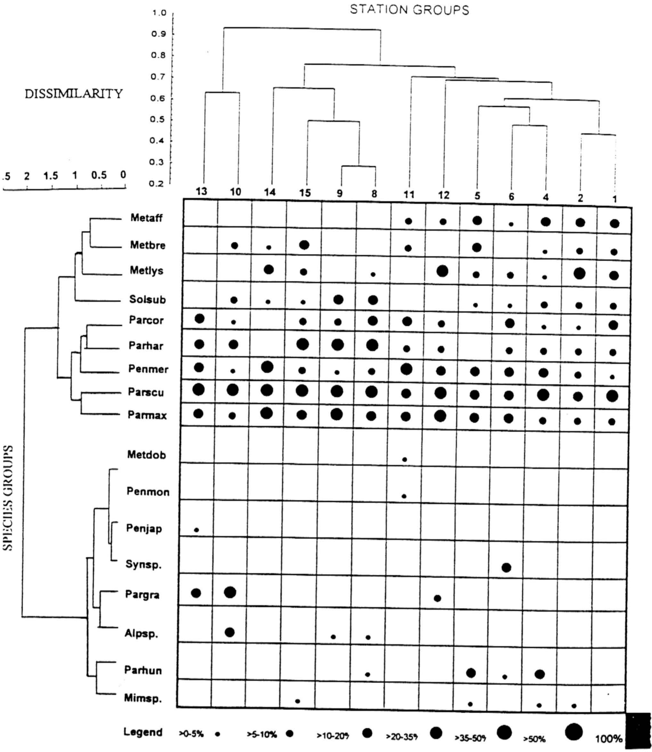


Fig. 49b: Summary of the cluster analysis results for the Prawns species in Klang Strait., with emphasis on the distribution of the Prawns species among the stations group. The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

conditions were *Metapenaeus affinis, Metapenaeus brevicornis, Metapenaeus lysianassa, Solenocera subnuda* and *Penaeus merguiensis* .

On the opposite branch of the dendrogram, Stations 8, 9, 15 and 14 which comprised another cluster of nearly similar species were stations characterised by sandy substrates and higher salinity. The dominant species found here, *Parapenaeopsis hardwickii, P. maxillipedo* and *P. sculptilis* probably prefer such environmental conditions. Stations 10 and 13, the most distant from the rest, were also characterised by sandy substrates, but they were situated adjacent or near to mangroves which abound on the islands of Pulau Kelang and Pulau Ketam. *Parapenaeopsis gracillima* were sampled from these stations only (the other was Station 12), and Penaeus *japonicus* was sampled from Station 13 only.

Penaeus merguiensis, Parapenaeopsis sculptilis and *Parapenaeopsis maxillipedo* had the widest distribution, which indicates their ability to live in the variable environmental conditions of the Klang Strait. *P. merguiensis* is a migratory species, with juveniles inhabiting mangrove creeks and adults in offshore waters.

P. sculptilis was found with highest mean densities of 142.1 ind.ha^{-1} in Station 1, located just outside River Selangor estuary. The other common prawn species were *P. hardwickii* and *P. maxillipedo* which, were found in mean densities of 61.74 ind.ha^{-1} and 41.58 ind.ha^{-1} respectively in the offshore Station 9 (Table 15). In terms of biomass, *P.sculptilis* was the most abundant (1.3 kg ha^{-1}) at Station 1, followed by *P. merguiensis* (0.19 kg ha^{-1}) at Station 12 and *M. affinis* (0.14 kg ha^{-1}) at Station 2 (Table 16). In general, it was observed that while the density of prawns was high in

Table 15: The mean abundance (ind/ha) of Prawns species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Penaeidae	*Metapenaeus affinis*	17.75	39.44	4.205	20.53	0.618	0	0	0	0.989	1.16	0	0	0
	Metapenaeus brevicornis	2.227	5.837	0.371	4.824	0	0	0	0.735	1.473	0	0	0.124	16.11
	Metapenaeus dobsoni	0	0	0	0	0	0	0	0	0.551	0	0	0	0
	Metapenaeus lysianassa	6.124	89.24	0.124	3.216	1.768	0.937	0	0	0	33.64	0	1.608	1.424
	Parapenaeopsis coromandelica	7.794	1.653	0.371	0	4.685	6.457	1.855	0.124	2.976	2.296	11.02	0	1.237
	Parapenaeopsis gracillima	0	0	0	0	0	0	0	4.483	0	2.11	8.267	0	0
	Parapenaeopsis hardwickii	3.897	5.136	0.989	0	1.488	61.74	22.96	1.47	0.937	1.757	4.22	0	33.93
	Parapenaeopsis hungerfordi	0	0	2.226	15.12	0.124	1.102	0	0	0	0	0	0	0
	Parapenaeopsis sculptilis	142.1	11.74	10.09	11.21	3.347	36.66	29.37	4	3.8	31.08	19.29	4.959	31.72
	Parapenaeopsis maxillipedo	5.745	1.861	1.44	9.009	5.116	18.71	41.58	0.937	2.148	0	2.813	12.81	19.32
	Penaeus merguiensis	1.113	2.663	3.648	6.864	6.495	1.659	0.509	0.124	9.514	13.59	3.595	4.082	1.35
	Penaeus japonicus	0	0	0	0	0	0	0	0	0	0	0.352	0	0
	Penaeus monodon	0	0	0	0	0	0	0	0	0.551	0	0	0	0
	Solenocera subnuda	5.629	4.409	0.742	1.237	0.469	4.685	7.496	0.469	0	0	0	0.247	0.618
Alpheidae	*Alpheus sp.*	0	0	0	0	0	0.469	0.469	1.406	0	0	0	0	0
	Synalpheus sp.	0	0	0	0	2.811	0	0	0	0	0	0	0	0
Hippolytidae	*Mimocaris sp.*	0	0.099	0.124	0.124	0	0	0	0	0	0	0	0	0.124
	Total	192.4	162.1	24.33	72.14	26.92	132.4	104.2	13.75	22.94	85.63	49.56	23.83	105.8

Table 16: The mean of biomass (kg/ha) of the Prawns species at the stations in the study period.

Family	Species	1	2	4	5	6	8	9	10	11	12	13	14	15
Penaeidae	*Metapenaeus affinis*	0.083	0.137	0.021	0.114	0.006	0	0	0	0.005	0.003	0	0	0
	Metapenaeus brevicornis	0.015	0.025	0.002	0.023	0	0	0	0.001	0.004	0	0	0.002	0.045
	Metapenaeus dobsoni	0	0	0	0	0	0	0	0	0.001	0	0	0	0
	Metapenaeus lysianassa	0.017	0.107	2E-04	0.004	0.001	2E-07	0	0	0	0.023	0	0.003	6E-04
	Parapenaeopsis coromandeli	0.012	0.004	5E-04	0	6E-07	0.024	0.005	4E-04	0.005	0.002	0.019	0	0.001
	Parapenaeopsis gracillima	0	0	0	0	0	0	0	0.002	0	0.004	0.016	0	0
	Parapenaeopsis hardwickii	0.009	0.015	0.001	0	6E-04	0.001	3E-06	0.002	1E-06	4E-07	0.005	0	0.057
	Parapenaeopsis hungerfordi	0	0	0.004	0.049	1E-04	0.004	0	0	0	0	0	0	0
	Parapenaeopsis sculptilis	1.297	0.094	0.126	0.174	0.076	0.186	0.022	0.014	0.015	0.309	0.209	0.092	0.192
	Parapenaeopsis maxillipedo	0.069	0.004	0.011	0.047	0.007	0.009	0.016	1E-07	9E-04	0	0.004	0.02	0.03
	Penaeus merguiensis	0.018	0.061	0.087	0.137	0.103	0.08	0.008	0.002	0.097	0.189	0.06	0.071	0.016
	Penaeus japonicus	0	0	0	0	0	0	0	0	0	0	0.003	0	0
	Penaeus monodon	0	0	0	0	0	0	0	0	0.041	0	0	0	0
	Solenocera subnuda	0.009	0.009	0.002	0.002	3E-08	9E-07	1E-06	4E-08	0	0	0	4E-04	9E-04
Alpheidae	*Alpheus sp.*	0	0	0	0	0	3E-07	3E-07	9E-07	0	0	0	0	0
	Synalpheus sp.	0	0	0	0	3E-06	0	0	0	0	0	0	0	0
Hippolytidae	*Mimocaris sp.*	0	3E-04	3E-04	5E-05	0	0	0	0	0	0	0	0	1E-04
	Total	1.53	0.46	0.25	0.55	0.19	0.3	0.05	0.02	0.17	0.53	0.31	0.19	0.34

nearshore waters, their biomass was low. It implied that the prawns were small in size or were juveniles.

