Feeding ecology of major carnivorous fish from four eastern Cape estuaries

J.F.K. Marais
Department of Zoology, University of Port Elizabeth, Port Elizabeth

Stomach content analyses were performed on eight carnivorous fish from four eastern Cape estuaries. Dietary importance was assessed by using three unrelated methods and by combining them to determine the index of relative importance of each food item. It was attempted to relate the percentage of fish with food in the stomach and the feeding intensity to the abundance of the fish in a particular estuary. In general fish consumed more food in estuaries where they were more abundant. The few exceptions that occurred could indicate that a particular estuary was selected for purposes other than food availability eg. *Tachysurus feliceps* in the Krom estuary for spawning grounds or because of inter- or intraspecific competition for food eg. *T. feliceps* and *Monodactylus falciformis* in the Krom and *Argyrosomus hololepidotus* in the Gamtoos and Sundays estuaries. Similarity analyses showed resource partitioning. Predators such as *A. hololepidotus, Elops machnata, Lichia amia* and *Platycephalus indicus* preferred teleost fishes such as mullets and *Gilchristella aestuarius*, whereas the stomach content of *Pomadasys commersonni, T. feliceps* and *M. falciformis* were dominated by Crustacea, particularly *Upogebia africana*. Most estuarine predators showed a diverse prey selection, but the food web was characterized by a high energy flow per pathway.
S. Afr. J. Zool. 1984, 19: 210 – 223

Maaginhoudanalises is gedoen vir agt karnivoorvisse afkomstig van vier Oos-Kaapse getyriviere. Die belangrikheid van voedselitems is bepaal deur drie onverwante metodes wat gekombineer is om die indeks van relatiewe belangrikheid aan te dui. Daar is gepoog om die persentasie vis met voedsel in die maag asook die voedingsintensiteit in verband te bring met die voorkeur van 'n vissoort vir 'n bepaalde getyrivier. Oor die algemeen het visse meer voedsel ingeneem waar hulle die volopste was. Die paar uitsonderings wat wel voorgekom het, kan 'n aanduiding wees dat getyriviere op grond van ander faktore as voedselbeskikbaarheid geselekteer word bv. *Tachysurus feliceps* in die Krom eerder vir kuitskiet as vir voeding, of as gevolg van tussen- of binnespesiekompetisie vir voedsel soos *T. feliceps* en *Monodactylus falciformis* in die Kromgetyrivier en *Argyrosomus hololepidotus* in die Gamtoos- en Sondagsgetyriviere. Analise van ooreenkomste het aangetoon dat hulpbronskeiding voorkom. Predatore soos *A. hololepidotus, Elops machnata, Lichia amia* en *Platycephalus indicus* het beenvisse soos die harders en *Gilchristella aestuarius* verkies terwyl *Pomadasys commersonni, T. feliceps* en *M. falciformis* voorkeur verleen het aan Crustacea, veral *Upogebia africana*. Die meeste getyrivier-roofvisse het 'n verskeidenheid voedselorganismes ingeneem hoewel die voedselketting gekenmerk is deur 'n hoë energievloei per baan.
S.-Afr. Tydskr. Dierk. 1984, 19: 210 – 223

J.F.K. Marais
Department of Zoology, University of Port Elizabeth, P.O. Box 1600, Port Elizabeth, 6000 Republic of South Africa

Received 20 June 1983; accepted 29 March 1984

Whitfield & Blaber (1978) investigated the feeding ecology of piscivorous fishes at St Lucia, Natal, but no similar extensive studies have yet been conducted for any other part of South Africa. In the present study stomach contents were collected from carnivorous fishes which were caught by means of gill-nets to determine fish abundance in the Swartkops, Sundays, Krom and Gamtoos estuaries (Marais 1981, 1982, 1983a,b; Marais & Baird 1980). Masson & Marais (1975) earlier investigated the stomach contents of mullets and Van der Westhuizen & Marais (1977) the stomach contents of *Pomadasys commersonni* (both from the Swartkops estuary) whilst Blaber (1974) studied the diet of *Rhabdosargus holubi* in the West Kleinemond estuary. Talbot (1982) investigated the diet of *Gilchristella aestuarius* caught in Swartkops estuary. These are the only food preference studies that have been conducted under natural conditions on estuarine fish in eastern Cape estuaries.

The aim of the present study was to determine and compare the food organisms that form the diet of carnivorous fish from four estuaries, all situated in the same region (furthest apart, Sundays and Krom ± 200 km), but with different configurations, flow characteristics, catchment areas and vegetation.

Methods

Fish of which the stomach contents were used for analysis, were caught in gill-nets in four eastern Cape estuaries. Nets were set during the following periods in the different estuaries: Swartkops (1975 – 1979, 17 months), Sundays (1976 – 1979, 18 months); Krom (1977 – 1980, 17 months) and Gamtoos (1981 – 1982, 15 months); and in the following four positions: Station 1 was selected to be representative of the mouth region, Station 2 of the middle reaches, Station 3 of the upper reaches and Station 4 of the head of the estuary. The general characteristics of these stations and estuaries are given in Table 1.

Nets were set in the evening, irrespective of tidal high, and lifted in the morning 12 h later. The exact methods and net specifications are given by Marais & Baird (1980). One catch per unit effort (CPUE) was taken as the number or mass of fish caught during the 12-h period in a net 50 m long and 3 m wide. Tables 2 – 4 contain information on the CPUE of fish caught in the different estuaries, as well as stomach content expressed as a percentage of body mass, percentage fish with food in the stomachs and size range of fish with stomachs containing food.

Fish were removed from the nets on the same morning that the nets were lifted. All fish were identified, standard lengths

Table 1 Comparative information of the four estuaries from which fish were obtained for stomach content analysis

	Swartkops				Sundays				Gamtoos				Krom			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Mean surface salinity (°/oo)	33,7	27,9	24,5	23,9	27,3	23,3	13,3	2,5	12,1	7,5	3,1	1,2	33,5	32,4	31,0	30,5
Mean turbidity (m)	1,15	1,15	1,25	1,50	0,98	0,75	0,35	0,25	0,75	0,75	0,55	0,35	1,05	0,78	0,85	1,75
Mean water depth (m)	2,1	1,0	3,2	2,0	2,6	1,7	2,0	1,8	4,1	1,0	3,3	2,1	2,2	3,7	3,7	5,1
Configuration	Low banks, extensive mud flats.				Channel-like apart from mouth.				Channel-like, no mud flats.				Head between mountains, then mud flats.			
Vegetation	Large salt marshes *Spartina* beds.				One small *Zostera* bed.				No *Spartina* or *Zostera* beds.				Scattered *Spartina* and large *Zostera* beds.			
Catchment area (km^2)[a]	1 365				20 730				34 438				936			
Major dams	Groendal				Lake Mentz, Van Rynevelds Pass				Paul Sauer, Loerie, Beervlei				Churchill, Elandsjacht			
Flood effects	Reduced salinity.				Complete flushing.				Complete flushing.				Reduced salinity.			

[a]K. Reddering, Department of Geology, University of Port Elizabeth (pers. comm.).

Table 2 CPUE of fish caught in gill-nets, mean stomach content as a percentage of body mass ($\bar{x}$) and maximum stomach content as a percentage of body mass (max) for four eastern Cape estuaries

	Swartkops			Sundays			Krom			Gamtoos		
Species	CPUE	$\bar{x}$	max	CPUE	$\bar{x}$	max	CPUE	$\bar{x}$	max	CPUE	$\bar{x}$	max
Argyrosomus hololepidotus	1,0	1,2	6,5	3,2	0,8	3,2	1,8	1,2	6,3	11,4	1,0	6,7
Lichia amia	1,5	1,3	4,1	1,1	1,3	3,3	6,9	1,8	6,9	5,2	2,6	9,0
Tachysurus feliceps	1,4	5,5	10,1	4,1	3,3	11,5	5,6	2,7	18,5	10,9	1,2	5,7
Pomadasys commersonni	4,4	0,8	3,9	2,3	0,9	3,5	1,1	0,4	1,0	1,6	0,6	1,2
Monodactylus falciformis	1,3	2,8	11,9	0,2			3,3	0,6	3,8	0,6	2,8	2,8
Elops machnata	1,2	0,9	5,9	0,9	0,5	1,6	0,1	3,7	7,1	<0,1	0,1	0,1
Pomatomus saltatrix	0,2	1,4	3,7	0,2	1,4	2,0	3,1	2,3	9,6	0,1	1,6	2,8
Platycephalus indicus	0,5	2,0	20,5	0,1			0			0		

Table 3 Percentage of total number of fish caught with stomachs containing food for each station sampled in the four eastern Cape estuaries. Empty spaces indicate that no specimen of a particular species was caught at that station

	Swartkops				Sundays					Krom					Gamtoos				
Species	1	2	3	Mean	1	2	3	4	Mean	1	2	3	4	Mean	1	2	3	4	Mean
Argyrosomus hololepidotus	71,4	56,1	32,1	46,0	46,4	31,3	33,9	28,2	33,3	50,0	20,0	36,7	29,6	39,7	49,0	41,9	47,0	61,5	51,5
Lichia amia	15,4	7,7	6,3	8,0	23,5	60,0	33,3		39,6	50,0	34,0	0,0	16,3	24,2	22,0	21,2	35,7	45,1	33,7
Tachysurys feliceps	31,7	5,0	0,0	14,8	12,3	14,3	34,3	0,0	19,6	15,8	12,3	11,4	14,0	13,0	10,0	12,7	27,9	0,0	11,5
Pomadasys commersonni	31,1	10,8	23,5	22,0	36,4	29,4	11,5	0,0	23,0	28,6	11,8	14,3	28,0	21,4	13,6	3,9	6,7	0,0	6,5
Monodactylus falciformis	0,0	33,3	1,5	3,9	0,0	0,0	0,0	0,0	0,0	34,5	26,0	43,8	14,7	30,4	6,7	0,0	0,0	0,0	2,5
Elops machnata	47,4	18,2	18,2	31,7	27,8	60,0	33,3		19,7		100,0	0,0	100,0	50,0	0,0		100,0		50,0
Pomatomus saltatrix	28,6	28,6	16,7	25,0	28,6	0,0			25,0	22,2	35,3	50,0	20,0	30,9	28,6				28,6
Platycephalus indicus	53,9	31,6	0,0	35,1															

(SL) taken and wet mass recorded. Stomach contents were removed from the fish, individual items identified to species level where possible and numbers and mass recorded. From this information Tables 5 – 13 were constructed to indicate the food preference of each (two tables for *Argyrosomus hololepidotus*) of the eight species studied. Table 14 gives the number and size of fish preyed upon by the carnivores.

