Salinity ranges of some southern African fish species occurring in estuaries

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The recorded salinity ranges of 96 fish species occurring in southern African estuaries are documented. Factors influencing the tolerance of fishes to low and high salinity regimes are discussed, with most species tolerant of low rather than high salinity conditions. This is important since most systems are subject to periodic freshwater flooding, especially during summer. The penetration of freshwater teleosts and elasmobranchs into estuaries is examined and the occurrence of marine fishes in rivers documented. Mortalities arising from salinity extremes in southern African estuaries are discussed, with temperature a key factor initiating such fish kills. Only eight fish species have been recorded spawning in estuaries although the fry of many species are attracted to estuarine waters. It is concluded that a small percentage of southern African fishes have succeeded in utilizing estuaries and this may be attributed to the paucity of strong osmoregulators.

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Die aangetekende perke in soutgehalte van 96 visspesies wat in suidelike Afrikaanse estuariums voorkom is gedokumenteer. Faktore wat die toleransie van visse in regimes van lae en hoë soutgehalte beïnvloed, word bespreek. Die meeste spesies toon 'n toleransie eerder vir lae, as vir hoë soutgehalte toestande. Dit is belangrik aangesien die meeste sisteme onderworpe is aan periodieke varswater oorstromings, veral gedurende die somer. Die binnedringing van varswaterteleoste en elasmobranche in estuariums is ondersoek en die voorkoms van mariene visse in riviere aangeteken. Mortaliteite wat voortspruit uit uiterstes in soutgehalte in suidelike Afrikaanse estuariums word bespreek, met temperatuur as 'n sleutelfaktor by die oorsaak van hierdie vissterftes. Slegs agt visspesies wat in estuariums broei is aangeteken, alhoewel die jong visse van baie spesies na estuariese waters aangetrek word. Daar is afgelei dat 'n klein persentasie van suidelike Afrikaanse visse daarin geslaag het om estuariums te benut en dat dit toegeskryf mag word aan die skaarste aan sterk osmoreguleerders.

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The upsurge in fish research within southern African estuaries during the last 20 years has shown that estuaries are dominated by marine species. In view of the importance of the salinity tolerance of fishes, with regard to management and conservation of estuaries, a review of existing knowledge on the subject has become necessary. Reports of the salinity ranges in which the various species occur are contained in a large array of published and unpublished papers. This review draws on both these sources together with the unpublished records of the authors.

The fishes inhabiting southern African estuaries can be divided into four main groups according to their origin and salinity tolerance. The stenohaline marine component occurs in those parts of the estuary close to the sea where there is no reduction in the salinity of the environment. These are inshore marine species which are unable to cope with the osmoregulatory stresses of lowered salinities and are thus ecologically distinct from estuarine forms (Wallace 1975a). Euryhaline marine fishes are the dominant group which penetrate estuaries for distances that vary according to their salinity tolerance. There are also euryhaline freshwater species whose salinity tolerance determines the degree to which they come into estuaries from rivers and finally true estuarine species which spend their entire life cycle in estuaries.

Materials and Methods

Fish were captured in the Kosi (26°54'S; 32°52'E), St Lucia (29°0'S; 32°30'E), Mhlanga (29°42'S; 31°06'E) and Swartvlei (34°0'S; 22°46'E) estuarine systems using seine, gill and cast nets. Salinities, to the nearest part per thousand, were measured at the site of collection with a Goldberg Temperature Compensated Refractometer (AO Instrument Company, New York).

Results and Discussion

The recorded salinity ranges of 96 fish species are shown in Figure 1. These ranges do not imply extended tolerance to the salinities indicated, since temperature and other factors will determine how long a fish can survive certain salinity regimes. Blaber (1973) found that there was little interaction between environmental temperature and the salinity tolerance of juvenile *Rhabdosargus holubi*. However Whitfield & Blaber (1976) determined that there was an interaction between these two parameters in the

