Diet composition and food habits of demersal and pelagic marine fishes from Terengganu waters, east coast of Peninsular Malaysia

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Abstract

Fish stomachs from 18 demersal and pelagic fishes from the coast of Terengganu in Malaysia were examined. The components of the fishes' diets varied in number, weight, and their frequency of occurrence. The major food items in the stomachs of each species were determined using an Index of Relative Importance. A "conceptual" food web structure indicates that fish species in the study area can be classified into three predatory groups: (1) predators on largely planktivorous or pelagic species; (2) predators on largely benthophagous or demersal species; and (3) mixed feeders that consume both pelagic and demersal species.

Introduction

Changes in the populations of marine fishes have prompted researchers to examine and assess their stocks. In the past decade, the management of marine resources has usually been defined on the basis of a single-species model that has been used to develop multi-species models of exploited fish populations, which provide insight into the fluctuation of the marine resources (Gulland 1991). The study of the feeding behavior of marine fishes is necessary for fish stock assessment and ecosystem modeling. For example, methods of multi-species virtual population analysis (Sparre 1991; Bulgakova et al. 2001) and the ECOPATH II ecosystem model (Christensen and Pauly 1993) need information on the dietary composition of fishes.

Predator pressure is a pervasive influence on the evolution of populations and on the structure and function of nearly all marine communities and ecosystems (Duffy and Hay 2001). Paine (1969) coined the term 'keystone' for species that have strong community impacts that are disproportionate to their abundance. Stomach content analysis, even in its most casual and anecdotal form, can yield incidental but immediately valuable information since predators are often better sampling devices than most commercial fishing gears (Caddy and Sharp 1986). Information on the food habits of marine fishes, such as the predator-prey relationships, is useful in order to assess the role of marine fishes in the ecosystem.

There are only a only a few studies that describe stomach content analysis of marine fishes from the South China Sea and east coast of Malaysia. Khalijah and Salleh (1985), Chan and Liew (1986) and Mohsin et al. (1987) studied the stomach contents of communities of small demersal fish. These studies did not include the moderate to large fish species. The present study was conducted for both commercial demersal and pelagic fishes from the Terengganu waters on the east coast of peninsular Malaysia in order to determine their dietary compositions and food habits. Since there is little published information on the diets of fish from the South China Sea near peninsular Malaysia, the results of this study are also aimed at better understanding the biology of predator and prey species as well as being useful for stock- and ecosystem-level analyses.

Materials and methods

Demersal and pelagic fish specimens (Table 1) were obtained from the fish landing complex of Pulau Kambing, Kuala Terengganu, Malaysia (Figure 1) from January 1993 to June 1994. The samples were selected randomly and then stored in boxes containing ice to slow any bacterial digestion process in the fish stomachs and make it easier to identify the prey. The fish samples were taken to a laboratory for further analysis.

The total length and fresh weight of the individual specimens were measured. The ventricle of the fishes was split open to determine the sex and then the fish guts were removed and cut open. All food items in the stomachs were identified to the most precise taxonomic level, i.e., genera, whenever possible (Fischer and Bianchi 1984; Lin 1992). The total number, wet weight, and frequency of occurrence of each prey item in the stomach of the fishes were recorded.

