A preliminary fish survey of the estuaries on the southeast coast of South Africa, Kayser's Beach – Kei Mouth: a comparative study

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ABSTRACT

A basic ichthyofaunal and physico-chemical survey of estuaries on the southeast coast of South Africa from Kayser's Beach to Kei Mouth was undertaken during September and October 1996. Twenty-eight (28) estuaries have been identified along this stretch of coastline, and these were grouped into three types: small (<10 ha) predominantly closed estuaries, moderate to large (> 10 ha) predominantly closed estuaries, and predominantly open estuaries. Multivariate analyses revealed significant differences between estuarine types both in terms of their physico-chemical characteristics and fish communities. These features were consistent with those reported in other parts of the south and southeast coast. Overall, predominantly closed estuaries had a lower species diversity than predominantly open estuaries and smaller systems had a lower species diversity than moderate to large systems. Although differences were observed between estuarine types, most systems provided important habitat for a number of estuarine-dependent marine species as well as resident species, which were often recorded in high numbers. Many of these species were also endemic, which further emphasises the importance of these estuaries in maintaining ichthyofaunal diversity in the region. This survey represents one of the few fish surveys undertaken along this little-studied section of coastline.

Keywords: ichthyofauna, estuarine survey, fish habitat, southeast coast

INTRODUCTION

Warm-temperate estuaries constitute important nursery areas for a number of estuarine-associated fish species (e.g. Potter and Hyndes, 1999; James et al., 2007a). Despite the importance of these systems as nursery areas, habitat degradation, hydrological manipulations, overexploitation and pollution increasingly threaten these systems (Whitfield and Cowley, 2010). In order to understand change in estuaries and maintain their ecological function, basic information is needed on fish assemblages. This information is often lacking, particularly for estuaries on the southeast coast of South Africa, around East London. Although studies have been carried out on the biology of the Nahoon (Steinke, 1986; Campbell et al., 2001; Bursey and Wooldridge, 2002; 2003; Sale, 2007; Geldenhuys, 2013), Nyara (Perisinotto et al., 2000, Walker et al., 2001), Goda (Vumazonke et al., 2008) and Haga Haga (Whitfield, 1992) estuaries, no information exists on fish biodiversity for the majority of systems along this coastline. There have only been two studies conducted which have focused of fish: one on recruitment of ichthyoplankton into the Haga Haga Estuary (Whitfield, 1992) and one on the feeding dynamics of four species in the Goda Estuary (Vumazonke et al., 2008). As part of a national assessment of South African estuaries, a fish survey was undertaken along the southeast coastline between Kayser's Beach and Kei Mouth; basic physico-chemical variables, fish community data and a comparative analysis are provided.

STUDY AREA

The Eastern Cape region falls within a transitional area of climatic zones and experiences relatively mild summers and winters (Kopke, 1988; Stone et al., 1998). Seasonality of rainfall is less pronounced than in other parts of the country (Stone et al., 1998) and, although rainfall may occur at any time of the year, it usually displays an autumn/spring bimodal pattern with peak rainfall in spring (Kopke, 1988). The coastline is influenced by the south-flowing Agulhas Current (Shannon, 1989; Heydorn, 1991). Being tropical in origin, the waters of this current are relatively warm; however, as it flows south it tends to cool with inshore water temperatures along the Eastern Cape coast varying between 14 and 20°C (Day, 1981). The section of coastline between Kayser's Beach and Kei Mouth extends some 68 km and is intersected by 31 river outlets (Fig. 1). The city of East London is the major metropolitan area situated on this coast.

MATERIALS AND METHODS

The estuaries between Kayser's Beach and Kei Mouth were sampled between September and October 1996. Each system was sampled once and took 1–3 days to survey, depending on the size of the system.

Physico-chemical

During each survey, selected physico-chemical parameters were measured at various sites within each system ranging from the mouth area (Site 1) upstream; the number of sites varied depending on the size of each system. Water depth and transparency were measured using a 20 cm diameter Secchi disc attached to a weighted shot line graduated at 10 cm intervals. Temperature (°C), salinity (psu), pH, dissolved oxygen ($mg \cdot L^{-1}$), and turbidity (NTU) were measured using a Horiba U-10 Water Quality Checker. Where water depth permitted (usually >0.5 m), both surface and bottom waters were measured. The mouth state of each system at the time of sampling was also noted.

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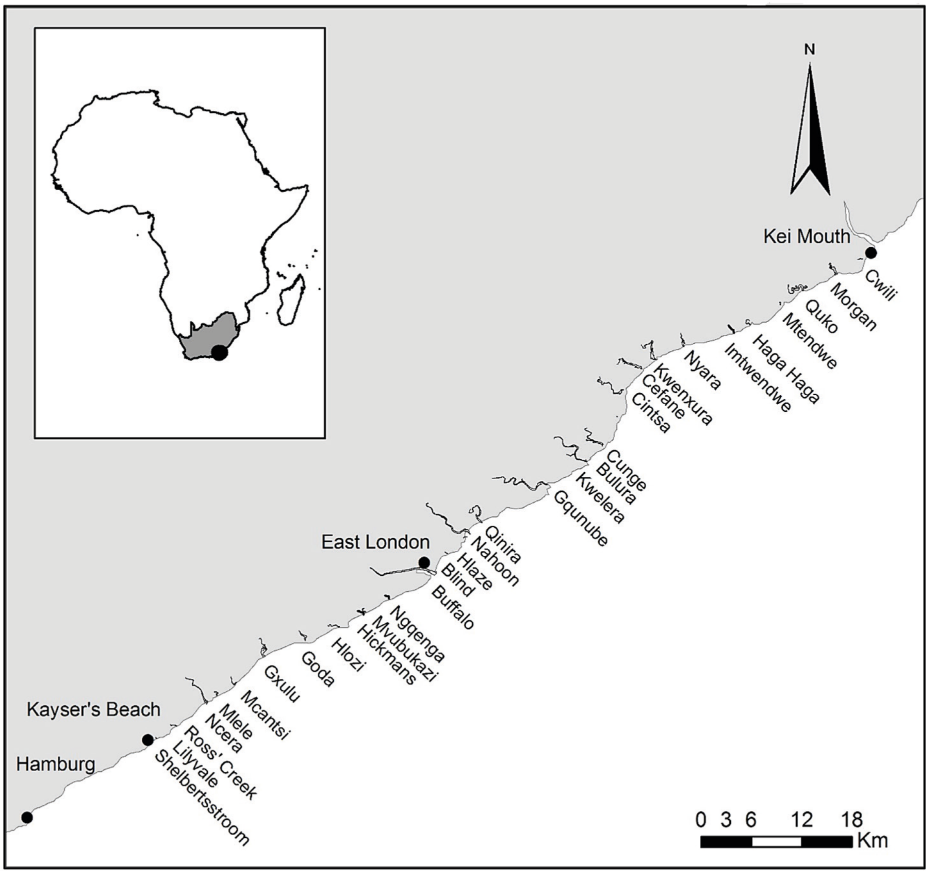

Figure 1

Coastal outlets between Kayser's Beach and Kei Mouth on the southeast coast of South Africa

Ichthyofauna

The ichthyofauna of each estuary was sampled using a 30 m long x 1.7 m deep x 15 mm bar mesh seine net fitted with a 5 mm bar mesh purse, and a fleet of multi-mesh gill nets. The gill nets were either 10 m or 20 m in length and 1.7 m in depth and consisted of three equal sections of 45 mm, 75 mm and 100 mm stretch meshes. Seine netting was carried out during daylight hours in shallow (< 1.5 m deep), unobstructed areas with gently sloping banks. Fish caught were identified and measured to the nearest millimetre standard length (SL) before being released. Where large catches of a species were made, a sub-sample was kept and returned to the laboratory where the fish were identified, measured and weighed to the nearest 1.0 g; specimens that could not be identified in the field were also kept and processed in the laboratory. All fishes were identified by reference to Smith and Heemstra (1991) and Skelton (1993); taxonomic identities of certain species were adjusted using information provided in Heemstra and Heemstra (2004). The total fish species composition, by number and mass, was calculated for each system. The relative biomass contribution of each species was calculated using actual recorded masses as well as masses derived from length–mass relationships provided in Harrison (2001).

Estuary classification

Estuaries were divided into two main groups on the basis of predominant mouth condition, according to the classification given in Harrison and Whitfield (2006). The two main groups were predominantly open estuaries and predominantly closed estuaries. Predominantly closed estuaries were further subdivided into two groups based on surface area: small closed estuaries with a surface area below 10 ha and moderate to large closed estuaries with a surface area above 10 ha.

Multivariate analyses

Data were analysed using the Plymouth Routines in Multivariate Ecological Research (PRIMER) package (version 6.0). A principal component analysis (PCA) was undertaken on the overall mean (surface and bottom) values of the physico-chemical variables recorded in each system. Each parameter was first examined for normality; only turbidity required log-transformation ($\ln[1 + x]$). The data were also examined for any inter-correlations (Pearson r); pH exhibited significant correlations ($p < 0.05$) with both dissolved oxygen and temperature and was omitted from the analysis. Although salinity and depth also showed a significant correlation, these parameters were retained. A PCA was performed based on the following normalised parameters: depth, temperature, salinity, dissolved oxygen, and turbidity. An analysis of similarities (ANOSIM) was also undertaken (using the normalised Euclidean distance similarity measure) to test for significant differences between estuarine types. Estuaries sampled during the latter part of the survey (Kwenxura – Cwili) were sampled following heavy rainfall in their catchments, which led to breaching of the mouths of closed estuaries, reduced salinities in some cases, and elevated turbidities. These estuaries were excluded from the ANOSIM test.

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Fish catch data were subject to non-metric multidimensional scaling (MDS) ordination. Specimens not identified to species level (e.g. Mugilidae) as well as exotic species (e.g. *Micropterus* spp.) were excluded from the analysis. Abundance and biomass data were first standardised and then square-root transformed before calculating a Bray-Curtis similarity matrix. Standardisation removed the effect of variable sampling while transformation scales down the importance of dominant species (Field et al., 1982; Clarke and Warwick, 2001). An ANOSIM test was applied to both the abundance and biomass data to examine differences in fish communities between estuary types. Obvious outliers identified in the MDS plots were omitted from the ANOSIM test. A similarity percentages analyses (SIMPER) was also undertaken to identify species that characterise estuary types as well as those that discriminate between estuary types.

RESULTS

A total of 31 systems were sampled between Kayser's Beach and Kei Mouth. Three systems, (Imtwendwe, Mvubukazi, and Ngqenga) comprised small coastal streams and were not considered further. Of the remaining systems, 5 were predominantly open estuaries and 23 were predominantly closed estuaries – 13 estuaries were small closed systems and 10 were moderate to large closed estuaries.

