Estuaries

Protecting nature's nurseries – Study highlights importance of natural flow to estuaries

Estuaries, those unique interfaces between marine and freshwater environments have also been highly impacted by human activities upstream. A completed study by the Nelson Mandela Metropolitan University (NMMU) and funded by the Water Research Commission has confirmed the uniqueness of estuaries and highlighted the importance of continuous monitoring and cooperative governance to address impacts and improve estuarine health.

Article by Petro Kotzé.

The Bloukrans estuary is one of the estuaries for which ecological water requirement studies have been completed.

All photographs courtesy NMMU

South Africa's National Water Act of 1998 is hailed internationally as a ground-breaking piece of legislation, in particular because it protects the right of our waterbodies' survival. Yet, the implementation of this law is often fingered as a problem, still leaving integral ecosystems open to exploitation.

However, a recently published study has pointed out how far we've come with the protection of some of our most sensitive ecosystems, namely estuaries. As the interfaces between the marine and freshwater environments, estuaries are complex, dynamic and productive ecosystems. These systems provide numerous ecosystem services, including erosion control, provision of food, support for fish nurseries and provision of recreation and tourism opportunities. Consequently, they are the most heavily utilised and threatened ecosystems worldwide. "People are easy to criticize the work that has been done, but the bottom line is that we've done a lot, and the results are now contributing to inform estuary management plans and other pieces of national legislation," says Prof Janine Adams of the NMMU. Prof Adams was the project leader of the recent assessment of completed Ecological Water Requirement studies for South African estuaries. The project also entailed a documentation of estuary responses to changes in freshwater inflow. In addition to the WRC, the project was co-funded by the

Department of Water and Sanitation and the National Research Foundation.

Prof Adams has already walked a long path with estuaries throughout her career. "It's a theme I've been working on since my doctoral studies, and it has continued from there," she says. Some of the work she has been involved in has been formalised in the National Water Act of 1998, and it is now being continued, not only by her, but by the students she has helped train throughout the years. She was thus in the ideal position to oversee the collection and interpretation of the unorganised body of work, in order to keep stock of what has been done in the past. "As a scientist I've been involved with much of the work, so I'm familiar with a lot of it." The researchers found that we are doing much better than what many may think.

How far have we come?

The mentioned Act requires the classification of all water resources in order to be able to secure water for its protection. Classification is accompanied by resource quality objectives that establish goals for the quality of the relevant water resource.

The Ecological Reserve, in turn, relates to the quantity and quality of river inflow required to protect the aquatic ecosystem of the water resource, which vary depending on the class of the resource. Because the classification process may take time, the Act allows for the preliminary determination of the Reserve. To this end, the Department of Water and Sanitation developed methods for the preliminary determination of ecological water requirements (EWRs). For estuaries, these preliminary methods include the determination of the present ecological status, ecological importance, the recommended ecological category, a recommended ecological flow scenario and ecological specification and monitoring programmes. The present ecological status data set informed the 2012 National Biodiversity Assessment.

South Africa supports close to 300 functional estuaries, which vary in type due to the differences in topography, fluvial and marine sediment supply. Our estuaries range from permanently open tide-dominated systems to permanently open river-dominated systems, temporarily open/closed systems, estuarine lakes and estuarine bays. Most of these are small systems, and over 70% have restricted inlets due to strong wave action and high sediment availability.

Because each estuary is unique, both due to its characteristics and how it responds to freshwater inflow, the EWR of each has to be calculated individually. According to the report findings, South Africa has been a forerunner in the development and application of methods to assess the EWRs of estuaries, which in essence, ensure the protection of aquatic ecosystems and maintain ecosystem services. The EWR (or, Ecological Flow Requirements) quantifies the water regime (quality, quantity and timing) required to ensure the adequate functioning and future persistence of estuaries.

The salt marshes at Langebaan. Open conditions are essential for maintaining the estuary's health as it promotes salt marsh growth and the recruitment of fish and invertebrates.

Researchers from Nelson Mandela Metropolitan University worked with colleagues at the South African Institute for Aquatic Biodiversity to undertake sampling at some of the estuaries.

"Estuaries are sensitive to a reduction in freshwater inflow, which is the main driver of their dynamic, variable nature."

The assessment found that studies have been conducted on 40% of South Africa's estuaries, although some studies are still ongoing. The majority (69%) of studies were completed as low confidence desktop or rapid levels. The classification of the Mvoti-Umzimkulu Water Management Area assessed 22% of South Africa's estuaries. Furthermore, the EWRs of half of South Africa's permanently open estuaries have been determined. Only three comprehensive Reserve determinations have been completed.

"In most cases the environmental flows have not been implemented, but the point of the report is that we have made progress," explains Prof Adams. Furthermore, the studies have alerted everyone to the existence of stressed catchments, and it has provided awareness that there isn't water left for development in these catchments anymore, she notes.