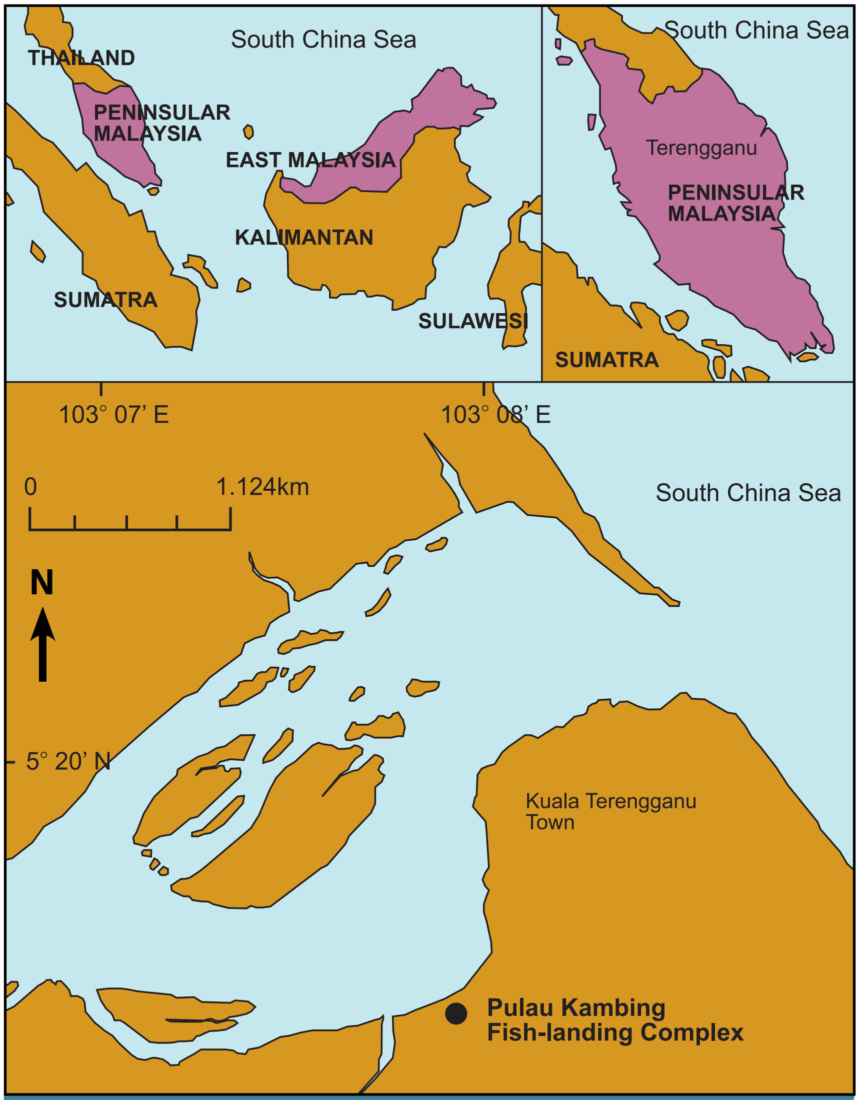

Figure 1. Location of Peninsular Malaysia and Pulau Kambing fish landing complex.

The dietary components for each species studied were expressed as a percentage of numerical composition (C_N), percentage of gravimetric composition (C_W) and percentage of frequency of occurrence (*F*) (Hyslop 1980). The most important food item was determined by using the Index of Relative Importance (*IRI*) of Pinkas et al. (1971):

$$IRI = (C_N + C_W) \times F$$

Results and discussion

The species of marine fishes selected for study are given in Table 1. It was possible to count and weigh all food items in the stomach and most of the prey items were easily identified because of their size. Some fish stomachs, however, were empty. For *Auxis thazard thazard, Carangoides ferdau, Caranx sexfasciatus, Euthynnus affinis, Sphyraena jello* and *S. obtusata,* 30 to 41 percent of the stomachs examined were empty. For the other species, 22 to 30 percent of stomachs examined were empty. A total of 44 prey items (Table 2) were found in the stomachs of the fish sampled. Thirty-six prey items were found in the stomach of demersal species, while 20 items were identified within pelagic species.

The fishes' feeding habits fell in the spectrum between generalist and specialist. For example, in the stomachs of demersal species, of the 36 prey items, 64 and 44 percent of them were found in *Rachycentron canadum* and *Lutjanus gibbus*, respectively. Of the 20 items in the pelagic species, 70 percent were found in *Coryphaena hippurus* and 40 percent in *Scomberomorus commerson*. This suggests that these species utilize a broad range of prey items. On the other hand, the low number of different food items in *Auxis thazard thazard, Carangoides ferdau, Euthynnus affinis, Sphyraena jello* and *S. obtusata* (Table 3) suggests that they are more selective in their diets and specialize on particular food items.

The composition of the diet indicated that the fully adult fishes were carnivores feeding on small marine animals, mainly teleosts. Cephalopods, crustaceans, echinoderm and molluscs also contributed to the diet (Table 3). However, it is important to recognize the actual complexity of the situation because species may feed at different levels in the food chain at different stages of their life cycle. For instance, Landry (1997) found that fully adult codfish are predators on herring, but when they are small (<50 cm long) they feed on copepods and other planktonic crustaceans. The food preference of predatory fishes is very complex and is influenced by many factors such as prey accessibility and mobility, prey abundance, prey energy content, prey size selection and seasonal changes (Nieland 1980; Hart and Ison 1991; Stergiou and Fourtouni 1991; Brewer and Warburton 1992; Barry and Ehret 1993). This should be kept in mind when interpreting the data presented here.

The percentages by number (C_N), weight (C_W) and frequency of occurrence (*F*) gave information on the main prey items in the diet (Table 3). The high frequency of occurrence of a certain prey item in fish diets (e.g., trout sweetlip in *Lutjanus gibbus*, bigeye scad in *Rachycentron canadum,* tuna in *Coryphaena hippurus,* torpedo scad in *Scomberomorus commerson*) does not mean that the given food types are of nutritional importance to the consumer.

Table 1. List of marine fishes selected for dietary composition studies from waters off Terengganu on the east coast of Peninsular Malaysia.

