Abundance, distribution and species composition of fish larvae in the Swartkops estuary

R. Melville-Smith and D. Baird
Sea Fisheries Branch, Department of Industries, Cape Town and Department of Zoology, University of Port Elizabeth, Port Elizabeth

A two-year quantitative survey of the ichthyoplankton of the Swartkops estuary has resulted in the identification of 17 larval fish. The ichthyoplankton was present through all months of the year, but was only abundant during the summer months (November – February). During both years sampled, the highest densities were recorded in December. An attempt was made to correlate the data with environmental parameters such as temperature, salinity and rainfall. The ichthyoplankton of the Swartkops is dominated by few species. The family Gobiidae (59,44%) and a clupeid species, *Gilchristella aestuarius* (31,12%), accounted for 90,56% of all the fish larvae sampled. The family Gobiidae were most common in the mouth and lower reaches of the estuary, while *G. aestuarius* dominated the mid- and upper estuary.
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Na twee jaar van kwantitatiewe igtioplankton-opnames in die Swartkopsriviermonding kon 17 larvale vis geïdentifiseer word. Igtioplankton was dwarsdeur die jaar teenwoordig, maar was alleenlik volop gedurende die somer (November – Februarie). Die hoogste konsentrasies het in Desember gedurende albei jare voorgekom. Daar is gepoog om die verband tussen die gegewens en temperatuur, soutgehalte en reënval te bepaal. Die igtioplankton word deur 'n paar spesies oorheers. Die Gobiidae (59,44%) en *Gilchristella aestuarius*, 'n klupeïede spesie (31,12%), verteenwoordig saam 90,56% van alle larwes. Die Gobiidae was goed verteenwoordig in die monding self en die onderste dele van die riviermonding, terwyl *G. aestuarius* meer oorheersend in die middelste en boonste dele was.
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R. Melville-Smith*
Sea Fisheries Branch, Department of Industries,
Sea Point, Cape Town 8001, South Africa, and
D. Baird
Department of Zoology, University of Port Elizabeth,
P.O. Box 1600, Port Elizabeth 6000, South Africa
*To whom all correspondence should be addressed

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The study of larval fish ecology has been neglected in South Africa to date. This survey of ichthyoplankton in the Swartkops River, may be considered to be the first intensive study of its kind to have been undertaken on larval fish in a South African estuary. It was initiated with the object of improving our knowledge of the abundance, distribution and species diversity of the early stages of fish present in the Swartkops River estuary and is part of a much larger programme which is being undertaken by the University of Port Elizabeth to examine the energy flow in that estuary.

That estuaries provide nursery areas for juvenile fish has been acknowledged internationally for many years. In South Africa, early authors (Day 1951; Talbot 1955) made mention of this fact and recent detailed work on this subject by Wallace (1975a,b) and Wallace and Van der Elst (1975) has emphasized the complexity of fish movements between estuaries and the marine environment. In the work of Wallace (1975a,b) and Wallace and Van der Elst (1975), some attempt was made to sample larval fish with scoop nets, though few fish larvae were positively identified. Similarly, in papers relating to general estuarine plankton surveys that have been undertaken on Southern African estuaries and lagoons, the ichthyoplankton component has been ignored (Grindley & Wooldridge 1974; Wooldridge 1977) or treated as virtually a 'black box' component of the plankton, with the majority of the fish larvae unidentified (Grindley 1970; 1977; Wooldridge 1976). To the authors' knowledge, all other studies on estuarine ichthyoplankton have been conducted in the United States of America and Canada. Those most relevant to this study are by Pearcy and Richards (1962), Herman (1963), Crocker (1965), Pearcy and Myers (1974), Austin (1976), Misitano (1977), and Able (1978).

Methods

Study area

The Swartkops estuary is situated approximately 10 km north-east of Port Elizabeth and is about 16 km from mouth to head (Fig. 1). It is characterized by extensive salt marshes, and the estuary itself has a relatively slow flow with little fresh water inflow. For details of the topographical features of the estuary *vide* MacNae (1957), Swartkops Trust (1971), McLachlan (1972) and Hill *et al.* (1974).

