First oceanographic survey of the entire continental shelf adjacent to the northern Agulhas Current

Authors:
Johann R. E. Lutjeharms[1]
Jonathan V. Durgadoo[1]
Mathilde Schapira[2]
Christopher D. McQuaid[2]

Affiliations:
[1]Department of Oceanography, University of Cape Town, Rondebosch, South Africa

[2]Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa

Correspondence to:
Johann Lutjeharms

email:
johann.lutjeharms@uct.ac.za

Postal address:
Department of Oceanography, University of Cape Town, 7700 Rondebosch, South Africa

How to cite this article:
Lutjeharms JRE, Durgadoo JV, Schapira M, McQuaid CD. First oceanographic survey of the entire continental shelf adjacent to the northern Agulhas Current. S Afr J Sci. 2010;106(9/10), Art. #410, 3 pages. DOI: 10.4102/sajs.v106i9/10.410

This article is available at:
http://www.sajs.co.za

The Agulhas Current is by far the largest western boundary current of the southern hemisphere[1] and carries about 70 × 10^6 m^3/s of seawater past the eastern shores of South Africa.[2] Being more than 2000 m deep, it follows the continental shelf edge quite closely. Its northern part, all the way downstream to Algoa Bay, has a very stable trajectory whereas the southern part meanders widely to either side of a mean geographical location,[3] in the process creating shear edge eddies and attendant plumes of warm surface water over the shelf.[4] However, the direct influence of the Agulhas Current on the waters and ecosystems of the adjacent shelf of South Africa remains largely unknown.

The Agulhas Current may act as a major barrier separating the open waters of the Indian Ocean from the coastal waters of South Africa. In some regions, by introducing warm, saline water onto the shelf and transporting pelagic organisms from the subtropical and tropical waters of its origins, the current may affect the biogeography of marine organisms along the whole eastern seaboard of South Africa, as well as broad ecosystem functioning. This would not only be in terms of species composition, but also in terms of the size structure of the planktonic communities, patterns of energy flow and nutrient recycling. The spatial dynamics of planktonic communities on the shelf adjacent to the Agulhas Current therefore requires special investigation. The influence of the current on the dispersal of the propagules of coastal species is for the most part also unknown. Benthic populations are believed to disperse their long-lived planktonic larvae over large regions so that populations of these species are genetically open. However, the scale of dispersal of such species and the degree of gene flow across populations are closely controlled by oceanographic conditions. To what extent do the Agulhas Current and the upwelling cells driven by the current[5,6] influence recruitment to near-shore populations in this area? And to what extent does the Agulhas Current influence the levels of endemism seen among the intertidal biota of the south coast by affecting larval dispersal and thus gene flow?

