Composition, distribution and abundance of ichthyoplankton in the Sundays River estuary

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Received 29 June 1989; accepted 19 March 1990

The species composition, distribution and seasonal abundance of ichthyoplankton in the Sundays River estuary was investigated at five stations from March 1986 to March 1987. Two estuarine taxa, the clupeid *Gilchristella aestuaria* and gobies *Caffrogobius* spp., accounted for 86% of the ichthyoplankton community, while the marine Mugilidae and sparid *Rhabdosargus holubi* together comprised 12% of the total catch. Ichthyoplankton densities were highest in the middle and upper reaches of the estuary where zooplankton stocks were greatest. Juvenile *G. aestuaria* predominated in the bottom waters throughout the system but the larvae were more evenly distributed (vertically) within the water column. In contrast, the mugilids were concentrated in surface waters throughout the estuary. Larvae were most abundant during spring and summer months, coinciding with the documented spawning period of most species and the peak in zooplankton biomass.

Die spesiesamestelling, verspreiding en seisoenale getalle van visplankton in die Sondagsriviermond is vanaf Maart 1986 tot Maart 1987 by vyf stasies ondersoek. Ses-en-tagtig persent het uit twee estuariene taksa bestaan, naamlik *Gilchristella aestuaria* en *Caffrogobius* spp., terwyl 12% uit die mariene Mugilidae en *Rhabdosargus holubi* bestaan het. Vislarwes was meer volop in die middel- en boonste gedeeltes waar die soöplanktonbiomassa die grootste was. Jong *G. aestuaria* het die bodemwaters dwarsdeur die sisteem oorheers, terwyl die larwes meer eweredig (vertikaal) binne die waterkolom versprei was. Daar teenoor was die Mugilidae in die oppervlakwaters van die hele tregtermond versprei. Gedurende die lente- en somermaande het vislarwes die grootste konsentrasies getoon, wat saamval met die belangrikste broeityd van die meeste spesies, asook met die spits in die staande voorraad soöplankton.

The importance of southern African estuaries as nursery areas for juvenile fishes is well established (e.g. Blaber 1974; Wallace & van der Elst 1975; Whitfield 1980; Wallace, Kok, Beckley, Bennett, Blaber & Whitfield 1984). The extent to which fish larvae utilize the estuarine environment is, however, poorly understood. Past research on estuarine ichthyoplankton has concentrated on the Swartkops estuary in the eastern Cape and Swartvlei system in the southern Cape (Melville-Smith & Baird 1980; Beckley 1985; Whitfield 1989a, 1989b). In this paper the species composition, seasonal abundance and distribution of fish larvae within the Sundays River estuary are outlined, thus complementing the studies of Beckley (1984) and Marais (1981) who investigated the juvenile and adult components, respectively, of this fish community.

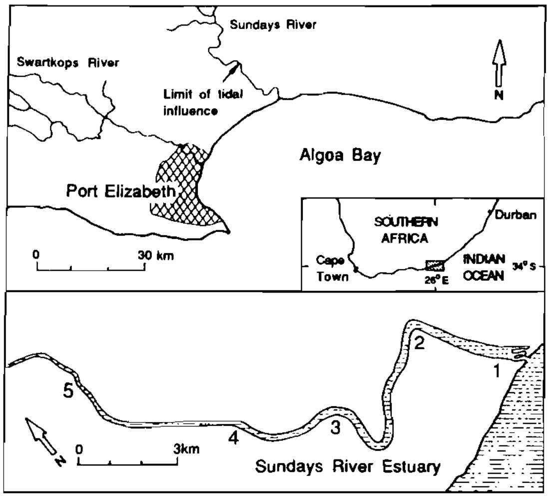

Figure 1 Map of the Sundays River estuary and location of the sampling stations.

Study area

The Sundays River is 310 km long with a catchment area of 20 729 km^2 and a mean annual rainfall of 323 mm (Reddering & Esterhuysen 1981). The estuary is one of two major systems that enter Algoa Bay (Figure 1) and is approximately 21 km long, 50 m wide over most of its length and has an average depth of 2,5 m. The mouth is permanently open and bordered by an extensive coastal dune field (Illenberger 1988). The estuary margin is characterized by steep banks (about 3–4 m high) and an absence of extensive mud flats. There are no salt marshes in the Sundays River estuary and marginal vegetation is limited to submerged *Potamogeton crispus* at the head, *Phragmites australis* in the upper reaches, benthic algae in the middle reaches and a small bed of *Zostera capensis* near the mouth (Beckley & Wooldridge 1988).

Materials and Methods

Five stations (Figure 1) were sampled during the period

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March 1986–March 1987. Two WP 2 plankton nets (57 cm mouth diameter and 90 μm aperture mesh), each fitted with a Kahlsico 005WA130 flowmeter, were used to simultaneously sample the near surface and near bottom waters at Stations 2, 3 and 4 (water depths 4–6 m at LWST). Each net was attached to a boom fitted in the bow of a flat-bottomed boat equipped with a 30 hp outboard engine. The nets were towed alongside the boat to ensure that they sampled 'undisturbed' waters more than 0,5 m from the bow. One net sampled just below the water surface while the other sampled 1–2 m above the substratum, depending on the boat's position relative to the shore. The bottom net was held at the required depth using a graduated pole operated from the deck of the boat. Surface waters only were sampled at the shallow stations 1 and 5 (water depths 1–2 m at LWST).