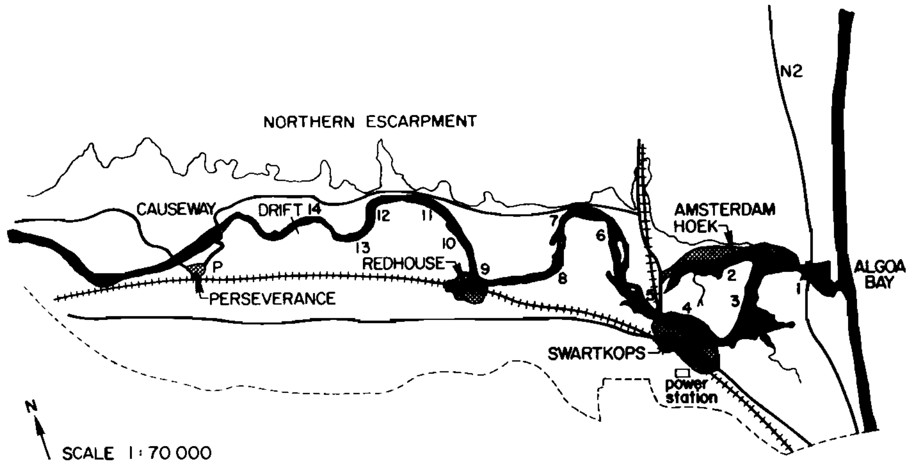

Fig. 1 Map of the Swartkops estuary, showing the sampling stations and main residential area (from Swartkops Trust 1971).

Collection of data

Altogether 14 stations were sampled on the Swartkops estuary (Fig. 1).The 2 km of estuary between Station 14 and the nick point are shallow, rocky and difficult to navigate by boat and were therefore unsampled. For the remaining 14 km sampling stations were equidistantly (approximately 1 km) spaced (Fig. 1). The ichthyoplankton was collected with a WP2 plankton sampler similar to that described by Anon (1968) and differing only in modifications which made it suitable for surface sampling. The mouth opening was 57 cm in diameter and the netting material used was St Martins nylon mesh with aperture size 190μ. A Kahlsico 005WA 130 flow-meter was fitted in the mouth of the net.

Sampling was carried out monthly. Netting commenced approximately one half hour after dark. Although not always possible, every effort was made to sample on a slack tide prior to its turning. Sampling always commenced at Station 14 and proceeded down the estuary to Station 1 (Fig. 1). The WP2 net was mounted on a boom on the bow of a 4,5 m skiboat and was towed alongside the boat, approximately 0,5 m away from the side. Samples were thereby taken in undisturbed water and not in the wake of the boat, thus reducing the possibility of the larger, fast-moving larvae avoiding the net.

The net was towed at approximately three knots for a period of 3 min. at each station. A circular to oval trajectory was followed; this allowed sampling near to the banks as well as in the mid-channel, thus eliminating any bias that might have resulted from following a more uniform course. Because the estuary depth seldom exceeds a few metres and in most parts is exceedingly shallow (1 – 2 m) with an uneven bottom, it was impractical to take samples at different levels of the water column and therefore only the surface was sampled to a depth of about 0,6 m (the net diameter was 0,57 m).

At each station the surface and bottom temperature and salinity were recorded immediately before a plankton tow, using a Yellow Springs YSI model 33 SCT meter. At point of capture, the plankton samples were placed into 5% formalin and stored until analysis. In the laboratory, fish larvae were separated from the rest of the plankton using a stereo-microscope. All larvae were then identified and their numbers expressed per m^3 of water sampled.

In this study the term 'fish larvae' is defined as the developmental period from the moment of hatching up to the point of metamorphosis into a juvenile fish. The transitional stage between larva and juvenile is difficult to define Ahlstrom (1968); however, Louw and O'Toole (1977) defined the juvenile stage as that in which the fish possesses all the basic adult characteristics which is the criterion we have used.

The changes which occur during metamorphosis are subtle, usually requiring study under magnification. These changes often extend over a considerable length increment of the fish and hence the maximum lengths of some larval species recorded in this study, may have been considered as juvenile fish in papers by other authors dealing with these species.