Physico-chemical

Small predominantly closed estuaries

Of the 13 small predominantly closed estuaries, 7 were open to the sea at the time of sampling. Systems such as the Haga-Haga, Mtendwe, and Cwili had all breached as a result of high river flows following heavy rainfall in their catchments. The outlets in the other systems appeared to have formed as a result of the lowering of the barrier at the mouth by wave action. All estuaries were relatively shallow, with average water depths generally not exceeding 1.0 m (Table 1). Water temperatures averaged between 17.8°C (Blind) and 24.6°C (Cunge). Mean salinities ranged from almost fresh (0.3) recorded in the Mtendwe to 27.7 recorded in the Hlozi. Salinities were fairly uniform throughout most of the systems with no clear horizontal or vertical gradients. Only the Hlozi and Hlaze estuaries exhibited a horizontal decrease in salinity of more than 1.0, while a marked vertical salinity gradient was only evident in the Cunge and Cwili estuaries. Average dissolved oxygen values ranged between 3.4 $mg{\cdot}L^{-1}$ (Mtendwe) and 11.8 $mg{\cdot}L^{-1}$ (Shelbertsstroom), with most systems exceeding 7.0 $mg{\cdot}L^{-1}$. Mean turbidity values ranged from 3.5 NTU (Hlozi and Hlaze) to 36.2 NTU (Cwili); relatively high (>33 NTU) average turbidities were recorded in the Haga-Haga, Mtendwe and Cwili systems, a result of heavy rainfall in their catchments. Average pH values (7.5–8.1) in all estuaries were characteristic of seawater (Table 1). Physico-chemical parameters by site are given in Table A1 (Appendix 1).

Moderate to large predominantly closed estuaries

Three (Kwenxura, Nyara, and Morgan) of the ten moderate to large predominantly closed estuaries were open to the sea at the time of this survey; high river flows following heavy rainfall in their catchments resulted in these estuaries breaching. Apart from those estuaries that had recently breached, mean water depths generally exceeded 1.0 m (Table 1). Water temperatures averaged between 19.0°C (Nyara) and 23.8°C (Cintsa). Water temperatures generally increased from the lower to the upper reaches of the estuaries; there was very little vertical temperature stratification. Mean salinities ranged from 8.6 (Morgan) to 33.7 (Ncera) with values generally exceeding 21.0. Salinities were fairly uniform in most systems with no clear horizontal or vertical gradients. A pronounced axial salinity gradient, however, was present in the Nyara and Morgan estuaries with salinities decreasing upstream from the mouth; this is a result of high freshwater inflow following rainfall in the catchment. Mean dissolved oxygen values ranged from 3.5 $mg{\cdot}L^{-1}$ (Nyara) to 8.4 $mg{\cdot}L^{-1}$ (Morgan) with most values exceeding 5.0 $mg{\cdot}L^{-1}$.

TABLE 1
Mean physico-chemical parameters measured in estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September-October 1996

Estuary	Mouth	Depth (m)	Temp. (°C)	Salinity	Diss. oxygen ($mg{\cdot}L^{-1}$)	Turbid. (NTU)	pH
Small closed estuaries							
Shelbertsstroom	Closed	1	19.8	6.8	11.8	6.6	8.1
Lilyvale	Closed	0.8	21	17.6	9.4	21.6	8
Ross' Creek	Closed	0.6	18.9	6.6	6.6	20	7.8
Mlele	Closed	1.1	19.8	15.3	7.5	16	7.8
Mcantsi	Open	1	23	14.1	7	7	7.9
Hlozi	Closed	1.3	20.2	27.7	7.3	3.5	7.7
Hickmans	Closed	1.6	22	18.8	6.4	5.2	7.5
Blind	Open	0.2	17.8	0.8	8.9	19	7.9
Hlaze	Open	0.5	21.5	23	9.3	3.5	8
Cunge	Closed	0.5	24.6	18.6	7.4	4	7.7
Haga-Haga	Open	0.5	21.3	25.8	8	33.7	7.7
Mtendwe	Open	0.8	21.8	0.3	3.4	33.5	7.8
Cwili	Open	0.8	20.6	16.6	7.7	36.2	7.8
Moderate to large closed estuaries							
Ncera	Closed	1.2	20.5	33.7	7.7	2.4	7.9
Gxulu	Closed	1.4	22.1	29.6	6.4	3.9	7.8
Goda	Closed	2	21	32.6	6.1	6.2	7.8
Qinira	Closed	1.7	21.5	28	6.4	4.8	7.7
Bulura	Closed	1.2	22.9	29.2	7.5	4	7.9
Cintsa	Closed	1.4	23.8	31.1	5.5	3.4	7.5
Cefane	Closed	0.9	23.5	28.9	5	7.1	7.6
Kwenxura	Open	0.8	19.7	29.1	7	34.6	7.9
Nyara	Open	0.6	19	21.8	3.5	73.3	7.9
Morgan	Open	0.6	22	8.6	8.4	103.7	7.6
Permanently open estuaries							
Buffalo	Open	3.4	18.2	31.2	7.8	12.8	7.9
Nahoon	Open	2.3	19.4	32.6	8.4	5.9	7.9
Gqunube	Open	1.7	20	32.8	6.8	17.4	7.9
Kwelera	Open	1.6	21	32.1	6.8	18.8	7.7
Quko	Open	1.5	20.7	10.4	8.3	265	7.7

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Most of the estuaries were fairly clear, with average turbidities not exceeding 10 NTU. Only the Kwenxura, Nyara and Morgan estuaries were turbid, averaging between 34.6 and 103.7 NTU; this is a result of turbid freshwater inflow following rains in their catchments. Mean pH values ranged from 7.5 to 7.9 (Table 1). Physico-chemical parameters by site are given in Table A2 (Appendix 1).

Predominantly open estuaries

Mean water depths recorded in the five predominantly open estuaries ranged from 3.4 m (Buffalo) to 1.5 m (Quko) (Table 1). Water temperatures averaged between 18.2°C (Buffalo) and 21.0°C (Kwelera). Generally, water temperatures increased upstream from the mouth in most systems; a marked vertical gradient was also recorded in the Buffalo with surface temperatures being warmer than those near the bottom. Mean salinities in most estuaries exceeded 31.0, with very little horizontal or vertical salinity variation. In contrast, surface salinities in the Quko decreased from 19.3 in the lower reaches to 0.0 in the upper reaches, while bottom salinities decreased from 31.5 to 0.0. This was as a result of freshwater inflows following rainfall in the catchment. Mean dissolved oxygen values ranged between 6.8 and 8.4 mg·L^{-1}. Most estuaries were clear, with mean turbidities of between 5.9 and 18.8 NTU. A high (265.0 NTU) mean turbidity was recorded in the Quko and this was due to turbid freshwater inflows following heavy rainfall in the catchment. The mean pH in all estuaries was similar to seawater (7.7–7.9) (Table 1). Physico-chemical parameters by site are given in Table A3 (Appendix 1).

Multivariate analysis

The PCA classification (Fig. 2) divided the estuaries based on depth, salinity and turbidity (Axis 1) and temperature and dissolved oxygen (Axis 2). The first two axes accounted for approximately 63% of the variation between the samples. Those turbid systems from the Kwenxura northward situated toward the right of the plot (Fig. 2). The remaining systems showed a gradation from small predominantly closed estuaries toward the right of the plot to moderate to large systems, situated toward the left of the plot; predominantly open estuaries were located toward the upper left of the plot (Fig. 2). The ANOSIM test revealed that estuarine types to the south of the Kwenxura were significantly different (global $R = 0.32$; $p < 0.05$).

Fish communities

Small predominantly closed estuaries

A total of 26 species were captured in small predominantly closed estuaries with between 5 (Hlaze) and 17 (Cwili) species captured per estuary. Numerically important species captured within this group of estuaries were *Gilchristella aestuaria* (mean = 30.4%), *Rhabdosargus holubi* (mean = 22.3%), *Myxus capensis* (mean = 14.2%), *Mugil cephalus* (mean = 9.7%), *Atherina breviceps* (mean = 7.1%), *Liza richardsonii* (mean = 4.1%), *Glossogobius callidus* (mean = 2.3%), juvenile mugilids (mean = 2.1%), *Monodactylus falciformis* (mean = 1.1%) and *Liza tricuspidens* (mean = 1.0%) (Table 2, Appendix 1: Table A4). Although present in most systems,

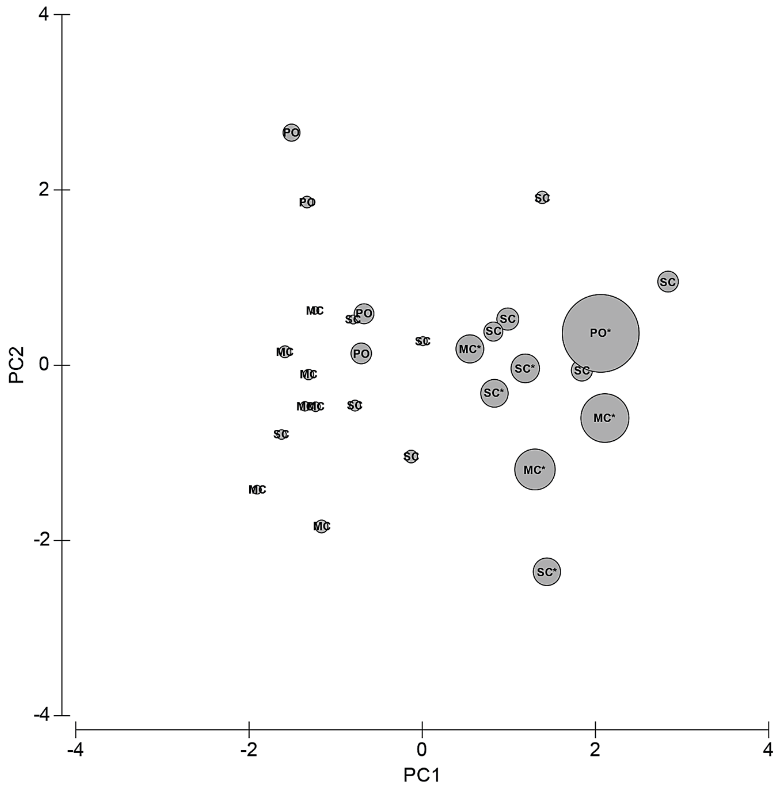

Figure 2

PCA ordination of physico-chemical variables measured in estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa (SC = small closed estuaries, MC = moderate to large closed estuaries, PO = predominantly open estuaries). Bubble plots represent the relative mean turbidity recorded in each system; systems marked with an asterisk (*) indicate estuaries from the Kwenxura northward, which were surveyed following heavy rainfall.