3.5.2.2 Crabs (including horse-shoe crabs)

Density and biomass distribution of brachyuran and horse-shoe crabs show that these animals were the most abundant over the mudflats fringing the mainland coast and the sand-mud flats north of Pulau Ketam (Figures 50 a & b). Their numbers decreased gradually northwesterly towards deep waters.

A total of 1,518 crabs and horse-shoe crabs were examined. There were 15 species of brachyuran crabs belonging to 11 genera from 6 families (Tables 6 and 7). *Charybdis feriata* and *Charybdis callianassa* were the most common species that were caught from all stations. Other common species were *Scylla serrata, Portunus pelagicus* and *Heikea japonica* (Figure 51a). *Doclea ovis* and *Charybdis natator* were found in only two but different stations which had turbid water and variable substrates; the former preferring fine sand while the latter clayey silt. *Thalamita crenata* was sampled only once in Station 14 where the bottom sediment was of fine sand. The rest of the species were widely but sporadically distributed in the Klang Strait (Figures 51a and 51b; Appendix 8). The horse-shoe crab, *Tachypleus gigas*, were more abundant in clayey silt substrates and more saline water, while another species, *Carcinoscorpius rotundicaudata*, favoured less saline estuarine waters.

The highest mean density of all crabs species was in 88.3 ind.ha^{-1} (Station 1). This station was at the entrance of the River Selangor. The highest mean biomass of all

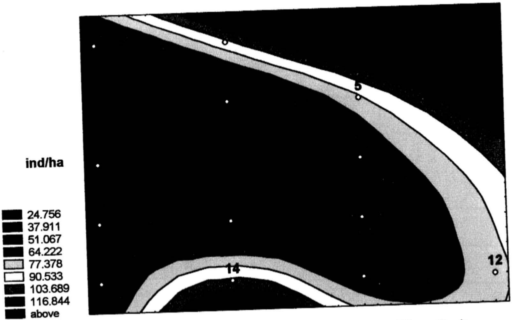


Fig.50a: Density distribution of crab species in Klang Strait

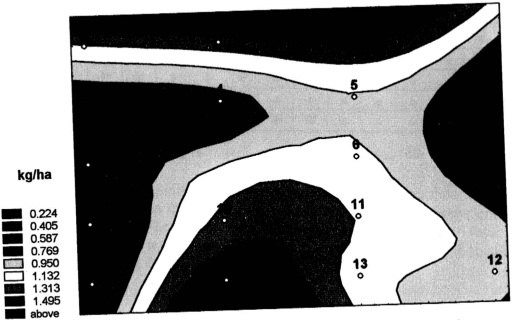


Fig.50a: Biomass distribution of crab species in Klang Strait

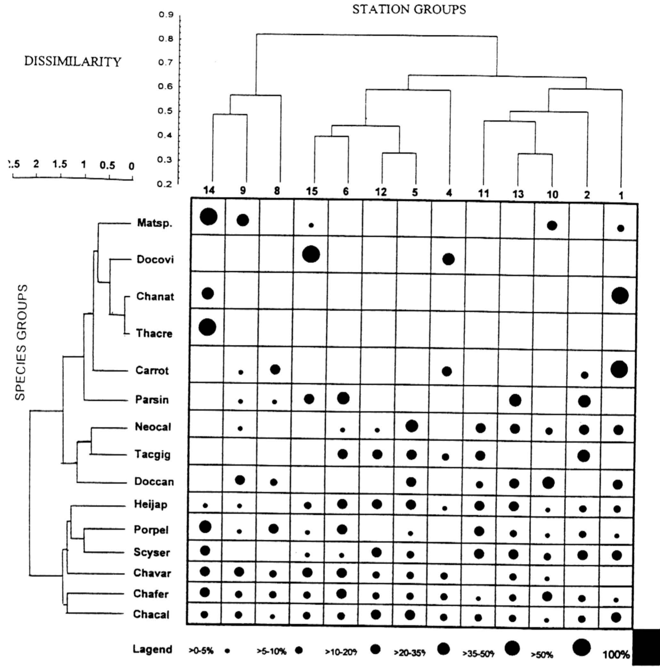


Fig. 51a: Summary of the cluster analysis results for the Crabs and horse-shoe crab species in Klang Strait., with emphasis on the distribution of the Crabs and horse-shoe crab species among the stations group. The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. See Table 6 for species code.

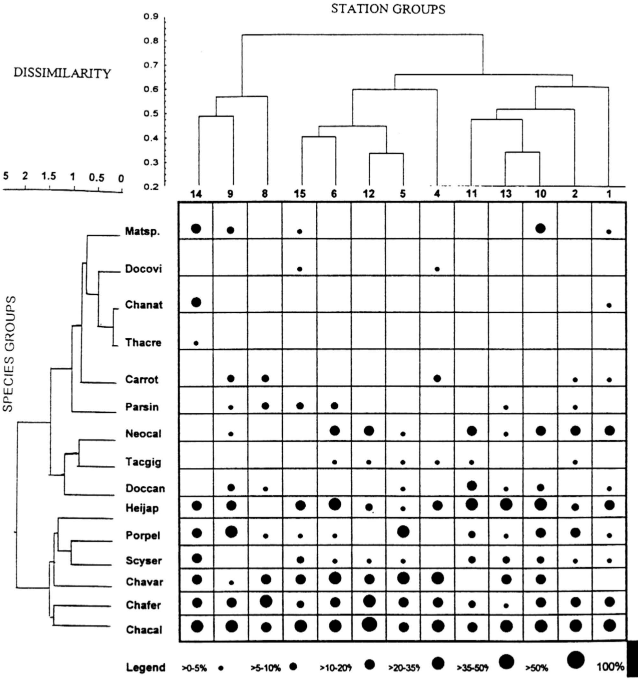


Fig. 51b: Summary of the cluster analysis results for the Crabs and horse-shoe crab species in Klang Strait., with emphasis on the distribution of the Crabs and horse-shoe crab species among the stations group. The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

crabs species (1.65kg ha^{-1}) was found in Station 14 which was located offshore in the southern part of the study area (Tables 8 and 9).

The highest mean density among crab species was *C. callianassa* (68.4 ind.ha^{-1}), followed by *Charybdis variegata* (28.7 ind.ha^{-1}), *Matuta sp.*(25.6 ind.ha^{-1}), *Heikea japonica* (18.5 ind.ha^{-1}), *Neodorippe callida* (10.5 ind.ha^{-1}), *Charybdis feriata* (8.7 ind.ha^{-1}), *Charybdis natator* (3.1 ind.ha^{-1}), *Carcinoscorpius rotundicauda* (2.4 ind.ha^{-1}), *Scylla serrata* (2.1 ind.ha^{-1}) and others (Table 17). The highest mean biomass values among crabs in order of magnitude is as follows: *C. feriata* (1.02 kg ha^{-1}), *P. pelagicus* (0.91 kg ha-1), *T. gigas* (0.5 kg ha-1), *S. serrata* (0.4 kg ha-1) , *C. callianassa* (0.33 kg ha^{-1}) and others (see Table 18).

