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ICHTHYOFAUNAL CHARACTERISTICS OF A TYPICAL TEMPORARILY OPEN/CLOSED ESTUARY ON THE SOUTHEAST COAST OF SOUTH AFRICA

by

Paul D. Cowley and Alan K. Whitfield

ABSTRACT

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The present study was undertaken to describe the species composition, size composition and distribution of the fish fauna associated with the temporarily open/closed East Kleinemonde Estuary on the southeast coast of South Africa. Data collected on the estuary mouth condition from March 1993 to August 1997 indicated that this system was predominantly closed, while open mouth conditions were unseasonal and prevailed for only a short duration following periods of high rainfall.

Fishes were sampled throughout the estuary between April 1993 and January 1997 using seine and gill nets. A total of 30 species belonging to 17 families were recorded, including the critically endangered estuarine pipefish *Syngnathus watermeyeri.* Besides the estuarine pipefish, an additional five species capable of completing their life cycle within the estuary were recorded. The ichthyofaunal community was dominated by 18 marine-spawning species with varying degrees of dependence on estuaries as nursery areas. The marine species that are not dependent on estuaries as nursery areas were represented by three species, while the euryhaline freshwater species, obligate catadromous species and facultative catadromous species were each represented by one species. The dominant members of the estuarine-spawning group were well represented by all post-larval life-history stages, whereas the mean size of each marine-spawning species indicated that juvenile size classes dominated this group.

Classification and ordination of both the small- and large-mesh seine net fish assemblages revealed a high degree of similarity throughout the estuary, with the exception of a distinct grouping associated with sandy substrata in the lower reaches of the system. Catch per unit effort (CPUE) data provided evidence of spatial segregation by several species as well as within some families (e.g. Gobiidae).

ICHTHYOFAUNAL CHARACTERISTICS OF A TYPICAL TEMPORARILY OPEN/CLOSED ESTUARY ON THE SOUTHEAST COAST OF SOUTH AFRICA

by

P.D. Cowley * and A.K. Whitfield *

INTRODUCTION

The 300 km stretch of coastline between Port Elizabeth and East London includes 38 estuaries. A large majority of these systems (80%) are classified as being temporarily open/closed according to Whitfield's (1992) characterization of southern African estuaries. A prominent feature of these systems is the presence of a sand bar in the mouth region that isolates the estuary from the sea for varying lengths of time. Linkage with the marine environment occurs by means of mouth-opening events and is usually associated with periods of high rainfall. Many parts of the South African coastline experience seasonal rainfall and hence mouth-opening events are also seasonal. For example, the small temporarily closed estuaries in KwaZulu-Natal normally open for a few weeks in summer, due to increased river discharges (Harrison & Whitfield, 1995); while in the Western Cape Province, mouth-openings occur mainly towards the end of the winter rainfall season (Bennett, 1989). Rainfall along the south eastern Cape coast is, however, highly variable. According to Kopke (1988) the area around Knysna in the south west experiences year-round rainfall, while Port Elizabeth receives an overall winter maximum. Farther east, Port Alfred exhibits a bimodal (spring and autumn) distribution of rainfall, which is largely spring dominant, while East London, on the other hand, has a pronounced autumn maximum. The highly variable rainfall along this stretch of coastline indicates that mouth-opening events of the temporarily open/closed estuaries are likely to be unseasonal, which in turn may influence the way in which marine-spawning estuarine-dependent fishes utilize these systems.

Despite the abundance of temporarily open/closed estuaries along the Eastern Cape coast, the fish assemblages associated with these systems have not been subject to detailed scientific investigation. Ichthyofaunal studies at the community level have, however, been conducted on some of the larger permanently open estuaries within the region (e.g. Marais, 1981; Whitfield et al., 1994; Paterson & Whitfield, 1996; Ter Morshuizen et al., 1996).

The findings of this investigation formed part of a broader study to elucidate aspects of the ecology, particularly population dynamics, of the fish community in the East Kleinemonde Estuary (Cowley, 1998). The aims of the present study were to examine the species composition and describe the contributions made by different life cycle categories of the ichthyofauna associated with this estuary. The study also describes the size composition and length range of fishes in the estuary. Emphasis has also been placed on determining how the distribution and relative abundance of the principal species vary in relation to estuarine region (i.e. lower, middle and upper) and habitat.

STUDY SITE

The East Kleinemonde Estuary is situated approximately 15 km north east of Port Alfred and reaches the sea on the coordinates 33° 32 S and 27° 03 E (Fig. 1). The estuary is relatively small with a surface area of approximately 175 000 m^2, excluding the shallow salt marsh area on the north western bank (above the road bridge), which is only inundated during periods of high water levels. It is navigable for approximately 3 km and the widest portion (in the lower reaches) is 120 m (see Fig. 2). The estuary is mostly shallow, with the main channel depth ranging between 1 and 2 m in the navigable portion of the system. During periods of extended mouth closure, the estuary water level often exceeds that of mean sea level (approximately MSL+2 m) due to extensive sandbar development on the seaward side of the mouth. However, following a mouth-opening event the estuary is very shallow with a maximum channel depth of approximately 1 m.

The catchment of the East Kleinemonde Estuary, with an estimated size of 46.3 km^2 (Badenhorst, 1988) consists of (a) a gentle sloped high-lying region which is used primarily for extensive cattle ranching, and (b) steep sloped stream and river valleys which are relatively undisturbed and covered by Valley Bushveld vegetation. The simulated mean annual run-off for the East Kleinemonde Estuary is estimated at 2 x 10^6 m^3 (Badenhorst, 1988).

No comprehensive survey of water quality in the East Kleinemonde Estuary has been done. However, Harrison et al. (1996) using the water quality rating index (after Cooper et al., 1994) described the water quality of the East Kleinemonde Estuary as good and awarded it a score of 7.3 out of a possible 10. The water quality impairment was attributed to slightly elevated *E. coli* levels. Although there is currently no evidence of pollution, attention has been drawn to the potential threat of microbial contamination of the estuary from septic tank overflows (Seafield Ratepayers and Residents Association *in litt.*).

A brief botanical survey of the estuary was conducted by Adams (1997). The dominant submerged macrophyte was *Ruppia cirrhosa*, which occurred mostly above the road bridge forming a continuous band along both banks of the estuary. The seagrass *Halophila ovalis* was also recorded in the system.

* J.L.B. Smith Institute of Ichthyology,
Private Bag 1015, Grahamstown, 6140
e-mail: P.Cowley@ru.ac.za
e-mail: A.Whitfield@ru.ac.za

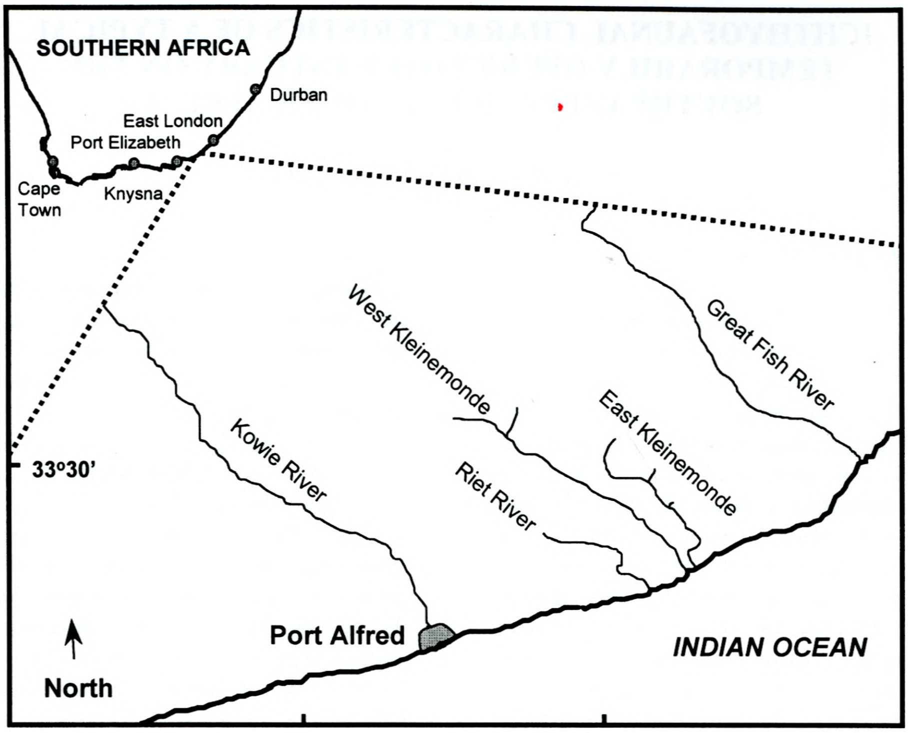

Figure 1. The location of the East Kleinemonde and nearby estuaries in the Eastern Cape Province.

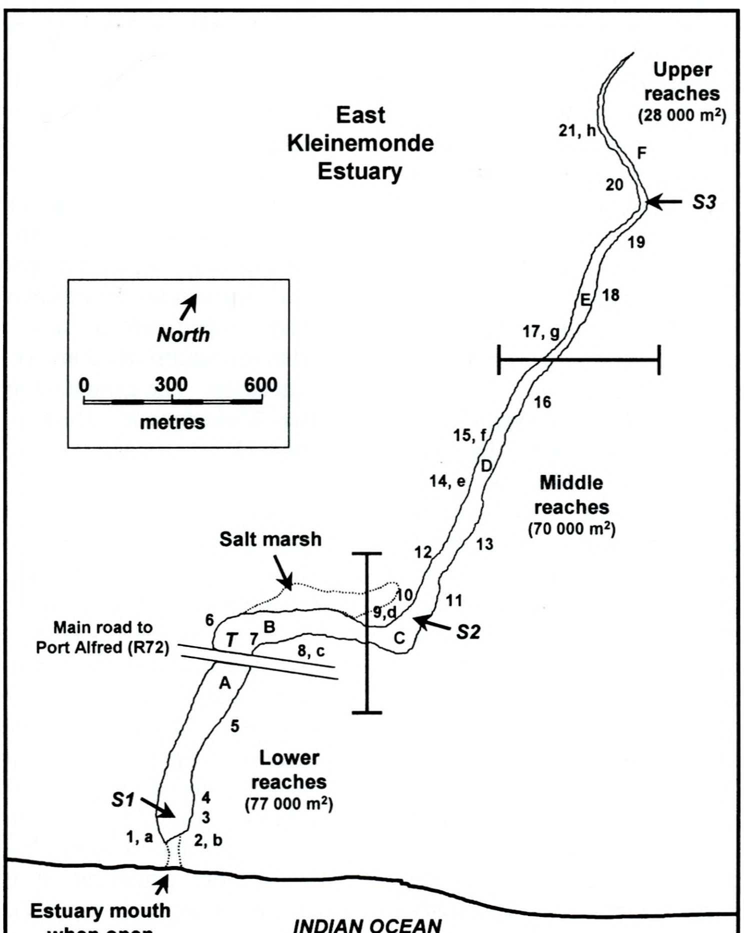

Figure 2. Map of the East Kleinemonde Estuary showing the sampling stations (a-h = small-mesh seine sites; 1-21 = large-mesh seine sites; A-F = gill net sites; ***T*** = temperature recording station; ***S1***, ***S2***, ***S3*** = salinity recording stations) and the extent of the three reaches (lower, middle and upper).