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TABLE 2
Mean numerical abundance (%) of fishes captured in small closed, moderate to large closed and permanently open estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996

Species	Small closed	Mod. to large closed	Perm. open
Acanthopagrus berda	0.03	0	0.26
Ambassis gymnocephalus	0	0.00	1.16
Ambassis productus	0	0	0.04
Amblyrhynchotes honckenii	0	2.07	0.02
Antennarias striatus	0	0	0.02
Argyrosomus japonicus	0.01	0.25	0.60
Atherina breviceps	7.05	13.12	3.56
Caffrogobius gilchristi	0.11	0.25	4.33
Caffrogobius nudiceps	0.01	0	0.78
Clinus superciliosus	0	0	0.04
Dasyatis kuhlii	0	0	0.02
Diplodus cervinus	0	0	0.04
Diplodus sargus	0.06	7.20	0.61
Elops machnata	0	0.01	0.48
Eugomphodus taurus	0	0	0.06
Gaelichthys feliceps	0	0.04	0.44
Gambusia affinis	0.01	0	0
Gilchristella aestuaria	30.38	30.87	48.96
Glossogobius callidus	2.25	3.29	2.89
Hemiramphus far	0	0	0.76
Heteromycteris capensis	0.02	0.04	0.33
Lichia amia	0	0.08	0.14
Lithognathus lithognathus	0.16	0.13	0.48
Liza alata	0.05	0	0
Liza dumerilii	0.60	4.30	6.09
Liza macrolepis	0.41	0.35	0.14
Liza richardsonii	4.13	4.00	2.07
Liza tricuspidens	0.97	1.80	1.68
Micropterus punctulatus	0	0.01	0
Micropterus salmoides	0.01	0.10	0
Monodactylus falciformis	1.06	0.38	0.30
Mugil cephalus	9.65	0.52	4.42
Mugilidae	2.06	0.54	2.30
Myliobatis aquila	0	0	0.25
Myxus capensis	14.18	5.32	0.66
Oligolepis keiensis	0	0.01	0
Oreochromis mossambicus	0.45	1.44	0
Parablennius lodosus	0	0.00	0
Platycephalus indicus	0	0	2.02
Pomadasys commersonnii	0.07	0.38	0.97
Pomadasys olivaceum	0	0	1.61
Pomatomus saltatrix	0	0.06	0.27
Psammogobius knysnaensis	0.08	1.87	1.48
Raja miraletus	0	0	0.02
Rhabdosargus globiceps	0	5.10	0
Rhabdosargus holubi	22.26	16.33	16.37
Rhabdosargus sarba	0	0.01	0
Sarpa salpa	0.02	0.03	0.13
Solea turbynei	3.88	0.08	0.42
Syngnathus acus	0	0	0.04
Torpedo fuscumaculata	0	0	0.02
Torpedo sinuspersici	0	0	0.02
Valamugil buchanani	0	0.01	0.10
Valamugil robustus	0	0	0.08
Number of species	**26**	**34**	**44**

TABLE 3
Mean biomass (%) of fishes captured in small closed, moderate to large closed and permanently open estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996

Species	Small closed	Mod. to large closed	Perm. open
Acanthopagrus berda	0.06	0	1.92
Ambassis gymnocephalus	0	0.00	0.07
Ambassis productus	0	0.01	0.01
Amblyrhynchotes honckenii	0	9.22	0.02
Antennarias striatus	0	0	0.00
Argyrosomus japonicus	1.65	0	10.79
Atherina breviceps	0.56	0.84	0.20
Caffrogobius gilchristi	0.02	0.06	0.21
Caffrogobius nudiceps	0.00	0	0.03
Clinus superciliosus	0	0	0.00
Dasyatis kuhlii	0	0	3.97
Diplodus cervinus	0	0	0.00
Diplodus sargus	0.00	0.06	0.01
Elops machnata	0	0.48	28.58
Eugomphodus taurus	0	0	14.25
Gaelichthys feliceps	0	1.21	8.69
Gambusia affinis	0.00	0	0
Gilchristella aestuaria	4.39	1.71	1.21
Glossogobius callidus	0.35	0.47	0.19
Hemiramphus far	0	0	0.04
Heteromycteris capensis	0.01	0.01	0.01
Lichia amia	0	3.97	7.14
Lithognathus lithognathus	2.57	0.55	1.62
Liza alata	3.32	0	0
Liza dumerilii	3.66	9.73	7.10
Liza macrolepis	0.79	0.84	0.21
Liza richardsonii	11.80	25.69	7.55
Liza tricuspidens	5.19	12.21	8.23
Micropterus punctulatus	0	0.00	0
Micropterus salmoides	0.38	0.06	0
Monodactylus falciformis	1.63	0.37	0.69
Mugil cephalus	24.07	3.01	3.35
Mugilidae	0.20	0.01	0.01
Myliobatis aquila	0	0	1.36
Myxus capensis	10.75	6.16	0.21
Oligolepis keiensis	0	0.00	0
Oreochromis mossambicus	8.82	8.55	0
Parablennius lodosus	0	0.00	0
Platycephalus indicus	0	0	0.73
Pomadasys commersonnii	0.62	5.54	1.87
Pomadasys olivaceum	0	0	0.12
Pomatomus saltatrix	0	1.11	3.99
Psammogobius knysnaensis	0.05	0.09	0.02
Raja miraletus	0	0	0.02
Rhabdosargus globiceps	0	0.53	0
Rhabdosargus holubi	19.12	8.05	6.46
Rhabdosargus sarba	0	0.75	0
Sarpa salpa	0.00	0.00	0.66
Solea turbynei	0.01	0.03	0.03
Syngnathus acus	0	0	0.00
Torpedo fuscumaculata	0	0	0.45
Torpedo sinuspersici	0	0	0.06
Valamugil buchanani	0	0.44	2.94
Valamugil robustus	0	0	0.01
Number of species	**26**	**34**	**44**

species such as *A. breviceps*, *G. aestuaria*, and *G. callidus* were not captured in either the Blind or Hlaze estuaries.

In terms of biomass, important species included *M. cephalus* (mean = 24.1%), *R. holubi* (mean = 19.1%), *L. richardsonii* (mean = 11.8%), *M. capensis* (mean = 10.8%), *Oreochromis mossambicus* (mean = 8.8%), *L. tricuspidens* (mean = 5.2%), *G. aestuaria* (mean = 4.4%), *Liza dumerili* (mean = 3.7%), *Lithognathus lithognathus* (mean = 2.6%), and *M. falciformis* (mean = 1.6%) (Table 3, Appendix 1: Table A5). Species such as *Argyrosomus japonicus* (mean = 1.7%) was only recorded in the Haga-Haga, while *Liza alata* (mean = 3.3%) was only captured in the Shelbertsstroom and Blind estuaries.

Moderate to large predominantly closed estuaries

A total of 34 species were captured in moderate to large predominantly closed estuaries with between 14 (Nyara) and 21 (Gxulu and Goda) species captured per estuary. The most abundant species within this group of estuaries overall were *G. aestuaria* (mean = 30.9%), *R. holubi* (mean = 16.3%), *A. breviceps* (mean = 13.1%), *Diplodus capensis* (mean = 7.2%), *M. capensis* (mean = 5.3%), *L. dumerili* (mean = 4.3%), *L. richardsonii* (mean = 4.0%), *G. callidus* (mean = 3.3%), *L. tricuspidens* (mean = 1.8%), and *O. mossambicus* (mean = 1.4%) (Table 2, Appendix 1: Table A6).

Dominant species overall in terms of biomass included *L. richardsonii* (mean = 25.7%), *L. tricuspidens* (mean = 12.2%), *L. dumerili* (mean = 9.7%), *A. japonicus* (mean = 9.2%), *R. holubi* (mean = 8.6%), *O. mossambicus* (mean = 6.8%), *M. capensis* (mean = 6.2%), *Pomadasys commersonnii* (mean = 5.5%), *Lichia amia* (mean = 4.0%), *M. cephalus* (mean = 3.0%), *G. aestuaria* (mean = 1.7%), *Gaelichthys feliceps* (mean = 1.2%) and *Pomatomus saltatrix* (mean = 1.1%) (Table 3, Appendix 1: Table A7).

Predominantly open estuaries

A total of 44 species were captured in the predominantly open estuaries with between 21 (Quko) and 35 (Kwelera) species captured per estuary. In terms of numbers, catches were dominated by *G. aestuaria* (mean = 49.0%), *R. holubi* (mean = 16.4%), *L. dumerili* (mean = 6.1%), *Caffrogobius gilchristi* (mean = 4.3%), *M. cephalus* (mean = 3.5%), *A. breviceps* (mean = 2.9%), *G. callidus* (mean = 2.3%), juvenile mugilids (mean = 2.3%), *L. richardsonii* (mean = 2.1%), *L. tricuspidens* (mean = 1.7%), *Psammogobius knysnaensis* (mean = 1.5%), and *Pomadasys olivaceus* (mean = 1.3%). (Table 2, Appendix 1: Table A8). The fish species mass in predominantly open estuaries was dominated by *E. machnata* (mean = 28.6%), *A. japonicus* (mean = 10.8%), *L. tricuspidens* (mean = 8.2%), *L. richardsonii* (mean = 7.6%), *L. dumerili* (mean = 7.1%), *G. feliceps* (mean = 7.0%), *R. holubi* (mean = 6.5%), *Lichia amia* (mean = 5.7%), *M. cephalus* (mean = 2.7%), *P. saltatrix* (mean = 2.4%), *Valamugil buchanani* (mean = 2.4%), *L. lithognathus* (mean = 1.6%), *P. commersonnii* (mean = 1.5%), and *G. aestuaria* (mean = 1.2%) (Table 3, Appendix 1: Table A9). *Carcharias taurus* (mean = 2.9%) was only recorded in the Nahoon estuary.

Multivariate analyses

The MDS based on abundance data produced a pattern where two small closed systems (Blind and Hlaze) were situated as distinct outliers to the right of the plot; the remaining systems formed a gradation from small closed estuaries situated in the centre of the plot to medium to large closed estuaries and predominantly open systems toward the left of the ordination (Fig. 3a). In terms of biomass, one small closed system (Mtendwe) was situated as an outlier at the bottom right of the ordination; the remaining systems formed a gradation from small closed estuaries situated toward the top centre of the plot to moderate to large closed estuaries and predominantly open estuaries located toward the bottom left of the ordination (Fig. 3b).

The ANOSIM test (excluding the Blind, Hlaze and Mtendwe estuaries) based on abundance data revealed significant differences between estuary types (global $R = 0.34$; $p<0.01$). Predominantly open systems were the most distinct group with R-values of between 0.44 and 0.62; small and moderate to large predominantly closed estuaries were also different from one another, although differences were not as distinct ($R = 0.16$). Biomass data yielded a similar result showing all estuary types as distinct (global $R = 0.57$; $p<0.01$). Predominantly open systems were also the most distinct group with R-values of between 0.65 and 0.86; small and moderate to large predominantly closed estuaries were also distinct, although differences were not as great ($R = 0.41$).

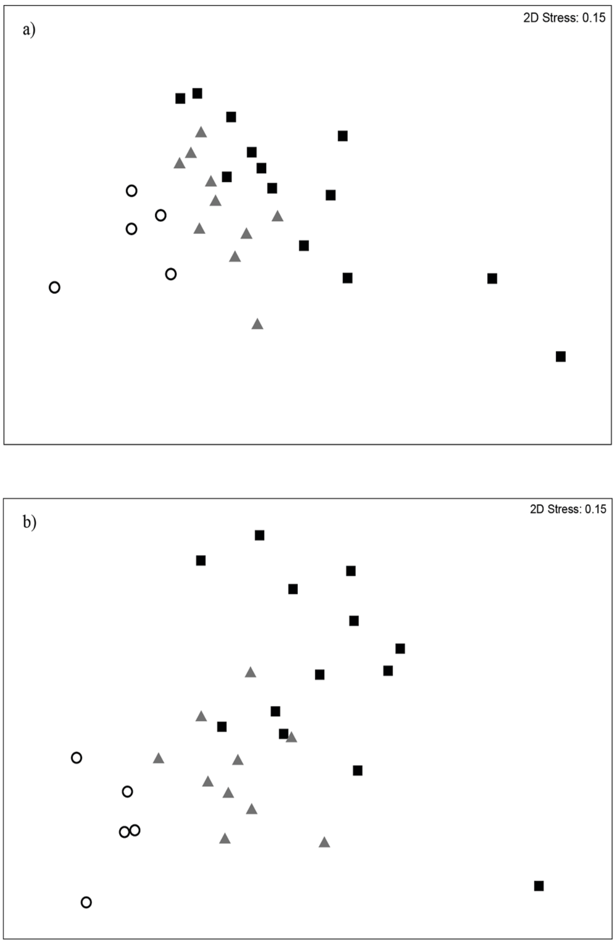

Figure 3

MDS ordination of fish communities in estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa based on (a) abundance and (b) biomass data (■ = small closed estuaries, ▲ = moderate to large closed estuaries, O = predominantly open estuaries)

SIMPER analysis based on abundance determined that small and moderate to large predominantly closed estuaries had an average dissimilarity of 36.9%. Species such as *M. falciformis*, *M. cephalus*, *M. capensis*, and *R. holubi*, which accounted for 10.2% of the dissimilarity, were more abundant in small closed systems, while species such as *A. breviceps*, *D. capensis*, *G. aestuaria*, *G. callidus*, *L. dumerili*, *L. tricuspidens* and *O. mossambicus* (which collectively accounted for 17.2% of the dissimilarity) were more abundant in moderate to large closed estuaries. Based on biomass these estuary types had an average dissimilarity of 48.7%. *Gilchristella aestuaria*, *L. lithognathus*, *M. falciformis*, *M. cephalus*, *M. capensis*, *O. mossambicus*, and *R. holubi* accounted for 19.2% of the dissimilarity and comprised a greater proportion of biomass catch in small closed estuaries; *A. japonicus*, *L. amia*, *L. dumerili*, *L. richardsonii*, *L. tricuspidens*, and *P. commersonnii* (which accounted for 20.4% of the dissimilarity) comprised a greater proportion of the biomass catch in moderate to large closed estuaries.