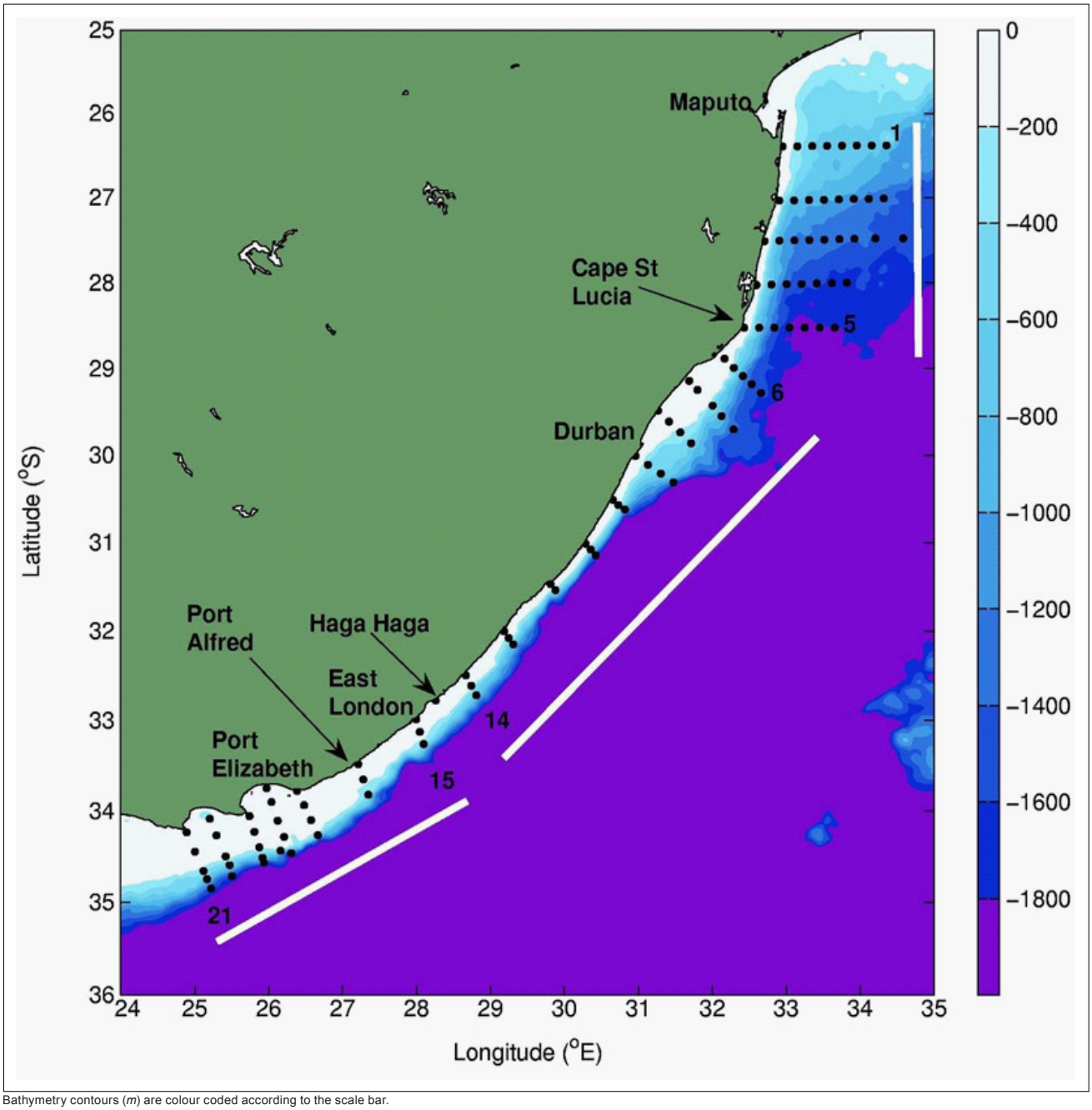
In order to gain insight into a number of these pressing and important questions, a major, multi-disciplinary cruise was organised (Figure 1) to cover the full extent of the landward border of the northern Agulhas Current for the first time. This was done under the auspices of the African Coelacanth Ecosystem Programme as a South African contribution to the international Agulhas and Somali Current Large Marine Ecosystem.[7] We report here on the cruise objectives, observations and some preliminary results.

Twenty-one transects were undertaken at right angles to the coast between Maputo, Mozambique and Cape St Francis from 02–23 October 2009 (Figure 2). Each transect started inshore and extended to the shelf edge, most right into the Agulhas Current, and a total of 103 stations were occupied. At each station vertical profiles of temperature, salinity, dissolved oxygen, photosynthetically active radiation and fluorescence were obtained. Current data were collected using a vessel-mounted Acoustic Doppler Current Profiler. Samples were also collected for the determination of suspended particulate matter, isotopic ratios, fatty acid composition, virus-like particles, auto- and heterotrophic prokaryotes as well as invertebrate larvae.