Prof Adams stresses that it is important to give the Department of Water and Sanitation credit for that. "They have taken the time to do this, and they have put a lot of money and effort into understanding EWRs; knowledge that everybody is now benefiting from."

These lessons and information are now being used in estuary management plans; essentially applying the requirements of the National Water Act into practice to the benefit of all.

Estuary responses to changes in freshwater inflow

Water quality and ecological functioning of estuaries closely reflect human activity, not only along the estuarine sector itself, but also within its entire upstream catchment.

The study pointed out that freshwater abstraction for human activities threatens the health and provisioning of ecosystem services supplied by aquatic ecosystems. "Estuaries are sensitive to a reduction in freshwater inflow, which is the main driver of their dynamic, variable nature. Input of discharge from waste water treatment works and agricultural return flow can result in increased freshwater inflow to estuaries."

Though the findings paint a negative picture of the impact of human activities on the health and sustainable future of estuaries, Prof Adams point out that all is, by far, not lost. Inversely, pointing out the negative impacts of freshwater abstraction from estuaries help to highlight the impact of development, and how and when it should be managed and mitigated.

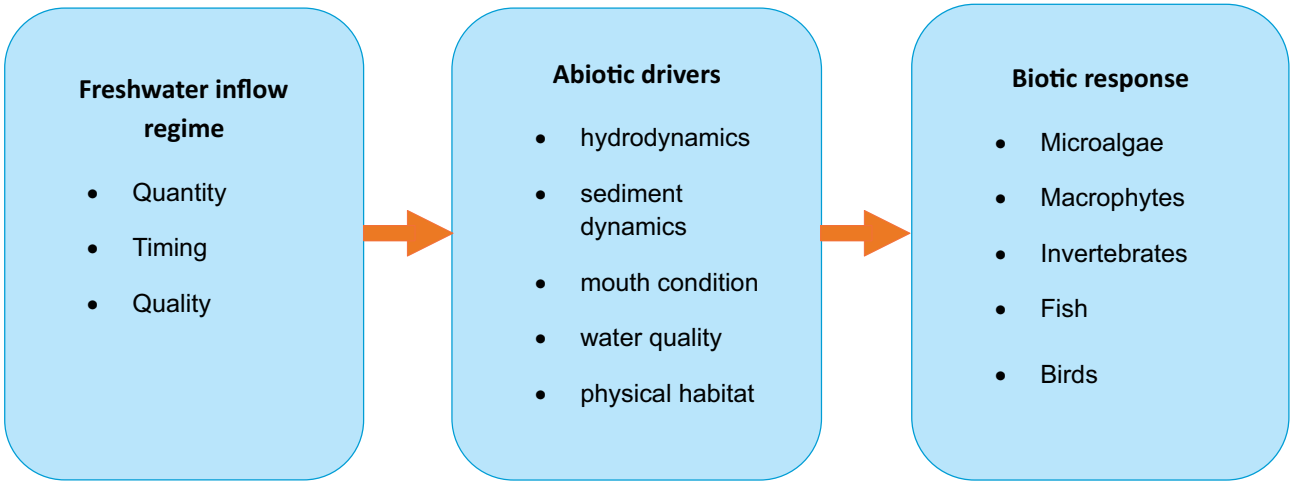
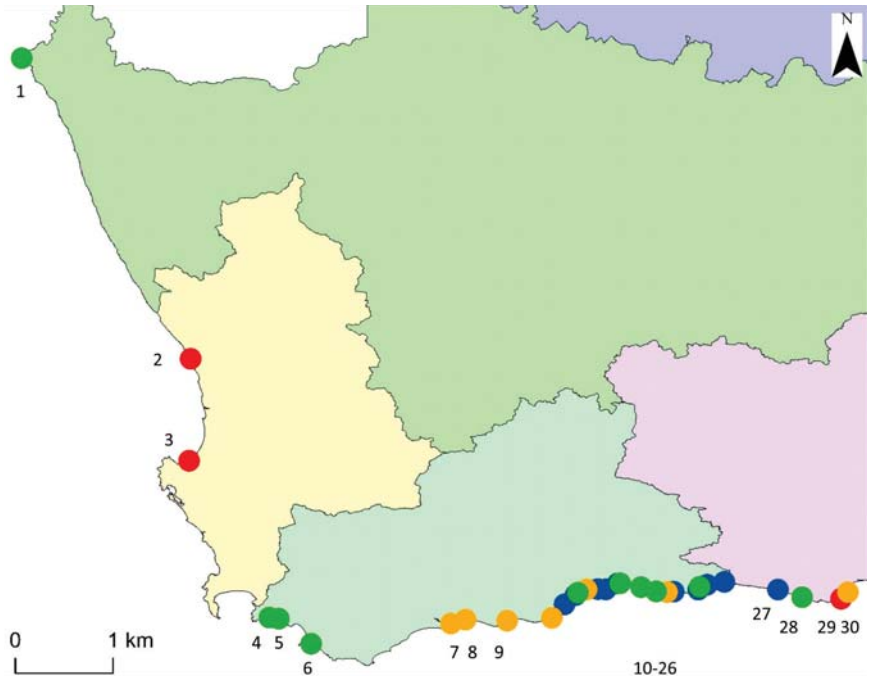


Figure 1: Conceptual model of freshwater inflow effects on estuaries.