Similarity analyses were performed on the main food items

Table 4 Number of stomachs containing food (n), size range (standard length in cm) and mean standard length ($\bar{x}$ SL) of carnivorous fish caught in Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops			Sundays			Krom			Gamtoos		
Species	n	Size range SL (cm)	$\bar{x}$ SL (cm)	n	Size range SL (cm)	$\bar{x}$	n	Size range SL (cm)	$\bar{x}$	n	Size range SL (cm)	$\bar{x}$
Argyrosomus hololepidotus	51	17,2 – 57,0	31,4	63	17,6 – 112,0	48,8	50	18,4 – 77,6	35,1	222	18,0 – 78,0	39,6
Lichia amia	10	31,9 – 49,0	38,0	14	15,5 – 62,0	42,8	61	15,7 – 63,2	35,5	103	16,5 – 55,5	35,2
Tachysurus feliceps	15	29,5 – 39,2	32,2	34	13,3 – 32,0	27,0	39	17,2 – 38,7	30,3	28	9,8 – 34,0	27,0
Pomadasys commersonni	60	11,5 – 57,3	35,5	23	13,7 – 52,5	45,5	9	25,0 – 54,5	43,0	7	33,5 – 49,2	43,2
Monodactylus falciformis	5	11,5 – 13,6	12,7				47	11,5 – 17,5	16,0	1	5,3	5,3
Elops machnata	22	54,6 – 84,4	65,7	17	52,2 – 73,5	61,1	2	84,0 – 84,3	84,2	1	59,5	59,5
Pomatomus saltatrix	5	20,0 – 37,5	30,5	2	41,5 – 61,6	51,6	15	24,7 – 50,7	35,7	2	43,2 – 50,5	46,9
Platycephalus indicus	14	26,2 – 30,5	34,2									

comprising the diet of the eight predatory fishes investigated (Field, Clarke & Warwick 1982), to establish interrelationships in food selection between these fish species in the four estuaries where they were caught (Figure 2). The dendrogram groups species with similar feeding preferences in the different systems together.

A food web, displaying trophic relationships (Figure 3) was drawn from the main dietary components (Tables 5 – 13) of the carnivores studied. The interlinking components of the web were extended by food items identified in mysids and fish caught in zooplankton nets in the Sundays estuary (Wooldridge & Bailey 1982) and in Brachyura from the Swartkops estuary (Els 1982).

Results and Discussion

From a comparison of the physical and general characteristics of the four Eastern Cape estuaries studied (Table 1), it becomes clear that the Sundays and Gamtoos estuaries have a number of similar properties as do the Krom and Swartkops estuaries. The first two are channel-like systems with large catchment areas, a definite salinity gradient from head to mouth and few if any vegetated areas. The Krom and Swartkops estuaries in contrast, have smaller catchment areas, larger mud-flats and vegetated areas, clearer water and high salinity throughout the estuary when the rivers are not in flood. In general, much larger gill-net catches were made in the former estuaries.

The three methods most commonly used to express importance of diet components are number, volume and frequency of occurrence. According to Cailliet (1976), the three methods tell the investigator different things about the feeding habits of the same fish. Numerical importance (expressed as per cent by number, % N) and frequency of occurrence (that proportion of stomachs containing a specific prey item, % F.O.) reflect the process of selection used by the fish in its feeding behaviour by pointing out how many prey items and how often a certain prey species was selected, but little about the amount of nutrition (or energy content) the fish gained from that item. On the other hand, volumetric importance (per cent by volume or mass, % M) of a prey item indicates more about the nutritional value of the prey item (Cailliet 1976). Pinkas, Oliphant & Iverson (1971) combined these three measures of 'importance' of prey by the 'Index of Relative Importance' (IRI) which still allow % N, % M and % F.O. to be presented separately. The IRI is calculated by adding % N and % M and multiplying the result by % F.O.

According to Hyslop (1980) two of the methods employed in the present study namely numerical importance (% N) and bulk (% M) would suffice to express the relative importance of a dietary item in the food of a fish species. However, apart from these two indices, % F.O. was also determined and combined with the mentioned methods to calculate IRI. According to Windell (1971) indices combining values determined from unrelated methods are more representative when assessing dietary importance.

Argyrosomus hololepidotus

Table 5 presents the relative importance of different food items in the diet of *A. hololepidotus* caught in eastern Cape estuaries (geographical positions are shown in Figure 1). Fish, which completely dominated the diet of kob, were found in 90% of stomachs. More kob fed on fish in the Gamtoos (% F.O. = 94) and Sundays (% F.O. = 89) estuaries where they are generally more abundant (Table 2), than in Swartkops (% F.O. = 86) and Krom (% F.O. = 76) estuaries. In the channel-like Sundays and Gamtoos estuaries, the family Mysidacea was the most important crustacean group and in the Swartkops and Krom with their larger mud-flats, it was the family Macrura.

The intensity of feeding (food expressed as a percentage of body mass, Table 2) varied between 0,8% (Sundays) and 1,2% (Swartkops and Krom estuaries). The fact that a larger food consumption was found in estuaries where less kob are normally caught, is contrary to expectations. It could be indicative of greater competition for food in estuaries preferred by kob.

Table 3, presenting the percentage of the total number of fish caught with stomachs containing food, shows that kob closer to the estuarine mouth were more likely to have food in the stomach. The only exception was Station 4 in the upper reaches of Gamtoos estuary where 62% of *A. hololepidotus* had food in the stomachs. This was due to large numbers of the freshwater *Micropterus salmoides* being present occasionally.

An analysis of *A. hololepidotus* stomach contents from Sundays estuary based on size (<43 cm and >43 cm SL) is presented in Table 6. The table reveals that smaller kob consumed relatively more Crustacea (IRI = 3848), especially mysids, than larger kob (IRI = 5). Smaller kob preferred smaller fish species such as *Gilchristella aestuarius*, mullet and Gobiidae whereas kob >43 cm SL also fed on larger fish with a longer circumference to body length ratio like *Rhabdosargus holubi, Monodactylus falciformis, Cyprinus carpio* and *Pomadasys commersonni.*

The complete dominance of fish in the diet of kob from eastern Cape estuaries (% F.O. = 90%) is the same as that found by Whitfield & Blaber (1978), in Lake St Lucia (% F.O.

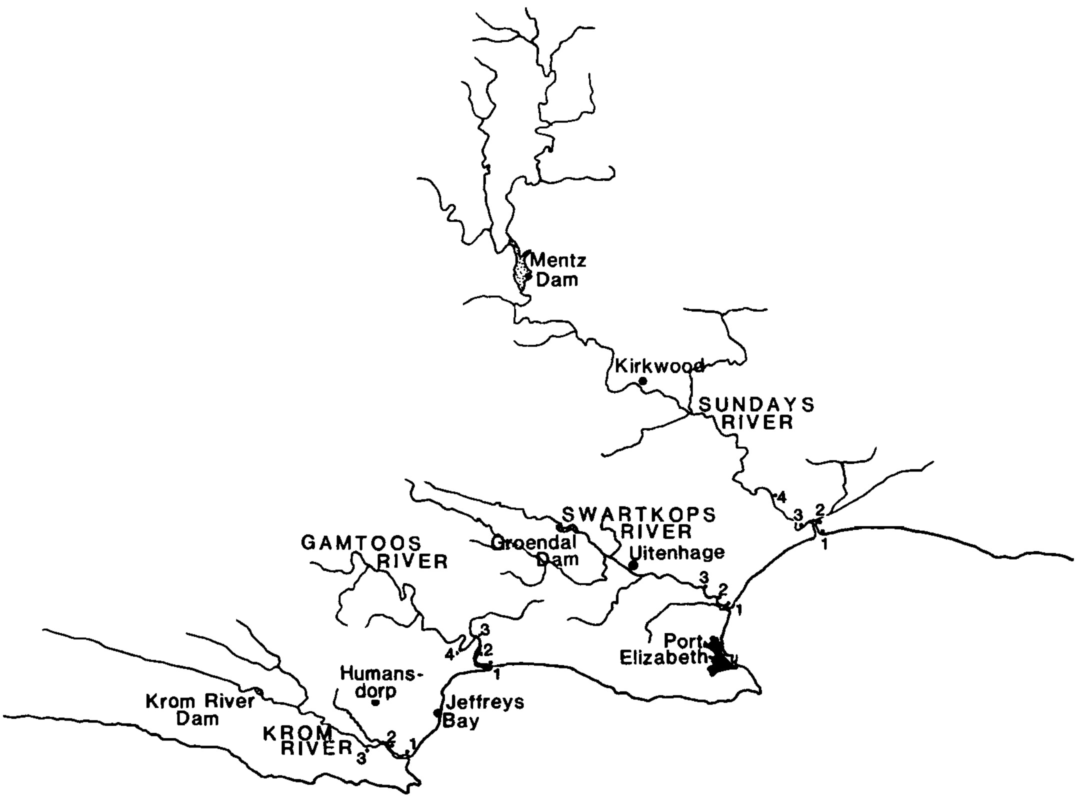

Figure 1 Location of four eastern Cape estuaries from which fish were obtained for stomach content analysis.

