Aspects of the biology of three benthic-feeding teleosts from King's Beach, Algoa Bay

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The lengths, abundance patterns and feeding habits of three species of benthic-feeding teleosts, *Lithognathus mormyrus*, *Lithognathus lithognathus* and *Umbrina capensis* from King's Beach, Algoa Bay are presented. Multiple regression analysis was used to elucidate the influence of the physical environment on the abundance of *L. mormyrus*. The feeding habits of these species were analysed on a quantitative basis by means of gravimetry and the frequency of occurrence of prey items.

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Die lengtesamestelling, getalpatrone en eetgewoontes van drie spesies van bodem-voedende teleosti, *Lithognathus mormyrus*, *Lithognathus lithognathus* en *Umbrina capensis*, word gegee. Veelvoudige regressie-analise is gebruik om die invloed van omgewingsversteurings op die aantal *L. mormyrus* te illustreer. Die eetgewoontes van dié drie spesies is op 'n kwantitatiewe basis deur middel van gravimetrie en die voorkomsfrekwensie van prooi-organismes geanaliseer.

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King's Beach (33°58′S/25°19′E) is the least exposed sandy beach within Algoa Bay. It is protected from the prevailing south-westerly winds by the mainland of Cape Receife. King's Beach experiences continuous, but moderate wave action; waves break at a distance of 50 – 100 m offshore and have an average breaking height of 0,7 m (McLachlan 1980).

Benthic-feeding teleosts form a major component of the fish associated with this beach. They accounted for 57,6% of the total mass of fish caught during a 26-month study (Lasiak 1982). The three major representatives within this trophic category are the sand steenbras *Lithognathus mormyrus*, white steenbras *Lithognathus lithognathus*, and the baardman *Umbrina capensis*. The latter two are restricted in their distribution to South Africa, whereas *L. mormyrus* has been recorded all around Africa (Smith 1965). The ecology, osmoregulation and reproductive biology of *L. lithognathus* from the Western Cape have been described by Mehl (1973). Data is presented on the lengths, abundance and feeding habits of the three species at King's Beach.

Methods

Between September 1978 and October 1980 seine-nets were used to catch specimens of *L. lithognathus*, *L. mormyrus* and *U. capensis* from the surf zone at King's Beach. Each month three hauls were made using a coarse-meshed net (stretched mesh size 40 mm) 60 m long and 2 m deep. Two additional hauls with a finer net (stretched mesh size 17 mm) 30 m long, 2 m deep with a 2 m deep purse bag situated at its midpoint were made each month between October 1979 and October 1980. Adjacent sampling sites were selected on the basis of wave height and frequency. Netting was standardized with respect to both tidal and diel cycles. Preliminary studies (McLachlan, pers. comm.) indicated poorer catches during daylight as compared to catches made in the early evening. All netting was therefore confined to a 2-h period around twilight. Coarse-net hauls were taken 1 h prior to twilight, at twilight and 1 h after twilight. Hauls with the fine net were taken $1^1/_2$ h before and after twilight. Sampling dates were chosen so that high water occurred within this period.

The total number and weight of each species caught per haul were recorded and summarized on a monthly basis for each net. The total wet mass, total length and standard length were recorded for each fish. A mid-ventral incision of the abdomen was used to expose the alimentary canal, which was removed and stored in 10% formalin prior to the analysis of stomach contents.

Methods for the analysis of stomach contents have been reviewed recently by Berg (1979) and Hyslop (1980). Two