A series of single samples were taken every two weeks at low spring tide, commencing about 30 min after dark at Station 5 and ending at Station 1. During the sampling procedure, the nets were simultaneously lowered into the water and towed for 1,5–2,0 min at a speed of approximately 1–2 knots. Where possible an oblique course across the axis of the estuary was followed, thus enabling samples to be taken near the banks as well as in the mid-channel. After each tow, flowmeter readings were recorded, the samples were immediately preserved in 5% formaldehyde and the nets thoroughly rinsed. The volume of water filtered by the plankton net ranged between 10 and 30 m^3 per sample. Surface and bottom salinity and temperature measurements, using corked bottles and a Valeport series 600 CTD instrument, were recorded at each station at the time of sampling.

In the laboratory, each sample was decanted into a counting tray and sorted using a Nikon stereo microscope, following the procedure recommended by Richards & Berry (1973). All larval, juvenile and adult fish were identified using Melville-Smith (1978), Brownell (1979), Smith & Heemstra (1986) and Neira, Beckley & Whitfield (1988). Each fish was measured to the nearest 0,1 mm notochord length (larvae) or standard length (juveniles) using vernier slide calipers or an eyepiece micrometer.

Terminology used follows that of Berry & Richards (1973) and Melville-Smith & Baird (1980) where a 'fish larva' is defined as the developmental stage from the moment of hatching to the period of metamorphosis into a juvenile fish. The juvenile stage is the stage between acquisition of the minimum adult fin ray complement and sexual maturity.

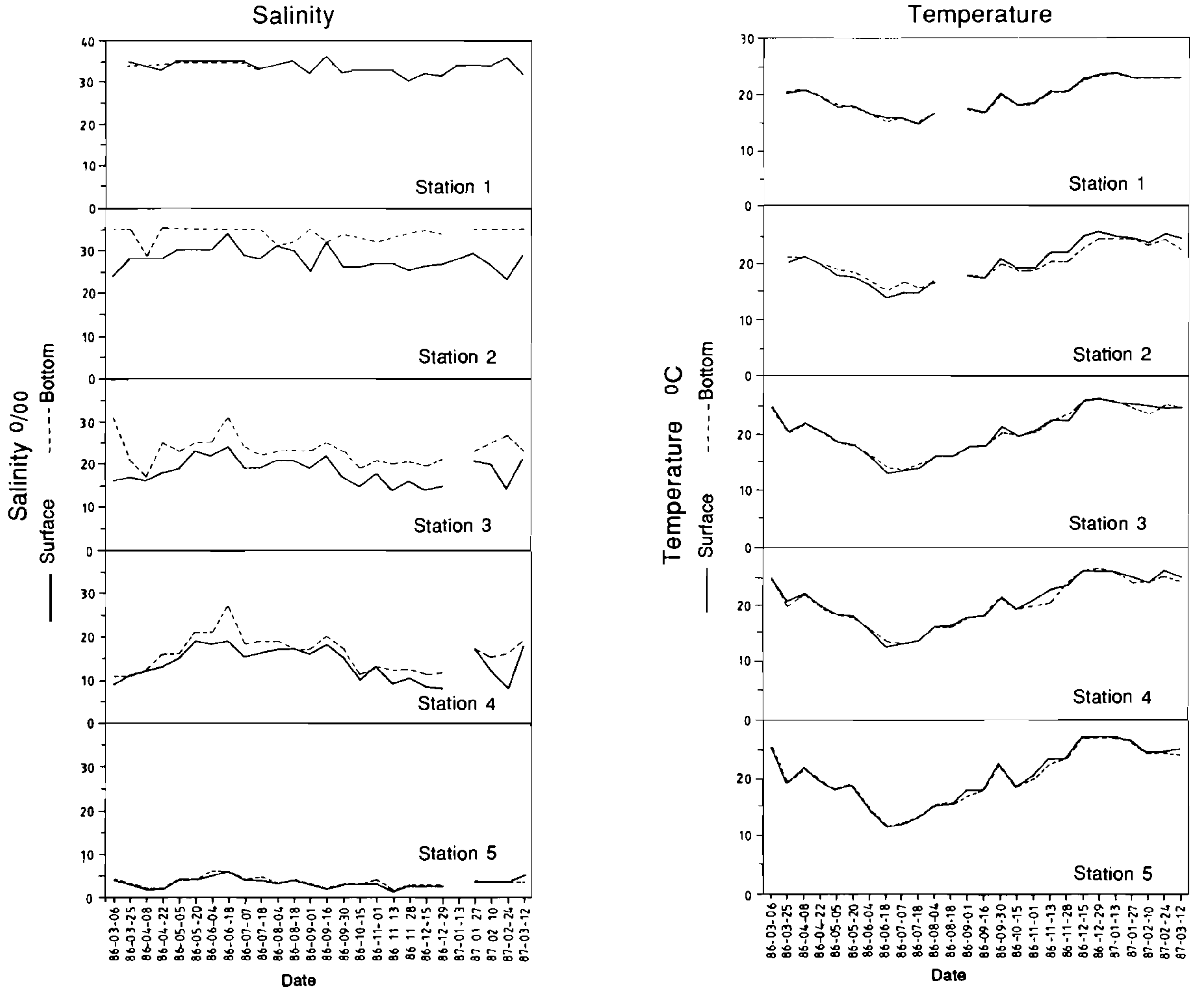

Figure 2 Surface and bottom temperatures and salinities at Stations 1–5 in the Sundays River estuary (March 1986–March 1987).