Table 5 Stomach content analysis of *Argyrosomus hololepidotus* caught in the Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 319	M = 433 g	S = 51		I = 445	M = 1357 g	S = 63		I = 442	M = 411 g	S = 50		I = 874	M = 2836 g	S = 222		I = 2080	M = 5033 g	S = 386	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Crustacea	31,9	9,3	29,4	1211	49,1	2,2	11,1	569	49,5	12,1	36,0	2218	21,2	1,9	10,4	240	34,6	8,0	16,3	618
Brachyura																	0,2	0,01	0,5	0,1
Unidentified					0,2	0,02	1,6	1									0,05	0,01	0,3	0,01
Cleistostoma edwardsii									0,9	0,1	2,0	2					0,2	0,01	0,3	0,2
Macrura	17,6	5,8	15,7	367	1,3	1,7	6,4	19	21,9	8,3	18,0	544	2,0	0,3	2,3	5	8,5	1,8	6,7	69
Palaemon pacificus	11,3	1,3	7,8	98	0,4	0,05	3,2	1	12,4	3,7	8,0	129	1,9	0,2	1,8	4	5,3	0,5	3,6	21
Macropetasma africanum					0,9	1,6	3,2	8	1,8	0,9	4,0	11	0,1	0,1	0,5	0,1	0,6	5,2	1,3	1
Penaeus indicus									0,2	2,1	2,0	5					0,05	0,2	0,3	0,1
Penaeus canaliculatus	0,3	1,0	2,0	3													0,05	0,1	0,3	0,05
Alpheus crassimanus	6,0	3,5	5,9	56													0,9	0,3	0,8	1
Caridea spp.									7,5	1,6	4,0	36					1,6	0,1	0,5	1
Mysidacea									26,0	3,2	16,0	467					23,7	0,5	6,5	157
Unidentified									6,8	0,4	2,0	12					1,4	0,03	0,3	0,4
Rhopalophthalmus terranatalis					47,4	0,5	6,3	302	10,4	0,3	4,0	43	14,4	0,2	5,0	73	18,4	0,3	4,4	82
Mesopodopsis slabberi	12,5	0,3	3,9	50					8,8	2,5	10,0	113					3,8	0,2	1,8	7
Anomura	1,8	3,2	11,8	59					0,7	0,5	6,0	7					2,5	1,1	4,4	16
Upogebia africana	0,9	0,5	5,9	8	0,2	0,4	1,6	2	0,5	0,1	4,0	2	4,8	1,4	3,2	20	2,3	0,8	3,4	10
Callianassa kraussi	0,9	2,7	5,9	21					0,5	0,4	2,0	2					0,2	0,3	1,0	0,5
Mollusca													0,2	0,2	0,9	0,5	0,3	2,2	1,6	4
Pelecypoda																				
Solen capensis													0,1	0,1	0,5	0,1	0,05	0,1	0,3	0,04
Cephalopoda																				
Sepia spp.					0,2	1,0	1,6	2	0,9	21,5	6,0	134	0,1	0,1	0,5	0,1	0,2	2,1	1,3	3

Table 5 (continued)

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 319	M = 433 g	S = 51		I = 445	M = 1357 g	S = 63		I = 442	M = 411 g	S = 50		I = 874	M = 2836 g	S = 222		I = 2080	M = 5033 g	S = 386	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Plant																		0,4	0,8	0,3
Unidentified													–	0,6	0,9	1	–	0,3	0,5	0,I
Spartina capensis									–	0,4	2,0	1						0,03	0,3	0,01
Amphibia																				
Xenopus laevis													0,2	1,4	0,9	1	0,1	0,8	0,5	0,4
Pisces	67,9	90,6	86,3	13679	50,5	96,7	88,9	13086	49,6	66,0	76,0	8786	78,1	96,0	93,7	16313	64,7	93,2	89,6	14148
Gilchristella aestuarius	56,1	37,1	56,9	5303	30,6	9,0	46,0	1822	20,6	17,4	38,0	1444	57,2	14,6	53,2	3820	43,6	17,0	43,0	2606
Unidentified	3,4	11,9	21,6	330	5,4	8,8	17,5	248	7,5	26,0	30,0	1005	12,6	14,6	26,1	710	8,6	13,7	24,6	549
Mugil cephalus					1,3	23,1	6,3	154					0,8	19,3	2,7	54	0,6	17,1	2,6	46
Liza richardsoni					0,7		3,2	36	0,2	6,0	2,0	12	0,7	15,6	1,8	29	0,5	13,7	2,1	30
Mugilidae	0,9	18,0	2,0	37	10,6	12,8	15,9	372					0,2	3,4	0,9	3	2,5	5,4	3,4	27
Rhabdosargus holubi	0,3	10,0	2,0	21	0,2	1,3	1,6	2					1,0	5,1	3,6	22	0,5	4,1	2,6	12
Etrumeus teres									20,1	14,1	12,0	410					4,3	1,1	1,6	9
Gobiidae	4,4	7,0	7,8	89	0,7	0,3	3,2	3					0,9	2,4	1,8	6	1,2	2,0	2,6	8
Orechrosomis spp.													1,0	5,6	1,8	12	0,4	3,1	1,0	3
Tachysurus feliceps									0,5	0,7	2,0	2	1,6	1,1	2,7	7	0,7	0,7	1,8	2
Liza dumerili					0,2	7,7	1,6	13					0,3	4,5	0,5	2	0,2	4,5	0,5	2
Pomadasys commersonni					0,4	15,4	3,2	52									0,1	4,2	0,5	2
Labeo umbratus													1,0	1,0	1,4	3	0,4	0,5	0,8	1
Cyprinus carpio					0,2	7,7	1,6	13									0,05	2,1	0,3	1
Myxis capensis													0,1	5,2	0,5	3	0,05	2,9	0,3	1
Argyrosomus hololepidotus	0,3	4,9	2,0	10									0,1	1,5	0,5	1	0,1	1,2	0,5	1
Lithognathus lithognathus													0,3	1,5	0,5	1	0,2	0,8	0,3	0,3
Micropterus salmoides													0,2	0,4	0,9	1	0,1	0,2	0,5	0,1
Hepsetia breviceps									0,7	1,8	2,0	5					0,1	0,1	0,3	0,1
Monodactylus falciformis					0,2	0,03	1,6	1					0,1	0,2	0,5	2	0,1	0,1	0,5	0,1
Pomatomus saltatrix	2,2	1,6	2,0	8													0,3	0,1	0,3	0,1

= 90%). However, unlike the Lake St Lucia study where *Thryssa vitrirostris* predominated in kob diets (a species which does not occur locally), *G. aestuarius* occurred in the largest number of kob stomachs (% F.O. = 43).

Crustacea, which were found in 16% of *A. hololepidotus* stomachs from eastern Cape estuaries, occurred in 18% of stomachs of fish in Lake St Lucia (Whitfield & Blaber 1978). In the surf-zone of Algoa Bay its % F.O. increased to 60% (Lasiak 1982). In contrast to the estuarine environment where the mysid *Rhopalophthalmus terranatalis* was the dominant crustacean, *Macropetasma africanus* predominated in kob stomachs caught in the surf-zone (Lasiak 1982).

The decline in the importance of Crustacea in the diet of older kob is emphasized by the work of Smale (1983) in the eastern Cape coastal region. The prey of kob 20 – 30 cm long, consisted predominantly of crustaceans (99,7% by number, 89% by mass). In kob of 30 – 50 cm, crustaceans made up 99% of the number and 14% of the mass taken. In *A. hololepidotus* of 50 – 100 cm, Crustacea accounted for 91% by number and 10% by mass which declined further to only 2% by number and about 1% by mass in kob >100 cm. As in the case of eastern Cape estuaries crustaceans were replaced in the diet of older kob caught in the sea by fish and to some extent by cephalopods.

Intensity of feeding was slightly higher in the surf-zone off Bluewater Bay (1,37%, Lasiak 1982) than in the estuaries (0,8 – 1,2%). In three of the four estuaries the maximum percentage stomach fill (Table 2) was close to 6% as opposed to 4,3% found in the sea by Lasiak (1982).

In general the mean percentage of kob with food in the stomachs in Gamtoos estuary (52%) was similar to that found in St Lucia (53%) (Whitfield & Blaber 1978). The mean percentage of *A. hololepidotus* with food in the stomach was highest in the Gamtoos estuary (Table 3) where more kob turned up in gill-nets (see CPUE values, Table 2) than in the other three eastern Cape estuaries.

Lichia amia

Table 7 shows that only 3% of 188 stomachs of *Lichia amia* examined contained Crustacea. Ninety-eight per cent of all leervis consumed fish prey of which the most abundant species were the freshwater *M. salmoides, G. aestuarius* and the different mullet species. The most important crustacean in the diet was the mysid *R. terranatalis.*

In general *L. amia* consumed more food in the Krom and Gamtoos estuaries (1,8 and 2,6% of body mass respectively) which are favoured by leervis (higher CPUE values, see Table 2) than in Swartkops and Sundays estuaries (both 1,3%).

Table 6 Stomach content analysis of *Argyrosomus hololepidotus* caught in the Sundays estuary divided into two size ranges (17,6 – 43,0 cm SL and 43,1 – 112,0 cm SL)

	17,6 – 43,0 cm SL				43,1 – 112,0 cm SL			
	l = 288 % n	M = 108g % m	S = 20 % F.O	I.R.I	l = 155 % n	M = 1248 g % m	S = 43 % F.O	I.R.I
Crustacea	75,0	10,5	45,0	3848				
Mysidacea	73,3	7,0	25,0	2007				
Rhopalophthalmus terranatalis	73,0	6,5	20,0	1590				
Mesopodopsis slabberi	0,3	0,5	5,0	4				
Macrura	1,0	3,4	15,0	66				
Palaemon pacificus	0,7	0,6	10,0	13				
Macropetasma africanum	0,3	2,8	5,0	16	0,6	1,5	2,3	5
Anomura								
Upogebia africana	0,3	0,5	5,0	4				
Brachyura								
Unidentified	0,3	0,2	5,0	3				
Mollusca								
Cephalopoda								
Sepia spp.					0,6	1,1	2,3	4
Pisces	24,0	89,5	80,0	9080	98,7	97,4	111,6	21885
Gilchristella aestuarius	12,8	44,1	55,0	2580	46,5	5,9	41,9	2196
Mugilidae	2,4	29,6	5,0	160	25,8	11,3	20,9	775
Unidentified	0,3	1,9	5,0	11	14,8	9,4	23,3	564
Mugil cephalus	0,3	9,5	5,0	49	3,2	24,3	7,0	64
Pomadasys commersonni					1,3	17,2	4,7	87
Liza richardsoni					1,9	11,6	4,7	63
Cyprinus carpio					0,6	8,4	2,3	21
Liza dumerili					0,6	7,8	2,3	19
Gobiidae	1,0	4,3	10,0	53				
Rhabdosargus holubi					0,6	1,4	2,3	5
Monodactylus falciformis					0,6	0,03	2,3	1

Maximum percentage stomach fill (6,9 and 9,0%) was also higher in the Krom and Gamtoos estuaries (4,1% in Swartkops and 3,3% in Sundays). However, contrary to expectations, more leervis in the Sundays estuary (40%) had food in their stomachs than in the Gamtoos estuary (34%). Since *L. amia* does not seem to have any problem in obtaining food in the Sundays estuary, the question might be raised why more of them are not encountered in that estuary.