Results

Hydrological

To present all the monthly temperature and salinity data would serve little purpose, especially in view of the fact that there was little variation between surface and bottom readings, or between one station and the next. The estuary has therefore been divided, on the basis of temperature and salinity, into four sections along its length, namely:

A The mouth region
(Stations 1, 2 & 3)

B The area affected by a warm water outlet from a nearby power station
(Stations 4, 5 & 6)

C The mid-estuarine reaches
(Stations 7, 8, 9 & 10)

D The upper estuary
(Stations 11, 12, 13 & 14).

Figure 2 shows the mouth region to have the least fluctuation in temperature presumably because of the moderating influence of the sea. The other three areas all showed large seasonal fluctuations with high temperatures in the summer months (November – February) and low temperatures in the winter months (June – August). The highest temperature recorded during the two-year survey was 31,5 °C (Station 6, February 1977) and the lowest was 13,8 °C (June 1977, Stations 6 – 11).

The area influenced by the warm-water outlet (B in Fig. 2) was usually slightly warmer than the rest of the estuary, particularly Station 5 which was at the mouth of the outlet.

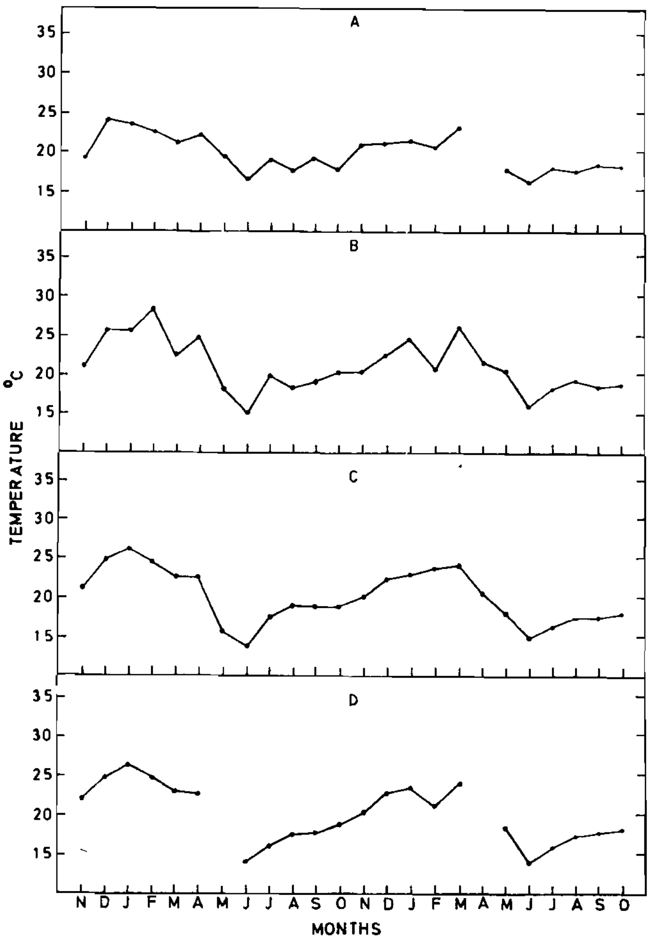

Fig. 2 Mean monthly surface temperature from November 1976 — October 1978. A = Mouth region (Stations 1—3); B = Warm-water outlet region (Stations 4—6); C = Mid-estuary region (Stations 7—10) and D = Upper estuary (Stations 11—14).

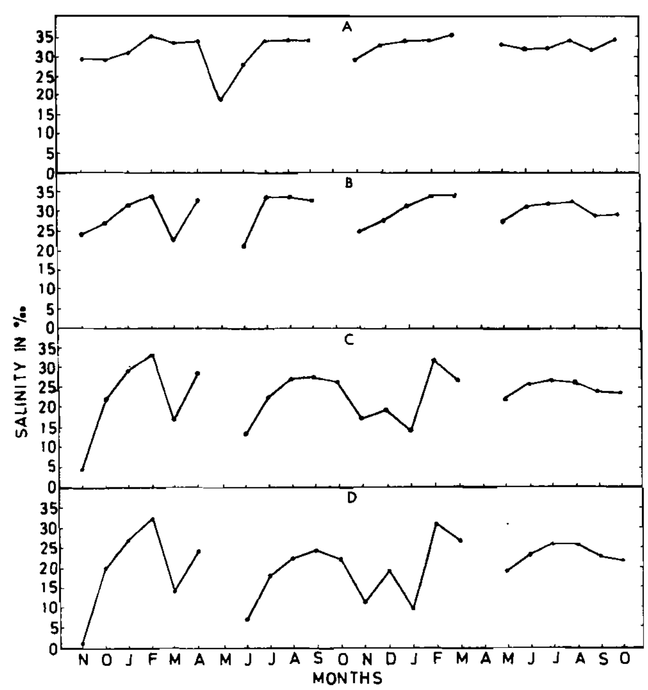

Fig. 3 Mean monthly surface salinities from November 1976 — October 1978. A = Mouth region (Stations 1—3); B = Warm-water outlet region (Stations 4—6); C = Mid-estuary region (Stations 7—10) and D = Upper estuary (Stations 11—14).

Table 1 Larval fish species in the Swartkops estuary during November 1976 — October 1978. The common names of the species are those suggested by Smith (1975). The fish are in order of abundance

Species	Common name	Frequency occurence in 314 tows
Gobiidae (ex. *P. knysnaensis*)	Gobies	147
Gilchristella aestuarius	Estuarine round-herring	135
Psammogobius knysnaensis	Knysna sandgoby	127
Omobranchus woodi	kappie blenny	103
Rhabdosargus sp.	Stumpnose	62
Hepsetia breviceps	Cape silverside	46
Monodactylus falciformis	Cape moony	46
Elops machnata	Tenpounder	25
Stolephorus commersoni	Tropical anchovy	25
Argyrosomus hololepidotus	Kob	24
Solea bleekeri	Blackhand sole	17
Etrumeus teres	Redeye round-herring	14
Heteromycteris capensis	Cape sole	8
Hemiramphus far	Spotted halfbeak	5
Pomadasys sp.	Grunters	4
Syngnathus acus	Longnose pipefish	4
Platycephalus indicus	Bartail flathead	3
Blenniidae (ex. *O. woodi*)	Blennie	2
Clinus superciliosus	Super klipfish	2

Rainfall in the catchment area of the Swartkops estuary is unseasonal, occurring all year round. The tendency is for a large proportion of the annual rain to fall during a few consecutive days often resulting in minor floods and consequently low salinities throughout the estuary (Fig. 3).

Difference between the surface and bottom waters was small. The temperature seldom varied by more than 1 °C while the salinity difference was usually of the order of 1‰ and never exceeded 4‰.

Biological

Species composition

The species composition and comparative abundance of each larval fish species is presented in Table 1. A total of 15 families, represented by 17 species was positively identified during November 1976 to October 1978. Although the juveniles and adults of the family Mugilidae numerically represent one of the most dominant families of the Swartkops estuary, no larvae were sampled in the estuary throughout the study period, though juvenile fish of 13 mm and larger were relatively abundant.

Relative species abundance

Comparative abundance of fish larvae have been expressed in two ways, *viz.* in terms of the number of plankton tows in which each species occurred, out of 314 (the total number of plankton tows performed over the two-year sampling period (Table 1) and as a percentage based on the sum of all the larvae expressed as numbers/m^3 water at each of the 314 stations sampled (Table 2).

The first method (Table 1) may over-emphasize the importance of some species merely because they have longer spawning seasons and the larvae are therefore present in the

Table 2 Larval fish in the Swartkops estuary in order of percentage composition which each species formed of the total number of larvae sampled (November 1976 — October 1978). The mean number of each species/m³ water positively sampled and the maximum (modal) and minimum sizes sampled over the same period are also recorded

Species	% Composition by number	Mean no./m³ water	Length (mm) min.	(modal)	max.
Gobiidae	56,233	1,324	2	(3)	18
Gilchristella aestuarius	31,124	0,907	2	(5)	28
Omobranchus woodi	6,725	0,306	3	(4)	22
Psammogobius knysnaensis	3,209	0,133	2	(3)	11
Hepsetia breviceps	0,865	0,074	4	(12)	20
Rhabdosargus sp.	0,519	0,056	6	(13)	20
Monodactylus falciformis	0,268	0,030	6	(8)	10
Argyrosomus hololepidotus	0,207	0,048	2	(3)	16
Etrumeus teres	0,205	0,063	14	(22)	33
Stolephorus commersonii	0,185	0,044	18	(28)	33
Solea bleekeri	0,127	0,039	4	(5)	6
Elops machnata	0,094	0,021	31	(34)	39
Heteromycteris capensis	0,057	0,033	7	(9)	10
Unidentified larvae	0,050	0,063	—	—	—
Syngnathus acus	0,036	0,042	10	(12)	14
Pomadasys sp.	0,019	0,029	10	(15)	19
Platycephalus indicus	0,018	0,046	7	(11)	12
Hemiramphus far	0,015	0,018	6	(—)	31
Clinus superciliosus	0,012	0,035	16	(—)	26
Blenniidae	0,009	0,028	8	(—)	14

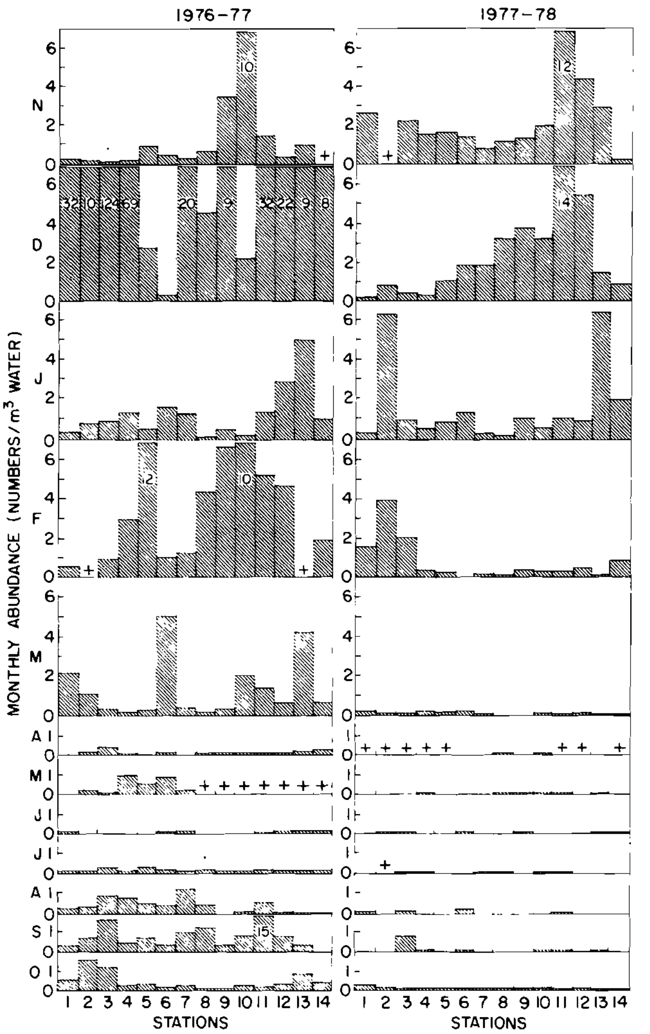

Fig. 4 Monthly abundance of all larval fish species in the Swartkops estuary, November 1976 — October 1978. (+ = Unsampled stations).

plankton for long periods of time. On the other hand, the second method (Table 2) may bias the importance of a single species due to one, or even several, patchy encounters of high larval numbers of a certain species.

Data from Table 2 leave no doubt that *Gilchristella aestuarius* (31,12%) and the family Gobiidae (59,44%) are the most important members of the larval fish community in the Swartkops estuary. In terms of numbers (Table 2) they accounted for 90,56% of all the larvae sampled over the two-year period. Aside from *Omobranchus woodi* (6,75%) no other species was particularly abundant numerically, though other species, *Rhabdosargus* sp., *Hepsetia breviceps* and *Monodactylus falciformis,* were abundant in terms of frequency sampled (Table 1). Their mean number/m³ water, however, was low (Table 2).

Spacial distribution

The combined distribution of the fish larvae in the Swartkops estuary over the period November 1976 to October 1978 is presented in Fig. 4. The figure shows large seasonal variations in numbers of larvae/m³ water, but no apparent spacial pattern. Since *G. aestuarius* and the family Gobiidae accounted for 90,57% of the ichthyoplankton sampled, it is largely their abundance which is reflected in Fig. 4. Separate figures therefore show the distribution of *G. aestuarius* (Fig. 5) and Gobiidae (Fig. 6).

