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A comparison of the ichthyofauna of two estuaries and their adjacent surf zones, with an assessment of the effects of beach-seining on the nursery function of estuaries for fish

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A COMPARISON OF THE ICHTHYOFAUNA OF TWO ESTUARIES AND THEIR ADJACENT SURF ZONES, WITH AN ASSESSMENT OF THE EFFECTS OF BEACH-SEINING ON THE NURSERY FUNCTION OF ESTUARIES FOR FISH

B. M. CLARK, B. A. BENNETT* and S. J. LAMBERTH**

The ichthyofaunas of an estuary open intermittently (Zandvlei) and one permanently open (Eerste) and of the surf zones of beaches adjacent to their mouths, Muizenberg and Macassar respectively, were sampled quarterly by beach-seining. Fish densities in the Zandvlei and Eerste estuaries (5,0 and 3,2 fish $\cdot m^{-2}$) were considerably higher than those recorded in the adjacent surf zones (0,6 and 0,4 fish $\cdot m^{-2}$). Catches in all four localities were dominated by a few species, 2–3 species making up 92–97% of the total numbers of fish caught. Juvenile fish were abundant in all areas, numerically constituting 48 and 97% of the estuarine and surf-zone samples respectively. Statistical analyses of the density distribution of marine and estuarine fish in the surf zone indicate that, although these estuaries are extensively utilized by juveniles of many species, beach-seine hauls in the vicinity of estuary mouths are potentially no more harmful to these fish than those farther away.

Die igtiofaunas van 'n afwisselend oop getymonding (Sandvlei) en 'n pal oop een (Eerste) en van die brandersones van strande langs hulle mondings, onderskeidelik Muizenberg en Macassar, is kwartaalliks met strandseëns bemonster. Visdigthede in die Sandvlei- en Eerste-getymondings (5,0 en 3,2 visse $\cdot m^{-2}$) was aansienlik hoër as in die naasliggende brandersones (0,6 en 0,4 visse $\cdot m^{-2}$). Op al vier plekke is die vangste deur 'n paar spesies oorheers en 2–3 spesies het tot 92–97% van die totale getal visse gevang, bedra. Jongvis was in al die gebiede volop en het getalsgewys onderskeidelik 48 en 97% van die estuariese en brandersonemonsters uitgemaak. Statistiese ontleding van die digtheidsverspreiding van mariene en estuariese vis in die brandersone toon aan dat, ofskoon die jongvis van vele spesies hierdie getymondings op groot skaal benut, strandseëntrekkery in die omgewing van getymondings nie potensieel skadeliker vir hierdie visse is as trekkery verder weg nie.

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Research worldwide has shown that estuarine fish communities are dominated by juveniles of marine species (Gunter 1938, Day *et al.* 1981, Wallace *et al.* 1984, Claridge *et al.* 1986, Potter *et al.* 1990). Life cycles of these marine species typically comprise a juvenile phase, which is largely estuarine, and an adult phase, which is primarily marine (Wallace and Van der Elst 1975, Whitfield 1990). After being spawned at sea, juveniles enter estuaries, where rapid growth takes place in the sheltered, food-rich and highly productive environments (Wallace 1975, Claridge *et al.* 1986, Potter *et al.* 1990, Whitfield and Kok 1992). Larvae, postlarvae and small juveniles are believed to enter estuaries either actively or by passive drift with incoming tides (Weinstein *et al.* 1980, Beckley 1985a, Whitfield 1989a), after accumulating in the vicinity of the mouths (Whitfield 1989b, Potter *et al.* 1990). The species sometimes return to the sea within a year, but they may remain for longer periods (Gunter 1938, Wallace and Van der Elst 1975, Beckley 1984, Claridge *et al.* 1986, Whitfield 1990).

The importance of estuaries to commercial and recreational fisheries, both as a prime fishing ground and in terms of the numbers of larger marine species that use estuaries as nursery areas, has been highlighted by numerous authors both in southern Africa and elsewhere (e.g. Caputi 1976, McHugh 1976, Pollard 1976, 1981, Marais and Baird 1980, Miller *et al.* 1984, Lenanton and Potter 1987, Van der Elst 1988). Indeed, juveniles of many commercially and recreationally important fish species in southern Africa are considered to be entirely (e.g. white steenbras *Lithognathus lithognathus*, leervis *Lichia amia*, Cape stumpnose *Rhabdosargus holubi*) or partially (e.g. white stumpnose *Rhabdosargus globiceps*, elf *Pomatomus saltatrix*, dassie *Diplodus sargus*) dependent on estuaries as nursery areas (Wallace and Van der Elst 1975, Day *et al.* 1981, Wallace *et al.* 1984, Bennett 1993). The accumulations of juvenile fish that may occur in the vicinity of estuary mouths during migrations between marine and estuarine environments make juveniles of these species potentially vulnerable to capture and disruption by beach-seiners operating there.