MATERIALS AND METHODS

Water temperatures (surface and bottom) were recorded once a week over a period of two years (January 1994 to December 1995) in the middle reaches of the estuary. Surface salinity was measured fortnightly (March 1994 to March 1996) in the middle reaches, and from July 1994 to March 1996 at an additional two sites representing the lower and upper reaches respectively (Fig. 2). The condition of the estuary mouth (i.e. whether the mouth was open, closed or overtopping) was recorded on a daily basis between March 1993 and August 1997. Rainfall data were obtained from the Weather Bureau records for the Fish River Lighthouse, which is situated approximately 10 km north east of the East Kleinemonde Estuary mouth.

Fish sampling

The ichthyofauna of the estuary was sampled using a variety of gear: a small-mesh seine, a large-mesh seine and a fleet of gill nets. Based on collection efficiency, quantitative catch data was gathered from either the small-mesh or the large-mesh seine for individual species. For example, the catches of the smaller estuarine-spawning species were more representative using the small-mesh seine, therefore quantitative data for these species were not recorded from the large-mesh seine.

The large-mesh seine (50 m x 2 m with a 15 mm bar mesh), fitted with a bag, was used to sample the marine-spawning species of all sizes except < 40 mm SL, which were able to escape through the net. Netting was carried out during daylight hours (mostly between 09h00 and 14h00) on 111 separate days between April 1993 and March 1996.

Due to fluctuations in water depth during the study period, as a result of mouth-opening and closing events, sampling stations were not fixed but were selected according to where the net could be laid unobstructed (Fig. 2). Sampling was conducted in a variety of littoral habitats (i.e. sandy, muddy and vegetated areas) in each of the three reaches (lower, middle and upper) of the estuary. The net was set in a semi-circle from a motorized boat and hauled ashore by three or four people, ensuring that the foot rope (lead line) was dragged along the bottom. The area covered by the net was dependent on the width of the estuary. In the lower reaches (widest portion of the estuary) the area sampled was estimated at approximately 550 m^2, while in the middle and upper reaches the net covered areas of approximately 525 m^2 and 500 m^2 respectively. All fish captured with this seine were measured to the nearest mm standard length (SL) in the field and returned alive to the water.

The small-mesh seine net (30 m x 2 m with a 5 mm bar mesh), fitted with a bag, was used to target the estuarine-spawning species and the smaller marine-spawning species (e.g. *Solea bleekeri* and *Heteromycteris capensis*). The general sampling procedure was the same as with the large-mesh seine. Netting was conducted during daylight hours at selected sites in the estuary on seven separate occasions between April 1995 and January 1997. A total of eight sampling stations, covering a variety of habitats, were selected in unobstructed areas with gently sloping banks (Fig. 2). The net was deployed from a motorized boat and the procedure was performed in the same manner at each sampling station. The area covered by the net was estimated at approximately 100 m^2. The fish captured using this net were brought back to the laboratory, with the exception of some larger individuals and *Syngnathus watermeyeri*, which were measured in the field and released. Standard length measurements were taken for all species.

Gill nets were used to sample both marine-spawning and freshwater species, particularly the larger individuals, which are known to actively avoid seine nets (Rozas & Minello 1997). Gill net sampling was kept to a minimum to avoid killing excessive numbers of fish in the estuary. Sampling was conducted at night on four separate occasions (2 November 1995, 2-3 June 1996 and 30 January 1997). Each net (10 m x 2 m) consisted of three equal lengths of 45 mm, 75 mm and 100 mm stretch mesh and were deployed in the evening (at about 18h00) and lifted the following morning (at about 06h00). On each sampling occasion two nets were set in each of three regions (lower, middle and upper) of the estuary (Fig. 2).

All fish taxa sampled during this study were identified using Smith & Heemstra (1986) and assigned an estuary-association category using the descriptions given in Table 1. To avoid subjective evaluation of spatial trends in the fish community, non-parametric multivariate analyses of the two seine netting data sets were performed using the software program PRIMER v3.1b (Clarke & Warwick 1994). The data were root-root transformed (without standardisation) prior to calculating the Bray-Curtis similarity matrix. The results are presented in a dendrogram format as well as a non-metric MDS (multidimensional scaling) format for ease of reading.

RESULTS

Temperature and salinity

Temperature data collected over a two-year period were pooled to provide a mean monthly surface and bottom temperature (Fig. 3). Mean monthly surface water temperatures ranged from 14.9°C in June to 27°C in January. Bottom water temperatures were almost invariably lower than surface temperatures, providing evidence of some vertical temperature stratification, which was slightly more pronounced during the summer months (Fig. 3).

During the period March 1994 to March 1996 the salinity regime of the East Kleinemonde Estuary ranged from oligohaline conditions (<5‰) to mostly mesohaline conditions (5 - 18‰), depending on the amount of rainfall and estuary mouth phase (Fig. 4). Mouth-opening events generally occurred during or shortly after periods of high rainfall (usually in months with rainfall exceeding 100 mm; Fig. 5). Salinity levels declined rapidly prior to mouth-opening events (e.g. July - September 1994 and December 1994 - January 1995) due to riverine input. During the open mouth phase, seawater rarely extended beyond the

Table 1. The estuary-association categories of fishes that utilize southern African estuaries (after Whitfield 1998).

Category	Description of categories
I	Estuarine species which breed in southern African estuaries. Further subdivided into: I a. Resident species which have not been recorded spawning in marine or freshwater environments. I b. Resident species which also have marine or freshwater breeding populations.
II	Euryhaline marine species which usually breed at sea with juveniles showing varying degrees of dependence on southern African estuaries. Further divided into: II a. Juveniles dependent on estuaries as nursery areas. II b. Juveniles occur mainly in estuaries, but are also found at sea. II c. Juveniles occur in estuaries but are usually more abundant at sea.
III	Marine species which occur in estuaries in small numbers but are not dependent on these systems.
IV	Freshwater species, whose penetration into estuaries is determined primarily by salinity tolerance. This category includes some species which may breed in both freshwater and estuarine systems.
V	Catadromous species which use estuaries as transit routes between the marine and freshwater environments but may also occupy estuaries in certain regions. Further divided into: V a. Obligate catadromous species which require a freshwater phase in their development. V b. Facultative catadromous species which do not require a freshwater phase in their development.

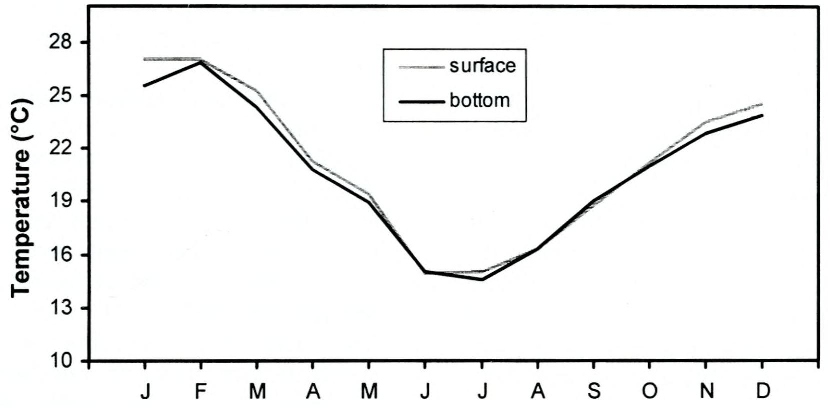

Figure 3. Mean monthly surface and bottom temperatures taken from the middle reaches of the East Kleinemonde Estuary.

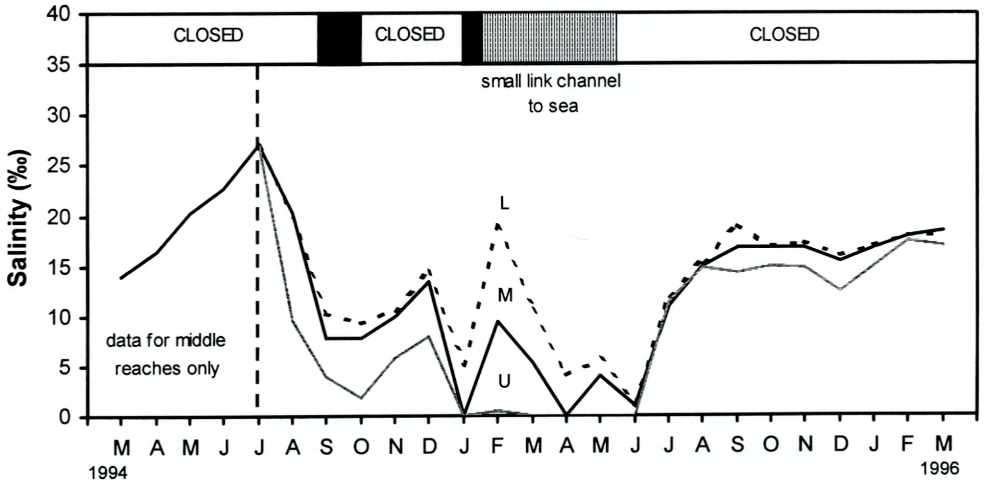

Figure 4. Mean monthly surface salinity in the lower (L), middle (M) and upper (U) reaches of the East Kleinemonde Estuary between March 1994 and March 1996. Solid bars indicate mouth-opening events.

lower reaches, thereby creating a steep salinity gradient between the mouth and head of the estuary (e.g. January - May 1995). After mouth closure, salinity levels increased at a rate dependent on the extent of bar topping (overwash) events. For example, during the period March to July 1994 salinity levels rose rapidly due to a number of large bar topping events. However, during the closed mouth phase subsequent to July 1996, salinity levels increased slowly due to evaporation and reduced overwash events (see Fig. 5). During periods of extended mouth closure, salinities were relatively uniform throughout the estuary, with the exception of the occasional decline in salinity in the upper reaches following river pulses.

Mouth dynamics

The daily record of the estuary mouth condition from March 1993 to August 1997 is given in Figure 5. The mouth was closed for 71.8% of the time, while open mouth conditions were recorded on only 43 days (2.6%). Overwash conditions consisting of small bar topping events (i.e. < 3 hours) occurred fairly frequently (23.7%), but large overwash events (i.e. 3 - 6 hours), associated with storm conditions and high seas, occurred on only 31 days (1.9%). During the study period, the mean duration of the open mouth phase was only four days (range = 1 to 13). The short duration of open mouth conditions were attributed to the predominantly north east bound aeolian and longshore sediment movement (Badenhorst, 1988), which result in the formation of sandbanks and ultimately mouth closure. However, the mass removal of sand in the mouth region following a flood event (mouth-opening) lowered the sandbar and allowed seawater to enter the estuary during bar topping events for varying lengths of time after mouth closure. Such conditions persisted for several months following the mouth-opening event in December 1994 (Fig. 5).

Mouth-opening events were associated with periods of high rainfall and usually occurred during months that experienced more than 100 mm of precipitation (Fig. 5). Furthermore, mouth-opening events were recorded during every month of the year except March and July.

Ichthyofaunal assemblage

Altogether, 30 fish species representing 17 families were recorded in the East Kleinemonde Estuary (Table 2). Most families were represented by a single species, with the exception of the Carangidae (three species), Gobiidae (three species), Haemulidae (two species), Mugilidae (five species), Soleidae (two species) and Sparidae (four species). In terms of estuary-association categories, the euryhaline marine species (category II) dominated the catch composition (Fig. 6). Marine-spawning species that are dependent on estuaries as nursery areas (category IIa) constituted 30% of all taxa recorded, followed by category IIb (17%) and category IIc (13%). The categories comprising the estuarine-spawning species (categories Ia and Ib) were represented by six species (20%), while the marine species that are not dependent on estuaries (category III) were represented by three species (10%). The euryhaline freshwater species (category IV), the obligate catadromous species (category Va) and the facultative catadromous species (category Vb) were each represented by a single species.

The percentage species composition of fishes belonging to the estuary-dependence categories Ia, Ib, IV, Va and Vb (i.e. estuarine, freshwater and catadromous species) in the East Kleinemonde Estuary were similar to that of all species that utilize southern African estuaries (Figure 6). However, the contribution (% species composition) of marine species (categories IIa, IIb, IIc and III) in the East Kleinemonde Estuary decreased with a decreasing dependence on estuaries (i.e. from IIa to III), while Whitfield (1998) showed that the number of these species usually increases with decreasing estuarine dependence in southern African estuaries (Fig. 6).

SMALL-MESH SEINE

Faunal composition

Although 16 species were captured in the small-mesh seine (Table 2), quantitative records were only kept for the six estuarine-spawning species and the two small marine-spawning species (viz. *Heteromycteris capensis* and *Solea bleekeri*). The overall catch composition of these taxa was numerically dominated by *Gilchristella aestuaria* (59.6%), *Atherina breviceps* (23%) and *Glossogobius callidus* (14.4%), while *Psammogobius knysnaensis*, *Caffrogobius gilchristi*, *Syngnathus watermeyeri*, *Heteromycteris capensis* and *Solea bleekeri* collectively contributed only 3% (Table 3).

Analysis of the size range distributions revealed the presence of all post-larval life history stages for the dominant species. The sizes of *Gilchristella aestuaria* ranged between 15 mm and 60 mm SL, with a bimodal size class distribution (Fig. 7a). The sizes of *Atherina breviceps*, *Glossogobius callidus* and *Psammogobius knysnaensis* ranged from 19 - 62 mm, 10 - 92 mm and 21 - 55 mm SL respectively (Table 3). The modal size class for *A. breviceps* and *G. callidus* were 30 - 34 mm SL (Fig. 7b) and 40 - 44 mm SL (Fig. 7c) respectively. *Psammogobius knysnaensis* had a bimodal size distribution with peaks at 25 - 29 mm SL and 45 - 49 mm SL (Fig. 7d). The catches of *Caffrogobius gilchristi*, *Heteromycteris capensis* and *Solea bleekeri* were represented by only a few juveniles, and *Syngnathus watermeyeri* by a few adolescent and adult specimens. The absence of all life-history stages for these estuarine-spawning species is attributed to the small sample sizes.

Distribution

The spatial trends in fish abundance were analysed from catch data. The mean catch per seine haul (CPUE) of the four dominant species sampled with the small-mesh seine in each of the three reaches of the estuary are given in Fig. 8. The two dominant pelagic species showed inverse distributional patterns. *Gilchristella aestuaria* was more abundant in the upper reaches, while *Atherina breviceps* was more abundant in the lower reaches. A similar trend was observed for the two dominant benthic species. *Glossogobius callidus* occurred throughout the estuary

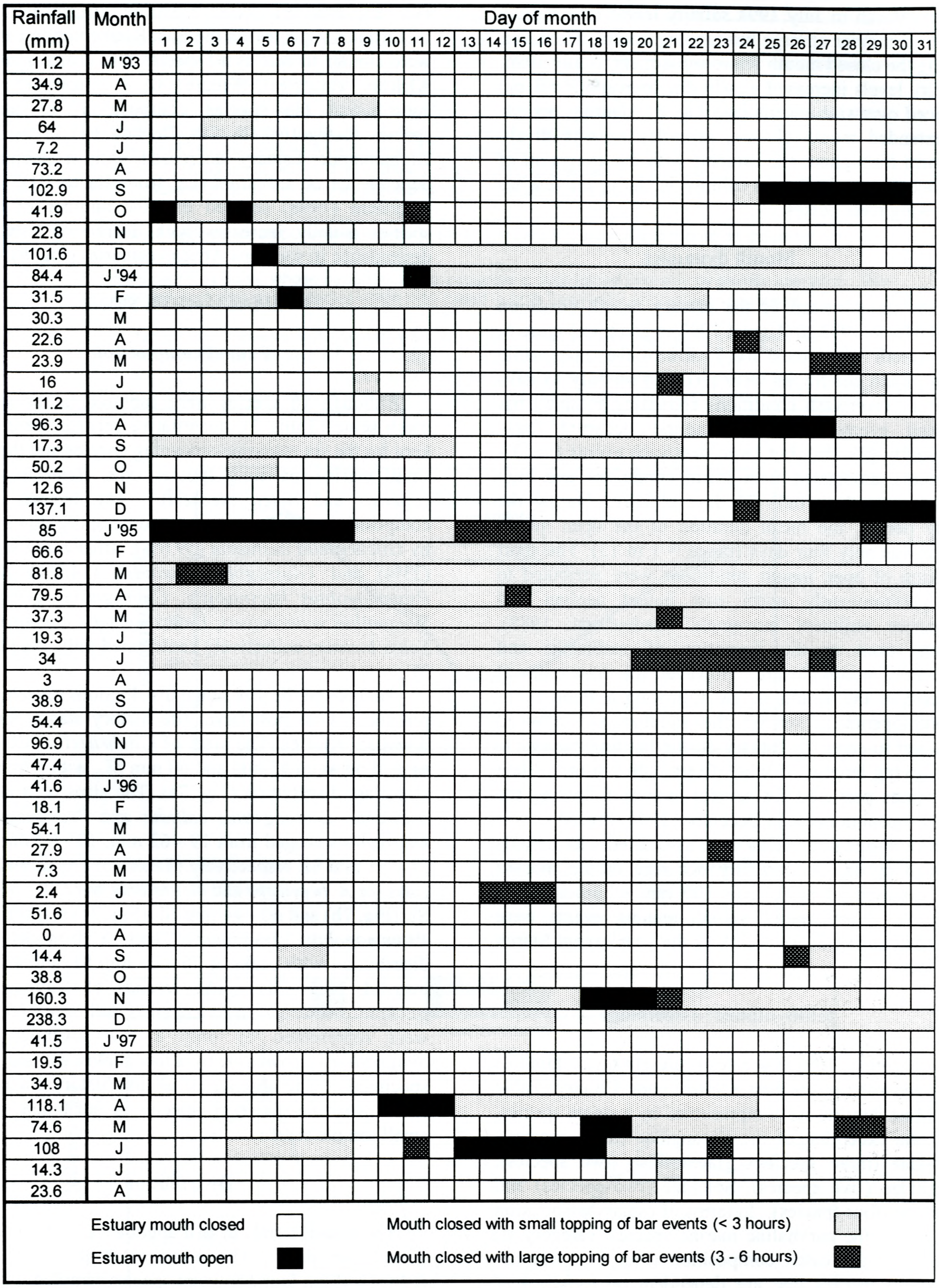

Figure 5. Monthly rainfall and condition of the East Kleinemonde Estuary mouth from March 1993 to August 1997.

Table 2. Ichthyofaunal species recorded in the East Kleinemonde Estuary using gill nets (GN), small- (SS) and large-mesh (LS) seine (* denotes a record from recreational angling). The estuary-dependence categories are after Whitfield (1998).

Family	Species	Common name	Estuary-Dependence category	Sampling gear
Anguillidae	*Anguilla marmorata*	Madagascar mottled eel	Va	LS
Atherinidae	*Atherina breviceps*	Cape silverside	Ia	SS, LS
Carangidae	*Caranx* sp.	Kingfish	IIb?	LS
	Lichia amia	Leervis	IIa	LS, GN
	Trachinotus africanus	Southern pompano	III	LS
Cichlidae	*Oreochromis mossambicus*	Mozambique tilapia	IV	SS, LS, GN
Clupeidae	*Gilchristella aestuaria*	Estuarine roundherring	Ia	SS, LS
Elopidae	*Elops machnata*	Ladyfish	IIa	*
Gobiidae	*Caffrogobius gilchristi*	Prison goby	Ib	SS
	Glossogobius callidus	Estuarine goby	Ib	SS, LS
	Psammogobius knysnaensis	Knysna sandgoby	Ib?	SS, LS
Haemulidae	*Pomadasys olivaceum*	Piggy	III	LS
	Pomadasys commersonnii	Spotted grunter	IIa	LS,GN
Monodactylidae	*Monodactylus falciformis*	Cape moony	IIa	SS, LS, GN
Mugilidae	*Liza dumerilii*	Groovy mullet	IIb	SS, LS, GN
	Liza richardsonii	Southern mullet	IIc	SS, LS, GN
	Liza tricuspidens	Striped mullet	IIb	SS, LS
	Mugil cephalus	Flathead mullet	IIa	SS, LS, GN
	Myxus capensis	Freshwater mullet	Vb	SS, LS, GN
Pomatomidae	*Pomatomus saltatrix*	Elf	IIc	*
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	IIa	LS
Soleidae	*Heteromycteris capensis*	Cape sole	IIb	SS, LS
	Solea bleekeri	Blackhand sole	IIb	SS, LS
Sparidae	*Diplodus sargus capensis*	Blacktail	IIc	LS
	Lithognathus lithognathus	White steenbras	IIa	LS,GN
	Rhabdosargus holubi	Cape stumpnose	IIa	SS, LS, GN
	Sarpa salpa	Strepie	IIc	LS
Syngnathidae	*Syngnathus watermeyeri*	Estuarine pipefish	Ia	SS, LS
Teraponidae	*Terapon jarbua*	Thornfish	IIa	*
Tetraodontidae	*Amblyrhyncotes honkenii*	Evileye blaasop	III	*

Psammogobius knysnaensis occurred only in the sandy areas of the lower reaches (Fig. 8). The distribution of *Syngnathus watermeyeri*, on the other hand, was site specific because of their association with submerged macrophyte (*Ruppia cirrhosa*) beds, which occur mostly above the road bridge. The distribution of the other species caught with the small-mesh seine net revealed no distinct trends. This is possibly due to the small sample sizes.

The distributional affinities of the fish species collected at each small-mesh seine sampling site (Fig. 2) were analysed using the Bray-Curtis measure of similarity (Fig. 9a). Despite the overall high level of similarity in the community, two distinct cluster groups were identified. The samples collected at sites with a sandy substratum in the lower reaches of the estuary (sites *a* and *b*) were distinguished from those collected at the other sites at the 70% similarity level. The other sampling sites (*c* to *h*) are characterized by a muddy substratum. This grouping was also portrayed in the ordination plot (Fig. 9b) using multidimensional scaling on the same similarity matrix as above.

Table 3 The catch composition (in order of family abundance) and size composition (mean, standard deviation and range) of the fish taxa sampled with the small-mesh seine in the East Kleinemonde Estuary between April 1995 and January 1997.

Species	Number caught	% catch composition	Rank	Mean SL (mm)	Standard deviation	Length range
Clupeidae			**1**			
Gilchristella aestuaria	7481	59.6	1	35.1	7.7	15 - 60
Antherinidae			**2**			
Atherina breviceps	2884	22.9	2	35.3	8.2	19 - 62
Gobiidae			**3**			
Glossogobius callidus	1808	14.4	3	41.6	12.8	10 - 92
Psammogobius knysnaensis	318	2.5	4	35.0	8.5	21 - 55
Caffrogobius gilchristi	5	0.04	7	37.4	3.5	33 - 42
Syngnathidae			**4**			
Syngnathus watermeyeri	43	0.3	5	104.3	9.5	84 - 128
Soleidae			**5**			
Heteromycteris capensis	7	0.05	6	69.1	8.1	56 - 79
Solea bleekeri	2	0.02	8	53.5	2.1	52 - 55

LARGE-MESH SEINE

Faunal composition

A total of 25 species representing 18 families were recorded in the large-mesh seine catches (Table 2). The overall catch composition was dominated by marine-spawning species. *Rhabdosargus holubi* was by far the most abundant species (75.3%), followed by three mugilids [*Liza richardsonii* (5.7%); *Myxus capensis* (5.5%); *Liza dumerilii* (4%)], *Monodactylus falciformis* (3.2%) and *Lithognathus lithognathus* (2.6%). The other species collectively contributed only 3.7% (Table 4).

The vast majority of fishes caught with the large-mesh seine were juveniles (Table 4). The species that were only represented by juvenile sizes classes included *Caranx* sp., *Lichia amia*, *Trachinotus africanus*, *Pomadasys olivaceum*, *Argyrosomus japonicus*, *Diplodus sargus capensis*, *Lithognathus lithognathus* and *Sarpa salpa*. Species that were also represented by adult specimens included *Pomadasys commersonnii*, *Monodactylus falciformis*, *Rhabdosargus holubi*, *Liza dumerilii*, *Liza richardsonii*, *Liza tricuspidens*, *Myxus capensis*, *Mugil cephalus*, and the freshwater cichlid *Oreochromis mossambicus*. The length frequency distributions for the dominant species captured in the large-mesh seine are given in Figs. 10 and 11.

Distribution

The principal marine-spawning species in the East Kleinemonde Estuary, *Rhabdosargus holubi*, showed a clear preference for the lower reaches. The mean catch per seine haul (CPUE) in the lower reaches (47.7) was higher than in the middle (27.2) and upper (25.1) reaches. The distributional trends, based on CPUE, for the other dominant marine-spawning species captured in the large-mesh seine net are given in Fig. 12. *Liza richardsonii* showed no distinct distributional trend but *Liza dumerilii* was more abundant in the lower reaches. Conversely, the other mugilids (*Mugil cephalus* and *Myxus capensis*) were more abundant in the upper reaches of the estuary. Most *Lithognathus lithognathus* were recorded in the lower reaches, while the majority of *Monodactylus falciformis* were caught in the upper reaches (Fig. 12).

Classification and ordination of the fish fauna sampled with the large-mesh seine at sites 1-21 (excluding sites 4 and 18) are given in Fig. 13. Sampling sites 4 and 18 were excluded because initial analyses revealed that they were unrepresentative due to the very low number of seine hauls conducted at these sites.

The Bray-Curtis classification grouped the entire fish community at a similarity level in excess of 70%. Similar to the small-mesh seine net assemblage, the samples collected at sites in the sandy areas of the lower reaches (sites 1, 2 and 3) were identified as a distinct cluster group (Fig. 13).

GILL NETS

Catch composition

A total of 284 fishes from 10 species and six families were recorded in the gill net catches (Table 5). According to their estuary-association categories, marine-spawning species that are dependent on estuaries (category IIa) dominated the catch composition with six species, while categories IIb, IIc, IV and Vb were each represented by a single species.

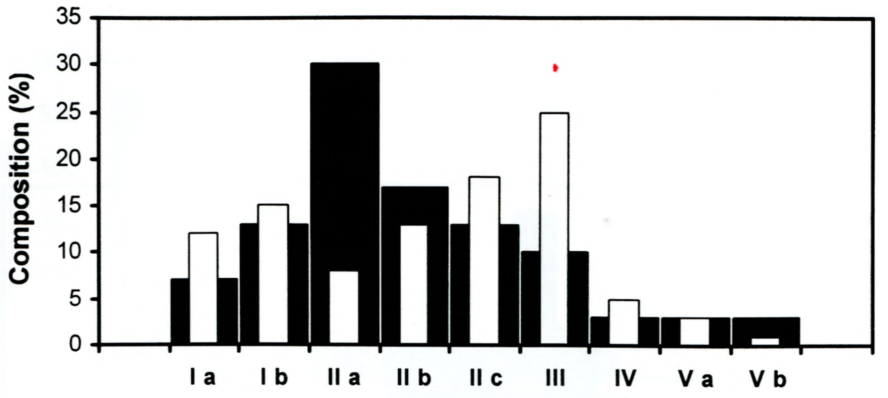

Figure 6. The percentage species composition of fishes in each estuary-dependence category sampled in the East Kleinemonde Estuary between April 1993 and January 1997 (closed bars), and of all fishes that utilize southern African estuaries (open bars; after Whitfield 1998).

No estuarine-spawning species were recorded in the gill nets due to the small size of these fish. The gill net assemblage was not analysed spatially due to the paucity of data.

The catch composition was dominated by four mullet species, which collectively contributed 47.9%. At the species level *Monodactylus falciformis* dominated the catch composition (26.4%), followed by *Mugil cephalus* (20.8%), *Liza richardsonii* (14.4%) and *Rhabdosargus holubi* (13.4%). Although the species composition differed considerably between the gill net and seine samples, the most striking difference between the catches from the two gear types was the size composition. In most cases the largest individuals for each species were recorded in the gill nets (Figs 10 and 11) and this was attributed to net selectivity.

DISCUSSION

A range of sampling gear, including both small and large-mesh seine and gill nets were used to sample the fishes of the East Kleinemonde Estuary. Rozas & Minello (1997) state that all sampling techniques have advantages and disadvantages, which influence the collection efficiencies of individual species. Therefore, the use of different gear types allowed for improved representation of the community in terms of diversity and size ranges, but made quantitative assessments of the overall fish assemblage highly subjective. As a result, the fish assemblage for each gear type was treated separately.

The use of multivariate techniques of classification and ordination have been used to describe the structure of estuarine fish communities in South African and abroad. Bennett (1989) identified distinct species groups on the basis of season in three Western Cape estuaries, and Whitfield et al. (1989) noted similarities within the fish assemblages of the Knysna and Swartvlei estuaries based on the presence or absence of submerged vegetation. The ichthyofaunal assemblages within the East Kleinemonde Estuary revealed a high degree of similarity throughout the estuary, but a distinct species grouping was identified in association with sandy substrata in the lower reaches of the system. The identification of this grouping was recorded at a similarity level of 70% and 72% for the small and large seine net fish assemblages respectively (Figs. 9 and 13). A similar pattern of homogeneity in the faunal composition was reported from the seasonally closed Wilson Inlet in Australia (Potter et al., 1993), while the faunal composition changed progressively from the mouth towards the upper reaches in the intermittently open Moore estuary (Young et al., 1997). The progressive shift in the latter system was attributed to the decline in the number of marine species with increasing distance from the mouth.

An analysis of the estuarine association categories revealed that the fish community of the East Kleinemonde Estuary was dominated by juvenile euryhaline marine species (categories IIa, IIb and IIc), which collectively comprised 60%. The estuarine species (categories Ia and Ib) constituted 20%, the marine species which are not dependent on estuaries (category III) comprised 10%, while the euryhaline freshwater species (category IV), the obligate catadromous species (category Va) and the facultative catadromous species (category Vb) each contributed 3.3% to the overall community. In contrast with a typical southern African estuary (Fig. 6), the East Kleinemonde Estuary fish community has an inferior contribution by category III marine species, but is well represented by estuarine dependent marine-spawning species (category IIa). This is probably a result of the predominantly closed condition of the estuary mouth during this study.

The overall species diversity is also lower when compared with equivalent subtropical systems. For example, Harrison & Whitfield (1995) working in KwaZulu-Natal recorded 47 and 56 species in the Mhlanga and Zotsha estuaries, respectively. Furthermore, temporarily open/closed estuaries usually have a lower species diversity than permanently open estuaries (Bennett, 1989; Whitfield & Kok, 1992; Potter & Hyndes, 1994; Young et at., 1997). For example, Whitfield et al. (1994) recorded a total of 31 and 39 species in the neighbouring permanently open Great Fish and Kowie estuaries respectively, while 30 species were recorded from the East Kleinemonde Estuary. The presence of a less diverse ichthyofauna in temporarily open/closed systems can be ascribed to the small size of the mouth-opening and the reduced

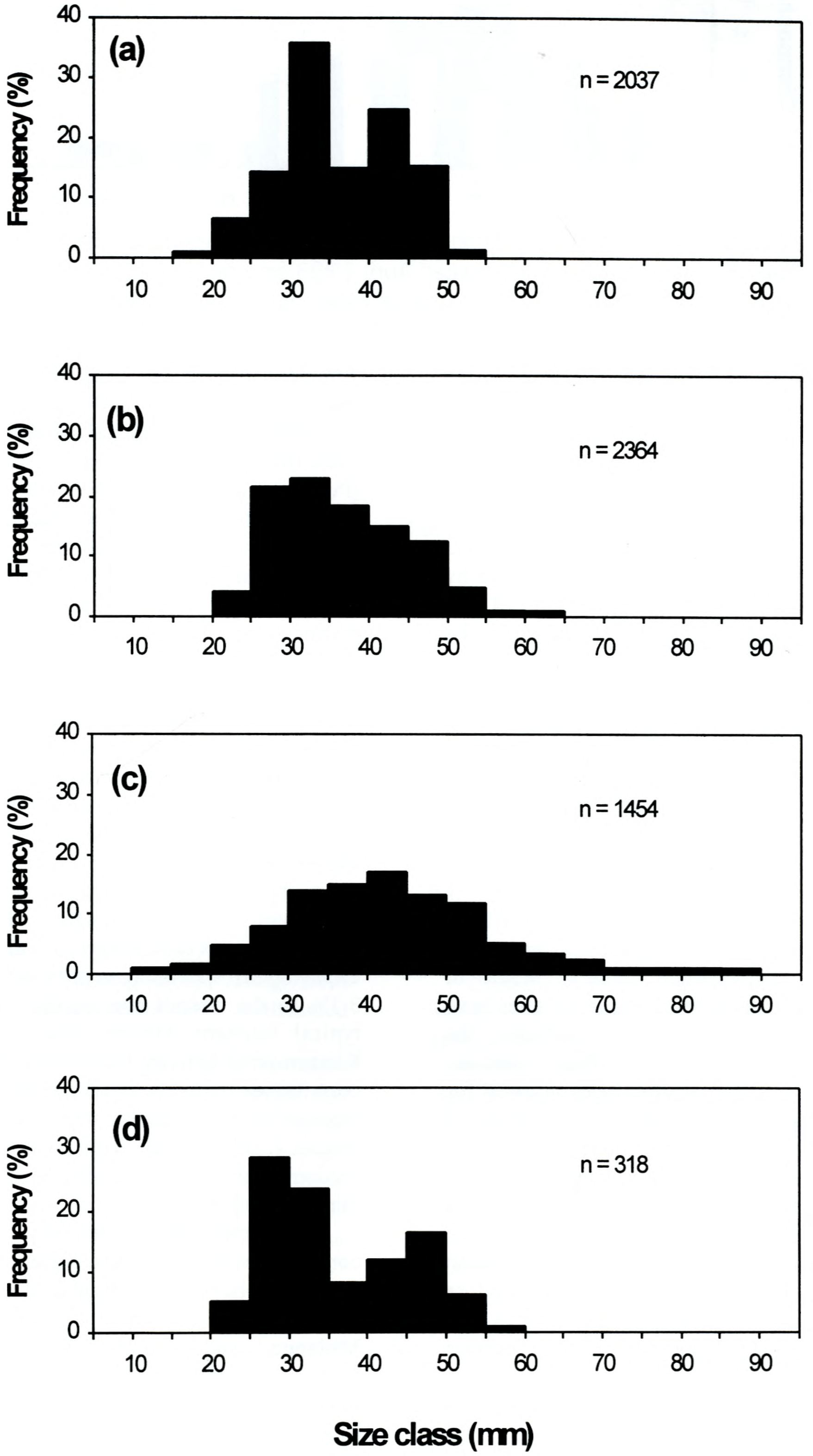

Figure 7. Length frequency distributions for **(a)** *Gilchristella aestuaria*, **(b)** *Atherina breviceps*, **(c)** *Glossogobius callidus* and **(d)** *Psammogobius knysnaensis* sampled with the small-mesh seine in the East Kleinemonde Estuary between April 1995 and January 1997.

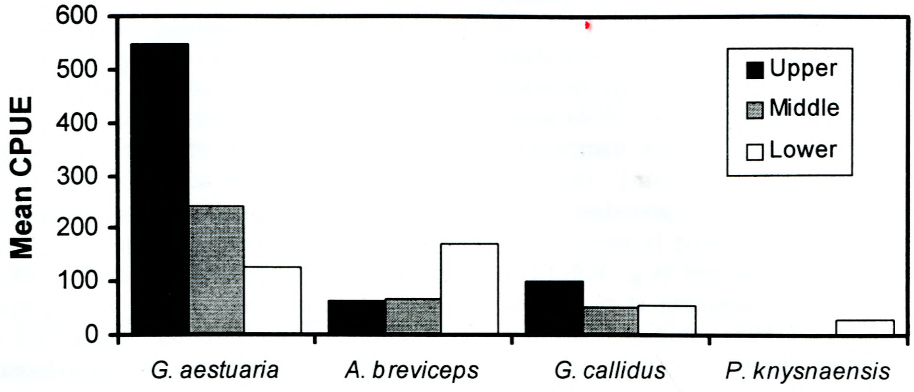

Figure 8. The mean CPUE of *Gilchristella aestuaria*, *Atherina breviceps*, *Glossogobius callidus* and *Psammogobius knysnaensis* sampled with the small-mesh seine in the upper, middle and lower reaches of the East Kleinemonde Estuary.

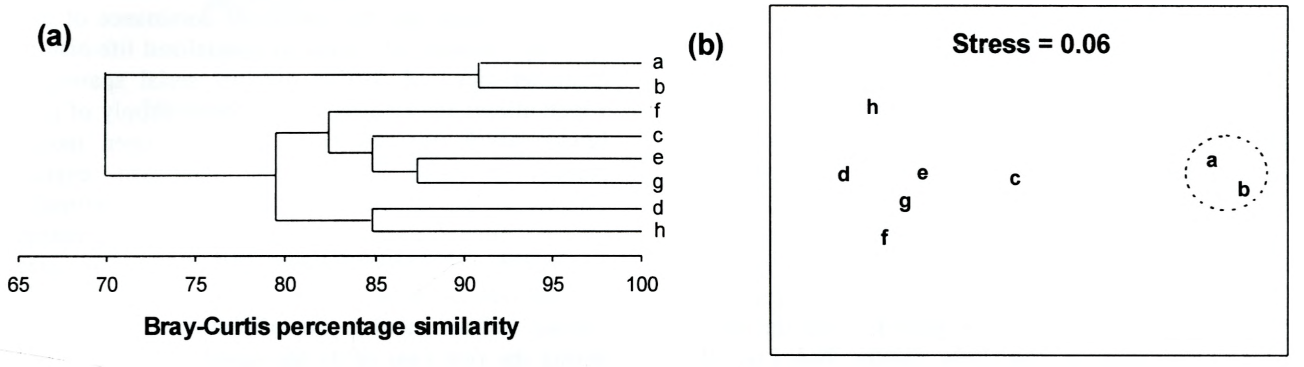

Figure 9. (a) Dendrogram showing the classification and **(b)** ordination by means of multi-dimensional scaling of the small mesh seine fish assemblage. The sites with a sandy substratum in the lower reaches are encircled with a dashed line.

duration of the open phase, which limits the recruitment opportunities for marine 'stragglers'. Furthermore, it has been suggested that the rarity of larvae of marine-spawning species in these systems is also linked to the frequent closed-mouth conditions (Neira & Potter, 1992; 1994). Therefore, it appears that the tendency for temporarily open/closed estuaries to be used as nursery areas by marine species is reduced. However, certain marine species (e.g. *Rhabdosargus holubi* and *Liza richardsonii*) that have an extended breeding season (serial spawners) are capable of immigrating into closed estuaries as post-larvae during marine overwash events (Cowley et al., 2001). It has been proposed that the adoption of this recruitment strategy prevents recruitment failure and also accounts for the numerical dominance of species such as *R. holubi* in the East Kleinemonde Estuary (Cowley 1998).