Figure 5 shows that *G. aestuarius* larvae occurred in large numbers in the middle and upper reaches of the estuary from October to January. This distribution of *G. aestuarius* larvae, together with the presence of adult and ripe fish in that part of the estuary during summer (Talbot 1978) would indicate that *G. aestuarius* undoubtedly spawns in the upper reaches. As the larvae grow older (18 mm & larger), their distribution often extends down to the mouth as in February, March and May 1977 and December and January 1978 (Fig. 5). It would appear from Fig. 3 that the distribution of *G. aestuarius* larvae in the upper estuary is unlikely to be related to salinity.

Figure 6 shows that larvae of the family Gobiidae (excluding *P. knysnaensis*) dominated the lower estuary especially the mouth region. Virtually all these gobiid larvae were identified as one species. Because *Gobius nudiceps* adults are common amongst the rocks and jetties along the east bank of the estuary, it is assumed these larvae were of that species. Small numbers of an obviously different larval gobiid were recorded at the head of the estuary (Fig. 6). It is assumed these were larvae of *Glossogobius giuris,* a species common in the upper estuary and even in the rivers feeding the estuary. Detailed distribution trends of other species encountered in the estuary have not been included in this paper. They are, however, discussed in some detail elsewhere (Melville-Smith 1978).

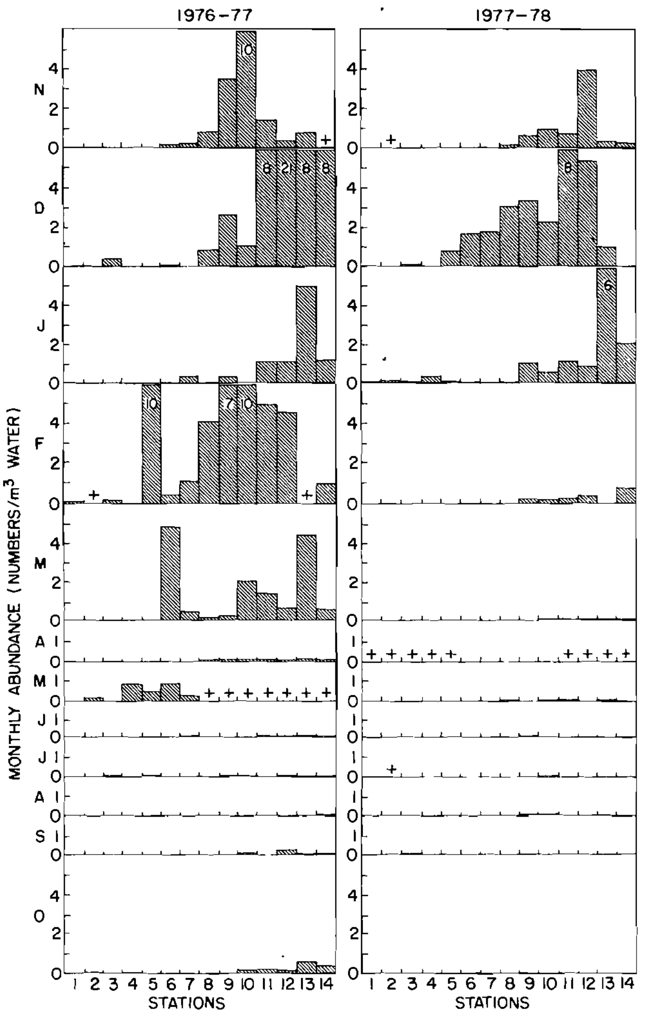

Fig. 5 Monthly abundance of *Gilchristella aestuarius* larvae in the Swartkops estuary, November 1976 — October 1978. (+ = Unsampled stations).