Groups/family/species	Common name	No. of samples	Ratio (M/F)	Size range (cm)	Weight range (kg)
DEMERSAL FISH					
ARIIDAE					
Arius oetik	Sea catfish	71	1.62	18.0 - 69.0	0.1 - 5.0
HAEMULIDAE					
Plectorhinchus pictus	Trout sweetlip	56	17.5	17.5 - 57.0	0.2 - 3.1
LUTJANIDAE					
Lutjanus gibbus	Humpback snapper	111	0.76	21.0 - 111.0	0.2 - 7.5
Lutjanus malabaricus	Malabar blood snapper	125	0.49	34.0 - 64.0	0.5 - 5.2
Lutjanus sanguineus	Humphead snapper	113	2.06	21.0 - 74.0	0.8 - 4.2
Pristipomoides filamentosus	Crimson jobfish	181	1.27	17.0 - 155.0	0.3 - 4.9
RACHYCENTRIDAE					
Rachycentron canadum	Cobia	98	0.97	33.0 - 139.0	0.9 - 1.5
SPHYRAENIDAE					
Sphyraena jello	Pickhandle barracuda	17	0.86	55.0 - 100.0	0.6 - 4.2
Sphyraena obtusata	Obtuse barracuda	52	1.56	21.0 - 88.0	0.3 - 1.5
PELAGIC FISH					
CARANGIDAE					
Carangoides ferdau	Blue trevally	38	0.75	42.0 - 62.0	1.0 - 5.6
Caranx sexfasciatus	Bigeye trevally	43	1.58	37.0 - 70.0	0.3 - 3.8
CORYPHAENIDAE					
Coryphaena hippurus	Common dolphinfish	171	0.52	47.5 - 106.0	0.7 - 9.0
ISTIOPHORIDAE					
Makaira indica	Black marlin	32	1.20	106.8 - 241.5	15.0 - 31.2
Istiophorus platypterus	Indo-Pacific sailfish	13	2.33	110.0 - 211.0	26.0 - 27.8
SCOMBRIDAE					
Auxis thazard thazard	Frigate tuna	47	1.14	31.0 - 43.0	0.6 - 1.3
Euthynnus affinis	Kawakawa	79	1.62	33.0 - 45.0	0.6 - 1.4
Scomberomorus commerson	Barred Spanish mackerel	80	0.43	20.0 - 103.0	0.8 - 9.4
Thunnus tonggol	Longtail tuna	112	2.44	32.0 - 61.0	0.3 - 3.2

They may be consumed with great regularity but in very small quantities (Table 3). On the other hand, the study showed that prey items that were small in size (e.g., anchovy, ponyfish and sergestid shrimp) were eaten in greater numbers, while the large size prey (e.g., bigeye scad, round scad and threadfin bream) were eaten in fewer numbers. However, comparing their weight gave the opposite result (Table 3). Percentage by number overemphasizes the importance of smaller prey since they weigh so much less than larger prey, but percentage by weight overemphasizes the importance of large prey (Pinkas et al. 1971; George and Hadley 1979; Hyslop 1980). Bowen (1983) suggests that if the investigation aims to determine the impact of the predator on a prey's population dynamics, then the percentage by number will provide useful data regardless of the size of different prey types. If the investigation aims to measure the contribution of a prey to the predator's nutrition, then percentage by weight is a fully adequate indicator. In this study, the use of the Index of Relative Importance (*IRI*) was found to be more useful in describing the relative importance of a prey species.

The fish species investigated in this study (Table 1) are commercially important. *Arius oetik*, *Lutjanus gibbus*, *L. malabaricus*, *L. sanguineus*, *Pristipomoides filamentosus* and *Plectorhinchus pictus* are a major component of demersal resources, while *Auxis thazard thazard*, *Euthynnus affinis*, *Scomberomorus commerson* and *Thunnus tonggol* are among the dominant pelagic fishes on the east coast of Peninsular Malaysia (Department of Fisheries Malaysia 1980-1991). In addition, *Coryphaena hippurus*, *Istiophorus platypterus*, *Makaira indica* and *Rachycentron canadum* are potentially important for sport fishing activities (Booth 1994). The prey of the fishes examined (Table 2) have also been commercially exploited and some have been found at the major fish landing sites in this area (SEAFDEC 1980-1990); Round scad (*Decapterus* spp.), for example, contributed around 10 percent of the total marine catches or 17 percent of the small pelagic catches. According to data from the Department of Fisheries, Malaysia (1980-1991), the catches decreased from 35 300 t in 1981 to 14 400 t in 1991. Studies conducted in temperate and tropical seas have revealed that the removal of marine consumers (herbivores or predators) often causes profound changes in community organization, habitat

Table 2. List of prey found in the stomach of fishes from Terengganu waters.

