The importance of estuarine-derived carbon for the nearshore marine environment: studies on two contrasting estuaries in South Africa

PD Vorwerk\textsuperscript{1} and PW Froneman\textsuperscript{2}\textsuperscript{*}

\textsuperscript{1} Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa; \textit{current address}:
SAEON, Grahamstown, South Africa

\textsuperscript{2} Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa

\textsuperscript{*} Corresponding author, e-mail: w.froneman@ru.ac.za

Abstract

The food web structure within and adjacent to two permanently open estuaries with contrasting flow regimes along the south-eastern coast of South Africa was investigated in 2005, employing stable isotope analysis. In the Kariega Estuary carbon sources assimilated by the zooplankton are derived from riparian vegetation in the upper reaches and from salt marsh and submerged macrophytes in the lower reaches of the system. In contrast, within the freshwater-dominated Great Fish Estuary the zooplankton appear to be sustained largely by allochthonous phytoplankton derived from freshwater inflow due to the interbasin transfer scheme. Estuarine-derived POM appears to be utilised only directly adjacent to the Kariega Estuary mouth.

Keywords: Eastern Cape, flow regime, food web, isotope, linkages
Introduction

It has long been hypothesised that, due to the direction of flow through estuaries being predominantly seaward, the net transport of material (both biological and non-biological) is in a seaward direction (Allen 1996; Roegner and Shanks 2001). South African estuarine research has largely focused on the spatial and temporal variability in the biology within these systems. The main findings of estuarine research have highlighted the importance of freshwater inflow in determining the species composition and food web structure within these systems (Froneman 2001; Vorwerk et al. 2003; Gama et al. 2005).

This study was conducted within, and adjacent to, estuaries with contrasting freshwater flow regimes along the south-eastern coast of South Africa. The aim of the study was to assess the importance of estuarine-derived carbon to the nearshore marine ecosystem and to highlight any differences in the estuaries resulting from altered flow regimes.

Materials and methods

Study area

The two estuaries studied are approximately 50 km apart along the Eastern Cape coast of South Africa (Figure 1). They included the freshwater-deprived, marine-dominated Kariega Estuary and the freshwater-dominated Great Fish Estuary. The Kariega Estuary (33°41′ S, 26°44′ E; Figure 1a) has a small catchment (686 km²), whilst the Great Fish Estuary (33°30′ S, 27°08′ E; Figure 1b) has a relatively large catchment (29 937 km²) with several impoundments along its channel.

Sample collection

Due to the continuous recycling of nitrogen within estuarine ecosystems, this study focused only on carbon stable isotopes (Fry and Sherr 1984). The collection of POM samples involved transporting five litres of estuarine or marine water from each station to the laboratory for subsequent filtering through precombusted...
(500 °C) GF/F filters and the manual removal of any faunal matter, using a dissecting microscope. Zooplankton was collected monthly, from January to December 2005, from all sites during the day by a series of surface tows of a WP-2 net (0.05 m² mouth area) with a mesh size of 60 μm.

**Stable isotope analysis**

Sample analysis was conducted in an online Carlo-Erba NA1500 preparation unit and δ¹³C determination was performed in a MAT 252 stable light isotope mass spectrometer. Merck gelatine was used as an internal standard, calibrated against several IAEA reference materials. The results were expressed as δ¹³C signatures in units of parts per thousand (‰) relative to the Pee Dee Belemnite solution …..

**Statistical analysis**

The post hoc Tukey test was performed to identify whether there were any significant differences in the isotopic signatures at different locations within the different biotic groups. The STATISTICA software package (Version 6.0; Statsoft, Inc.) was utilised to conduct the analysis.

**Results**

**The Kariega Estuary and adjacent marine environment**

**Primary producers and particulate organic matter (POM)**

The riparian vegetation sampled demonstrated a δ¹³C ratio of between −28.05‰ and −21.07‰, while the salt marsh and littoral vegetation covered a greater range from −29.97‰ to −14.29‰ (Figure 3, Table 1). The most depleted δ¹³C signatures recorded were those for the salt marsh plant *Sarcocornia perennis* (−29.97‰) and the riparian plant *Sideroxylon inerme* (−28.05‰). The most enriched signatures were recorded for eelgrass, *Zostera capensis* (−16.88‰), and the salt marsh plant, *Sporobolus virginicus* (−14.29‰) (Table 1, Figure 3).
Consumers (filter feeders and zooplankton)

The marine filter feeders collected were either *Pyura stolonifera* (red bait) or an unidentified sponge species. A post hoc Tukey test identified two significantly different groupings, with the δ¹³C ratios of the filter feeders near the estuary mouth being more depleted than those further away along the coast (Table 3). ….. A Tukey test identified two significantly different groups, the estuarine copepods and the marine copepods (Table 4).

