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Diversity and Abundance of Fish and Invertebrates of Semerak Estuary and Adjacent Inshore Waters, Kelantan.

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ABSTRACT Construction of the Tok Bali channel-jetty and channelization of the Semerak River in Bachok had removed and reduced its fringing mangroves, nevertheless, the river modification has improved estuarine circulation. There was invasion of the estuary by at least 59 marine and euryhaline species, including 47 fish species, but prawn and crab fauna were poor. The fish in the estuary included economically-important species of leiognathids, lutjanids, catfishes, barracudas, pomfrets and squids. Bachok's coast provides habitat, feeding and nursery areas to mainly juveniles of 71 fish and 22 invertebrate species. Leiognathids, mullids, cephalopods and portunid crabs were the dominant coastal fishes and invertebrates. The coastal fish fauna including a few reef-associated species was much richer (59 species) to the north of Tok Bali jetty than south of it (16 species). The Leiognathidae with eight species displayed clear spatial distribution from coastal to estuarine waters.

ABSTRAK Pembinaan terusan-jeti Tok Bali dan pelurusan Sungai Semerak di Bachok telah mengakibatkan kehilangan hutan bakau tebing sungai di kawasan sekitarnya. Walaupun bagaimanapun, pengubahsuaian sungai ini telah memperbaiki peredaran air di muara. Terdapat invasi kawasan muara oleh sekurang-kurangnya 59 spesis eurihalin, termasuk 47 spesis ikan, namun demikian bilangan fauna ketam dan udang adalah rendah. Spesies ikan yang ditemui di muara termasuklah spesis yang penting dari segi ekonomi seperti leiognatid (kekek), lutjanid (jenahak), catfish (ikan duri), barracuda (alu-alu), bawal dan sotong. Pesisiran Bachok menyediakan habitat, serta kawasan nurseri dan pemakanan bagi 71 spesies ikan juvenil dan 22 spesis invertebrata. Leiognathid (kekek), mullid (belanak), sotong dan ketam portunid merupakan ikan dan invertebrata pesisir yang utama. Kepelbagaian fauna ikan, termasuk beberapa spesis yang berkait dengan terumbu karang adalah lebih tinggi (59 spesies) di utara Tok Bali berbanding bahagian selatan. Spesis ikan kekek menunjukkan taburan spatial yang jelas dari pesisir ke muara sungai.

(**Keywords:** fish and invertebrates, mangroves, inshore waters, Semerak River, Bachok coast, Kelantan)

INTRODUCTION

Linkages between mangroves and fisheries have been well documented in Malaysia [1] and throughout the world [e.g. 2, 3, 4, 5]. In peninsular Malaysia, most mangrove fish and invertebrate studies have mainly focused on its west coast where mangroves are the dominant coastal habitats, e.g. Langkawi [7, 8] and Merbok [9, 10] in Kedah; Dinding [11] and Matang [12, 13, 14, 15, 16] in Perak; Klang [17, 18, 19, 20] and Kuala Selangor [21] in Selangor; and Sungai Pulai and Sungai Johor in Johor [22]. Excluding Johor, the east coast of the peninsula has a total of only 3,711 ha of mangrove reserves with 3,286 ha of stateland forest as opposed to respectively 65,195 ha and 7,042 ha on the west coast [23]. Most of Johor's reserved and stateland mangroves (17,185 + 3,348 ha) are located on the southern end of the peninsula. The state of Kelantan located at the northeastern region of peninsular Malaysia has no mangrove reserve but stateland mangrove forests of 744 ha [23] are found inside the various estuaries including that of the Semerak river.

Kelantan's annual fisheries catch amounted to 46,494 tonnes in 2005 [24]. It may be stated that mangroves will have little influence on Kelantan's coastal fisheries which appear to depend heavily on pelagic fish. Nevertheless, as in the case of northern Pahang, sheltered coastal bays, lagoons and estuaries may be important nursery or feeding areas for demersal fishes including spawning grounds for squids and cuttlefish [25].

The objective of this study was to determine the diversity and abundance of the Semerak estuary and adjacent nearshore waters along Bachok's coast in Kelantan. This study formed part of an expedition to Bachok, organized by the Institute of Ocean & Earth Sciences (IOES), University of Malaya (UM), from 14-20 June 2008. The main purpose of this expedition was to discover and inventorize the biodiversity of Kelantan's coastal environment, particular that of the district of Bachok where the IOES has recently set up its marine station (UMBMS) at Kuala Rekang.

MATERIALS AND METHODS

Study area

From its headwaters near Kg. Gong Jelor (5° 52.5'N, 102°23.5'E), the Semerak River meanders its way along the southern borders of Pasir Putih and Bachok districts down to the Kelantan coastline. The river drains through patchy secondary lowland forests and swamps, as well as supplying irrigation water to padi fields and coconut plantations. Extensive sand spits and dunes have almost closed the original entrance of the estuary, thus creating a shallow lagoon at the river mouth. This lagoon is heavily used for floating fish cage, pen and pond culture.

Estuarine flushing of the river is now maintained through the construction of a 1km - long by 0.3km wide dug-through channel from the river at Tok Bali, across the coastal strip to the sea. The channel continues upstream along a straight path from Tok Bali jetty to about 7.5km upstream where a tidal barrage (N5°50.9', E 102°26.3') impounds the river water upstream of it (Figure 1). The barrage thus marks the upper limit of the altered Semerak estuary. The channelization process cuts off the natural meandering section of the Semerak River from Kg. Hutan Beris to Gong Tok Yah. The upper channel from the latter to the barrage has a width of 0.15km. The deep and wide Tok Bali channel with its extended jetties allows the passage of large boats.

The entire Bachok coastline is lined by a narrow sandy beach backed by mainly coconut plantations. Mangrove forest patches are found around the Semerak lagoon, extending upstream to near Tok Bali jetty where the best patches are found just south of it. The river channelization process had removed most of the mangroves along it, with only patchy narrow fringes or remnants surviving along the river up to the tidal barrage. Twenty-one sampling stations were established in the Semerak and Rekang estuary and adjacent coastal waters of Bachok. Their GPS positions (Table 1) were recorded using a GARMIN Rhino 130. Stations 1-5 were located on the northern section of the coast from Tok Bali jetty, varying from 0.5 - 3 km, off Kuala Rekang (stations 1,2) off Kuala Kandis (station 3) and off Kg. Tok Kedarat (stations 4) and off Kg. Pak Ya'akob (5) (Figure 1). Water depths varied from 4-7m. In the southern coastal section, the four stations were located off Tok Bali jetty (station 6), off Kg. Tok Bali (station 7), off Kg. Kuala Semarak (station 8) and off Kg. Dalam Ru (station 9), the latter located about 3km from the state border between Kelantan and Terengganu.

Sampling stations within the Semerak estuary in water depths varying between 4-6m included five stations from Kampong Mak Yong (station 10) upstream to the tidal barrage (station 14); the sixth station near Kg. Ketik Buloh (station 15) was the farthest downstream. Samplings were also conducted at Semerak lagoon (stations 16-19, 4m depth). Rekang estuary (station 20, 1.5m) and the surf zone (station 21, 1.2m) near its mouth were the northern most stations sampled. At the time of sampling, the small Rekang river in the dry season did not flow out to the sea. Shifting berms or sand dunes which characterized the east coast often blocked off the access of small rivers. The Rekang sites, near to the IOES marine station, were however not the main focus of the present study.

