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Comparison of larval fish assemblages in three large estuarine systems, KwaZulu-Natal, South Africa

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Abstract The structure of the larval fish assemblages in three large estuarine systems on the KwaZulu-Natal coast of South Africa was examined using a combination of univariate, distributional and multivariate techniques. The database was comprised of a full annual set of larval fish samples taken from each estuarine system: Durban Harbour, Richards Bay Harbour and St Lucia Estuary. The mean monthly densities of each species in each system were used in the species matrix, and the mean monthly values of salinity, temperature and turbidity were used in the environmental matrix. The mean species diversity and evenness index were significantly higher in Durban Harbour ($H' = 1.03, J' = 0.65$) than in the other two systems. The cumulative dominance curve showed that St Lucia Estuary has a high dominance of a few species, with Richards Bay Harbour intermediate and Durban Harbour being the most diverse.

Classification and MDS (multiple-dimensional scaling) analyses of larval fish densities in all three systems grouped together into three main clusters on the basis of system. The species similarity matrix (inverse analysis) clustered into five groups at the 25% similarity level. The MDS analysis of the same matrix showed that the groups separated out according to the degree of estuarine association of a species and hence habitat type. The species most responsible for system groupings were: Glossogobius callidus, Gilchristella aestuaria, Stolephorus holodon, Croilia mossambica and Gobiid 12. The “best fitting” of the environmental variables to explain the larval fish community patterns in each system was turbidity on its own (weighted Spearman’s rank correlation, $r_w = 0.55$). The relationship of larval densities to environmental conditions was shown to be species-specific with estuarine species (e.g. G. callidus and G. aestuaria), having a strong positive correlation with temperature and turbidity but negative correlations with salinity. In summary, much longer term studies with more sites within each system are needed to assess whether the larval fish assemblages are stable or at an equilibrium (both spatially and temporally) and whether these assemblages are indicative of the relative “health” and nursery function of the system.

Introduction

Southern African estuaries are highly variable, unstable and unpredictable habitats, where environmental stress is pronounced and fish species diversity low (Whitfield 1994). Environmental stress on these systems is caused by both natural processes (e.g. temperature and salinity variations) and anthropogenic activities (e.g. canalisation and pollution). Perturbations to estuarine systems have been shown to dramatically reduce the diversity of the ichthyofauna in an estuarine system (Day et al. 1955; Begg 1978; Haedrich 1983; Felley 1987; Cooper et al. 1995). However, despite the physical instability and low species diversity of southern African estuaries, the species composition of ichthyofauna within these systems is relatively stable, and the fishes have more or less predictable patterns of abundance and distribution (Whitfield 1994).

The species composition and abundance of fish larvae in estuaries changes both on temporal and spatial scales (Felley 1987; Gaughan et al. 1990; Loneragan and Potter 1990; Neira et al. 1992; Tzeng and Wang 1992; de Morais and de Morais 1994). Although seasonal variations in fish larvae in estuaries are well recorded (e.g.
Melville-Smith and Baird 1980; de Lafontaine et al. 1984; Roper 1986; Whitfield 1989; Gaughan et al. 1990; Tzeng and Wang 1992; Neira and Potter 1994), temporal stability in estuarine ichthyoplankton has been shown to occur (de Morais and de Morais 1994; Witting et al. 1999). Spatial changes of fish larvae in estuaries are generally related to differences in environmental conditions and habitat variability in the different regions of an estuary (Neira et al. 1992; Tzeng and Wang 1992; Whitfield 1998). Habitat type and topography are important determinants of larval fish assemblage structure (Leis 1993).

In assessing the larval fish assemblages in estuarine systems the majority of studies give basic descriptions of the species composition of the assemblage and analyse patterns of abundance and seasonality. The analyses are generally descriptive with graphical representations of abundance patterns and simple or univariate statistical tests (ANOVAs and regressions) applied to the data (e.g. Able 1978; Melville-Smith and Baird 1980; de Lafontaine et al. 1984; Whitfield 1989; Gaughan et al. 1990; Tzeng and Wang 1992). In addition to these methods, more recent studies have used multivariate techniques of classification/cluster analysis and multidimensional scaling (MDS) to gain better insight into how the assemblages are structured (Neira and Potter 1992, 1994; Neira et al. 1992; de Morais and de Morais 1994; Witting et al. 1999). These latter studies describe how estuarine larval fish communities are structured in a particular pattern.