Discussion

Previous studies have demonstrated that the main carbon source assimilated by primary and secondary consumers within South African estuaries appears to be dependent on the volume of fresh water flowing into the system (de Villiers 1990; Jerling and Wooldridge 1995). In those systems characterised by sustained freshwater inflow, phytoplankton appear to be the main carbon source utilised by the zooplankton (Jerling and Wooldridge 1995).

The Kariega Estuary

Stable isotope analysis within the Kariega Estuary indicated two distinct carbon pathways that were spatially separated from one another. The δ¹³C signatures of the POM in the upper reaches of the estuary were closely linked to the δ¹³C signatures of the group of plants comprising the riparian vegetation, whereas in the lower reaches the δ¹³C signatures of POM were closely related to those of *Spartina maritima*, *Zostera capensis* and *Sporobolus virginicus* (Figure 3). …..

The Great Fish Estuary

As in the Kariega Estuary, the vegetation sampled within the Great Fish Estuary grouped into a highly depleted group (~29.94‰ to ~26.88‰) and a group comprising the relatively enriched *S. virginicus* (~14.43‰) (Figure 4). The highly depleted group comprised riparian vegetation and two species of reeds, as well as the salt marsh plant *S. perennis*. …..
Acknowledgements

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References


Table 1: $\delta^{13}$C signatures (‰) of primary producers collected from the Kariega Estuary in April 2005. Different grouping letters indicate significantly different groups (Tukey test; $p < 0.05$, df = 8).

<table>
<thead>
<tr>
<th>Species</th>
<th>Habitat type</th>
<th>Mean $\delta^{13}$C</th>
<th>SD</th>
<th>Max.</th>
<th>Min.</th>
<th>Grouping according to Tukey test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarcocornia sp.</td>
<td>Salt marsh</td>
<td>−29.97</td>
<td>1.50</td>
<td>−28.91</td>
<td>−31.03</td>
<td>A</td>
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<tr>
<td>Sideroxylon inerme</td>
<td>Riparian</td>
<td>−28.05</td>
<td>0.25</td>
<td>−27.87</td>
<td>−28.22</td>
<td>C</td>
</tr>
<tr>
<td>Sporobolus</td>
<td>Salt marsh</td>
<td>−14.29</td>
<td>0.92</td>
<td>−13.64</td>
<td>−14.94</td>
<td>D</td>
</tr>
<tr>
<td>Rhus sp.</td>
<td>Riparian</td>
<td>−27.11</td>
<td>1.19</td>
<td>−26.26</td>
<td>−27.95</td>
<td>C</td>
</tr>
<tr>
<td>Chenolea diffusa</td>
<td>Salt marsh</td>
<td>−26.70</td>
<td>1.27</td>
<td>−25.80</td>
<td>−27.59</td>
<td>BC</td>
</tr>
<tr>
<td>Schotia affra</td>
<td>Riparian</td>
<td>−26.12</td>
<td>0.72</td>
<td>−25.61</td>
<td>−26.63</td>
<td>C</td>
</tr>
<tr>
<td>Portulacaria affra</td>
<td>Riparian</td>
<td>−21.07</td>
<td>0.02</td>
<td>−21.07</td>
<td>−21.09</td>
<td>CD</td>
</tr>
<tr>
<td>Spartina maritima</td>
<td>Salt marsh</td>
<td>−24.28</td>
<td>0.82</td>
<td>−23.70</td>
<td>−24.86</td>
<td>D</td>
</tr>
<tr>
<td>Zostera capensis</td>
<td>Littoral</td>
<td>−16.88</td>
<td>1.33</td>
<td>−15.94</td>
<td>−17.83</td>
<td>D</td>
</tr>
</tbody>
</table>
FIGURES

Figure 1: Locations of the two study estuaries, the Kariega Estuary (a) and the Great Fish Estuary (b). Hatched areas indicate salt marshes. The causeway forming the upper limit of the Kariega Estuary is indicated by a dotted line.