Inshore small-mesh trawling survey of the Cape south coast. Part 3. The occurrence and feeding of *Argyrosomus hololepidotus, Pomatomus saltatrix* and *Merluccius capensis*

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Marine nurseries of *Argyrosomus hololepidotus* (kob), *Pomatomus saltatrix* (elf) and *Merluccius capensis* (shallow-water hake) between Algoa Bay and Mossel Bay are described. Juvenile *A. hololepidotus* and *P. saltatrix* are most abundant in the shallows (<20 m) while *M. capensis* juveniles were more common in deeper stations (>30 m). Seasonal variations were found in the depth distribution patterns of these nurseries. *A. hololepidotus* was most abundant in Algoa Bay while the other species showed less regional variation. Prey choice of *A. hololepidotus* and *P. saltatrix* varied with depth and locality although overlap was noted between these species and *M. capensis*. Mysidacea, especially *Mesopedopsis slabberi*, were major prey of small juveniles, and post-larval fishes were particularly dominant in *P. saltatrix*. Ontogenetic changes in prey species and prèy size selection were recorded in each predator.
S. Afr. J. Zool. 1984, 19: 170 – 179

Die verspreiding van mariene grootwordgebiede van *Argyrosomus hololepidotus, Pomatomus saltatrix* en *Merluccius capensis* tussen Algoabaai en Mosselbaai word beskryf. Jong *A. hololepidotus* en *P. saltatrix* is die volopste in die vlakwaters (<20 m) terwyl *M. capensis*-jongelinge meer algemeen was in dieper waters (>30 m). Variasies in die diepteverspreidingspatrone wat gevind is blyk seisoensgebonde te wees. *A. hololepidotus* was volop in Algoabaai terwyl die ander spesies minder streekvariasies getoon het. Prooivoorkeure van *A. hololepidotus* en *P. saltatrix* verskil met diepte en plek hoewel daar 'n oorvleueling opgemerk is tussen dié twee spesies en *M. capensis*. Mysidacea, veral *Mesopedopsis slabberi*, was die oorwegende prooi van jongvisse en post-larvale visse was veral dominant in *P. saltatrix*. Ontogenetiese veranderinge in prooispesies en grootteseleksie van prooi van elke roofvis is aangeteken.
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The occurrence and distribution of shallow (<50 m) marine fish nursery areas in South Africa are poorly known although littoral studies have suggested that inshore areas may be important for some species (Lasiak 1981; Berry, van der Elst, Hanekom, Joubert & Smale 1982). Conversely, estuaries have received considerable attention (Day, Blaber & Wallace 1981) and some knowledge of the distribution and recruitment of marine fishes has been reported from these studies. It has been established that the largest group of estuarine fish are marine migrants and some of these, for example *Argyrosomus hololepidotus* and *Pomatomus saltatrix* are also known to occur at sea as juveniles (Wallace 1975; Blaber & Blaber 1980; Blaber 1981; Lasiak 1981). Recently there has been debate on the importance of estuaries as nursery areas and the dependence of the fish fauna on them (Lasiak 1981; Blaber 1981). The current survey was undertaken in an attempt to resolve this question and this paper is one of a series which describes the occurrence of fishes in shallow coastal waters of the southern Cape.

The biology of some of the more important commercial deep-water species such as *Merluccius capensis* is well known (Botha 1971; Botha 1980; Hatanaka, Sato, Augustyn, Payne & Leslie 1983). Despite this, the occurrence of *M. capensis* in shallow coastal waters (<50 m) of the southern Cape has not been described.

The importance of *A. hololepidotus, P. saltatrix* and *M. capensis* in the recreational and commercial fisheries of the southern Cape coast has been established (Hecht 1976; Smale & Buxton, in press) and knowledge of the occurrence and geographic distribution of nursery areas is a necessary pre-requisite to their management.

This paper reports on the occurrence and depth distribution of nursery areas of *A. hololepidotus, P. saltatrix* and *M. capensis* between Algoa Bay and Mossel Bay and provides a detailed analysis of the feeding habits of the juveniles of these species which are piscivorous predators as adults (Davies 1949; Smale 1983).

Methods

Sampling was undertaken quarterly in February, May, August and November 1980 using the R.V. *Thomas B. Davie* to sample selected stations between Algoa Bay and Mossel Bay. The principal sampling gear was a 20 m otter trawl of 50 mm stretch mesh with a cod end of 3 m lined with 12 mm stretch mesh knotless anchovy netting. The otter boards measured 1,7 × 0,88 m. Trawls were restricted to daytime and generally lasted 10 min. Limited additional material was obtained using a 4 m try-net and a nocturnal blanket-net. The entire catch, or randomly selected subsamples of 50 – 200 fish of each species in large catches was measured on board. Total length was used for *A. hololepidotus* and *M. capensis* and fork length for *P. saltatrix*. Additional details of sampling procedures and catch and station data are given by Wallace, Kok, Buxton & Bennett (1984).

A subsample of 20 fish per species over the size range was selected, labelled and frozen to – 15 °C for stomach analysis ashore where invertebrates were removed and formalinized prior to identification and counting. Prey showing no sign of digestion were discarded as they may have been swallowed in the net. Otoliths were used to identify teleost prey by comparison with the reference collection of otoliths held at the Port Elizabeth Museum. Prey were dried to constant weight at 60 °C.

The length distribution of the total catch is presented as the number caught per unit effort (10-min haul) of each size-class. Only material from undamaged trawls was used.

Results

Argyrosomus hololepidotus (Lacépède, 1802) — kob

Catch composition

A total of 5 678 *A. hololepidotus* of 41 – 1 590 mm were caught between Algoa Bay and Mossel Bay. The catch composition according to depth is shown in Figure 1. The highest overall catch rate was recorded in shallow water (0 – 9 m). The modal size varies from 143 mm at 0 – 9 m to 203 mm at 40 – 49 m. Wallace & Schleyer (1979) showed that *A. hololepidotus* attains 230 mm at one year and 440 mm at two years of age. Assuming a similar growth rate locally, it appears that waters down to 50 m are used as a nursery for nought-year-old fish and that the shallows are most important.

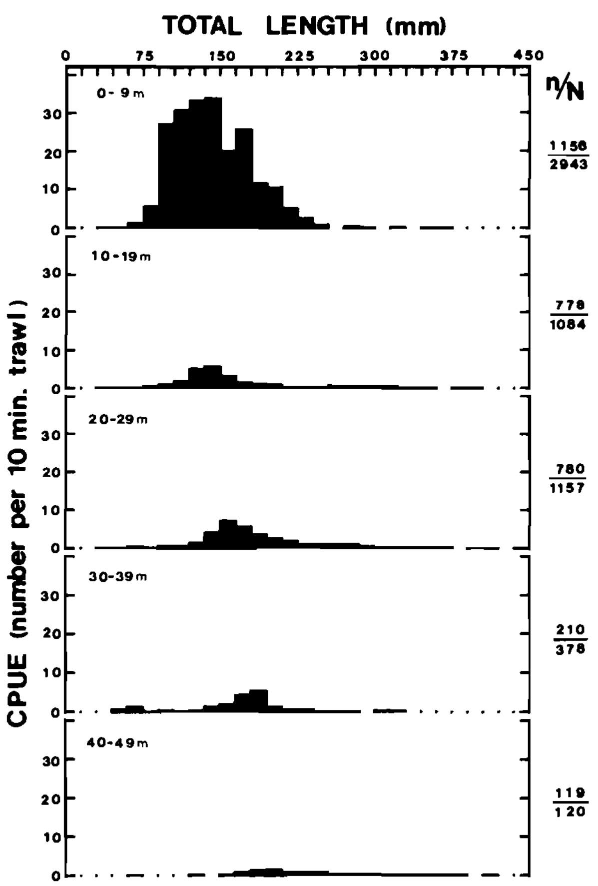

Figure 1 Length composition of *Argyrosomus hololepidotus* expressed as the number of fish caught per 10-min trawl at 10 m depth intervals, all cruises combined.

