Recruitment, diversity and the influence of constrictions on the distribution of fishes in the Wilderness lakes system, South Africa

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The Wilderness lakes system (22°35'E/34°00'S) comprises three interconnected lakes; Rondevlei, Langvlei and Eilandvlei. The latter is further connected by the Serpentine channel to a lagoon at Wilderness. The fish fauna is dominated by euryhaline marine species which migrate into the system as 0+ juveniles. During February 1984 it was calculated that 52 000 juvenile marine fishes migrated up the Serpentine towards Eilandvlei which serves as the system's major nursery area. Migration occurred mainly during the day and mostly towards high water. Fish communities throughout the system were sampled using seine and gill nets, and the Shannon-Weaver function used to describe them in terms of diversity. The system can be divided into three areas on the basis of this function. The lowest diversity in numbers and biomass occurs in Rondevlei and Langvlei which are furthest from the estuary mouth. Eilandvlei has an intermediate diversity with the Wilderness lagoon supporting the most diverse community. Although Eilandvlei and Langvlei have similar environments, there is a lower diversity in Langvlei. This is attributed to macrophyte encroachment and the shallow depth of the channel connecting these two lakes. In comparison with other South African coastal lake systems the fish fauna of the Wilderness lakes system is species poor. This is partly a result of the shallowness of interconnecting channels, intermittent open mouth phase and low diversity of marine/estuarine fishes in adjacent coastal waters.

Die Wildernis-meresisteem (22°35'O/34°00'S) bestaan uit drie mere wat met mekaar verbind is; Rondevlei, Langvlei en Eilandvlei. Laasgenoemde is verder by wyse van die Serpentine-kanaal verbind aan die strandmeer by Wildernis. Die visfauna word gedomineer deur eurihaliene mariene spesies wat in die sisteem immigreer as 0+ jong visse. Daar is bereken dat 52 000 jong visse gedurende Februarie 1984 deur die Serpentine beweeg het na Eilandvlei, wat dien as die sisteem se hoof kweekgebied. Migrasie het hoofsaaklik gedurende die dag en meesal teen hoogwater plaasgevind. Visgemeenskappe dwarsdeur die sisteem is met trek- en steinette gemonster, en diversiteit is met gebruik van die Shannon-Weaver funksie beskryf. Die sisteem kan in drie gebiede verdeel word op grond van hierdie funksie. Die laagste diversiteit in getalle sowel as biomassa kom voor in Rondevlei en Langvlei, wat verste van die monding is. Eilandvlei se diversiteit is intermediêr en Wildernis-strandmeer het die grootste verskeidenheid. Alhoewel Eilandvlei en Langvlei soortgelyke omgewings is, is daar 'n laer diversiteit in Langvlei. Dit word toegeskryf aan makrofietindringing en die vlak water van die kanaal tussen die twee mere. In vergelyking met ander Suid-Afrikaanse kusmeersisteme is die visfauna van die Wildernis-meresisteem arm aan spesies. Dit is gedeeltelik toe te skryf aan die vlakte van die verbindings, wisselvallige oopmondfase en lae diversiteit van mariene/estuariese visse in aangrensende kuswaters.

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Several workers (e.g. Wallace 1975; De Silva & Silva 1979; Torricelli, Tongiori & Almansi 1982) have examined the recruitment of juvenile fishes into estuaries. Although the seasonality of migration has been investigated, quantification of juvenile recruitment has been neglected (Beckley 1985). This paper examines day/night migration patterns in a channel leading to the major nursery area of the Wilderness lakes system and provides an estimate of the numbers of juvenile marine fishes entering the middle section of the system during the main recruitment period (Allanson & Whitfield 1983). In addition the distribution and diversity of fishes within the system is related to various environmental factors, including physico-chemical characteristics, extent of aquatic macrophyte communities and the condition of the channels connecting the lakes.

Study area

The Wilderness lakes system is composed of a series of coastal lakes of two main origins. The first two lakes, Eilandvlei and Langvlei are barrier lagoons while the third, Rondevlei is a deflation basin which has been artificially connected by a channel to Langvlei (Figure 1). The lakes and their associated wetlands provide a lateral flood plain for the principal river inflow, the Touw River, of which the Wilderness lagoon is its proper estuary. In common with many estuaries along the South African coast, they are subject to wide variation in hydrology largely as a result of mouth closure by easterly transport of sand in the longshore current, and erratic river inflow (Heydorn & Tinley 1980). During this study (June 1982 – February 1984) the Touw River mouth was closed only between July and September 1982.