Sampling methods

The main fish sampling gear used was a commercial otter trawl with a head rope length of 16m and codend stretched mesh size of 2 cm. At sampling station, the trawl net was deployed and fished for variable durations of 10-30 min during day time (Table 1). Longer trawling time was taken at coastal stations to cover a longer trawl over distance, whereas in the estuary shorter times were taken because adjacent stations were closer to each other. The ground speed of the boat during fishing was estimated by the chip board cast method and validated by GPS.

Since the trawl boat could not approach the lagoon due to the bridge across the river at Kg. Cherang Ruku, the sampling methods adopted at Semerak lagoon were the use of a gill net, 3-layered trammel net and beam trawl. The gill and trammel nets measured 180 x 3m and 90 x 2m (L x D) with mesh sizes of 2.5" and 6"-1.75"-6" respectively. The beam trawl had a fixed width of 2 m and codend mesh size of 0.5". A cast net and beach seine were used at the small Rekang river and the beach fronting UMBMS, respectively.

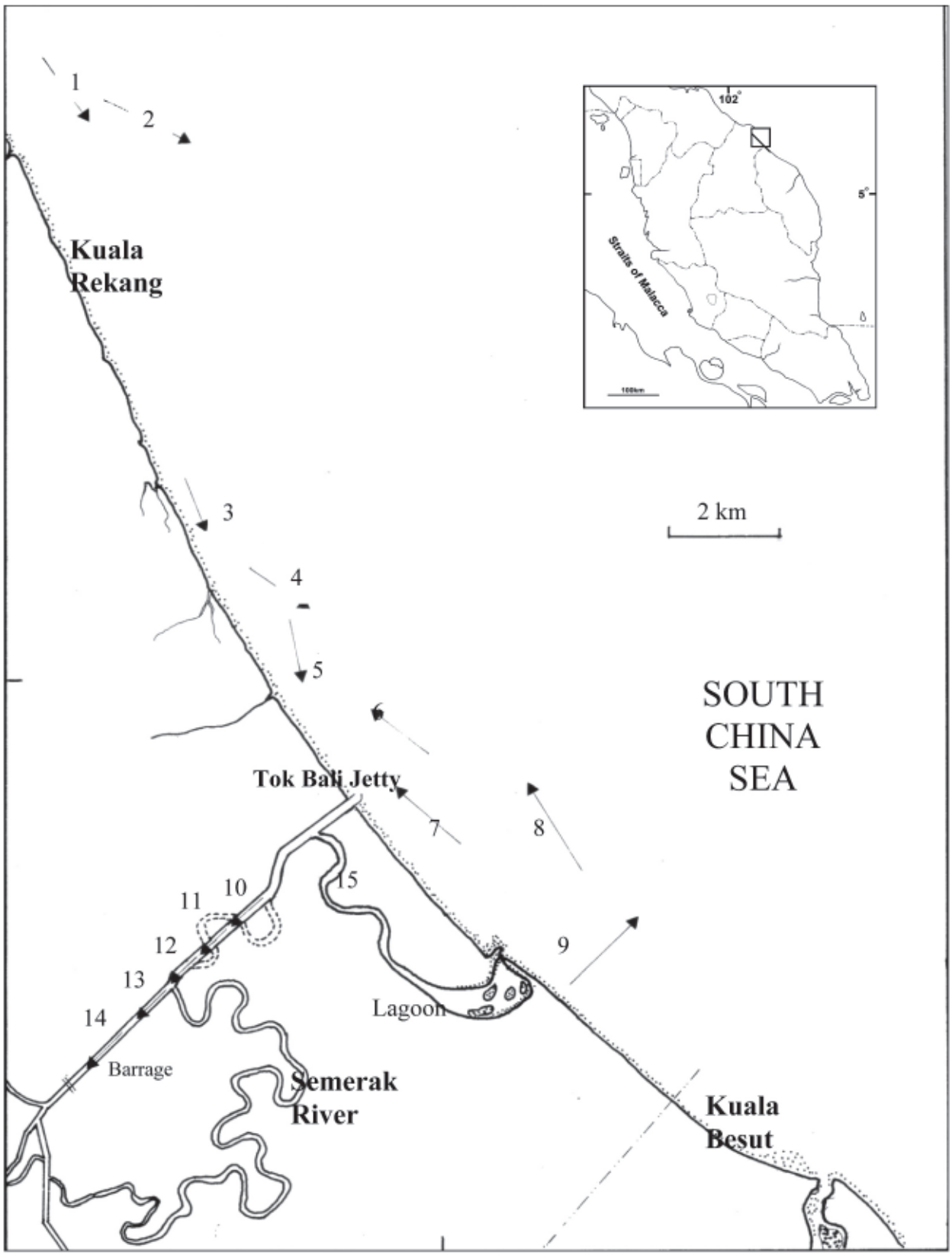

Figure 1. Map showing trawling stations (1 – 15) along Semerak River and coastal waters of Bachok, Kelantan. Arrow head indicates end of trawl. Inset shows study area (boxed) in Kelantan, peninsula Malaysia.

Table 1. Sampling information of Bachok (Kelantan) coastal fish and invertebrate study.

Location	Date	Station	Sample	Start * Longitude	Latitude	End* Longitude	Latitude	Depth (m)
Northern	16-Jun-08	1	N1	102.42785	6.03517	102.43388	6.02636	
Coast	16-Jun-08	2	N2	102.42963	6.03318	102.44990	6.02374	
	16-Jun-08	3	N3	102.45570	5.95133	102.45765	5.94562	5.0
	16-Jun-08	4	N4	102.47267	5.93714	102.47691	5.92926	6.6
	16-Jun-08	5	N5	102.47079	5.92522	102.47402	5.91734	4.4
Southern	15-Jun-08	6	S4	102.49717	5.91232	102.48631	5.91855	
Coast	15-Jun-08	7	S1	102.49157	5.90110	102.50424	5.88935	
	15-Jun-08	8	S2	102.50745	5.89303	102.52170	5.88319	
	15-Jun-08	9	S3	102.52299	5.85526	102.53502	5.87294	
Estuary	17-Jun-08	15	R6	102.48162	5.88500	102.47845	5.88096	4.2
	17-Jun-08	10	R1	102.46888	5.87863	102.46297	5.87593	4.4
	17-Jun-08	11	R2	102.46291	5.87573	102.45727	5.87101	5.3
	17-Jun-08	12	R3	102.45891	5.87248	102.45461	5.86796	4.1
	17-Jun-08	13	R4	102.45573	5.86603	102.44837	5.86097	5.8
	17-Jun-08	14	R5	102.44599	5.85811	102.44144	5.85284	6.1
Sg. Rekang (surf zone)	18-Jun-08	21	B1, B2	102.42735	6.00722			1-2
Semerak Lagoon	19-Jun-08	18	M(2), G(2)	102.50962	5.86290			4.0

* Start and End indicate start and end GPS positions of otter trawl hauls (N1-N5, S1-S4, and R1-R6).

All fish and invertebrate catches were taken whole, but subsampled if the catch was too large. Only the Leiognathidae were sub-sampled because their catches were superfluous at some stations. Fish samples were immediately chilled in ice kept inside a Coleman ice-chest.