Figure 2 shows that a relatively greater proportion of the catch from Algoa Bay was made up of small fish, and that catch rates are higher than elsewhere, suggesting that this is an important nursery area. *A. hololepidotus* was particularly abundant near Swartkops River mouth which may in part result from the sewage out-fall there attracting prey. Mossel Bay and St Francis Bay appear to be less important parts of the nursery, and the concentrations of Knysna/Wilderness and Plettenberg Bay were minimal.

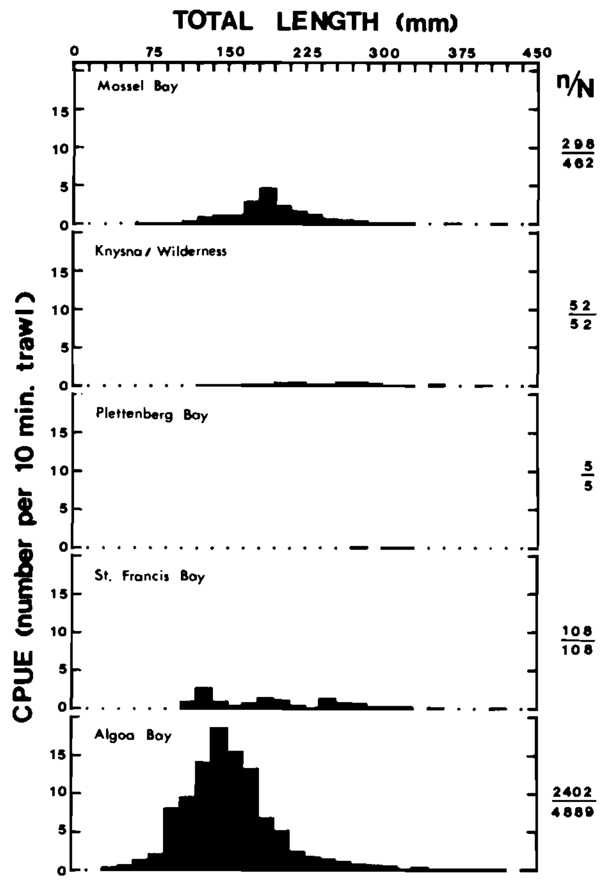

Figure 2 Length composition of *Argyrosomus hololepidotus* expressed as the number of fish caught per 10-min trawl from five areas of the southern Cape coast.

The catch per unit effort (CPUE) of the overall catch is shown for all areas combined in Figure 3 for 10-m depths on a quarterly basis. The highest values for *A. hololepidotus* were obtained from 0 – 9 m in November and February. Lumping the data reduced the very high values recorded in Algoa Bay in November (861/10 min). The catch of 240/10 min in February was obtained from Algoa Bay. No other areas were trawled at this depth range in February. In May and August the catch rates were generally lower, suggesting that the schools may have dispersed from the trawled areas or moved into deeper water. This was most noticeable in Algoa Bay and could be a response to fluctuating environmental factors such as temperature. Mean monthly surf temperatures in Algoa Bay in May and August are 16,5 °C and 15 °C, compared to 19 °C and 19,8 °C in November and February (Beckley & McLachlan 1979).

Feeding

Mysidacea were the major prey items of juvenile *A. hololepidotus* (Table 1). They were the most frequent prey at each

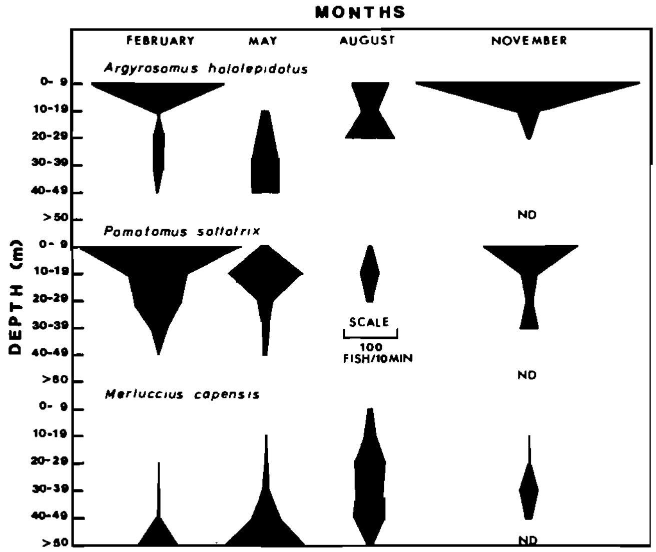

Figure 3 Catch per 10-min trawl of *Argyrosomus hololepidotus, Pomatomus saltatrix* and *Merluccius capensis* taken at 10 m depth intervals on each cruise, all sizes and all areas combined. ND is no data recorded at that depth.

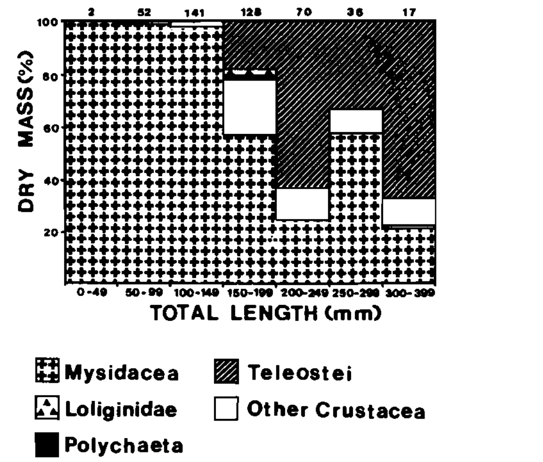

Figure 4 The prey of *Argyrosomus hololepidotus* in 50 mm length groups. The top numbers are the sample sizes of each group.

depth and dominated by number and mass in the shallows of Algoa Bay and Mossel Bay. The prey taken at a particular station was generally very similar suggesting that the most abundant suitable prey was taken. Owing to the state of digestion it was not possible to identify all the invertebrates to species. About 95% of those mysids reliably identified were *Mesopedopsis slabberi. Mysidopsis major* and *Gastrosaccus sanctus* were found occasionally. Mixed species of mysids were found together in 16% of the stomachs. The ony brachyuran identified was *Ovalipes punctatus* and *Macropatasma africanum* was the only macruran identified. Macrura were common prey at 15 – 19 m in Algoa Bay and between St Francis Bay and Wilderness.

The loliginids found appeared to be *Loligo reynaudi.* Fish were represented by benthic (*Cynoglossus capensis*), suprabenthic (*A. hololepidotus, Pomadasys olivaceum*, Cheilodactylidae, Gobiidae) and pelagic species (*Engraulis capensis*). The high proportion of unidentified fish was largely juveniles, some of which appeared to be Engraulidae and Clupeidae. The advanced state of digestion and undifferentiated otoliths prevented reliable identification. Unidentified, juvenile fish and *Engraulis capensis* were dominant prey off Mossel Bay but contributed less in other areas.