The Wilderness lagoon is shallow, varying from 1 m deep in the lower reaches to 3,5 m in the vicinity of the Serpentine. The lakes are all deeper than the lagoon, with a maximum depth of 6,5 m in Eilandvlei, 4,0 m in Langvlei and 6,0 m in Rondevlei. Water temperature ranged from 13 – 26°C during the study period and dissolved oxygen remained at near saturation (Hall 1985). The reversed salinity gradient (Eilandvlei = 4‰, Langvlei = 5‰, Rondevlei = 9‰) is due to reduced riverflow in the upper parts of the system (Figure 1), coupled with evaporation which normally exceeds freshwater inflow.

During the study period, submerged macrophyte communities in the lakes recovered from a major die-back which occurred between 1979 and 1981. Biomasses in excess of 1000 g m^{-2} dry weight were recorded during 1983 in both Eilandvlei and Langvlei, where *Potamogeton pectinatus* was the dominant species. These macrophytes support a rich epibenthic invertebrate community (Davies 1982). In Rondevlei, where *Ruppia cirrhosa* was the dominant species, growth was less prolific. However, from May 1982 to May 1983 macrophyte beds in this lake expanded from 30% to approximately 90% of the littoral zone (Hall 1985).

The interconnecting channels between the lakes can be

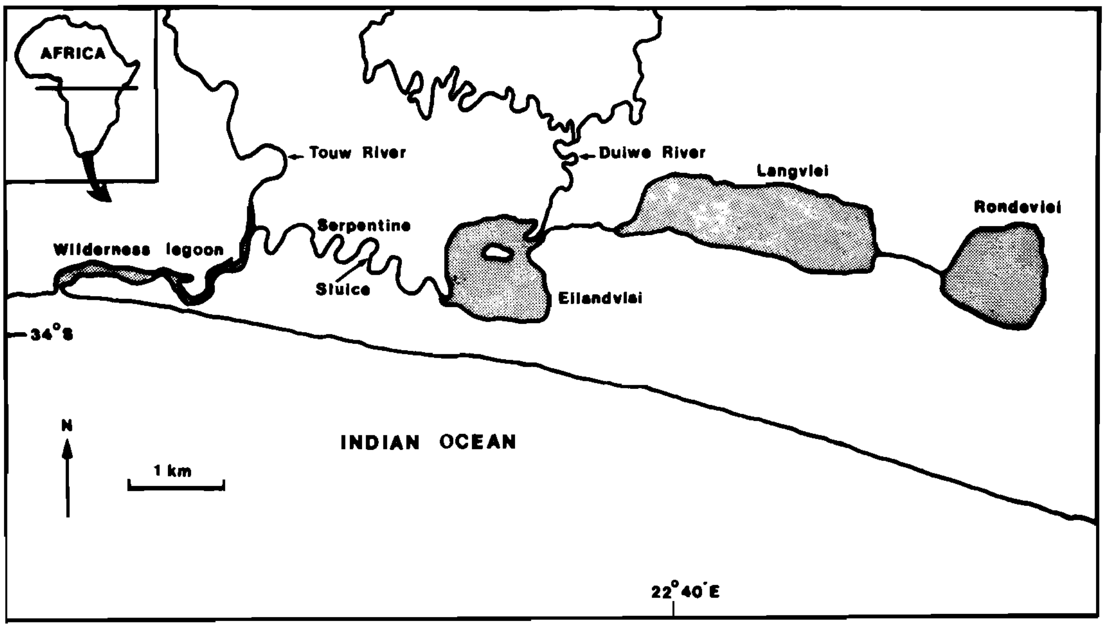

Figure 1 Map of the Wilderness Lakes system on the southern Cape coast.

characterized by depth and degree of macrophyte encroachment. The Langvlei/Rondevlei channel normally exceeds a depth of 1 m and was not subject to severe macrophyte encroachment. In December 1982 approximately 30% of the channel supported macrophytes with a mean biomass of 662 g m^{-3} dry weight. The Eilandvlei/Langvlei channel was very shallow and when water levels drop to below 1,0 m above mean sea level, sections become exposed and free water exchange between the lakes ceases. Unlike the Langvlei/Rondevlei channel the Langvlei/Eilandvlei channel has many inlets penetrating a surrounding wetland. In December 1982 macrophytes grew over 80% of the channel with a mean biomass of 1468 g m^{-3} dry weight and maximum biomasses in excess of 4000 g m^{-3} dry weight were recorded. During this study the Serpentine only supported macrophytes in its upper reaches and in December 1982 a mean biomass of 393 g m^{-3} dry weight was measured (Hall 1985).