3.5.2.3 Stomatopoda

Stomatopoda or mantis shrimps were largely caught in the southern waters over sandy-mud flats north and northwest of Pulau Klang and Pulau Ketam (Figure 52a). Their numbers were comparatively lower in estuaries and in the waters around Pulau Angsa.

There were three species belonging to the genera *Harpiosqulla* and *Oratosquilla* of the family Squillidae. *Oratosquilla perpensa* was found in all the stations, whereas *Oratosquilla interoupta* and *Harpiosqulla harpax* were widely distribution in the Klang Strait waters. During the study, 386 specimens were examined (Table 7). The maximum mean density of all Stomatopoda was found in the offshore Station 9 with a value 27.41 ind.ha^{-1} (Table 19). The maximum mean biomass of all Stomatopoda

Table 17: The mean abundance (ind/ha) of Crabs and horse shoe crab species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Calappidae	*Matuta sp.*	0.618	0	0	0	0	0	3.19	0.992	0	0	0	25.62	0.298
Dorippidae	*Heikea japonica*	4.932	2.204	0.866	9.142	14.76	0	0.937	1.672	18.45	9.891	14.05	1.102	3.52
	Neodorippe callida	4.329	2.204	0	10.51	0.469	0	0.469	1.406	7.028	0.586	2.756	0	0
Majidae	*Doclea canalifera*	1.113	0	0	0.551	0	0.367	1.304	1.406	0.469	0	0.919	0	0
	Doclea ovis	0	0	0.247	0	0	0	0	0	0	0	0	0	0.596
Portunidae	*Charybdis feriata*	1.67	2.196	6.398	6.084	8.699	3.425	4.977	7.968	0.716	6.081	1.973	8.472	6.634
	Charybdis callianassa	68.38	21.27	13.94	41.48	15.82	4.584	25.43	3.365	10.45	52.27	11.06	9.176	11.19
	Charybdis natator	3.092	0	0	0	0	0	0	0	0	0	0	0.469	0
	Charybdis variegata	0	0	1.979	4.002	6.413	4.28	28.71	0.496	0	2.319	5.275	23.71	12.96
	Portunus pelagicus	0.618	2.03	0	0.662	5.258	5.859	0.959	0.496	7.44	0	2.11	43.22	0.469
	Scylla serrata	1.097	1.856	0	0.495	0.124	0	0	0.496	0.937	1.734	2.11	1.102	0.367
	Thalamita crenata	0	0	0	0	0	0	0	0	0	0	0	0.469	0
Xanthidae	*Parapanope singaporensis*	0	0.897	0	0	1.113	0.126	0.12	0	0	0	1.055	0	0.367
Merostomata	*Carcinoscorpius rotundicauda*	2.412	0.188	0.6	0	0	0.469	0.124	0	0	0	0	0	0
	Tachypleus gigas	0	0.618	0.247	0.415	0.469	0	0	0	0.551	0.586	0	0	0
	Total	88.26	33.47	24.27	73.35	53.12	19.11	66.22	18.3	46.03	73.47	41.31	113.3	36.4

Table 18: The mean of biomass (kg/ha) of the Crabs and horse shoe crab species at the stations during the study period.

Family	*Species*	1	2	4	5	6	8	9	10	11	12	13	14	15
Calappidae	*Matuta sp.*	0.041	0	0	0	0	0	0.061	0.021	0	0	0	0.292	0.004
Dorippidae	*Heikea japonica*	0.03	0.006	0.005	0.062	0.002	0	7E-07	0.005	0.006	0.021	0.027	0.002	0.011
	Neodorippe callida	0.006	0.006	0	0.02	8E-08	0	7E-08	3E-07	1E-06	9E-08	0.012	0	0
Majidae	*Doclea canalifera*	0.016	0	0	0.005	0	4E-04	0.002	2E-06	7E-07	0	8E-04	0	0
	Doclea ovis	0	0	0.015	0	0	0	0	0	0	0	0	0	0.032
Portunidae	*Charybdis feriata*	0.089	0.11	0.35	0.267	0.775	0.239	0.041	1.019	0.002	0.404	0.163	0.446	0.157
	Charybdis callianassa	0.325	0.096	0.061	0.24	0.053	6E-04	6E-04	0.008	0.04	0.236	0.052	0.053	0.058
	Charybdis natator	0.019	0	0	0	0	0	0	0	0	0	0	4E-06	0
	Charybdis variegata	0	0	0.008	0.025	0.018	0.011	9E-04	0.003	0	0.011	0.037	0.133	0.035
	Portunus pelagicus	0.126	0.074	0	0.154	0.102	0.194	0.026	0.102	0.908	0	0.478	0.371	8E-06
	Scylla serrata	0.371	0.315	0	0.069	0.026	0	0	0.029	0.046	0.177	0.045	0.35	0.028
	Thalamita crenata	0	0	0	0	0	0	0	0	0	0	0	4E-06	0
Xanthidae	*Parapanope singaporensis*	0	0.013	0	0	0.031	0.003	0.006	0	0	0	0.06	0	8E-04
Merostomata	*Carcinoscorpius rotundicauda*	0.225	0.026	0.026	0	0	5E-06	0.006	0	0	0	0	0	0
	Tachypleus gigas	0	0.473	0.151	0.093	3E-05	0	0	0	0.149	2E-05	0	0	0
	Total	1.249	1.119	0.615	0.934	1.007	0.448	0.142	1.187	1.151	0.85	0.873	1.647	0.326

Table 19: The mean abundance (ind/ha) of Stomatopoda species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Squillidae	*Harpiosquilla harpax*	0	0	2.505	0.124	0.371	0	1.608	0	1.113	1.148	0.919	0	0.247
	Oratosquilla interrupta	3.084	9.851	0.92	0	3.396	0	0.12	0	1.334	1.148	0	0.596	0.247
	Oratosquilla perpensa	2.59	1.326	7.987	2.597	3.673	7.915	25.68	1.938	2.849	18.18	6.136	19.47	16.96
	Total	5.674	11.18	11.41	2.721	7.44	7.915	27.41	1.938	5.296	20.48	7.054	20.07	17.45

Table 20: The mean of biomass (kg/ha) of the Somatopoda species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Squillidae	*Harpiosquilla harpax*	0	0	0.096	0.006	9E-04	0	0.048	0	0.03	0.005	0.018	0	0.009
	Oratosquilla interrupta	0.116	0.231	0.027	0	0.111	0	0.002	0	0.026	0.004	0	0.004	0.006
	Oratosquilla perpensa	0.041	0.007	0.096	0.036	0.105	0.038	0.037	0.017	0.037	0.104	0.079	0.2	0.271
	Total	0.157	0.238	0.218	0.042	0.217	0.038	0.088	0.017	0.093	0.113	0.097	0.204	0.286

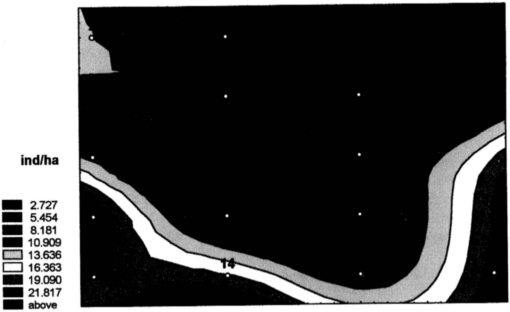


Fig.52a: Density distribution of Stomatopoda species in Klang Strait

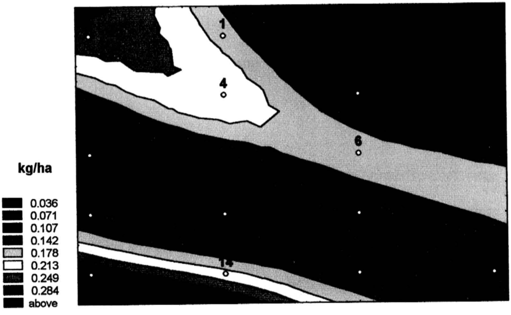


Fig.52b: Biomass distribution of Stomatopoda species in Klang Strait

with a value of 0.39kg ha^{-1} was recorded in the offshore Station 15 (Table 20). Both stations were sandy-bottom stations with comparatively higher salinity than the others.