Table 1 Composition and mean density (numbers 10 m^{-3}) of ichthyoplankton at five stations in the Sundays River estuary (March 1986–March 1987)

	Station 1 Surface only		Station 2 Surface and bottom		Station 3 Surface and bottom		Station 4 Surface and bottom		Station 5 Surface		Total	
Species	No. 10 m^{-3}	%	No. 10 m^{-3}	%	No. 10 m^{-3}	%	No. 10 m^{-3}	%	No. 10 m^{-3}	%	No. 10 m^{-3}	%
Gilchristella aestuaria	0,13	4,63	2,82	57,18	72,02	95,54	26,11	87,79	1,34	7,65	20,48	78,61
Mugilidae	0,18	6,50	0,05	1,10	0,01	0,02	0,76	2,55	13,12	75,05	2,82	10,84
Caffrogobius spp.	1,62	59,01	1,63	33,04	2,27	3,01	1,36	4,56	2,50	14,33	1,88	7,20
Rhabdosargus holubi	0,02	0,72	0,02	0,50	0,61	0,81	0,99	3,31	0,34	1,92	0,40	1,52
Omobranchus woodi	0,12	4,27	0,11	2,23	0,21	0,28	0,16	0,54			0,12	0,46
Psammogobius knysnaensis	0,20	7,21	0,10	2,04	0,05	0,07			0,02	0,10	0,07	0,28
Monodactylus falciformis	0,02	0,72					0,04	0,13	0,15	0,83	0,04	0,16
Gobiidae (unidentified)			0,01	0,26	0,05	0,07	0,12	0,39	0,02	0,12	0,04	0,15
Solea bleekeri	0,10	3,61	0,02	0,45	0,02	0,03					0,03	0,11
Atherina breviceps	0,10	3,49			0,04	0,06					0,03	0,11
Engraulis japonicus			0,10	1,96							0,02	0,07
Diplodus sargus	0,10	3,50									0,02	0,07
Unidentified spp.	0,08	3,08					0,01	0,03			0,02	0,07
Heteromycteris capensis	0,07	2,53	0,01	0,11							0,01	0,06
Sparidae (unidentified)	0,02	0,72			0,02	0,03					0,01	0,03
Lithognathus lithognathus					0,03	0,04					0,01	0,02
Stolephorus holodon			0,03	0,52							0,01	0,02
Etrumeus whiteheadi			0,02	0,38							<0,01	0,01
Platycephalus indicus							0,02	0,05			<0,01	0,01
Total number 10 m^{-3}	5,67		4,93		75,38		29,75		17,48		26,64	
Total number captured	90		366		2986		1983		517		5942	

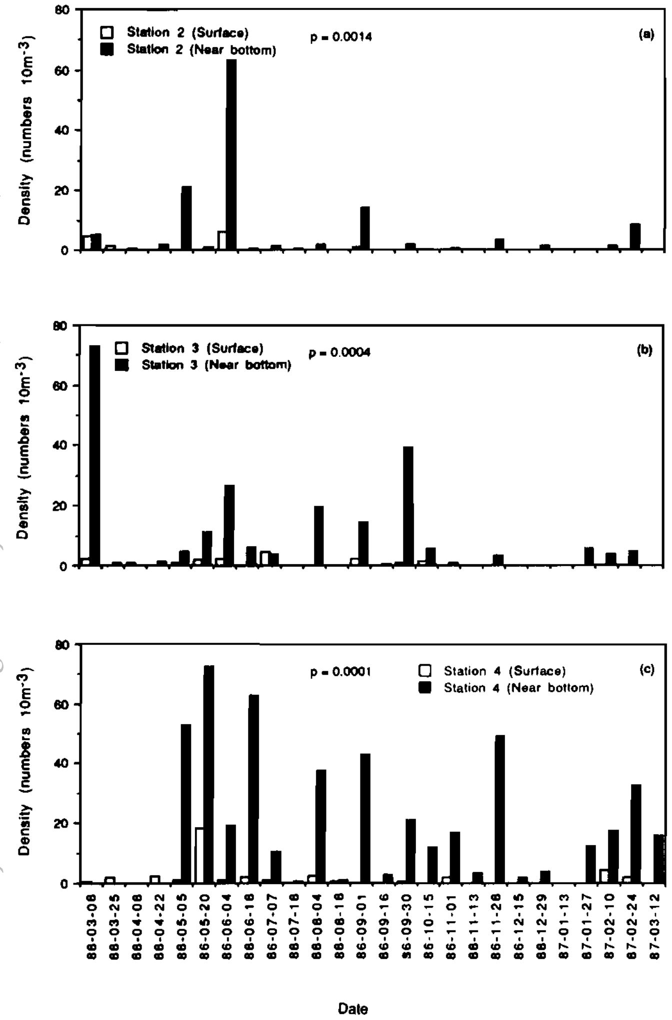

Figure 3 Densities of *Gilchristella aestuaria* juveniles (14–27 mm S.L.) in surface and near-bottom waters at Stations 2, 3 and 4. Wilcoxon signed rank test probability values are also shown.