Predominantly closed small estuaries and predominantly open estuaries had an average dissimilarity of 46.5% based on abundance data. Species such as *A. breviceps*, *L. richardsonii*, *M. flaciformis*, *M. cephalus*, *M. capensis*, *O. mossambicus*, and *R. holubi* comprised 16.4% of the dissimilarity and comprised a greater proportion of the abundance catch in small closed estuaries. *Argyrosomus japonicus*, *C. gilchristi*, *E. machnata*, *G. aestuaria*, *G. callidus*, *L. dumerili*, *L. tricuspidens*, *P. commersonnii*, and *P. knysnaensis* contributed 18.2% to the dissimilarity and were more abundant in predominantly open estuaries. In terms of biomass, small closed estuaries and predominantly open estuaries had an average dissimilarity of 62.8%; *G. aestuaria*, *L. lithognathus*, *L. richardsonii*, *M. falciformis*, *M. cephalus*, *M. capensis*, *O. mossambicus*, and *R. holubi* contributed 22.6% to the dissimilarity and comprised a greater proportion of the biomass catch in small closed estuaries. *Argyrosomus japonicus*, *E. machnata*, *G. feliceps*, *L. amia*, *L. dumerili*, *L. tricuspidens*, *P. commersonnii*, *P. saltatrix*, and *V. buchanani* contributed 30.3% to the average dissimilarity and comprised a greater proportion of the catch in predominantly open estuaries.

Average dissimilarities, based on abundance, between moderate to large predominantly closed estuaries and predominantly open estuaries measured 39.9%. *Atherina breviceps*, *G. callidus*, *L. richardsonii*, *L. tricuspidens*, *M. capensis*, *O. mossambicus*, and *R. holubi* contributed 15.3% to the dissimilarity and comprised a greater proportion of the catch in moderate to large closed estuaries. Species such as *C. gilchristi*, *E. machnata*, *G. aestuaria*, *L. dumerili*, *M. cephalus*, *P. commersonnii*, *P. olivaceus*, and *P. knysnaensis* contributed 13.8% to the dissimilarity and were numerically more important in predominantly open estuaries. In terms of biomass, moderate to large closed estuaries and predominantly open estuaries had an average dissimilarity of 49.8%. *Atherina breviceps, G. aestuaria, L. dumerili*, *L. richardsonii*, *L. tricuspidens*, *M. capensis*, *O. mossambicus*, *P. commersonnii*, and *R. holubi* contributed 19.2% to the dissimilarity and comprised a greater proportion of the biomass catch in moderate to large closed estuaries. Species such as *A. japonicus*, *E. machnata*, *G. feliceps*, *L. amia*, *L. lithognathus, P. saltatrix*, and *V. buchanani* contributed 20.5% to the dissimilarity and comprised a greater proportion of the biomass catch in predominantly open estuaries.

DISCUSSION

Although this survey represents a single temporal snapshot of estuaries along the East London and surrounding coastline, it does provide a preliminary understanding of estuarine fish communities in a poorly studied section of our coastline. Some 31 coastal outlets were included in this survey (Fig. 1); three systems, however, (Imtwendwe, Mvubukazi, and Ngqenga) were very small coastal streams and probably serve little or no function for estuarine-associated fishes. The majority of estuaries along this coastline are predominantly closed systems that are isolated from the sea for varying periods by the formation of a sand barrier at the mouth; 13 estuaries are small (<10 ha) closed estuaries while 10 are moderate to large (> 10 ha) predominantly closed estuaries. The remaining 5 estuaries are predominantly open estuaries, where river flow and/or tidal currents are sufficient to maintain a connection with the sea.

Closed warm-temperate estuaries usually breach during periods of high fluvial discharge, particularly after rainfall in the catchment (Perissinotto et al., 2000; Cowley and Whitfield, 2001). All closed estuaries from the Kwenxura northward were open at the time of this survey and this was a result of heavy rainfall and runoff in their catchments. A similar situation was noted during surveys of south coast estuaries as well as in the Nyara estuary where mouth breaching had occurred following rains in the catchment (Perissinotto et al., 2000; James and Harrison, 2009). Breaching can also occur as a result of high seas overtopping and lowering the sand bar to a point that allows an outlet to form. The outlets at the Blind and Hlaze estuaries during this survey were probably created by this process. Unlike closed estuaries, river flow and/or tidal currents act to maintain a connection with the sea in predominantly open systems (Cooper, 2001).

Rainfall and runoff in estuaries from the Kwenxura northward was also responsible for high turbidities recorded in these estuaries (>33 NTU) and this accounted for their relatively distinct location in the PCA plot (Fig. 2). The remaining systems showed a gradation from small closed estuaries toward to moderate to large systems and to predominantly open estuaries. The ANOSIM test also revealed that these estuarine types were distinct. Small closed estuaries were typically shallow (mostly < 1.0 m) systems with mesohaline (5–18) to polyhaline (18–30) salinities; mean water temperatures ranged between 19 and 25°C and the waters were relatively clear (mostly < 20 NTU). Because of their small catchments, mouth opening events due to rainfall and runoff are likely to be relatively short-lived, limiting tidal intrusion of seawater. Seawater, however, may also enter these systems via barrier overwash which would raise salinities. Moderate to large closed estuaries were generally deeper (mostly > 1.0 m) systems with clear (mostly < 10 NTU), polyhaline conditions prevailing; mean water temperatures were between 20 and 24°C. The higher salinities may be a result of longer periods of mouth opening when they breach and thus more seawater exchange; these systems are also often formed behind long barriers, which probably enables more seawater to enter these systems via waves overtopping the barrier during high seas. Predominantly open estuaries were fairly deep systems (>1.5 m) and were characterised by euhaline (>30) salinities and low turbidities (< 20 NTU); temperatures were also generally lower (mean 18–21°C) than closed estuaries. These conditions are a reflection of the predominantly open mouth condition, which enables clear, cooler, seawater to penetrate these systems. Similar conditions were also reported

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from comparable surveys on the south and southeast coast (Harrison, 1999; Vorwerk et al., 2001; James and Harrison, 2008; 2009; 2010a; 2010b; 2011). Small closed estuaries were typically shallow (< 1.0 m) systems with oligohaline (0.5–5.0) to polyhaline salinities while moderate to large estuaries were deeper systems (mostly > 1.0 m) with mainly mesohaline to polyhaline salinities; predominantly open estuaries were relatively deep (mostly >1.5 m) and were mostly polyhaline to euhaline. This suggests that similar hydrological and morphological processes operate within each broad estuarine type and this is reflected in their physico-chemical conditions.

High rainfall and runoff in estuaries from the Kwenxura northward resulted in these estuaries grouping separately in the PCA plot based on physico-chemical variables, and a fairly mixed clustering of all estuaries. Multivariate analyses based on fish communities showed that the various estuarine types contained somewhat distinct fish communities, irrespective of the anomalous physico-chemical conditions encountered in the northern estuaries. A total of 26 species were captured in small predominantly closed estuaries with between 5 and 17 species per system. Overall, dominant species numerically and/or by biomass included *A. breviceps*, *G. aestuaria*, *G. callidus*, *L. lithognathus*, *L. dumerili*, *L. richardsonii*, *L. tricuspidens*, *M. falciformis*, *M. cephalus*, *M. capensis*, *O. mossambicus*, and *R. holubi*. A total of 34 species were captured in moderate to large closed estuaries; important species within this group of estuaries overall were *A. japonicus*, *A. breviceps*, *D. capensis*, *G. feliceps*, *G. aestuaria*, *G. callidus*, *L. amia*, *L. dumerili*, *L. richardsonii*, *L. tricuspidens*, *M. cephalus*, *M. capensis*, *O. mossambicus*, *P. commersonnii*, *P. saltatrix*, and *R. holubi*. The highest numbers of species (44 in total) were captured in predominantly open estuaries. Catches were dominated by *A. japonicus*, *A. breviceps*, *C. gilchristi*, *E. machnata*, *G. feliceps*, *G. aestuaria*, *G. callidus*, *L. amia*, *L. lithognathus*, *L. dumerili*, *L. richardsonii*, *L. tricuspidens*, *M. cephalus*, *P. commersonnii, P. olivaceus*, *P. saltatrix*, *P. knysnaensis*, *R. holubi*, and *V. buchanani*.

Similar species were found to dominate the fish catches of south and southeast Cape coast estuaries; species such as *A. breviceps*, *G. aestuaria*, *G. callidus, L. lithognathus, L. dumerili*, *L. richardsonii*, *M. falciformis, M. cephalus*, *M. capensis*, *O. mossambicus*, *P. knysnaensis*, and *R. holubi* were among the dominant taxa in small predominantly closed estuaries (Harrison, 1999; Vorwerk et al., 2001; James and Harrison, 2008; 2009; 2010a; 2010b; 2011). Dominant species in moderate to large predominantly closed estuaries included *A. japonicus*, *A. breviceps*, *C. gilchristi, E. machnata, G. aestuaria*, *G. callidus, H. capensis, L. amia, L. lithognathus, L. dumerili*, *L. richardsonii*, *L. tricuspidens, M. falciformis, M. cephalus, M. capensis, O. mossambicus, P. commersonnii, P. knysnaensis*, and *R. holubi*. Predominantly open estuaries were dominated by *A. japonicus*, *A. breviceps*, *C. gilchristi*, *C. natalensis, C. nudiceps, Clinus superciliosus, D. capensis, E. machnata, G. feliceps*, *G. aestuaria*, *G. callidus*, *L. amia*, *L. lithognathus*, *L. dumerili*, *L. richardsonii*, *L. tricuspidens*, *M. falciformis, M. cephalus*, *M. capensis*, *P. commersonnii, P. knysnaensis*, *Rhabdosargus globiceps*, *R. holubi*, *Sarpa salpa*, *Solea turbynei*, and *V. buchanani* (Harrison, 1999; Vorwerk et al., 2001; James and Harrison, 2008; 2009; 2010a; 2010b; 2011).

Predominantly open estuaries had a higher species richness (mean = 28 species) than both small closed estuaries (mean = 12) and moderate to large closed estuaries (mean = 19 species). A similar pattern has been described by other workers where open estuaries were found to contain more species than closed systems (e.g. Bennett, 1989; Whitfield and Kok, 1992, Vorwerk et al., 2003; Harrison and Whitfield, 2006). The higher species richness in predominantly open estuaries is often attributed to an increase in the number of marine-spawning species (particularly marine stragglers) in permanently open estuaries (Bennett, 1989). Marine stragglers, which are mainly stenohaline species and not dependent on estuaries, are virtually absent from predominantly closed estuaries (Harrison, 2003). In this study, marine stragglers were only found in predominantly open estuaries and included *Amblyrhynchotes honckenii*, *Antennarias striatus, Dasyatis kuhlii, Diplodus cervinus*, *C. taurus, Myliobatis aquila, P. olivaceus,* and *Raja miraletus* (Table 2 & 3). These species, however, did not contribute appreciably to the dissimilarity between predominantly open systems and predominantly closed estuaries.

Marine migrant species, which depend on estuaries during part of their life cycle and estuarine resident species were the main groups that accounted for the differences between these estuary types. Vorwerk et al. (2003) also found significant differences between the fish assemblages of permanently open estuaries and intermittently open (closed) estuaries on the Eastern Cape coast between Port Alfred and Hamburg and that the taxa that accounted for these differences were primarily estuarine resident and marine migrant species. During this study, marine migrant species such as *A. japonicus*, *E. machnata*, *G. feliceps*, *L. amia*, *L. lithognathus*, *L. dumerili*, *L. tricuspidens*, *P. saltatrix*, and *V. buchanani* contributed toward the dissimilarity between predominantly open estuaries and predominantly closed systems and generally comprised a greater proportion of the abundance and/or biomass catch in predominantly open systems. This is probably a result of year-round access of these species to predominantly open estuaries and limited recruitment opportunities in closed systems (Vorwerk et al., 2003). Estuarine species such as *C. gilchristi* and *P. knysnaensis* also contributed to the dissimilarity between predominantly open systems and closed estuaries and were found to be more abundant in predominantly open estuaries. These species are reported to prefer the sandy lower reaches of open estuaries and are also thought to have marine breeding populations (Whitfield, 1998).

Some marine migrant species, such as *L. richardsonii*, *M. falciformis*, *M. capensis*, and *R. holubi*, which also accounted for the dissimilarity between predominantly open estuaries and predominantly closed systems, comprised a greater proportion of the abundance/biomass catch in closed estuaries. Vorwerk et al. (2003) also found that species such as *M. falciformis* and *R. holubi* occurred in higher proportions in closed estuaries than in open systems. Many estuarine-dependent marine species have been shown to be able to recruit into closed estuaries during bar overwash events (Cowley et al., 2001; Kemp and Froneman, 2004; Vivier and Cyrus, 2001; James et al., 2007b). This recruitment strategy probably accounts for the relative importance of these species in predominantly closed estuaries. Estuarine resident species such as *A. breviceps* and *G. callidus* also contributed toward the dissimilarity between these estuarine types and comprised a greater proportion of the abundance/biomass captured in predominantly closed estuaries relative to predominantly open systems. A similar situation was reported by Vorwerk et al. (2003) where resident species such as *A. breviceps* and *G. callidus* represented a greater proportion of the catch in temporarily open/closed estuaries compared with permanently open systems; they also accounted for a large degree of the dissimilarity between these systems. Short-lived estuarine resident species are well adapted to the estuarine environment and can dominate the fish communities of estuaries numerically (Potter et al., 1990). The freshwater species *O. mossambicus* also contributed toward the dissimilarity between predominantly open estuaries and closed systems and comprised a greater proportion of the abundance/biomass catch in closed estuaries. *Oreochromis mossambicus* is sometimes abundant in coastal lakes and predominantly closed estuaries but is usually absent from permanently open estuaries (Whitfield and Blaber, 1979).

Dissimilarities between predominantly open estuaries and closed systems were also due to some species comprising a higher proportion of the abundance in open systems but being more important in closed systems in terms of biomass. These included the estuarine species *G. aestuaria* and the marine migrant species *M. cephalus* and *P. commersonnii*. Vorwerk et al. (2003) also found that *G. aestuaria* dominated the catches in permanently open estuaries but contributed less to the catch in temporarily open/closed estuaries. While recruitment of marine migrant species into closed estuaries may take place via barrier overwash, migration back to the marine environment can only occur when a connection is formed with the sea following mouth breaching. The high biomass contribution of marine migrant species in closed estuaries may be a result of these species being trapped in these systems for extended periods and the energy obtained from feeding put into growth (Vorwerk et al., 2001).

Multivariate analyses also showed differences in the fish communities of small predominantly closed estuaries and moderate to large closed estuaries. Species richness was higher in the moderate to large closed estuaries than in small closed estuaries. Marine migrant species such as *M. falciformis*, *M. cephalus*, *M. capensis*, and *R. holubi* contributed toward the dissimilarity between these systems and comprised a greater proportion of the abundance and biomass catch in small estuaries. All these species are able to tolerate prolonged periods of isolation from the sea and reduced salinities (Whitfield, 1998).

Several marine migrant species that accounted for some of the dissimilarity between predominantly open estuaries and closed systems also accounted for the dissimilarity between moderate to large closed estuaries and small closed estuaries. Species such as *A. japonicus*, *G. feliceps*, *L. amia*, *L. dumerili*, *L. richardsonii, L. tricuspidens*, *P. commersonnii*, and *P. saltatrix* comprised a greater percentage of the abundance and/or biomass in moderate to large closed estuaries relative to small closed systems. The estuarine resident species *A. breviceps* and *G. callidus* were also more important in moderate to large closed estuaries. Dissimilarities between moderate to large closed estuaries and small closed estuaries was also due to species such as *G. aestuaria* and *O. mossambicus* comprising a higher proportion of the abundance in moderate to large closed systems but being more important in small closed estuaries in terms of biomass. The absence of these species also accounted for the small closed Blind and Hlaze estuaries being identified as outliers in the MDS ordination. Both the Blind and Hlaze estuaries are heavily modified systems that fall within the East London city area. The absence of any freshwater or estuarine resident species in these estuaries is probably an indication of the poor water quality in these systems; resident taxa are most susceptible to degradation of estuaries as they are entirely dependent on estuaries.

Vorwerk et al. (2003) demonstrated significant differences between the fish assemblages in smaller (< 5 ha) and larger (>15 ha) temporarily open/closed estuaries between Port Alfred and Hamburg. Small closed estuaries had a much lower species richness and density than larger closed estuaries. In addition, marine migrant species that accounted for the separation between these estuaries were similar to those responsible for the dissimilarity between permanently open estuaries and temporarily open/closed systems. These differences were attributed to a much weaker recruitment response in the smaller estuaries as a result of much lower water volumes entering the sea during mouth opening events (Vorwerk et al., 2003). Large closed estuaries have higher nutrient input, positive salinity gradients and, more importantly, are open for longer periods. Prolonged closed phases in small estuaries (which also have lower habitat diversity) result in a low recruitment potential for juvenile marine fish and effectively prevent the emigration of adults back to sea. In addition, during a prolonged closed phase, salinity may either decrease due to freshwater input or increase due to evaporation, allowing only strongly euryhaline species to tolerate these conditions (Vorwerk et al., 2003).

This survey represents one of the few fish surveys undertaken along this section of coastline. The estuarine types identified were found to be distinctive both in terms of their physicochemical characteristics and fish communities and these were consistent with those reported in other parts of the south and southeast Cape coast (e.g. Harrison, 1999; Vorwerk et al., 2001; James and Harrison, 2008; 2009; 2010a; 2010b; 2011). These differences are primarily a result of predominant mouth condition and estuary size (Vorwerk et al., 2001; Harrison and Whitfield, 2006). However, both permanently open estuaries and predominantly closed systems along this section of the coastline were found to support a number of estuarine-dependent marine species as well as resident species. It should also be noted that many of the dominant species recorded during this survey are endemic species, which further emphasises the importance of these estuaries in maintaining the ichthyofaunal diversity in the region.

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APPENDIX 1

TABLE A1
Physico-chemical parameters measured in small closed estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996

System	Site	Depth (m)	Temperature (°C)		Salinity		Dissolved oxygen (mg·L^{-1})		Turbidity (NTU)		pH	
			S	B	S	B	S	B	S	B	S	B
Shelbertsstroom	1	0.2	20.1		7.0		11.7		4.0		8.1	
	2	2.1	19.9	19.3	6.8	6.8	12.3	11.4	5.0	9.0	8.1	8.0
	3	0.6	19.7	19.8	6.8	6.8	11.8	11.7	6.0	9.0	8.1	8.1
Lilyvale	1	0.2	22.1		17.9		9.4		15.0		8.0	
	2	1.3	20.8	20.0	17.6	17.6	10.0	9.1	22.0	26.0	8.0	8.0
	3	0.9	21.9	20.1	17.5	17.3	9.9	8.7	11.0	34.0	8.0	7.9
Ross' Creek	1	1.0	18.5	18.5	6.7	6.8	7.9	7.9	20.0	20.0	8.0	8.0
	2	0.2	19.3		6.3		6.3		20.0		7.8	
	3	0.5	19.2	19.2	6.5	6.6	5.6	5.4	20.0	20.0	7.6	7.6
Mlele	1	0.9	19.7	19.9	15.3	15.4	7.8	7.8	16.0	16.0	7.9	7.9
	2	1.2	19.7	19.9	15.3	15.4	7.4	7.4	16.0	16.0	7.8	7.8
	3	1.1	19.7	19.7	15.1	15.3	7.4	7.3	16.0	16.0	7.8	7.8
Mcantsi	1	1.1	22.9	22.9	14.5	14.5	8.2	8.4	8.0	5.0	8.1	8.1
	2	1.0	23.1	22.7	12.9	14.0	6.3	5.2	3.0	4.0	7.8	7.7
	3	1.0	23.8	22.8	13.8	14.9	6.4	7.4	9.0	13.0	7.8	7.7
Hlozi	1	0.9	19.9	20.0	27.6	27.6	7.5	7.2	2.0	2.0	7.7	7.7
	2	1.7	20.3	20.4	27.7	27.7	7.3	7.1	5.0	5.0	7.7	7.7
Hickmans	1	1.5	21.9	22.0	17.7	18.2	7.8	6.8	4.0	5.0	7.7	7.6
	2	2.0	21.5	22.0	16.6	21.0	8.8	4.0	4.0	11.0	7.8	7.3
	3	1.3	22.5	22.0	18.0	21.5	6.8	4.4	3.0	4.0	7.5	7.2
Blind	1	0.2	17.8		0.8		8.9		19.0		7.9	
Hlaze	1	0.3	21.7		23.6		9.1		3.0		8.0	
	2	0.6	21.3		22.4		9.6		4.0		8.1	
Cunge	1	1.4	25.4	25.8	17.6	20.0	7.5	6.5	3.0	3.0	7.8	7.6
	2	2.8	23.3	24.0	15.7	21.0	9.1	6.4	3.0	7.0	8.0	7.3
Haga-Haga	1	0.2	22.3		25.6		8.1		14.0		7.7	
	2	0.5	21.3	20.4	25.2	26.6	8.0	8.0	32.0	55.0	7.7	7.7
Mtendwe	1	0.8	21.9	21.6	0.3	0.3	3.0	3.7	35.0	32.0	7.9	7.8
Cwili	1	0.3	21.6		11.3		7.6		31.0		7.7	
	2	0.9	21.8	19.0	10.5	24.6	7.1	7.9	30.0	30.0	7.7	7.9
	3	1.2	21.6	18.8	11.0	25.5	7.5	8.3	40.0	50.0	7.7	7.9