1. Orange	8. Duiwenhoks	15. Maalgate	22. Noetsie
2. Olifants	9. Goukou	16. Gwaing	23. Piesang
3. Berg	10. Gouritz	17. Kaaimans	24. Matjies
4. Palmiet	11. Blinde	18. Wilderness	25. Bloukrans
5. Bot	12. Hartenbos	19. Swartvlei	26. Groot
6. Uilkraals	13. Klein Brak	20. Goukamma	
7. Breede	14. Great Brak	21. Knysna	

Figure 3: Ecological water requirement studies completed for estuaries on the west and south coast of South Africa (blue indicating desktop assessments, green: rapid, yellow: intermediate and red: comprehensive).

Key lessons learnt

The researchers have identified twelve key lessons from the estuaries' assessments:

1. Each estuary is unique in terms of its EWR.
2. Water can be released from dams to supply the EWR, but cannot mimic the entire natural flow regime.
3. Floods are needed to flush out and reset estuaries.
4. Increased flow, for example wastewater input or agricultural return flow, increases mouth breaching resulting in unstable conditions in temporarily open/closed estuaries.
5. Deterioration in water quality is a growing concern.
6. The importance of groundwater input to South African estuaries is unknown.
7. The offshore marine environment also has an EWR, but this does not form part of the current legal framework.
8. A catchment to coast integrated water management approach is necessary to ensure connectivity.
9. Co-operative governance is required to address non-flow related impacts and improve estuary health.
10. Field and long-term data are needed for high confidence EWR assessments.
11. Monitoring must take place in a strategic adaptive management cycle.
12. The tools developed to determine the EWR of an estuary are now being used to meet other legislative requirements

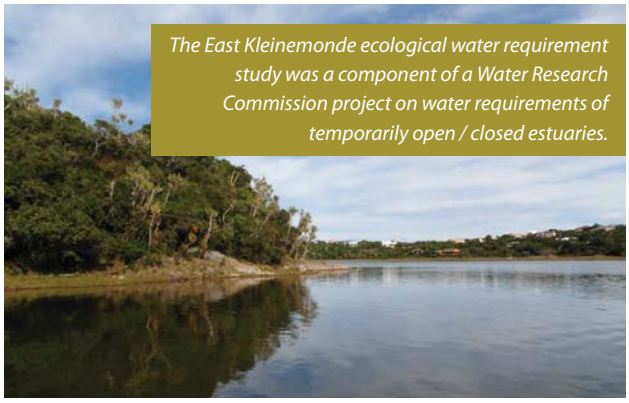
She lists a good example as the St Lucia Estuary. This highly important estuary had the lowest Present Ecological Status of the estuarine lakes assessed. Studies have found that, aside from a reduction in flow, developments such as the drainage and canalisation of the Umfolozi swamps, the construction of weirs and an overall reduction in bird habitat on a national and international scale have contributed to its poor health.

In 2004, an ecological water requirement study highlighted the urgency of reconnecting inflow from the uMfolozi to the St Lucia Estuary. This is now taking place; in 2016 with the aid of GEF funding, iSimangaliso Wetland Park Authority appointed a contractor to remove dredge spoil impeding uMfolozi flow into Lake St Lucia. Scientists have shown that further removal of dredge spoil, inflows of freshwater from uMfolozi and an increase in the connectivity with the sea will improve the ecological health of St Lucia. However, at the same time there should be no further abstraction of freshwater from the uMfolozi and St Lucia catchments as these inflows are necessary to maintain the health of this nationally important estuarine lake.

"As a scientific community we said that the St Lucia Estuary needs water from the Umfolozi River, and this is now being done after our recommendations," notes Prof Adams. She also points out that public perception of the importance of estuaries has increased concurrently over the years, and that the public's involvement is increasingly helping to help safeguard these sensitive ecosystems' futures. Already, she says, there are many examples along the coast where this is happening.

Going forward

The researchers have come to the conclusion that South Africa's holistic approach to determine EWRs for estuaries is at the forefront of methods internationally. According to the final report, "the procedure is well documented and soundly embedded in an understanding of the structure and function of South Africa's estuaries."