The preferred prey of *A. hololepidotus* change with size (Figure 4). Mysidacea are the dominant prey of small fish (<150 mm), but larger prey especially Macrura and small teleosts form a greater proportion of the diet of larger fish. Although teleosts dominate with increased predator size, Mysidacea are taken until a length of at least 400 mm is attained. In a previous study mysids were found to be taken by *A. hololepidotus* up to a length of 656 mm (Smale 1983). A concomitant increase in prey size is found with growth (Figure 5). The ratio of prey to predator length was between 2% and 36% of predator length.

Pomatomus saltatrix (Linnaeus, 1766) — elf

Catch composition

A total of 6 717 *P. saltatrix* measuring 32 – 267 mm fork length were caught between Algoa Bay and Mossel Bay. The length frequency at 10 m depth intervals is indicated in Figure 6. Van der Elst (1976) has shown that *P. saltatrix* attain 230 mm (fork length) at one year, indicating that almost the entire catch (99,7%) was made up of nought-year-old fish. They were caught down to 50 m but the CPUE was greatest in shallower stations (0 – 19 m).

The catch from Mossel Bay to Algoa Bay is shown in Figure 7. A similar size distribution was recorded from all areas. The catch rate was highest in Algoa Bay and Mossel Bay.

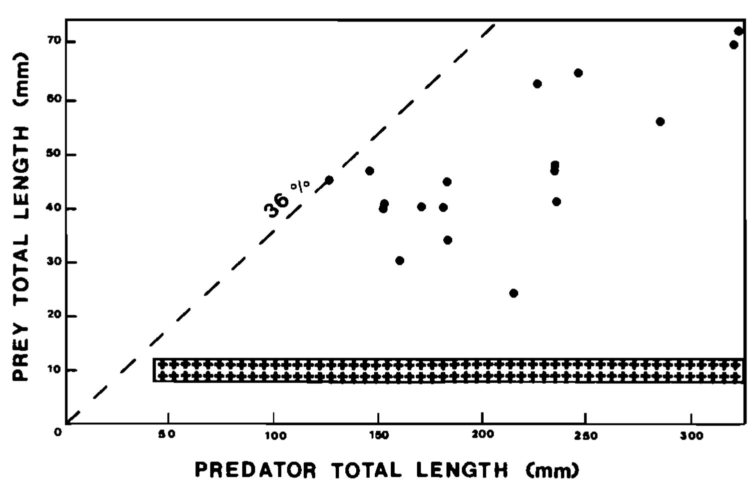

Figure 5 Diagram of prey total length against total length of *Argyrosomus hololepidotus*. Mysids are represented by a solid bar and fish by dots. The dashed line illustrates the maximum relationship of 36%.

Table 1 Feeding analysis of *Argyrosomus hololepidotus* at 15 m depth intervals from three areas of the southern Cape coast. The length range (LR) is shown and the mean is bracketed. The percentage frequency (%F), percentage number (%N) and percentage dry mass (%M) are presented. The total number of stomachs with contents, total number of prey items and total dry mass are given for each depth

	Algoa Bay			St Francis Bay – Wilderness			Mossel Bay		
Prey	%F	%N	%M	%F	%N	%M	%F	%N	%M
Depth 0–14 m	LR = 43 – 384 mm (154)			LR = 74 – 281 mm (228)			LR = 87 – 283 mm (153)		
Polychaeta	0,9	<0,1	0,5	–	–	–	–	–	–
Crustacea									
Mysidacea	88,6	99,7	78,5	60	83,1	10	100	96,5	71
Macrura	4,3	0,1	4,7	60	6,2	9,7	–	–	–
Anomura	1,9	<0,1	0,5	–	–	–	–	–	–
Brachyura	1,4	<0,1	<0,1	–	–	–	–	–	–
Unidentified crustaceans	0,9	<0,1	0,3	–	–	–	–	–	–
Osteichthyes									
Argyrosomus hololepidotus	0,9	<0,1	8,5	–	–	–	–	–	–
Pomadasys olivaceum	0,5	<0,1	2,4	40	10,8	80,3	–	–	–
Unidentified and juvenile fish	5,7	0,1	4,3	–	–	–	52,9	3,5	29
Amorphous material	0,9	<0,1	0,4	–	–	–	–	–	–
Totals	211	14 144	18,235	5	65	1,434	17	600	0,815
Depth 15–29 m	LR = 91 – 364 mm (188)			LR = 101 – 280 mm (186)			LR = 71 – 355 mm (180)		
Polychaeta	3,6	0,3	1,4	2,3	0,1	1,0			
Crustacea									
Mysidacea	44	50	11,4	81,8	96	22,5	100	98,6	47,7
Amphipoda	2,4	0,1	<0,1	2,3	0,1	0,1	–	–	–
Isopoda	2,4	0,2	<0,1	2,3	0,3	0,9	–	–	–
Anomura	7,1	0,4	9,1	–	–	–	–	–	–
Macrura	29,8	40,2	31,7	22,7	1,8	25,2	13,3	0,9	1,0
Brachyura	19	5,9	3,5	4,5	0,2	1,5	–	–	–
Unidentified crustaceans	15,5	1,7	4,4	2,3	0,2	2,2	–	–	–
Mollusca									
Loliginidae	1,2	0,1	3,8	4,5	0,2	1,3	–	–	–
Osteichthyes									
Gonorynchus gonorynchus	1,2	0,1	5,9	–	–	–	–	–	–
Cynoglossus capensis	1,2	0,1	4,5	2,3	0,1	1,6	–	–	–
Cheilodactylus sp.	1,2	0,1	4,9	–	–	–	–	–	–
Pomadasys olivaceum	–	–	–	9,1	0,5	16	6,7	0,5	51,2
Gobiidae	2,4	0,2	1,7	2,3	0,1	4,4	–	–	–
Unidentified juvenile fish	6	0,4	17,1	4,5	0,2	23,3	–	–	–
Amorphous material	3,6	0,2	0,7	–	–	–	–	–	–
Totals	84	1 456	7,122	44	881	5,658	15	221	0,41
Depth 30+ m	LR = 56 – 375 mm (187)			LR = 350 mm			LR = 69 – 256 mm (195)		
Polychaeta	2	0,1	4,2	–	–	–	–	–	–
Crustacea									
Mysidacea	58,8	94	19,5	–	–	–	50	77,7	2,0
Euphausiacea	–	–	–	–	–	–	5,6	2,1	0,2
Amphipoda	2	0,1	0,1	–	–	–	5,6	1,1	0,1
Macrura	13,7	2,5	4,8	100	50	25,1	–	–	–
Brachyura	3,9	0,9	6,9	–	–	–	–	–	–
Unidentified crustaceans	9,8	0,8	2,2	–	–	–	5,6	1,1	0,4
Mollusca									
Loliginidae	3,9	0,3	1,3	100	12,5	2,5	–	–	–
Osteichthyes									
Engraulis capensis	2	0,1	15,0	–	–	–	44,4	9,6	68,9
Cynoglossus capensis	2	0,1	16,3	–	–	–	5,6	1,1	2,4
Pomadasys olivaceum	–	–	–	–	–	–	11,1	2,1	23,3
Gobiidae	2	0,1	0,1	–	–	–	–	–	–
Unidentified fish	13,7	1	29,7	100	37,5	72,4	22,2	5,3	2,7
Totals	51	896	6,339	1	8	0,549	18	94	4,481