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TABLE A2 Physico-chemical parameters measured in moderate to large closed estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996													
System	**Site**	**Depth (m)**	**Temperature (°C)**		**Salinity**		**Dissolved oxygen (mg·L⁻¹)**		**Turbidity (NTU)**		**pH**		
			S	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	
Ncera	1	1.2	19.8	19.8	34.3	34.3	10.0	12.2	0.0	0.0	8.4	8.6	
	2	0.9	20.5	20.3	34.2	34.3	8.1	8.0	4.0	4.0	8.1	8.1	
	3	1.2	20.6	20.6	34.0	34.0	6.4	6.4	6.0	6.0	7.8	7.8	
	4	1.0	20.9	21.0	33.3	33.4	5.7	5.6	2.0	2.0	7.6	7.6	
	5	1.8	20.5	20.6	32.3	32.5	7.4	7.3	0.0	0.0	7.7	7.8	
Gxulu	1	1.1	20.9	21.0	30.0	30.0	7.3	6.6	3.0	2.0	7.8	7.8	
	2	1.5	23.1	21.8	29.0	30.1	7.6	6.1	5.0	6.0	7.8	7.8	
	3	1.5	20.9	21.0	30.3	30.3	6.5	6.4	7.0	7.0	7.8	7.8	
	4	1.1	21.9	21.6	29.5	30.2	6.7	7.1	3.0	3.0	7.8	7.8	
	5	1.6	23.4	22.5	29.0	30.0	6.4	5.3	0.0	4.0	7.8	7.7	
	6	1.4	23.1	23.5	28.0	29.3	5.6	5.5	1.0	6.0	7.7	7.7	
Goda	1	2.4	20.4	20.6	32.5	32.6	6.5	6.4	3.0	3.0	7.8	7.8	
	2	1.9	20.9	21.0	32.5	32.6	6.4	5.5	10.0	15.0	7.8	7.8	
	3	1.6	21.5	21.6	32.4	32.7	6.3	5.3	3.0	3.0	7.9	7.9	
Qinira	1	1.7	21.3	21.5	28.5	28.6	6.9	6.0	3.0	3.0	7.8	7.8	
	2	1.6	21.1	21.3	28.2	28.3	6.9	6.9	7.0	7.0	7.8	7.8	
	3	1.5	21.1	21.5	27.2	28.2	7.1	5.8	5.0	8.0	7.7	7.6	
	4	2.0	22.0	22.2	27.1	28.0	6.5	5.1	3.0	2.0	7.6	7.5	
Bulura	1	0.9	21.7	21.7	30.7	30.8	7.9	7.8	3.0	3.0	7.9	7.9	
	2	1.4	22.3	22.5	28.7	30.1	7.7	7.3	3.0	8.0	8.0	7.9	
	3	0.9	22.9	23.1	29.2	29.4	7.9	8.0	2.0	3.0	8.1	8.1	
	4	1.5	23.7	25.3	25.5	29.5	7.4	6.4	2.0	8.0	7.8	7.8	
Cintsa	1	1.6	22.3	22.3	31.8	31.8	6.5	6.5	3.0	3.0	7.6	7.6	
	2	1.6	23.3	23.5	31.7	31.8	5.5	5.3	5.0	4.0	7.5	7.5	
	3	1.2	24.3	24.2	31.1	31.1	5.0	5.0	3.0	3.0	7.5	7.5	
	4	1.1	25.1	25.2	29.7	30.0	5.2	5.2	3.0	3.0	7.4	7.4	
Cefane	1	0.9	22.3	22.3	29.2	29.2	5.2	5.1	3.0	4.0	7.8	7.8	
	2	0.9	23.4	23.4	29.2	29.2	5.3	5.2	11.0	11.0	7.8	7.8	
	3	1.4	24.6	24.8	29.0	29.1	4.9	4.8	8.0	15.0	7.6	7.6	
	4	0.5	23.5	23.7	28.0	28.3	4.8	4.7	2.0	3.0	7.3	7.3	
Kwenxura	1	0.2	24.1		16.7		6.2		33.0		7.8		
	2	0.7	19.0	18.9	32.0	32.1	6.7	6.2	69.0	58.0	7.9	7.9	
	3	1.5	18.2	18.3	32.3	32.4	7.8	8.0	5.0	8.0	8.0	8.0	
Nyara	1	0.8	18.5	18.0	27.0	31.3	3.5	3.7	50.0	31.0	7.9	8.0	
	2	0.3	20.6		7.0		3.3		139.0		7.9		
Morgan	1	0.5	22.2	19.9	24.7	26.2	7.8	8.1	88.0	103.0	7.9	7.9	
	2	0.5	22.3	21.8	0.3	0.4	8.8	8.8	110.0	110.0	7.5	7.4	
	3	0.7	22.9	22.8	0.1	0.1	8.4	8.4	103.0	108.0	7.3	7.3	

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TABLE A3
Physico-chemical parameters measured in predominantly open estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996

System	Site	Depth (m)	Temperature (°C)		Salinity		Dissolved oxygen ($mg \cdot L^{-1}$)		Turbidity (NTU)		pH	
			S	B	S	B	S	B	S	B	S	B
Buffalo	1	5.3	18.1	17.2	31.9	32.2	6.8	7.2	10.0	15.0	7.9	7.9
	2	3.6	18.6	15.9	31.5	32.8	6.8	7.0	7.0	19.0	7.9	7.9
	3	1.4	19.8	19.4	28.6	30.0	9.8	9.4	13.0	13.0	7.9	7.9
Nahoon	1	2.0	19.8	19.8	33.3	33.4	7.0	6.9	1.0	1.0	8.1	8.1
	2	3.7	18.4	18.4	32.8	33.0	7.4	7.3	9.0	9.0	8.0	8.0
	3	3.8	18.8	18.7	32.8	32.9	10.0	9.2	7.0	7.0	8.0	8.0
	4	1.2	19.3	19.2	32.2	32.6	9.9	9.3	5.0	5.0	7.8	7.9
	5	0.9	21.2	20.5	31.3	31.8	8.9	8.7	7.0	8.0	7.8	7.7
Gqunube	1	1.2	18.6	18.5	32.8	32.9	7.7	7.6	33.0	25.0	8.0	8.0
	2	2.2	19.7	19.6	32.7	32.8	6.9	6.9	11.0	19.0	7.9	8.0
	3	2.2	20.6	20.5	32.6	32.9	6.7	6.4	12.0	25.0	7.9	7.9
	4	1.1	21.1	21.2	32.9	32.9	6.1	6.1	7.0	7.0	7.8	7.8
Kwelera	1	1.4	18.7	18.2	32.6	32.7	7.3	7.3	13.0	13.0	7.8	7.9
	2	1.4	20.4	20.0	32.3	32.5	7.1	7.2	20.0	30.0	7.8	7.8
	3	0.5	22.6	22.6	32.1	32.1	7.2	7.2	26.0	29.0	7.8	7.8
	4	2.3	23.0	20.6	31.7	32.3	6.6	6.4	8.0	25.0	7.6	7.6
	5	2.2	22.5	21.5	31.0	31.9	6.5	5.6	12.0	12.0	7.6	7.5
Quko	1	1.3	19.6	17.8	19.3	31.5	8.1	8.4	130.0	27.0	7.9	8.0
	2	1.2	21.8	20.0	0.1	17.4	8.0	9.5	240.0	103.0	7.5	7.9
	3	1.4	21.9	20.9	0.1	14.4	7.8	8.3	515.0	496.0	7.7	7.8
	4	2.1	21.6	21.6	0.0	0.0	8.0	8.5	301.0	308.0	7.6	7.6

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TABLE A4
Numerical abundance of fishes captured in small closed estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996
(*n* = number; % = percentage contribution)

Species	Shelbertsstroom		Lilyvale		Ross' Creek		Mlele		Mcantsi		Hlozi		Hickmans		Blind		Hlaze		Cunge		Haga-Haga		Mtendwe		Cwili	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Acanthopagrus vagus									1	0.09															2	0.35
Argyrosomus japonicus																					1	0.13				
Atherina breviceps	95	28.61	166	19.06	78	7.50	48	5.83	119	10.22	155	11.22							43	5.55	41	5.41	6	3.17	1	0.17
Caffrogobius gilchristi																					2	0.26	1	0.53	4	0.69
Caffrogobius nudiceps																									1	0.17
Diplodus capensis													6	0.83												
Gambusia affinis			1	0.11																						
Gilchristella aestuaria	55	16.57	384	44.09	299	28.75	383	46.54	301	25.86	978	70.77	507	69.74					125	16.13	68	8.97	125	66.14	83	14.36
Glossogobius callidus			75	8.61	54	5.19	16	1.94	7	0.60			8	1.10					1	0.13	59	7.78	2	1.06	18	3.11
Heteromycteris capensis											2	0.14							1	0.13						
Lithognathus lithognathus			2	0.23	2	0.19	2	0.24	8	0.69	3	0.22			9	0.38	2	0.21	1	0.13					1	0.17
Liza alata	2	0.60													1	0.04										
Liza dumerili	1	0.30					14	1.70	16	1.37			1	0.14	16	0.67			1	0.13	28	3.69			3	0.52
Liza macrolepis	1	0.30																					1	0.53	26	4.50
Liza richardsonii	91	27.41	4	0.46	36	3.46	22	2.67	145	12.46	32	2.32	6	0.83	51	2.13	61	6.55	1	0.13	9	1.19			2	0.35
Liza tricuspidens	9	2.71	6	0.69	4	0.38	35	4.25	60	5.15	2	0.14			8	0.33					6	0.79			4	0.69
Micropterus salmoides																									1	0.17
Monodactylus falciformis	6	1.81	14	1.61	5	0.48	11	1.34	7	0.60			6	0.83					1	0.13	16	2.11			30	5.19
Mugil cephalus	12	3.61	15	1.72	9	0.87	5	0.61	19	1.63	1	0.07	15	2.06	1772	73.93	183	19.66	20	2.58	128	16.89			15	2.60
Mugilidae	2	0.60					1	0.12	17	1.46	3	0.22			8	0.33	186	19.98			35	4.62			1	0.17
Myxus capensis	33	9.94	14	1.61	12	1.15	5	0.61	106	9.11	1	0.07	16	2.20	527	21.99	326	35.02	272	35.10	116	15.30	5	2.65	313	54.15
Oreochromis mossambicus	5	1.51	17	1.95	4	0.38	1	0.12	16	1.37			7	0.96					1	0.13	1	0.13				
Pomadasys commersonnii							2	0.24	1	0.09					1	0.04					3	0.40			1	0.17
Psammogobius knysnaensis			1	0.11							1	0.07							7	0.90						
Rhabdosargus holubi	20	6.02	172	19.75	537	51.63	274	33.29	334	28.69	204	14.76	155	21.32	4	0.17	173	18.58	301	38.84	245	32.32	49	25.93	72	12.46
Sarpa salpa									7	0.60																
Solea turbynei							4	0.49																		
Total mass	**332**		**871**		**1 040**		**823**		**1 164**		**1 382**		**727**		**2 397**		**931**		**775**		**758**		**189**		**578**	
Total taxa	**13**		**13**		**11**		**15**		**16**		**11**		**10**		**10**		**6**		**13**		**15**		**7**		**18**	

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TABLE A5

Biomass composition of fishes captured in small closed estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996 (g = mass; % = percentage contribution)