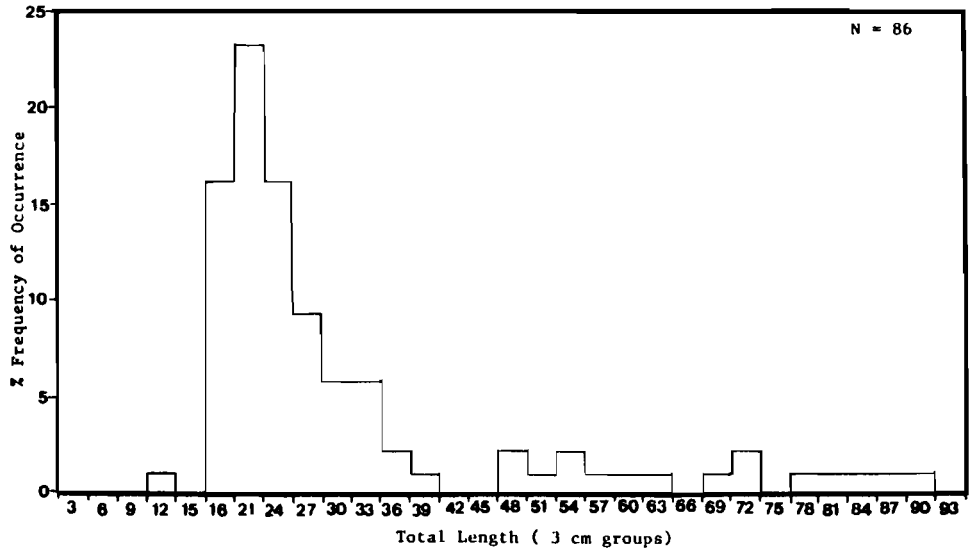

Figure 1 Lengths of *Lithognathus lithognathus* from the coarse-meshed seine hauls.

methods were adopted in the present study, that of frequency of occurrence and gravimetry. The mass of prey items was determined on both a wet and dry basis. In the former, surface water was removed by blotting on tissue paper. Dry mass estimates were made after a period of 24 h in an oven at 60°C. The mass of each taxonomic group was measured to 0,01 g. Prey organisms were identified to the lowest taxonomic level possible. No attempts were made to identify small crustaceans below the ordinal level. Polychaetes were usually incomplete or too well digested for positive identification, consequently they were grouped together. Insufficient numbers of fish were caught to permit statistical comparisons between the diets of juveniles and adult fish. Morisita's (1959) index of association was used to estimate diet overlap. This has been applied to studies of fish feeding habits by Pearcey & Ambler (1974) and Bray & Ebeling (1975).

Stepwise multiple regression analysis (BMDP 2R program) was used in an attempt to relate the abundance of *L. mormyrus* with several environmental variables. The latter included monthly rainfall, photo-period, mean monthly sea temperature, sea temperature during sampling, wind direction, and the average wind speed for the preceding 12 h, 24 h and 48 h. Only the statistically significant relationships are presented. The final output includes the intercept and regression coefficients, multiple correlation coefficient R and the coefficient of determination R^2.

Results

Lithognathus lithognathus — white steenbras

Length and abundance

Specimens caught off King's Beach ranged in length from 12,2 cm to 89,6 cm with the majority falling within the 18 – 27 cm range (Figure 1). The majority of fish were caught between September and December; very few fish were caught between February and June.

Feeding habits

The predominant food items identified from the stomach contents were the swimming prawn, *Macropetasma africana*; bivalves, *Donax* spp. and various polychaetes. These three prey items contributed 27,9%, 14,6% and 13,4% of the food consumed (Table 1). These food items were also the most frequently encountered food items in the stomachs. Unidentified matter accounted for 33% of the stomach contents. A total of 88 stomachs was examined, 31,8% of which were found to be empty. The mass of food contained within the stomachs weighed between 0,005% and 3,06% of the total body mass, with a mean of 0,40%.

Lithognathus mormyrus — sand steenbras

Length and abundance and their relationship to environmental fluctuations

L. mormyrus caught in the surf zone at King's Beach varied in length from 2,1 cm to 29,1 cm. The mean-sized individual obtained in the fine-meshed net was 5,5 cm. Fish of 11,0 cm