Groups/family	Common name	Scientific name
TELEOST		
ARIIDAE	Sea catfish	*Arius oetik*
BALISTIDAE	Triggerfish	*Abalistes* spp.
BALISTIDAE	Filefish	*Monacanthus* spp.
BELONIDAE	Needlefish	*Tylosurus* spp.
CARANGIDAE	Yellowtail scad	*Atule mate*
CARANGIDAE	Torpedo scad	*Megalaspis cordyla*
CARANGIDAE	Bigeye scad	*Selar crumenophthalmus*
CARANGIDAE	Yellowstripe scad	Selaroides leptolepis
CARANGIDAE	Round scad	*Decapterus* spp.
CLUPEIDAE	Sardine	*Dussumieria* spp.
DASYATIDAE	Pale-edged stingray	*Dasyatis zugei*
ENGRAULIDAE	Anchovy	*Stolephorus* spp.
EXOCOETIDAE	Flyingfish	*Exocoetus* spp.
FISTULARIDAE	Cornetfish	*Fistularia* spp.
GERREIDAE	Silver-biddy	*Gerres* spp.
HAEMULIDAE	Trout sweetlip	*Plectorhinchus pictus*
HEMIRAMPHIDAE	Dussumier's halfbeak	*Hyporamphus* spp.
LEIOGNATHIDAE	Ponyfish	*Leiognathus* spp.
LEIOGNATHIDAE	Splendid ponyfish	*Leiognathus splendens*
LUTJANIDAE	Bigeye snapper	*Lutjanus lutjanus*
MURAENESOCIDAE	Conger eel	*Muraenesox* spp.
NEMIPTERIDAE	Threadfin bream	*Nemipterus* spp.
PARALICHTHYIDAE	Flounder	*Pseudorhombus* spp.
PLOTOSIDAE	Catfish eel	*Plotosus* spp.
PRIACANTHIDAE	Purple-spotted bigeye	*Priacanthus tayenus*
SCIAENIDAE	Croaker	*Johnius* spp.
SCOMBRIDAE	Indian mackerel	*Rastrelliger* spp.
SCOMBRIDAE	Tuna	*Thunnus* spp.
SIGANIDAE	Rabbitfish	*Siganus* spp.
SILLAGINIDAE	Silver sillago	*Sillago sihama*
SPHYRAENIDAE	Barracuda	*Sphyraena* spp.
SYNODONTIDAE	Greater lizardfish	*Saurida tumbil*
TETRAODONTIDAE	Pufferfish	*Chelonodon* spp.
TRICHIURIDAE	Ribbonfish	*Trichiurus* spp.
CRUSTACEAN		
PENAEIDAE	Penaeid shrimps	*Penaeus* spp.
PORTUNIDAE	Crab	*Portunus* spp.
SCYLLARIDAE	Flathead locust lobster	*Thenus orientalis*
SERGESTIDAE	Sergestid shrimp	*Acetes* spp.
SQUILLIDAE	Mantis shrimp	*Squilla* spp.
MOLLUSC		
MYTILIDAE	Mussel	Unidentified
STRUTHIOLARIDAE	Snail	Unidentified
CEPHALOPOD	Squid	Unidentified
ECHINODERM		
HOLOTHURIOIDAE	Sea cucumber	Unidentified
OPHIUROIDEA	Brittle star	Unidentified

structure and ecosystem processes (Duffy and Hay 2001). Furthermore, Pauly et al. (1998) showed that current fishing efforts have a global impact and that the mean trophic level of animals harvested from the sea is decreasing.

The information on the dietary composition of the fishes from the Terengganu waters was used to illustrate the predator-prey food web (Figure 2). The fishes and their prey items were classified into 26 groups in order to reduce the complexity of the figure. Although only the stomach contents of 18 fish species were analyzed, the results are representative of the key commercial fish communities, especially those at the higher tropic level. Furthermore, the food web can be expanded by including the previous data available on dietary composition of prey species (e.g., Chong 1973; Khalijah and Salleh 1985; Chan and Liew 1986; Mohsin et al. 1987). The conceptual food web structure indicates that three basic predatory groups may be recognized: (1) predators on largely planktivorous or pelagic species; (2) predators on largely benthophagous or demersal species; and (3) predators on both pelagic and demersal species.

Overholtz et al. (1991) studied the impact of predatory fish, marine mammals and seabirds on the pelagic fish ecosystem of the northeastern USA and found that predatory fish, primarily spiny dogfish, had caused most of the predation mortality in the system, followed by marine mammals and seabirds. Furthermore, Kitchell et al. (1994) showed that at the community and population scales, prey selection by predators alters habitat selection behaviors of prey species as well as their abundance, size distribution, life histories and the consequent effects on their own prey. Therefore, both direct and indirect predation effects are important aspects that can give guidelines for the management of marine resources in this region.

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References

Barry, J.P. and M.J. Ehret. 1993. Diet, food preference, and algal availability for fishes and crabs on intertidal reef communities in southern California. Environ. Biol. Fish. 37:82-92.

Booth, G. 1994. Modern fishing's game fish records and rules. Federal Publishing Company Pty. Ltd. Inc.

Table 3. Percentage Index of Relative Importance (*IRI*), percentage numerical composition (C_N), percentage gravimetric composition (C_W), and percentage frequency of occurrence (*F*) of prey items in the diet of demersal and pelagic fishes from Terengganu waters.