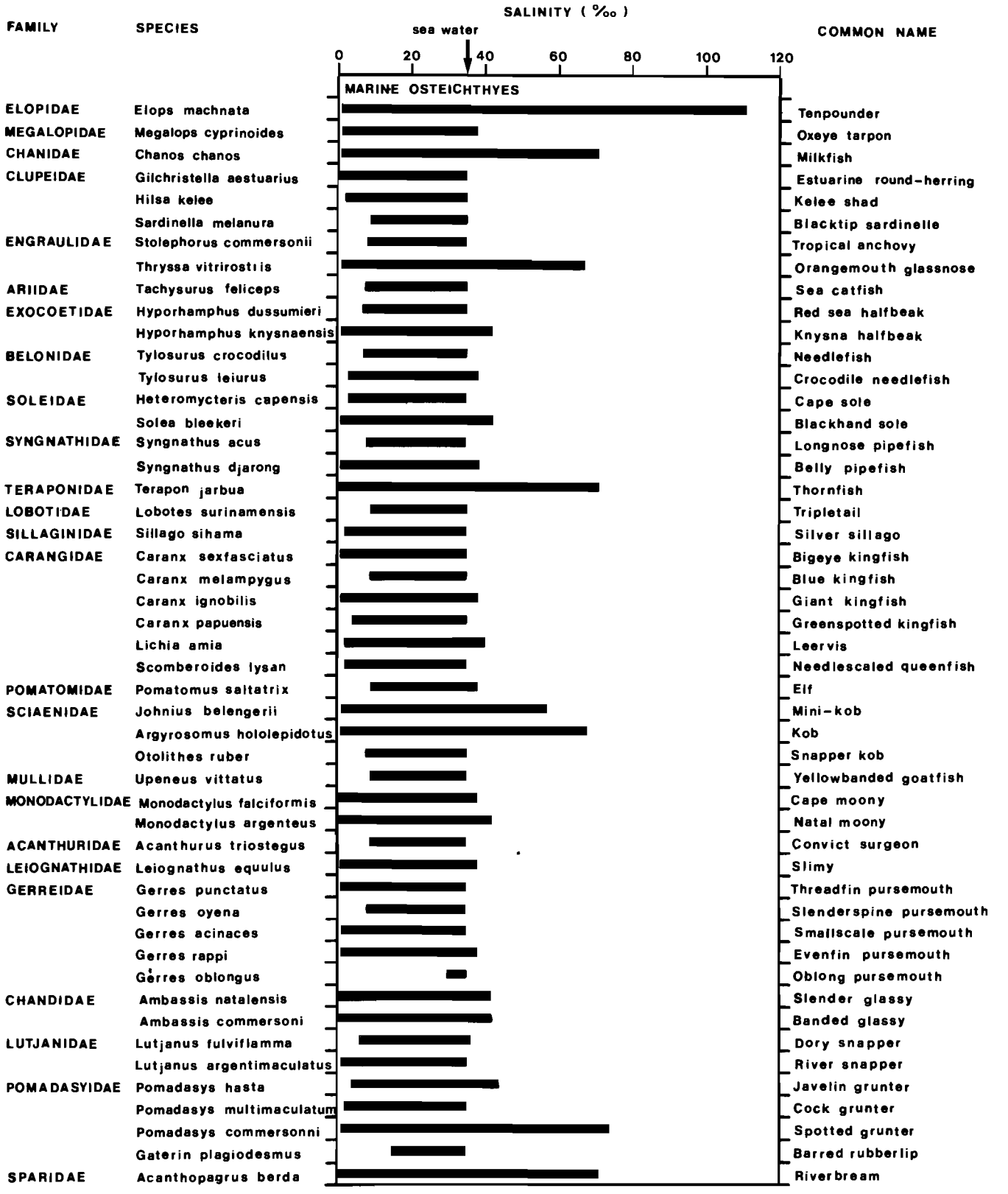

Figure 1 Salinity ranges of fish species from southern African estuaries (data from this programme; Bass *et al.* 1973; Hill *et al.* 1975; Millard & Broekhuysen 1970; Millard & Scott 1954; Wallace 1975a; Whitfield 1977). Nomenclature after Smith & Jackson (1975).

case of *Tilapia rendalli*.

Blaber (1974) has demonstrated that juvenile *R. holubi* are able to maintain their internal osmotic concentration for 10 h when exposed to a new salinity, and this may be important to fish living in areas subject to short term salinity changes. Therefore ranges shown in Figure 1 may possibly be extended for short periods in the case of species which are strong osmoregulators.

