

The utilization of tidal currents by the larvae of an estuarine fish

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The mechanisms employed by *Gilchristella aestuarius* larvae to maintain their position in an estuary were investigated in the Sundays River estuary, South Africa. The larvae predominated in the bottom water on both the flood and ebb tides and by so doing, utilized the flood-tide bottom-water current and avoided the ebb-tide surface current, the net result being a transport of the larvae upstream. There was no evidence to suggest that the larvae migrate laterally toward favourable, or away from unfavourable, currents.

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Die meganismes waardeur die larwes van *Gilchristella aestuarius* hul posisie in 'n getyrvier behou, is in die Sondagsriviermond, Suid-Afrika, ondersoek. Larwes kom hoofsaaklik in die bodemwater gedurende beide inkomende en uitgaande gety voor. Op hierdie manier gebruik hul die bodemstrome om hul posisie in die riviermond te behou en vermy so die vinnig uitvloeiende oppervlakstrome. Daar is geen bewyse dat die larwes lateraal na meer geskikte strome of uit ongeskikte strome migreer nie.

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The retention of indigenous plankton within an estuary is a serious problem facing a planktonic population and the methods used by the zooplankton have been the subject of numerous papers (*inter alia* those by Bosch & Rowland Taylor 1973, Grindley 1972, Jacobs 1968, Lockwood 1976, Trinast 1975). The bulk of the work to date has been mainly on planktonic crustaceans and the authors have all reported on vertical migration of zooplankton as a means of moving with or against the tidal current and have tended to ignore the possibility of plankton utilizing the slower-moving water nearest the bank of an estuary.

The purpose of this study was to investigate the mechanisms by which the larvae of an estuarine fish species, *Gilchristella aestuarius*, maintains its position in an estuary. The possibilities of fish larvae making use of vertical migration and/or the slower-flowing shallow bank waters to maintain their relative position were examined.

This study formed part of an overall project on the plankton of the Sundays River estuary. The utilization of tidal currents by the zooplankton was investigated at the same time as the present study and will be reported on elsewhere. The Sundays River is situated approximately 35 km northeast of Port Elizabeth, South Africa. The estuary is approximately 20 km long, channel-like in appearance with steep banks and with strong semi-diurnal currents.

Methods

Data were collected at six stations on two bends in the estuary, approximately 7.5 km from the mouth (Fig. 1). The first three stations (1, 2 and 3) were approximately 350 m from the second set (4, 5 and 6). Two sets of stations were chosen so that the results could be compared. The flow in the main current was determined by means of a Savonius current meter and depth profiles were determined from lead-line soundings. The trajectory of the main current during a pushing and a receding tide is indicated in Fig. 1.

Stations 1 and 4 were on the outer deep bends (3 m at LWS), 2 and 5 were in the centre channel (2 m at LWS) and 3 and 6 were in the shallow lee of the bend (1 m at LWS). Each station was marked by two bouys anchored approximately 50 m apart, with approximately 30 m between stations.

Sampling was conducted during a moonless night to avoid light influencing vertical migration patterns of the

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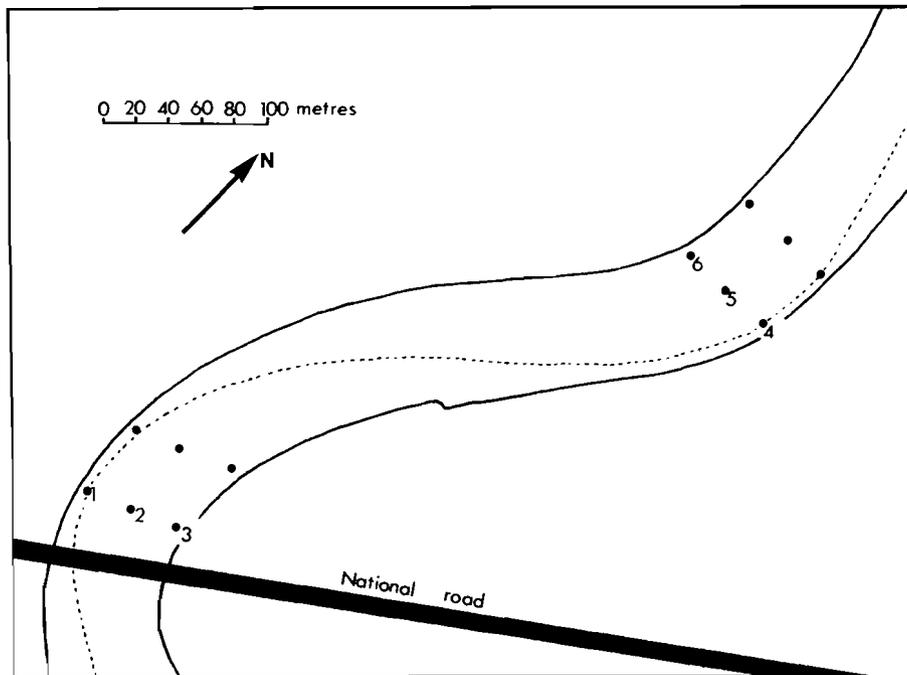


Fig. 1 Part of the Sundays River estuary showing the position of the stations referred to in the text. The dotted line indicates the main current trajectory.

fish larvae and shortly after spring tide while current flow was still maximal. The samples were collected over a period of 11,5 h between sunset and sunrise, with sampling commencing at 19h45 and terminating by 06h15.

A series of samples was taken every 1,5 h starting at Station 1 and proceeding sequentially to Station 6. At each station a standard procedure was followed. Surface and bottom temperature and salinity readings, representative for each series, were measured at Station 1 at the start of each of the seven sampling series, using a YSI model 33 SCT meter. Current speed was measured at each station using a Savonius rotor, prior to taking a plankton tow at that station. Surface current speed was measured 0,25 m from the surface and bottom current speed 1,25 m off the bottom.

After the recording of physical data, a plankton tow was taken between the two bouys for that station. The tows were always with the current, at a speed of approximately 3 knots. For these tows, two similar plankton nets were used simultaneously. Each net had a mouth opening of 75 cm diameter and the netting material used was St Martins nylon mesh, with aperture size 190 μm . Kahlsico 005 WA 130 flow meters were fitted to each net to quantify the data.

Both nets were mounted on the bow of the boat, one on either side. The net sampling bottom water was fitted with a weighted depressor vane on its under surface to keep it submerged with minimum effort. It was held in position 1 m off the bottom by a pole connected to the upper surface of the net mouth and operated by a worker on the boat. Bottom samples were taken 1 m off the bottom at the deep stations (1, 2, 4 and 5), in order to avoid possible obstacles. At Stations 3 and 6 the water was too shallow for a bottom sample (1 m at LWS) and the surface sample thus adequately represented the water column for those two stations.

Samples were placed into 5% formalin and stored. In the laboratory, fish larvae were separated from the rest of

the plankton and their numbers expressed per m^3 of water. The larvae of only one fish species was used for the purpose of this study, namely *Gilchristella aestuarius* (Gilchrist 1914), since this species predominated in terms of numbers and could easily be identified. The size of larvae used was restricted to those between 7 and 13 mm total length.

Results

Hydrological

Table 1 shows that the bottom water was generally warmer and more saline than the surface water. The increase in salinity during Series 6 and 7 was due to the incoming sea-water after the turn of the tide (Fig. 2). Water current speeds varied according to the state of the tide (Fig. 3).

Current velocity measurements for Series 5 show the turn of tide; with the exception of a weak surface current recorded at Station 1, no other water movement was detected (Fig. 3). During the following series of samples, 1,5 h later, current velocity at the bottom was faster than

Table 1 Surface and bottom temperatures and salinities from the sampling series. Measurements were taken at Station 1 at the commencement of each series

Series	Salinity (‰)		Temperature (°C)	
	Surface	Bottom	Surface	Bottom
1	23,0	24,5	20,0	20,5
2	22,5	22,5	19,8	20,0
3	19,5	22,0	19,5	20,2
4	18,0	22,5	20,0	20,8
5	16,5	18,5	19,0	*
6	17,5	24,5	19,0	*
7	20,5	24,5	19,0	*

*unreliable data

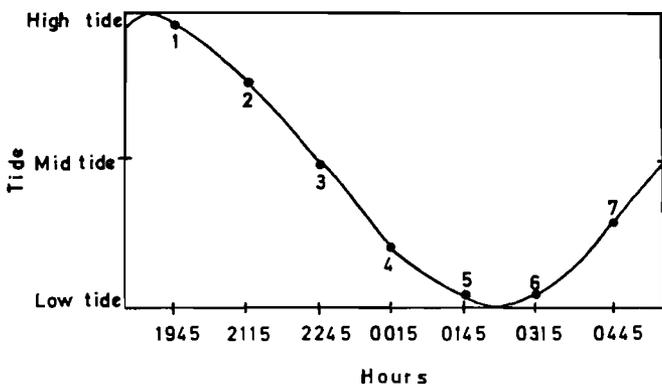


Fig. 2 A diagrammatic representation of the tidal cycle during the sampling series. The time at which each series started is indicated on the x axis. The sampling series are numbered 1 to 7 in the figure.