Dramatic declines in these and other rock-and-surf-angling species in False Bay over the past 50 years (Bennett 1991) are a source of considerable concern to anglers and conservationists, who attribute them largely to commercial beach-seining (Lamberth and Bennett 1993). One of the main items of concern is netting in the vicinity of river mouths, which is believed to dis-

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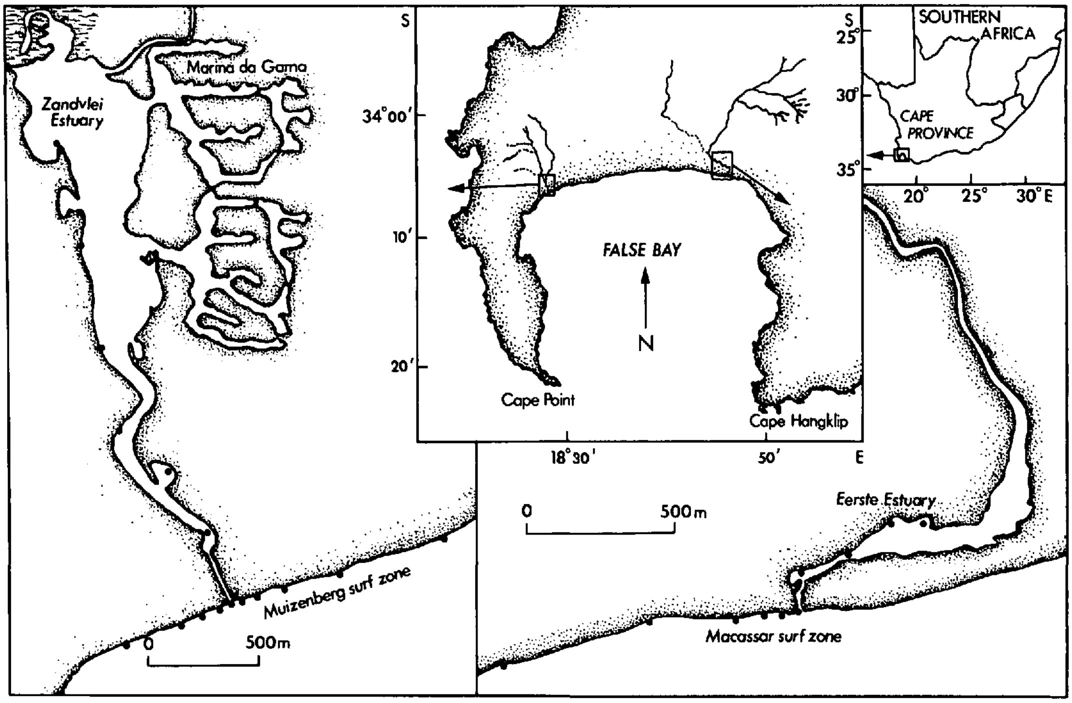

Fig. 1: Map of southern Africa and the South-Western Cape (insets) and the location of the sampling sites in the two estuaries and adjacent surf zones sampled

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rupt the nursery function of estuaries. Reductions in the numbers of seine-net permits issued, as well as the introduction of numerous restrictions on remaining permit-holders by management authorities, have been implemented in an effort to reduce the impact of beach-seining and have resulted in considerable hardship among the fishermen participating in this relatively small-scale fishery. These restrictions (which include a ban on beach-seining within 500 m of any river mouth in False Bay), were formulated largely in the absence of sound scientific data and are considered to be too stringent and largely unjustified by seine fishermen. Given the importance of estuaries in the life cycles of numerous marine species and the undisputed importance of the South African shore-angling fishery (Van der Elst 1989, Bennett 1992), data are urgently needed for the resolution of this controversy.

In this paper, the species composition and abundance of fish populations inhabiting two estuaries in False Bay and their adjacent surf zones are documented in an attempt to examine the potential impact of beach-seining in the immediate vicinity of estuary mouths. Data are used to evaluate the justification for a 500 m limit implemented on beach-seining.

MATERIAL AND METHODS

Study areas

Zandvlei (34°05′S, 18°28′E) is an intermittently closed estuary in the north-western corner of False Bay with a total surface area of 121,0 ha (Fig. 1). It is made up of three components: a relatively shallow main vlei basin (57,4 ha), the Marina da Gama canal system (32,6 ha) and the Westlake wetland (31,0 ha) — Morant and Grindley (1982). The main vlei (where all samples were collected) is approximately 2,5 km long with a maximum width of 0,5 km and a maximum depth of about 1,5 m (Begg 1981, Morant and Grindley 1982). Three influent streams (Sand, Westlake and Keysers) drain a catchment area of 85 km². The mouth of the estuary was open when the August and May samples were collected, but closed during the other two sampling periods.

The Eerste (34°05′S, 18°46′E) is a small estuary in the north-eastern part of False Bay (Fig. 1), the major feature of which is an elongated lagoon approximately 650 m long and 100 m wide (Grindley 1982). The in-

Table I: Mean temperature and turbidity readings taken in the Zandvlei and Eerste estuaries and Muizenberg and Macassar surf zones during four seasonal sampling periods

Area	Temperature (°C)				Turbidity (FTU)			
	August 1991	November 1991	January 1992	May 1992	August 1991	November 1991	January 1992	May 1992
Zandvlei Estuary	14,5	23,0	24,0	14,5	38	40	33	24
Eerste Estuary	12,5	20,0	24,0	15,0	18	18	26	21
Muizenberg	13,5	20,0	22,0	14,0	5	3	4	3
Macassar	14,0	19,0	21,0	15,0	5	4	2	3

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fluent Eerste River and tributaries drain a catchment area of approximately 660 km², which is augmented by the influx of treated sewage and discharges from various industries situated upstream (Grindley 1982). The estuary was open to the sea throughout the sampling period.