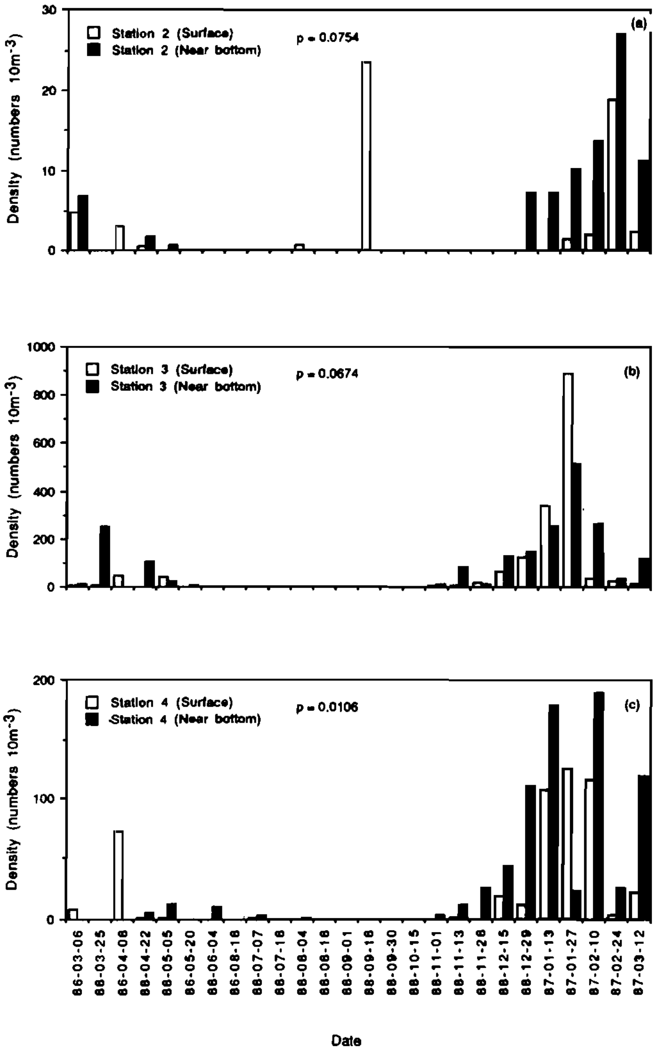

Figure 4 Densities of *Gilchristella aestuaria* larvae (< 14 mm N.L.) in surface and near-bottom waters at Stations 2, 3 and 4. Wilcoxon signed rank test probability values are also shown.

Densities of ichthyoplankton represent the mean of the numbers per 10 m^3 of water recorded for surface and near-bottom waters at Sites 2, 3 and 4, and surface samples only at Sites 1 and 5. The relative contribution of the various species to the total ichthyoplankton community were calculated after adjustment of the numbers at each site to a constant volume of 10 m^3.

Results

Physical environment

Temperature fluctuated seasonally at all five stations with the lowest values recorded in June 1986 and highest in December 1986 (Figure 2). Temperatures recorded at Station 1 showed the smallest range with a high of 24°C in January 1987 and a low of 14°C in July 1986. Station 5, at the head of the system, had the largest range in temperature with a high of 27°C in December 1986 and a low of 12°C in June 1986. There was little thermal stratification within the system.

The highest salinities were recorded near the mouth at Station 1 and values lower than 30‰ were not recorded in this region. At the upper station (Station 5) salinities did not exceed 10‰. The most noticeable vertical stratification was recorded throughout the year at Stations 2, 3 and 4 with the halocline being most marked at Station 2 (Figure 2).

Ichthyoplankton composition

A total of 5 942 larvae and 0+ juveniles, representing 10 families, were collected during the study period. The species composition and mean density at each of the sampling stations is shown in Table 1. The three dominant taxa, *Gilchristella aestuaria* (78,6%), Mugilidae (10,8%) and *Caffrogobius* spp. (7,2%), comprised more than 96% of the Sundays ichthyoplankton community (Table 1).

Horizontal distribution

Larval fish densities were significantly higher (Kruskal-Wallis one way analysis) at Stations 3 and 4 (Table 1) owing to the dominance of *G. aestuaria. Rhabdosargus holubi* were also most abundant in the middle reaches of the estuary (Stations 3 and 4), with the Mugilidae dominating at Station 5 in the upper reaches. The distribution and abundance of *Caffrogobius* spp. revealed no marked trends, and densities were only slightly higher at Stations 3 and 5 (Table 1). The densities of other species were too low to determine any distribution patterns.

