The impact of the 1996 floods on a tidal sand bank in the Knysna estuary, Western Cape

M.E. Marker* and B. Maree

We report on the cumulative effect of three flood events during October and November 1996, their impact on the intertidal banks of the Salt River estuary and on a single bank in the Knysna middle estuary (19°01'E; 34°04'S) upstream of the railway bridge. We found that where land-derived, medium-to-fine coversand did not exceed 0.03 m, the invertebrate fauna survived and recovered within two years. Burial to a depth of 0.20 m, also over a pre-existing marine bank, affected the fauna so that only 42% of the original numbers were present after two years. At a site 100 m southwest of the other location, where 0.40–0.50 m of land sediment had accumulated over a bank not previously exposed even at neap low tide, only 6.7% of the pre-flood faunal population was evident. Upogebia africana (mud prawn), once common on the bank, was absent; Callianassa krausi (sand prawn) was the only prawn present.

The flood events

Heavy rainfall in the southern Cape in October and November 1996 was responsible for three flood events (Table 1). The first brought sediment down the Salt River into the Knysna estuary. The final flood brought timber and debris down the Knysna River and further sediment from the Salt River. The estuarine bank (bank 4) that is the focus of the study reported here lies opposite the mouth of the Salt River estuary, in the middle Knysna estuary immediately upstream of the railway bridge (Fig. 1). The Salt River is the most dynamic tributary catchment entering the Knysna estuary. The band of coversand had sharp textural road and quarry sediment.3 Fine sediment passes into the Knysna estuary during the three flood events.3 Sediment remains within the Salt River estuary, including almost all the relatively coarse-textured road and quarry sediment.3 Fine sediment passes into the Knysna estuary after each heavy fall of rain. Sedimentation therefore continues.

Table 1. Extreme rainfall in 1996 that resulted in floods.

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<tr>
<th>Date</th>
<th>Knysna town</th>
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<tbody>
<tr>
<td>Oct., 20–26</td>
<td>214</td>
<td>257</td>
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<tr>
<td>Nov., 5–9</td>
<td>44</td>
<td>69</td>
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<tr>
<td>Nov., 12–26</td>
<td>189</td>
<td>244</td>
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Sediment deposition

Coversand washed into the Knysna estuary, where it was deposited over an existing intertidal bank, abutting and extending it to the southwest (Fig. 1). Most deposition took place at the onset of flood tide, causing sediment to move upstream. Studies were conducted of the depth and extent of the sediment during 1997. Within the Salt River estuary itself, intertidal estuarine banks were buried by 0.38–0.17 m of yellow-brown coversands. Coring to a depth of 1.30 m revealed that the estuary had received influxes of land-derived coversands from discrete flood events on five earlier occasions.3 However, the depth deposited in 1996 was greater than before, because a large area of the catchment had been destabilized by construction. In the Salt River estuary the banks of coversands had sharp contacts with the underlying grey estuarine sediment.3

Over a period of months in 1997 (taking advantage of spring tide low-water conditions), we investigated the Knysna

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Fig. 1. Location of bank 4, opposite the Salt River mouth, in the middle Knysna estuary upstream of the railway bridge. Sediment depths on banks 1, 2, 3 and 4 were recorded in 1997. Bank 4, the most severely affected, was the site of the invertebrate fauna investigation in October 1996; two years after the flood deposition. The locations of sites 1, 2 and 3 on bank 4, where invertebrate recovery was investigated, are indicated by small numbers. The differentiated broken lines in the key shows the outlines of the banks in the years 1973, 1989, 1993 and 1997 after the floods.
mid-estuary banks upstream of the railway bridge (Fig. 1). All the banks in this area are submerged at neap tides and are exposed for 1 hour to 1.5 hours at spring low tide. Bank 4 had been severely impacted. Fresh, land-derived coversand overlaid the pre-existing silty-sand intertidal bank to a depth of 0.01–0.02 m, increasing in depth towards the west and extending into deeper water to form a new intertidal bank of pale, land-derived sand. The depth of new sediment there was up to 0.50 m (Table 2).