The present study focuses on three of the largest estuarine systems on the KwaZulu-Natal coast, Durban Harbour, Richards Bay Harbour and St Lucia Estuary, which together account for approximately 89% of total estuarine area in KwaZulu-Natal (Begg 1978). All three estuarine systems have changed considerably from their original state: Durban and Richards Bay now function as important harbours with major developments existing on their perimeters, whilst the St Lucia Estuary suffers from very high siltation rates due to poor farming practices upstream in the catchment, with additional pressure from recreational activities (Taylor 1982; Wright and Mason 1993). The larval fish assemblages in St Lucia Estuary, Richards Bay Harbour and Durban Harbour have been described in detail in Harris and Cyrus (1995, 1997, 1999, respectively) using graphical and certain univariate and multivariate statistical techniques (ANOVAs and stepwise regressions). Results from those studies suggest that intercorrelations exist between the environmental factors measured, with different combinations of factors accounting for the variability in larval densities of each estuarine-association group.

The aim of the present paper is to compare the structures of the larval fish assemblages in these three estuarine systems and to relate this to the environmental factors which may be important in structuring those communities. A combination of univariate (diversity indices), distributional (dominance curves) and multivariate (classification and ordination) techniques are used since each method gives different information aiding in the interpretation of the data. The following questions are addressed:

- does each system have a different larval fish assemblage structure and composition?
- if they do differ, how and why?
- what intercorrelations exist between abiotic factors and fish densities, and how does this influence assemblage structure?
- are these communities stable or at an equilibrium in the three different estuarine environments, and does this give an indication of relative “health” and nursery function of the system?

## Methods

### Study sites

The estuaries of KwaZulu-Natal fall into a subtropical region between latitudes 26°S and 31°S, an area characterised by high summer rainfall but with periods of severe drought occurring approximately every 10 years (Dyer and Tyson 1977). The catchment area for the St Lucia system is considerably larger than for both Durban and Richards Bay (St Lucia – 8982 km² compared with, say, Durban Harbour – 210 km², from Begg 1978) and is the largest estuarine system in southern Africa (Blaber 1985). For the purpose of the present study, and in the southern African context, a definition of an estuarine system is “a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation in salinity due to the mixture of seawater with freshwater derived from land drainage” (Day 1980; Whitfield 1998).

### Durban Harbour

Prior to the development of the harbour, in the late 1800s “Port Natal” was permanently open to the sea and shallow (< 3 m), with the depth varying depending on the state of the sandbar in the entrance channel (Hay et al. 1995). Today, Durban Harbour is better defined as an “estuarine bay” since the system is tidally dominated (tidal prism = 13.5 m³ × 10⁵) and there is constant mixing of the water column (Forbes et al. 1994, Whitfield 1998). Salinities are therefore near-marine in the lower and middle reaches of the system but with some freshwater input occurring from the Umbilo and Mhlathuzana Rivers in the upper reaches, where salinities of ± 27%o are usually recorded (Begg 1978). Continuing developments and increased pollution inputs and recreational activities have contributed to considerable degradation of Durban Bay and therefore its function as an estuarine habitat (Begg 1978; Guastella 1994; Hay et al. 1995).

### Richards Bay Harbour

Unlike Durban Bay, Richards Bay was only developed as a shipping port in the early 1970s (Brackenbury 1991) and is situated approximately 153 km north of Durban at 28°49’S; 32°05’E (Fig. 1). Richards Bay Harbour is also defined as an “estuarine bay” (Whitfield 1998), with a large tidal exchange volume of 25 × 10⁶ m³ and hence strong mixing of the water column (Forbes et al. 1994; Whitfield 1998). Basically marine salinities exist in the lower and middle reaches and salinities below 30%o are usually recorded in the upper reaches (Begg 1978; Whitfield 1998). Hay et al. (1995) give an apt description of the changes to Richards Bay: