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

Comment [c1]: Title should include the country in which the research was conducted

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Comment [c2]: Give only initials, not full names

Comment [c3]: Always write "and" in full, *not* as "&"

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Abstract

Comment [Ed.5]: Not more than 200 words, summarising the objectives, findings and conclusions of the research

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.

Comment [c6]: Always use 'passive voice'

Comment [c7]: The year/s when the research was conducted should be mentioned

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

Comment [Ed.8]: Maximum of 8 keywords, listed alphabetically, separated by commas. Exclude words used in the title of the article

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 km^2), whilst the Great Fish Estuary (33°30′ S, 27°08′ E; Figure 1b) has a relatively large catchment (29 937 km^2) 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

Comment [Ed.9]: A broad overview of the subject in hand.
Headings / sub-headings must not be numbered

Comment [c10]: Do not put a comma between name and date

Comment [Ed.11]: References listed chronologically, separated by semi-colons. "et al." is NOT italicised

Comment [c12]: The research's objectives, and the hypothesis tested, should be clearly stated

Comment [Ed.13]: Level 1 heading: bold; sentence case; line space above and below

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(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 m^2 mouth area) with a mesh size of 60 µm.

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Stable isotope analysis

Sample analysis was conducted in an online Carlo-Erba NA1500 preparation unit and $\delta^{13}C$ 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 $\delta^{13}C$ 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

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The Kariega Estuary and adjacent marine environment

Primary producers and particulate organic matter (POM)

The riparian vegetation sampled demonstrated a $\delta^{13}C$ 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 $\delta^{13}C$ 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).

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Consumers (filter feeders and zooplankton)

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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 $\delta^{13}C$ 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

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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 $\delta^{13}C$ signatures of the POM in the upper reaches of the estuary were closely linked to the $\delta^{13}C$ signatures of the group of plants comprising the riparian vegetation, whereas in the lower reaches the $\delta^{13}C$ 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

The authors would like to express their appreciation to Joe Sparks, Rhodes University, for field assistance. The running expenses of this study were funded by Rhodes University and the Water Research Commission. The stable isotope analysis was conducted by the Department of Archaeology, University of Cape Town.

References

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Tables

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)

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

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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

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