at the surface (Series 6, Stations 1 and 2, Fig. 3). This indicates the tongue of high-salinity sea-water entering the estuary, whilst the colder, low-salinity surface water had only just started flowing back into the estuary and had yet to pick up greater speed than the bottom water. By Series 6, Stations 4 and 5, and Series 7, Stations 1, 2, 4 and 5 (Fig. 3), the surface water was flowing faster than the bottom water.

It took approximately ten minutes to sample the hydrology and take a plankton tow at each station. This time lapse between stations accounts for the apparent anomalies in the hydrology of Stations 1, 2 and 3, when compared to Stations 4, 5 and 6. For example, the current velocities of Series 6, Stations 1 and 2 differ vastly from those of Stations 4 and 5 of the same series. This difference is directly attributable to the 30-min time lapse between the two sets of readings.

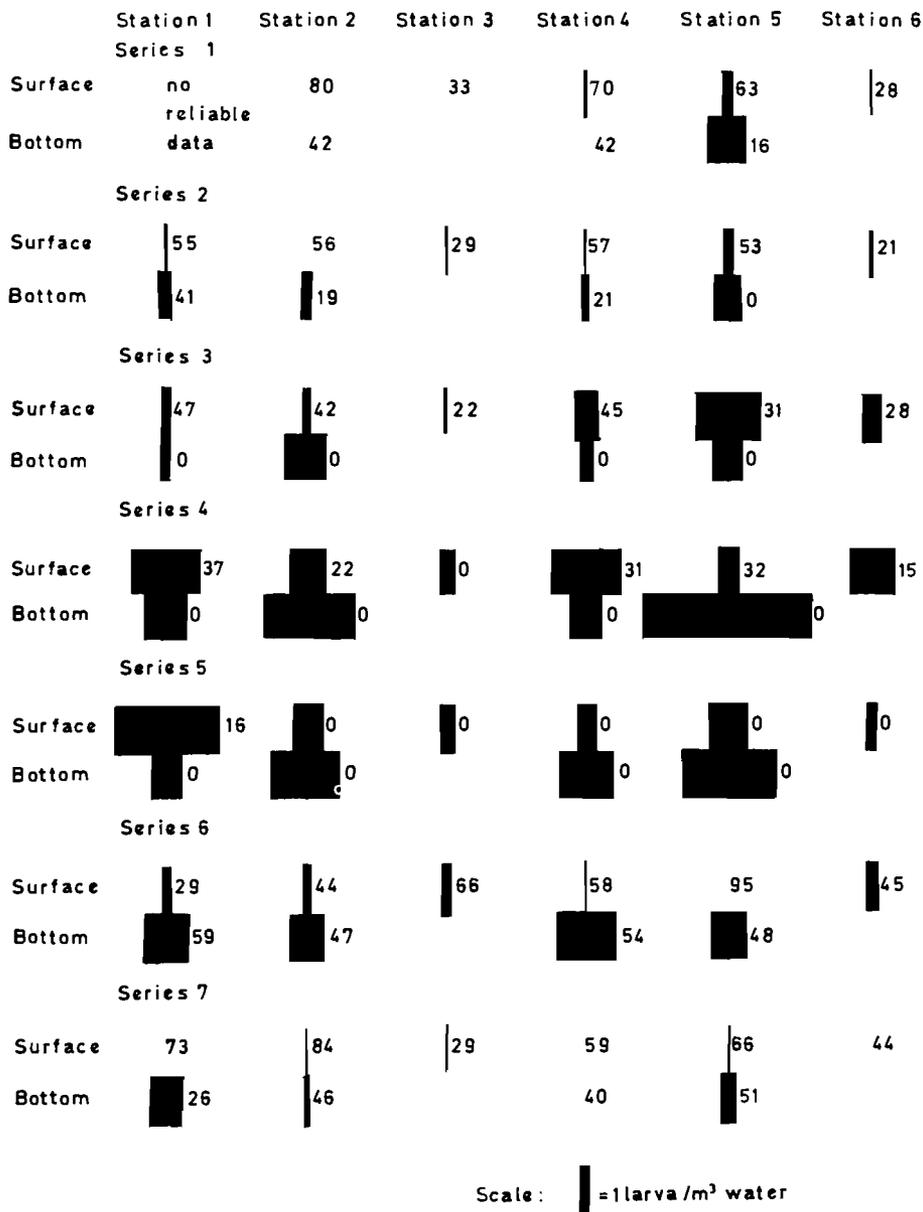


Fig. 3 The number of *Gilchristella aestuarius* larvae per m³ of water. The figures next to the distribution polygons indicate the current speed as recorded by Savonius rotor just prior to the plankton tow. Current flow is given in revolutions of the Savonius rotor per minute (60 rotations /min ≈ 24 m/min).

Biological

Results of plankton trawls at the surface and bottom in terms of *G. aestuarius* larvae per m³ water are presented in Fig. 3.

Discussion

The results in Fig. 3 show a number of trends. The number of *G. aestuarius* larvae per m³ of water increased with the outgoing tide, reaching a maximum at low water (Series 4 and 5, Fig. 3). With an incoming tide the number of larvae decreased rapidly. The explanation for this observation is that, spatially, *G. aestuarius* larvae occur in maximum numbers in the upper reaches of the estuary (Melville-Smith & Baird 1980). On an outgoing tide (Series 1 to 5), the larval population drifted toward the mouth with the tidal plug of estuarine water and consequently, increasing numbers of animals were sampled as the core of the population was carried toward the sampling sites. On a pushing tide (Series 6), the reverse trend was experienced and fewer *G. aestuarius* larvae were sampled.

Little is known about the swimming powers of larval fish, but Bishai (1960) has shown that 0,7 cm herring larvae (a species of the same family as *G. aestuarius*) are able to maintain their position against a current of 1 cm/s for 45 minutes. The tidal currents in the Sundays estuary were stronger than 1 cm/s but it may be assumed that the *G. aestuarius* larvae were at least capable of similar weak movements in order to alter their position in the water column, particularly in a lateral and vertical plane.