The small-mesh seine assemblage was numerically dominated by two small shoaling planktivorous species (*Gilchristella aestuaria* and *Atherina breviceps*), which collectively constituted 82.6% of the catch. The numerical dominance of these two endemic species has been recorded in many South African estuarine environments (Beckley, 1984; Bennett, 1989; Whitfield et al., 1989). The success of these species can be ascribed to their typically altricial life-history style (Balon, 1981) and possession of a number of eurytopic traits that include wide distribution and a broad habitat tolerance range (Whitfield, 1994). Both species are strongly euryhaline (0 - > 40 ‰) and have been found to breed in estuaries throughout the year with a peak in spring and summer (Talbot, 1982; Ratte, 1989; Whitfield, 1996). Despite their similar life-history styles, the two species showed inverse distributional trends in the East Kleinemonde Estuary. *Gilchristella aestuaria* was almost five times more abundant in the upper reaches than in the lower reaches, while the abundance of *Atherina breviceps* was more than two fold greater in the lower reaches (Fig. 8). Although the distribution of *Gilchristella aestuaria* has been linked to the abundance of suitable prey (Ter Morshuizen et al., 1996), as well as spawning behaviour (Talbot, 1982), it generally prefers the upper reaches of estuaries (Branch & Grindley, 1979; Harrison & Whitfield, 1995). It is interesting to note that spatial segregation of *Atherina breviceps* and *Gilchristella aestuaria* in the East

Kleinemonde Estuary parallels the situation found with two members of the antherinid family in the permanently open Swan estuary in south-western Australia (Prince et al., 1982).

Glossogobius callidus and *Psammogobius knysnaensis* in the East Kleinemonde Estuary revealed a similar distribution pattern to that of *Gilchristella aestuaria* and *Atherina breviceps*. The numerically dominant goby species (*G. callidus*) occurred throughout the estuary but was more abundant in the upper reaches (Fig. 8). This finding is mirrored by several other South African studies (e.g. Whitfield, 1980; Beckley, 1984; Ter Morshuizen et al., 1996). Harrison & Whitfield (1995) studied the fish communities of three KwaZulu-Natal estuaries (Damba, Mhlanga and Zotsha) and found that *G. callidus* was only an important component of the ichthyofauna in those estuaries which were characterized by a predominantly muddy substratum. *Psammogobius knysnaensis*, on the other hand, prefers sandy substrata (this study; Whitfield, 1988; Ter Morshuizen & Whitfield, 1994; Ter Morshuizen et al., 1996), a habitat which usually predominates in the mouth region of most estuaries. Therefore, the distribution and abundance of Gobiidae in South African estuarine systems appear to be linked to substratum type. A similar pattern of spatial segregation has been proposed for various species of gobies that are found within the Swan Estuary, Australia (Gill & Potter, 1993).

A noteworthy inclusion in the East Kleinemonde fish assemblage was the estuarine pipefish *Syngnathus watermeyeri*. This estuarine-restricted species, previously known as the river pipefish, was declared extinct according to the 1994 IUCN Red List of Threatened Animals (Groombridge, 1993). However, it should not have been classified as extinct, since 50 years had not elapsed since the last specimens were collected (Whitfield, 1995). *Syngnathus watermeyeri* was known only from the Bushmans, Kariega and Kasouga estuaries, and the last specimens were collected in 1963. The disappearance of *S. watermeyeri* from these estuaries (localized extinction) is attributed to the prolonged absence of freshwater inflow and the influence of these conditions on the available planktonic food supply (Ter Morshuizen & Whitfield, 1994). Based on the limited knowledge of the Bushmans/Kariega population, it appears that this species has specialized needs in terms of the physical and biotic characteristics of an estuary, including sufficient macrophytic plant beds and a regular freshwater supply. Whitfield (1995) suggests that pulses of freshwater supply are essential to provide nutrients for phytoplankton development, which together with particulate organic material brought down by the rivers, support zooplankton communities on which pipefishes depend for food. At present, the East Kleinemonde Estuary (this study) and the neighbouring West Kleinemonde Estuary (Cowley, unpublished data) are refuge to the only known viable populations of *S. watermeyeri*. Based on the above-mentioned criteria, these estuaries offer a number of favourable characteristics for its existence. These include dense stands of the submerged macrophyte *Ruppia cirrhosa*, limited freshwater abstraction from the catchment, fairly low human recreational and development pressures, and low levels of piscivorous predation. The absence of the longsnout pipefish *Syngnathus acus* from the East Kleinemonde Estuary indicates that potential competition between the two syngnathids is also lacking, in contrast to the situation in the Kariega estuary where these species lived sympatrically (Whitfield & Ter Morshuizen, 1992).

The presence of life-history stages, ranging from early juvenile to adult size classes (Table 3), of the dominant estuarine-spawning species (*Gilchristella aestuaria*, *Atherina breviceps*, *Glossogobius callidus* and *Psammogobius knysnaensis*) indicated that they all bred successfully in the East Kleinemonde Estuary during the study period. Although it is proposed that a viable breeding population of *Syngnathus watermeyeri* occurs in the East Kleinemonde Estuary, no juveniles were recorded.

The fishes recorded in the large-mesh seine were dominated by *Rhabdosargus holubi*, which constituted 75.3% of the overall catch. It was also the most abundant taxon within the ichthyoplanktonic component of the surf zone adjacent to the estuary mouth (Cowley et al., 2001). As mentioned above, it is hypothesized that the numerical dominance of this species is a result of a suite of specialized life-history characteristics. *R. holubi* exhibits serial spawning, which allows for an almost continuous supply of post larvae which not only recruit during open mouth phases but also during bar overwash events. Therefore, this species has the ability to optimally utilize 'blind' estuaries because of the temporal uncertainty of open mouth phases. The size composition of *R. holubi* in the East Kleinemonde Estuary indicates that it primarily utilizes this estuary during the first year of its life cycle. They enter the estuary during either open mouth phases or via overtopping events at a size of approximately 10 to 15 mm SL and emigrate with the onset of sexual maturity (approximately 150 mm SL; Cowley et al., 2001). Similar results have been documented from other South African estuaries, e.g. West Kleinemonde (Blaber, 1973), Sundays (Beckley, 1984), Knysna and Swartvlei (Whitfield & Kok, 1992), and Great Fish and Kowie (Whitfield et al., 1994). *Rhabdosargus holubi* was reported to be more abundant in the middle and upper reaches of the Knysna, Swartvlei and Kariega estuaries (Whitfield & Kok, 1992; Ter Morshuizen & Whitfield, 1994). Hankom & Baird (1984) recorded significantly higher numbers of *R. holubi* in vegetated (*Zostera*) areas than in non-vegetated areas within the Kromme Estuary. Whitfield et al. (1989) also found it to be closely associated with *Zostera* beds in the Knysna and Swartvlei estuaries. The distribution of *R. holubi* in estuaries therefore appears to be linked to the presence of macrophytic beds, which are used as foraging and refuge areas. However, this ubiquitous species in the East Kleinemonde Estuary showed a preference for the lower reaches, which is not as heavily vegetated as the middle and upper reaches. It is possible that the abundance of *R. holubi* in the lower reaches was associated with the epipsammic filamentous algal mats, which develop between late winter and early summer. Under these conditions frequent catches of more than 200 individuals per seine haul were recorded in the lower reaches of the East Kleinemonde

Table 4. The catch composition (in order of family abundance) and size composition (mean, standard deviation and range) of fishes captured with the large-mesh seine in the East Kleinemonde Estuary between April 1993 and March 1996.

Species	Number caught	% catch composition	Rank	Mean SL (mm)	Standard deviation	Length range
Sparidae			**1**			
Diplodus sargus capensis	12	0.04	12	52	21.8	26 - 80
Lithognathus lithognathus	842	2.6	6	144.1	71.6	34 - 382
Rhabdosargus holubi	24409	75.3	1	81.7	18.5	23 - 222
Sarpa salpa	224	0.7	8	84.4	8.1	37 - 107
Mugilidae			**2**			
Liza dumerilii	1303	4	4	138.2	44.8	51 - 285
Liza richardsonii	1861	5.7	2	157.1	46.5	49 - 309
Liza tricuspidens	37	0.1	11	127.4	35.4	93 - 244
Mugil cephalus	224	0.7	8	136	48.7	46 - 398
Myxus capensis	1785	5.5	3	166.6	48.4	63 - 375
Monodactylidae			**3**			
Monodactylus falciformis	1042	3.2	5	67.8	22.7	16 - 141
Cichlidae			**4**			
Oreochromis mossambicus	559	1.7	7	123.6	98.9	20 - 300
Carangidae			**5**			
Caranx sp.	12	0.04	12	130.8	19.5	104 - 164
Lichia amia	71	0.2	9	354.2	65.4	264 - 580
Trachinotus africanus	1	< 0.01	13	130	-	-
Haemulidae			**6**			
Pomadasys olivaceum	1	< 0.01	13	75	-	-
Pomadasys commersonnii	44	0.1	10	318.5	161.7	79 - 586
Sciaenidae			**7**			
Argyrosomus japonicus	1	< 0.01	13	446	-	-
Anguillidae			**7**			
Anguilla marmorata	1	< 0.01	13	not taken	-	-

abundance of *R. holubi* in association with filamentous algal mats in the sandy upper reaches of the Swartvlei estuary.

The distribution of the other Sparidae (*Diplodus sargus capensis*, *Lithognathus lithognathus* and *Sarpa salpa*) in the East Kleinemonde Estuary also showed a preference for the lower reaches (Fig. 12). The abundance of *L. lithognathus*, a macroinvertebrate feeder, in the lower reaches can be attributed to the dominance of sand prawns (*Callianassa kraussi*) in this region. *Diplodus sargus capensis* and *Sarpa salpa* were almost exclusively recorded in the lower reaches, possibly in response to the slightly elevated salinity levels within this region and close proximity to the sea.

The Mugilidae are among the most abundant marine-spawning fishes found in South African estuaries (Blaber, 1987; Bennett, 1989; Whitfield et al., 1994; Harrison & Whitfield, 1995). Most species are strongly euryhaline (Whitfield, 1996), have extended spawning seasons (Wallace et al., 1984; Blaber, 1987; Whitfield & Kok, 1992) and are able to recruit into estuaries under a range of mouth conditions (Hall et al., 1987; Harrison & Whitfield, 1995). These traits, together with the fact that they occupy a primary position in the food chain (i.e. detrivores), provide the attributes for their successful adaptation to estuarine environments. The distribution of the dominant mugilids in the East Kleinemonde

Table 5. The catch composition in order of family abundance and size composition (mean, standard deviation and range) of the fish taxa sampled with gill nets in the East Kleinemonde Estuary.