Materials and Methods

Recruitment

Two traps based on a fyke-net design were built to catch all fishes moving across a section of the Serpentine. Their rectangular steel frames, which measured 1 m × 1 m × 2 m, were covered in monofilament netting with a rectangular mesh size of 1 × 2 mm. The front of each trap supported a funnel with a mouth measuring 10 × 15 cm, which extended 0,5 m into the trap. The back of each trap was covered from the bottom up by a sheet of netting measuring 1,0 m × 0,6 m. The 1,0 m × 0,4 m gap above this sheet allowed access to the trap so that it could be emptied with a 0,5-mm mesh dip net.

The traps were placed back to back in a shallow area of the Serpentine. Two wings made of 1 × 2 mm netting were sewn onto them and angled across the width of the Serpentine so that fish encountering them would be funnelled into the mouth of the trap. The bottom of the wings were anchored and each was long enough to span the width of the Serpentine under all tidal conditions. They were set in February 1984 for a total of 56 h, during which time both day and night sampling was undertaken. The nets were emptied hourly and the mean water depth and current direction also recorded.

Distribution and diversity

The system was sampled for one year on a seasonal basis (winter = June – August; spring = September – November; summer = December – February; autumn = March – May) using four types of fishing gear. During each sampling a set of five multifilament gill-nets, each measuring 25 m × 2,75 m with stretch meshes of 35, 45, 57, 73 and 93 mm were set for three nights in different positions on each of the lakes and the lagoon. Three beach seines were also used. The smallest measured 10 m × 2 m deep and was constructed from 28 mm stretch mesh anchovy netting in the wings and 10 mm stretch mesh for the bag. This seine-net was laid by hand in water < 1,0 m deep and was used 10 times in each of the lakes and lagoon per season. A larger multifilament seine-net (30 m × 3 m × 28 mm stretch mesh) was laid from a boat approximately 30 m offshore and employed in Rondevlei, Eilandvlei and Wilderness lagoon during the winter and spring. Filamentous algae which grew over the littoral zone of the lakes in the summer of 1982/83 clogged the large multifilament seine so it was replaced by a monofilament net with a 50 mm stretch mesh. This net was also set from a boat and was used 10 times in each of the lakes and lagoon during the summer and autumn.

Fish catches were analysed by number of fish per species and weight of fish per species. Community analyses were performed using the following indices:

(a) The Shannon-Weaver function $H = -\Sigma P_i \log_e P_i$ where P_i = proportion of ith species (Shannon & Weaver 1963). Both numerical and gravimetric data were used (Wilhm 1968).

(b) Heip's evenness index $E = (e^H - 1)/(S - 1)$ where e is the base of natural logs, H is the calculated value for diversity and S is the number of species (Heip 1974).

Results

Recruitment

The traps were found to be selective for fishes above 10 mm standard length (SL) and the majority of fishes captured were in the 10 – 20 mm SL size class. Over 98% of individuals captured measured < 60 mm SL and only two fish > 100 mm SL were recorded. These were both *Liza richardsonii* (160 mm, 195 mm SL) and were captured moving down the system towards the lagoon. Altogether 14 species were captured. These were: the flathead mullet *Mugil cephalus*, southern mullet *Liza richardsonii*, groovy mullet *Liza dumerilii*, freshwater mullet *Myxus capensis*, Cape stumpnose *Rhabdosargus holubi*, white steenbras *Lithognathus lithognathus*, Cape moony *Monodactylus falciformis*, estuarine roundherring *Gilchristella aestuaria*, Cape silverside *Atherina breviceps*, kurper bream *Oreochromis mossambicus*, Knysna sandgoby *Psammogobius knysnaensis*, prison goby *Caffrogobius multifasciatus*, checked goby *Redigobius dewaali* and Cape kurper *Sandelia capensis*. The first seven species listed form a marine migratory component (Wallace 1975).