Species	Prey	% IRI	C_N	C_W	F
DEMERSAL FISHES					
Arius oetik	Ponyfish	62.55	19.26	32.95	29.73
	Crab	16.60	2.96	10.89	2.70
	Sergestid shrimp	9.66	74.07	14.63	2.70
	Squid	6.69	0.74	19.74	8.11
	Conger eel	1.17	0.25	10.49	8.11
	Flathead locust lobster	1.08	0.74	2.58	2.70
	Sea cucumber	1.05	0.49	4.31	8.11
	Penaeid shrimp	0.82	0.99	1.51	29.73
	Mussel	0.27	0.25	2.22	2.70
	Indian mackerel	0.10	0.25	0.67	5.41
Lutjanus gibbus	Squid	90.02	52.46	41.25	2.38
	Ponyfish	2.23	11.48	3.21	2.38
	Indian mackerel	1.81	3.28	8.68	4.76
	Silver-biddy	1.77	6.56	10.95	4.76
	Penaeid shrimp	0.89	4.92	0.92	7.14
	Greater lizardfish	0.88	3.28	5.41	7.14
	Ribbonfish	0.38	3.28	4.28	2.38
	Yellowstripe scad	0.33	1.64	4.82	2.38
	Pufferfish	0.30	1.64	4.39	2.38
	Threadfin bream	0.28	1.64	3.82	2.38
	Conger eel	0.27	1.64	3.78	2.38
	Torpedo scad	0.27	1.64	3.72	2.38
	Sliver whiting	0.23	1.64	2.85	2.38
	Trout sweetlip	0.13	1.64	1.00	45.24
	Sardine	0.12	1.64	0.68	7.14
	Flathead locust lobster	0.09	1.64	0.24	2.38
Lutjanus malabaricus	Ponyfish	42.26	70.97	29.08	14.29
	Squid	23.28	12.90	5.47	14.29
	Threadfin bream	16.92	3.23	36.84	14.29
	Round scad	11.52	6.45	20.82	14.29
	Bigeye snapper	6.02	6.45	7.79	42.86
Lutjanus sanguineus	Round scad	94.15	66.67	89.00	62.50
	Squid	4.75	16.67	9.51	18.75
	Crab	0.57	8.33	1.10	6.25
	Flathead locust lobster	0.27	4.17	0.29	6.25
	Penaeid shrimp	0.26	4.17	0.10	6.25
Plectorhinchus pictus	Sergestid shrimp	27.34	54.55	3.61	13.33
	Round scad	26.23	3.64	52.17	6.67
	Crab	19.14	9.09	18.05	26.67
	Penaeid shrimp	17.92	14.55	4.51	13.33
	Ponyfish	6.39	12.73	14.44	6.67
	Mantis shrimp	1.28	1.82	3.61	20.00
	Mussel	0.85	1.82	1.81	6.67
	Brittle star	0.85	1.82	1.81	6.67
Pristipomoides filamentosus	Ponyfish	90.03	90.32	65.28	44.44
	Purple-spot bigeye	7.09	4.84	19.66	22.22
	Squid	1.96	1.61	11.90	11.11
	Crab	0.48	1.61	1.71	11.11
	Rabbitfish	0.44	1.61	1.44	11.11
Rachycentron canadum	Rabbitfish	73.51	49.90	33.14	1.74
	Round scad	7.59	0.66	13.63	11.30
	Sergestid shrimp	6.55	40.77	3.66	3.48
	Filefish	5.39	6.90	13.38	7.83
	Catfish eel	3.78	0.32	9.53	1.74
	Squid	1.43	0.30	6.61	1.74
	Crab	0.82	0.28	3.68	0.87
	Croaker	0.23	0.15	1.81	0.87
	Tuna	0.19	0.06	2.12	0.87

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Bowen, S.H. 1983. Quantitative description of the diet, p. 325-336. ***In*** L.A. Nielson and D.L. Johnson (eds.) Fisheries Techniques. An. Fish Sor. Bethesda, Maryland.

Brewer, D.T. and K. Warburton. 1992. Selection of prey from a seagrass/ mangrove environment by golden lined whiting, *Sillago analis* (Whitley). J. Fish Biol. 40:257-271.

Bulgakova, T., D. Vasilyev and N. Daan. 2001. Weighting and smoothing of stomach content data as input for MSVPA with particular reference to the Barents Sea. ICES J. Mar. Sci. 58:1208-1218.

Caddy, J.F. and G.D. Sharp. 1986. An ecological framework for marine fishery investigations. FAO Fisheries Technical Paper 283. FAO, Rome.

Chan, E.H. and H.C. Liew. 1986. Characteristics of an exploited tropical shallow-water demersal fish community in Malaysia, p. 349-352. ***In*** J.L. Maclean, L.B. Dizon and L.V. Hosillos (eds.) The first Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.