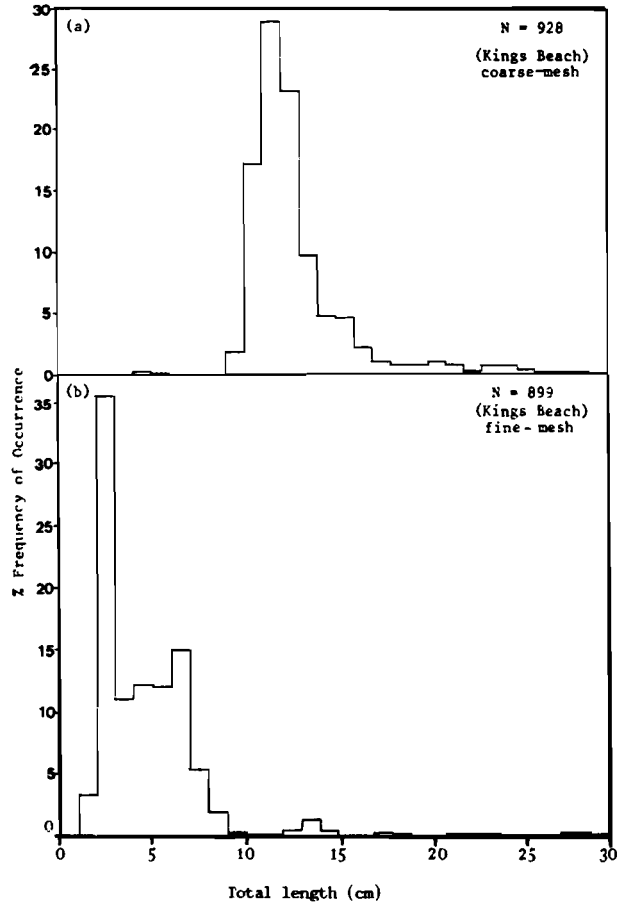

Figure 2a and b Lengths of *Lithognathus mormyrus* caught between September 1978 and October 1980.

Table 1 Summarized details of stomach contents analyses on components of the benthic feeder trophic group

	Lithognathus lithognathus						*Lithognathus mormyrus*						*Umbrina capensis*					
	Wet mass		Dry mass		Freq.		Wet mass		Dry mass		Freq.		Wet mass		Dry mass		Freq.	
Food item	(g)	(%)	(g)	(%)	*N*	(%)	(g)	(%)	(g)	(%)	*N*	(%)	(g)	(%)	(g)	(%)	*N*	(%)
Sand	0,06	0,2	0,03	0,5	1	1,7	0,02	0,2	<0,01		2	2,5						
Unidentifiable	9,49	33,0	1,26	22,1	40	66,7	2,05	16,1	0,27	11,7	34	42,5	8,54	11,9	1,14	8,1	30	39,5
Algae	0,02	0,07	<0,01		1	1,7	0,01	0,08	0,01		2	2,5						
Nemertean													2,19	3,1	0,30	2,1	2	2,6
Polychaeta	3,86	13,4	0,61	10,7	15	25,0	0,37	2,9	0,06	2,6	4	5,0	26,19	36,5	4,17	29,6	40	52,6
Bryozoa													0,01	0,01	0,01		1	1,3
Bivalvia																		
Donax spp.	4,21	14,6	2,01	35,4	10	16,7	1,14	9,0	0,54	23,5	12	15,0	4,96	6,91	2,37	16,8	12	15,8
Gastropoda													0,01	0,01			1	1,3
Bullia spp.							0,06	0,5			3	3,8						
Cephalopoda							2,74	21,5	0,41	17,8	2	2,5						
Parechinus																		
Echinocardium							0,19	1,5	0,07	3,0	1	1,3						
Ophiuroidea	0,03	0,1	0,01	0,2	1	1,7	0,22	1,7	0,04	1,7	3	3,8						
Echiurida													1,43	2,0	0,41	2,9	1	1,3
Sipunculida													2,07	2,9	0,59	4,2	6	7,9
Chaetognatha							0,31	2,4	0,03	1,3	3	3,8						
Brachyura	0,04	0,1	0,01	0,2	1	1,7							6,90	9,6	1,52	10,8	6	7,9
G. psammodytes	0,16	0,6	0,03	0,5	5	8,3	1,05	8,3	0,22	9,6	2	2,5	2,89	4,0	0,60	4,3	34	44,7
M. slabberi							0,43	3,4	0,05	2,2	4	5,0						
Other mysids							0,07	0,6	0,01	0,4	2	2,5						
Isopoda							0,01	0,08	<0,01		1	1,3	0,04	0,06	0,01	0,07	2	2,6
Amphipoda							0,09	0,7	0,01	0,4	4	5,0	0,12	0,2	0,03	0,2	7	9,2
Tanaids							0,01	0,08	<0,01		1	1,3						
Callianassa	1,12	3,9	0,23	4,1	2	3,3	0,37	2,9	0,08	3,5	2	2,5	8,75	12,2	1,80	12,8	2	2,6
Copepoda							0,09	0,7	0,01	0,4	8	10,0						
Cladocera	0,35	1,2	0,04	0,7	1	1,7	0,01	0,08	<0,01		1	1,3						
Macropetasma	8,02	27,9	1,24	21,8	6	10,0	2,75	21,6	0,42	18,3	4	5,0	6,61	9,2	1,02	7,2	16	21,1
Unidentified crustacea	0,71	2,5	0,06	1,1	2	3,3	0,61	4,8	0,05	2,2	11	13,8	0,77	1,1	0,06	0,4	3	4,0
Pisces	0,68	2,4	0,15	2,6	2	3,3	0,13	1,0	0,03	1,3	1	1,3	0,27	0,4	0,06	0,4	3	4,0
Total	28,76		5,68		60		12,73		2,30		80		71,75		14,08		76	