More than 99% of the fishes were captured in the net facing Wilderness lagoon (downstream) and catches increased as water levels approached high tide and decreased towards low tide. Figure 2(a) illustrates the changes in size composition of *L. richardsonii* captured during the day at three different water depths and Figure 2(b) shows the same trend with *R. holubi* captured at night. The immigration per hour, i.e. the number of fishes moving upstream minus those moving downstream is plotted relative to depth in Figure 3 with curves showing both day and night immigration. Juvenile fish migrated upstream on both the flood and ebb tide, provided water depths were > 5 cm. Water velocities in the Serpentine during the study period seldom exceeded 20 cm s^{-1} (Hall 1985).

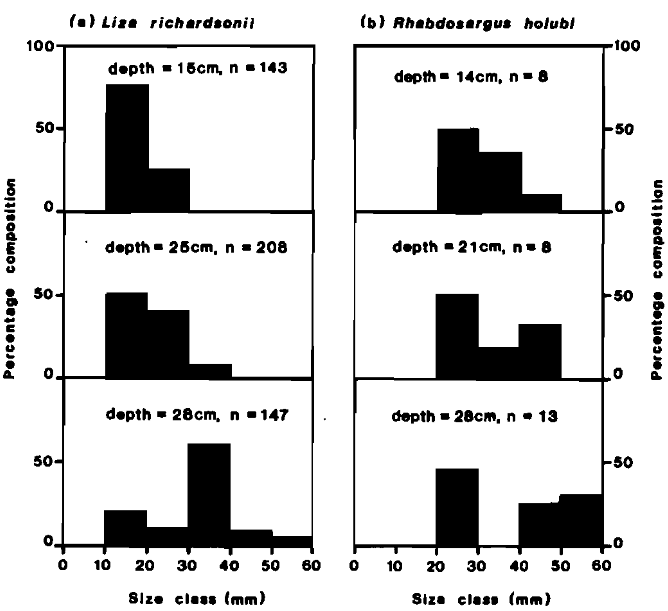

Figure 2 Size composition of (a) *Liza richardsonii* captured during the day and (b) *Rhabdosargus holubi* sampled at night in three different water depths.

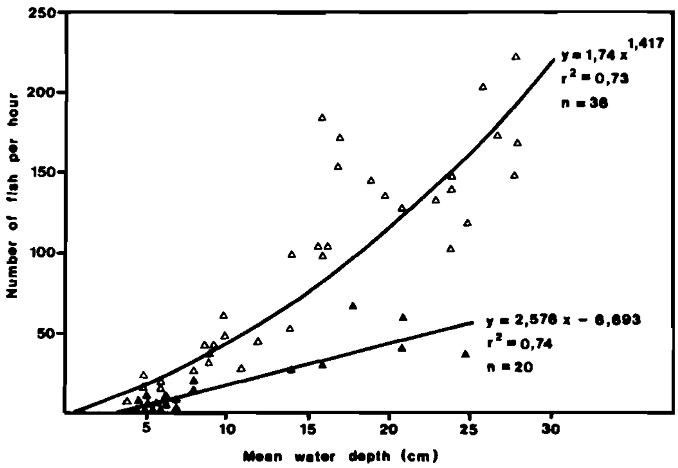

Figure 3 Numbers of juvenile marine fish migrating up the Serpentine per hour relative to water depth during the day (△) and night (▲).

Of the 2527 juvenile marine fishes caught during the day, 84% were *L. richardsonii*. Altogether the Mugilidae comprised 99% of the daytime catch with only one *M. falciformis* and four *R. holubi* being recorded. At night, however, 18% of the 358 juvenile marine fishes captured were *R. holubi* and 11% *M. falciformis*. Mullet comprised 71% of the catch at night and most of these individuals were *L. dumerilii* which constituted 40% of the total catch. The catch composition of species comprising > 10 individuals during both the day and night is shown in Figure 4.

Over the range of depths examined, daytime migration was always greater than movement at night. The total number of juvenile marine fishes migrating into Eilandvlei during February 1984 was estimated using the curves in Figure 3. Over this month in the southern Cape, there are approximately 14 h between sunrise and sunset, with about 10 h of darkness. Water level data from the netting area were matched with the hours of daylight and darkness and it was calculated that approximately 52 000 fishes migrated up the Serpentine during February.

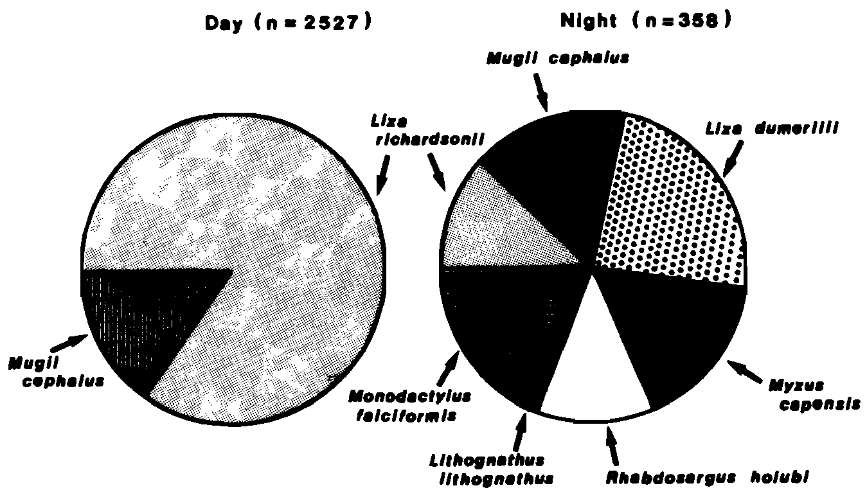

Figure 4 Catch composition of juvenile marine species from the Serpentine trap during the day and night (*n* = number of fish in sample).

Distribution and diversity

A total of 32 fish species was recorded in the system. The catch composition of all fishes from Wilderness lagoon, Eilandvlei, Langvlei and Rondevlei is shown in Table 1. Altogether 23 species were recorded in the Wilderness lagoon, 16 in Eilandvlei, 11 in Langvlei and 12 in Rondevlei.

The system was dominated by species from the families Mugilidae and Cichlidae, with the former comprising over 40% of the total catch biomass in each area. *Liza richardsonii* was the numerically dominant mullet species in all areas and was also gravimetrically dominant except in Eilandvlei where *Liza dumerilii* was the major species. The size of mullet increased from Eilandvlei, where individuals less than 50 mm SL were the dominant size group, to Rondevlei where individuals greater than 300 mm SL were common. The mean individual weight of mullet in Eilandvlei was 26 g, Langvlei 135 g and Rondevlei 154 g. The cichlid *Oreochromis mossambicus* contributed 28%, 22% and 34% to the total biomass of fish captured in Eilandvlei, Langvlei and Rondevlei respectively. However, 99% of these fish were captured during the summer and autumn. This species was captured in both gill and seine-nets, but during the winter and spring was rarely caught in the latter gear.

The only other fishes to exhibit seasonal trends were the small pelagic species *Atherina breviceps* and *Gilchristella aestuaria*. These showed an 18-fold increase in the number of individuals captured between winter and summer. *A. breviceps* was the most common individual species encountered in all the lakes but accounted for < 1% of the total catch from Wilderness lagoon. *A. breviceps* and *G. aestuaria* together comprised 96%, 94% and 54% of the total catch (numerical) in Langvlei, Rondevlei and Eilandvlei respectively.

Other major contributors to the fish fauna of the lakes were the sparids *Rhabdosargus holubi* and *Lithognathus lithognathus*. While only one *R. holubi* was captured in Langvlei, 701 were caught in Eilandvlei and 33 in Rondevlei. Together with the 204 *L. lithognathus* caught in Eilandvlei, they constituted 21% of the biomass of fish captured in this lake. Like the Mugilidae, the smallest sparids were found in Eilandvlei and the largest in Rondevlei. The mean individual weight of *R. holubi* captured in Eilandvlei was 30 g and in Rondevlei 144 g.