The most frequently occurring species was *O. perpensa* which, occurred at the highest mean density of 25.68 ind.ha^{-1} at Station 9. Highest mean density of *O. interrupta* was 9.85 ind.ha^{-1} at Station 2, while for *H. harpax* was 2.51 ind.ha^{-1} at Station 4 (Table 19); both stations were characterised by muddy substrates adjacent to the estuary of Selangor River. However, in terms of mean biomass and order of importance, *O. perpensa* (0.27 kg ha^{-1}, Station 15) dominated, followed by *O. interrupta* (0.23 kg ha^{-1}, Station 2) and *H. harpax* (0.1 kg ha^{-1}, Station 4) (Table 20).

3.5.2.4 Cephalopoda

More Cephalopoda were caught in coastal waters south of Sungai Buloh to the Kapar power plant, off and west of the River Selangor estuary and south Angsa Bank (Figures 53 a & b).

During the study, 843 specimens were examined. Only 3 Cephalopoda species were found and widely distributed in the Klang Strait, and these belonged to 3 species, *Octopus* sp., *Sepia esculenta* and *Loligo edulis* (Tables 6 and 7). The highest mean density of cephalopods of 39.25 ind.ha^{-1} and biomass of 0.9 kg ha^{-1} were recorded in Station 6 (Tables 8 and 9). The mean biomass of total Cephalopoda varied from 0.9 kg ha^{-1} at Station 6 to 0.14 kg ha^{-1} at Station 9 (Table 22).

Table 21: The mean abundance (ind/ha) of Cephalopoda species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Octopodidae	*Octopus sp.*	0	0	3.89	1.844	3.316	2.778	0.124	2.68	0.866	0	3.165	1.501	5.06
Sepiidae	*Sepia esculenta*	12.12	14.97	14.81	15.78	23.26	4.554	4.67	1.474	15.58	18.54	4.22	7.538	21.09
Loliginidae	*Loligo edulis*	8.052	15.52	5.302	7.094	12.66	15.28	2.219	12.59	5.169	20.1	14.48	2.155	8.659
	Total	20.17	30.49	24	24.72	39.25	22.61	7.013	16.75	21.61	38.65	21.87	11.19	34.81

Table 22: The mean of biomass (kg/ha) of the Cephalopoda speacies at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Octopodidae	*Octopus sp.*	0	0	0.13	0.15	0.14	0.1	0.01	0.12	0.13	0	0.41	0.06	0.2
Sepiidae	*Sepia esculenta*	0.23	0.54	0.4	0.51	0.67	0.1	0.1	0.03	0.59	0.41	0.15	0.19	0.43
Loliginidae	*Loligo edulis*	0.19	0.09	0.11	0.05	0.09	0.1	0.03	0.27	0.05	0.13	0.1	0.06	0.01
	Total	0.42	0.63	0.64	0.71	0.9	0.3	0.14	0.42	0.77	0.54	0.67	0.31	0.64

Fig.53a: Density distribution of Cephalopoda in Klang Starit

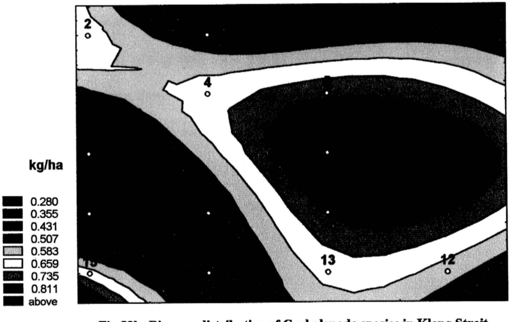


Fig.53b: Biomass distribution of Cephalopoda species in Klang Strait

S. esculenta and *L. edulis* occurred in all the stations, but *Octopus* sp. was found in all stations except Stations 1, 2 and 12 (Appendix 8). The mean values of abundance indicated that *S. esculenta* occurred at the highest mean density of 23.27 ind.ha^{-1} in Station 6, and were relatively more abundant in other nearshore stations (Table 21). *L. edulis* like *S. esculenta* were widely distributed, with the highest density of 20.1 ind.ha^{-1} in Station 12 which was located near shore and close to mangroves. *Octopus* sp. had a wide distribution., with a mean abundance of 5.06 ind.ha^{-1} in Station 15 which was located offshore (Table 21).

3.5.2.5 Echinodermata

Echinoderms were mostly observed in the River Selangor estuary and in or just off the mudflat north of the estuary (Figures 54 a & b).

A total of 923 specimens were examined. The highest mean density and biomass value for all species in this group was 99.4 ind.ha^{-1} and 2.1 kg ha^{-1} respectively (Tables 8 and 9). There were three different groups of Echinodermata. These groups were sea cucumbers which includes one species only, Malpodinae (Species A) ; sea urchins which includes two species *Lovenia elongata* and *Salmacis dussumieri*; and starfish which includes three species, *Ophitrichoides nereidina* and *Luidia penangensis* (Table 6).

The regular sea urchin *S. dussumieri* was widely distributed in the Klang Strait, while the sea cucumber (Malpodinae) were present in all but Stations 13, 14 and 15 (Figure 55). Both species however appeared in greater abundance over muddy

Table 23: The mean abundance (ind/ha) of Echinodermata species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Spatangidae	*Lovenia elongata*	0.796	0	8.115	13.45	0	0	0	0	0	0	0	0	0
Ophiotrichidae	*Ophiotrichoides nereidina*	0	0	0	0	0	0.251	0	0	0	0	0	0	0
Temopleuridae	*Salmacis dussumieri*	40.7	20.47	32.6	58.97	15.73	10.9	0.371	1.486	0.247	7.385	9.143	1.788	1.102
Luidiidae	*Luidia penangensis*	0.742	0	1.592	5.024	2.181	0	0	0.592	1.9	4.22	1.055	0	0
Holothuriidae	*Malpodinae* (Sp.A)	21.34	51.29	2.661	21.94	6.061	1.531	0.247	1.406	1.406	3.844	0	0	0
	Total	63.57	71.75	44.97	99.39	23.97	12.68	0.618	3.483	3.553	15.45	10.2	1.788	1.102

Table 24: The mean of biomass (kg/ha) of the Echinodermata species at the stations during the study period.