to 14,0 cm were predominant in the coarse-net hauls, while the fine-net hauls were dominated by fish within the 3 cm to 8 cm range (Figure 2). These two modes are believed to represent fish of the 1+ and 0+ age groups respectively (Lasiak 1983). An increase in abundance of *L. mormyrus* was noted between March and July (Figure 3). This was particularly noticeable in April and June 1980 when peak numbers and mass were recorded respectively. No distinct trends could be detected in collections made with the fine net, although peak mass was recorded in April 1980 (Figure 4).

Stepwise multiple regression analyses indicated that the number of *L. mormyrus* caught in fine-net hauls was significantly related ($p < 0,05$) to the average wind speed for a period of 12 h prior to sampling, and to wind direction. Together these two environmental parameters accounted for 61,9% of the variability in numbers. Their respective contributions to this variation, given by the coefficient of determination, R^2, were 39,9% and 22,0% (Table 2). The relationship is given by the equation:

$$y = -19,841 + 13,553\,x_1 - 53,329\,x_2.$$

The mass of the steenbras caught in the fine net showed a significant relationship ($p < 0,05$) with wind speed over the preceding 12 h and with the average monthly temperature. These two independent variables could explain 60,4% of the variation in mass. They respectively accounted for 40,1% and 20,3% of the variability. The relationship is expressed by the equation:

$$y = -1805,848 + 133,727\,x_1 + 69,557\,x_2.$$

Feeding habits

Sand steenbras of $\geqslant$ 10 g total mass fed predominantly on *Donax* spp., Cephalopoda, *Macropetasma* and the mysid *Gastrosaccus psammodytes*. On a wet-mass basis these four prey items accounted respectively for 9,0%; 21,5%; 21,6% and 8,3% of the overall food consumed. The importance of *Donax* spp. was considerably elevated on a dry-mass basis (23,5%) because no attempt was made to separate soft tissue from shell. The latter is not digested and was often the only indication that these bivalves had been consumed. This may be a result of accumulation of shells prior to regurgitation. Comparison of percentage composition based on gravimetric analyses with the frequency of occurrence data revealed large discrepancies. Despite their prominence on a mass basis the food items referred to above were only encountered in 2,5%; 2,5%; 5,0% and 15,0% of the stomachs examined, respectively (Table 1). A total of 118 stomachs was examined and of these 32,2% were found to be empty. The mass of food found within the stomachs weighed between 0,003% and 2,37% of the total body mass, with a mean of 0,38%.