Nine of the 23 species recorded in Wilderness lagoon were not found in other parts of the system. Of these the major species were *Lichia amia* and *Argyrosomus hololepidotus*, which constituted 30% of the biomass captured in gill-nets set in the lagoon. Table 1 shows that species richness declines towards Rondevlei despite the higher numbers of fishes

Table 1 Gill and seine-net catch composition in different areas of the Wilderness lakes system between June 1982 and May 1983 ([1] = euryhaline marine species, [2] = estuarine species, [3] = freshwater species)

		Wilderness lagoon		Eilandvlei		Langvlei		Rondevlei	
Fish species	Family	Numbers	Biomass (g)	Numbers	Biomass (g)	Numbers	Biomass (g)	Numbers	Biomass (g)
Amblyrhynchotes honckenii[1]	Tetraodontidae	1	40	–	–	–	–	–	–
Atherina breviceps[2]	Atherinidae	6	10	8114	4270	30893	2075	43531	31266
Argyrosomus hololepidotus[1]	Sciaenidae	61	38001	–	–	–	–	–	–
Caffrogobius multifasciatus[2]	Gobiidae	132	71	9	335	–	–	–	–
Clinus superciliosus[2]	Clinidae	–	–	–	–	–	–	1	2
Diplodus sargus[1]	Sparidae	7	804	–	–	–	–	–	–
Galeichthys feliceps[1]	Ariidae	37	10910	–	–	–	–	–	–
Gilchristella aestuaria[2]	Clupeidae	336	310	2101	2447	964	637	2919	1411
Heteromycteris capensis[1]	Soleidae	18	133	26	29	–	–	684	1862
Hyporhamphus capensis[2]	Hemiramphidae	–	–	40	111	14	19	–	–
Lichia amia[1]	Carangidae	116	25278	–	–	–	–	–	–
Lithognathus lithognathus[1]	Sparidae	162	29541	204	24060	–	–	–	–
Liza dumerilii[1]	Mugilidae	341	26062	717	43127	17	1601	126	16387
Liza richardsonii[1]	Mugilidae	1581	47800	2106	32897	347	43602	572	79735
Liza tricuspidens[1]	Mugilidae	17	3774	–	–	–	–	–	–
Micropterus salmoides[3]	Centrarchidae	–	–	6	2554	5	4	–	–
Monodactylus falciformis[1]	Monodactylidae	40	1049	200	8558	–	–	1	8
Mugil cephalus[1]	Mugilidae	278	5826	475	4536	72	87892	73	22559
Myxus capensis[1]	Mugilidae	20	3949	34	6737	6	711	12	4828
Oreochromis mossambicus[3]	Cichlidae	63	7161	4058	59981	756	37892	1550	83784
Pomadasys commersonnii[1]	Haemulidae	4	574	–	–	–	–	–	–
Psammogobius knysnaensis[1]	Gobiidae	64	60	9	10	–	–	–	–
Rhabdosargus holubi[1]	Sparidae	590	14796	701	21357	–	135	33	4764
Rhabdosargus sarba[1]	Sparidae	–	–	1	27	–	–	–	–
Syngnathus acus[2]	Syngnathidae	–	–	–	–	–	–	3	4
Sarpa salpa[1]	Sparidae	151	102	–	–	–	–	–	–
Solea bleekeri[2]	Soleidae	21	132	–	–	1	26	–	–
Trachurus capensis[1]	Carangidae	2	111	–	–	–	–	–	–
Total		4048	216494	18801	211056	33075	174594	49504	246610
Number of species		23		16		11		12	

captured in the Langvlei/Rondevlei area. Analysis of numerical and gravimetric data in terms of the Shannon-Weaver function (*H*) reinforces the conclusion that diversity declines up the system (Figure 5). Community structure in terms of Heip's evenness index suggests that Wilderness lagoon and Eilandvlei differ from Langvlei and Rondevlei which are similar (Figure 5).

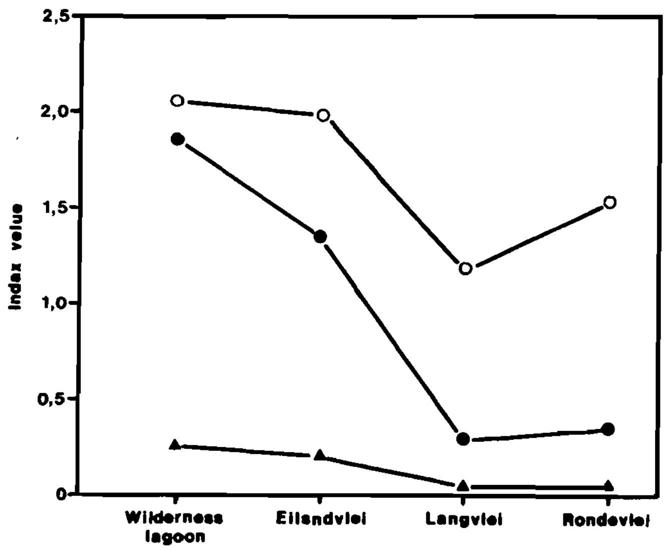

Figure 5 Fish species diversity values from the Wilderness Lakes system. The Shannon-Weaver diversity index (numerical = ●, gravimetric = ○) and Heip's evenness index (▲) are shown.