Muizenberg beach, which flanks the mouth of the Zandvlei estuary (Fig. 1), has a gently sloping intertidal profile (2°) and is moderately exposed, experiencing a mean estimated wave height of 0,9 m. Sampling in the surf zone adjacent to the Eerste Estuary was undertaken on Macassar beach, which extends westwards from the mouth of the estuary (Fig. 1). The shore there is more exposed, having a steeply sloping upper portion (7°) which changes abruptly into a more gently sloping lower portion (2,1°). Waves breaking on the shore there (estimated mean height 1,4 m) were considerably larger than those observed at Muizenberg.

The average water temperatures and turbidities measured are given in Table I. Water temperatures ranged from 12,5–15°C during winter (August and May) to 19–24°C during summer (November and January). Estuarine turbidity remained relatively constant throughout the sampling period, but turbidity varied in the surf zone depending on the location of diatom plumes, wind direction, wave height and distance from the estuary mouth. It was usually higher immediately opposite open estuary mouths in the surf zone owing to the input of turbid estuarine water.

Sampling and data analysis

Sampling of the estuarine and surf-zone ichthyofauna was undertaken on four occasions (August and November 1991, January and May 1992). Four and six hauls were made in the Eerste and Zandvlei estuaries respectively during each period. Sampling of the surf zone was undertaken at six distances (0, 50, 100, 200, 500 and 1 000 m) from the river mouths. A sample was taken on either side of the Zandvlei mouth at each distance, whereas both samples at each distance were collected from the western side of the Eerste, because access to its eastern area was not permitted. All sampling was undertaken with a 30 × 2 m, 12-mm stretched mesh net fitted with a weighted foot rope and a 2-m deep bag at its midpoint. The net was laid parallel to the shore between 20 and 50 m offshore in water approximately 1 m deep. It was hauled by four persons, one holding each end of the net and one holding each rope. The size of the area seined (estimated as distance offshore multiplied by the mean width of the haul) was determined primarily by depth, and ranged from 225 to 900 m².

All samples were sorted into species and counted. The total length (*TL*) or disc width (*DW*, for the Myliobatidae only) of each fish was measured to the nearest 1 mm, except where samples were very large, in which case measurements were restricted to a subsample of 200 individuals per species.

Species were subdivided into three major groups based on the classification of Lenanton and Potter (1987). Species were classified as either marine — species that spawn in the marine environment (*M*); estuarine — species that spend their entire lifecycles in estuaries (*E*); or freshwater — freshwater species straying into estuaries (*F*). The marine species were further subdivided into species found predominantly in estuaries during the first year of life (*M*1); species frequently abundant in estuaries and inshore marine environments (*M*2); and species that rarely, if ever, enter estuaries (*M*3). This classification corresponds essentially to categories of southern African estuarine-associated fish species identified by Wallace *et al.* (1984), because Category 1 of their classification is equivalent to the "estuarine species", Category II to Category *M*1, Categories III and IV to Category *M*2, and Category V to Category *M*3. Numbers of juvenile fish in each species were estimated by calculating the number of individuals smaller than the size at 50% maturity reported in the literature for each species. Estimates, based on gonad condition, were made for those less common species for which published information was not available.

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Table II: Species composition, abundance and length ranges (*TL*) of fish captured in 40 seine-net hauls from the Zandvlei and Eerste estuaries. Species are categorized as being estuarine (*E*), marine (*M*1-*M*3) or freshwater (*F*), as described in text

Family	Species	Class	Zandvlei		Eerste		Zandvlei & Eerste		Length range (mm)	Size at maturity† (mm)	% Juveniles
			All samples	% Numbers	All samples	% Numbers	All samples	% Numbers			
Atherinidae	*Atherina breviceps*	*M*2	2 836	6,8	1	<0,05	2 837	4,0	26–77	43[a]	19,3
Carangidae	*Scomberoides* sp.	*M*3	1	<0,05			1	<0,05	43		100
Clariidae	*Clarias gariepinus*	*F*			1	<0,05	1	<0,05	630	820[b]	100
Cichlidae	*Oreochromis mossambicus*	*F*	34	0,1			34	0,05	33–215	200[c]	97,1
	Tilapia sparrmanii	*F*	101	0,2			101	0,1	23–125	≈50[d]	38,6
Clupeidae	*Gilchristella aestuaria*	*F*	20 349	49,1	682	2,2	21 031	29,3	22–80	34[e]	8,2
Cyprinidae	*Cyprinus carpio*	*F*	31	0,1	3	<0,05	34	0,05	66–946		14,7
Gobiidae	*Caffrogobius multifasciatus*	*E*	8	<0,05			8	<0,05	38–88	60[a]	12,5
	Psammogobius knysnaensis	*E*	401	1,0	615	2,0	1 016	1,4	18–70	37[a]	18,4
Mugilidae	*Liza dumerilii*	*M*2			2 108	6,9	2 108	2,9	41–115	200[e]	100
	*L. richardsonii**	*M*2	17 411	42,0	26 042	85,8	43 453	60,6	17–356	230[f]	99,7
	L. tricuspidens	*M*2			35	0,1	35	0,05	43–122	400[e]	100
	Mugil cephalus	*M*1	21	0,05	831	2,7	852	1,2	54–445	450[g]	100
Pomatomidae	*Pomatomus saltatrix*	*M*2	4	<0,05	4	<0,05	8	<0,05	109–135	240[h]	100
Soleidae	*Heteromycteris capensis*	*M*2			3	<0,05	3	<0,05	43–64	≈45[d]	66,7
	Solea bleekeri	*M*2	14	<0,05	5	<0,05	19	<0,05	32–90	100[e]	100
Sparidae	*Lithognathus lithognathus*	*M*1	12	<0,05			12	<0,05	100–212	650[i]	100
	L. mormyrus	*M*3	1	<0,05			1	<0,05	47	190[j]	100
	Rhabdosargus globiceps	*M*2	179	0,4	5	<0,05	184	3	26–127	310[k]	100
Total			41 402		30 335		71 738				68,4
Number of species			15		13		20				
Total area seined (m^2)			8 250		9 375		17 625				
Number of fish per m^2			5,0		3,2		4,0				