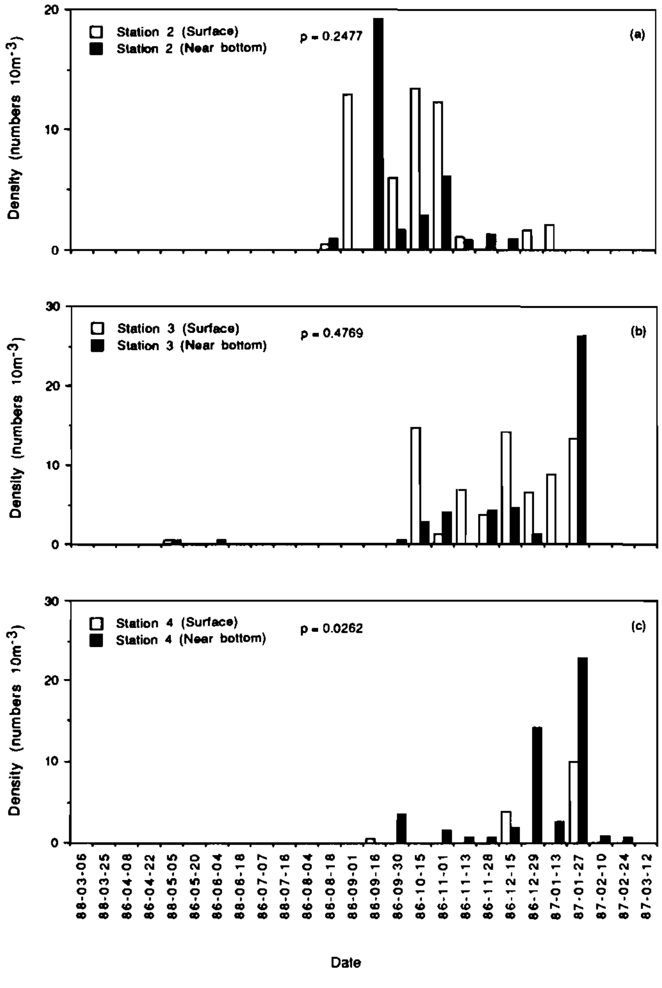

Figure 5. Densities of *Caffrogobius* spp. (mostly < 7 mm N.L.) in surface and near-bottom waters at Stations 2, 3 and 4. Wilcoxon signed rank test probability values are also shown.

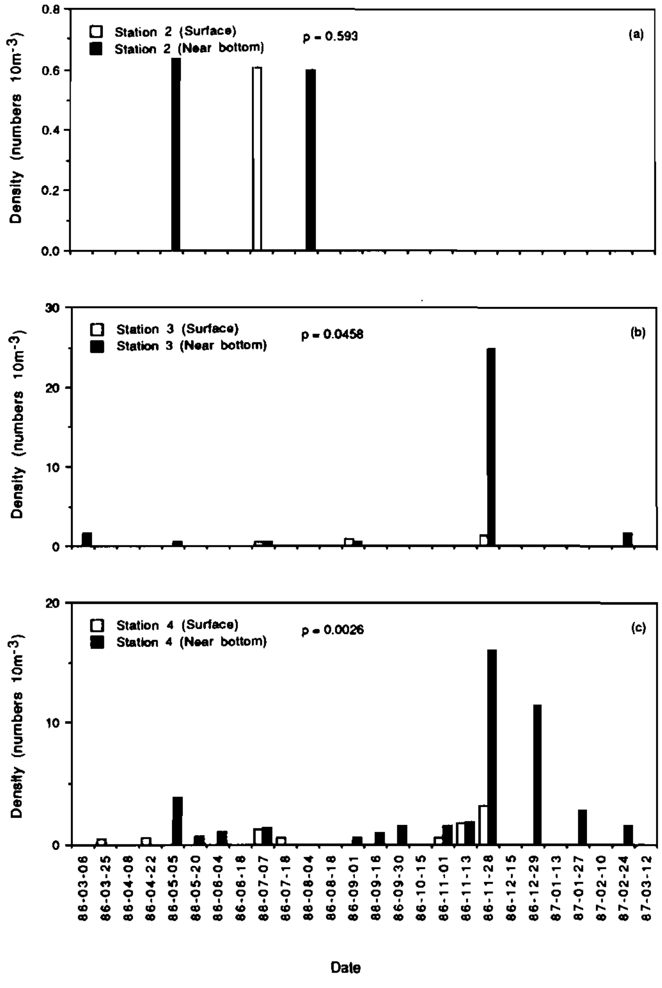

Figure 6 Densities of *Rhabdosargus holubi* (mostly < 15 mm S.L.) in surface and near-bottom waters at Stations 2, 3 and 4. Wilcoxon signed rank test probability values are also shown.

Vertical distribution

The densities of *G. aestuaria, Caffrogobius* spp., *R. holubi* and Mugilidae in surface and bottom waters for Stations 2, 3 and 4 are shown in Figures 3, 4, 5, 6 and 7. To determine whether there were any significant differences in densities between surface and bottom samples, the Wilcoxon signed rank test (Conover 1980) for a paired experiment was applied to the data ($p > 0,05$ = not significant; $p < 0,05$ = significant; $p < 0,01$ = highly significant). The juveniles of *G. aestuaria* are shown to have concentrated in the bottom waters at all three stations (Figure 3). Although the larvae of *G. aestuaria* and *Caffrogobius* spp. also predominated in bottom waters at Station 4, there were no significant differences between surface and bottom samples taken at Stations 2 and 3 (Figures 4 and 5). *R. holubi* was concentrated in the bottom waters at Stations 3 and 4 but samples did not differ significantly at Station 2 (Figure 6). Mugilids appeared to predominate in the surface waters throughout the system (Figure 7).

Seasonality

The seasonality of ichthyoplankton catches is illustrated in Figure 8. Larval densities were greatest during the summer (November–March) and lowest in winter (May–September). The abundance of *Gilchristella aestuaria* larvae was low during the period May 1986–October 1986 but increased in November 1986, before reaching a peak in January 1987 (Figure 8). The larvae of *Caffrogobius* spp. were present in the plankton from September 1986, reaching a peak in January 1987, and declined markedly in February 1987 (Figure 8). Mugilid and *Rhabdosargus holubi* larvae and juveniles were present throughout the study period, with the highest densities recorded in January 1987 and November 1986, respectively (Figure 8).