Source: Photo taken by A. de Lecea

Figure 1: Crew members of the research vessel FRV *Algoa* preparing to launch a rosette sampler with conductivity-temperature-depth, oxygen sensors and fluorometer during the ACEP II cruise of October 2009

Article #410
South African Journal of Science



Bathymetry contours (*m*) are colour coded according to the scale bar.
Contours deeper than 1800 m are masked.

Figure 2: Geographic distribution of hydrographic stations occupied during the survey along 21 transects. Note the three regions along the Northern Agulhas Current are defined by the thick white lines: transects 1–5 (KwaZulu Natal Coast), 6–14 (Transkei Coast) and 15–21 (Eastern Cape Coast).

The northernmost sector of the survey was undertaken to establish where the Agulhas Current starts to influence the circulation on the shelf (Figure 2). Studies on sediment distribution on the local shelf[8] have indicated that this probably takes place somewhere between Cape St Lucia and Maputo. However, no hydrographic observations in this region have been available to support this hypothesis. Current speeds indicated that the core of the Agulhas Current lay about 30 nautical miles – 50 nautical miles offshore. At Cape St Lucia, the current was encountered closer inshore, as was evident from both the gradient in sea surface temperature and current speeds.

In the next downstream sector (Figure 2), the circulation on the Natal Bight (between Cape St Lucia and Durban) is influenced by the Agulhas Current in a number of different ways, including an upwelling cell at Cape St Lucia and an eddy of Durban.[9,10] These were all identified and two special transects were undertaken within the Durban eddy at the southern edge of the Natal Bight shelf.[9] Large eddies were identified offshore.[11] Therefore, the data collected will provide information on the influence that these features have on the shelf circulation. Downstream of the Natal Bight, extensive meandering of the current was observed.

Worldwide, the near-shore distribution of intertidal larvae and their transport onto the shore are still poorly understood.[12] We hypothesised that the inshore edge of the Agulhas Current forms a boundary defining a body of water that forms an arena within which the alongshore dispersal and supply of larvae are determined. The data collected during this survey, linking invertebrate larval distribution with the movement of large-scale oceanographic features, will help us test this hypothesis.

The very near-shore sampling conducted around Algoa Bay and Jeffrey's Bay, the next downstream sector (Figure 2), was

Source: Photos taken by C.E.O. von der Meden and K.R. Nicastro

Figure 3: Mussel bed near Keurbooms River on the south coast of South Africa. The inserted image (A) shows recent settlers of the mussel *Perna perna* stained with the fluorescent dye, calcein

complemented by onshore sampling of larval settlement (Figure 3) and will offer further understanding of larval dispersal at smaller scales and how this is affected by coastline topography. Preliminary analyses indicate that there is an extremely strong decline of larval numbers within the first few kilometres of the coast, with a more gradual decline farther offshore. There are markedly fewer larvae and less onshore settlement at headlands than within bays. In addition, this survey provided a unique opportunity to collect samples for genetic studies to investigate the pelagic distribution of larvae of the easterly and westerly lineages that exist in adult populations of the mussel *Perna perna* to test the competing hypotheses[13] of dispersal and selection that could account for the adult patterns of distribution (Figure 3).

As expected, three patches of relatively colder waters were observed inshore of the Agulhas Current: off Cape St Lucia,[5,9,10] at Port Alfred[6] and at Jeffrey's Bay.[14] Favourable wind conditions produced a localised offshore movement of surface water off Cape Recife into Jeffrey's Bay.[15] Additional data from hand-held conductivity-temperature-depth probes (CTDs) deployed during boat-based grids at Jeffrey's Bay and Cape Recife will provide further understanding on the consequences of these active upwelling cells on the pelagic ecosystem functioning.

