THE INFLUENCE OF TURBIDITY ON THE FORAGING BEHAVIOUR OF LITTLE TERNS *STERNA ALBIFRONS* OFF THE ST LUCIA MOUTH, ZULULAND, SOUTH AFRICA

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Received 19 March 1991, accepted 23 October 1991

SUMMARY

CYRUS, D.P. 1991. The influence of turbidity on the foraging behaviour of Little Terns *Sterna albifrons* off the St Lucia Mouth, Zululand, South Africa. *Marine Ornithology* 19: 103-108.

Observations made at sea in the vicinity of a highly tubid plume of water, emanating from the Mfolozi River, showed that it had a profound effect on the foraging behaviour of the Little Terns *Sterna albifrons* which were present in the area. Information on turbidity patterns off the Mfolozi mouth over a two-day period are provided and these are related to the observed activities of the terns. The occurrence and implications of such events along the entire Natal coast are considered as is this event in relation to observations on the foraging activities of seabirds and particularly terns, in water of varying turbidity, in other parts of the world. It is concluded that it is not the turbid water itself but rather factors associated with the outflowing plume which influenced the foraging patterns of the terns in the area.

INTRODUCTION

The Little Tern *Sterna albifrons* is a nonbreeding Palaearctic migrant to the southern African coastline being rare on the west and south coasts and fairly common on the east coast (Maclean 1985). In Natal the species is sparse south of Durban (29 46S, 31 00E), becoming more common as one heads north (Cyrus & Robson 1980). The species regularly roosts on sandbanks or islands at the mouths of estuaries, particularly at the Mvoti, Tugela, Mfolozi, St Lucia and Kosi Estuaries and Richards Bay (Ryan *et al.* 1986). The numbers present at the Mfolozi and adjacent St Lucia Estuary (28 24S, 32 25E) in any given year may fluctuate from <50 to in excess of 300 birds (pers. obs.).

Although small numbers may occasionally be observed hunting prey in the estuaries, up the St Lucia narrows and even in Lake St Lucia itself, the bulk of birds which roost at the mouths of the St Lucia and Mfolozi rivers fly out to sea to forage. Prey is hunted over a wide area from immediately behind the backline, where the first set of waves begin to form, to in excess of 5 km offshore (pers. obs.). The typical foraging pattern consists of flying into the prevailing wind at a height of about five to eight metres with head held down observing for potential prey in the water. After foraging in this manner for varying lengths of time a bird will turn and fly with the wind for a short while before turning back into the wind and resuming the head down foraging flight. This foraging pattern may be undertaken singly or in small groups of four to five birds in loose association.

Although it is not known what food items are taken in the St Lucia area, birds have been observed to seek out tightly packed shoals of small 'bait fish', at which time a rapid series of vertical or near-vertical plunge dives are carried out before the shoal scatters or disappears to an inaccessible depth below the surface (pers. obs.). On other occasions birds have been observed carrying out a fairly steep dive and then dipping, almost at the water surface, to skim prey off of the water.

METHODS

As part of a recruitment study of larval fish into St Lucia Estuary, ichthyoplankton samples were collected on a monthly basis at sea adjacent to the St Lucia and Mfolozi River mouths. The sampling programme carried out with a ski boat covered an area extending up to three kilometres out to sea and three to five kilometres north and south of the estuaries. Over the period 2-3 February 1991, following heavy rain in the Mfolozi catchment, the river came down in a spate sending a highly turbid plume of water into the sea. This period coincided with the monthly sampling programme during which time various physical parameters, including turbidity, salinity and temperature were being measured.

Visual observations of the pattern and extent of the turbidity plumes were made and additional readings were taken in order to obtain a more accurate picture of the event. Turbidity was measured in Nephelometric Turbidity Units (NTU) using a Hellige 1000 turbidimeter, while salinity was measured with a temperature compensated Reichert Optical Salinometer with readings in parts per thousand of salt ($^{0}/_{00}$). Temperatures were measured with a mercury in glass thermometer set inside a Hydrobios water sampling bottle.

Observation of Little Terns in the area and their foraging behaviour, in relation to water conditions, were undertaken over a period of some five hours on each of the two days that larval fish sampling was in progress.

RESULTS

Turbidity, salinity and temperature patterns

The data collected were used to plot the turbidity patterns present at sea off the St Lucia and Mfolozi mouths on the outgoing daylight tides of 2 & 3 February 1991 (Figs. 1 & 2).