Discussion

In common with most South African estuaries (Day, Blaber & Wallace 1981), the fish fauna of the Wilderness lakes system is composed largely of a marine migratory component. Recruitment of these species into the lakes was investigated using the Serpentine fish trap. This gear captured seven of the eight marine species represented by juveniles in the lakes, the exception being a solitary individual of *Rhabdosargus sarba* recorded in Eilandvlei. Apart from *Liza dumerilii*, the mullet species were well represented in the 10–20 mm size group, thus corresponding to length classes recruiting into other South African estuaries (Wallace & van der Elst 1975). *Liza richardsonii* in the Serpentine tended to migrate during the day which contrasts to observations on *Mugil cephalus* in Sri Lanka (De Silva & Silva 1979). However, in the Arno River, Italy, two peaks in the catches of five species of juvenile mullet, one after sunset and a slightly reduced peak in the morning have been recorded (Torricelli *et al.* 1982). *L. dumerilii* in the Serpentine were captured mainly at night (Figure 4) and in the St Lucia system this species was nocturnally active (Blaber 1976) which may account for its abundance in night catches. The deeper-bodied species such as *Rhabdosargus holubi, Lithognathus lithognathus* and *Monodactylus falciformis* were mainly captured at night (Figure 4) and only around high tide during the day. This suggests that these species may experience difficulty negotiating shallow water than more elongate Mugilidae. Their predominance in night catches may also be a predator avoidance behaviour.

The presence of only two fish greater than 100 mm SL in the traps may be attributed to the low water levels in the Serpentine during the investigation as well as a greater degree of trap avoidance by large individuals. Furthermore, at the time of sampling the estuary mouth had been continuously open for 16 months, thus affording ample opportunity for sub-adults and adults to emigrate to the sea.

A literature review suggests that this investigation is one of the few (Yakupzack, Herke & Perry 1977; Beckley 1985) to quantify the magnitude of juvenile marine fish migration in an estuarine system. To date most workers examining the activity of marine fishes in estuaries have used active sampling methods which are more selective than the passive sampling used in this study. The advantages of the traps used in the Serpentine were that they sampled its entire width and there was minimal human interference during sampling. Their effectiveness was endorsed by observations suggesting that the traps captured the majority of fish shoals moving into the area. Nevertheless, the fact that fish were occasionally seen to swim up the wings of the trap before moving away suggests the migration estimates can be regarded as conservative.

Although water depth influenced fish migration (Figure 3) the direction of tidal flow appeared to be unimportant, possibly a result of low water current velocities (< 20 cm s^{-1}). Beckley (1985), working in the Swartkops estuary mouth where current velocities > 100 cm s^{-1} were recorded, ascertained that flood tide immigration of juvenile *Liza richardsonii, Rhabdosargus holubi* and *Monodactylus falciformis* was significantly greater than ebb tide efflux. In contrast De Silva & Silva (1979) found that tides had little influence on the migratory behaviour of *M. cephalus*. However, Torricelli *et al.* (1982) noticed that catches of five species of mullet, including *M. cephalus* increased around high tide. The increase in the number of juveniles migrating up the Serpentine around high water was independent of flow direction and may have been a function of the shallowness of the sampling station at low tide. Fish avoid swimming in exceptionally shallow water possibly because of increased vulnerability to bird predation (Kushlan 1976). If migration was hindered by water depth, then the number of juvenile marine fishes recruiting into the lakes during February may have been lower than for the same month in years when water levels were higher.

The dominance of the Mugilidae in the Serpentine traps was similar to their dominance of the marine fish component in seine and gill-net catches throughout the system. This family is often dominant in other South African estuaries e.g. Mhlanga (Whitfield 1980), Gamtoos (Marais 1982) and Kei (Plumstead, Prinsloo & Schoonbee 1985). The small size of mullet in Eilandvlei suggests that it serves as the system's initial nursery area for these species. The fact that larger individuals were found in Rondevlei may in part be a function of the Wilderness lakes systems reversed salinity gradient. Whitfield & Blaber (1978) have suggested that seasonal migration of adult *M. cephalus* towards the sea might be a negative response to freshwater cues. The Serpentine introduces both fresh and saline water into the lakes, and the low salinity 'plug' during the closed phase may cause some species to migrate up towards Rondevlei where salinities are higher but no sea link exists.