A characteristic of many fish species entering estuaries is an ability to adapt to both low and high salinity regimes (Figure 1), although it is significant that only 10 marine and one freshwater species have their upper recorded limits above 70‰, whereas more than 40 species can survive in water with a salinity of less than 2‰. Fishes resident in southern African estuaries are therefore more tolerant of low rather than high salinity conditions. This

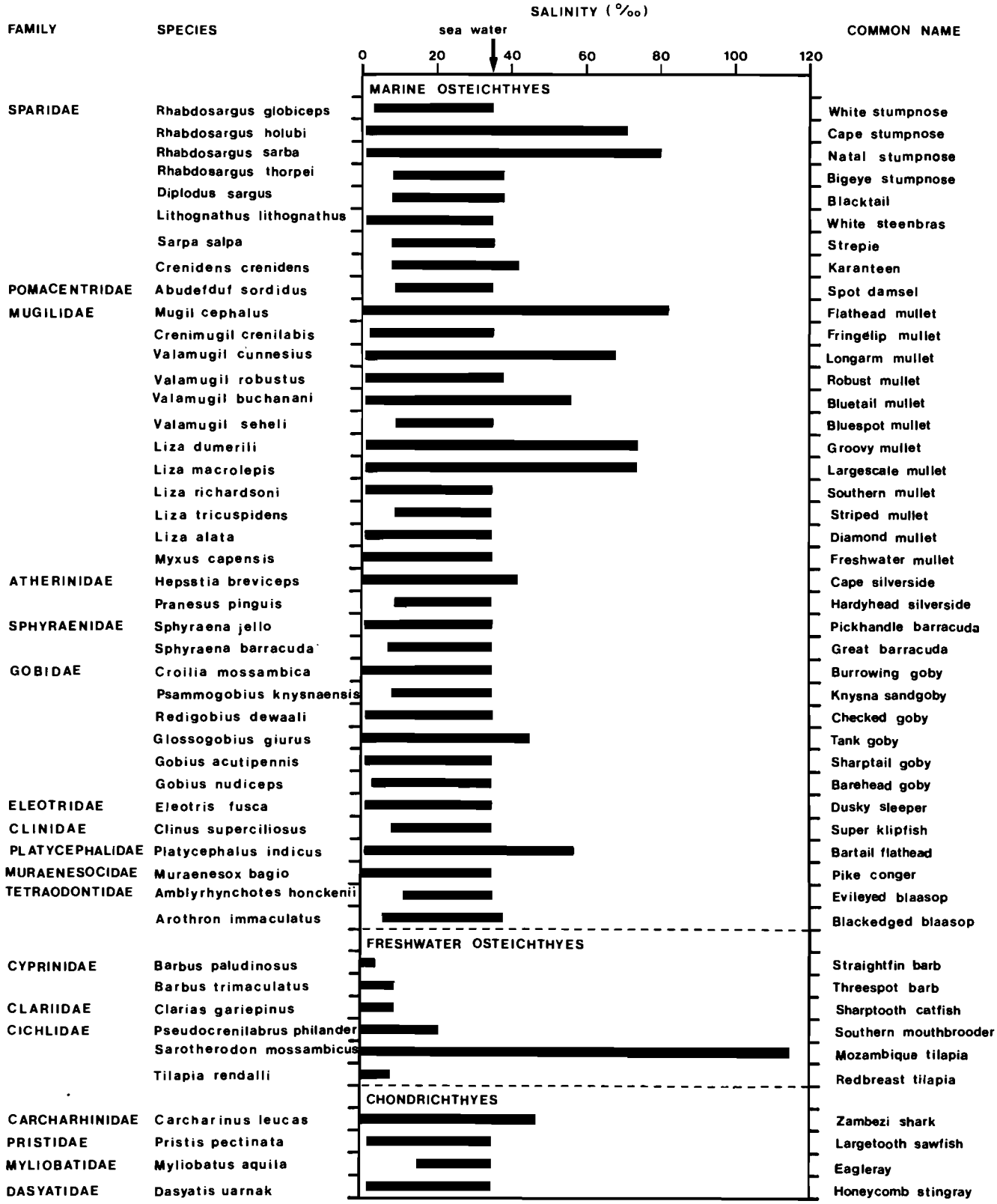

Figure 1 Continued.

is important since most estuaries are subject to periods of freshwater flooding, whereas salinities seldom rise above seawater except at St Lucia and a few Cape west coast estuaries. Furthermore, the closure of many South African estuaries is associated with decreased salinities and only fishes tolerating these conditions are able to utilize the rich food resources available within these systems.

Six species of freshwater fishes have been recorded penetrating southern African estuaries (Figure 1). *T. rendalli* was a dominant species in the saline Lagoa Poelela (Hill, Blaber & Boltt 1975) and *Sarotherodon mossambicus, Pseudocrenilabis philander, Barbus trimaculatus, Barbus paludinosus* and *Clarias gariepinus* were all present at Lake St Lucia during the low salinity regime (Whitfield 1977). When salinities at St Lucia increase, the

freshwater species (with the exception of *S. mossambicus*) retreat up the rivers flowing into the lake or perish in large numbers (Mitchell pers. comm.). *S. mossambicus* were abundant at St Lucia during hypersaline conditions and were recorded in areas where the salinity exceeded 110‰ (Wallace 1975a).