* May include low numbers of other Mugilidae because of difficulties in identifying species <50 mm

† a. Bennett (1989); b. Quick and Bruton (1984); c. Bruton *et al.* (1982); d. Personal observation; e. Wallace (1975); f. De Villiers (1987)‡; g. Day *et al.* (1981; h. Van der Elst (1976); i. Bennett (1993); j. Lasiak (1982)§; k. Talbot (1955)§

‡ Measurement corrected from fork length to *TL*

§ Measurement corrected from standard length to *TL*

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Table III: Species composition, abundance and length ranges (*TL/DW*) of fish captured in 96 seine-net hauls from the Muizenberg and Macassar surf zones. Species are categorized as being estuarine (*E*), or marine (*M1*-*M3*) as described in text

Family	Species	Class	Muizenberg		Macassar		Muizenberg & Macassar		Length range (mm)	Size at maturity† (mm)	% Juveniles
			All samples	% Numbers	All samples	% Numbers	All samples	% Numbers			
Atherinidae	*Atherina breviceps*	*M2*	3 690	20,7	2 802	37,9	6 492	25,8	28–124	43[a]	16,3
Blenniidae	*Parablennius cornutus*	*M3*	1	<0,05			1	<0,05	60	42[b]	0
Carangidae	*Lichia amia*	*M1*			2	<0,05	2	<0,05	78–89	600[c]	100
	Scomberoides sp.	*M3*	1	<0,05			1	<0,05	44		100
	Trachinotus botla	*M3*			1	<0,05	1	<0,05	56		100
Clupeidae	*Gilchristella aestuaria*	*E*	276	1,5	39	0,05	315	1,2	27–62	34[a]	11,1
Dichistiidae	*Dichistius capensis*	*M3*	3	<0,05			3	<0,05	26–29	310[d]	100
Coryphaenidae	*Coryphaena hippurus*	*M3*	3	<0,05			3	<0,05	43–47		100
Engraulidae	*Engraulis capensis*	*M3*	1	<0,05			1	<0,05	58		0
Mugilidae	*Liza dumerilii*	*M2*			5	0,1	5	<0,05	46–108	200[e]	100
	*L. richardsonii**	*M2*	13 463	75,6	4 028	54,0	17 491	69,4	19–347	230[f]	98,5
	L. tricuspidens	*M2*			2	<0,05	2	<0,05	125–127	400[e]	100
	Mugil cephalus	*M1*	2	<0,05	3	<0,05	5	<0,05	98–113	450[g]	100
Myliobatidae	*Myliobatis aquila*	*M3*	2	<0,05			2	<0,05	530–860	540[h]	50,0
Pomatomidae	*Pomatomus saltatrix*	*M2*	177	1,0	459	6,2	636	2,5	32–180	240[i]	100
Rhinobatidae	*Rhinobatos annulatus*	*M3*	17	0,1			17	0,07	250–720	700[j]	94,1
Soleidae	*Heteromycteris capensis*	*M2*			4	0,05	4	<0,05	64–88	≈50[k]	0
Sparidae	*Rhabdosargus globiceps*	*M2*	153	0,9	9	0,1	162	0,06	25–143	310[l]	100
	R. holubi	*M1*			1	<0,05	1	<0,05	86	180[g]	100
Tetraodontidae	*Amblyrhynchotes honckenii*	*M3*	26	<0,05	39	0,05	65	0,3	26–187	80[g]	23,1
	Arothron stellatus	*M3*	1	<0,05			1	<0,05	18		100
Total			17 816		7 394		25 210				76,1
Number of species			15		12		21				
Total area seined (m^2)			29 175		20 625		49 800				
Number of fish per m^2			0,6		0,4		0,5				

* May include low numbers of other Mugilidae because of difficulties in identifying species <50 mm