The ability of *L. amia* to accommodate prey fish much longer than its own stomach length, is amazing. On a few occasions freshly eaten mullet, which had been scaled, skinned and folded into three equal lengths, were found in seemingly over-distended leervis stomachs.

L. amia caught in eastern Cape coastal water preyed on the crustacean, *Macropetasma africana* (Smale 1983), as was found in Krom estuary (Table 7). Some members of the family Sepiidae were also taken in the sea but the bulk of its prey consisted of pelagic or schooling demersal species. In both Knysna and Swartvlei (Smale & Kok 1983) as was found in eastern Cape estuaries, fish completely dominated in the diet of *L. amia*. However, crustacea were of increasing importance in smaller leervis.

From a study of the literature and the data of Table 7, it is evident that prey selection by *L. amia* varies considerably in different environments. In the Swartkops estuary, leervis fed exclusively on fish as was recorded by Whitfield & Blaber (1978) for St Lucia. According to Coetzee (1982), *L. amia* preyed upon the sand-shrimp *Palaemon pacificus* near the mouth of the Swartvlei system, predominantly on fish in the middle reaches and only on fish in the upper reaches. The round herring, *G. aestuarius*, and *P. pacificus* occupied 45% (by mass) of leervis stomach contents in that system. Begg (1976) found that juvenile mullet was the main prey item of *L. amia* in Sandvlei on the south-western Cape coast.

It thus seems that *L. amia* generally feed on whatever prey is available, depending on its abundance and accessibility, as was shown for piscivorous fishes in St Lucia which fed on fish (Whitfield & Blaber 1978). In the eastern Cape, *L. amia* only consumed *M. salmoides* in the upper freshwater reaches of the Gamtoos estuary. During 1982, *M. salmoides* were present in 40 of the 50 stomachs of *L. amia* caught at Station 4. On the same occasion only two out of 19 *L. amia* caught at Station 1 of the Gamtoos estuary, contained food in the stomach. It thus seems that this truly piscivorous species will consume Crustacea when abundant (Swartvlei system) or will move to the upper freshwater regions of estuaries when prey of the preferred size range is abundant there (Gamtoos, Table 7).

Tachysurus feliceps

Sea-catfish, *Tachysurus feliceps*, consumed a wide variety of organisms, including Mollusca, Annelida, Porifera, plant remains, fish and especially Crustacea (Table 8). Most of its food

Table 7 Stomach content analysis of *Lichia amia* caught in the Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 33	M = 120 g	S = 10		I = 42	M = 201 g	S = 14		I = 234	M = 756 g	S = 61		I = 363	M = 1892 g	S = 103		I = 672	M = 2970 g	S = 188	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Crustacea									9,7	2,7	4,8	28					19,8	0,9	2,6	54
Mysidacea																				
Rhopalophthalmus terranatalis					47,6	0,05	7,1	338					24,8	0,2	0,9	23	16,4	0,2	1,1	18
Anomura									3,8	1,1	3,2	16					1,3	0,3	1,1	2
Macrura																				
Macropetasma africanum									5,9	1,6	1,6	12,0					2,1	0,4	0,5	2
Pisces	100,0	100,0	100,0	20000	52,3	99,5	92,8	14087	86,3	97,1	96,7	17735	75,2	99,8	99,0	17325	80,2	99,1	97,9	17553
Unidentified					2,3	10,2	7,1	89	65,4	57,4	70,5	8657	14,0	17,9	29,1	928	30,5	26,7	39,4	2254
Micropterus salmoides													39,9	36,8	38,8	2976	21,5	23,4	21,3	956
Gilchristella aestuarius	66,7	14,5	50,0	4050	26,1	7,1	14,3	475	11,5	5,1	11,5	191	7,4	0,8	8,7	71	12,9	2,9	12,2	193
Mugilidae	12,1	25,0	10,0	270	7,1	21,2	21,4	606	1,3	8,4	4,9	48	3,0	12,1	9,7	147	3,1	12,3	9,0	139
Mugil cephalus					4,7	16,7	14,3	306					1,9	14,2	6,8	110	1,3	10,2	4,8	55
Liza richardsoni					9,5	37,8	28,5	1348	0,4	5,6	1,6	10	1,1	6,3	3,9	29	1,3	8,0	4,8	45
Pomadasys olivaceum									0,4	5,6	1,6	10	5,0	4,5	2,9	28	2,8	4,3	2,1	15
Rhabdosargus holubi	6,1	39,6	20,0	914					1,3	2,7	3,2	13	0,3	0,1	0,9	0,4	0,9	2,4	2,7	9
Gobiidae									4,7	2,2	4,9	34	0,3	0,03	0,9	0,3	1,7	0,6	2,1	5
Pomadasys commersonni	3,0	15,8	10,0	180									0,3	3,1	0,9	3	0,3	2,6	1,1	3
Hepsetia breviceps	12,1	5,0	10,0	170					3,8	2,9	1,6	11					2,0	0,9	1,1	3
Lichia amia									1,3	7,2	3,2	27					0,4	1,8	1,1	3
Orechrosomis spp.													1,7	1,7	1,9	7	0,9	1,1	1,1	2
Argyrosomus hololepidotus													0,3	2,1	0,9	2	0,1	1,3	0,5	1
Liza dumerili					2,3	6,4	7,1	62									0,1	0,4	0,5	0,3

is derived from the anomuran mud-prawn *Upogebia africana* (% F.O. = 50). The large amounts of unidentifiable fish remains in *T. feliceps* stomachs, suggest that it scavenges on dead fish.

The most noticeable difference in the food preferences of fish in the different estuaries was the importance of Crustacea in the diet of *T. feliceps* in the Swartkops (% F.O. = 100) and also in the Sundays (% F.O. = 50) estuaries. On the other hand sea-catfish consumed more fish in the Gamtoos (% F.O. = 32) and Krom (% F.O. = 44) estuaries than in the Swartkops (14%) and Sundays (9%) estuaries.

T. feliceps showed a mean feeding intensity of 5,5% in the Swartkops estuary (Table 2). This was to a large extent the effect of post-flood conditions during which sea-catfish consumed up to 41 *U. africana* when these animals evacuated their burrows apparently because of osmotic stress (Marais 1982). The mean value of 3,3% found in the Sundays estuary could also be ascribed to similar post-flood feeding conditions. However, the maximum number of mud-prawns taken in the channel-like Sundays estuary was only four.

The lowest feeding intensity found for fish of the Krom and Gamtoos estuaries (2,7 and 1,2%) respectively is surprising when it is considered that CPUE for these two estuaries (5,6 and 18,5) is considerably higher than for the Swartkops (1,4) and Sundays (4,1) estuaries (Table 2). Three possible reasons could account for this apparent paradox. Selection of estuaries by *T. feliceps* could be for ideal breeding grounds and not for food availability. Secondly, sampling in the Krom estuary took place during years that floods did not occur (Marais 1983a). Furthermore it was pointed out by Marais (1983a & b) that the area for colonization of *U. africana* in the first two estuaries is limited, which could result in reduced food intake because of competition.

The maximum food consumption of a sea-catfish of 18,5% of body mass in the Krom estuary (Table 2) was due to three *Cleistostoma algoense* (60 g) and two *Ovalipes punctatus* (30 g) preyed upon in the mouth region.

The fact that *T. feliceps* enter estuaries to breed probably explains the low number of fish caught with food in the stomach (Table 3). However, sea-catfish in a pre-spawning condition did not seem to be at all inhibited when food was abundant after floods. On one such an occasion in the Swartkops estuary, a female (725 g) with gonads weighing 62 g (60 eggs) devoured 27 *U. africana* as well as some other food items totalling 49 g.

Pomadasys commersonni

Table 9 clearly shows that *Upogebia africana* was the single most important item in the diet of *Pomadasys commersonni* in the Swartkops, Sundays and Gamtoos estuaries. In the Krom estuary the pelecypod, *Solen corneus*, was the most abundant prey item. *U. africana* was taken by 53% spotted grunters, with *Calianassa kraussi* (% F.O. = 23) second in order of preference. Although *P. commersonni* also consumed Mollusca, Annelida, plant material (probably accidentally) and fishes, Crustacea was by far the most important dietary component in the fish of eastern Cape estuaries (% F.O. = 85).