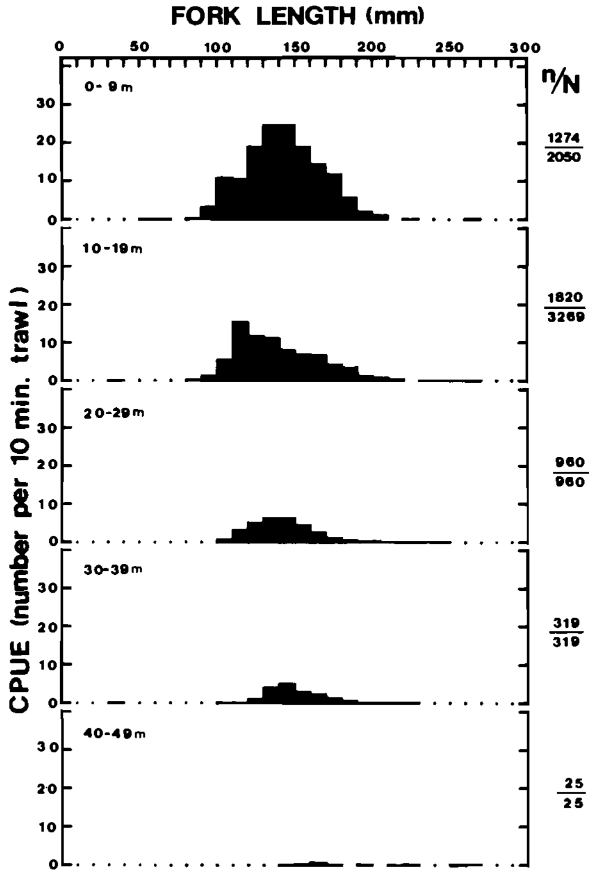

Figure 6 Length composition of *Pomatomus saltatrix* expressed as the number of fish caught per 10-min trawl at 10 m depth intervals, all cruises combined.

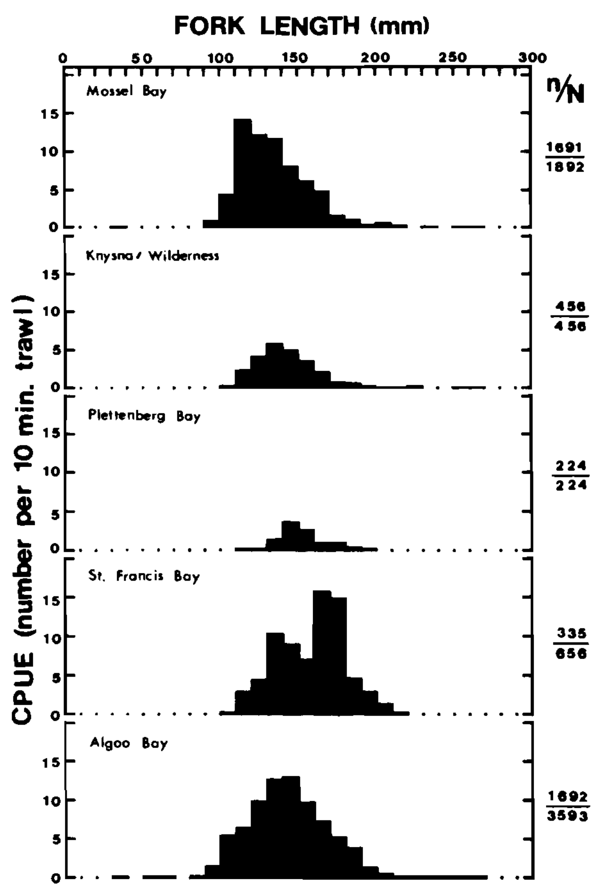

Figure 7 Length composition of *Pomatomus saltatrix* expressed as the number of fish caught per 10-min trawl from five areas of the southern Cape coast.

The CPUE of all sizes combined is shown from each cruise at 10 m depth intervals in Figure 3. This figure shows that the highest catch rate was made in the shallows (0–9 m) in February. Catch rates in May and particularly August are lower, but increase again in November. These trends in seasonal CPUE conform with data collected from shore and ski-boat fishermen in the eastern Cape (van der Elst 1976; Smale & Buxton, in press). Unlike the adults, however, juveniles would not be migrating to Natal to spawn but they may move to warmer water or to more productive feeding areas during winter.

Feeding

Mysids were the dominant prey of *P. saltatrix* juveniles taken from the shallows of Algoa Bay (Table 2). *Mesopedopsis slabberi* accounted for about 86% of the mysids identified. *Mysidopsis* spp. made up the balance. Juvenile *Engraulis capensis* and unidentified juvenile fishes were also important prey. There was considerable similarity in the prey of individuals taken from the same station. In deeper water and in areas further west the importance of mysids is reduced. Unidentified juveniles, schooling fish and squid predominate, suggesting their higher availability and more pelagic hunting by *P. saltatrix*.

There is little change in preferred prey over the size range of *P. saltatrix* examined (Figure 8). Teleosts were the most dominant prey by mass despite the importance of mysids in shallow stations. The fish taken by the small size classes were post-larvae or juveniles. Mysids and other crustaceans were not recorded in *P. saltatrix* larger than 200 mm, conforming to a previous study (Smale & Kok 1983). A concomitant increase in maximum prey size with growth was noted although post-larvae and juveniles were taken over the entire size range (Figure 9). The largest prey was 43% of predator length, the smallest, 4%.

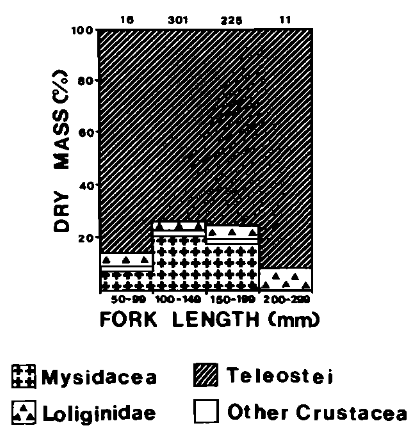

Figure 8 The prey of *Pomatomus saltatrix* in 50 mm length groups. The top numbers are the sample sizes of each group.