Bank 4 sediment had moved to form a low bar along the western and northwestern outer (upstream) margin. By October 1998, three sub-parallel bars had formed. The 1997 bar is lower and lies closer to the main channel than the inner bars 2 and 3. The higher bars may not be re-colonized by *Zostera capensis* (eelgrass), formerly present, as their height precludes sufficient tidal inundation.

Bank 4 was revisited in 1998 to assess the extent to which the estuarine environment had recovered from burial during the two years since the flood events. Coring showed that some mixing had occurred. The contacts between flood sediment and marine sediment were no longer sharp, implying that burrowing had occurred by invertebrate recovery (Table 2). However, the surface 0.01–0.02 m of coversand may not be remnants of the 1996 deposition, since the rains of May 1998 would have moved further sediment from the Salt River estuary.

By March 2004 (8 years later), the lowest bar was still present. Bars 2 and 3 had amalgamated to form a higher bar shored up by wave and wake wash. Some *Zostera capensis* has colonized between these bars. The coversand extension shows little evidence of sand mixing and limited faunal presence.

**Bank 4 sediment and invertebrate fauna**

To establish the degree of invertebrate recovery and/or recolonization, three sites on bank 4 were investigated in 1998 (Fig. 1). Site 1 was at the eastern end of the 1996 deposition over a bank where only 0.01–0.02 m of flood sediment had covered an established estuarine bank. Here the *Zostera capensis* beds were thick (100% cover) and rooted to a depth of 0.15 m.

Site 2 lay 20 m to the west and had been covered by 0.20 m of flood sediment with an abrupt transition to the underlying grey sands. By 1998, *Z. capensis* had begun to recolonize the area with 15% cover and was rooted to a depth of 0.10 m. There was no abrupt transition in sediment colour.

Site 3 was located on the edge of the new deposition on the original bar, 100 m southwest of site 1. Almost 0.50 m of sediment had been deposited in this area. In 1998 this area remained bare of any vegetation. Wave and wake action was greater adjacent to the main channel, so sediment remained mobile. Some *Z. capensis* was beginning to recolonize the swale between the bars.

**The invertebrate results**

The invertebrate results are expressed as numbers per square metre and are an average of two samples taken at each site. Each sample was taken from a 0.0625-m² area dug to a depth of 0.3 m. The fine sand was sieved on site and the invertebrate species were collected in jars and subsequently counted in the Thesen Environmental Studies laboratory.

Site 1 on a portion of the original bank, minimally affected by flood deposition (0.01–0.02 m depth) had 952 specimens per square metre and 10 species or genera. *Upogebia africana* (mud prawn), which is the basis of much of the estuarine food chain, comprised 21.8% of the count (Table 3). This site was used for comparison purposes as there was no previous sampling of bank 4. Site 2, where 0.20 m of flood sediment had buried a pre-existing bank, showed some recovery with 400 specimens (42% of the numbers of the less damaged bank). *Upogebia africana*, however, comprised only 12% of the fauna. Site 3, which had been covered by 0.40–0.50 m of sediment over an area not previously exposed at low tide, showed least recovery. Only 64 specimens were collected, which represented only 6.7% of the faunal numbers at site 1. No mud prawns were present (Table 3).

**Discussion**

The evidence presented here demonstrates that flood-related sediment deposition greater than 0.03 m depth is detrimental to the survival of estuarine mudbank fauna and that their numbers remain low even after two years (Table 3). Furthermore, as the integration of land-derived flood sediment into estuarine deposits depends on faunal mixing, recolonization is restricted where the depth of new sediment exceeds about 0.03 m. Wave and wake action on the loose sediment results in bar development. The height of the bars constrains re-colonization by *Zostera capensis*, since the inundation period is restricted. Some of the new sand behind the bars shows evidence of turbulence, limiting re-seeding.