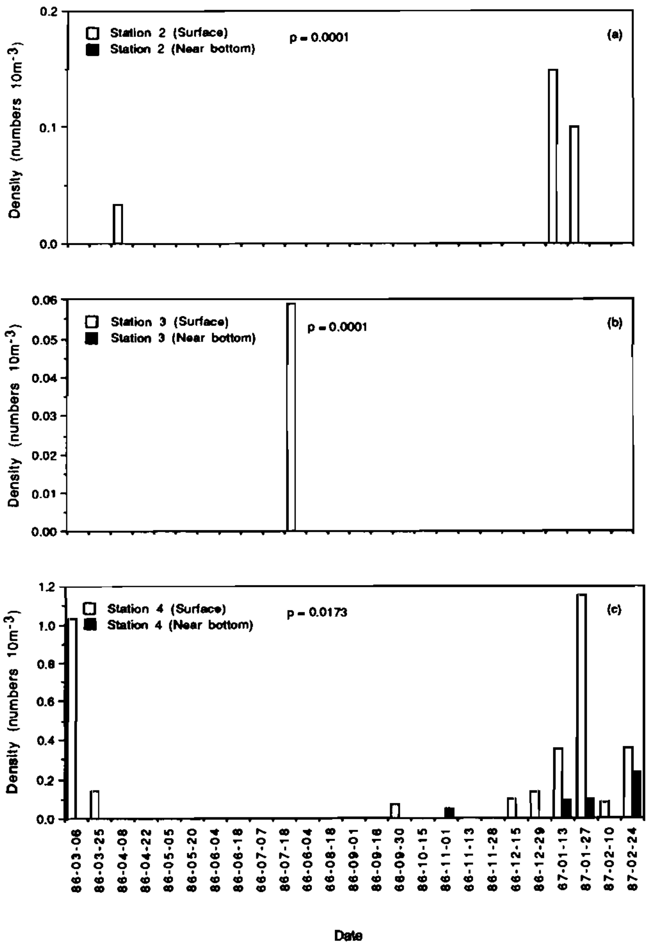

Figure 7 Densities of Mugilidae (mostly < 15 mm S.L.) in surface and near-bottom waters at Stations 2, 3 and 4. Wilcoxon signed rank test probability values are also shown.

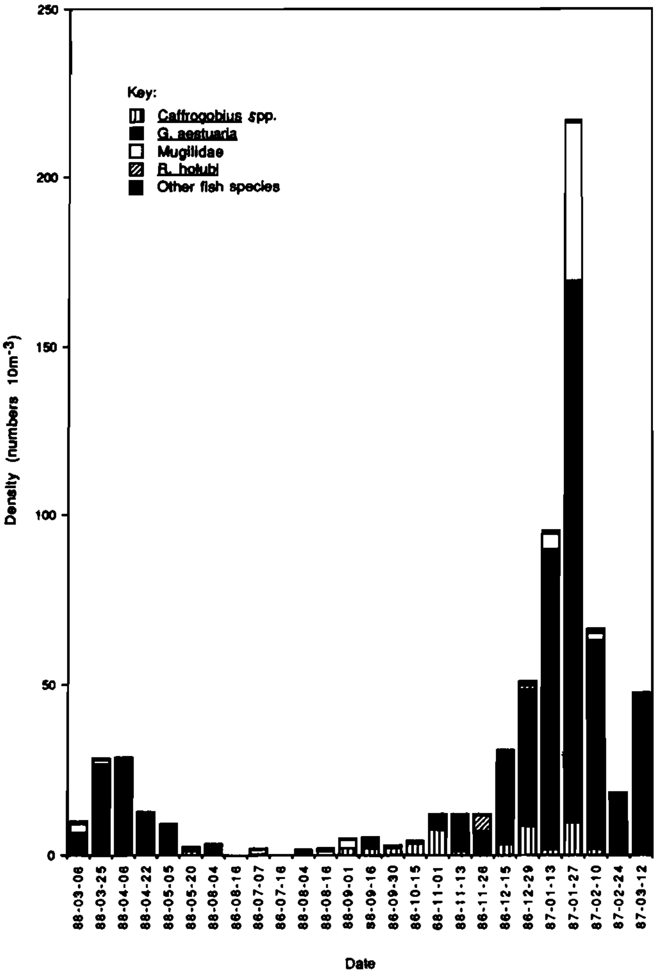

Figure 8 Ichthyoplankton densities in the Sundays River estuary (March 1986–March 1987).

Seasonal changes in the densities of *Pseudodiaptomus hessei* nauplii, copepodites and adults (Jerling 1988) together with changes in ichthyoplankton densities (this study) are shown in Figure 9. The results of a Spearman rank test (Conover 1980) on the data revealed a positive correlation between *P. hessei* densities and ichthyoplankton densities (Figure 9).

Discussion

Ichthyoplankton composition

Gilchristella aestuaria, Caffrogobius spp., *Omobranchus woodi, Psammogobius knysnaensis* and *Atherina breviceps* are all species which spawn and can complete their lifecycles in estuaries (Wallace *et al.* 1984; Whitfield