† a. Bennett (1989a); b. Eyberg (1984); c. Van der Elst (1988); d. Bennett and Griffiths (1986); e. Wallace (1975); f. De Villiers (1987)‡; g. Day *et al.* (1981; h. Wallace (1967a); i. Van der Elst (1976); j. Wallace (1967b)§; k. Personal observation; l. Talbot (1955)§

‡ Measurement corrected from fork length to *TL*

§ Measurement corrected from standard length to *TL*

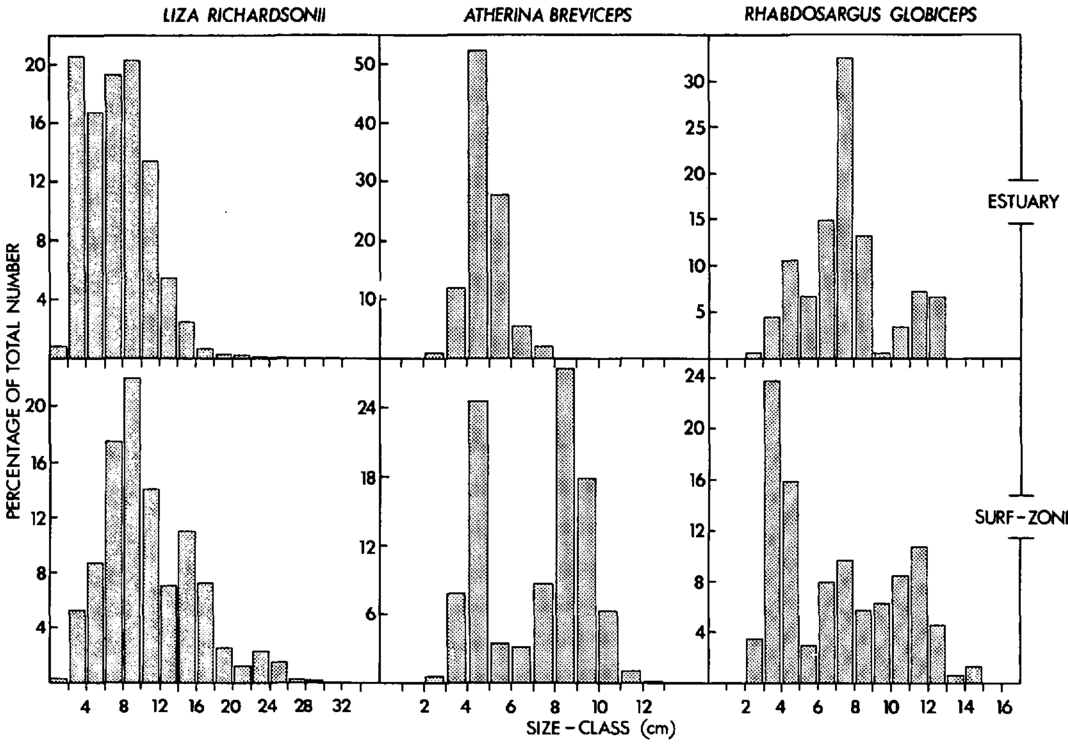

Fig. 2: Size distribution of *Liza richardsonii*, *Atherina breviceps* and *Rhabdosargus globiceps* in the Zandvlei and Eerste estuaries and the Muizenberg and Macassar surf zones

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One-way analysis of variance (ANOVA) was used to test for the existence of a significant relationship between distance from the estuary mouth and fish density at the 95% confidence level. Turbidity of surf-zone and estuarine waters was measured in formazin turbidity units (FTU), where 1 FTU = 1 NTU when made with a nephelometer, by means of a Hach DR/2000 spectrophotometer.

RESULTS

Fish populations

A total of 41 402 fish representing 15 species was captured in the Zandvlei Estuary during the four sampling periods (Table II). *Gilchristella aestuaria* (49,1%), *Liza richardsonii* (42,0%), *Atherina breviceps* (6,8%) and *Psammogobius knysnaensis* (1,0%) were numerically the most abundant species, together constituting 97,9% of the total catch. Three estuarine species (*G. aestuaria, P. knysnaensis* and *Caffrogobius multifasciatus*) made up 50,1% of the total number of fish caught. Seven marine species (Categories *M*1–*M*3) were captured, together making up 49,5% of the total catch. Three freshwater species (*Cyprinus carpio, Oreochromis mossambicus* and *Tilapia sparrmanii*) were also captured. Mean fish density in the Zandvlei Estuary was calculated as 5,0 fish·m^{-2}. Juveniles of all 15 fish species sampled were present in the catches, together providing 48,2% of the total number of fish caught.

A total of 30 335 fish representing 13 species was captured in the Eerste Estuary (Table II). *L. richardsonii* (85,8%), *L. dumerilii* (6,9%), *Mugil cephalus* (2,7%), *G. aestuaria* (2,2%) and *P. knysnaensis* (2,0%) were the only species to contribute more than 1% of the catch. Seven species contributed <0,05%. Two estuarine species (*G. aestuaria* and *P. knysnaensis*) made up 4,2% of the total. Marine fish (Categories *M*1-*M*3) totalled nine species, together providing 95,7% of the catch. Two freshwater species (*Cyprinus carpio* and *Clarias gariepinus*) were also found. Average density was approximately 3,2 fish·m^{-2}, and 12 of the 13 species sampled were represented by juveniles, together making up 96,2% of the sample.