Family	Species / Stations	1	2	4	5	6	8	9	10	11	12	13	14	15
Spatangidae	*Lovenia elongata*	0.006	0	0.05	0.133	0	0	0	0	0	0	0	0	0
Ophiotrichidae	*Ophiotrichoides nereidina*	0	0	0	0	0	4E-04	0	0	0	0	0	0	0
Temopleuridae	*Salmacis dussumieri*	0.131	0.115	0.103	0.312	0.045	0.12	0.005	0.287	0.002	0.088	0.149	0.016	0.024
Luidiidae	*Luidia penangensis*	0.011	0	0.087	0.272	0.046	0	0	0.009	0.052	0.333	0.073	0	0
Holothuriidae	*Mealpodinae* (Sp.A)	0.648	0.014	0.076	1.341	0.146	0.025	0.035	2E-05	1E-05	0.153	0	0	0
	Total	0.7968	0.1286	0.3149	2.0576	0.2369	0.1453	0.04	0.2952	0.0543	0.5736	0.2221	0.0159	0.0244

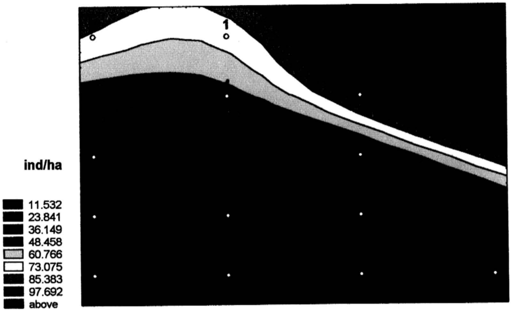


Fig.54a: Density distribution of Echinodermata species in Klang Strait

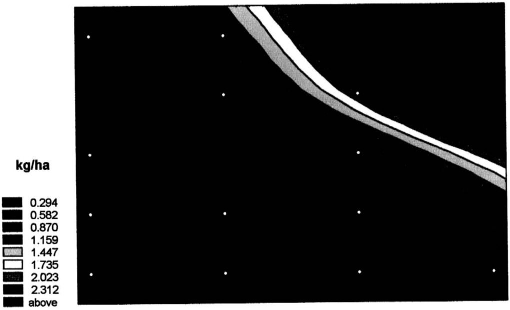


Fig.54b: Biomass distribution of Echinodermata species in Klang Strait

substrates. The starfish, *L. penangensis* was observed in all but the furthest stations, apparently preferring the coastal mud flats. The irregular sea urchin, *L. elongata,* was sampled only in the near shore Stations 1, 4 and 5, near to the estuaries. Another starfish, *O. nereidina,* was recorded only once in Station 8 during the study see Figure 55 and (Appendix 8).

The highest mean density values of these echinoderms in order of importance are as follows: *S. dussumieri* (58.97 ind.ha-1), Malpodinae (51.3 ind.ha^{-1}), *L. elongata* (13.5 ind.ha^{-1}), *L. penangensis* (5.02 ind.ha^{-1}) and *O. nereidina* (0.3 ind.ha^{-1}). Highest mean biomass values in order of importance are as follows: *M. intercedens* (1.34 kg ha^{-1}), *L. penangensis* (0.33 kg ha^{-1}), *T. siamense* (0.31 kg ha^{-1}), *L. elongata* (0.13 kg ha^{-1}) and *O. nereidina* (0.004 kg ha^{-1}) (see Tables 23 and 24).

3.6 SPECIES DIVERSITY AND SIMILARITY

Two groups of stations grouped according to their similarity in fish and macroinvertebrate species were obtained from the cluster analysis (Figure 56). This grouping essentially reflected the grouping of nearshore stations (Stations 1, 2, 4, 5, 11 and 12; right cluster) on one hand and 'far' shore stations (Stations 8, 9, 10, 13, 14 and 15; left cluster) on the other. Although the close proximity of adjacent stations could have accounted for this, it may also be due to similar species preferring similar environmental conditions. For instance, the nearshore stations could have species that preferred muddy sediments in turbid water, while the farshore stations had species that preferred more sandy substrates in less turbid water.

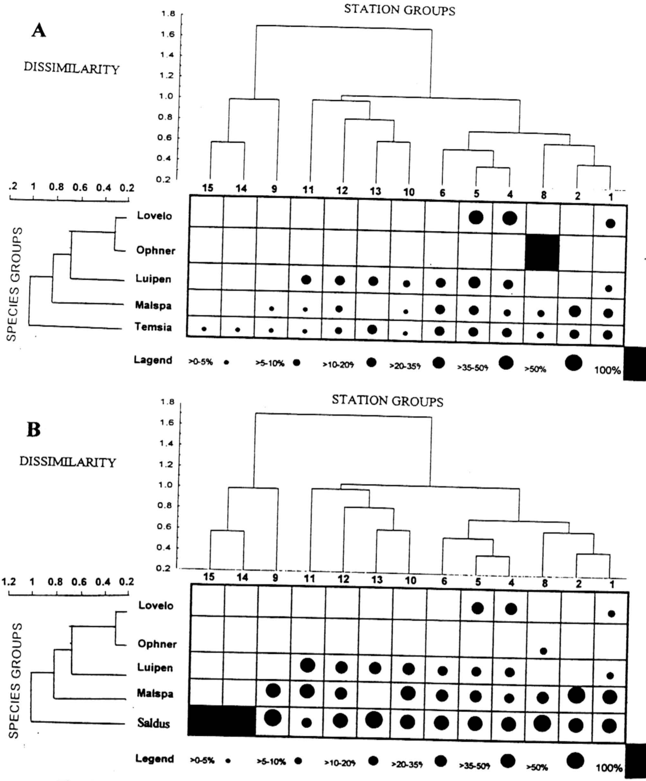


Fig. 55: Summary of the cluster analysis results for the Echinodermata species in Klang Strait., with emphasis on the distribution of the Echinodermata species among the stations group. (A) The symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (row) sum to 100%. (B) symbols in the two-way table summary represent the percentages of a species group across station groups; thus the percentages for a species group (column) sum to 100%. See Table 6 for species code.

Cluster analysis of stations based on similarity of demersal fish species gave similar results as the analysis of total species (Figure 57), that is, there were two clusters of grouped stations, one grouping nearshore stations while the other grouped farshore stations.

Cluster analysis of stations based on similarity of pelagic fish species however gave four main clusters (Figure 58). The stations that were grouped together in the same cluster were not adjacent stations, often very far apart.

Diversity indices were used to describe the differences in the community structure of the fish and macroinvertebrates in the various stations. Shannon-Weiner diversity indices (H`) of the stations ranged from 3.37 (Station 1) to 3.99 (Station 4) both located near the mouth of the Selangor river. In general all the stations had nearly similar H' values (Table 25). Maximum H` (or H'max) ranged from 4.09 (Stations 12 and 13) to 4.44 (Station 10). The lowest evenness 0.77 was recorded at Station 1, and the highest 0.95 at Station 13. The species richness of the stations ranged from 8.34 to 11.92 and these were recorded at Stations 15 and 10 respectively (Table 25).

3.7 RELATIONSHIP BETWEEN ABUNDANCE OF SPECIES AND ENVIRONMENTAL FACTORS

To assess the relationship between species abundance and environmental factors in the Klang Strait, canonical correspondence analysis (CCA) was performed only on the common species of each taxon. The total number of species of pelagic fish, demersal fish, prawns and crabs used were 23, 48, 17 and 15 species, respectively, while 12

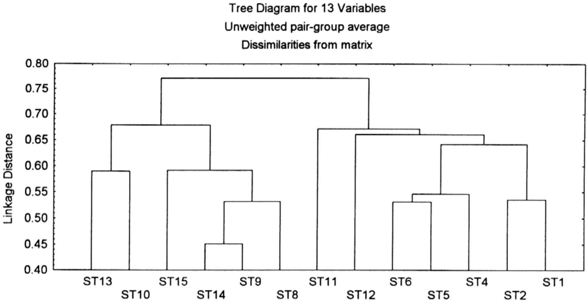


Fig.56: Cluster analysis of sampling stations grouped according to similarity of all species distributions and abundance.

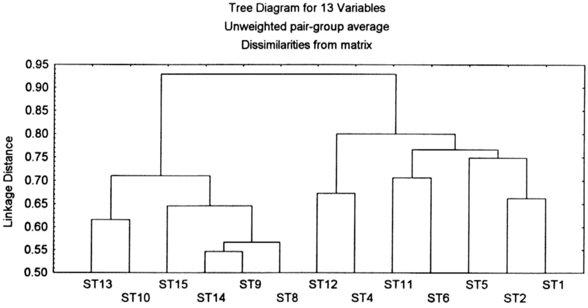


Fig.57: Cluster analysis of sampling stations grouped according to similarity of demersel fish species distributions and abundance.