Water parameters were measured in-situ by an YSI 556MPS meter, which included salinity (ppt), conductivity (mS cm^{-1}), temperature (^oC), pH and dissolved oxygen (mg l^{-1}). Water depth (m) at station was measured by a Speedtech M5 hand-held echosounder.

At base camp, all fish and invertebrates were immediately identified to the species level using relevant taxonomic keys [26, 27, 28, 29, 30, 31]. Difficult species were tagged and preserved in 10% formaldehyde kept in lidded, 5-gallon plastic tubs. After identification, all specimens of the same species were counted and weighed together. Minimum and maximum standard lengths (SL) were measured. Unidentified species were photographed with high resolution digital camera, and brought back to UM's laboratory for further identification and confirmation. The valid fish species name as given in Fishbase [32] was adopted.

Quantification

The following diversity indices with their usual notations were computed for the estuarine and coastal fish and invertebrate communities (except the Rekang sites) Margalef's species richness (D_a) = $(s-1)/\log_e N$; Shannon-Weiner's diversity index (H') = $-\sum p_i \log_e p_i$; Maximum diversity (H'_{max}) = $\log_e s$, and Pielou's evenness index (J') = H'/H'_{max}, where s = number (no.) of species, N= total number of specimens and p_i = proportion of the i^{th} species.

Fish density (no. ha^{-1}) and biomass (kg ha^{-1}) were computed using the swept area method with a fish retention ratio of 0.5 as recommended for tropical trawl surveys [33]. The method also recommends calculation of the swept area width as half the headrope length, i.e. in the present case, 8m.

The fish and invertebrate lists of the estuary and coastal waters were compared by computing Jaccard's coefficient of community, given by S = a/j, where a = no. of species in common, j = total no. of species excluding species absent in both communities.

Table 2. Water parameters measured at Semerak Estuary and Bachok's coastal waters (15-19 June 2008).

Location	Station	Date	Time	Depth layer	Temp (°C)	Cond (mS/cm)	TDS (g/L)	Sal (ppt)	DOsat (%)	DO (mg/L)	pH
Northern Coast	1	16-Jun	10:51	surface	30.93	56.88	33.21	33.37	80.47	4.99	7.91
		16-Jun	10:51	surface	0.11	0.03	0.06	0.06	1.16	0.08	0.13
	2	16-Jun	11:58	surface	31.33	57.12	33.12	33.25	81.30	5.01	8.06
		16-Jun	11:58	surface	0.30	0.25	0.03	0.04	0.62	0.06	0.00
	2	16-Jun	11:59	bottom	31.08	56.88	33.12	33.26	81.33	5.03	8.07
		16-Jun	11:59	bottom	0.36	0.28	0.04	0.06	0.82	0.08	0.01
	3	16-Jun	13:11	surface	31.58	57.58	33.24	33.38	84.40	5.18	8.05
		16-Jun	13:11	surface	0.02	0.01	0.01	0.01	0.10	0.01	0.03
	3	16-Jun	13:11	bottom	31.57	57.55	33.24	33.37	84.53	5.19	8.09
		16-Jun	13:11	bottom	0.00	0.01	0.00	0.00	0.12	0.01	0.00
	4	16-Jun	14:19	surface	30.84	55.36	32.37	32.42	88.43	5.52	7.71
		16-Jun	14:19	surface	0.55	0.02	0.30	0.36	0.32	0.02	0.14
	4	16-Jun	14:19	bottom	31.22	56.77	32.99	33.11	89.67	5.54	8.03
		16-Jun	14:19	bottom	0.17	0.27	0.26	0.29	0.12	0.01	0.03
	5	16-Jun	15:01	surface	31.74	49.68	28.61	28.21	131.57	8.30	8.07
		16-Jun	15:01	surface	0.49	0.88	0.38	0.41	55.29	3.57	0.14
	5	16-Jun	15:01	bottom	31.54	55.98	32.35	32.37	96.53	5.96	8.13
		16-Jun	15:01	bottom	0.17	1.06	0.70	0.80	1.36	0.10	0.01
	5	16-Jun	15:27	surface	32.37	34.19	19.48	18.40	96.48	6.34	8.03
		16-Jun	15:27	surface	0.02	0.14	0.08	0.09	0.33	0.02	0.01
Southern Coast	6	15-Jun	15:35	surface	32.22	52.37	29.95	29.63	88.43	5.49	7.17
		15-Jun	15:35	surface	0.07	0.23	0.11	0.18	0.32	0.02	0.82
	7	15-Jun	12:03	surface	31.28	57.60	33.43	33.60	89.13	5.49	7.72
		15-Jun	12:03	surface	0.01	0.01	0.00	0.00	0.21	0.01	0.33
	8	15-Jun	13:08	surface	31.54	57.79	33.40	33.55	87.10	5.34	7.95
		15-Jun	13:08	surface	0.07	0.02	0.05	0.05	0.10	0.01	0.16
	9	15-Jun	14:06	surface	32.03	57.89	33.18	33.29	85.17	5.20	8.00
		15-Jun	14:06	surface	0.03	0.12	0.08	0.10	0.68	0.04	0.03
Semerak River	10	17-Jun	9:59	surface	30.94	32.55	20.78	19.99	64.37	4.28	7.40
		17-Jun	9:59	surface	0.44	18.46	9.54	10.10	8.91	0.46	0.49
	11	17-Jun	10:29	surface	31.27	32.46	22.74	21.95	60.70	3.96	7.51
		17-Jun	10:29	surface	0.01	0.17	6.65	7.15	11.61	0.58	0.38
	11	17-Jun	10:29	bottom	31.45	52.72	30.54	30.35	74.27	4.64	7.97
		17-Jun	10:29	bottom	0.01	0.18	0.07	0.08	0.12	0.01	0.01
	12	17-Jun	11:07	surface	31.43	27.00	15.63	14.46	54.30	4.02	7.50
		17-Jun	11:07	surface	0.02	0.57	0.33	0.33	0.10	0.55	0.42
	12	17-Jun	11:07	bottom	31.49	53.34	30.84	30.69	72.90	4.26	7.64
		17-Jun	11:07	bottom	0.03	0.79	0.48	0.53	0.36	0.48	0.33