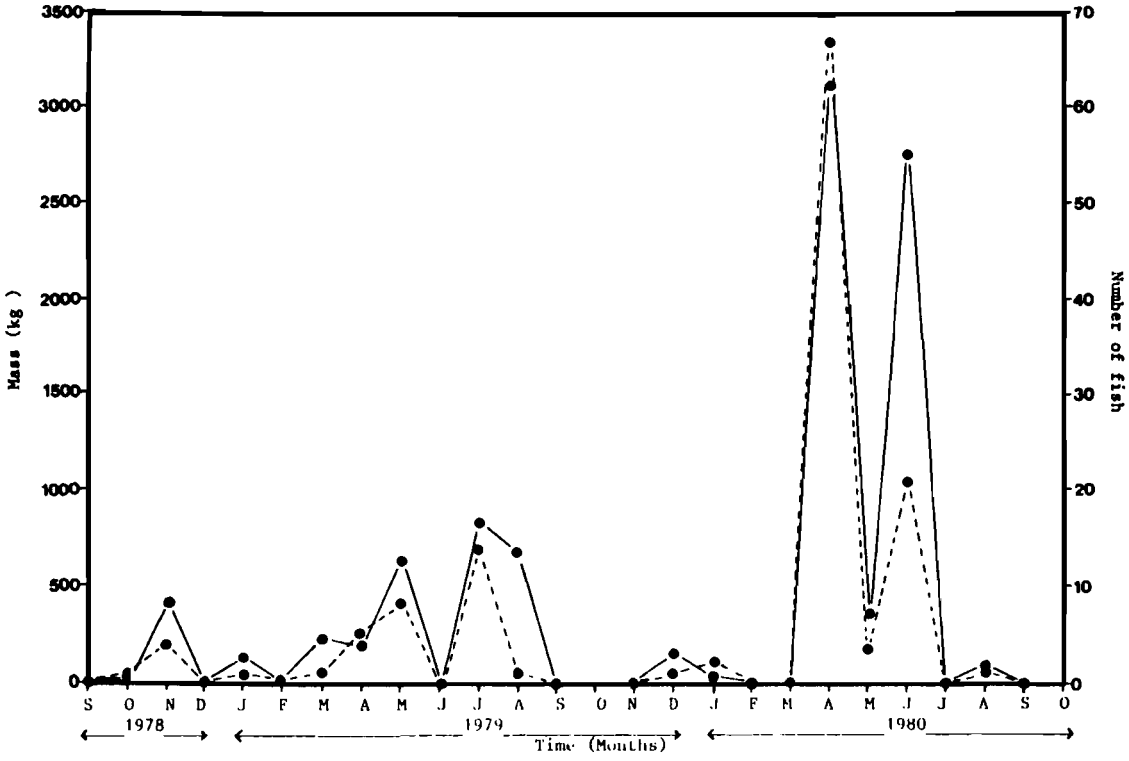

Figure 3 Fluctuations in the mass (solid line) and number (broken line) of *Lithognathus mormyrus* caught in coarse-meshed seine hauls at King's Beach.

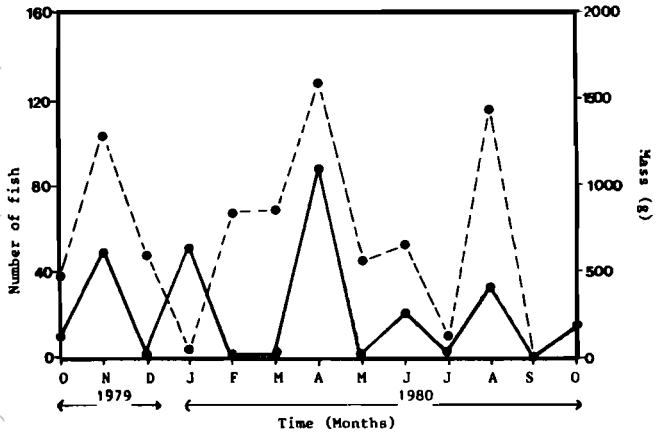

Figure 4 Fluctuations in the mass (broken line) and numbers (solid line) of *Lithognathus mormyrus* caught in fine-meshed seine hauls at King's Beach.