Table 25: Ecological indices related to diversity of fish and macroinvertebrates at stations in Klang Strait.

Station no	1	2	4	5	6	8	9	10	11	12	13	14	15
No. of spp.	77	68	83	80	74	74	73	85	69	60	60	69	74
H'	3.37	3.87	3.99	3.63	3.39	3.46	3.82	3.51	3.84	3.85	3.87	3.79	3.46
H'max	4.34	4.22	4.42	4.39	4.30	4.32	4.29	4.44	4.23	4.09	4.09	4.23	4.23
J	0.78	0.92	0.90	0.83	0.79	0.80	0.89	0.79	0.91	0.94	0.95	0.89	0.82
D	9.56	8.95	11.42	10.38	9.45	10.31	9.74	11.92	9.43	8.66	9.19	9.30	8.34

Note: Species diversity (H'),H' max, Evenness index (J) and Species richness (D).

abiotic variables were used in the CCA. CCA was performed separately for each group. CCA was also carried out for another group of 11 species, comprising Cephalopoda, Stomatopoda and Echinodermata. Rare species were weighted down to reduce their influence on the results by selecting Option 1 ["Scaling of Ordination Scores"] in the software program.

3.7.1 Demersal fish

Results of CCA of the relationships between the environmental factors and the abundance of selected common demersal fish species is shown in Table 26. The eigenvalues for CCA axis 1, (0.24), axis 2 (0.22), axis 3 (0.15), and axis 4 (0.12) accounted for 21.2%, 19.8%, 13.2%, and 11% of the total variance in the data respectively.

Salinity, turbidity, percent clay, percent silt and percent organic matter of bottom sediment were the only environmental factors that showed statistically significant ($p<0.05$) relationships with the abundance of the common species of demersal fish. The species-environmental correlations were 0.99 and 0.99 on axis 1 and axis 2 respectively (Table 25).

The distribution of demersal fish species along the first CCA axis indicates that the fish families differed in their response to water salinity and turbidity and to the clay, silt and organic matter content of the bottom sediment (Figure 59). The Ariidae namely, *Arius caelatus* and *Osteogeneiosus militaris*, were more abundant in turbid, lower salinity water where the bottom sediment was clayey, silty and with a high content of organic matter. *Arius venosus* were more abundant on sandy substrate in more saline water. However, other two species *Arius maculatus* and *Arius sagor*, were more abundant in less turbid, more saline water and over silty bottom (Figure 59).

Of the seven species of Leiognathidae, *Leiognathus brevirostris, Leiognathus bindus* and *Leiognathus daura* were abundant in turbid water with bottom sediment which had a higher content of clay and organic matter. Three species *Leiognathus equulus, Leiognathus elongatus* and *Gazza minute*, had peak abundance in more saline water where bottom substrate had a low percentage of silt, clay and organic matter content. *Secutor insidiator* was equally affected by all environmental factors.

According to the CCA ordination biplot (Figure 59), the sciaenid species *Johnius dussumieri, Johnius trachycephalus* and *Nibea soldado*, were mainly found in very turbid and least saline water, where the bottom substrate had a high content of clay and organic matter. Five species, namely, *Dendrophysa russelli, Johnieops weberi, Otolithes ruber, Panna microdon* and *Pennahia macropthalmus*, were also abundant in clayey, silty and organically-rich bottoms, but in more saline water. *Johnius belangerii, Johnius carutta,* and *Chrysochirs auratus* were more abundant in saline, less turbid water, but where the bottom substrate had a low content of clay-silt and organic matter. *Johnius vogleris* and *Johnius carouna*, were abundant in saline and clearer water, over silty substrates.

Of the four species of Dasyatidae, Dasyatis *kuhlii, Dasyatis uarnak* and *Dasyatis zugei* had peak abundance in more saline and less turbid waters. *Dasyatis imbricatus*

Table 26. Results of the canonical correspondence analysis showing the relationship between demersal fish abundances with only the statistically significance environmental variables in Klang Strait.

Canonical coefficients for standarised variable:	Axis1	Axis2
Salinity	-0.60	-0.23
Turbidity	0.30	-0.80
Clay %	0.42	0.11
Organic matter content	-0.48	0.11
Silt %	-0.60	-0.58
Inter-set correlation of environmental varibles:		
Salinity	-0.90*	-0.13
Turbidity	0.58*	-0.25
Clay %	0.58*	0.49
Organic matter content	0.52*	0.52
Silt %	0.29	0.56*
Summary statistics for two axes	**Axis1**	**Axis2**
Eigenvalue	0.24	0.22
Fractions of species-environmental variation explained	21.2	19.8
Species-environment correlations	1.00	0.99

* Significant at $p<0.05$

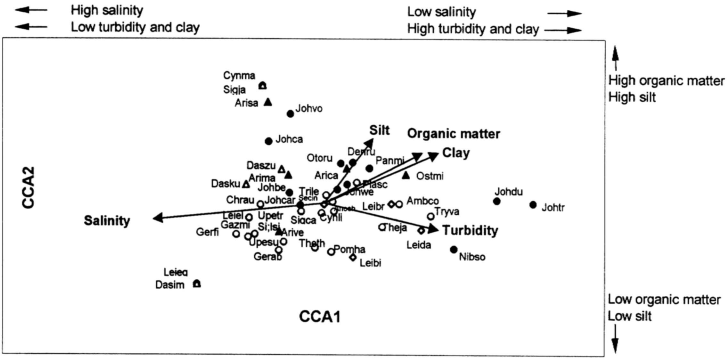


Fig. 59: CCA ordination biplot showing the statistically significant environmental variables (arrows) and demersal fish family. See Table 6 for species code.

▲ Ariidae, ◇Leiognathidae, ● Sciaenidae, △ Dasyatidae, and ○ other families.

was more abundant in more saline, clearer water, and where the substrate was low in silt and clay content and organic matter.

Seven species, *Osteogeneiosus militaris, Arius caelatus, Dendrophysa russelli, Panna microdon, Johnieops weberi, Otolithes ruber* and *Platycephalus scaber* which belonged to the families Ariidae, Sciaenidae and Platycephalidae were abundant in very turbid water, with sediments rich in clay and organic matter. *Dasyatidis imbricatus, Leiognathus equulus, Leiognathus elongatus, Gazza minute, Gerrer filamintosus, Gerrer abbreviatus, Upeneus sulphureus, Upeneus tragula, Sillago sihama* and *Siganus canaliculatus* which belonged to the families Dasyatidae, Leiognathidae, Gerridae, Mullidae, Sillaginidae and Siganidae had peak abundance in high salinity water over sandy substrates (Figure 59).

3.7.2 Pelagic fish

Table 4.23 shows the relationships between water and sediment variables and the abundance of pelagic fish species. The eigenvalues of the CCA axis 1 (0.17), axis 2 (0.15), axis 3 (0.11) and axis 4 (0.09) accounted for 22%, 19%, 10.6% and 12.2% of the observed variation in the data, respectively.

Only four of 12 environmental variables namely, sediment pH, water turbidity, salinity and depth showed statistically significant relationships ($p<0.05$) with the abundance of the pelagic species in the CCA. Species-environment correlations were 0.95 and 0.99 on axis 1 and axis 2 respectively (Table 27).