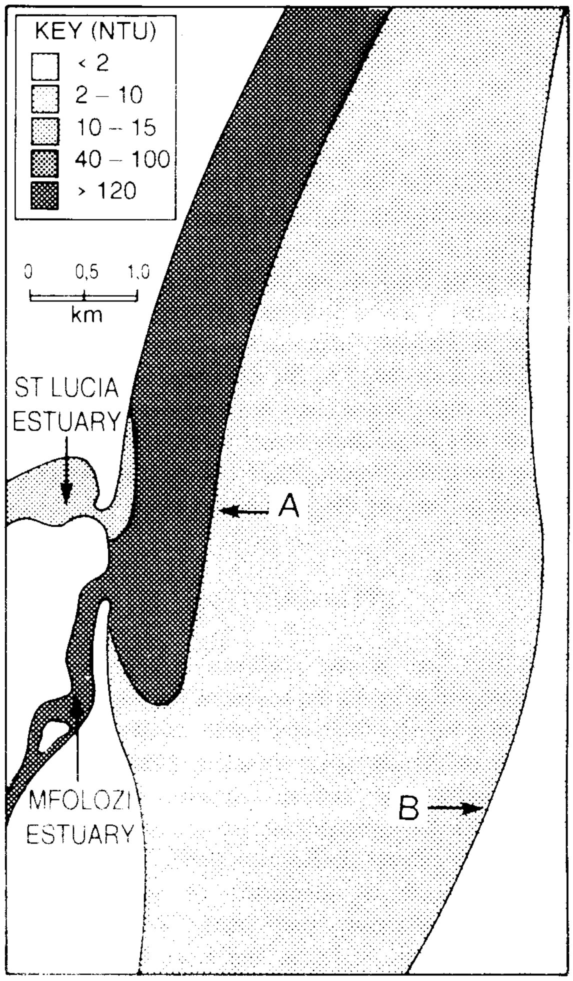

Figure 1

Turbidity patterns off the St Lucia and Mfolozi Estuaries at low tide on 2 February 1991

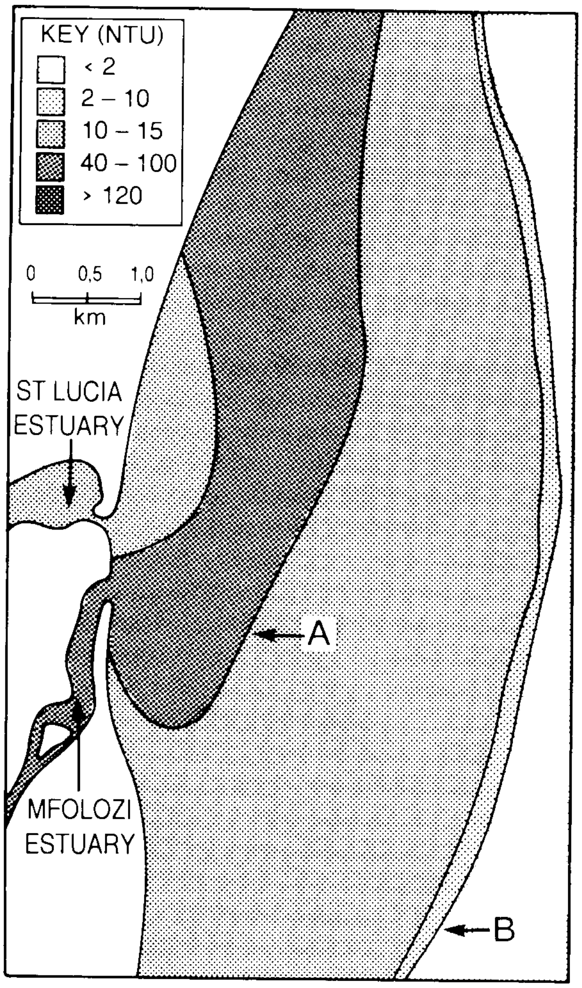

Figure 2

Turbidity patterns off the St Lucia and Mfolozi Estuaries at low tide on 3 February 1991

On 2 February 1991, from a ski boat positioned behind the backline, it could be clearly seen that the Mfolozi was flushing and that the presence of a south-westerly wind (c.4 ms^{-1}) was causing the plume of turbid water to be pushed northward (Fig. 1). Water in the plume was a deep chocolat brown in colour with surface turbidities rangin from 120 to 220 NTU. The St Lucia Estuary range from 10 to 15 NTU, whereas the water on th seaward side of the plume had a typical summe residual turbidity gradient from 10 down to 2 NTU at about 3.5 km offshore. Only beyond this poin were the first typically marine waters (<2 NTU encountered. The only clearly visible boundary wa the edge of the main plume (Fig. 1, line A) Because there was a gradient present out to the poin where clear marine waters were first encountre (<2 NTU), no clearly visible boundary was presen in that area (Fig. 1, line B).