Throughout the duration of both tides, the greatest concentrations of larvae were in the bottom waters (Fig. 3). This trend was tested statistically by applying the Wilcoxon signed rank test for matched pairs to surface and bottom observations (*i.e.* number of larvae/m³). The test showed that there were significantly more larvae in the bottom than in the surface layer at the 2% level.

Gilchristella aestuarius is an estuarine species. If the larvae were to remain in the surface waters, they would undoubtedly be carried out to the sea in the course of a single tidal flush of the estuary. By predominating in the

slow-moving bottom waters their seaward movement is minimised. (Series 3, 4 and 5 all had zero bottom-water current readings while the surface current readings of particularly Series 3 and 4 were relatively high.)

On the incoming tide, there was an initial tongue of fast-moving bottom water (Fig. 3, Series 6, Stations 1 and 2), which served to transport the larvae back upstream. By predominating in the bottom water during both ebb and flood tides, the fish larvae apparently utilize the flood-tide bottom-water current and avoid the ebb-tide current, the net result being a transport of the larvae upstream.

There was no evidence in this study (Fig. 3) to suggest that *G. aestuarius* larvae employ lateral migration in order to avoid or utilize estuarine tidal currents.

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References

- BISHAI, H.M. 1960. The effect of water currents on the survival and distribution of fish larvae. *J. Cons. perm. int. Explor. Mer.* 25: 134–146.
- BOSCH, H.F. & ROWLAND TAYLOR, W. 1973. Diurnal vertical migration of an estuarine cladoceran, *Podon polyphenoides* in the Chesapeake Bay. *Mar. Biol. Berlin* 19: 172–181.
- GRINDLEY, J.R. 1972. The vertical migration behaviour of estuarine plankton. *Zool. afr.* 7: 13–20.
- JACOBS, J. 1968. Animal behaviour and water movement as codeterminants of plankton distribution in a tidal system. *Sarsia* 34: 355–370.
- LOCKWOOD, A.P.M. 1976. Physiological adaptation to life in estuaries. In: *Adaptation to environment*, ed. R.C. Newell. Butterworth, London.
- MELVILLE-SMITH, R. & BAIRD, D. 1980. Abundance, distribution and species composition of fish larvae in the Swartkops estuary, Port Elizabeth. *S. Afr. J. Zool.* 15: 72–78.
- TRINAST, E.M. 1975. Tidal currents and *Acartia* distribution in Newport Bay, California. *Estuar. cstl mar. Sci.* 3: 165–176.