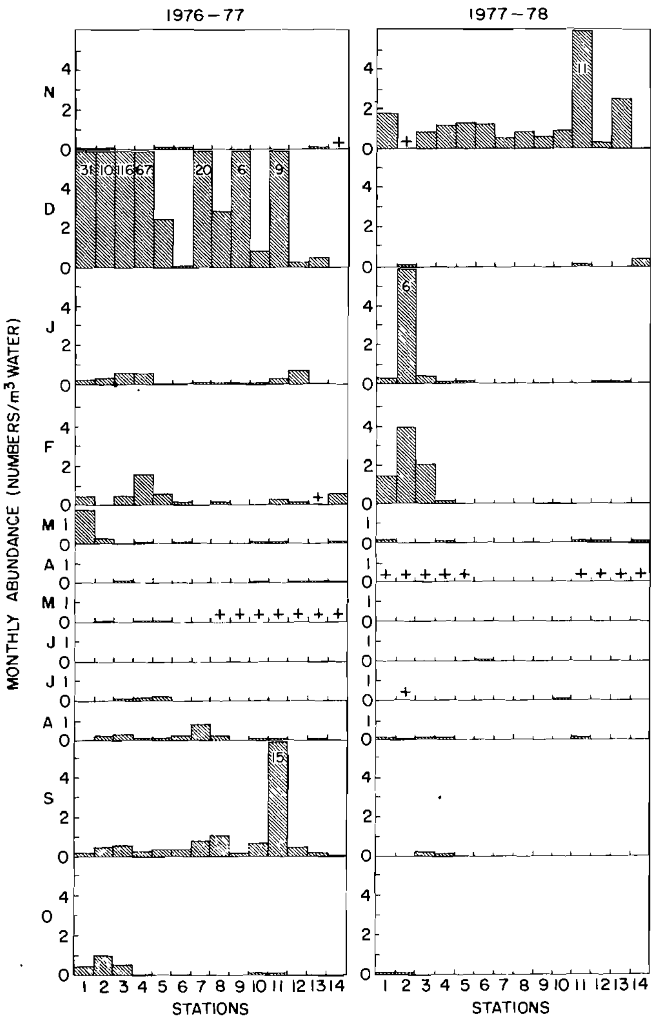

Fig. 6 Monthly abundance of gobiid larvae (excluding *P. knysnaensis*) in the Swartkops estuary, November 1976 — October 1978. (+ = Unsampled stations).

Seasonal occurrence

Figure 4 shows the monthly abundance of all fish larvae sampled during the survey period. During both years of the survey, the warm summer water experienced from November to February (Fig. 2) was characterized by the presence of large numbers of fish larvae in the estuary. An increase in water temperature is a recognized spawning stimulus in fish of the temperate zones (Hoar 1969) and the consequent high larval numbers in these months was therefore to be expected.

Environmental conditions appear to have been more favourable during the 1976/77 season (November 1976 – October 1977) than the corresponding period in 1977/78, because during the former year larvae were sampled in relatively high numbers during the cooler months of March, August, September and October.

Detailed seasonal fluctuations of the dominant larvae are apparent from Figs. 5 and 6. Figure 7 gives an indication of the seasonal fluctuations of all species and families recorded in the estuary based on their presence or absence in any one month. This figure clearly shows that although most of the larval fish species were present in the estuary over several months, virtually all were absent during the mid-winter months of low water temperatures (Fig. 2).

Discussion

Species composition and abundance

The diversity of larval fish sampled in the Swartkops estuary was extremely poor, especially when a total of 232 juvenile and adult fish species have been recorded in estuaries on the east coast of South Africa (Wallace 1975a).

There are no other quantitative data on South African estuarine fish larvae with which to compare numerical abundance; however the number of larvae/m³ water in this survey was high compared to similar American studies by, *inter alia*, Pearcy and Richards (1962), Herman (1963), Crocker (1965), Pearcy and Myers (1974), Austin (1976), Misitano (1977) and Able (1978).

The two dominant families in this study, Gobiidae and Clupeidae, also contained the most dominant species of the estuarine ichthyoplankton in the American studies cited above. In the 11-year survey of the ichthyoplankton of the Yaquina Bay estuary, Oregon, Pearcy and Myers (1974) found that two species, *Clupea harengus pallasi* (Pacific herring) and *Lepidogobius lepidus* (bay goby) accounted for 90% of all the fish larvae collected in their study. The similarity of these figures and families to those in the present study, are possibly indicative of parallel niche evolution of the dominant Gobiidae and Clupeidae in the two areas.