On the second day (Fig. 2) it was apparent that th outflow of turbid Mfolozi water had decreased witl the main plume only having turbidities of betweer 40 and 100 NTU. The zone on the seaward sid stretched from 1 to 3.5 km offshore and had a background turbidity of between 10 and 15 NTU At the outer edge there was a narrow band some 60 100 m in width with turbidities between 2 and 1(NTU, thereafter very clear marine water <2 NTU was encountered (Fig. 2). Two very clearly define boundaries could be seen in the waters off the S Lucia and Mfolozi Estuaries (Fig. 2, lines A & B).

Bottom salinities over the entire area were unaffected by the freshwater input from the Mfolozi River, whereas northward moving inshore curren aided by the southwesterly wind caused rapid mixing of the surface waters adjacent to the Mfolozi mouth. The extent to which this occurred can be gauged by the fact that at a distance of 500 m off the mouth surface salinities were already 26 ‰, increasing to full seawater by 2 km offshore. The mixing which occurred ensured that there was no salinity 'front' present in conjunction with that of turbidity. By the next day salinities throughout the area were all that of full seawater. The recorded temperature range was 25.5 to 28°C with a maximum of 1° difference between surface and bottom waters. No clear temperature 'front' was found to be associated with the turbidity one.

Foraging behavour of Little Terns

On the first day it could clearly be seen that the Little Terns had changed their foraging pattern in apparent response to the turbidity levels. Instead of foraging over a wide area with a randomly scattered distribution almost the entire population in the area, some 60 to 100 birds, was concentrated along the line which formed the seaward edge of the turbidity plume (Fig. 1, line A) where they were foraging. The birds seldom moved more than 2 m either side of the turbid/clear water interface, concentrating their fishing efforts in this way and continually moving in a northerly direction. It was assumed that the birds followed the plume boundary until it petered out and that only then did they turn and head southwards to start the whole foraging procedure over again. Both the plunge and dip diving techniques were used by the terns but no prey items which they caught could be identified.

On closer inspection it was noted that a tremendous amount of plant and other debris were located and concentrated at the interface between the highly turbid water and that with only a background turbidity level (Fig. 1, line A). This in turn had attracted large numbers of smaller fish which could clearly be seen from the ski boat as the shoals broke the surface. Many small to medium-sized piscivorous fish hovered around the boundary of the plume, whereas ten to twenty metres farther out several larger predatory fish could occasionally be seen.

On the second day of observations some of the terns were noted still foraging along the outer boundary (Fig. 2, line A) of the plume coming out of the Mfolozi. despite the fact that the debris and fish which had been concentrated in this area on the previous day had dispersed and that turbidity levels had decreased to between 40 and 100 NTU. However, the majority of the terns was now concentrated along the fairly clearly visible outer boundary adjacent to the clear marine waters. Here they foraged almost exclusively within the 60 - 100 m band of water shown in Fig. 2, line B. The pattern used was essentially the same as on the previous day in that the birds followed the turbidity boundary in a northerly direction for quite some time before turning south. The density of debris and small fish on the outer boundary was substantially less than had been present along the boundary of the main plume the previous day. Although the foraging pattern was clearly concentrated along this line, the level of activity had decreased judging by the number of catch attempts made by the terns. Not a single tern was observed foraging away from these two turbidity boundaries.

The only other tern species seen out at sea over the two days of observations was the Swift or Crested Tern *S. bergii* which was only noted on the second day when 31 birds were counted as they closely followed the turbidity boundary (Fig. 2, line B), all heading in a northerly direction. No attempts at prey capture were noted despite the fact that the birds were very clearly following the exact path of turbidity boundary, nor were any southwards return flights observed.