In late 2010, a second cruise is planned to study the influence of the Port Alfred upwelling on the vertical stratification of the Agulhas Bank and the effect this has on primary productivity and ecosystem structure over the Agulhas Bank. Although observations have been and are being made on the Agulhas Bank, the last full geographic coverage of the shelf with hydrographic observations in a quasi-synoptic manner was carried out in the 1960s.[16] By using a collection of historical hydrographic data, it has been inferred[1] that the thermocline on this shelf is strengthened from below by cold water from the Port Alfred upwelling cell.[6] Such an unusual increase in vertical gradients may be very conducive to keeping planktonic organisms in the upper layers and concentrating the food supply. This is particularly important because the Agulhas Bank is the main spawning area for pelagic fish, such as the anchovy that are subsequently advected into the Benguela system, aided by mesoscale by-products of the Agulhas Current.[17]

These two surveys will provide the very first set of complementary oceanographic and biological data of the full shelf region under the influence of the Agulhas Current. ■

REFERENCES

1. Lutjeharms JRE. The Agulhas Current. Springer-Verlag, Heidelberg, 2006; p. 329.
2. Bryden HL, Beal LM, Duncan LM. Structure and transport of the Agulhas Current and its temporal variability. J Oceanogr. 2005;61(3):479–492.
3. Paldor N, Lutjeharms JRE. Why is the stability of the Agulhas Current geographically bi-modal? Geophys Res Lett. 2005;36:L14604, doi:10.1029/2009GL038445.
4. Lutjeharms JRE, Catzel R, Valentine HR. Eddies and other border phenomena of the Agulhas Current. Cont Shelf Res. 1989;9(7):597–616.
5. Lutjeharms JRE, Gründlingh ML, Carter RA. Topographically induced upwelling in the Natal Bight. S Afr J Sci. 1989;85(5):310–316.
6. Lutjeharms JRE, Cooper J, Roberts M. Upwelling at the inshore edge of the Agulhas Current. Cont Shelf Res. 2000;20(7):737–761.
7. Vousden D, Scott LEP, Sauer W, Bornman T, Ngoile M, Stapley J, et al. Establishing a basis for ecosystem management in the western Indian Ocean. S Afr J Sci. 2008;104(11/12):417–420.
8. Flemming B, Hay R. Sediment distribution and dynamics of the Natal continental shelf. In: Coastal Ocean Studies off Natal, South Africa. editor Schumann EH, Lecture Notes on Coastal and Estuarine Studies 26, Springer-Verlag, Berlin, 1988; p. 47–80.
9. Lutjeharms JRE, Valentine HR, Van Ballegooyen RC. The hydrography and water masses of the Natal Bight, South Africa. Cont. Shelf Res. 2009;20:1907–1939.
10. Meyer AA, Lutjeharms JRE, De Villiers S. The nutrient characteristics of the Natal Bight, South Africa. J Mar Syst. 2002;35(1-2):11–37.
11. Gründlingh ML. Review of cyclonic eddies in the Mozambique Ridge Current. S Afr J Mar Sci. 1988;6:193–206.
12. Levin LA. Recent progress in understanding larval dispersal: new directions and digressions. Integr Compar Biol. 2006;46:282–297.
13. Shanks AL, Brink L. Upwelling, downwelling, and cross-shelf transport of bivalve larvae: test of a hypothesis. Mar Ecol Progr Ser. 2005;302:1–12.
14. Schumann EH, Perrins LA, Hunter IT. Upwelling along the south coast of the Cape Province, South Africa. S Afr J Sci. 1982;78(6):238–242.
15. Goschen WS, Schumann EH. Upwelling and the occurrence of cold water around Cape Recife, Algoa Bay, South Africa. S Afr J Mar Sci. 1995;16:57–67.
16. Bang ND, Pearse FC. Hydrological data. Agulhas Current Project, March 1969. Data Rep. Inst. Oceanogr, University of Cape Town, 1970;4:26.
17. Lutjeharms JRE, Durgadoo JV, Ansorge IJ. Surface drift at the western edge of the Agulhas Bank. S Afr J Sci. 2007;103(1/2):63–67.