The most noticeable difference in food preference between

Table 8 Stomach content analysis of *Tachysurus feliceps* caught in the Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 268	M = 406 g	S = 14		I = 106	M = 463 g	S = 34		I = 389	M = 534 g	S = 39		I = 49	M = 118 g	S = 28		I = 812	M = 1520 g	S = 115	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Crustacea	97,0	95,8	100,0	19280	83,0	87,7	91,2	15568	81,3	53,6	82,1	11075	73,5	39,4	64,3	7259	86,2	74,0	82,6	13234
Brachyura	1,5	0,2	14,3	23	18,9	2,0	26,3	548	67,9	32,8	82,0	8257				8	35,6	12,5	38,3	1835
Unidentified									25,4	2,1	2,8	352	2,0	0,2	3,6	8	14,7	1,4	13,0	209
Cleistosoma edwardsii									0,8	0,2	2,6	3					0,4	0,1	0,9	0,4
Cleistosoma algoense	1,1	0,1	7,1	9	5,7	0,2	2,9	17,1	4,1	11,7	17,9	283					3,0	4,0	7,8	56
Hymenosoma orbiculare	0,4	0,05	7,1	3	11,3	1,1	17,6	218	34,7	6,3	25,6	1047					18,2	2,6	14,8	308
Philyra punctata									0,3	0,2	2,6	1					0,2	0,3	1,7	1
Sesarma catenata									0,8	0,5	5,1	7					0,5	0,2	2,6	2
Ovalipes punctatus									1,0	8,6	7,7	74					0,5	2,9	2,6	9
Pinnotheres dofleini									0,5	0,4	5,1	5					0,2	0,1	1,7	1
Scylla serrata									0,3	2,8	2,6	8					0,1	1,0	0,9	1
Anomura					59,4	85,2	79,4	11481	12,1	20,6	53,8	1759	34,7	38,5	53,6	3920	46,5	61,3	66,9	7218
Upogebia africana	93,6	94,1	100,0	18770	39,6	71,6	50,0	5560	11,6	20,0	48,7	1539	18,4	30,1	28,6	1385	42,7	56,3	50,0	4989
Callianassa krausii					19,8	13,6	29,4	982	0,5	0,6	5,1	6	16,3	8,4	25,0	618	3,8	5,0	16,5	145
Macrura									1,3	0,2	5,2	4					1,8	0,7	5,2	13
Penaeidae	1,9	1,6	21,4	69	4,7	0,6	2,9	15									1,2	0,6	3,4	6
Alpheus crassimanus									0,5	0,1	2,6	2					0,2	0,03	0,9	0,2
Palaemon pacificus									0,8	0,1	2,6	2					0,4	0,01	0,9	0,4
Mysidacea																				
Rhopalophthalmus terranatalis													36,7	0,7	10,7	401	2,2	0,5	2,6	7
Mollusca									9,7	15,1	17,9	445					5,3	8,6	10,4	145
Gastropoda									8,7	0,3	7,7	70					4,3	0,1	3,4	15
Assiminea spp.					0,9	0,4	2,9	3									0,1	0,01	0,9	0,1
Nassa spp.									0,5	0,03	5,1	3					0,2	0,01	1,7	0,4
Haminea alfredensis									8,2	0,3	2,6	22					3,9	0,1	0,9	3
Cephalopoda																				
Sepia spp.									0,5	14,4	5,1	76	8,2	41,8	14,3	714	0,7	8,3	5,2	47
Pelecypoda																				
Solen capensis									0,5	0,4	5,1	5					0,2	0,1	1,7	1
Annelida																				
Polychaeta																	2,1	2,7	2,6	12
Unidentified	1,1	0,5	14,3	22													0,4	0,2	1,7	1
Arenicola loveni					13,2	8,6	2,9	63									1,7	2,6	0,9	3
Porifera	–	0,2	7,1	1													–	0,04	0,9	0,03
Plant	–	0,3	7,1	2						8,1	5,1	41					–	2,9	2,6	8
Pisces									9,1	32,2	43,6	1404	18,4	18,8	32,1	1196	6,4	11,5	27,0	483
Unidentified	1,9	3,5	14,3	74	2,8	3,4	8,8	55	5,9	12,8	30,8	576	16,3	13,7	28,6	857	4,8	7,5	21,7	267
Rhabdosargus holubi									0,5	2,8	5,1	17	2,0	5,2	3,6	26	0,4	1,4	2,6	5
Mugilidae									0,5	2,0	5,1	13					0,2	0,7	1,7	2
Lithognathus lithognathus									0,3	3,9	2,6	11					0,1	1,4	0,9	1
Gilchristella aestuarius									1,0	0,6	2,6	4					0,5	0,2	0,9	1
Monodactylus falciformis									0,3	0,6	2,6	2					0,1	2,1	0,9	0,3
Gobiidae									0,3	0,3	2,6	2					0,1	0,1	0,9	0,2
Solea bleekeri									0,3	0,1	2,6	1					0,1	0,03	0,9	0,1

the different eastern Cape estuaries, was the increased importance of *S. corneus* in the Sundays (I.R.I. = 2990) compared to the Swartkops and Gamtoos estuaries where none were consumed. More Brachyura were taken in the Swartkops and Krom estuaries with their larger shallow mud-flat areas with *Spartina* beds than in the other two more channel-like estuaries.

In general *P. commersonni* stomachs contained little food. This could be because gill-netting caused regurgitation of food,

Table 9 Stomach content analysis of *Pomadasys commersonni* caught in the Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 339	M = 491 g	S = 60		I = 84	M = 379 g	S = 23		I = 19	M = 59 g	S = 9		I = 26	M = 68 g	S = 7		I = 468	M = 988 g	S = 99	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Crustacea	98,4	89,7	96,7	18189	57,2	28,7	60,9	5231	57,9	41,0	66,6	6587	100,0	100,0	100	20000	89,5	67,7	84,9	13346
Brachyura	23,8	17,6	21,6	894					26,3	5,2	33,3	1049					18,6	13,4	17,2	550
Unidentified	3,2	0,3	8,3	29					15,8	3,2	22,2	422	3,8	4,4	14,3	117	3,2	0,6	8,1	31
Sesarma catenata	7,7	8,1	8,3	131													5,6	4,1	5,0	48
Hymenosoma orbiculare									10,5	2,0	11,1	139					0,4	0,1	1,0	1
Cleistostoma edwardsii	10,0	6,9	3,3	56													7,3	7,5	2,0	30
Thaumastoplax spiralis	2,9	2,3	1,7	9													2,1	1,1	1,0	3
Anomura	58,7	72,0	88,4	11554	57,2	28,7	56,5	4853	31,6	35,8	33,3	2244	96,2	95,6	114,3	21923	59,4	54,2	78,8	8952
Unidentified	0,3	2,3	1,7	4													0,2	0,2	1,0	0,4
Upogebia africana	32,7	44,6	51,7	3996	42,9	27,1	52,2	3654	15,8	23,5	22,2	872	88,5	88,1	100,0	17660	37,0	39,8	52,5	4032
Calianassa krausii	24,2	24,6	31,7	1547	14,3	1,6	8,7	138	15,8	12,3	11,1	312	7,7	7,5	14,3	217	22,2	14,0	23,0	833
Diogenes spp.	1,5	0,5	3,3	7													1,1	0,2	2,0	2
Isopoda	0,6	0,02	3,3	2													0,4	0,01	2,0	1
Amphipoda	15,3	0,1	3,3	51													11,1	0,1	2,0	22
Mollusca																				
Pelecypoda																	7,7	23,0	12,1	371
Solen capensis	0,3	0,7	1,7	3													0,2	0,4	1,0	1
Solen corneus					34,5	49,8	34,8	2934	31,6	58,2	33,3	2990					7,5	22,6	11,1	334
Nematoda (Parasite)	0,9	1,6	1,7	4													0,6	0,8	1,0	1
Annelida																				
Polychaeta					5,9	3,1	8,7	78									1,1	1,2	2,0	5
Plant	–	2,2	11,7	22													0,4	1,2	6,1	10
Zostera capensis	–	1,9	6,7	13													–	1,0	4,0	4
Spartina capensis	–	0,3	5,0	1													–	0,2	3,0	1
Acasia cyclops									20,5	0,7	11,1	124					0,4	0,04	1,0	1
Pisces																	0,6	8,0	2,0	3
Gobidae	0,3	2,7	1,7	5													0,2	0,9	1,0	0,2
Soleidae					2,4	18,4	4,3	89									0,4	7,1	1,0	8

probably to a larger extent in *P. commersonni* than in other species. The highest mean feeding intensities were recorded for the Sundays (0,9% of body mass) and Swartkops (0,8%) estuaries (Table 2). *P. commersonni* was also more abundant in these two estuaries. Maximum food consumption was also recorded in these two estuaries (3,5 and 3,9% respectively, Table 2). Twenty per cent of all spotted grunters caught in the Swartkops, Sundays and Krom estuaries had stomachs containing food when caught as compared to only 7% of those caught in the Gamtoos estuary (Table 3).

Whitfield (1980) showed that *P. commersonni* preyed on Mollusca, Polychaeta and Crustacea in Lake St Lucia. He did not indicate preference or feeding intensity.

Monodactylus falciformis

The main prey items of *M. falciformis* in the estuarine environment (see Table 10) were found to be mysids (% F.O. for all species = 30), *Upogebia africana* (% F.O. = 23) and *Palaemon pacificus* (17%). It also consumed some small sluggish fish such as Soleidae and *G. aestuarius*, although only to a limited extent (fish % F.O. = 13). Too few Cape moonies were caught in estuaries other than the Krom to allow comparison of food preference between estuaries.

Feeding intensity of the five Cape moonies caught in the Swartkops estuary (2,8% of body mass) was higher than in the Krom (0,6%), an estuary normally preferred by *M. falciformis* (Table 2). However, in the Swartkops (4%), Sundays (0%) and Gamtoos (3%) estuaries, the percentage of *M. falciformis* stomachs containing food was considerably lower than in the Krom estuary (30%).

Little information has been published on the feeding behaviour of *M. falciformis* previously. Lasiak (1982) categorized it as a planktivore since its major prey items in the surf-zone were megalopa (% F.O. = 15,9) *Macropetasma africanum* (3,7%), *Mesopodopsis slabberi* (13,6) and fish (3,7%). In the Mhlanga estuary, Whitfield (1980) observed that juvenile *M. falciformis* fed predominantly on insects, copepods and crustacean larvae.

Maximum percentage food intake by *M. falciformis* in the surf-zone near Port Elizabeth was 5% (Lasiak 1982) as compared to 11,9% for a Cape moony from the Swartkops estuary (Table 2). The higher feeding intensity found in the Swartkops and Krom estuaries, compared to the sea (0,3%, Lasiak 1982), suggests that it could be nutritionally advantageous for Cape moonies to visit estuaries. That mature *M. falciformis* do have a definite migration pattern between the sea and the Krom estuary which is determined by their breeding cycle, was shown by Marais (1983a).