Table 2 Multiple regression analysis of *Lithognathus mormyrus* abundance (y) against independent environmental parameters (x_i) measured during the fine-meshed seine-net survey. (R is the multiple correlation coefficient, R^2 is the coefficient of determination, F is the F-ratio calculated by analysis of variance and C is the regression coefficient)

y	Step number	(x_i)	R	R^2 %	F	C
mass	1	wind 12 h	0,63	40,1	6,68	133,727
	2	ave. temp.	0,78	20,3	6,86	69,557
		y-intercept is −1805,848				
log mass	1	wind 12 h	0,61	37,1	5,89	0,279
	2	ave. temp.	0,80	26,3	7,77	0,205
	3	rainfall	0,83	6,0	6,06	0,008
		y-intercept is −3,837				
numbers	1	wind 12 h	0,63	39,9	6,64	13,553
	2	wind dir.	0,79	22,0	7,32	−53,329
		y-intercept is −19,841				

Umbrina capensis — baardman

Length and abundance

Specimens caught at King's Beach varied between 3,5 cm and 83,7 cm, the majority of fish falling within the 27 cm to 45 cm size range (Figure 5). No seasonal trends in abundance could be discerned because of the low numbers taken.

Feeding habits

The major food items consumed by the baardman were polychaetes, the pink anomuran prawn *Callianassa kraussi*, brachyurans (juvenile *Ovalipes punctatus*), *Macropetasma* and *Donax* spp. These organisms accounted for 36,5%; 12,2%; 9,6%; 9,2% and 6,9% of the food consumed by this benthic feeder as determined on a wet-mass basis. With the exception of the prawns and the crab the items specified above tended to be those most frequently encountered in stomachs. The respective occurrence frequencies of polychaetes, *M. africana* and *Donax* were 52,6%; 21,1% and 15,8% (Table 1). A total of 99 specimens was examined during this study, 23,2% of these were found to be empty. The total mass of food present within stomachs ranged from 0,003% to 2,47% of the body mass, with a mean of 0,34%.

Discussion

Length and abundance patterns

Lithognathus lithognathus

Small white steenbras have been recorded in South African estuaries by Talbot (1955), Mehl (1973), Winter (1980) and Marais & Baird (1980a,b). Large individuals (> 50 cm total

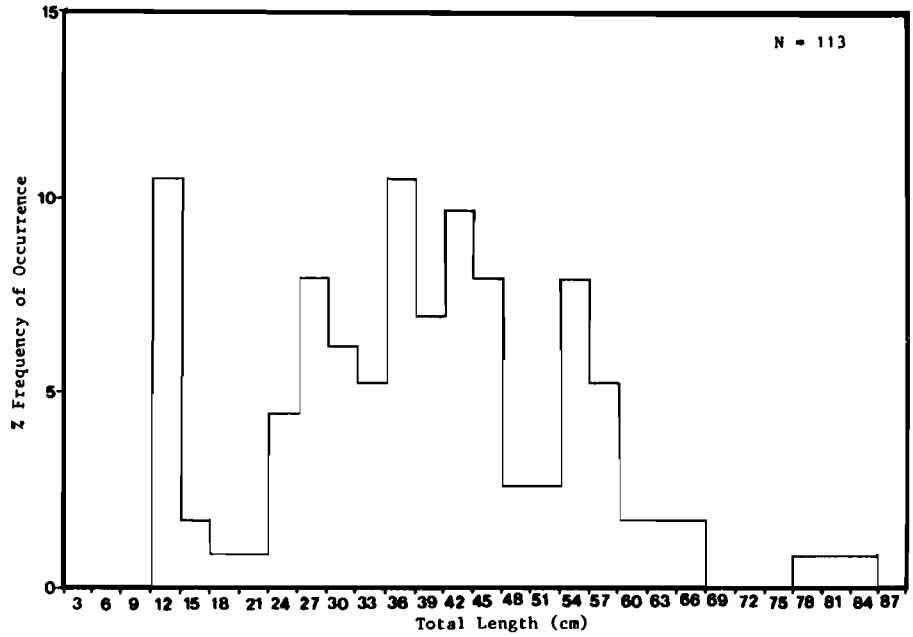

Figure 5 Lengths of *Umbrina capensis* from coarse-meshed seine hauls at King's Beach.

length) were rarely caught in estuaries. A much wider size range has been recorded from the surf zone. Fish caught at King's Beach ranged from 12,2 cm to 89,6 cm, with individuals in the 18 – 27 cm size group predominating. Mehl (1973) recorded a similar size range from the Strand coastline, near Cape Town, where fish ranged in length from 25 – 83 cm fork length. Mehl (1973) noted that anglers' catches of white steenbras along the southern Cape coast fluctuated considerably depending on weather conditions. The best conditions result in a strong swell which stirs up the sandy bottom increasing prey availability. The present study indicated that the majority of specimens was caught between September and December which corresponds to the windy season in Port Elizabeth and this tends to support Mehl's theory.