Merluccius capensis Castelnau, 1861 — shallow-water hake

Catch composition

A total of 2 123 *M. capensis* of 62–643 mm were caught between Algoa Bay and Mossel Bay. The catch rate of the size classes recorded at various depths is shown in Figure 10. Fifteen fish larger than 450 mm were caught but are not shown in the figure. Hecht (1976) and Kono (1980) show that *M. capen-*

Table 2 Feeding analysis of *Pomatomus saltatrix* at 15 m depth intervals from three areas of the southern Cape coast. The length range (LR) is shown and the mean is bracketed. The percentage frequency (%F), percentage number (%N) and percentage dry mass (%M) are presented. The total number of stomachs with contents, total number of items and total dry mass are given for each depth

	Algoa Bay			St Francis Bay – Wilderness			Mossel Bay		
Prey	%F	%N	%M	%F	%N	%M	%F	%N	%M
Depth 0 – 14 m	LR = 53 – 236 mm (146)			LR = 111 – 200 mm (135)			LR = 95 – 206 mm (140)		
Crustacea									
Mysidacea	79,4	98,2	52,0	62,2	88,6	30,1	20,2	69,5	4,8
Euphausiacea	–	–	–	–	–	–	4,8	4,5	0,5
Macrura	3,3	0,1	1,6	13,5	0,7	7,4	–	–	–
Unidentified Crustacea	0,9	<0,1	0,1	–	–	–	–	–	–
Mollusca									
Loliginidae	1,9	<0,1	2,5	2,7	0,1	5,3	1,1	0,1	0,2
Osteichthyes									
Etrumeus teres	1,9	<0,1	1,1	–	–	–	–	–	–
Sardinops ocellata	1,4	<0,1	0,6	–	–	–	–	–	–
Engraulis capensis	16,8	1,0	24,5	–	–	–	10,7	1,0	10,9
Bregmaceros macclellandi	–	–	–	–	–	–	1,1	0,1	1,0
Trachurus capensis	–	–	–	8,1	0,4	18,5	10,7	1,1	39,1
Pomadasys olivaceum	1,9	0,1	3,8	–	–	–	–	–	–
Scomber japonicus	–	–	–	–	–	–	1,1	0,1	8,7
Unidentified and juvenile fish	19,2	0,5	13,8	37,8	10,2	38,6	56	23,7	34,9
Amorphous material	0,5	<0,1	0,1	–	–	–	–	–	–
Totals	214	11 878	23,129	37	834	3,136	84	917	14,194
Depth 15 – 30 m	LR = 133 – 230 mm (163)			LR = 107 – 198 mm (150)			LR = 109 – 184 mm (137)		
Polychaeta	–	–	–	3,1	0,4	1,4	–	–	–
Crustacea									
Mysidacea	9,1	10,8	0,1	6,3	26,0	2,3	19,5	32,8	2,7
Euphausiacea	–	–	–	–	–	–	8,7	27,4	2,4
Macrura	–	–	–	6,3	1,5	2,7	–	–	–
Mollusca									
Loliginidae	27,3	18,5	9,3	4,2	0,5	2,9	–	–	–
Osteichthyes									
Etrumeus teres	9,1	4,6	21,8	–	–	–	–	–	–
Sardinops ocellata	4,5	1,5	36,5	–	–	–	–	–	–
Engraulis capensis	54,5	41,5	21,1	6,3	0,9	28,4	43,5	16,8	35,7
Trachurus capensis	–	–	–	5,2	0,8	9,7	–	–	–
Pomatomus saltatrix	4,5	1,5	2,8	–	–	–	–	–	–
Pomadasys olivaceum	–	–	–	3,1	0,4	4,4	–	–	–
Scomber japonicus	9,1	3,1	3,0	–	–	–	–	–	–
Tetraodontidae	–	–	–	3,1	0,5	4,2	–	–	–
Unidentified and juvenile fish	31,8	18,5	5,4	74	69	44,2	37	23	59,2
Totals	22	65	17,787	96	785	15,096	46	274	6,014
Depth 30+ m	LR = 159 – 180 mm (169)			LR = 156 – 223 mm (182)			LR = 110 – 184 mm (151)		
Crustacea									
Macrura	–	–	–	–	–	–	2,7	0,7	4,4
Mollusca									
Loliginidae	67	50	67,7	7,1	5,9	14,6	8,1	2,1	6,8
Osteichthyes									
Engraulis capensis	–	–	–	57,1	52,9	63,5	24,3	14,6	12,1
Trachurus capensis	33	25	27,9	14,3	11,8	13,3	2,7	1,4	13,4
Tetraodontidae	–	–	–	7,1	5,9	1,0	2,7	0,7	0,5
Unidentified fish	33	25	4,3	28,5	23,6	7,6	59,5	79,9	62,2
Amorphous material	–	–	–	–	–	–	2,7	0,7	0,5
Totals	3	4	0,693	14	17	11,602	37	144	6,293

sis on the Agulhas Bank attains 270 mm at about 2 years. Using the von Bertalanffy growth parameters provided by Hecht (1976), the size of one-year-old fish would be about 165 mm. The specimens collected in this study therefore included nought- to five-year-old fish. Most (70%) were one-year-olds and 18% were nought-class.

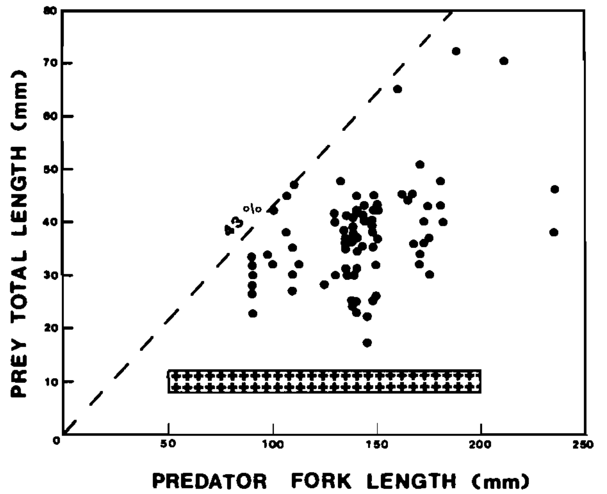

Figure 9 Diagram of prey total length against fork length of *Pomatomus saltatrix*. Mysids are represented by the solid bar and fish by dots. The dashed line illustrates the maximum relationship of 43%.

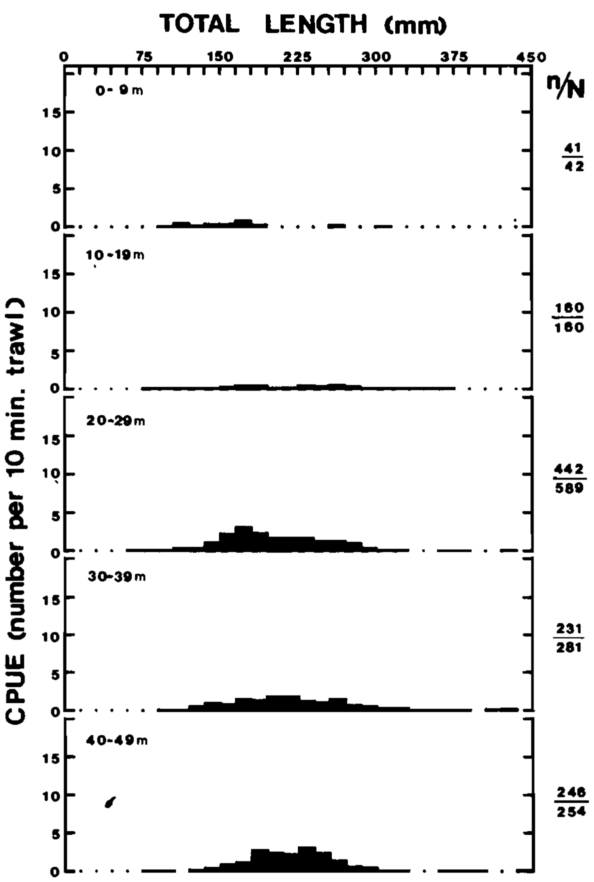

Figure 10 Length composition of *Merluccius capensis* expressed as the number of fish caught per 10-min trawl at 10 m depth intervals, all cruises combined.