Species	Shelbertsstroom		Lilyvale		Ross' Creek		Mlele		Mcantsi		Hlozi		Hickmans		Blind		Hlaze		Cunge		Haga-Haga		Mtendwe		Cwili	
	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
Acanthopagrus vagus									108.0	0.69															3.6	0.04
Argyrosomus japonicus																					1 558.0	21.41				
Atherina breviceps	110.2	1.02	256.9	1.48	80.8	0.35	37.4	0.24	161.8	1.03	123.9	1.26							8.5	0.32	39.0	0.54	5.5	0.98	0.6	0.01
Caffrogobius gilchristi																					3.1	0.04	1.1	0.19	2.8	0.03
Caffrogobius nudiceps																									0.2	0.00
Diplodus capensis													1.0	0.01												
Gambusia affinis			0.4	0.00																						
Gilchristella aestuaria	69.3	0.64	153.0	0.88	211.9	0.92	224.2	1.47	397.8	2.53	1 158.8	11.80	774.3	5.26					133.2	5.03	53.9	0.74	151.7	27.19	55.1	0.60
Glossogobius callidus			89.6	0.52	48.8	0.21	15.3	0.10	8.0	0.05			16.8	0.11					0.1	0.00	141.8	1.95	7.3	1.30	33.5	0.36
Heteromycteris capensis											12.3	0.12							0.3	0.01						
Lithognathus lithognathus			1600.0	9.22	82.9	0.36	1 401.6	9.17	170.1	1.08	816.8	8.32			3.3	0.05	0.9	0.12	126.9	4.79					26.2	0.28
Liza alata	4609.0	42.61													37.2	0.54										
Liza dumerili	125.0	1.16					691.3	4.52	1 052.3	6.68			87.0	0.59	304.2	4.43			93.0	3.51	1 922.9	26.43			22.8	0.25
Liza macrolepis	110.0	1.02																					25.6	4.59	424.8	4.60
Liza richardsonii	881.2	8.15	234.4	1.35	5 240.9	22.67	3 468.7	22.69	2 749.7	17.47	2 980.4	30.35	729.6	4.96	395.5	5.76	190.9	27.82	3.3	0.13	778.6	10.70			129.1	1.40
Liza tricuspidens	355.6	3.29	14.5	0.08	1 292.4	5.59	2 635.5	17.24	1 965.8	12.49	1 667.0	16.97			343.8	5.00					331.3	4.55			211.4	2.29
Micropterus salmoides																									455.0	4.93
Monodactylus falciformis	198.0	1.83	485.5	2.80	108.0	0.47	394.7	2.58	120.9	0.77			585.6	3.98					23.0	0.87	254.8	3.50			411.9	4.46
Mugil cephalus	3 169.7	29.31	5 669.0	32.68	9 172.0	39.68	1 990.6	13.02	89.8	0.57	346.0	3.52	4 868.7	33.09	5 408.5	78.71	303.7	44.26	764.8	28.89	191.4	2.63			603.8	6.54
Mugilidae	0.4	0.00					0.1	0.00	10.9	0.07	0.5	0.00			2.8	0.04	16.3	2.37			5.4	0.07			0.1	0.00
Myxus capensis	123.8	1.14	160.4	0.92	486.7	2.11	250.9	1.64	2 010.6	12.77	125.0	1.27	3 145.0	21.37	322.5	4.69	95.8	13.97	165.4	6.25	294.1	4.04	1.1	0.20	6 404.0	69.32
Oreochromis mossambicus	763.0	7.05	5 848.0	33.71	634.3	2.74	521.0	3.41	3 959.0	25.15			2 541.0	17.27					634.0	23.95	98.5	1.35				
Pomadasys commersonnii							483.0	3.16	393.0	2.50					8.2	0.12					159.6	2.19			3.3	0.04
Psammogobius knysnaensis			3.3	0.02							2.7	0.03							16.1	0.61						
Rhabdosargus holubi	300.6	2.78	2 833.3	16.33	5 758.4	24.91	3 157.1	20.66	2 540.0	16.14	2 588.2	26.35	1 965.8	13.36	45.4	0.66	78.6	11.46	678.6	25.63	1 443.3	19.84	365.7	65.54	450.3	4.87
Sarpa salpa									3.7	0.02																
Solea turbynei							13.6	0.09																		
Total mass	**10 815.9**		**17348.2**		**23 117.1**		**15 284.9**		**15 741.5**		**9 821.4**		**14714.9**		**6 871.3**		**686.1**		**2 647.1**		**7 275.5**		**558.0**		**9238.4**	
Total taxa	**13**		**13**		**11**		**15**		**16**		**11**		**10**		**10**		**6**		**13**		**15**		**7**		**18**	

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TABLE A6
Numerical abundance of fishes captured in moderate to large closed estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996 (*n* = number; % = percentage contribution)

Species	Ncera		Gxulu		Goda		Qinira		Bulura		Cintsa		Cefani		Kwenxura		Nyara		Morgan	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Ambassis dussumieri															1	0.05				
Amblyrhynchotes honckenii							1	0.04												
Argyrosomus japonicus			4	0.19	8	0.11					1	0.09	9	0.51	34	1.54			1	0.09
Atherina breviceps	141	9.16	144	6.96	212	3.00	588	20.65	392	21.83	555	47.52	630	36.02	91	4.13	13	2.95		
Caffrogobius gilchristi									8	0.45	1	0.09	6	0.34			3	0.68	11	0.95
Diplodus capensis	171	11.10	6	0.29	31	0.44	2	0.07	2	0.11			3	0.17	2	0.09				
Elops machnata															2	0.09				
Gaelichthys feliceps	2	0.13	2	0.10	7	0.10									2	0.09				
Gilchristella aestuaria	551	35.78	1 377	66.59	4 695	66.42	1 701	59.75	177	9.86	108	9.25	459	26.24	1 260	57.22	130	29.48	76	6.58
Glossogobius callidus	21	1.36	5	0.24	74	1.05	38	1.33	23	1.28	55	4.71	220	12.58	40	1.82	16	3.63	72	6.23
Heteromycteris capensis			5	0.24	2	0.03			2	0.11										
Lichia amia	1	0.06			1	0.01	3	0.11	1	0.06	2	0.17	1	0.06	2	0.09				
Lithognathus lithognathus	11	0.71	6	0.29	3	0.04	7	0.25	1	0.06	1	0.09							1	0.09
Liza dumerilii	69	4.48	94	4.55	177	2.50	15	0.53	122	6.79	14	1.20	53	3.03	59	2.68	42	9.52	95	8.23
Liza macrolepis							1	0.04	1	0.06			4	0.23	3	0.14	5	1.13	14	1.21
Liza richardsonii	16	1.04	10	0.48	450	6.37	48	1.69	18	1.00	85	7.28	15	0.86	59	2.68	71	16.10	37	3.20
Liza tricuspidens	21	1.36	76	3.68	129	1.82	2	0.07	16	0.89	8	0.68	3	0.17	57	2.59	30	6.80		
Micropterus punctulatus																			1	0.09
Monodactylus falciformis	3	0.19	1	0.05	4	0.06	4	0.14	7	0.39	11	0.94	7	0.40	12	0.54	3	0.68	3	0.26
Mugil cephalus	3	0.19	4	0.19	3	0.04			5	0.28	1	0.09	2	0.11	10	0.45	4	0.91	34	2.94
Mugilidae	8	0.52			5	0.07	9	0.32	14	0.78	1	0.09			11	0.50			26	2.25
Myxus capensis	188	12.21	124	6.00	837	11.84	22	0.77	70	3.90	51	4.37	17	0.97	76	3.45	30	6.80	42	3.64
Oligolepis keiensis																			1	0.09
Oreochromis mossambicus			3	0.15			13	0.46	2	0.11	3	0.26	6	0.34	3	0.14	46	10.43	29	2.51
Parablennius lodosus			1	0.05																
Pomadasys commersonnii			1	0.05	4	0.06			8	0.45	1	0.09	3	0.17	9	0.41			30	2.60
Pomadasys olivaceus													1	0.06						
Pomatomus saltatrix					2	0.03	1	0.04			4	0.34								
Psammogobius knysnaensis	6	0.39	39	1.89	1	0.01	5	0.18	11	0.61	4	0.34	15	0.86			1	0.23	9	0.78
Rhabdosargus globiceps					1	0.01														
Rhabdosargus holubi	322	20.91	164	7.93	418	5.91	387	13.59	915	50.95	261	22.35	286	16.35	466	21.16	47	10.66	672	58.18
Rhabdosargus sarba	1	0.06									1	0.09								

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TABLE A6 (continued)

Species	Ncera		Gxulu		Goda		Qinira		Bulura		Cintsa		Cefani		Kwenxura		Nyara		Morgan	
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Sarpa salpa	4	0.26	1	0.05																
Solea turbynei	1	0.06	1	0.05	5	0.07			1	0.06			9	0.51					1	0.09
Valamugil buchanani															3	0.14				
Total numbers	**1 540**		**2 068**		**7 069**		**2 847**		**1 796**		**1 168**		**1 749**		**2202**		**441**		**1 155**	
Total taxa	**19**		**21**		**22**		**18**		**21**		**20**		**20**		**21**		**14**		**19**	

TABLE A7
Biomass composition of fishes captured in moderate to large closed estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996 (g = mass; % = percentage contribution)

Species	Ncera		Gxulu		Goda		Qinira		Bulura		Cintsa		Cefani		Kwenxura		Nyara		Morgan	
	g	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**
Ambassis dussumieri															1.3	0.00				
Amblyrhynchotes honckenii							31.54	0.10												
Argyrosomus japonicus			2 377.0	11.13	5 263.0	13.03					1 040.0	6.30	6 573.0	27.96	20 654.0	31.65			318.0	2.17
Atherina breviceps	103.3	0.93	75.0	0.35	241.3	0.60	82.5	0.26	293.0	1.69	220.7	1.34	713.9	3.04	92.1	0.14	13.5	0.09		
Caffrogobius gilchristi									6.4	0.04	1.5	0.01	18.7	0.08			16.4	0.11	44.9	0.31
Diplodus capensis	27.3	0.25	4.7	0.02	80.0	0.20	0.8	0.00	0.9	0.01			19.6	0.08	1.4	0.00				
Elops machnata															3 149.0	4.83				
Gaelichthys feliceps	844.0	7.61	741.0	3.47	369.0	0.91									100.0	0.15				
Gilchristella aestuaria	283.2	2.55	382.4	1.79	1 319.9	3.27	754.3	2.37	160.8	0.93	40.1	0.24	569.3	2.42	990.3	1.52	197.8	1.37	94.5	0.64
Glossogobius callidus	48.6	0.44	3.8	0.02	114.5	0.28	62.8	0.20	30.5	0.18	58.8	0.36	338.8	1.44	98.3	0.15	78.1	0.54	168.4	1.15
Heteromycteris capensis			15.2	0.07	1.4	0.00			0.4	0.00										
Lichia amia	1 048.0	9.45			1 242.0	3.08	3 288.0	10.32	447.0	2.58	1 301.0	7.88	930.0	3.96	1 587.0	2.43				
Lithognathus lithognathus	253.5	2.29	1.2	0.01	366.5	0.91	137.3	0.43	140.6	0.81	1.5	0.01							153.0	1.04

TABLE A7 (continued)