The estuarine banks in the Knysna estuary are stable only where colonized by *Z. capensis* beds. Elsewhere the sediment is highly mobile. The absence or burial of eelgrass results in a marked decline in the species which exploit this habitat. *Upogebia africana* is seriously affected. Other species influenced are primarily *Hymenosoma orbiculare*, *Paridotea*,

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<th>Table 2. Coversand deposits on bank 4.</th>
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<td>Distance SW (m)</td>
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<td>10</td>
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<td>20</td>
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<td>100</td>
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<th>Table 3. Species distribution and numbers per square metre at three sites on bank 4.</th>
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<tr>
<td>Species Common name</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Upogebia africana</td>
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<tr>
<td>Cleistostoma edwardsii</td>
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<tr>
<td>Hymenosoma orbiculare</td>
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<tr>
<td>N. kraussianus</td>
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<tr>
<td>Protolemna capensis</td>
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<tr>
<td>Paridotea ungulata</td>
</tr>
<tr>
<td>Pinnirethes dolfinei</td>
</tr>
<tr>
<td>Callianassa kraussi</td>
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<tr>
<td>Genus level only</td>
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<tr>
<td>Polychaete species</td>
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<td>Isopoda species</td>
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<td>Tellina species</td>
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<tr>
<td>Density (m⁻²)</td>
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<td>Number of species/taxa</td>
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Protomella, and Nassarius kraussianus. Cleiostoma edwardsii and polychaete species are also affected but do not totally disappear. They act as pioneer species and primary colonizers together with Callianassa kraussi (sand prawn), jointly contributing towards mixing in of the flood sediment. Since the total faunal population is small, mixing is slow.

Once land sediment is partially mixed with grey marine sediments, Zostera capensis may begin to colonize. Thus organisms such as U. africana, H. orbiculare and N. kraussianus, commonly found within the Zostera beds, begin to re-appear. This is the present situation at site 2. Species such as Protomella capensis, which requires well-mixed, detritus-rich estuarine sediment, and Paridotea ungulata, which inhabits only established eelgrass beds, were not found at site 2. We believe that the Z. capensis bed was insufficiently established to support these populations.

Site 3 was inhabited only by Cleiostoma edwardsii, a mobile species, polychaete and isopod species, both generalists, and Callianassa kraussi (common sand prawn). Site 3 showed no sign of recovery, either because it was new or because bank height had reduced tidal inundation, thus preventing colonization by Z. capensis.

Our investigation suggested that where sediment deposition does not exceed 0.03 m, fauna are able to recover within two years and maintain a relatively high density and number of species as at site 1. Where sedimentation was at least 0.20 m, density and numbers are reduced and U. africana was particularly affected. Where sedimentation exceeds 0.40 m the fauna altered. Only primary colonizers were present as Zostera recovery was slow. Fewer and different species were present.

Although extreme flood events such as those of 1996 have a detrimental effect on all estuarine fauna through the effect of reduced salinity of seawater and impaired water clarity, where sedimentation is relatively thin, the fauna recovers noticeably within two years. Thicker sediment cover impairs faunal recovery.

**Conclusion**

This study is of limited scope but we believe the results to be important since few other such investigations have been conducted. Most have focused on rocky rather than sandy environments. All flood events impact on estuarine fauna. Where salinity depletion is combined with relatively thick sediment deposition, the estuarine fauna are under stress and pathways become simpler affecting invertebrate numbers. Sediment mixing is a prerequisite for Zostera recolonization, yet mixing is largely a function of invertebrate activity. Estuarine bank stability is also dependent on the presence of Z. capensis. Nevertheless, it must be stressed that local research has suggested that invertebrate numbers vary widely within the Knysna estuary.

Knysna’s economy depends on tourism and the estuary is its prime drawcard. Two things are clear from this study: land sediment is vulnerable to erosion and recovery of the estuarine banks is inhibited where flood sediment is thick. The evidence presented here demonstrates that greater emphasis should be placed on sediment control through strict planning for new developments and construction projects in the catchment. We thank South African National Parks for assistance with sampling, and the Knysna Basin Project for knowledge derived from 4 years of research in the estuary on estuarine fauna (B.M.), on sediment studies (M.M.), and for the use of facilities in the Thesen Environmental Field Laboratory.