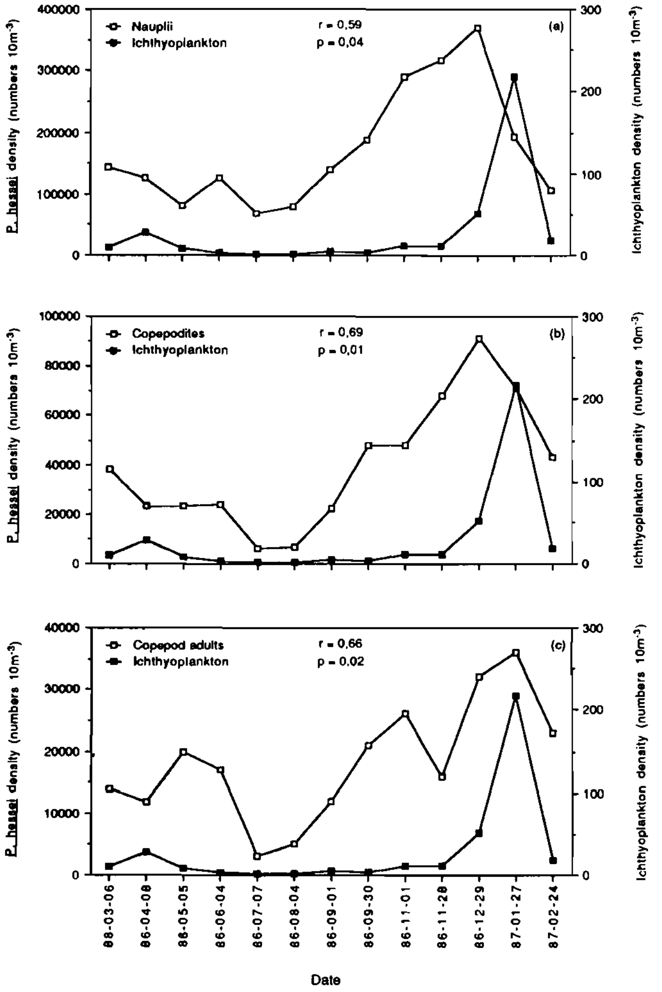

Figure 9 Densities of *Pseudodiaptomus hessei* nauplii, copepodites and adults (Jerling 1988), and corresponding ichthyoplankton densities (this study) in the Sundays River estuary (March 1986–February 1987). The results of the Spearman rank correlation are also given, with the coefficient ranging from $r = -1$ (perfect disagreement) to $r = +1$ (perfect agreement).

1990). These species accounted for 86,6% of the total ichthyoplankton community in the Sundays River estuary. *Rhabdosargus holubi* and mugilids, which comprised 12,4% of the total catch, are marine taxa which spawn at sea but use estuaries as nursery areas (Blaber 1974; Blaber & Whitfield 1977). Seine net catches from the Sundays estuary (Beckley 1984) showed that *G. aestuaria* (80%), Mugilidae (6.4%), *R. holubi* (3,6%) and Gobiidae (2,8%) were also dominant amongst the juvenile and adult components in this estuary. The larvae of *G. aestuaria* and Gobiidae were also found to be the most abundant taxa in the nearby Swartkops estuary (91%) (Melville-Smith & Baird 1980), Kromme estuary (97%) (Melville-Smith 1981) and Swartvlei lake (84%) (Whitfield 1989a).

Incidental marine species such as *Engraulis japonicus* and *Etrumeus whiteheadi* constituted less than 0,1% of the total larval catch in the Sundays estuary. The above fishes are both pelagic shoaling species which are abundant in the inshore ichthyoplankton of Algoa Bay (Beckley 1986). *E. whiteheadi* and *E. japonicus* have both been recorded passively entering the Swartkops (Beckley 1985) and Swartvlei (Whitfield 1989b) systems on the flood tide, only to be washed back into the marine environment on the ebb tide. The occurrence of these species in the lower reaches of the Sundays system (Table 1) may therefore be due to them being temporarily swept into the estuary from the adjacent marine environment.

Horizontal distribution

The larvae of *G. aestuaria* were most abundant at Stations 3 and 4 (Table 1). In the Swartkops and Swartvlei estuaries, *G. aestuaria* numerically dominated catches in the middle and/or upper reaches of these systems (Melville-Smith 1978; Whitfield 1989a). This species spawns in the upper reaches of open estuaries and as the larvae grow, their distribution extends towards the mouth (Melville-Smith & Baird 1980; Talbot 1982). This probably accounts for the relatively high densities of *G. aestuaria* larvae found in the middle stations 3 and 4, and lower densities at Stations 1 and 2 in the Sundays estuary.

G. aestuaria is a zooplanktivore feeding primarily on copepods and juveniles of the mysid *Mesopodopsis slabberi* (Talbot & Baird 1985). Analysis of stomach contents from specimens caught in the Sundays River estuary revealed that the food items recorded clearly mirror the availability of prey species in different parts of the estuary and during different seasons (Wooldridge & Bailey 1982). *Pseudodiaptomus hessei,* an important food item of *G. aestuaria*, was the most important component of the copepod standing stock within the Sundays system. Wooldridge & Bailey (1982) found maximum standing stocks of this species in the middle and upper reaches during the summer months. The high densities of *G. aestuaria* larvae caught at Stations 3 and 4 may therefore also be related to the availability of suitable prey items in this region.

Beckley (1984) found that the most abundant goby species in the Sundays River estuary were *P. knysnaensis* and *C. multifasciatus*. The larvae of these species, together with that of the blenny *Omobranchus woodi* were also common in the Swartkops (Melville-Smith & Baird 1980) and Swartvlei (Whitfield 1989a; 1989b) systems. The most abundant goby species recorded in this study were *Caffrogobius* spp. and *Psammogobius knysnaensis* which, together with the blenny *O. woodi,* were found in relatively high proportions at Stations 1 and 2 (Table 1). Melville-Smith & Baird (1980) found that *P. knysnaensis, Caffrogobius* spp. and *O. woodi* larvae were also concentrated in the lower reaches of the Swartkops estuary. The relatively high contribution of these species to the ichthyoplankton of the lower reaches may be due to them leaving the system on the ebb tide as documented by Beckley (1985) and Whitfield (1989b).