According to Panikkar (1960) only a few species of sharks and rays are known to enter estuarine waters because of their method of osmoregulation. Nevertheless three species of elasmobranchs were recorded from St Lucia during 1975 and 1976. *Carcharinus leucas, Dasyatis uarnak* and *Pristis pectinata* all occurred in water with a salinity of 2‰ (Figure 1) although residence time at these salinities was not determined. Both *C. leucas* and *Pristis microdon* have been captured in southern African river systems hundreds of kilometers from the sea (Jubb 1967). *C. leucas* was also regularly netted at St Lucia in salinities up to 47‰ by Bass, D'Aubrey & Kistnasamy (1973) but moved out of areas where the salinity exceeded 50‰. *Myliobatus aquila* occurred in the temporarily closed Swartvlei estuary during May 1979, and Smith & Smith (1966) describe how this species enters estuaries to give birth.

Several euryhaline marine fish species penetrate rivers with *Acanthopagrus berda* and *Mugil cephalus* recorded from the Pongolo system (Pooley 1975), *Glossogobius giurus, Eleotris fusca* and *Myxus capensis* from freshwater areas in Natal (Crass 1964) and *Megalops cyprinoides, Monodactylus falciformis, Monodactylus argenteus* and *Hepsetia breviceps* from other southern African freshwater systems (Jubb 1967). Thomson (1957) recorded *Rhabdosargus sarba* from the Albert River in Australia and the same species is known to occur in low salinity water in South Africa (Figure 1).

Both Wallace (1975a) and van der Elst, Blaber, Wallace & Whitfield (1976) have shown that there is an inverse relationship between salinity and fish species diversity at St Lucia. Gill-net catch rates during low salinities (< 20‰) increased by 100% when compared to high salinity conditions (> 50‰) (van der Elst *et al.* 1976) and this may be attributed mainly to the disappearance of certain food resources during hypersaline conditions (Boltt 1975; Wallace 1969). Wallace (1975a) found that *Pomadasys commersonni* and *R. sarba* captured in areas where the salinity was in excess of 70‰ were no longer feeding on normal molluscan and crustacean prey but were consuming filamentous green and blue-green algae. Furthermore, certain fish species would leave high salinity areas because of osmoregulatory stress, even though food was available.

Fish mortalities arising from low and high salinity conditions at St Lucia have been documented by Blaber & Whitfield (1976) and Wallace (1975a). In both instances the mortalities were associated with low water temperatures but only five species were recorded dying under hypersaline conditions and 11 species during low salinity conditions. The lower mortalities observed by Wallace (1975a) may be due to the southward movement of fish away from hypersaline areas in the north of St Lucia, whereas the low salinity conditions of 1976 occurred throughout the lake. A minimum of 100 000 fish died during 1976 but only small numbers of dead specimens were observed during 1970. Large scale fish mortalities which may be attributed to salinity have also been reported by Ruello (1976) in the hypersaline Lake Eyre and by Thomas & White (1969) under abnormally low salinity conditions in the Bideford estuary.

The spawning of seven marine/estuarine and one freshwater fish species in estuaries has been documented by Wallace (1975b), Blaber (1979) and Whitfield (1980). The eggs and fry of these species are able to survive moderate changes in salinity whereas the eggs of many marine species cannot survive decreased salinities (Sylvester, Nash & Emberson 1975) although the fry of the same species are attracted to low salinity estuarine waters (Blaber & Whitfield 1977; Mires & Shak 1974; Wallace & van der Elst 1975).

The most essential adaptation by fish species penetrating estuaries is an adjustment to changes in salinity. A few freshwater teleosts such as *S. mossambicus* have developed the power of hypotonic regulation but most species are incapable of this adaptation. Marine fishes such as *M. cephalus* and *Elops machnata* are strong osmoregulators capable of surviving in low and high salinity water, but of the total marine ichthyofauna it is apparent that only a small percentage of southern African fish species have succeeded in utilizing estuaries. Physiological evidence is that the teleosts originated in freshwater, from which a large section colonized the sea (Panikkar 1960). Estuarine fishes are examples of recent recolonization of estuaries by marine fishes, with few species having adapted their entire life cycle to the fluctuating conditions of the estuarine environment.

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