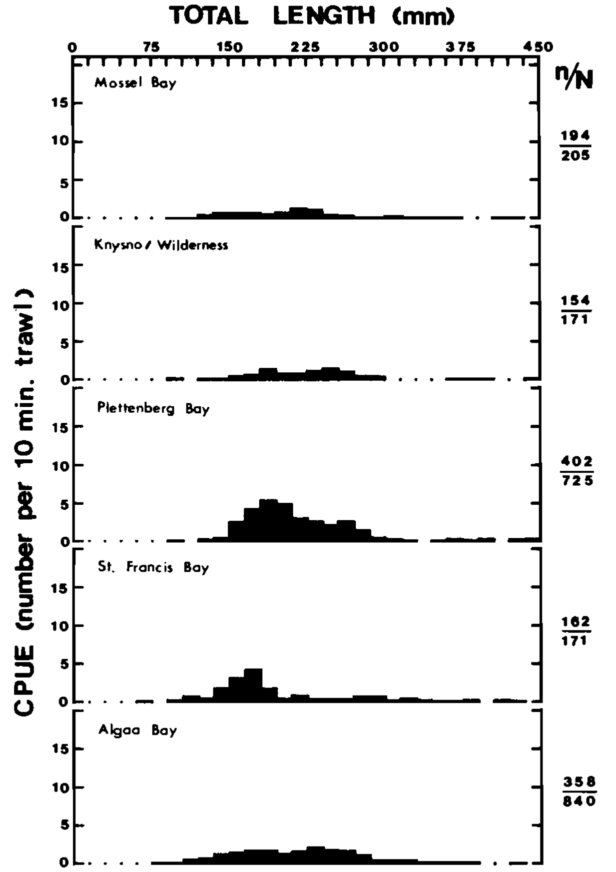

Figure 11 Length composition of *Merluccius capensis* expressed as the number of fish caught per 10-min trawl from five areas of the southern Cape coast.

A similar size range was recorded in all areas sampled (Figure 11). The apparent differences in catch rates in different areas should be interpreted with caution as most of the effort was concentrated at shallow depths, where *M. capensis* is uncommon, and deeper sampling effort was not uniform at all localities.

Catch rates of *M. capensis* are compared on a quarterly basis with depth in Figure 3. Although most abundant in deeper water, the diagram shows an increased catch at shallow stations in May and particularly in August, when a sample was collected at 0 – 9 m in Algoa Bay. Inshore movement of immature (<400 mm) *M. paradoxus* in February to April and December has been demonstrated by Botha (1980). The depth range he sampled, 150 – 640 m, was too deep to demonstrate similar movement for immature *M. capensis*, although he suggests a similar pattern may exist. Results from this survey, however, suggest that inshore migrations by small *M. capensis* on the southern Cape coast occur mainly in winter, unlike the spring and summer inshore migration demonstrated for *M. paradoxus* (Botha 1980). The possible reasons for this are discussed below.

Feeding

Eighty seven of the 187 *M. capensis* stomachs examined contained prey remains (Table 3). Euphausiacea and Mysidacea were lumped as they were found together in stomachs and were often too digested to separate. Two species could be identified, *Nyctiphanes capensis* and *Mesopedopsis slabberi*. Although these crustaceans made a substantial contribution numerically, teleosts dominated by mass. Pelagic and demersal fish were taken and cannibalism was recorded, confirming observations by Davies (1949), Hecht (1976), Macpherson (1980) and Botha (1980). Although similarities with these earlier programmes are evident, the main differences are the presence of shallow coastal organisms in the diet, such as the Sparidae, Pomadasyidae and Ariidae recorded here. This is attributable to the shallow stations worked during the present survey.

The diet of *M. capensis* changed from one dominated by crustaceans below 150 mm to increased piscivory in larger fish (Figure 12). This conforms to the findings of Davies (1949) and Botha (1980). Bentz (1976) demonstrated a change in gill

Table 3 Feeding analysis of *Merluccius capensis* from all depths between Algoa Bay and Mossel Bay. The length range (LR) is shown and the mean is bracketed. The total number of stomachs examined, the total number of prey and the total dry mass are given for each depth

	Algoa Bay – Mossel Bay		
Prey	%F	%N	%M
Depth 10 – 40 m	LR = 74–360 mm (192 mm)		
Crustacea			
Mysidacea and Euphausiacea	56,3	94,3	5,9
Amphipoda	1,1	0,1	0,1
Anomura	2,3	0,2	3,3
Macrura	4,6	0,4	2,1
Brachyura	9,2	0,8	0,7
Mollusca			
Loligo sp.	1,1	0,1	3,5
Osteichthyes			
Gonorynchus gonorynchus	2,3	0,2	1,6
Etrumeus teres	6,9	0,7	10,7
Engraulis capensis	2,3	0,3	7,0
Galeichthyes feliceps	1,1	0,1	1,0
Merluccius capensis	2,3	0,2	10,4
Cynoglossus capensis	1,1	0,1	0,8
Trachurus capensis	1,1	0,1	5,7
Argyrosomus hololepidotus	1,1	0,2	0,1
Pomadasys olivaceum	2,3	0,2	10
Pagellus natalensis	1,1	0,1	5,1
Scomber japonicus	2,3	0,2	13,4
Gobiidae	1,1	0,1	0,8
Unidentified fish	14,9	1,4	18,1
Totals	87	973	22,836

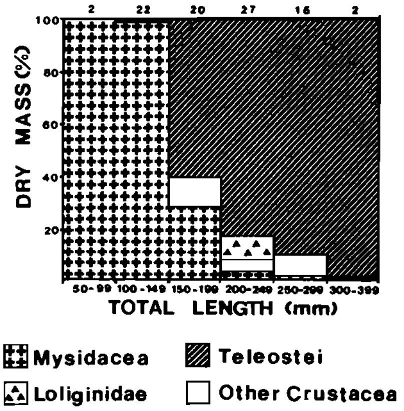

Figure 12 The prey of *Merluccius capensis* in 50 mm length groups. The top numbers are the sample sizes of each group.

length and spacing in *M. capensis* and *M. paradoxus* and related this to a change of diet at about 400 mm. In this study the change occurred at a smaller size, possibly as a result of the higher availability of small fish in the relatively shallow water sampled here.

Discussion

This study has shown that *A. hololepidotus* juveniles are abundant in the shallows of Algoa Bay throughout the year, especially off Swartkops River mouth and near Jahleel Island. Previous work in estuaries (Wallace 1975; Winter 1979; Melville-Smith & Baird 1980) and in the surf-zone (Lasiak 1981) has shown juveniles and larvae to be present almost throughout the year, suggesting a prolonged breeding season. Day (1967) reported a ripe female off Cape Infanta and subsequent studies in the eastern Cape have confirmed that spawning occurs in the Cape south coast region (Smale in prep).

The geographical extent of the nursery of *A. hololepidotus* is unclear although Wallace & van der Elst (1975) have reported juveniles of 80+ mm entering estuaries in Natal, including Lake St Lucia and Richards Bay. In view of the large catches made at sea in this study, however, it is unlikely that estuaries form the main part of the nursery. Further investigations are needed along the coast to put the importance of the south coast nursery into perspective.