The CCA ordination of pelagic fish families indicates that their abundance varied with sediment pH, turbidity, salinity and depth gradients (Figure 60). Of the seven observed Carangidae species, *Alepes djeddaba, Carangoides malabaricus and Scomberoides commersonianus* were more abundant below the midpoint (= 7.76) of the sediment pH gradient as well as the midpoint (=31.65 ppt) of the salinity gradient. Both *Carangoides armatus* and *Megalaspis cordyla* (juveniles) were abundant in shallow waters where the water was very turbid; however, the former was abundant where the sediment pH was the lowest, whereas the latter preferred higher salinity water. *Alectis indicus* and *Atropus atropus* preferred waters which were more saline, comparatively turbid, and where the sediment pH was high .

The Clupeidae species, namely *Escualosa thoracata*, had peak abundance in deeper water, where turbidity was high but salinity low. *Sardinella fimbriata, Illisha elongata* and *Hilsa toli* were found in waters with average condition of the four environmental variables. *Herklotsichthys punctatus* were abundant in turbid, high salinity water where sediment pH was high.

Three of 6 species of Engraulididae, namely *Coilia dussumieri, Thryssa dussumieri* and *Thryssa kammalensis* were more abundant in deep but turbid waters, over sediments having a relatively high pH. However, *Thryssa hamiltonii, Setipinna taty* and *Stolephorus baganensis* showed preference for less turbid, less saline and relatively shallow waters, where sediment pH was comparatively lower (Figure 60).

Pomadasys hasta one of two species belonging to the family Pomadasyidae preferred low salinity, low turbidity and shallow waters where sediment pH was low.

Table 27. Results of the canonical correspondence analysis showing the relationship between pelagic fish abundances with only the statistically significant environmental variables in Klang Strait.

Canonical coefficients for standarised variable:	Axis1	Axis2
Soil pH	-0.70	0.62
Turbidity	-0.25	-0.25
Salinity	0.30	-0.17
Depth	-0.23	-0.49
Inter-set correlation of environmental varibles:		
Soil pH	-0.61*	0.31
Turbidity	-0.41*	-0.35
Salinity	-0.14	0.62*
Depth	-0.19	-0.88*
Summary statistics for two axes	**Axis1**	**Axis2**
Eigenvalue	0.17	0.15
Fractions of species-environmental variation explained	22	19
Species-environment correlations	0.95	0.99

* Significant at $p<0.05$

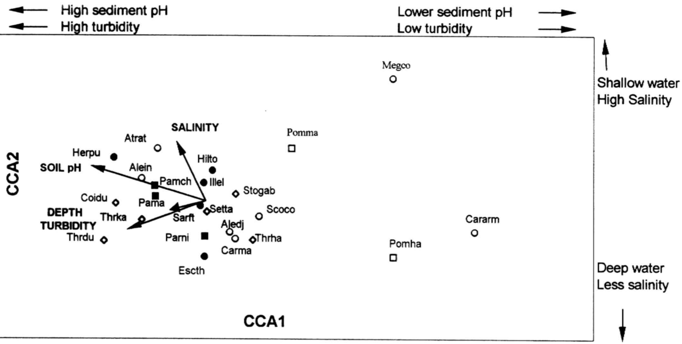


Fig. 60: CCA oridination biplot showing the statistically significant environmental variables (arrows) and pelagic fish families. See Table 6 for species code.

○ Carangidae, ● Clupeidae, ◇ Engraulididae, □ Pomadasyidae, and ■ Stromatidae.

Pomadasys maculatus was more abundant in shallow, low turbidity but more saline water where sediment pH was higher.

The Stromatidae namely, *Pampus argenteus* and *Pampus chinensis*, had higher abundance in turbid, high salinity and deep waters, where bottom sediment pH was above the midpoint of the pH gradient. However, another stromatid, *Parastromateus niger* preferred turbid but less saline waters where the sediment pH was lower (Figure 60).

3.7.3 Prawns

The relationships between the environmental variables and abundance of prawn species as analysed by CCA are shown in Table 28. The eigenvalues for CCA axis 1 (0.24), axis 2 (0.16), axis 3 (0.13), and axis 4 (0.11) accounted for 27.8%, 17.1%, 15.1% and 13.2%, of the total variance in the data, respectively.

Only six of 12 environmental factors, namely percent clay, percent fine sand, percent organic matter, salinity, depth and dissolved oxygen showed statistically significant relationships with the abundance of the prawn species. The species-environment correlation was 0.99 and 0.99 for axis 1 and axis 2 respectively (Table 28).

Essentially the abundance of the prawn species were distributed along two opposing environmental gradients; clayey substrate and high organic matter on one side, but high dissolved oxygen, salinity and fine sand on the other. The other gradient was depth with a midpoint at 5.7 m (Figure 61).

Table 28. Results of the canonical correspondence analysis showing the relationship between prawns species abundances with only the statistically significance environmental variables in Klang Strait.

<u>Canonical coefficients for standarised variable:</u>	Axis1	Axis2
Clay %	-0.11	-1.00
Fine sand %	0.10	-0.46
Salinity	-0.38	-0.14
Depth	0.17	0.30
Organic matter coentent	-1.00	0.19
Dessolved oxygen	0.11	-0.16
<u>Inter-set correlation of environmental varibles:</u>	Axis1	Axis2
Clay %	-0.64*	-0.41
Fine sand %	0.61*	0.36
Salinity	0.58*	0.36
Depth	0.46	-0.79*
Organic matter coentent	-0.49	-0.74*
Dessolved oxygen	0.29	0.71*
<u>Summary statistics for two axes</u>	Axis1	Axis2
Eigenvalue	0.24	0.16
Fractions of species-environmental variation explained	27.8	17.1
Species-environment correlations	0.99	0.99

* Significant at $p<0.05$

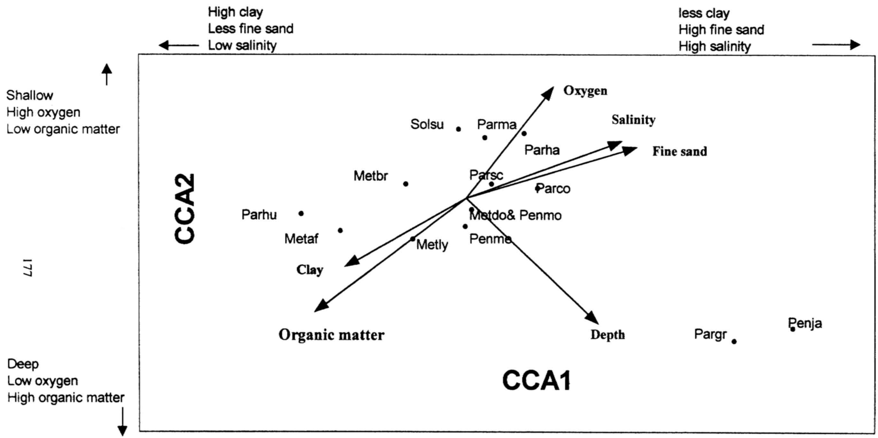


Fig. 61. CCA ordination bioplot showing the statistically significant environmental variables (arrows) and prawns species circles. See Table 6 for species code.

Penaeid prawns preferring clayey substrates containing higher organic matter in shallow, less saline waters were *Metapenaeus affinis*, *Metapenaeus brevicornis*, *Metapenaeus lysianassa*, *Parapenaeopsis hungerfordi* and *Penaeus merguiensis*, whereas those preferring fine sand substrates in shallow but more saline water were *Parapenaeopsis hardwickii*, *Parapenaeopsis coromandelica*, *Parapenaeopsis maxillipedo*, *Parapenaeopsis sculptilis* and *Solenocera subnuda*. *Metapenaeus dobsoni* and *Penaeus monodon* showed preference for the midpoints of these environmental gradients (see values in Figure 61). Two species which preferred sandy substrates in deep waters were *Parapenaeopsis gracillima* and *Penaeus japonicus*.