Table 10 Stomach content analysis of *Monodactylus falciformis* caught in the Swartkops, Krom and Gamtoos estuaries

	Swartkops				Krom				Gamtoos				Total			
	I = 70	M = 9 g	S = 5		I = 350	M = 49 g	S = 47		I = 10	M = 0,3 g	S = 1		I = 430	M = 58 g	S = 53	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Crustacea	94,2	56,1	100,0	15030	95,8	92,4	83,0	15621					93,3	86,6	88,7	15957
Unidentified					0,6	0,2	2,1	2					0,5	0,2	1,9	1
Mysidacea					19,5	4,0	25,6	601					20,9	5,8	30,2	806
Unidentified	31,4	16,4	80,0	3824	6,9	2,0	8,5	76					10,7	4,2	15,1	225
Mesopodopsis slabberi					6,3	1,4	12,8	98					5,1	1,2	11,3	71
Rhopalophthalmus terranatalis					6,3	0,6	4,3	30					5,1	0,5	3,8	21
Anomura	2,8	12,1	40,0	596	53,4	60,5	46,8	5330					44,0	53,0	45,3	4394
Unidentified					1,1	1,8	8,5	25					0,9	1,5	7,5	18
Upogebia africana	1,4	6,4	20,0	156	44,6	40,5	23,4	1991					36,5	35,2	22,6	1620
Callianassa kraussi	1,4	5,7	20,0	142	7,7	18,2	14,9	386					6,5	16,3	15,1	344
Macrura																
Palaemon pacificus					8,6	17,7	19,1	502					7,0	15,0	17,0	374
Brachyura																
Hymenosoma orbiculare					1,4	2,2	10,6	38					1,2	1,9	9,4	29
Isopoda	2,9	2,3	20,0	208	12,3	7,8	12,8	257					10,5	6,9	11,3	197
Amphipoda	57,1	25,3	20,0	1648									9,3	3,8	1,9	25
Annelida																
Polychaeta	1,4	9,2	20,0	212									0,1	1,4	1,9	3
Pisces	4,3	34,5	40,0	1552	2,0	7,2	10,5	97					2,3	11,3	13,2	180
Soleidae					0,6	3,5	4,2	17					0,5	2,9	3,8	13
Gilchirstella aestuarius	1,4	11,5	20,0	258	0,3	1,0	2,1	3					0,5	2,6	3,8	12
Unidentified					1,1	2,7	4,2	16					0,9	2,3	3,8	12
Mugilidae	2,9	23,0	20,0	518									0,5	3,4	1,9	7
Unidentified					2,3	0,3	8,5	22	100	100	100	20000	4,2	0,8	9,4	47

Elops machnata

The tenpounder, *Elops machnata*, was only caught in large enough numbers to determine its diet preference in the Swartkops and Sundays estuaries. Fish comprised 6% in terms of numbers, 63% of mass and 71% in terms of frequency of occurence (Table 11). Of the fish preyed upon in local estuaries, *E. machnata* preferred members of the family Mugilidae followed by *G. aestuarius.*

An attempt to determine the most important component in the diet of *E. machnata* emphasizes the importance of having more than one index in food preference studies. Although 94% of the total number of food items consumed by *E. machnata* in eastern Cape estuaries were Crustaceans, they only comprised 37% of the food of *E. machnata* gravimetrically. Percentage F.O. for Crustacea was only 57% as against 71% for fish in local estuaries. However, I.R.I. values combining the three indices favoured Crustacea (7497) rather than fish (4912).

Feeding intensity was higher in the Swartkops estuary (0,9% of body mass) where tenpounder is more abundant (Table 2) than in the Sundays (0,5%). More tenpounder were caught in the Swartkops estuary with stomachs containing food (32%; Table 3) than in the Sundays estuary (20%).

Considerable differences were found in the food preference of *E. machnata* in eastern Cape estuaries compared to Lake St Lucia (Whitfield & Blaber 1978). In Lake St Lucia the I.R.I. value for Crustacea (calculated from the data of Whitfield & Blaber 1978) was only 969 as against 7497 for eastern Cape estuaries. The I.R.I. value for fish prey in St Lucia was 12596 compared to 4912 in local estuaries. Furthermore, *G. aestuarius* was more important in the diet of *E. machnata* than members of the family Mugilidae in Lake St Lucia. More *E. machnata* had stomachs containing food in St Lucia (48%) than in either the Swartkops (32%) or Sundays (20%) estuaries (Table 3).

Pomatomus saltatrix

Stomach contents analysis of the elf, *Pomatomus saltatrix* is presented in Table 12. In the four eastern Cape estuaries, fish formed a larger component of the diet (% F.O. = 63) than Cephalopoda (*Sepia* spp. % F.O. = 38). *G. aestuarius* was the most important fish species preyed upon while the various mullet species were also taken readily.

In both Krom and Sundays estuaries, Cephalopoda (I.R.I. = 5996 and 5970 respectively) were more important in the diet than fish (I.R.I. = 4086 and 4030, Table 8). In contrast, the seven elf caught in Swartkops and Gamtoos estuaries, fed exclusively on fish. *A. hololepidotus*, as is the case with *P. saltatrix*, consumed more *Sepia* spp. in Krom estuary than in any of the other three eastern Cape estuaries, which could indicate a greater abundance of *Sepia* spp. in that estuary. The mean intensity of feeding in the Krom estuary (2,3%) was higher than in the other eastern Cape estuaries (1,4 – 1,6%). A much higher maximum value was also found (9,6% as against 2,0 – 3,7%, Table 2).

In the Knysna estuary, elf <10 cm consumed mainly Crustacea followed by smaller fish (Smale & Kok 1983). *P. saltatrix* >10 cm, as was found in the present study, preferred fish prey and also took fair amounts of Cephalopoda in

Table 11 Stomach content analysis of *Elops machnata* caught in the Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 8897	M = 591 g	S = 22		I = 1796	M = 205 g	S = 17		I = 165	M = 310 g	S = 2		I = 2	M = 2 g	S = 1		I = 10862	M = 1114 g	S = 42	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Crustacea	98,1	54,0	72,2	11058	96,0	43,3	70,6	9835									94,3	37,0	57,1	7497
Brachyura																	0,02	0,06	4,8	0,3
Unidentified	0,01	0,01	5,0	0,1													0,01	0,05	2,4	0,2
Cleistostoma edwardsii					0,06	0,04	5,9	1									0,01	0,01	2,4	0,1
Anomura																				
Upogebia africana	0,1	2,1	5,0	11	0,5	1,6	11,8	24									0,2	1,4	19,0	30
Mysidacea	94,3	42,0	22,7	3094	94,1	38,7	41,2	5471									92,8	29,7	28,5	3491
Unidentified	1,1	0,3	5,0	7	57,1	25,3	17,7	1458	10,4								10,4	4,8	9,5	144
Mesopodopsis slabberi	93,2	41,7	18,2	2455													73,3	22,4	9,5	938
Rhopalophthalmus terranatalis					37,0	13,4	23,5	1184	6,1								6,1	2,5	9,5	81
Macrura	3,7	9,9	18,2	24,8													1,2	5,8	14,3	100
Palaemon pacificus	1,0	2,9	9,1	35	1,3	3,0	11,8	39									1,0	2,1	9,5	29
Penaeus canaliculatus	0,02	1,0	5,0	5													0,02	0,5	2,4	8
Macropetasma africanum	2,7	6,0	5,0	44													0,2	3,2	2,4	1
Pisces	4,3	77,7	77,3	6339	4,1	56,7	94,1	5721	100	100	100	20000					5,7	63,1	71,4	4912
Mugilidae (unidentified)	3,7	37,9	31,8	1322	0,06	2,0	5,9	12									3,0	20,7	19,0	450
Gilchristella aestuarius	0,5	3,5	22,7	91	1,0	10,0	29,4	323					100	100	100	20000	0,6	3,9	26,2	118
Gobiidae (unidentified)	0,1	3,5	9,1	33	2,6	19,5	23,5	519	1,8	1,9	50,0	185					0,5	6,0	16,7	109
Estrumeus teres									97,0	95,8	50,0	9640					1,5	26,7	2,4	68
Soleidae (unidentified)	0,02	1,0	9,1	9	0,06	5,4	5,9	32	0,6	1,9	50,0	125					0,04	2,0	9,5	19
Tachysurus feliceps					0,2	6,5	11,8	79									0,03	1,2	4,8	6
Liza dumerili					0,06	9,3	5,9	55									0,01	1,7	2,4	4
Unidentified					0,1	4,0	11,8	48									0,02	0,7	4,8	3
Monodactylus falciformis									0,6	0,4	50,0	50					0,01	0,1	2,4	0,3
Pomadasys olivaceum	0,01	0,1	5,0	1													0,01	0,05	2,4	0,2

Table 12 Stomach content analysis of *Pomatomus saltatrix* caught in the Swartkops, Sundays, Krom and Gamtoos estuaries

	Swartkops				Sundays				Krom				Gamtoos				Total			
	I = 13	M = 38 g	S = 5		I = 3	M = 72 g	S = 2		I = 21	M = 305 g	S = 15		I = 3	M = 44 g	S = 2		I = 40	M = 459 g	S = 24	
	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I	% n	% m	% F.O	I.R.I
Mollusca																				
Cephalopoda																				
Sepia sp.					33,3	86,1	50,0	5970	38,1	74,4	53,3	5996					22,5	63,0	37,5	3206
Pisces	100,0	100,0	100,0	20000					61,9	25,6	46,7	4086	100,0	100,0	100,0	20000	77,5	37,0	62,5	7156
Unidentified	7,7	5,3	20,0	260	66,7	13,9	50,0	4030	42,9	25,2	40,0	2724					30,0	19,4	33,3	1645
Gilchristella aestuarius	61,5	7,4	40,0	2768					19,0	0,4	13,3	258					30,0	0,9	16,7	516
Mugil cephalus													100,0	100,0	100,0	20000	7,5	9,6	8,3	142
Liza richardsoni	7,7	62,3	20,0	1400													2,5	5,1	4,2	32
Mugilidae	7,7	23,8	20,0	630													2,5	2,0	4,2	19
Hepsetia breviceps	7,7	0,5	20,0	164													2,5	0,04	4,2	11
Gobiidae	7,7	0,4	20,0	162													2,5	0,03	4,2	11

the Knysna study. The same general pattern emerged from the study of Smale (1983) in eastern Cape coastal waters. Small elf (10 – 40 cm) took Crustacea, Cephalopoda and fish prey, larger elf (40 – 50 cm) Cephalopoda and fish and the largest size range (50 – 70 cm) only fish.

It thus seems that smaller elf in both estuaries and the sea, consumed a greater proportion of Crustacea. Larger elf took fish and Cephalopoda more readily (Lasiak 1982; Smale 1983) in both environments. In the marine environment Crustacea seemed to be more important in the diet than in the estuaries whereas it was just the opposite with squid since only 2% of *P. saltatrix* netted by Lasiak (1982) in the surf off King's Beach and Bluewater Bay consumed Cephalopoda.