Chong, B.J. 1973. Studies on the taxonomy and distribution of Ikan Kembung, *Rastrelliger* spp. in west Malaysia. Malay. Agri. 49(2):143-153.

Christensen, V. and D. Pauly. 1993. A guide to the ECOPATH II software system (version 2.1). ICLARM, Manila, Philippines.

Department of Fisheries Malaysia. 1980-1993. Annual Fisheries Statistics of Malaysia.

Duffy, J.M. and M.E. Hay. 2001. The ecology and evolution of marine consumer-prey interaction, p. 131-157. ***In*** M.D. Bertness, S.D. Gaines and M.E. Hay (eds.) Marine community ecology. Sinauer Associates, Inc., Sunderland.

Fischer, W. and G. Bianchi. 1984. FAO species identification sheets for fishery purposes: Western Indian Ocean (Fishing Area 51). Vol. I–V. FAO, Rome.

George, E.L. and W.F. Hadley. 1979. Food and habitat partitioning between rock bass (*Ambloplites rupestris*) and smallmouth bass (*Micropterus dolomicui*) young of the year. Trans. Amer. Fish. Soc. 108:253-261.

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Rachycentron canadum	Bigeye scad	0.14	0.04	2.27	26.09
	Threadfin bream	0.08	0.02	2.71	0.87
	Pale-edged stingray	0.07	0.02	2.29	15.65
	Fusilier	0.04	0.06	0.70	0.87
	Ribbonfish	0.04	0.08	1.29	0.87
	Flounder	0.04	0.04	0.62	2.61
	Purple-spotted bigeye	0.03	0.06	1.02	6.09
	Sea catfish	0.02	0.02	0.67	6.09
	Sardine	0.01	0.02	0.39	0.87
	Penaeid shrimp	0.01	0.08	0.31	0.87
	Snail	0.01	0.15	0.02	4.35
	Mussel	0.00	0.06	0.01	0.87
	Mantis shrimp	0.00	0.02	0.10	1.74
	Flathead locust lobster	0.00	0.02	0.03	1.74
Sphyraena jello	Yellowstripe scad	88.99	75.00	70.88	75.00
	Bigeye scad	11.01	25.00	29.12	25.00
Sphyraena obtusata	Ponyfish	51.51	57.14	12.24	66.67
	Squid	48.49	42.86	87.76	33.33
PELAGIC FISHES					
Auxis thazard thazard	Anchovy	51.67	95.45	40.81	33.33
	Squid	48.33	4.55	59.19	66.67
Carangoides ferdau	Filefish	98.83	90.24	90.43	90.00
	Indian mackerel	1.17	9.76	9.57	10.00
Caranx sexfasciatus	Filefish	96.68	96.99	77.79	63.64
	Round scad	2.66	1.50	15.30	18.18
	Croaker	0.61	0.75	6.92	9.09
	Squid	0.06	0.75	0.80	9.09
Coryphaena hippurus	Round scad	85.54	29.31	52.47	10.20
	Filefish	9.56	50.74	8.69	9.52
	Bigeye scad	3.40	3.47	16.24	1.36
	Triggerfish	0.62	3.57	9.82	3.40
	Indian mackerel	0.40	1.05	5.94	0.68
	Pufferfish	0.19	7.56	0.88	1.36
	Rabbitfish	0.08	1.37	0.32	1.36
	Sardine	0.06	0.42	1.26	0.68
	Yellowtail scad	0.06	0.21	2.25	2.72
	Tuna	0.05	0.32	1.85	61.90
	Yellowstripe scad	0.04	1.68	0.05	2.04
	Needlefish	0.00	0.11	0.11	2.72
	Purple-spot bigeye	0.00	0.11	0.09	1.36
	Squid	0.00	0.11	0.03	0.68
Euthynnus affinis	Anchovy	56.87	71.43	42.31	50.00
	Indian mackerel	43.13	28.57	57.69	50.00
Istiophorus platypterus	Anchovy	70.71	63.64	22.16	45.45
	Round scad	23.08	8.36	51.64	21.21
	Squid	3.34	3.27	5.42	6.06
	Rabbitfish	1.79	21.45	11.16	3.03
	Bigeye scad	0.73	2.91	3.72	3.03
	Dussumier's halfbeak	0.34	0.36	5.91	21.21
Makaira indica	Anchovy	64.30	82.09	13.94	33.33
	Bigeye scad	22.48	10.45	34.32	8.33
	Flyingfish	6.60	2.99	16.72	25.00
	Yellowtail scad	4.71	1.49	26.66	16.67
	Round scad	1.27	1.49	6.10	8.33
	Squid	0.63	1.49	2.26	8.33
Scomberomorus commerson	Round scad	51.53	26.67	41.11	12.00
	Sardine	22.89	26.67	15.48	4.00
	Indian mackerel	11.00	16.67	8.64	16.00
	Torpedo scad	7.81	10.00	13.96	28.00
	Yellowstripe scad	2.88	6.67	6.58	4.00
	Squid	1.81	6.67	1.67	8.00
	Barracuda	1.25	3.33	8.13	20.00
	Purple-spotted bigeye	0.84	3.33	4.43	8.00
Thunnus tonggol	Filefish	87.79	64.86	75.72	61.90
	Anchovy	9.98	32.75	13.41	21.43
	Squid	2.23	2.39	10.87	16.67

Gulland, J.A. 1991. Some problems of management of shared stocks. FAO Fisheries Technical Paper. No 206. FIRM/T206. FAO, Rome.