Most fish species captured during this study showed no distinct seasonality in abundance. However, *Oreochromis mossambicus* was rarely caught during winter and spring but accounted for 57% of the total biomass recorded from all lakes during the summer months. A similar winter disappearance of this fish from seine-net catches in Lake Sibaya has been documented by Bruton & Boltt (1975). The observed 18-fold increase in the numbers of *G. aestuaria* and *A.*

breviceps captured in the lakes between winter and summer corresponds closely with data from neighbouring Swartvlei where Whitfield (1982) calculated a 20-fold increase in the density of *G. aestuaria* between these two seasons.

Only one shoal of *O. mossambicus* was captured in the Wilderness lagoon during the closed phase with none recorded during the open phase. Although a freshwater species, this fish can withstand high salinities (Whitfield, Blaber & Cyrus 1981) but is rarely present in open tidal estuaries where current speeds exceed 0,1 m s^{-1} (Whitfield & Blaber 1979). Accordingly, this species may avoid the lagoon when the mouth is open because of strong water currents.

When diversity indices were applied to the fish data they were found to correspond well with field observations and suggest that the fish fauna of Langvlei and Rondevlei have similar structures with a low diversity. The fishes in these two lakes can be divided into the gravimetrically dominant Mugilidae and Cichlidae, and numerically abundant Atherinidae. In Eilandvlei, which is the major nursery area in the system, the species richness and diversity were higher than Rondevlei and Langvlei but lower than the Wilderness lagoon. Although the species composition and diversity of each area differ, the physico-chemical environment within the system has been shown by Hall (1985) to be similar.

The channels that connect the various lakes may restrict the movement of fishes, particularly during low water level periods which prevailed during this study. Upon entering the system the first channel encountered by marine fishes is the Serpentine. Species recorded west of the Serpentine and which were not sampled in the lakes were mainly large predators such as *A. hololepidotus, L. amia* and *G. feliceps*. In the Wilderness lagoon these species were normally found in deep water (> 2 m), whereas extensive shallow areas (< 0,5 m) within the Serpentine may act as a barrier to the movement of large fishes. The majority of juvenile marine fishes entering Eilandvlei do not migrate into Langvlei or Rondevlei, yet Langvlei supports prolific aquatic macrophyte beds which, like those in Eilandvlei, have a rich epifaunal invertebrate community (Allanson & Whitfield 1983). The Eilandvlei/Langvlei channel is shallow and supports dense submerged macrophyte beds which would restrict fish movement. This results in a considerable decline in diversity between Eilandvlei and Langvlei (Figure 5). Fish are, however, able to move up to Langvlei during the closed phase when water levels are higher. Having reached Langvlei it is easier for fishes to swim into Rondevlei than to return to Eilandvlei because the Langvlei/Rondevlei channel is both deeper and less encroached by macrophytes. Furthermore, Rondevlei may be more attractive to marine fishes because of its higher salinity. Once in Rondevlei, these fishes probably experience difficulty in leaving the system as no river enters this lake and no positive salinity gradient exists. This may account for the presence in Rondevlei of the largest marine fishes within the system.

In comparison with other southern African coastal lakes, the fish fauna of the Wilderness lakes system is species poor. Several authors (Wallace & van der Elst 1975; Blaber 1981; Whitfield 1983) have discussed ichthyofaunal diversity in southern African estuaries in terms of zoogeographical affinities. Many tropical and subtropical Indo-Pacific species, while common in the estuaries of Mozambique, Natal and Transkei, do not occur off the southern Cape coast and are therefore absent from adjacent estuaries. The number of fish species present in a periodically closed estuary is dependent on both the time that the mouth opens and the duration of the open phase (Whitfield 1980). During this study the mouth at Wilderness was closed between July and September 1982 which is not a peak recruitment period (Allanson & Whitfield 1983). Conditions were therefore ideal for the system to receive maximum recruitment and to attain a high species diversity. The low diversity in comparison with other estuarine systems may therefore be largely attributed to the relatively low species diversity of euryhaline marine fishes in adjacent coastal waters and shallowness of channels within the lakes system.

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