The preferred food of *P. saltatrix* was more regularly available in the sea since the stomachs of 62% of elf caught off Bluewater Bay contained food as against only 31% in the Krom estuary (Lasiak 1982; Table 3). However, mean feeding intensity and maximum percentage stomach fill were higher in the Krom estuary than in the sea.

Platycephalus indicus

Platycephalus indicus, of which 14 with stomachs containing food were caught in Swartkops estuary, preyed on both fish (% F.O. = 70; I.R.I. = 9578) and Crustacea (% F.O. = 64; I.R.I. = 4148; Table 13). Most important single dietary items were *Liza richardsoni*, Gobiidae, *Upogebia africana*, *Penaeus indicus* and *Palaemon pacificus*. Although the mean feeding intensity of *P. indicus* was only 2%, the maximum amount of food consumed as a percentage of body mass was 21%. A *P. indicus* of 608 g, swallowed a *L. richardsoni* of 125 g!

Table 13 Stomach content analysis of *Platycephalus indicus* caught in Swartkops estuary

	Swartkops			
	I = 29 % n	M = 159 g % m	S = 14 % F.O.	I.R.I
Crustacea	58,4	6,4	64,1	4148
Unidentified	3,4	0,03	7,1	24
Anomura				
Upogebia africana	10,3	5,4	21,4	336
Macrura	41,3	0,7	28,4	1192
Penaeidae	3,4	0,09	7,1	25
Penaeus indicus	6,9	0,3	14,2	102
Palaemon pacificus	31,0	0,3	7,1	222
Brachyura				
Hymenosoma orbiculare	3,4	0,3	7,1	26
Plant				
Spartina capensis	–	0,4	7,1	3
Pisces	41,2	93,1	71,3	9578
Liza richardsoni	3,4	78,8	7,1	584
Gobiidae	13,8	3,4	21,4	368
Unidentified	10,3	5,6	21,4	340
Gilchristella aestuarius	6,9	1,3	7,1	58
Lutianus spp.	3,4	3,1	7,1	46
Soleidae	3,4	0,9	7,1	31

Similarity analysis

The dendrograms in Figure 2 clearly show resource partitioning and divide the samples into two main groupings. Group A links together at a similarity level of >68%. Predators included in this group are *A. hololepidotus* and *E. machnata* from all four estuaries as well as *L. amia* from three estuaries (the exception is Sundays) and *P. indicus*. The main prey items responsible for the high similarity in food preference are teleost fishes, especially *G. aestuarius* and members of the family Mugilidae (see also Table 14). *L. amia* from Sundays estuary is only joined to group A at the 54% similarity level because of the relatively large percentage of stomachs (% F.O. = 71) that contained members of the family Mugilidae compared to the other estuaries.

Of the thirteen samples comprising group A, five are from the Swartkops estuary. This high similarity (>68%) of food preference by five piscivores from one estuary could indicate competition for food between these species. Swartkops is the only eastern Cape estuary where <2 specimens of all piscivores were caught per gill-net over an extended period (Table 2).

Group B consisted of *P. commersonni* from all four estuaries, *T. feliceps* from three estuaries and *M. falciformis* from the Krom estuary (the only estuary where more than three specimens were caught per net; Table 2). The main food items responsible for the similarity in food choice (>59%), are the anomurans *U. africana* and *C. kraussi*. The reason why *T. feliceps* from the Krom estuary linked up at a slightly lower level (57%) to this group, is the importance of Brachyura (% F.O = 82) in its diet in Krom estuary. Shifting its food preference from Anomura to Brachyura in the Krom estuary, probably allows *T. feliceps* to compete more successfully with *M. falciformis* which utilizes the estuary seasonally (Marais 1983). Apart from the reasons forwarded earlier for the lower percentage stomach fill of *T. feliceps* in the Krom and Gamtoos estuaries (2,7 and 1,2% of body mass) compared to Swartkops and Sundays (5,5 and 3,3%), it could also be that food consumption was lower because of intra-specific competition (Table 2).

Only *P. saltatrix* caught in the Swartkops estuary linked up with group A at a high level of similarity (>78). Elf from Sundays and Gamtoos estuaries probably did not link at a higher percentage similarity to form part of group A because only four elf were caught in these two estuaries and this cannot be regarded as a representative sample. The large number of elf that consumed Cephalopoda in the Krom estuary (% F.O. = 53) explains why this species did not link up with either group A or B at a percentage similarity of >50%.

M. falciformis fed mainly on mysids in the Swartkops estuary (% F.O. = 80), whereas in the Krom estuary Anomura, (% F.O. = 47), especially *U. africana*, formed the

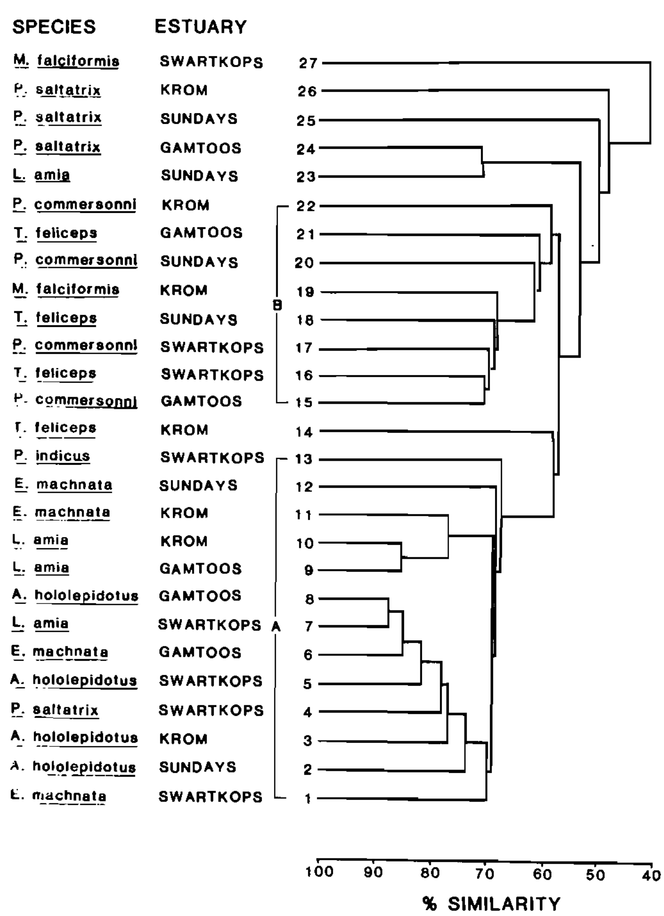

Figure 2 Dendrogram showing classification of eight carnivores from Sundays, Swartkops, Krom and Gamtoos estuaries. Percentage F.O. was used for comparisons according to the Buy-Curtis measure.

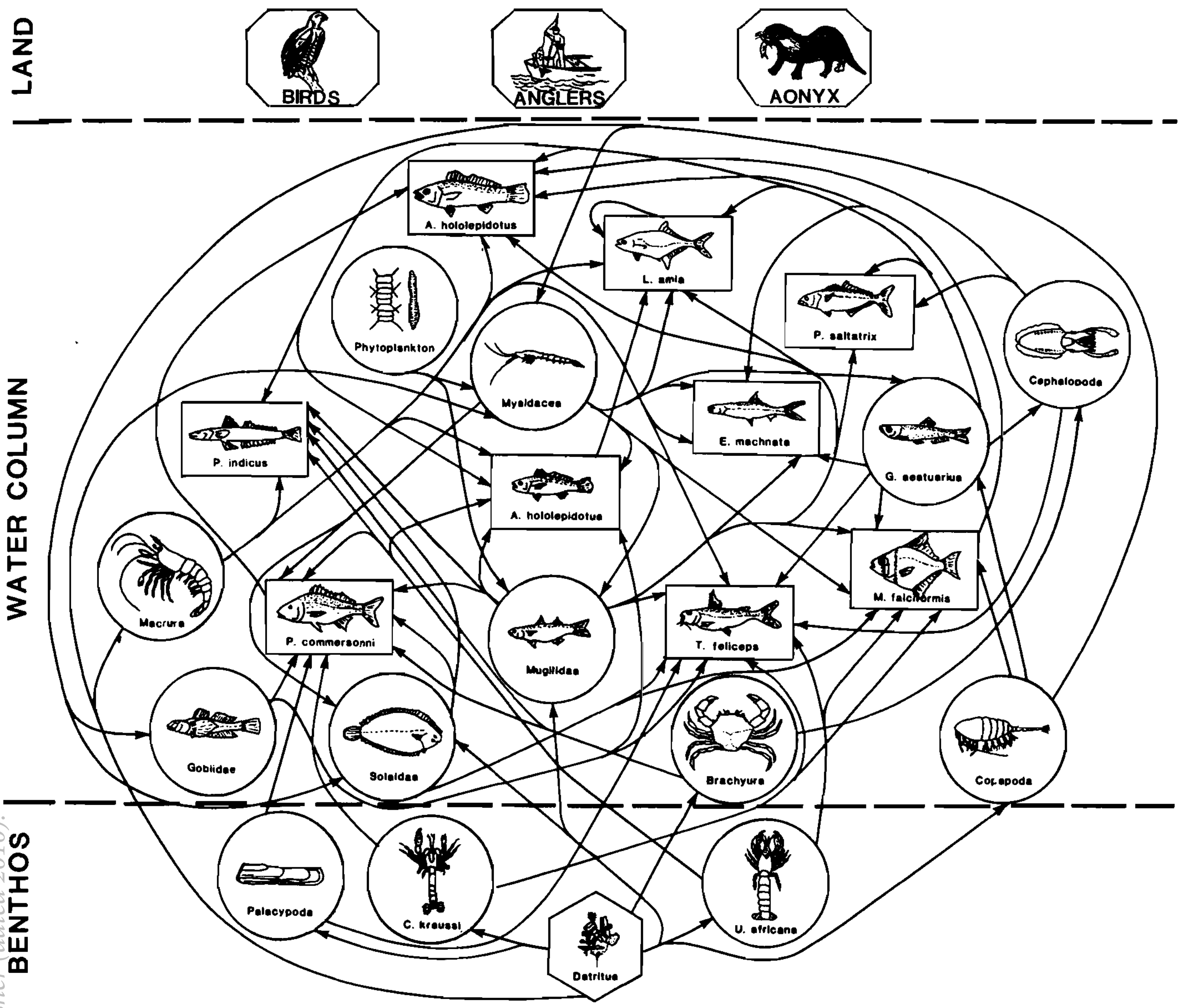

Figure 3 Trophic relationships of carnivores (square blocks) in eastern Cape estuaries.

most important single dietary item. That resulted in Cape moonies from the Krom estuary linking up with group B at a similarity of 68% while in the case of the Swartkops estuary, it was only 41%.