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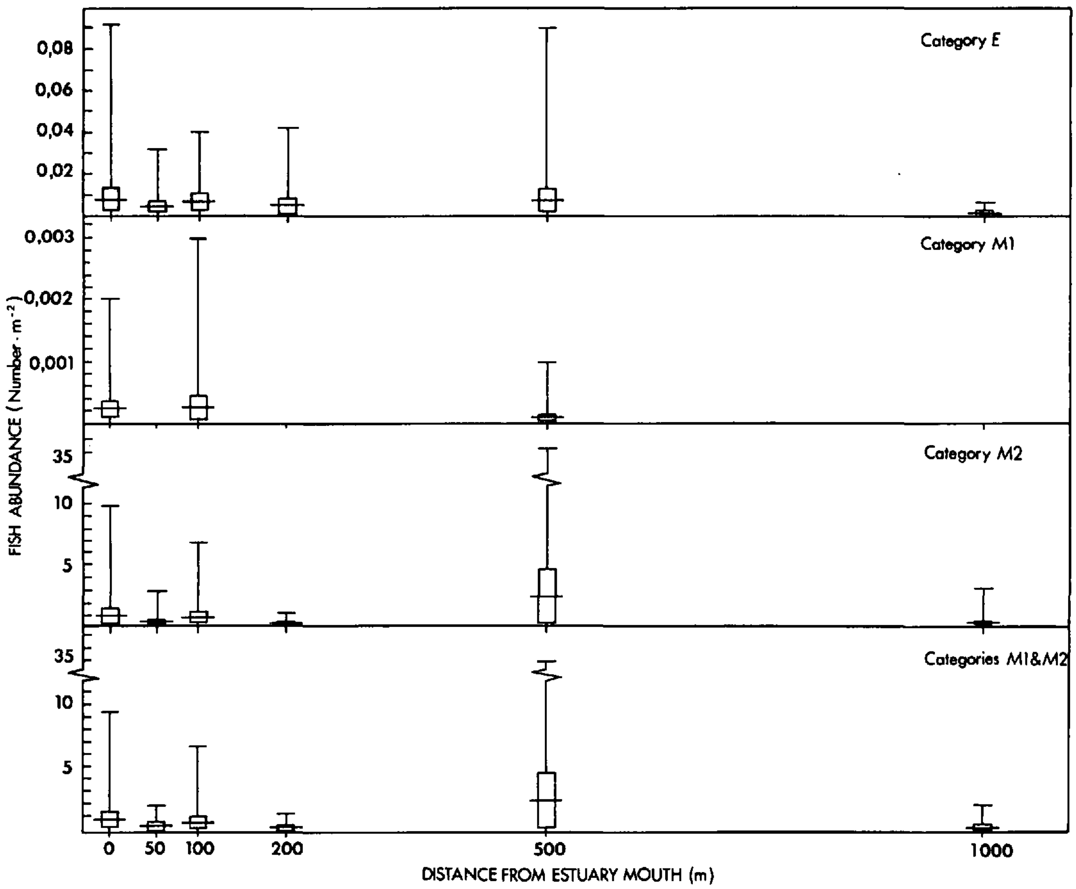

Fig. 3: Box-and-whisker plots depicting density distribution patterns of marine and estuarine fish fauna in the surf zone at increasing distances from the estuary mouth. Horizontal lines represent the mean, boxes the standard error and vertical lines the range in fish density in 96 seine-net hauls made during the four sampling periods during 1991 and 1992

A total of 17 816 individuals of 15 species was netted in the surf zone adjacent to the Zandvlei mouth (Table III). *L. richardsonii* (75,6%) was the most abundant species, followed by *A. breviceps* (20,7%), *G. aestuaria* (1,5%) and *Pomatomus saltatrix* (1,0%). In all, 10 species contributed <0,05% of the total catch. Juveniles of five marine species (Categories *M*1–*M*3) captured in this area accounted for 83,0% of the total catch. Mean density was 0,6 fish · m^{-2}.

Netting in the surf zone adjacent to the mouth of the Eerste River yielded a total of 7 394 fish from 13 species (Table III). In terms of abundance, 58,3% of these were juvenile marine species of Categories *M*1-*M*3. Juveniles of eight species in these categories were present. *L. richardsonii* was again the most abundant species, making up 54,0% of the total catch, with *A. breviceps* providing 37,9%. Mean density in this area was calculated to be 0,4 fish · m^{-2}, similar to the figure for the Muizenberg surf zone.

Length frequency distributions of *Liza richardsonii*, *Atherina breviceps* and *Rhabdosargus globiceps* captured in the estuarine and surf-zone sampling areas are depicted in Figure 2. Numbers of larger *L. richardsonii* (>120 mm) were considerably greater in the surf zone than in the estuarine catches. Individuals >70 mm, which constituted the bulk of the *A. breviceps* surf-zone sample, were poorly represented in the estuarine catches, in which there were no individuals >80 mm. Length frequency distributions of the *R. globiceps* catches, composed entirely of juvenile fish, were similar for the two environments.