	13	17-Jun	11:59	surface	31.70	24.21	13.95	12.77	58.93	4.04	7.20
		17-Jun	11:59	surface	0.01	0.43	0.25	0.25	0.21	0.02	0.01
	13	17-Jun	11:59	bottom	31.54	53.95	31.17	31.05	55.50	3.46	7.89
		17-Jun	11:59	bottom	0.00	0.02	0.01	0.02	0.20	0.01	0.00
	14	17-Jun	12:24	surface	31.87	33.91	13.68	12.53	71.43	4.87	7.32
		17-Jun	12:24	surface	0.28	17.38	0.09	0.07	0.21	0.01	0.01
	14	17-Jun	12:26	bottom	31.66	54.69	30.63	31.45	63.40	3.93	7.92
		17-Jun	12:26	bottom	0.01	0.01	0.03	0.01	0.17	0.01	0.00
	15	17-Jun	13:03	surface	31.95	38.49	22.09	21.15	102.10	6.66	8.01
		17-Jun	13:03	surface	0.02	0.02	0.00	0.00	0.85	0.06	0.02
	15	17-Jun	13:05	bottom	31.14	54.43	31.67	31.62	73.33	4.57	8.06
		17-Jun	13:05	bottom	0.00	0.03	0.02	0.02	0.06	0.01	0.00
Semerak Lagoon	16	19-Jun	10:39	surface	31.05	43.59	25.40	24.73	39.63	2.57	7.46
		19-Jun	10:39	surface	0.02	0.01	0.00	0.01	0.75	0.05	0.00
	16	19-Jun	10:40	bottom	30.88	43.56	25.45	24.78	32.93	2.14	7.43
		19-Jun	10:40	bottom	0.01	0.00	0.01	0.01	1.27	0.08	0.01
	17	19-Jun	10:56	surface	31.43	43.70	25.31	24.61	69.97	4.52	7.82
		19-Jun	10:56	surface	0.06	0.02	0.01	0.01	0.15	0.01	0.01
	17	19-Jun	10:57	bottom	31.38	43.97	25.48	24.79	67.33	4.32	7.79
		19-Jun	10:57	bottom	0.01	0.01	0.01	0.01	0.32	0.05	0.00
	18	19-Jun	11:31	surface	31.67	43.97	25.35	24.65	85.03	5.46	7.92
		19-Jun	11:31	surface	0.00	0.01	0.00	0.00	0.06	0.01	0.00
	18	19-Jun	11:32	bottom	31.65	49.19	28.37	27.94	41.23	2.60	7.75
		19-Jun	11:32	bottom	0.00	0.01	0.01	0.01	0.35	0.03	0.00
	19	19-Jun	11:46	surface	31.49	43.77	25.31	24.61	69.67	4.49	7.80
		19-Jun	11:46	surface	0.01	0.00	0.00	0.00	0.06	0.00	0.01
	19	19-Jun	11:47	bottom	30.77	44.30	25.94	25.31	38.93	2.53	7.58
		19-Jun	11:47	bottom	0.00	0.00	0.00	0.00	0.06	0.00	0.00
Rekang surf zone	21	18-Jun	17:23	surface	32.32	57.84	33.00	33.08	82.73	5.03	8.08
		18-Jun	17:23	surface	0.06	0.02	0.01	0.01	0.32	0.02	0.01

Temp = temperature, Cond = conductivity, TDD = total dissolved solids, Sal = salinity, DOsat = dissolved oxygen (% saturation); DO = dissolved oxygen (mg/L). For each station, first row indicates mean, second row indicates standard deviation (n=3).

RESULTS AND DISCUSSION

Water parameters

Mean (±SE) surface and bottom temperature, conductivity, total dissolved solids, salinity, dissolved oxygen and pH values recorded at the various locations and stations are given in Table 2. At Semerak estuary, the mean surface salinity increased from 12.53 ppt (Station 14) near the tidal barrage to 21.15 ppt near to Kg. Ketik Buloh (Station 15) on the downstream. Further downstream at Semarak lagoon (river mouth), mean salinity varied little between 24.61 ppt to 24.73 ppt. Mean bottom salinity readings were high and consistent from upstream to downstream, ranging from 30.05 ppt to 31.62 ppt, indicating a partially-mixed estuary to a well-mixed one, e.g. Semerak lagoon. Mean surface TDS (13.68 - 21.15 mS cm^{-1}) and pH (7.32 - 8.01) followed the same trend as salinity, increasing from upstream to lagoon. Mean surface temperature remained consistent at about 31 – 32^{o}C, while mean surface dissolved oxygen ranged between 4 – 7mg l^{-1}, with sufficient oxygenation at the bottom for most marine life (not less than 3.5 mg l^{-1}).

Coastal waters away from river mouths had high surface salinities that exceeded 33 ppt. Near to the Tok Bali jetty entrance, the mean salinities recorded at two occasions were 28.21 ppt and 29.63 ppt. Sea surface temperatures ranged from 30.84 ppt to 32.03 ppt, while DO and pH levels were generally higher than in the estuary or lagoon.

There is no published record of the estuarine circulation in Semerak River prior to channelization and construction of the Tok Bali jetty, but its sinuous morphology suggests a weak, slow flowing river with little tidal exchanges due to massive sand blockage at its mouth. Construction of the by-pass (deep channel) and jetty at Tok Bali appears to have improved its estuarine circulation at present.

Species diversity, composition and abundance

Community indices

The various indices for the fish and invertebrate communities of Semerak estuary and adjacent coastal waters are tabulated in Table 3. A total of 47 fish and 12 invertebrate species were sampled from Semerak estuary (and lagoon), while in the near coastal waters there were 71 and 22 species respectively.

Table 3. Community indices of Bachok's coastal water and Semerak Estuary.

INDEX *	S	D	H'	J'	H'_{max}
COAST					
Whole Community	93	10.92	3.12	0.69	4.53
Fish	71	8.31	2.80	0.66	4.26
Invertebrate	22	3.10	1.90	0.62	3.09
ESTUARY					
Whole Community	58	7.61	2.20	0.54	4.06
Fish	47	6.15	2.14	0.56	3.85
Invertebrate	12	3.61	2.03	0.82	2.48

S = number of species, D_a = Margalef species richness, H' = Shannon-Weiner diversity index, J' = Pielou's evenness, H'_{max} = maximum diversity.

The species numbers and diversity indices (H', H' max) for fish in Semerak estuary (s=47, D= 6.15, H'=2.14, H'_{max} = 3.85) were low and comparable to the Dinding estuary (49, 2.87, 3.89) of Perak, where a similar situation of degraded mangroves occurs [22]. The low diversity is attributed to the presence of high numbers of certain dominant families (see below) as evident from the low evenness value (0.56). Relatively undisturbed mangrove swamps of Matang (Perak) had corresponding higher values of 89, 7.58, 3.66 and 4.47 respectively.

The coastal fish community indices (s = 71, D=8.31, H'=2.80, H'_{max}=4.26) of Bachok had comparable or higher values than that of northern Pahang's richest coastal waters at Chendur (47, 7.32, 2.52, 3.85) [25] and Klang coastal waters (58, 7.71, 2.78, 4.06) [19].

Macroinvertebrate species richness and diversity were low for both estuarine (3.61, 2.03) and coastal waters (3.1, 1.9). These values were about similar to the highest obtained from the coastal waters off the mouth of the Kuantan River to Tanjung Pelindung (3.2, 1.9) [25].

Semerak estuary

At the lower reaches of the river (station 15) just before it opens into the enclosed lagoon at Kuala Semerak, the highest number of species (31) were sampled. The fish comprised of 24 species which were dominated by the Leiognathidae, commonly called ponyfishes or ikan kekek (>2,000 indiv. ha^{-1}; 80% of total). The mainly juvenile fish (2 -13.5cm SL) were five species ranked as follows: *Secutor ruconius, Leiognathus brevirostris, L. splendens, L. equulas* and *Gazza minuta* (Table 4, Figure 2). Highly valuable commercial fish included the Chinese pomfret (*Pampus chinensis*, 13.7-15.1cm), silver pomfret (*P.argenteus*, 14.6cm), largetooth flounder (*Pseudorhombus arsius*) and the mangrove snapper (*Lutjanus johnii*, 15.5-10cm). A rare find is the highly venomous stonefish, *Leptosynanceia asteroblepa* (Figure 3). Seven species of juvenile invertebrates were sampled, which included starfish (*Astropecten vappa*), crabs (*Portunus pelagicus, Charybdis japonica*, *Thalamita crenata* and Doriipidae), squids (*Loligo* sp.) and prawns (*Metapenaeus lysianassa* and *M. mastersii*).