Species	Number caught	% catch composition	Rank	Mean SL (mm)	Standard deviation	Length range
Mugilidae			**1**			
Liza richardsonii	41	14.4	3	244.8	34.2	189 - 303
Mugil cephalus	59	20.8	2	299.2	62.3	181 - 450
Myxus capensis	26	9.2	5	254.7	38.2	193 - 303
Monodactylidae			**2**			
Monodactylus falciformis	75	26.4	1	111.6	14.1	69 - 128
Sparidae			**3**			
Rhabdosargus holubi	38	13.4	4	108.1	7.2	94 - 123
Lithognathus lithognathus	8	2.8	7	250.1	64.8	195 - 383
Cichlidae			**4**			
Oreochromis mossambicus	17	6.0	6	222.2	59.3	115 - 300
Haemulidae			**5**			
Pomadasys commersonnii	8	2.8	7	349.9	142.7	150 - 540
Carangidae			**6**			
Lichia amia	2	0.7	8	448.0	82	390 - 506

of the dominant mugilids in the East Kleinemonde Estuary showed some interesting trends (Fig. 12). *Liza richardsonii* was common throughout the system, but CPUE values for *Liza dumerilii* were higher in the lower reaches than in the middle and upper reaches. Conversely, *Myxus capensis* and *Mugil cephalus* revealed a distinct preference for the upper reaches. A similar distribution pattern for these two species was recorded from the Great Fish and Kowie estuaries (Whitfield et al., 1994). Marais (1981; 1983) also recorded higher numbers of *M. cephalus* in the upper reaches of the Sundays and Gamtoos estuaries. Bok (1979) states that *M. capensis* and *M. cephalus* are catadromous species, and therefore show a distinct preference for the riverine areas of estuaries in the Eastern Cape. It is tempting to suggest that the distributional trend of Mugilidae in the East Kleinemonde Estuary is also a consequence of resource partitioning, but this requires further detailed investigation.

Monodactylus falciformis (16 - 141 mm SL) was the fifth most dominant taxa in the large-mesh seine catches in the East Kleinemonde Estuary (Table 4). This species showed a distinct preference for the upper reaches of the estuary (Fig. 12). Similar trends have been documented by several authors (e.g. Beckley, 1983; 1984; Whitfield, 1984; Whitfield & Kok, 1992; Ter Morshuizen et al., 1996). Ter Morshuizen & Whitfield (1994) also reported a higher abundance of this species in the upper reaches of the Kariega Estuary, which was characterized by a reversed salinity gradient. Consequently, they indicated that factors other than salinity attract *M. falciformis* to the upper reaches of estuaries.

Gill netting provided a method for sampling larger individuals and highly mobile fish that actively avoid seine nets (Marais, 1985). A distinct difference in the size and species composition was observed between the gill net and the seine fish assemblages. The gill net catch composition consisted mostly of marine-spawning species that were consistently larger than those represented in the seine catches (Figs. 10 and 11). The numerical dominance of *Monodactylus falciformis* and *Mugil cephalus* in the gill nets suggest that these species actively avoid seines. *M. falciformis*, which is known to be associated with vegetated areas (Beckley, 1984; Hanekom & Baird, 1984; Whitfield, 1984), has a decreased seine net catch efficiency. It is also possible that the elevated gill net catches of this species are a result of increased nocturnal activity. *Mugil cephalus*, on the other hand, actively avoids seines by jumping over the bouyed head rope of the encircling net. Catches of *Pomadasys commersonnii* and larger individuals (18 - 30 cm SL) of other mugilid species (e.g. *Liza richardsonii*, *Liza dumerilii* and *Myxus capensis*) were also proportionally higher in the gill nets than in the seines.

In summary, the findings of this study indicate that the fish community of the East Kleinemonde Estuary is dominated by juvenile size classes of estuarine dependent marine-spawning species and represents that of a typical warm-temperate southern African

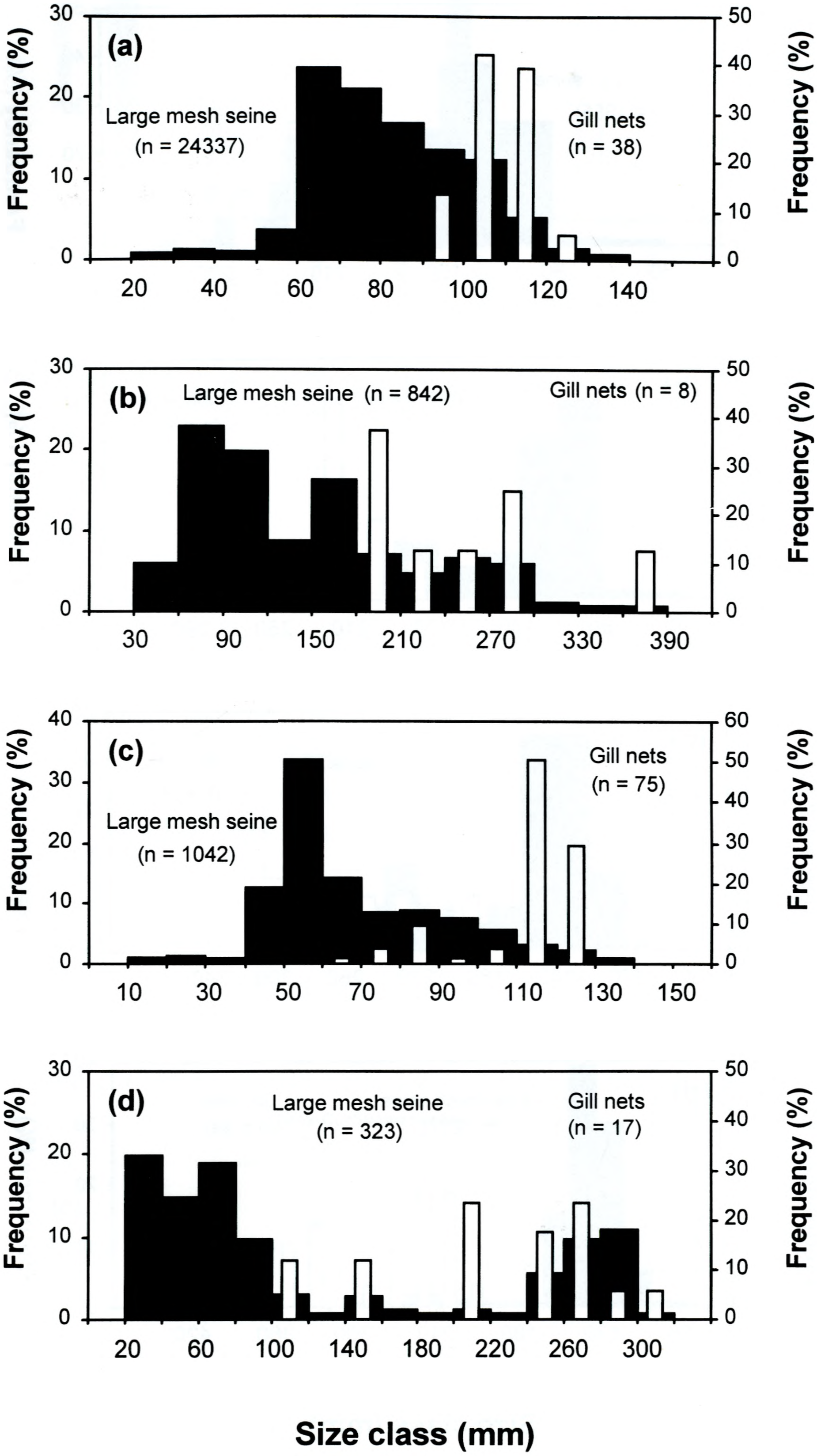

Figure 10. Length frequency distributions for (a) *Rhabdosargus holubi*, (b) *Lithognathus lithognathus*, (c) *Monodactylus falciformis* and (d) *Oreochromis mossambicus* sampled with the large-mesh seine (shaded bars) and gill nets (open bars) in the East Kleinemonde Estuary.

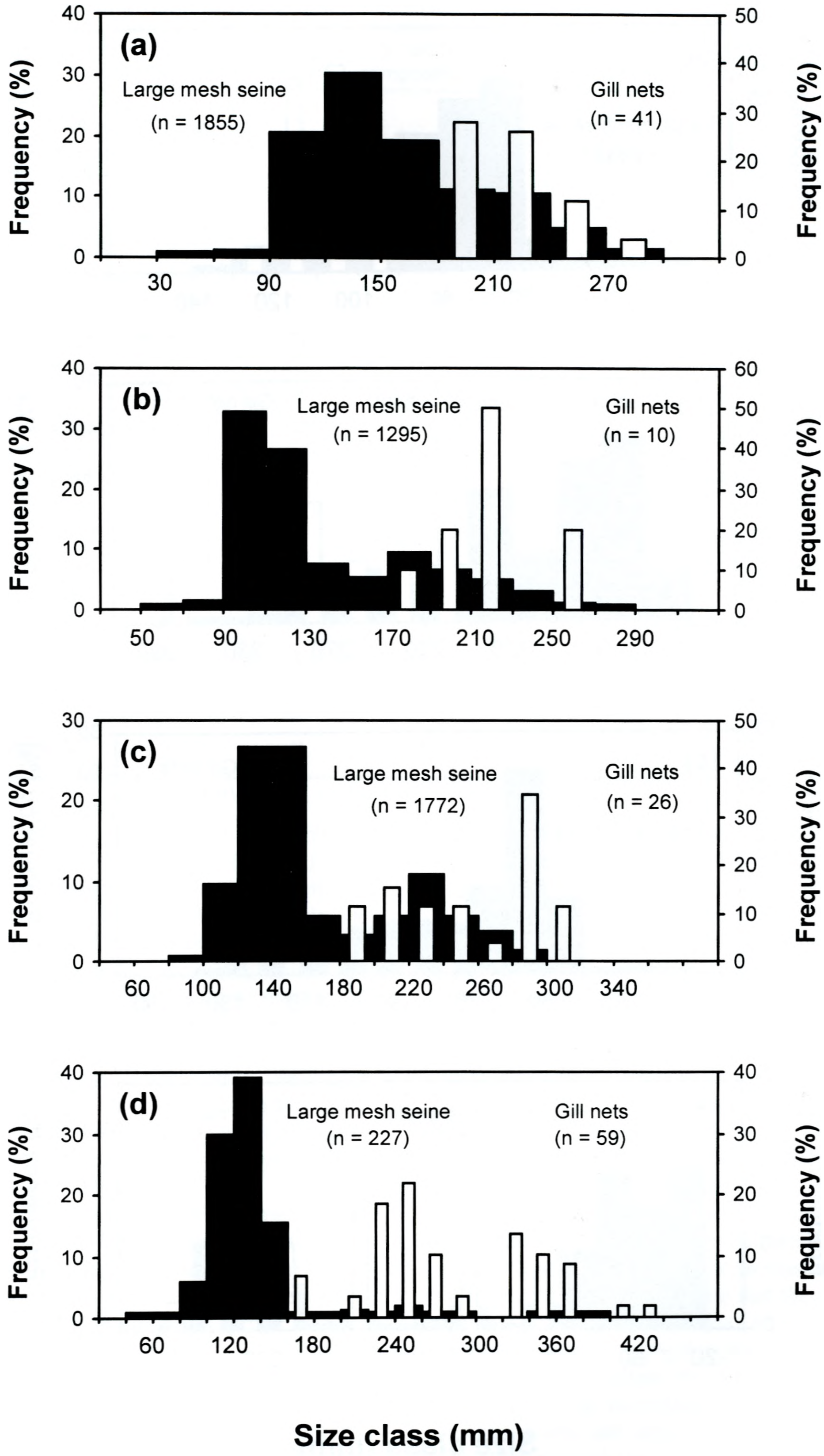

Figure 11. Length frequency distributions for **(a)** *Liza richardsonii*, **(b)** *Liza dumerilii*, **(c)** *Myxus capensis* and **(d)** *Mugil cephalus* sampled with the large-mesh seine (shaded bars) and gill nets (open bars) in the East Kleinemonde Estuary.

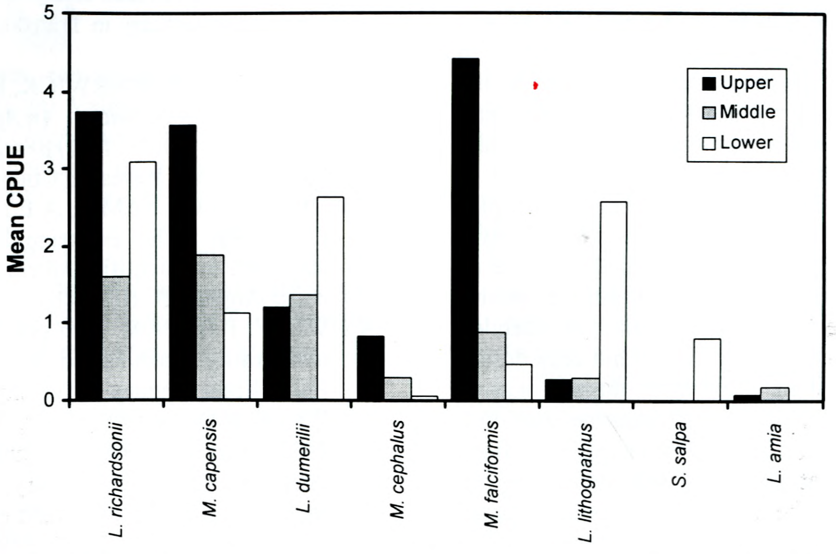

Figure 12. The mean CPUE for several marine-spawning species captured with the large-mesh seine in the three reaches of the East Kleinemonde Estuary.

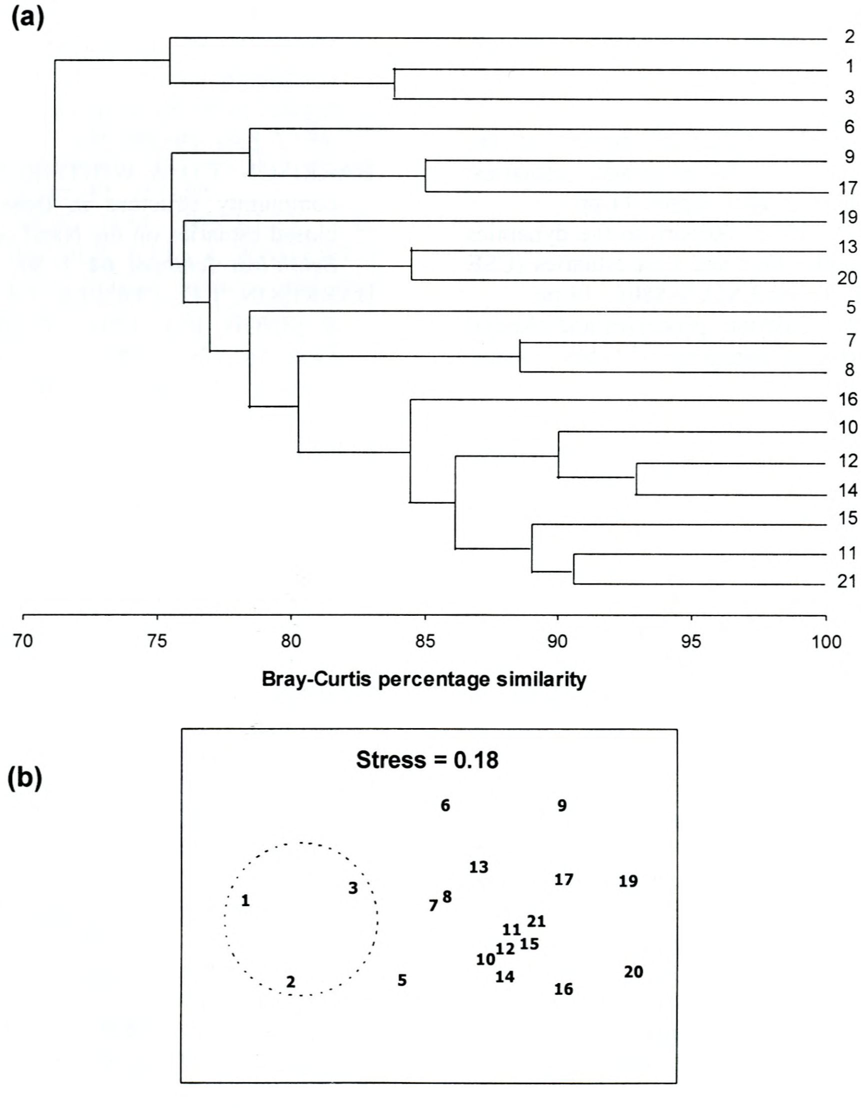

Figure 13. (a) Dendrogram showing classification and (b) ordination by means of multi-dimensional scaliing of the large-mesh seine fish assemblage. The sites with a sandy substratum in the lower reaches are encircled with a dashed line.

estuary. The lower species diversity in comparison with similar estuarine systems in KwaZulu-Natal and neighbouring permanently open estuaries is a consequence of biogeographical position and the estuary being closed to the sea for much of the year, respectively. Multivariate analyses (classification and ordination) of the catches revealed a high degree of similarity throughout the estuary, except for samples collected at sites with a sandy substratum in the lower reaches of the estuary. The numerical dominance of *Rhabdosargus holubi* and several Mugilidae species was attributed to the fact that they exhibit an extended breeding season and are able to recruit not only during open mouth conditions but also during marine overwash events. The dominant estuarine-spawning species were represented by all post larval life-history stages, suggesting that they bred successfully in the estuary; and finally, the East Kleinemonde Estuary also serves as a refuge to a viable population of *Syngnathus watermeyeri*.

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STYLE OF THE HOUSE

Hyphens: Certain substantive compounds are hyphenated: gill-raker, soft-ray, type-species, type-locality, type-series, type-specimen. Other words often used together are not hyphenated unless they are used in adjectival expressions before a noun: anal fin / anal-fin rays; lateral line / lateral-line scales; gill arch / gill-arch filaments, etc.

Word usage: Although the following word pairs are often used interchangeably, we believe that consistent use of the first word as a noun and the second as an adjective will improve the precision of our writing: mucus / mucous; maxilla / maxillary; opercle / opercular, operculum / opercular. The operculum (= gill cover) comprises (usually) four separate bones: opercle, subopercle, preopercle and interopercle. The words preoperculum, suboperculum and interoperculum are unnecessary substitutes and not to be used for preopercle, subopercle and interopercle. The plural of operculum is opercula.

Decimal comma versus decimal point: Contrary to most journals published in South Africa and some European countries, we will not use a comma in place of a decimal point. Most computers do not read a comma as a decimal point. In addition, it is common in ichthyological papers to give sequences of measurements that include decimal numbers, with each measurement separated by a comma. If the comma is used to separate items in a series, as well as being used to indicate a decimal number, it will cause considerable confusion.

Fin formulae: Fin formulae will be designated as follows: D XII,10-12 indicates on continuous fin with 12 spines and 10-12 soft (segmented) rays; DX/I,10-12 indicates a fin divided to the base in front of the last spine; and D X+I,12 indicates two separate dorsal fins, the first with 10 spines and the second with 1 spine and 12 soft rays. If it is necessary to differentiate branched and unbranched soft-rays, lower-case Roman numerals will be used for unbranched rays and Arabic numerals for branched rays, e.g. D iii,S. Principal caudal-fin rays are defined as those that touch the hypural bones. The number of principal caudal rays is usually the number of branched rays plus two. If the principal caudal rays are in two separate groups, the number of rays in the dorsal group is given first: thus, "principal caudal rays 8+7" means that there are 15 principal caudal rays, with 8 rays in the dorsal group and 7 in the ventral group.

Abbreviations: Abbreviations normally end with a full stop: et al., e.g., etc., n.b., (note: these commonly used abbreviations of Latin words are not italicized). Dr (Doctor) and Mr (Mister) and compass directions (north, west, northwest, etc.) are abbreviated using capital letters without full stops: N, W, NW. We recommend the following abbreviations for ichthyological terms: SL - standard length, TL - total length, FL - fork length, GR – gill-rakers, LL - lateral line.

P.C. Heemstra, Editor
L-A. Fargher, Layout and production
J.L.B. Smith Institute of Ichthyology, Private Bag 1015, Grahamstown 6140, South Africa.