P. saltatrix is known to move up the east coast of South Africa in winter to spawn in Natal, where ripe-running fish have been recorded from the Tugela Banks (van der Elst 1976; 1981). Larvae are thought to move south to Cape waters in the Agulhas Current, which sweeps south-west along the continental shelf (Heydorn, Bang, Pearce, Flemming, Carter, Schleyer, Berry, Hughes, Bass, Wallace, van der Elst, Crawford & Shelton 1978). Juvenile *P. saltatrix* are rarely found in Natal's estuaries but have been recorded more commonly in the estuaries of the eastern and southern Cape (van der Elst 1976; Winter 1979). Smale & Kok (1983) reported juvenile recruitment into Knysna estuary between September and December, but suggest that estuaries are unlikely to provide the only nursery for this species. The discovery of a major nursery in the shallow marine waters of the southern Cape confirms this, as 99,7% of the trawled catch consisted of nought-year-old fish. Kendall & Walford (1979) reviewed the information on spawning and nursery areas of *P. saltatrix* on the east coast of North America and they also found that both marine and estuarine nurseries are used by *P. saltatrix* in that region.

M. capensis is a relatively deep-living fish which is widespread on the Agulhas Bank and along the western Cape coast. It occurs down to about 500 m but is generally trawled between 50 and 300 m (Davies 1949; Botha 1971; Kawahara & Nagai 1980; Hatanaka *et al.* 1983). Juvenile *M. capensis* are known to inhabit shallower water than larger specimens (Botha 1980), and specimens smaller than 260 mm have been found on the central part of the Agulhas Bank (Hatanaka *et al.* 1983), although their survey was generally confined to water deeper than 90 m. The results of the present survey suggest that the major part of the *M. capensis* nursery is deeper than 30 m but that juveniles may move inshore in winter. Botha (1980) demonstrated that *M. capensis* occurs in waters of about 7–10 °C although Hatanaka *et al.* (1983) recorded small specimens (<260 mm) in areas where the bottom water temperature was over 10 °C. They found no clear relationship between temperature and distribution of larger specimens. It seems likely, therefore, that for much of the year the shallow coastal water, where the mean monthly temperature varies from about 14–20 °C (Beckley & McLachlan 1979), is well above its preferred temperature.

It is therefore evident that the marine nursery areas of *A. hololepidotus* and *P. saltatrix* overlap while that of *M. capensis* overlaps to a lesser degree. Both *A. hololepidotus* and *P. saltatrix* are euryhaline and eurythermal inshore species which may enter estuaries, while *M. capensis* is strictly marine and is commonly found in deeper water. Little is known about the physical factors which characterize the nurseries of these fish, unlike the more tropical inshore fish fauna (Blaber & Blaber

1980). In view of their ecological and economic importance, further work is needed to ensure adequate protection of their nurseries.

Feeding

Mysidacea have been shown to be key prey of early juveniles of the three species discussed here and *Mesopedopsis slabberi* was found to dominate. Other studies confirm the importance of this mysid as prey of fish both in estuaries (Smale & Kok 1983) and in the sea (Lasiak 1982, 1983; Smale 1983). *M. slabberi* is found in estuaries and in the sea (Tattersall & Tattersall 1951). In Algoa Bay *M. slabberi* is the dominant mysid seawards of the surf zone, where it forms dense concentrations in the water column to at least 20 m. Wooldridge (1983) also found that they are patchily distributed with highest concentrations just behind the breaker line. It is an active, almost transparent species which may exhibit vertical migrations, but shows no substrate preference (Wittmann 1977; Wooldridge 1983). Chemical cues are thought to aid swarming (Mauchline 1980) and these may be used by predators to locate swarms in turbid water. Swarming is believed to be in part an anti-predatory tactic which reduces the likelihood of encounter between predator and prey. When preyed upon, the swarm breaks up and moves away from the point of attack, which results in a lower catch rate by the predator (Clutter 1969; Wittmann 1977; Mauchline 1980). The predators examined in this study are all schooling species. This tactic is widely believed to be an important behaviour for defence and in overcoming the advantage of schooling or swarming prey (Radakov 1973; Bruton 1979; Smale 1983). It appears that these fish are optimizing their use of the most abundant suitable invertebrate prey species.

The mysids *Gastrosaccus* and *Mysidopsis* occurred infrequently as prey of these three fishes. This is probably a result of behavioural responses. *Gastrosaccus* is buried in the substrate diurnally and only emerges at night, while *Mysidopsis* is dark in colour and is associated with fallout of dark terrigenous material (Mauchline 1980). These mysids are also relatively uncommon locally (Wooldridge 1983).

Of the 18 teleost prey types recorded in this study, an overlap between all three predators was found for the most common; *Engraulis capensis, Pomadasys olivaceum* and juvenile engraulids and clupeids. Overlap between *M. capensis* and *A. hololepidotus* was found with six fish; between *P. saltatrix* and *A. hololepidotus* with three and between *P. saltatrix* and *M. capensis* six. *M. capensis* took 13 of the 18 fish recorded, *P. saltatrix* 10 and *A. hololepidotus* eight. The overlap was most marked in the most abundant species and this suggests that there is opportunistic sharing of suitable highly abundant food resources, as was also found in the predation of invertebrate groups. These results conform to other synecological feeding studies (Darnell 1961; Okata, Ishikawa & Kosai 1981; Lasiak 1983; Smale 1983).

It is unlikely, however, that these predators are simply trophic generalists. Potential competition is reduced by microhabitat use and prey preference. *M. capensis* is usually found in deeper water than the other two species and feeds most actively at night when both mature and immature fish move up into the water column to feed (Botha 1980). Hatanaka *et al.* (1983), however, report that small (<260 mm) *M. capensis* do not exhibit diurnal migration on the Agulhas Bank. This clearly needs to be resolved. It may result from the smaller size range not being well represented in Botha's samples, and it may be a mechanism to reduce intraspecific competition and cannibalism.

Different microhabitat use is also shown between *A. hololepidotus* and *P. saltatrix*. *A. hololepidotus* is a suprabenthic predator which preys heavily on mysids, suprabenthic and benthic fish while pelagic fish were only represented when highly abundant. On the other hand, *P. saltatrix* is primarily a pelagic midwater predator which feeds mainly on pelagic and suprabenthic fish species and to a lesser extent on mysids. Both these species appear to reduce potential intraspecific competition by taking both larger prey and a greater proportion of teleosts with growth, as is generally found with piscivorous fishes (Smale 1983).

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References

BECKLEY, L.E. & McLACHLAN, A. 1979. Studies on the littoral seaweed epifauna of St Croix Island. 1. Physical and biological features of the littoral zone. *S. Afr. J. Zool.* 14: 175 – 182.

BENTZ, K.L. 1976. Gill arch morphology of the Cape hakes *Merluccius capensis* Cast. and *M. paradoxus* Franca. *Fish. Bull. S. Afr.* 8: 17 – 22.

BERRY, P.F., VAN DER ELST, R.P. HANEKOM, P., JOUBERT, C.S.W. & SMALE, M.J. 1982. Density and biomass of the ichthyofauna of a Natal littoral reef. *Mar. Ecol. Prog. Ser.* 10: 49 – 55.

BLABER, S.J.M. 1981. The zoogeographical affinities of estuarine fishes in south-east Africa. *S. Afr. J. Sci.* 77: 305 – 307.

BLABER, S.J.M. & BLABER, T.G. 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. *J. Fish Biol.* 17: 143 – 162.

BOTHA, L. 1971. Growth and otolith morphology of the Cape hakes, *Merluccius capensis* Cast. and *M. paradoxus* Franca. *Investl Rep. Div. Fish. S. Afr.* 97: 1 – 32.