In the channelized part of the river at Kg. Pak Mayong (Station 10), 13 species of fish with no invertebrates were sampled. As in the lower station, the fish community comprised of mainly species of the Leiognathidae (>1000 indiv. ha^{-1}), constituted by mainly juveniles (2-8.2cm SL) of the above stated species. Other abundant fish included the estuarine pufferfish (*Tetraodon fluviatilis*) and catfishes (*Arius*

Table 4. List of fish and invertebrate species, their abundance (number/ha) and body size (SL, cm), as sampled from Semerak Estuary and Bachok coastal waters, Kelantan. numbers in parentheses indicate actual numbers.

	SOUTHERN COAST							NORTHERN COAST							SEMERAK ESTUARY									SEMERAK LAGOON	REKANG SURF	REKANG ESTUARY
SAMPLING METHOD*	T	T	T	T				T	T	T	T	T			T	T	T	T	T	T				G, B	N	C
STATION	6	7	8	9		Size		1	2	3	4	5		Size	10	11	12	13	14	15		Size		16-19	21	20
SAMPLE	S4	SI	S2	S3	Average	Min	Max	N1	N2	N3	N4	N5	Average	Min Max	R1	R2	R3	R4	R5	R6	Average	Min	Max	M=2; G=(2)	B1, B2	C1,C2,C3
SPECIES																										
Fish																										
Alectis indicus			2		0.59	16.9	17.4									3					0.53	19.0				
Alepes djedaba			30		7.62	9.5	11.6			9		14	5.57	4.0 5.6											(1)	
Allenbatrachus grunniens																				3	0.58	16.0				
Apogon ellioti											6		1.49													
Apogon quadrifasciatus									188		22		52.45	3.8 5.0												
Arius arius												3	0.68	13.5	43	1590	777				401.67	6.5	20.5			
Arius oetik																6					1.05	14.7	16.3			
Arius maculatus										134			33.41	6.6 10.0												
Arius sagor																									(1)	
Arius venosus															7	32	107				24.15	8.6	15.7			
Callionymus sagitta									14	86	12	3	28.69	3.5 10.0												
Caranx ignobilis															3						0.55	18.0				
Carcharhinus sorrah				4	0.89																					
Chanos chanos																										(1)
Cynoglossus bilineatus										22	2	14	9.30	8.4 15.6												
Cynoglossus lingua									1	4	2		1.92	4.8 9.5												
Cynoglossus puncticeps									1	4			1.43	10.1 10.2												
Cynoglossus, sp A												3	0.68	9.8												
Dasyatis zugei										17			4.31	23.0 29.6												
Dendrophysa russelii												8	2.05	8.8 10.2		16	6	3		7	5.40	4.3	11.3			
Drepane longimana										9			2.16	9.9 10.7												
Drepane punctata																6		3			1.59	13.1				
Dussumieria acuta									10				2.44	1.1 1.4												
Ephippus orbis									1				0.35	1.1												
Epinephelus coioides																3		7			1.61	11.0	11.5			
Escualosa thoracata										103			25.86	7.2 7.6					3		0.54	7.4				
Fistularia petimba									1				0.35	1.6												
Gazza minuta		506			126.41		7.6			9		16	6.25	5.5 7.9	39	19				7	10.88	4.2	5.6		(1)	
Gerres erythrourus																3	3				1.06	9.4	10.1			
Gerres filamentosus						3.6				4		11	3.81	7.2 8.0						10	1.73	7.1	7.5	(1)	(1)	
Gerres oyena									1				0.35													
Glossogobius sparsipuppilus															7		3			7	2.79	5.1	5.9			
Gobiidae, sp. C																3					0.53	17.9				
Gobiidae, sp. D																								(1)		
Grammetobothis polyopthalmus											36		8.93	4.8 14.3												
Himantura walga												3	0.68	30.6						7	1.15	28.6	36.2		(1)	
Ilisha melastoma				2	0.59		10.7										3				0.54	8.1				
Ilisha sp (juvenile)	5				0.00	3.4																				
Johnius belangerii										4			1.08	11.4												
Johnius, sp 1										13			3.23	8.0 10.7												

	SOUTHERN COAST							NORTHERN COAST								SEMERAK ESTUARY									SEMERAK LAGOON	REKANG SURF	REKANG ESTUARY
SAMPLING METHOD*	T	T	T	T				T	T	T	T	T				T	T	T	T	T	T				G, B	N	C
STATION	6	7	8	9		Size		1	2	3	4	5		Size		10	11	12	13	14	15		Size		16-19	21	20
SAMPLE	S4	SI	S2	S3	Average	Min	Max	N1	N2	N3	N4	N5	Average	Min	Max	R1	R2	R3	R4	R5	R6	Average	Min	Max	M=2; G=(2)	B1, B2	C1,C2,C3
Johnius, sp 2										60			15.09	8.0	10.9												
Lagocephalus lunaris									74		12	5	22.79	4.4	8.3				3	3		1.08	3.6	4.5			
Lagocephalus sceleratus											56		13.89	5.0	7.0												
Leiognathidae , sp. 2		2								13			3.23	4.4	7.0												
Leiognathidae, sp A						6.1					976		244.05	4.3	6.8												
Leiognathidae, sp B												11	2.73	3.3	5.7												
Leiognathidae, sp. 1											10		2.48	5.4	6.5												
Leiognathus brevirostris										1547	4	161	428.03	4.5	7.0	309	444	240	117		857	327.93	3.0	6.9	(1)		
Equulites elongatus		63			15.73	2.5	3.5		379	224	333	1201	534.30	2.5	8.0												
Leiognathus equulus																303	323	359	16		111	185.20	2.4	13.5	(47),(66)		
Liza subviridis																										(1)	(3)
Equuiltes leuciscus						2.5	7.5			108	563	120	197.87	3.3	7.5												
Eubleekeria splendens			12188	507	3173.53	7.5	10.7					163	40.68	2.9	6.8	174	252	427	114		235	200.47	3.0	4.8			
Leptosynanceia asteroblepa																					3	0.58	12.7				
Lutjanus erythropterus (juvenile)									1				0.35	3.5													
Lutjanus johnii																33	13	3	7		31	14.39	7.8	19.7			
Megalaspis cordyla			6		1.46	12.7	16										6					1.05	12.8	13.2			
Nematalosa nasus																				3		0.54	10.2				
Nemipterus peronii									85	4	14		28.79	4.2	10.1												
Pampus chinensis																					3	0.58	14.9				
Panna microdon																		6				1.08	14.3	14.3			
Parastromateus niger				4	0.89	10.4																					
Pennahia anea										4			1.08	1.9						3		0.54	10.2				
Platycephalus indicus											2	8	2.55	14.8	70.5		3				3	1.10	13.6	33.4			
Platycephalus sp 1											4		0.99	4.7	15.8												
Plotosus lineatus																	202	311				85.40	8.9	12.5			
Pomadasys kaakan																	3					0.53	11.3				
Pomadasys maculatus										65			16.16	7.4	9.9												
Priacanthus tayenus											2		0.50	9.4													
Protonibea diacanthus										4			1.08	15.7													
Pseudorhombus sp.									1				0.35	4.1	14.2												
Pseudorhombus arsius									72		52	63	46.70	1.0	14.5			3			3	1.12	11.9	15.1			
Pseudotriacanthus strigilifer																					3	0.58	8.9				
Rastrelliger brachysoma			5		1.17	9.4	10																				
Sardinella frimbriata											6		1.49	8.0	8.5	46.05						7.68					
Saurida tumbil									47		19	36	25.47	5.0	15.2												
Sciaenidae juvenile																			10			1.63	3.4	5.1			
Scolopsis affinis									4				1.04	2.7	5.2												
Scomberoides tol																	9	6				2.65	9.0	19.8			
Secutor insidiator		90			22.38		3.2										13					2.10	2.0	3.0			
Secutor ruconius										159		435	148.55	2.6	6.2	434	1191	635	362	3	909	589.01	2.0	6.4			
Selaroides leptolepis	1		13	1	3.55	8.7	11.9				12	3	3.66	9.7	10.5												
Setipinna taty										4			1.08	8.8													
Sillago sihama									4	22			6.43	5.5	16.4			3			3	1.12	10.4	14.2		(1)	
Sphyraena barracuda						8.8										3	6					1.60	16.8	44.6			
Stolephorus commersonii		5			1.21		6.9			22			5.39	3.4	6.8				13		73	14.26	4.0	6.4			
Stolephorus sp A						6.8																					
Terapon theraps										4			1.08	9.1											(3)	(3)	
Tetraodon fluviatilis																132	85	3	3			37.18	8.5	12.5			
Thryssa hamiltonii																					31	5.17	2.4	9.1			