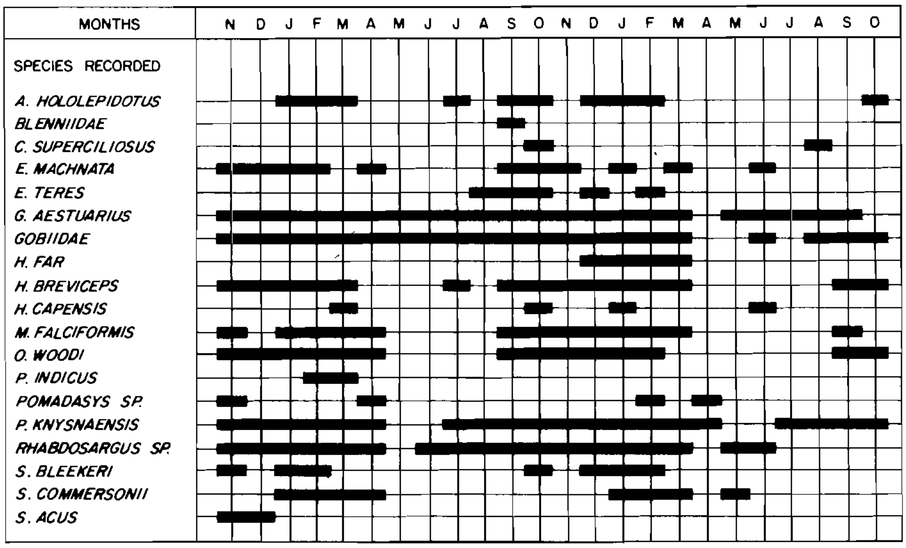

Fig. 7 Monthly occurrence of all the larval fish in the Swartkops estuary.

Distribution

It was apparent from the lengths recorded (Table 2), the number of times each species was recorded (Table 1), and the distribution of early larval stages in the estuary, that there are few fish species which spawn in the estuarine environment. There is little doubt that this is because estuaries are very unstable environments prone to vast salinity variations and constantly experiencing tidal currents. Few fish therefore spawn in this environment and few larvae enter estuaries until they are fully in control of their movements. For most fish species this is not until the juvenile stage of development.

Those species which appear to spawn in the Swartkops estuary include *Gilchristella aestuarius; Solea bleekeri; Syngnathus acus; Omobranchus woodi* and more than one gobiid species. Other larvae that were sampled in this study were species which are common in estuaries during the juvenile phase of their life cycle. Wallace (1975b) has presented evidence to show that the adults of many of the latter estuary-associated species spawn inshore, often near to estuary mouths, and hence the presence of small numbers of larvae inside the estuary is not surprising, since they could easily have been washed in with the tidal exchanges.

There are other families which spawn in the estuarine environment which have reproductive specializations enabling them to overcome the obvious difficulties that might befall eggs and larvae in this type of environment. Because of these specializations, these larvae were not in the plankton and therefore could not be sampled effectively with ichthyoplankton sampling equipment. The male of the family Syngnathidae, for example, has a brood-pouch in which the eggs and young are carried until an advanced developmental stage (Russell 1976). The family Tachysuridae, of which *Tachysurus feliceps* is a representative, is common in estuaries in South Africa (Smith 1965) and is a mouth brooder. Lastly, the family Clinidae is viviparous, thereby giving the ultimate protection to their offspring.

Seasonal occurence

The fact that, as suggested by Wallace (1975b), estuarine fish generally have extended spawning seasons to act as 'a "buffering" action against failure of recruitment as a result of droughts or unseasonal floods', was very apparent from the presence of larvae during most months of the year (Fig. 7).

It was noticed that there were small numbers of larvae recorded throughout the year, even in mid-winter months *Rhabdosargus* sp., *G. aestuarius* and species of Gobiidae (Fig. 7). This would at face value, suggest that spawning was taking place virtually all year round for these species, but only at a lower intensity during the winter months. However, Iles and Johnson (1962) reported for *Clupea sprattus,* that a portion of one year-class appears to be slow-growing and overwinters in a larval state. Although there is no evidence to confirm it, a similar situation may be occurring in some larval fish species sampled during winter in the present study.

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