The variation in mean density of estuarine and marine fish in the surf with distance from the estuary mouths is shown in Figure 3. Densities of estuarine and Category 1 marine individuals were considerably lower (≤ 1 fish·m^{-2}) than for Category 2 marine species, which ranged up to 35 fish·m^{-2}. No relationships were evident between fish density and distance from the estuary mouths in this analysis (Table IV, ANOVA $p > 0,05$).

Table IV: One sample analysis (ANOVA) of the variation in estuarine (*E*) and marine (*M1* and *M2*) fish density in the surf zone with distance from the Zandvlei and Eerste estuary mouths

Class*	*df*	*F*	Level of significance
Category *E*	95	0,47	0,80
Category *M*1	95	1,20	0,32
Category *M*2	95	0,98	0,44
Category *M*1+*M*2	95	0,71	0,62

DISCUSSION

Ichthyofaunal assemblages

The total number of species captured and the mean densities of fish in the Zandvlei (15 species, 5,0 fish·m^{-2}) and Eerste estuaries (13 species, 3,2 fish·m^{-2}) were similar. Both assemblages were dominated by a few species. *Gilchristella aestuaria*, *Liza richardsonii* and *Atherina breviceps* made up 97,9% of the Zandvlei catches, whereas *L. richardsonii* and *L. dumerilii* made up 92,7% of the Eerste catches. Of a total of 20 species, nine occurred in both areas. Estuarine and marine species made up approximately equal portions in the intermittently open Zandvlei Estuary (50,1 and 49,5% respectively), whereas the abundance of marine migrants in the permanently open Eerste Estuary (95,7%) was far greater than that of resident species (4,2%). These differences can be related to differences in the duration of connection between these estuaries and the sea (Bennett 1989a, Whitfield and Kok 1992), because the formation of a sandbar across the mouth of the Zandvlei Estuary effectively terminates the influx of marine species into this estuary.

Comparison between the seine-net samples from the Muizenberg and Macassar surf zones reveals little difference between the fish communities inhabiting those areas. *L. richardsonii* and *A. breviceps* dominated the catches from both areas, together making up 96,3 and 91,9% of the Muizenberg and Macassar samples respectively. Both the mean density and the total number of species captured in each area (Muizenberg 0,6 fish·m^{-2}, 15 species; Macassar 0,4 fish·m^{-2}, 12 species) were similar. Although only seven of the 21 species sampled were captured in both areas, none of the remaining species made up more than 0,1% of the total sample, and together they provided only 0,2% of the total.

Numbers of species and average standing stocks (densities) of fish in the Zandvlei and Eerste estuaries are similar to those found by Bennett (1989a), who undertook seine-net surveys in the nearby Bot (14 species, 2,2 fish·m^{-2}), Kleinmond (18 species, 1,4 fish·m^{-2}) and Palmiet estuaries (15 species, 1,4 fish·m^{-2}), all situated in the South-Western Cape. A great deal of similarity is also evident in the overall species compositions and in those species recorded as numerical dominants (*L. richardsonii*, *A. breviceps*, *G. aestuaria*, *L. dumerilii*) in the five estuaries considered either here or by Bennett (1989a). The number of species and the mean standing stocks of fish recorded in the Muizenberg and Macassar surf zones were very low compared to those noted by Bennett (1989b) at nearby Fishhoek beach (20 species, 1,9 fish·m^{-2}). Species dominating the Muizenberg and Macassar catches (*L. richardsonii* and *A. breviceps*) were among the three most abundant at Fishhoek beach. A number of other species (*Lithognathus mormyrus*, *Pomadasys olivaceum* and *Diplodus sargus*), well represented in the catches made by Bennett (1989b), were however notably absent from the surf zones sampled during this survey.

Numerical domination of both estuarine and exposed surf-zone assemblages by a few species appears to be a common occurrence throughout the world (e.g. Gibson 1973, Warburton 1978, Quinn 1980, Ross 1983, Lasiak 1984, Claridge *et al.* 1986, Al-Daham and Yousif 1990). Another characteristic common to the fish populations in the estuarine and surf-zone areas sampled was the abundance of juveniles in the catches. Juveniles made up 68,4 and 76,1% of the total number of individuals, and 100 and 86% of the species were recorded as juveniles in the surf-zone and estuarine catches respectively. This is a characteristic common to a great variety of inshore and nearshore habitats, such as mangrove forests, intertidal rock pools, inshore reefs, estuaries and the surf zones of sandy beaches. It has led to the recognition of many of these habitats as juvenile nursery areas (Gunter 1938, Gibson 1973, Wallace and Van der Elst 1975, Berry *et al.* 1982, Lenanton 1982, Lasiak 1983, 1986, Robertson and Lenanton 1984, Beckley 1985b, Bennett 1987, 1989b, Ross *et al.* 1987).

Examination of the size compositions of estuarine and surf-caught *L. richardsonii*, *R. globiceps* and *A. breviceps* (Fig. 2) show that both the surf-zone and estuarine habitats are utilized extensively by these species as nursery areas. The first two species (*L. richardsonii* and *R. globiceps*) spawn in the marine environment (Talbot 1955, Wallace 1975, Day *et al.* 1981), whereas

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A. breviceps spawns in estuaries (Day *et al.* 1981, Bennett 1989a) and probably the sea as well (Bennett 1989b). 0+ and 1-year-old *L. richardsonii* (i.e. <120 mm, Ratte 1977) were captured in abundance in both estuaries and surf zones, making up 91 and 67% of these catches respectively. Individuals >160 mm (i.e. 2-year-old fish, Ratte 1977) were virtually absent from the estuarine samples (<1%), but remained important in the surf zone, where they provided 15% of the catch. *Rhabdosargus globiceps* catches made during this survey consisted entirely of juveniles, the size compositions being similar to those noted by other authors who have sampled in similar habitats (e.g. Talbot 1955, Lasiak 1986, Bennett 1989b). Distinct differences are evident in the maximum sizes and size compositions of estuarine- and surf-caught *A. breviceps* (Fig. 2). Estuarine individuals reach a maximum size of approximately 80 mm total length *TL*, whereas those in the surf reach c. 130 mm *TL*.

Estuarine and adjacent surf-zone ichthyofaunal assemblages are clearly similar in several respects, sharing numerous species and other important characteristics. One important difference evident in the results of this survey, however, merits further attention. Fish densities (number$\cdot$m^{-2}) were calculated to be, on average, almost an order of magnitude greater in estuaries (Zandvlei 5,0, Eerste 3,2) than in the surf zone (Muizenberg 0,6, Macassar 0,4). While these differences may in part be attributed to difficulties associated with seining in exposed surf zones (Schaefer 1967, McLachlan 1983, Romer 1986, Bennett 1989b), they probably also reflect real differences. Factors listed by Potter *et al.* (1990) as contributing to the quality of estuaries as areas for utilization by juvenile marine fish, which include high spring and summer temperatures, low incidence of piscivores, protection offered by turbid waters and the reduced costs of osmoregulation in the less saline estuarine waters, could all conceivably contribute to the greater fish densities in estuaries.

Impact of beach-seining on the nursery function of estuaries

It is clear from the results gathered during this survey that marine fish (Categories *M*1–*M*3) are abundant in the Zandvlei and Eerste estuaries. These fish totalled 12 species (60% of the total) and made up approximately 69% of the total number of fish caught. Those fish would have been spawned in the marine environment and at some stage have migrated through (or from) the surf zone into the estuary. The majority of the surviving migrants would, after having spent varying lengths of time in these habitats (Wallace 1975, Potter *et al.* 1990, Whitfield and Kok 1992), have undertaken a return migration back through or into the surf zone. If such fish were to accumulate in the plumes of estuarine water found immediately in front of the mouths during their migrations, it could conceivably enhance their susceptibility to netting operations conducted in these areas.

Comparisons between the species composition of the Zandvlei and Eerste catches with those from the surf zones immediately adjacent to their mouths reveals that a number of fish species were indeed common to both areas. Most (8) of these were marine species (Categories (*M*1–*M*3), whereas only one (*Gilchristella aestuaria*) was an estuarine resident. Examination of the density distribution patterns of these individuals in the surf zone with distance from the river mouth (Fig. 3) failed, however, to reveal any relationship between these variables, either when all species were lumped together or when separated into estuarine and marine categories. Statistical analysis of these distribution patterns (Table IV) corroborated the results, indicating that no relationship existed between fish density and distance from the river mouths (ANOVA $p > 0{,}05$).

Results presented in this paper therefore indicate no accumulations of estuarine-associated fish fauna in the surf zones immediately adjacent to the estuary mouths during the survey periods. Also, densities did not attenuate with distance from the mouths. Although larvae and small juveniles of some species would almost certainly have been poorly sampled by the meshes of the net used for this survey (12-mm stretched mesh), they would undoubtedly also pass through the meshes of a commercial beach-seine (≥44 mm stretched mesh). Larger individuals may accumulate for short periods during times of peak emigration, following a flood for example. However, as commercial seiners avoid seining in the vicinity of river mouths at these times, because debris (leaves, branches and reeds) tends to wash out, foul and damage the nets, such aggregations would be of little consequence. In addition, because the abundance of species undoubtedly originating in the estuarine environments, viz. the estuarine species, does not attenuate with distance from the mouths (Fig. 3), horizontal transport attributable to the efflux of estuarine waters and the physical processes in the surf zone must be strong enough to ensure that these accumulations are of very short duration only. Furthermore, examination of the seasonal distribution of netting effort reveals that the greatest number of seine hauls (>80%) are made during summer, when the predominantly seasonal estuaries are cut off from the sea.

In the light of these results, it is apparent that commercial beach-seines conducted in the immediate vicinity of river mouths are potentially no more harmful to marine fish utilizing estuaries than those made farther away. Declines in the abundance of estuarine-associated angling species are therefore likely to be attributable to other factors, such as degradation and destruction of estuarine habitats, such as is occurring on a large scale in southern Africa (Heydorn 1979, Blaber *et al.* 1984). Overexploitation of these vulnerable fish stocks, which is reflected in changing catch compositions and declining catch rates (Van der Elst 1988, 1989, Bennett 1992, 1993), is almost certainly contributing to these declines.

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