The marine *R. holubi* and Mugilidae were most abundant in the middle and upper reaches of the Sundays estuary (Table 1). The diet of the larvae and pelagic juveniles of the above species is dominated by zooplankton (Blaber & Whitfield 1977; Whitfield 1985), and since zooplanktonic abundance was greatest in the middle and upper reaches of the above estuary (Wooldridge & Bailey 1982), this may account for the concentration of *R. holubi* and mugilids in this region.

Vertical distribution

Juvenile *Gilchristella aestuaria* (14–27 mm S.L.) predominated in the bottom waters of the Sundays estuary (Figure 3). Melville-Smith, Baird & Wooldridge (1981) found that *G. aestuaria* larvae between 7 mm and 13 mm T.L. also concentrated in the bottom waters of the above estuary. They suggested that by inhabiting the slow-moving bottom waters, the larva's seaward movement was minimized and a tongue of fast-flowing bottom water on the incoming tide transported them back upstream. In contrast, this study found no significant differences between surface and bottom samples of larval *G. aestuaria* at Stations 2 and 3. They did, however, appear to predominate in the bottom waters at Station 4 (Figure 4). Conte, Otto & Miller (1979) and Rijnsdorp, van Stralen & van der Veer (1985) have suggested that water currents can disperse larvae vertically, thus affecting abundances in surface catches. The Sundays estuary is subject to strong tidal currents (Wooldridge & Erasmus 1980), and this may account for the apparent lack of differences in vertical distribution of *G. aestuaria* and *Caffrogobius* spp. larvae in the middle and lower stations (Figures 4 and 5).

Melville-Smith *et al.* (1981) found that in the Sundays estuary, current velocity at the surface rapidly exceeded current velocity at the bottom on the flood tide. Marine Mugilidae and *R. holubi* in the lower reaches may therefore have migrated into surface waters (Figures 6 and 7) during the slack ebb tide in order to be transported upstream by the subsequent faster surface flood tide currents. In this manner these species could rapidly reach the middle and upper reaches where zooplankton was most abundant.

Seasonality

Wooldridge & Bailey (1982) recorded *G. aestuaria* eggs in the plankton of the Sundays River estuary from October to April, with the highest egg densities occurring in December. The peak in larval densities of *Gilchristella aestuaria* during this study occurred in January (Figure 8), which corresponds to the middle of the main spawning period. In the Swartkops estuary, *G. aestuaria* spawn during August–March, with a peak in activity during November (Talbot 1982). *G. aestuaria* larvae first appeared in October, reaching a peak in December and declined after March (Melville-Smith 1978).

Caffrogobius spp. were most abundant in the plankton from early spring to mid-summer (Figure 8). Beckley (1984) recorded peak periods of recruitment of *Caffrogobius multifasciatus* in the Sundays estuary during the summer months. In the Swartkops estuary, Melville-Smith (1978) found that gobiid larvae first appeared in significant numbers during August with large numbers occurring erratically throughout the summer season. In the Swartkops (Beckley 1985) and Swartvlei (Whitfield 1989b) estuaries large numbers of *Caffrogobius* larvae were recorded leaving these systems during October–November and Whitfield (1989b) found an influx of 0+ juveniles (8–10 mm S.L.) of this species during late summer (January–March).

The larvae and 0+ juveniles of *R. holubi* and Mugilidae did not exhibit any marked seasonality, although higher densities were recorded during the summer (Figure 8). In the Swartkops estuary, *R. holubi* were never exceptionally abundant but did tend to decline in numbers during the winter months (May–October) (Melville-Smith 1978).

Whitfield (1989b, 1989c) recorded a peak immigration of marine larvae/postlarvae into the Swartvlei estuary during summer (January–March), and in Swartvlei lake Whitfield (1989a) found the highest densities of estuarine fish larvae (mainly *G. aestuaria*) in summer, which also coincided with peaks in zooplankton abundance. Blaber (1979) determined that *G. aestuaria* in Lake St Lucia spawned during early summer and that the early life stages were present when zooplankton was most abundant. Zooplankton standing stocks in the Sundays estuary were also highest during the summer months, with a relatively low biomass during winter (Wooldridge & Bailey 1982). In addition, Jerling (1988) found that the abundance of the dominant copepod, *Pseudodiaptomus hessei,* was low during the winter months and increased during spring, with a peak in abundance during December. The seasonal abundance of ichthyoplankton in the Sundays estuary is positively correlated to copepod abundance (Figure 9), thereby increasing the potential growth and survival of fish larvae and 0+ juveniles in this system.

Acknowledgements

We thank Mr H. Jerling and Dr T. Wooldridge from the University of Port Elizabeth for making the study material available, and for their help and co-operation in obtaining additional data. Mr A. Scholtz, Mrs E. Whitfield, Mrs S. Radloff and Mrs R. Seillier provided assistance in processing the samples, analysing the data and generating graphs on the computer. The support and co-operation of Dr A. Ramm, Mr A. Cooper and Mr A. Singh is also gratefully acknowledged. The Division of Water Technology (CSIR) and South African National Committee for Oceanographic Research (CSIR) provided financial assistance.

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