DISCUSSION

Both Brown (1980) and Hunt & Schneider (1987) have alluded to the fact that seabird concentrations may be associated with salinity 'fronts' at the outflow of major rivers. In the present study however, no true salinity 'front' developed because the northwardly moving inshore current mixed rapidly with the fresher surface waters coming out of the Mfolozi. This resulted in a salinity gradient, with a difference of 10 ‰ over 2 km, developing in the surface waters. On the other hand a distinct turbidity 'front' did develop as a result of the outflow from the Mfolozi River.

Water turbidities off the St Lucia and Mfolozi Estuaries during the winter months are usually <2 NTU, which are similar to levels considered to be typically marine (e.g. Blaber & Blaber 1980). During the summer months turbidities offshore vary considerably depending on river outflow resulting from rainfall in the catchment (Cyrus 1988);

however, a residual or background turbidity of up to 15 NTU may be present in the sea off these estuaries. The turbidity of the water coming out of the Mfolozi on 2 February 1991 must have been extremely high, as after initial mixing on the first day with inshore waters of about 10-15 NTU, the turbidity plume still ranged between 120 and 220 NTU.

Ainley (1977) showed that with regard to seabirds, plunge-diving as carried out by Little Terns is associated with tropical areas and clear waters whereas deep diving from the water surface is associated with polar and subpolar regions and high turbidities. However, none of the species studied in the former group had distributions which covered the entire range of water clarity under review. Hence the variation in diving habit could be related to the species itself rather than to the condition of the water.

On the other hand Haney & Stone (1988), who studied plunge-diving among a number of seabirds, including six tern species, along a turbidity gradient, found that only one plunge-diving species was significantly more common in clear water whereas five species (four terns) were all significalty more common in turbid water. The authors concluded, that as their findings were directly opposite to those of Ainley (1977), that water clarity still has to be clearly implicated as an influence on the foraging tactics of aerial seabirds.

In addition to the above, Eriksson (1985) has shown that plunge-divers such as terns can reach prey only in the uppermost part of the water column, implying that increases in water transparency will not compensate should there be a decrease in fish density in a particular area. On the opposite end of the scale, Becker *et al.* (1985) working on Common Terns *S. hirundo* found that a deterioration in water clarity in the foraging area of his birds limited their feeding efficiency.

It can thus be concluded that something associated with the turbid water rather than the turbidity itself attracted the terns to the 'front', off the Mfolozi and St Lucia mouths, along which they were observed foraging. This was more than likely due to the presence of detritus and other debris, which had become trapped at the surface of the turbidity 'front'. These attracted the smaller 'bait fish' to the area, which in turn attracted larger predatory fish as well as the terns.

The observations described in this paper clearly indicate that the Little Tern, and possibly the Swift Tern, change their foraging strategy as a direct response to an input of highly turbid water from estuaries. This in turn may also lead to an increased rate of foraging by the terns, and cause them to become concentrated along the boundary of the turbidity 'front'.

The turbidity levels of many of Natal's estuaries are high in the summer months (Cyrus 1988), when large quantities of silt are transported out of their catchments after heavy rains. The presence of highly turbid plumes at sea off the mouths of Natal estuaries are thus not an uncommon site during this season. As some Little Terns are to be found roosting at most estuary mouths along the east coast (Ryan *et al.* 1986), it seems likely that the change to the foraging behaviour observed off St Lucia is not an uncommon event, occurring regularly during the summer months.

During further periods of flooding, it would be useful to obtain data on the foraging success of Little Terns under both clear and turbid water conditions as well as detailed information on what food items are taken when the different conditions prevail. In addition, data on the influence of foraging success of Little Terns along turbidity 'fronts' would be of interest. Safina (1990) recorded that the presence of the predatory Bluefish *Pomatomus saltatrix*, which is also present off the Mfolozi, significantly affected the feeding success of Common and Roseate Terns *S. dougallii* as well as depressing the foraging activities of the latter species.

ACKNOWLEDGEMENTS

I thank Tim Martin and John Travis who assisted with the field observations and collection of the turbidity data, my wife Rose who made critical comment on the draft of this note, Busi Mngomezulu for typing the manuscript and the Media Services Unit of the University of Zululand for preparing the figures. D.C. Duffy and W. Suter are thanked for their constructive comments on the original manuscript. These observations were made while carrying out fieldwork for the Estuaries Special Programme (Natal Section), funded as a Joint Venture through the Foundation for Research and Development.

ACKNOWLEDGEMENTS

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