	SOUTHERN COAST							NORTHERN COAST							SEMERAK ESTUARY									SEMERAK LAGOON	REKANG SURF	REKANG ESTUARY
SAMPLING METHOD*	T	T	T	T				T	T	T	T	T			T	T	T	T	T	T				G, B	N	C
STATION	6	7	8	9		Size		1	2	3	4	5		Size	10	11	12	13	14	15		Size		16-19	21	20
SAMPLE	S4	SI	S2	S3	Average	Min	Max	N1	N2	N3	N4	N5	Average	Min Max	R1	R2	R3	R4	R5	R6	Average	Min	Max	M=2; G=(2)	B1, B2	C1,C2,C3
Thryssa mystax																				7	1.15	7.0				
Trichiurus lepturus				1.2	0.30	24.5				9			2.16	41.5 43.5						3	0.58	17.9				
Upeneus sulphureus	4	813	8	6	206.76	5.3	9.5		207	39	77	88	102.79	4.0 6.8												
Valamugil buchanani																									(1)	
Vespicula trachinoides												5	1.37	5.6												
Invertebrate																										
Anthozoa, sea pen									6		34	5	11.16													
Astropecten vappa											12	754	191.45							3	0.58					
Pitar citrinus												8	2.05											14, 8		
Tapes belcheri																								6,1		
Carcinoscopius rotundicauda																								(6), 1		
Charybdis affinis						43.2						3	0.68	4.9												
Charybdis anisodon												5	1.37	4.4												
Charybdis feriatus									3		2		1.19	6.8 9.2												
Charybdis japonica																				3	0.58	5.3				
Neodorippe sp.										4	2		1.57	3.9				3		35	6.29	1.7	7.7			
Harpiosquilla sp.											2		0.50	1.8												
Anomura, hermit crab 1										349	6	55	102.43					7			1.09					
Loligo duvacelli			11		2.64	7	14		38		20	55	28.02	1.9 15.5												
Loligo sp (squid)	6	129			32.36	4.4	22.4			56		19	18.79	4.6 10.8						3	0.58	4.6				
Matuta planipes																									(4)	
Metapenaeus brevicornis																	3				0.54	1.5				
Metapenaeus lysianassa																				3	0.58					
Metapenaeus mastersii																	10			7	2.77	1.2				
Metapeneus affinis												8	2.05	1.5 2.2												
Miyakea nepa										9		8	4.20	2.5 3.2												
Penaeus indicus										4			1.08	3.5										1		
Penaeus merguiensis										9			2.16	3.4 5.0												
Phylira sp.										4			1.08													
Placuna placenta												19	4.78	2.7 2.7												
Salmacis dussumieri									1			38	9.91													
Scylla sp																3					0.53	7.3				
Sepia aculeata											6		1.49	9.0 12.3												
Sepiella inermis									4			3	1.73	2.8 6.5												
Thalamita crenata																				3	0.58	5.5				
Thenus orientalis									3		14	3	4.85	2.1 3.2												
TOTAL SPECIES	4	7	8	7	18				24	36	31	36	78		13	24	19	14	5	28	55			9	10	2
TOTAL NO./HA	17	1608	12263	524	3598				1149	3142	2319	3355	2494		1533	4235	2910	668	16	2378	1957					

* T = Trawl, G = Gill /trammel Net, M = Beam Trawl, B = Beach Seine, C = Cast Net

Figure 2. Common ponyfish, *Leiognathus equula* (6.5cm SL)

Figure 3. Stonefish, *Leptosynanceia asteroblepa* (dorsal view, 12.7cm SL)

venosus, A. arius). Highly valuable commercial fish included the juveniles of the mangrove snapper (*Lutjanus johnii*, 7.8-19.7cm), giant trevally (*Caranx ignobilis*, 18cm) and reef barracuda (*Sphyraena barracuda*, 16.8-44.6cm).

Proceeding from Station 10 to stations further upstream, the number of fish species recorded was 25, 19, 14 and 5 at stations 11, 12, 13 and 14, respectively. The leiognathid fishes continued to dominate at all stations, except at Station 11 where the threadfin sea catfish (*Arius arius*, 6.5-20.5cm) alone (1590 ha^{-1}) outnumbered all other species. An interesting record is the striped eel catfish (*Plotosus lineatus*); juveniles (8.9-12.5cm) were abundantly caught from stations 11 to 12. They are the only eel catfish found in coral reefs, but are also known to be found in estuaries and open waters. According to Fishbase's notes [32], juveniles often form dense ball-shaped schools of about 100 fish, whereas adults (males up to 32 cm TL) are solitary or occur in smaller groups of around 20. Other commercially-important marine species recorded were juveniles of the Indian threadfish (*Alectis indicus*, 19cm), needlescaled queenfish (*Scomberoides tol*, 18.2-19.8cm), the torpedo scad (*Megalaspis cordyla*, 12.8-13.2cm) and orange-spotted snapper (*Epinephelus coioides*, 11.3cm). Low numbers and few species of fish were caught at the furthest station near the tidal barrage where the salinity was the lowest (12.5 ppt). The fish included the white sardine (*Escualosa thoracata*), Bloch's gizzard shad (*Nematolosa nasus*), greyfin croaker (*Pennahia anea*), green rough-backed pufferfish (*Lagocephalus lunaris*) and deep pugnose ponyfish (*Secutor ruconius*).

Invertebrate fauna were poor; the invertebrates sampled from only stations 11-13 were the mangrove mudcrab (*Scylla* sp.), porter crab (*Neodorippe*), hermit crab and two prawn species (*Metapenaeus brevicornis, M. mastersii*).

The Semerak estuary had low numbers and abundance of prawn species, as was also the case for Kuantan estuary on the east coast where four species had been reported [25]. In contrast, the number of prawn species reported for Langkawi, Matang, Klang, Sungai Pulai and Sungai Johor mangroves on the west and south coast of the peninsula were 8 [7], 20[11], 9 [19], 15 [22] and 17 [22], respectively.

Semerak lagoon

Six fish and five invertebrate species were sampled by the beam trawl and gill nets (Table 4). Their catches were low, except for the common ponyfish (Leiognathus *equulus*) which were captured in quite large numbers by the gill nets. Captured invertebrates not found elsewhere in this study included the horseshoe crab (*Carcinoscopius rotundicauda*) and a bivalve, Belcher's venus (*Tapes belcheri*, Figure 4). Another species of common bivalve found was the yellow pitar venus (*Pitar citrinus*, Figure 5) which was only sampled in the coastal waters at Station 5. The generally poor numbers of large species of fish in Semerak lagoon is likely due to its isolation from the sea and anthropogenic impacts from extensive aquaculture activities.

Bachok coastal waters

In the northern half of the surveyed area, the first station (1.5 km offshore) yielded no catch, but station 2 located 3 km offshore yielded 18 species of fish, the lowest among the northern stations sampled. The fish catch comprised largely of one species of

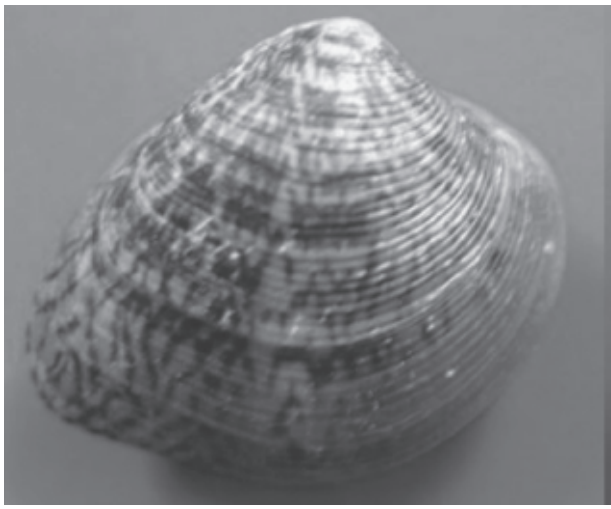

Figure 4. Venerid bivalve - Belcher's venus, *Tapes belcheri* (3.7 cm TL, 2.8 cm HT)

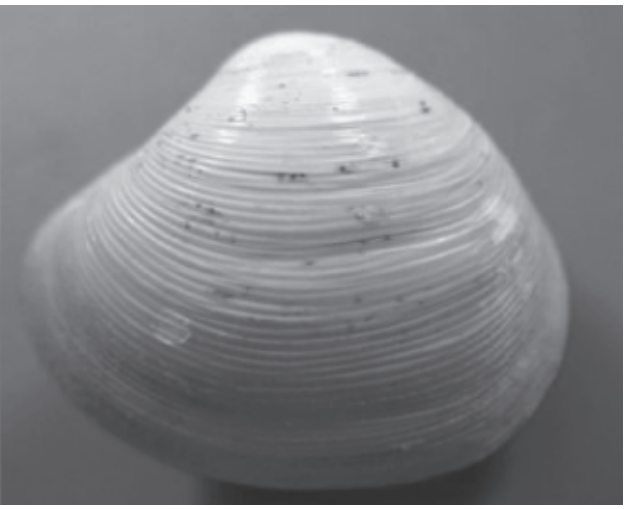

Figure 5. Pitar venus shell, *Pita citrinus* (3 cm TL, 3.2 cm HT)

Leiognathidae, the slender ponyfish (*Equulites elongatus*), the sulfur goatfish (*Upeneus sulphureus*) and twostripe cardinal (*Apogon quadrifasciatus*) (see Table 3). Nine species of invertebrates were sampled, including young squids (*Loligo duvacelli*, 1.9-15.5cm) and the flower portunid crab (*Portunus pelagicus*, 1.6-11.9 cm).

South of stations 1 and 2, the coastal waters between Kg. S. Dua and Kg. Tekah Dua were heavily fished by gillnet fishers. These waters were therefore avoided by our trawl boat. Stations 3, 4 and 5 located further south yielded the highest number of species (40, 32, 38) among the 14 stations sampled by the trawl net. The leiognathids again dominated these waters, the main identified species being the shortnose ponyfish (*Leiognathus brevirostris*), whipfin ponyfish (*Equulites leuciscus*), deep pugnose ponyfish and the slender ponyfish. The highest number of invertebrate species was also recorded from these waters which were dominated by squids and juvenile flower crabs. Other interesting species recorded from here and nowhere else from this study included the three-spot swimming crab (*Portunus sanguinolentus*, Figure 6), the oriental flathead lobster (*Thenus orientalis*) and the smalleyed squillid mantis shrimp (*Miyakea nepa*).

From Tok Bali jetty to the south, the coastal waters had the poorest number of species sampled (4-8 species). Overall, the southern section had a total of only 18 species sampled as compared to the northern section with 83 species. The only invertebrate sampled were two species of squid. Nevertheless, the largest single mass of fish sampled in this study came from station 8, comprising more than 12,000 ha^{-1} of juvenile splendid ponyfish, (*Eubleekeria splendens,* 7.5-10.7mm). another leiognathid species, the toothed pony, (*Gazza minuta*, 506ha^{-1}) and the sulphur goatfish (813ha^{-1}) occurred in abundance at station 7.

Although no coral reefs have been reported in Bachok waters, the occurrence of three reef-associated fish species is interesting. These were the red cornetfish (*Fistularia petimba*), Peters' monocle bream (*Scolopsis affinis*) and purple-spotted bigeye (*Priacanthus tayenus*); all three were sampled from the northern coastal waters.

Rekang estuary and surf zone

The most surprising and interesting catch from the small river was a large milkfish (*Chanos chanos*, 29 cm, 500g; Figure 7) caught by cast net. According to the villagers in Kg. Rekang, large numbers of even larger milkfish come into the Rekang estuary during the flood or northeast monsoon season from December-January. Fishase [32] reported that milkfish can grow up to a very large size of 124 cm (14kg). Milkfish has never been reported by research surveys on the west coast or from commercial fish landings. A few greenback mullets (*Liza subviridis*) were also caught in the river which had a salinity of almost 0 ppt.

Just outside the river mouth which was blocked up by shifting sand, nine species of fish and the colorful flower moon crab (*Matuta planipes*, Figure 8) were sampled from the surf water by a beach seine (Table 4). The dwarf whipray (*Himantura walga*) and bluetail mullet (*Valamugil buchanani*) were sampled only here.

Figure 6. Three-spot swimming crab, *Portunus sanguinolentus* (11.5 cm CW).

Figure 7. Milkfish, *Chanos chanos* (29 cm SL).

Standing stock biomass

Semerak estuary

Inside the channelized Semerak River, the total standing stock biomass estimated for the 5 stations, ranged from 0.63 to 47.62 kg ha^{-1}, with a mean of 17.79 ± 16.79 (Table 5**).** While leiognathids were largely important by numbers, the larger fish from the Ariidae, Plotosidae, Lutjanidae and Sphrynaenidae contributed substantially to the standing stock biomass.

Despite the impoundment and channelization impact, the Semerak estuary had a standing stock biomass comparable to that of Sementa Kecil River in Selangor (mean = 21.4 kg ha^{-1}) [19] and Pulai estuary in Johor (10.41 - 46.23 kg ha^{-1}) [22], but lower than six Matang estuaries in Perak which ranged from 43.09 – 116.12 kg ha-1) [34].

Bachok coastal waters

The standing stock biomass of fish and invertebrates from off Kuala Rekang (station 1) to Tok Bali jetty ranged from 0 to 26.27 kg ha^{-1}, with mean of 12.00 ± 10.05 while that of the southern coast from Tok Bali Jetty to off Kg. Dalam Rhu (station 9) ranged from 0.36 to 355.93 kg ha^{-1} with a mean of 94.36 ± 174.48 (Table 5). The largest standing stocks in the northern and southern waters were at station 3 (off Kuala Kandis) and at station 8 (off Kuala Semerak), attributable to the large concentrations of leiognathids.

Compared to the nearshore waters of Klang Strait which had close values of H' (= 2.78) and J' (=0.68) but a total mean biomass of only 7.61 kg ha^{-1} [19], Bachok's inshore waters had a generally higher standing stock biomass. The monthly fish stock biomass of Matang coastal waters, with monthly H' that ranged from 1.95 - 3.05 and J' from 0.53 -0.82, ranged from 0.75 – 2.72 kg ha^{-1} [35] only, indicating that both Perak and Selangor coastal waters were heavily overfished.

Between estuarine and coastal waters

The community similarity indices between the northern coastal and southern coastal waters with Semerak estuary were 0.214 and 0.132 respectively. These results indicate low resemblance between the coastal and estuarine communities. Thus, there is little connectivity or contribution of mangrove species to coastal fisheries production. In areas where mangrove forests are more significant, as for instance Matang, fish production contribution could be more than 50% [12]. Among the fish families, the Leiognathidae is probably the most connected between the coastal and disturbed estuarine waters of Bachok demonstrating their adaptability to human disturbance.

Leiognathid distribution

The entire coastal waters of Bachok were occupied by largely Leiognathidae, with at least eight species identified. Leiognathid predominance in Bachok waters resembles the situation along Pahang's northern coast where leiognathids also dominated the fish community. In both Bachok and north Pahang, the predominant species were *Eubleekeria splendens* and *Secutor rucornius*, but in Pahang, *Gazza minuta* was also abundant [25]. In Bachok, *Equulites elongatus* was common in coastal waters, while *Leiognathus brevirostris* and *L. equulas* were common and abundant in Semerak estuary.

In contrast, leiognathids do not dominate coastal waters in the Straits of Malacca by sheer numbers as they did in the South China Sea. *Leiognathus brevirostris*, *L. daura* and *Secutor insidiator* were the

Table 5. Main taxa and estimates of total stock biomass by station in Bachok coastal waters and Semerak Estuary, Kelantan (15-17 June, 2008).

Area	Date	Station	Trawl	Biomass (kg/ha)	Main taxa
Northern Coast	16-Jun	1	1	0.00	No catch
	16-Jun	2	2	5.70	Leiognathidae, *Loligo*,*Pseudorhombus*, *Nemipterus*
	16-Jun	3	3	26.27	Leiognathidae, Dasyatidae, Sciaenidae, Ariidae,
	16-Jun	4	4	16.05	Leiognathidae, Sepiidae, *Pseudorhombus*
	16-Jun	5	5	11.97	Leiognathidae, *Loligo*
	mean			12.00	
	SD			10.05	
Southern Coast	15-Jun	6	4	0.36	*Loligo*
	15-Jun	7	1	6.51	*Loligo*, Leiognathidae
	15-Jun	8	2	355.93	Leiognathidae,
	15-Jun	9	3	14.65	Leiognathidae,
	mean			94.36	
	SD			174.48	
Semerak Estuary	17-Jun	15	6	19.27	Leiognathidae, Lutjanidae, *Pampus*, Platycephalidae
	17-Jun	10	1	19.92	Leiognathidae, Lutjanidae, Ariidae
	17-Jun	11	2	47.62	Ariidae, Leiognathidae, Tetraodonidae, Sphrynaenidae, Plotosidae
	17-Jun	12	3	16.25	Ariidae, Leiognathidae,
	17-Jun	13	4	3.08	Leiognathidae
	17-Jun	14	5	0.63	Sciaenidae, Clupeidae
	mean			17.79	
	SD			16.79	

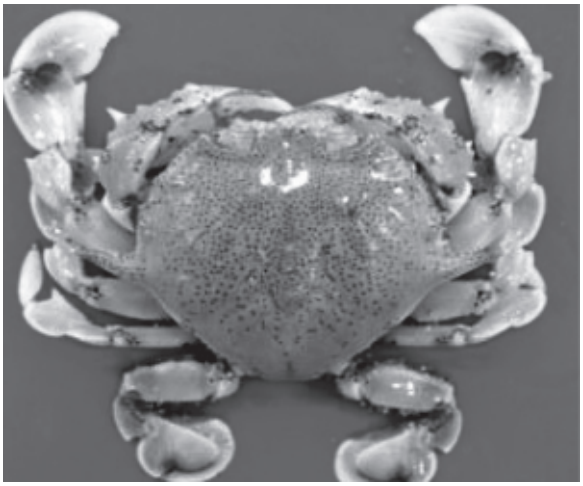

Figure 8. Flower moon crab, *Matuta planipes* (3.5 cm CW).

dominant leiognathids in Klang Strait but their numbers constituted no more than 10% [19], while in Matang estuaries, the most recent study indicated four species, the most widespread being *L. brevirostris* [34]. This species and *S. rucornius* were the common leiognathids in Matang nearshore waters [35]. In northeastern Langkawi waters, six species of leiognathids have been recorded of which the most common and abundant were also *L. brevirostris* and *S. rucornius* [7].

Leiognathids also called slipmouths show very interesting adaptations of their mouth structure which could protrude down to pick up benthic worms, foraminiferans, small fish, crustaceans and bivalves from soft bottoms, or protrude up to feed on pelagic organisms like zooplankton [32]. These adaptations suggest niche separation of often co-occurring species in similar habitats or a geographical region. This appears to be the case in the present study where eight identified species were found together in Bachok waters.

The leiognathids appear to be spatially separated as evidenced below:

- *Equulites elongates* was only distributed on the northern section of the coast, while *Secutor insidiator* was mainly found on the southern coast.

- The congener, *S. rucornius*, was however found only in the northern coast but was clearly also distributed inside the estuary.
- The distribution of *Eubleekeria splendens* was mainly in the southern coast but extended deeply into the estuary.
- *Leiognathus equulus* was only sampled inside the estuary.
- *Leiognathus brevirostris* was particularly abundant at station 3, not observed in the southern coast, but also distributed inside the estuary.
- *Equulites leuciscus* was distributed from station 3 to station 5, and neither observed in the estuary or southern coast.

Niche separation of co-occurring species could be further verified by diet analysis as well as fish activity or behavioural studies.

CONCLUSIONS

The modified Semerak estuary shows a partially-mixed estuary that is visited by at least 59 marine and euryhaline species, including 47 fish species. The fish include economically-important species of leiognathids, lutjanids, catfishes, baraccudas, pomfrets and squids. Bachok's nearshore waters provide habitat, feeding or nursery space for at least 71 fish and 22 invertebrate species. Young leiognathids, mullids, cephalopods and portunid crabs were dominant. The former with eight species displayed spatial distribution from coastal to estuarine waters. Bachok's coastal fish diversity is generally high, with larger standing stock biomass than similar habitats on the west coast of peninsular Malaysia. It would be of interest to further monitor the fish assemblage in the channelized river and to compare it with the natural segment of the river to assess the impacts of the river modification.

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