3.7.4 Crabs

Results of the CCA showing the relationships between the environmental factors (water and sediment variables) and abundance of crab species are shown in Table 29 and Figure 62. The eigenvalue for axis 1 (0.12), axis 2 (0.12), axis 3 (0.10), and axis 4 (0.06) accounted for 33.5%, 20.1%, 16.6%, and 9.3% of the total variance in the data respectively.

Only six of 12 environmental variables namely, dissolved oxygen, salinity, percent clay, percent silt, percent organic matter and sediment pH showed statistically significant ($p<0.05$) relationships with crab abundance. The species-environment correlation were 0.98 and 0.96 for axis 1 and axis 2 respectively (Table 29).

The distribution of crab species abundance along the CCA axes indicates that species of different families were different in their response to dissolved oxygen, salinity, sediment pH and substrate type, particularly the amount of clay, silt and organic matter content. Essentially the crabs were distributed along two opposing environmental gradients; sediment pH, oxygen and salinity on one side and organic matter, clay and silt content on the other (Figure 62).

The one only *Matuta* sp. of the family Calappidae was abundant in high salinity water, where dissolved oxygen was rich and sediment pH was high. Two species of Dorippidae, *Heikea japonica* and *Neodorippe callida* and one species of the Majidae, *Doclea canalifera*, were more abundant in sediment with high clay, silt and organic matter content. However, another species of Majidae, *Doclea ovis*, preferred low clay-silt substrates in high salinity water.

The Portunidae namely, *Thalamita crenata, Charybdis variegata, Portunus pelagicus* and *Charybdis feriata* generally had higher abundance in high salinity water rich in oxygen but low in silt, clay and organic matter content. However, two other portunids, *Scylla serrata, Charybdis callianassa* and *Charybdis natator* preferred clay-silt substrates that were higher in organic matter (Figure 62). Like the latter three portunid species, the xanthid species, *Parapanope singaporensis* preferred substrates comparatively richer in clay, silt and organic matter.

The two species of horse-shoe crabs (Merostomata), *Carcinoscorpius rotundicauda* and *Tachypleus gigas*, were more abundant in clayey-silt substrates that were higher in organic matter, in less saline water (Figure 62).

Table 29. Results of the canonical correspondence analysis showing the relationship between crab species abundances with only the statistically significance environmental variables in Klang Strait.

Canonical coefficients for standarised variable:	Axis1	Axis2
Dessolved oxygen	0.72	0.71
Salinity	0.28	-0.71
Clay %	-0.71	-0.77
Organic matter coentent	0.42	-0.12
Silt %	0.43	0.59
Soil pH	0.22	0.11
Inter-set correlation of environmental varibles:	**Axis1**	**Axis2**
Dessolved oxygen	0.67*	0.26
Salinity	0.66*	-0.40
Clay %	-0.65*	-0.20
Organic matter coentent	-0.61*	-0.19
Silt %	-0.58*	-0.32
Soil pH	0.57*	0.23
Summary statistics for two axes	**Axis1**	**Axis2**
Eigenvalue	0.20	0.12
Fractions of species-environmental variation explained	33.27	20.1
Species-environment correlations	0.98	0.96

* Significant at $p<0.05$

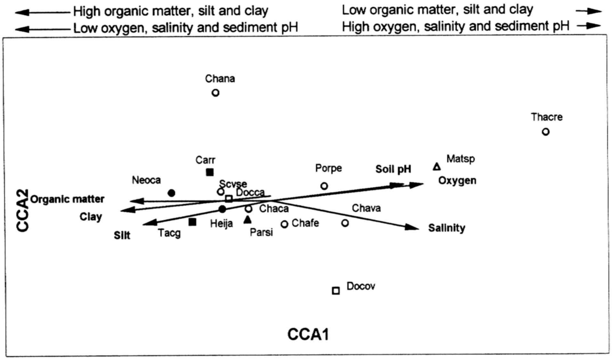


Fig. 62: CCA ordination biplot showing the statistically significant environmental variables (arrows) and the crab species. See Table 6 for species code.

△ Calappidae, ● Dorippidae, ▫ Majdae, ○ Portunidae, ▲ Xanthidae, and ■ Merostomata. species, 3.7.5 Cephalopoda, Stomatopoda, and Echinodermata species

Results of CCA of the relationships between the environmental factors and abundance of Cephalopoda, Stomatopoda and Echinodermata species are given in Table 30. The eigenvalues of CCA, for axis 1 (0.16), axis 2 (0.09), axis 3 (0.05), and axis 4 (0.04) accounted for 41.1%, 23.5%, 13.2%, and 8.6% of the variance in the data respectively.

Five of 12 measured environmental variables, namely salinity, percent clay, percent silt, percent organic matter and water depth showed statistically significant relationships with the abundance of the cephalopods, stomatopods and echinoderms (Fig. 63). The species-environment correlations were 0.99 and 0.95 for axis 1 and axis 2 respectively.

The cuttlefish *Sepia esculenta* and squid *Loligo edulis* responded equally to the environmental factors (at their midpoints), while the *Octopus* sp. preferred slightly higher salinity and deeper water (Figure 63).

The stomatopods, *Harpiosquilla harpax* and *Oratosquilla perpensa*, were generally more abundant in higher salinity and deeper waters, than another species *Oratosquilla interrupta* which was more abundant in shallow waters (Fig. 63).

Echinoderms such as the sea urchins, *Lovenia elongata* and *Salmacis dussumieri*, and the starfish *Luidia penangensis* were abundant in substrates richer in clay, silt and organic matter, in deeper waters. However, the unidentified species of sea cucumber belonging to the Malpodinae preferred substrates high in clay, silt and organic matter

Table 30. Results of the canonical correspondence analysis showing the relationship between cephalopoda,stomatopoda and echinoderms species abundances with only the statistically significance environmental variables in Klang Strait.

Canonical coefficients for standarised variable:	Axis1	Axis2
Salinity	-0.40	-0.26
Organic matter coentent	-0.36	-0.20
Clay %	-0.26	-0.12
Depth	-0.70	-0.16
Silt %	0.22	0.84
Inter-set correlation of environmental varibles:	**Axis1**	**Axis2**
Salinity	0.89*	-0.20
Organic matter coentent	-0.81*	-0.14
Clay %	-0.75*	-0.42
Depth	0.11	-0.82*
Silt %	-0.65*	-0.23
Summary statistics for two axes	**Axis1**	**Axis2**
Eigenvalue	0.16	0.09
Fractions of species-environmental variation explained	41.1	23.5
Species-environment correlations	0.996	0.95

* Significant at $p<0.05$

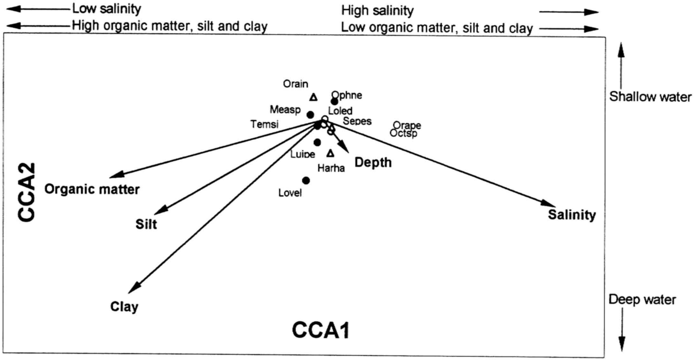


Fig. 63. CCA oridination biplot showing the statistically significant environmental variables (arrows) and the ○ Cephalopoda, △ Stomatopoda, and ● Echinodermata species. See Table 6 for species code.

in shallow waters. The brittle-star *Ophiotrichoides nereidina,* were more abundant in shallow waters low in silt-clay sediments.

In general, echinoderms were more abundant in substrates characterised by higher clay, silt and organic matter content. Cephalopod species were generally not significantly affected by these environmental factors. However, stomatopods were affected by salinity and water depth (Figure 63).