Hart, P.J.B. and S. Ison. 1991. The influence of prey size and abundance, and individual phenotype on prey choice by the three-spined stickleback, *Gasterosteus aculeatus* L. J. Fish Biol. 38:359-372.

Hyslop, E.J. 1980. Stomach content analysis: A review of methods and their application. J. Fish Biol. 17:411-422.

Khalijah, S.D. and M.M.T. Salleh. 1985. Stomach contents of selected demersal species from South China Sea, p. 187-192. ***In*** A.K.M. Mohsin, M.M.I. Ibrahim and M.A. Ambak (eds.) Ekspedisi Matahari '87. Universiti Pertanian Malaysia, Serdang.

Kitchell, J.F., L.A. Eby, X. He, D.E. Schindler and R.A. Wright. 1994. Predator-prey dynamics in an ecosystem context. J. Fish Biol. 45(Supplement A):209-226.

Landry, M.R. 1997. A review of important concepts in the trophic organization of pelagic ecosystems. Helgolander Wissenschaften Meeresuntersuchungen 30:8-17.

Lin, H.S. 1992. Coral reefs of Malaysia. Tropical Press Sdn. Bhd.

Mohsin, A.K.M., S. Hayase, M.A. Ambak, S.M.M. Zaki and A.H.T. Khan. 1987. Feeding habits of fishes found in the EEZ off Sarawak, p. 145-143. ***In*** A.K.M. Mohsin and M.M.I Ibrahim (eds.) Ekspedisi Matahari '87. Universiti Pertanian Malaysia, Serdang.

Nieland, H. 1980. Experiments on whether schooling by their prey affects the hunting behaviour of cephalopods and fish predators. J. Zool. 174(4):149-167.

Overholtz, W.J., S.A. Murawski and K.L. Foster. 1991. Impact of predatory fish, marine mammals and seabirds on the pelagic fish ecosystem of the northeastern, USA. ICES Mar. Sci. Symp. 193:198-208.

Paine, R.T. 1969. A note on trophic complexity and community stability. Amer. Nat. 103:91-93.

Pauly, D., V. Christensen, V. Dalsgaard, R. Froese and F. Torres Jr. 1998. Fishing down marine food webs. Science 279: 860-863.