Lithognathus mormyrus

Juvenile sand steenbras have been found to enter estuaries in South Africa infrequently (Talbot 1955; Winter 1980). A wide size range of fish has been recorded from the surf zone at King's Beach, with the 0 + and 1 + year age groups predominating. Juveniles were caught at King's Beach throughout the year (Lasiak 1983a), which suggests that this environment forms a suitable nursery area for this species. Multiple regression analysis indicated that abundance was influenced to a greater extent by short-term variability in wind strength than by seasonal fluctuations in other environmental parameters. However, this does not imply that wind strength *per se* influences abundance. Wind may influence other factors such as wave action, turbidity, prey availability and localized temperature changes as a result of upwelling.

Umbrina capensis

No data have been published on the biology of baardman in South Africa. The present study indicated that a wide size range of fish was present at King's Beach. The number of individuals obtained was insufficient to draw any conclusions on temporal changes in abundance.

Feeding habits

Both motile and infaunal organisms were consumed by benthic-feeding teleosts at King's Beach. McFarland (1963) noted large quantities of zooplankton in the diet of many bottom-feeding teleosts caught in the surf at Mustang Island, Texas. The present study shows that the swimming prawn, *Macropetasma africana*, was a major component in the diets of the three species examined. Mysids and copepods were also consumed by *L. mormyrus* (Table 1). The sand steenbras took the widest variety of prey items, with *Donax* spp., cephalopods, *M. africana* and the mysid *Gastrosaccus psammodytes* predominating. Froglia (1977) reported that adult *L. mormyrus* from the Adriatic Sea were strictly benthos consumers. The allied species *L. lithognathus* showed the least varied diet; major prey items were *M. africana, Donax* spp. and polychaetes. White steenbras in estuaries of the Western Cape feed on a wide variety of organisms, particularly the prawn *Callianassa kraussi*, amphipods, brachyurans, algae, polychaetes and the gastropod *Assiminea globulus* (Mehl 1973). Differences in the feeding habits of fish from King's Beach and the Western Cape reflect differences in prey availability in the two environments, estuaries versus surf zone. No accounts have been published on the biology of *U. capensis* in South Africa. The present study indicated that polychaetes, *C. kraussi*, the crab *Ovalipes punctatus* and *M. africana* were important prey items.

The use of Morisita's (1959) index of association revealed diet overlaps of 0,80 between *L. lithognathus* and *L. mormyrus*, 0,66 between *L. lithognathus* and *U. capensis* and 0,51 between *L. mormyrus* and *U. capensis*. The high values estimated are not necessarily indicative of potential competition for food. Niche segregation may result from temporal, spatial and behavioural differences. The sporadic occurrence and low numbers of benthic feeders caught during 24-h studies (Lasiak 1982) preclude comments on temporal segregation. Turbid conditions within the surf zone prevented diving observations on spatial segregation and feeding behaviour. Feeding habit studies showed that infaunal beach organisms made only a small contribution (12% on a dry-mass basis) to the food base utilized by the total fish assemblage at King's Beach (Lasiak 1983b). The primary food source utilized by the assemblage were motile organisms. The loss of beach and subtidal macrofaunal production as a result of fish predation has been estimated at 83%, consequently food is unlikely to be

a limiting factor for the benthic feeders (Lasiak 1983b).

Multiple regression analysis revealed a significant relationship between the biomass of benthic feeders at King's Beach and wind direction, photoperiod, wind speed in the preceding 48 h and the average monthly temperature (Lasiak 1982). Benthic feeders showed a tendency to predominate in the fish assemblage after periods of easterly winds. These are onshore winds which result in steep waves that have a scouring action on the substrate. This may be advantageous to benthic feeders as the scouring action may expose infaunal prey organisms thus increasing prey availability. Mehl (1973) noted that *L. lithognathus* was more abundant inshore subsequent to such wind conditions which may facilitate the capture of prey. However, the relationship between abundance and wind conditions has yet to be substantiated.

Acknowledgements

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