BOTHA, L. 1980. The biology of the Cape hakes *Merluccius capensis* Cast. and *M. paradoxus* Franca in the Cape of Good Hope area. Unpubl. Ph.D. thesis, University of Stellenbosch.

BRUTON, M.N. 1979. The food and feeding behaviour of *Clarias gariepinus* (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids. *Trans. zool. Soc. Lond.* 35: 47 – 114.

CLUTTER, R.I. 1969. The microdistribution and social behaviour of some pelagic mysid shrimps *J. Exp. Mar. Biol. & Ecol.* 3: 125 – 155.

DARNELL, R.M. 1961. Trophic spectrum of an estuarine community, based on studies of Lake Pontchartrain, Louisiana. *Ecology* 42: 553 – 568.

DAVIES, D.H. 1949. Preliminary investigations on the foods of South African fishes. *Investl Rep. Div. Fish. S. Afr.* 11: 1 – 36.

DAY, J.H. 1967. The biology of Knysna estuary, South Africa. In: Estuaries. (ed.) Lauff, G.H. *A.A.A.S. Bulletin* Washington. (83) pp.397 – 407.

DAY, J.H., BLABER, S.J.M. & WALLACE, J.H. 1981. Estuarine fishes. In: Estuarine Ecology. (ed.) Day, J.H. Balkema, Cape Town. pp.197 – 221.

HATANAKA, H., SATO, T., AUGUSTYN, J., PAYNE, A. & LESLEY, R. 1983. Report on the Japan/South Africa joint trawling survey on the Agulhas Bank in November/December 1980. Japan Marine Fishery Resource Research Centre, Tokyo: 1 – 73.

HECHT, T. 1976. The general biology of six major trawl fish species of the eastern Cape coast of South Africa, with notes on the demersal fishery, 1967 – 1975. Unpubl. Ph.D. thesis, University of Port Elizabeth, South Africa.

HEYDORN, A.E.F., BANG, N.D., PEARCE, A.F., FLEMMING, B.W., CARTER, R.A., SCHLEYER, M.H., BERRY, P.F., HUGHES, G.R., BASS, A.J., WALLACE, J.H., VAN DER ELST, R.P., CRAWFORD, R.J.M. & SHELTON, P.A. 1978. Ecology of the Agulhas current region: An assessment of biological responses to environmental parameters in the south-west Indian Ocean. *Trans. R. Soc. S. Afr.* 43: 151 – 190.

KAWAHARA, S. & NAGAI, T. 1980. Mixing of three species of *Merluccius* in the ICSEAF area. *Colln scient. Pap. int. Commn SE. Atl. Fish.*7: 169 – 174.

KENDALL, J. & WALFORD, L.A. 1979. Sources and distribution of bluefish, *Pomatomus saltatrix*, larvae and juveniles off the east coast of the United States. *Fish. Bull.* 77: 213 – 227.

KONO, H. 1980. Age and growth of the Cape hakes, *Merluccius capensis* and *Merluccius paradoxus*, on the Agulhas Bank and adjacent slopes. *Colln scient. Pap. int. Commn SE. Atl. Fish.* (2): 175 – 209.

LASIAK, T.A. 1981. Nursery grounds of juvenile teleosts: evidence from the surf-zone of King's Beach, Port Elizabeth. *S. Afr. J. Sci.* 77: 388 – 390.

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

LASIAK, T.A. 1983. The impact of surf-zone fish communities on faunal assemblages associated with sandy beaches. In: Sandy beaches as ecosystems. (eds.) McLachlan, A. & Erasmus, T. pp.501 – 506. Junk, The Hauge.

MACPHERSON, E. 1980. Algunos comentarios sobre el canibalismo en *Merluccius capensis* de la subarea I. *Colln scient. Pap. int. Commn. SE. Atl. Fish.* 7(2): 217 – 222.

MAUCHLINE, J. 1980. The biology of mysids and euphausiids. In: Advances in marine biology, (eds) Blaxter, J.H.S., Russel, F.S. & Yonge, N. 18: 3 – 369. Academic Press, London.

MELVILLE-SMITH, R. & BAIRD, D. 1980. Abundance, distribution and species composition of fish larvae in the Swartkops estuary. *S. Afr. J. Zool.* 15: 72 – 78.

OKATA, A., ISHIKAWA, K. & KOSAI, K. 1981. On the predator-prey relationships among larval and juvenile fishes in a shallow sea community. In: The early life history of fish: recent studies. *Rapports et proces-verbaux des Reunions* 178: 361 – 363.

RADAKOV, D.V. 1973. Schooling in the ecology of fish. 173pp. Wiley, New York.

SMALE, M.J. 1983. Resource partitioning by top predatory teleosts in the eastern Cape coastal waters (South Africa). Unpubl. Ph.D. thesis, Rhodes University. 285pp.

SMALE, M.J. & BUXTON, C.D. (in press). Exploitation and management of marine fishes in the eastern Cape with emphasis on the ski-boat fishery. Symposium: Towards an environmental plan for the eastern Cape. Rhodes University.

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.

TATTERSALL, W.M. & TATTERSALL, O.S. 1951. The British Mysidacea. The Ray Society, London.

VAN DER ELST, R.P. 1976. Game fish of the east coast of southern Africa. 1. The biology of the elf *Pomatomus saltatrix* (Linnaeus) in the coastal waters of Natal. *Investl Rep. oceanogr. Res. Inst.* 44: 1 – 59.

VAN DER ELST, R.P. 1981. A guide to the common sea fishes of Southern Africa. 365pp. Struik, Cape Town.

WALLACE, J.H. 1975. The estuarine fishes of the East Coast of South Africa. 1. Species composition and length distribution in the estuarine and marine environments. Part 2: Seasonal abundance and migrations. *Investl Rep. oceanogr. Res. Inst.* 40: 1 – 72.

WALLACE, J.H., KOK, H.M., BUXTON, C.D., BENNETT, B. 1984. Inshore small-mesh trawling survey of the Cape south coast. Part 1. Introduction, methods, stations and catches. *S. Afr. J. Zool.* 19: 154 – 164.

WALLACE, J.H. & SCHLEYER, M.H. 1979. Age determination in two important species of South African angling fishes the kob (*Argyrosomus hololepidotus* Lacep.) and the spotted grunter (*Pomadasys commersonni* Lacep.). *Trans. R. Soc. S. Afr.* 44: 15 – 26.

WALLACE, J.H. & VAN DER ELST, R.P. 1975. The estuarine fishes of the east coast of South Africa. IV: Occurrence of juveniles in estuaries. *Investl Rep. oceanogr. Res. Inst.* 42: 1 – 63.

WINTER, P.E.D. 1979. Studies on the distribution, seasonal abundance and diversity of the Swartkops estuary ichthyofauna. Unpubl. M.Sc. thesis, University of Port Elizabeth. 184pp.

WITTMANN, K.J. 1977. Modification of association and swarming in North Adriatic mysidacea in relation to habitat and interacting species. In: Biology of Benthic Organisms (eds.) Keenan, B.F., Ceidigh, P.O. & Boaden, P.J.S., pp.605 – 612, Pergaman Press, New York.

WOOLDRIDGE, T.H. 1983. Ecology of beach and surf-zone mysid shrimps in the eastern Cape, South Africa. In: Sandy beaches as ecosystems (eds.) McLachlan, A. & Erasmus, T., pp.449 – 460, Junk, The Hague.