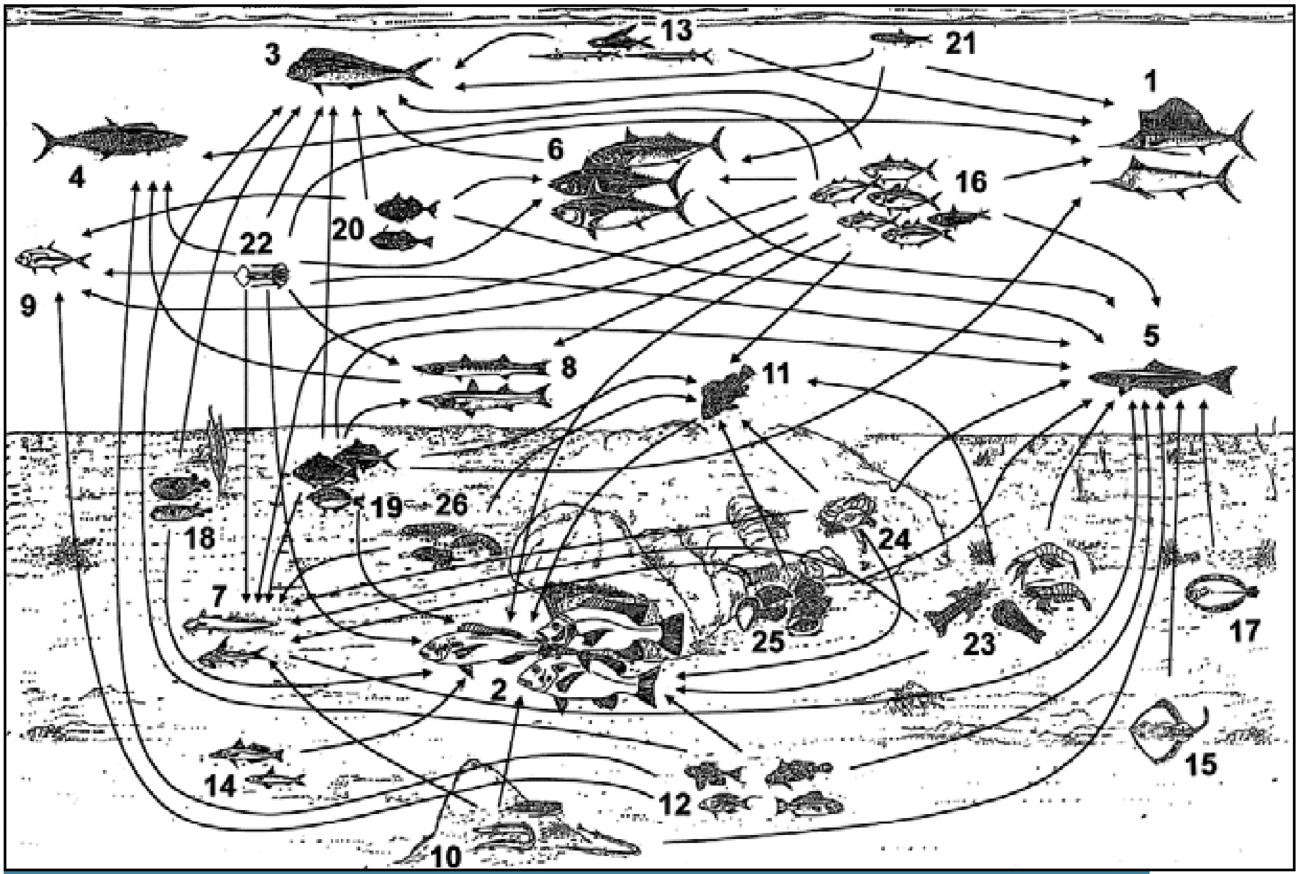

Figure 2. A "conceptual" food web structure constructed from the food relationships between marine fishes and their prey in Terengganu waters, east coast of Peninsular Malaysia.

The predators and prey were grouped into:
(**1**) Black marlin (*Makaira indica*) and sailfish (*Istiophorus platypterus*); (**2**) Red snapper (*Lutjanus gibbus, L. malabaricus* and *L. sanguineus*) and jobfish (*Pristipomoides microlepis*); (**3**) Mahi mahi (*Coryphacna hippurus*); (**4**) Barred spanish mackerel (*Scomberomorus commerson*); (**5**) Black kingfish (*Rachycentron canadus*); (**6**) Tuna (*Auxis thazard, Euthynnus affinis* and *Thunnus tonggol*); (**7**) Catfish (*Arius utik* and *Plotosus canius*); (**8**) Barracuda (*Sphyraena jello* and *S. obtusata*); (**9**) Jack (*Carangoides ferdau* and *Caranx sexfasciatus*); (**10**) Silver conger eel (*Muraenesox cinerus*) and ribbonfish (*Trichiurus* spp.); (**11**) Sweetlip (*Plectorhinchus pictus*); (**12**) Croaker (*Johnius* spp.), purple-spotted bigeye (*Priacanthus tayenus*), rosy snapper (*L. lutjanus*) and threadfin bream (Nemipterus spp.); (**13**) Flyingfish (*Exocoetus* spp.) and dussumier's halfbeak (*Hyporamphus* spp.); (**14**) Lizardfish (*Saurida tumbil*) and silver-whiting (*Sillago sihama*); (**15**) Stingray (*Dasyatis zugei*); (**16**) Small pelagic (*Atule mate, Decapterus* spp., *Megalaspis cordyla, Sardinella* spp., *Selar crumenophthalmus, Selaroides leptolepis* and *Rastrelliger* spp.); (**17**) Flounder (*Psettodes* spp.); (**18**) Pufferfish (*Diodon* spp.); (**19**) Ponyfish (*Leiognathus* spp.), rabbitfish (*Siganus* spp.) and silver-biddy (*Gerres* spp.); (**20**) Filefish (*Monacanthus* spp.) and triggerfish (*Abalistes* spp.); (**21**) Anchovy (*Stolephorus* spp.); (**22**) Squid; (**23**) Shrimp/prawn (*Acetes* spp., *Penaeus* spp. and *Squilla* spp.) and lobster (*Thenus orientalis*); (**24**) Crab (*Portunus* spp.); (**25**) Mollusc (snail and mussel); and (**26**) Echinoderm (sea cucumber and brittle star).

Pinkas, L., M.S. Olipham and I.L.K. Iverson. 1971. Food habits of albacore, bluefin tuna and bonito in Californian waters. California Fish Game 152:1-105.

SEAFDEC (1980-1990). Fishery statistical bulletin for the South China Sea area. SEAFDEC, Kuala Terengganu.

Sparre, P. 1991. Introduction to multispecies virtual population analysis. ICES Mar. Sci. Symp. 193:12-21.

Stergiou, K.I. and H. Fourtouni. 1991. Food habits, ontogenetic diet shift and selectivity in *Zeus faber* Linnaeus, 1758. J. Fish Biol. 39:589-603.

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