Trophic relationships

The importance of detritus at the base of the food web is evident (Figure 3). Day (1951) suggested that detritus plays a dominant role in the bionomics of South African estuaries. This was supported by data obtained from the Mhlanga estuary by Whitfield (1980). Figure 3 also shows the importance of *Upogebia africana*, which forms the dominant food item (from I.R.I. values) in the diet of *Tachysurus feliceps*, *Pomadasys commersonni* and *Monodactylus falciformis* and is readily taken by *Argyrosomus hololepidotus*, *Elops machnata* and *Platycephalus indicus*, in the estuarine food web. Interspecific competition could be expected with so many predators concentrating on a single food item. Johnson (1977) expressed the view that competition was likely where % F.O. exceeded 25 in the two or more predators. This was found for *U. africana*, taken in large numbers by *T. feliceps* and *P. commersonni* in the Swartkops, Sundays and Gamtoos estuaries.

Competition is determined by a number of factors and the % F.O. of 25 was taken arbitrarily. Recruitment of predator and prey are probably important determining factors, as is the space available for colonization in the case of *U. africana*. Competition for an available resource (in this case *U. africana*) could be less in an estuary like the Swartkops with extended mud-flats and sandbanks compared to the Sundays and Gamtoos estuaries which are channel-like. The Krom has its upper reaches between mountains and shalestone on the northern banks of the estuary (Figure 2; Marais 1983a). It was pointed out earlier that *T. feliceps* consumed proportionally more Brachyura than Anomura, normally preferred by sea-catfish, in the Krom estuary.

Johnson (1977) found that the productivity released by removing one species from a lake ecosystem might be assimilated by other species that feed at the same tropic level. Differential effects of angling (87% of fish caught in Swartkops estuary are *P. commersonni*; Marais & Baird 1980) bird or aonyx (often observed in Sundays) predation, may be beneficial to one or more species when an overlap of food preference occurs. A species such as *P. commersonni* might have benefited by the drastic reduction in *Pomatomus saltatrix* numbers in Swartkops estuary (because of angling pressure?) from early this century to the present day (Marais & Baird 1980).

Key species in the food chain of group A samples (Figures 2 & 3), were members of the family Mugilidae and the estuarine round-herring, *Gilchristella aestuarius*. The importance of these species as a source of food for piscivores in local estuaries, is reflected by Table 14. *G. aestuarius* was of the same mass (mean = 0,8 – 0,9 g) in all four estuaries with largest numbers being taken in the Gamtoos estuary. Smallest mullet were caught in the Swartkops estuary (mean = 0,8 g) where large shoals of fry are often observed in the shallows, whereas largest specimens were taken in the Gamtoos 25 g). Larger mullet abound in the upper, muddy and more freshwater regions (Table 1) of the Gamtoos and Sundays estuaries which are also the hunting grounds of *A. hololepidotus* (Marais 1981; Marais 1983b).

The diversity of prey taken by estuarine carnivores is clear from a study of Figure 3 and Tables 5 – 13. A species like kob consumed a total of 33 identifiable prey species which varied considerably between estuaries (Table 5). Partitioning by prey size was especially evident in kob (Table 6), with larger predators taking larger prey which meant more fish and less Crustacea as was found by Smale (1983) in the sea. *Lichia amia* prey selection varied spatially as was also shown by Coetzee (1982). Whitfield & Blaber (1978) illustrated the flexibility of feeding patterns among piscivores and stated that abundance, type and size of prey fish are important in the selection of a prey item. This probably also applies to non-piscivorous carnivores like *T. feliceps, M. falciformis* and *P. commersonni* which selected a great variety of prey species with considerable variation between estuaries.

Finally it seems that the food web in eastern Cape estuaries is also characterized by a comparatively small number of energy pathways and therefore a high energy flow per pathway, as well as the input of a large amount of energy in the form of detritus as was suggested by Barnes (1974). Whitfield (1980) found the same situation in Mhlanga estuary. The main pathways to the group A species including most piscivores, are via detritus and phytoplankton to mullet and/or via detritus and Copepoda to *G. aestuarius*. The main pathway to B group species containing mostly benthivores is via detritus and *U. africana*.

Acknowledgements

Grateful acknowledgement is paid to the University of Port Elizabeth, the Department of Evironmental Affairs and the Fisheries Development Corporation for financial support; Miss M. Maree for drawing the figures and Mrs A.J. Gerber for typing the manuscript.

References

BARNES, R.S.K. 1974. Estuarine Biology. Edward Arnold, London.

BEGG, G.W. 1976. Some notes on the Sandveld fish fauna, Muizenberg Cape. *Pisator* 96: 5 – 14.

BLABER, S.J.M. 1974. Field studies of the diet of *Rhabdosargus holubi* (Pisces: Teleostei: Sparidae). *J. Zool., Lond.* 173: 407 – 417.

CAILLIET, G.M. 1976. Several approaches to the feeding ecology of fishes. In: Fish food habits studies, (Eds.) Simenstad, C.A. & Lipovsky, S.J. University of Washington, Seattle, Washington. pp.1 – 13.

COETZEE, D.J. 1982. Stomach content analysis of the leervis, *Lichia amia* (L.), from the Swartvlei system, southern Cape. *S. Afr. J. Zool.* 17: 177 – 181.

DAY, J.H. 1951. The ecology of South African estuaries. Part 1. A review of estuarine conditions in general. *Trans. roy. Soc. S. Afr.* 33: 53 – 91.

ELS, S. 1982. Distribution and abundance of two crab species on the Swartkps estuary saltmarshes and the energetics of the *Sesarma catenata* population. Ph.D. thesis, University of Port Elizabeth, Port Elizabeth.

FIELD, J.G., CLARKE, R.K. & WARWICK, R.M. 1982. A practical strategy for analysing multispecies distribution patterns. *Mar. Ecol. Prog. Ser.* 8: 37 – 52.

HYSLOP, E.J. 1980. Stomach content analysis — a review of methods and their application. *J. Fish Biol.* 17: 411 – 429.

JOHNSON, F.H. 1977. Responses of walleye (*Stizostedion vitreum vitreum*) and yellow perch (*Perca flavescens*) populations to the removal of white sucker (*Catostomus commersoni*) from a Minnesota lake 1966. *J. Fish. Res. Bd. Can.* 34: 1633 – 1642.

LASIAK, T. 1982. Structural and functional aspects of the surf-zone fish community in the eastern Cape. Ph.D. thesis, University of Port Elizabeth, Port Elizabeth.

MARAIS, J.F.K. 1981. Seasonal abundance, distribution and catch per unit effort by gill-nets of fishes in the Sundays estuary. *S. Afr. J. Zool.* 16: 144 – 150.

MARAIS, J.F.K. 1982. The effects of river flooding on the fish populations of two eastern Cape estuaries. *S. Afr. J. Zool.* 17: 96 – 104.

MARAIS, J.F.K. 1983a. Seasonal abundance, distribution and catch per unit effort of fishes in the Krom estuary, South Africa. *S. Afr. J. Zool.* 18: 96 – 102.

MARAIS, J.F.K. 1983b. Fish abundance and distribution in the Gamtoos estuary with notes on the effects of floods. *S. Afr. J. Zool.* 18: 103 – 109.

MARAIS, J.F.K. & BAIRD, D. 1980. Seasonal abundance, distribution and catch per unit effort of fishes in the Swartkops estuary. *S. Afr. J. Zool.* 15: 66 – 71.

MASSON, H. & MARAIS, J.F.K. 1975. Stomach content analysis of mullet from the Swartkops estuary. *Zool. afr.* 10: 193 – 207.

PINKAS, L., OLIPHANT, M.S. & IVERSON, I.L.K. 1971. Food habits of albacore, bluefin tuna and bonito in Californian Waters. *Calif. Fish Game* 152: 1 – 105.

SMALE, M.J. 1983. Resource partitioning by top predatory teleosts in eastern Cape coastal waters (South Africa). Ph.D. thesis, Rhodes University, Grahamstown.

SMALE, M.J. & KOK, H.M. 1983. The occurrence and feeding of *Pomatomus saltatrix* (elf) and *Lichia amia* (leervis) juveniles in two Cape south coast estuaries. *S. Afr. J. Zool.* 18: 337 – 342.

TALBOT, M.M.J-F. 1982. Aspects of the ecology and biology of *Gilchristella aestuarius* in the Swartkops estuary, Port Elizabeth. M.Sc. thesis, University of Port Elizabeth, Port Elizabeth.

VAN DER WESTHUIZEN, H.C. & MARAIS, J.F.K. 1977. Stomach content analysis of *Pomadasys commersonii* from the Swartkops estuary (Pisces: Pomadasyidae). *Zool afr.* 12: 500 – 504.

WHITFIELD, A.K. 1980. A quantitative study of the trophic relationships within the fish community of the Mhlanga estuary, South Africa. *Estuar. Coast. Mar. Sci.* 10: 417 – 435.

WHITFIELD, A.K. & BLABER, S.J.M. 1978. Food and feeding ecology of piscivorous fishes at Lake St Lucia, Zululand. *J. Fish Biol.* 13: 675 – 691.

WINDELL, J.T. 1971. Food analysis and rate of digestion. In: Methods for assessment of Fish Production in Fresh Waters 2nd edn (Ed.) Ricker, W.E. Blackwell Scientific Publications, Oxford. pp.215 – 226.

WOOLDRIDGE, T. & BAILEY, C. 1982. Euryhaline zooplankton of the Sundays estuary and notes on trophic relationships. *S. Afr. J. Zool.* 17: 151 – 163.