Species	Ncera		Gxulu		Goda		Qinira		Bulura		Cintsa		Cefani		Kwenxura		Nyara		Morgan	
	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
Liza dumerilii	1 366.4	12.32	2 455.1	11.49	6 559.2	16.24	889.9	2.79	3 426.4	19.78	338.1	2.05	1 690.2	7.19	2 625.7	4.02	1 146.2	7.93	1 972.1	13.45
Liza macrolepis							630.0	1.98	68.0	0.39			173.6	0.74	47.3	0.07	162.5	1.12	597.6	4.08
Liza richardsonii	1 358.6	12.25	3 840.6	17.98	8 329.7	20.63	17 510.3	54.95	3 719.9	21.47	8 021.0	48.56	1 851.2	7.88	14 033.3	21.51	6 101.6	42.21	1 388.8	9.47
Liza tricuspidens	1 988.0	17.93	6 397.7	29.95	2 553.9	6.32	10.8	0.03	5 200.0	30.01	1257.9	7.61	615.7	2.62	8 394.6	12.86	2 126.6	14.71		
Micropterus punctulatus																			1.1	0.01
Monodactylus falciformis	46.2	0.42	0.3	0.00	117.2	0.29	95.0	0.30	134.8	0.78	58.9	0.36	146.3	0.62	79.4	0.12	86.0	0.59	68.9	0.47
Mugil cephalus	162.5	1.47	1 576.6	7.38	197.0	0.49			234.8	1.35	1.9	0.01	199.3	0.85	3 434.6	5.26	182.3	1.26	1 768.5	12.06
Mugilidae	0.6	0.01			4.4	0.01	1.2	0.00	2.7	0.02	0.3	0.00			2.2	0.00			4.6	0.03
Myxus capensis	2 021.2	18.23	1 148.4	5.38	3 205.4	7.94	478.5	1.50	665.8	3.84	732.5	4.43	313.6	1.33	518.6	0.79	565.6	3.91	2 087.9	14.24
Oligolepis keiensis																			1.1	0.01
Oreochromis mossambicus			1 646.0	7.71			6478.0	20.33	205.4	1.19	19.9	0.12	1 120.3	4.77	381.8	0.59	3187.3	22.05	1 705.5	11.63
Parablennius lodosus			1.0	0.00																
Pomadasys commersonnii			63.0	0.29	2 734.0	6.77			1 659.0	9.57	659.0	3.99	2 540.0	10.81	4 219.0	6.47			2 559.0	17.46
Pomadasys olivaceus													12.6	0.05						
Pomatomus saltatrix					2 019.0	5.00	135.0	0.42			923.0	5.59								
Psammogobius knysnaensis	18.9	0.17	65.6	0.31	1.4	0.00	6.3	0.02	11.8	0.07	5.5	0.03	27.1	0.12			2.0	0.01	11.2	0.08
Rhabdosargus globiceps					12.6	0.03														
Rhabdosargus holubi	869.2	7.84	543.6	2.54	5 637.9	13.96	1 272.7	3.99	913.1	5.27	1 565.9	9.48	5 626.8	23.94	1 981.7	3.04	588.0	4.07	1 711.4	11.67
Rhabdosargus sarba	645.0	5.82									272.0	1.65								
Sarpa salpa	0.7	0.01	0.8	0.00																
Solea turbynei	3.3	0.03	23.0	0.11	15.4	0.04			5.5	0.03			24.9	0.11					3.3	0.02
Valamugil buchanani															2 862.0	4.39				
Total numbers	**1 540**		**2 068**		**7 069**		**2 847**		**1 796**		**1 168**		**1 749**		**2202**		**441**		**1 155**	
Total taxa	**19**		**21**		**22**		**18**		**21**		**20**		**20**		**21**		**14**		**19**	

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TABLE A8
Numerical abundance of fishes captured in predominantly open estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996 (*n* = number; % = percentage contribution)

Species	Buffalo		Nahoon		Gqunube		Kwelera		Quko	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Acanthopagrus vagus	2	0.51					1	0.02		
Ambassis ambassis					2	0.04				
Ambassis dussumieri					58	1.16				
Amblyrhynchotes honckenii							1	0.02		
Antennarias striatus							1	0.02		
Argyrosomus japonicus	3	0.76	12	0.75	6	0.12	11	0.24	13	1.12
Atherina breviceps	1	0.25	155	9.66	200	3.99	16	0.35		
Caffrogobius gilchristi	36	9.09	91	5.67	74	1.48	191	4.19	14	1.20
Caffrogobius nudiceps	8	2.02	13	0.81	6	0.12	7	0.15		
Carcharias taurus			1	0.06						
Clinus superciliosus			1	0.06	1	0.02				
Dasyatis kuhlii							1	0.02		
Diplodus capensis	1	0.25	21	1.31	26	0.52	17	0.37		
Diplodus hottentotus					3	0.06	1	0.02		
Elops machnata	3	0.76	16	1.00	11	0.22	4	0.09	4	0.34
Gaelichthys feliceps	3	0.76			3	0.06	12	0.26	8	0.69
Gilchristella aestuaria	140	35.35	435	27.10	3 391	67.73	2 527	55.45	688	59.16
Glossogobius callidus			45	2.80	228	4.55	98	2.15	24	2.06
Hemiramphus far	3	0.76								
Heteromycteris capensis			7	0.44	9	0.18	1	0.02	8	0.69
Lichia amia	1	0.25			6	0.12	4	0.09	1	0.09
Lithognathus lithognathus	6	1.52	4	0.25	3	0.06	19	0.42	2	0.17
Liza dumerili	40	10.10	118	7.35	256	5.11	245	5.38	29	2.49
Liza macrolepis					1	0.02	11	0.24	2	0.17
Liza richardsonii	3	0.76	11	0.69	18	0.36	320	7.02	18	1.55
Liza tricuspidens	1	0.25	14	0.87	13	0.26	305	6.69	4	0.34
Monodactylus falciformis	2	0.51	1	0.06	17	0.34	11	0.24	4	0.34
Mugil cephalus			234	14.58	89	1.78	40	0.88	5	0.43
Mugilidae	24	6.06	22	1.37	72	1.44	109	2.39	3	0.26
Myliobatis aquila	1	0.25								
Myxus capensis			8	0.50			1	0.02	17	1.46
Platycephalus indicus	8	2.02								
Pomadasys commersonnii			8	0.50	9	0.18	32	0.70	29	2.49
Pomadasys olivaceus	17	4.29	25	1.56	19	0.38	9	0.20		
Pomatomus saltatrix	3	0.76			1	0.02	1	0.02		
Psammogobius knysnaensis	19	4.80	12	0.75	22	0.44	21	0.46	11	0.95
Raja miraletus							1	0.02		
Rhabdosargus holubi	67	16.92	342	21.31	436	8.71	513	11.26	275	23.65
Sarpa salpa					1	0.02	11	0.24		
Solea turbynei	4	1.01	6	0.37	22	0.44	4	0.09	2	0.17
Syngnathus temminckii			1	0.06	1	0.02				
Torpedo fuscumaculata					1	0.02				
Torpedo sinuspersici							1	0.02		
Valamugil buchanani			1	0.06	2	0.04	6	0.13	2	0.17
Valamugil robustus			1	0.06			4	0.09		
Total numbers	396		1 605		5 007		4 557		1 163	
Total taxa	24		27		33		36		22	

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TABLE A9
Biomass composition of fishes captured in predominantly open estuaries between Kayser's Beach and Kei Mouth on the southeast coast of South Africa, September–October 1996 (g = mass; % = percentage contribution)

Species	Buffalo		Nahoon		Gqunube		Kwelera		Quko	
	g	%	g	%	g	%	g	%	g	%
Acanthopagrus vagus	476.4	3.17					460.8	0.67		
Ambassis ambassis					3.1	0.01				
Ambassis dussumieri					39.5	0.07				
Amblyrhynchotes honckenii							12.4	0.02		
Antennarias striatus							1.5	0.00		
Argyrosomus japonicus	825.0	5.49	4360.0	7.76	4 075.9	6.95	6 588.3	9.58	8 210.0	24.17
Atherina breviceps	1.1	0.01	183.2	0.33	266.3	0.45	21.4	0.03		
Caffrogobius gilchristi	28.4	0.19	133.6	0.24	127.3	0.22	254.1	0.37	15.2	0.04
Caffrogobius nudiceps	3.4	0.02	28.1	0.05	10.2	0.02	20.2	0.03		
Carcharias taurus			8 004.0	14.25						
Clinus superciliosus			0.2	0.00	2.5	0.00				
Dasyatis kuhlii							2 728.0	3.97		
Diplodus capensis	0.3	0.00	5.8	0.01	6.0	0.01	8.9	0.01		
Diplodus hottentotus					1.1	0.00	0.6	0.00		
Elops machnata	4 683.0	31.14	26 732.0	47.58	20 289.0	34.60	7 351.0	10.69	6 417.0	18.89
Gaelichthys feliceps	1 749.0	11.63			1 562.0	2.66	6 752.0	9.82	3 619.4	10.66
Gilchristella aestuaria	107.5	0.71	274.8	0.49	1 188.3	2.03	929.0	1.35	496.5	1.46
Glossogobius callidus			38.0	0.07	237.7	0.41	131.3	0.19	38.0	0.11
Hemiramphus far	5.7	0.04								
Heteromycteris capensis			3.3	0.01	1.7	0.00	0.1	0.00	4.1	0.01
Lichia amia	1 366.0	9.08			5 690.0	9.70	5 935.0	8.63	388.0	1.14
Lithognathus lithognathus	828.7	5.51	46.3	0.08	11.2	0.02	1 074.2	1.56	308.0	0.91
Liza dumerili	1 512.7	10.06	2 186.9	3.89	7422.0	12.66	5 749.9	8.36	184.7	0.54
Liza macrolepis					13.6	0.02	359.6	0.52	24.1	0.07
Liza richardsonii	365.3	2.43	2 183.1	3.89	1 388.5	2.37	5 307.0	7.72	7 254.0	21.36
Liza tricuspidens	282.0	1.87	6 495.0	11.56	5 697.8	9.72	7 917.8	11.51	2 206.6	6.50
Monodactylus falciformis	211.0	1.40	64.0	0.11	225.9	0.39	918.0	1.33	64.7	0.19
Mugil cephalus			1 283.1	2.28	2 742.9	4.68	3 044.1	4.43	680.6	2.00
Mugilidae	1.9	0.01	2.1	0.00	8.0	0.01	11.6	0.02	0.7	0.00
Myliobatis aquila	205.0	1.36								
Myxus capensis			10.4	0.02			1.0	0.00	203.9	0.60
Platycephalus indicus	109.9	0.73								
Pomadasys commersonnii			774.4	1.38	104.6	0.18	2 646.1	3.85	703.1	2.07
Pomadasys olivaceus	6.3	0.04	129.6	0.23	75.9	0.13	39.8	0.06		
Pomatomus saltatrix	1 316.4	8.75			1 242.0	2.12	753.0	1.09		
Psammogobius knysnaensis	3.8	0.03	8.6	0.02	15.1	0.03	12.8	0.02	7.0	0.02
Raja miraletus							11.1	0.02		
Rhabdosargus holubi	945.9	6.29	3199.3	5.69	4 623.4	7.88	5 145.4	7.48	1 680.6	4.95
Sarpa salpa					0.2	0.00	901.0	1.31		
Solea turbynei	5.4	0.04	7.0	0.01	25.5	0.04	6.9	0.01	8.4	0.02
Syngnathus temminckii			0.1	0.00	0.4	0.00				
Torpedo fuscumaculata					265.8	0.45				
Torpedo sinuspersici							43.5	0.06		
Valamugil buchanani			24.9	0.04	1 283.7	2.19	3 628.3	5.28	1 447.0	4.26
Valamugil robustus			6.4	0.01			12.1	0.02		
Total numbers	**15 040.0**		**56 184.2**		**58 646.9**		**68 777.6**		**33 961.5**	
Total taxa	**24**		**27**		**33**		**36**		**22**	

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