The East Kleinemonde ecological water requirement study was a component of a Water Research Commission project on water requirements of temporarily open / closed estuaries.

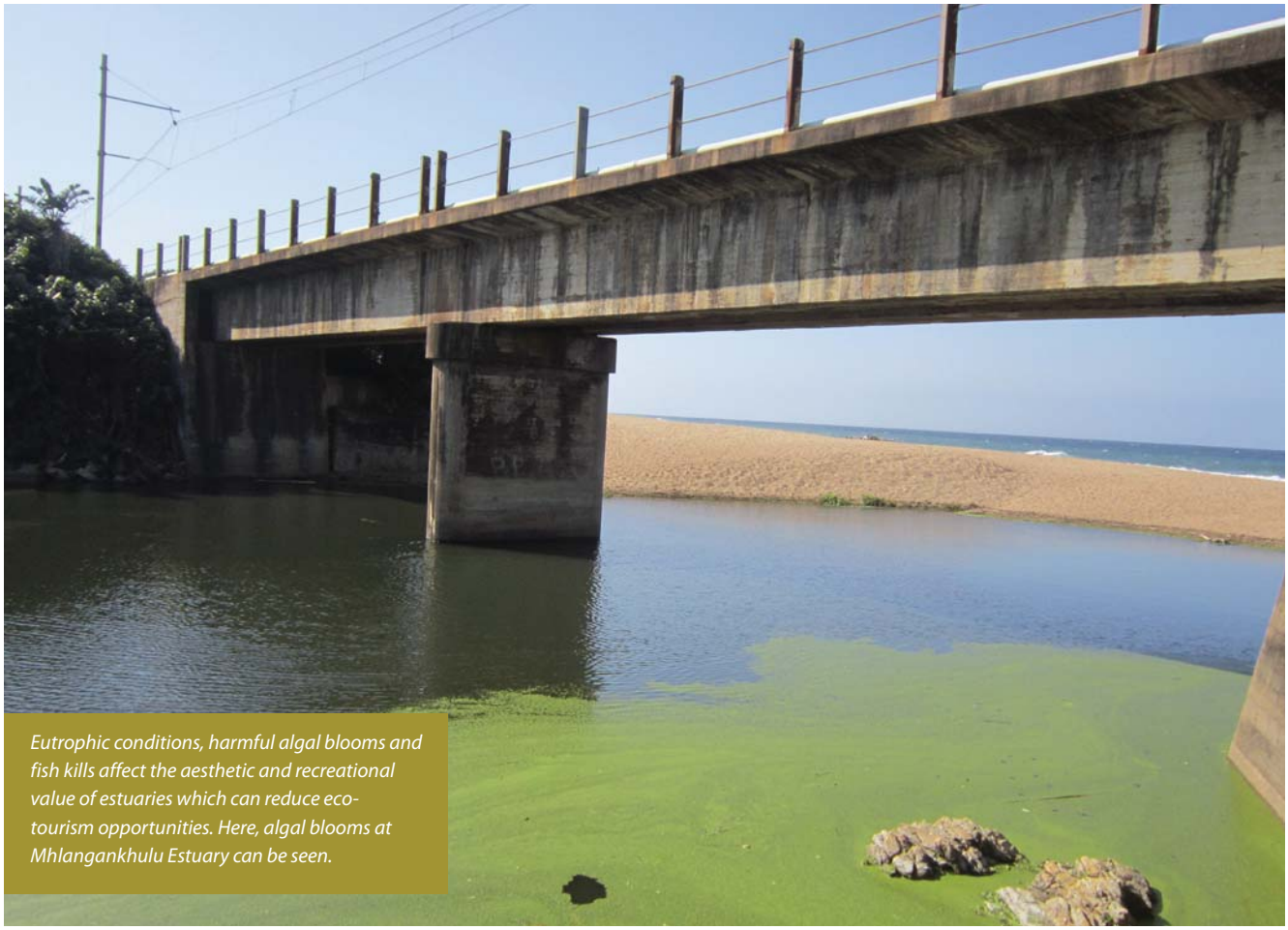
Hippos at the mouth of St Lucia, one of South Africa's most important estuaries.

Furthermore, a learning-by-doing approach has ensured that the methods used to assess the EWRs of South Africa's estuaries have improved over time. The use of multidisciplinary scientific teams and panel workshops are integral to the method and are a strength. A potential weakness that has been identified is the failure to support the process with adequate data.

Prof Adams points out that for her, going forward; water quality is one of the major issues that will have to be dealt with. However, "we are lucky that in South Africa, guidance is provided by national legislation, resulting in work that is done as part of a coordinated effort towards the same goal – something that is rarely the case in many other countries." Another benefit of working in South Africa is that we can link science and policy closely together.

There are many negatives in the country but, there are also some positives, she says, and the work that has been done on estuaries in South Africa is one of them. "Look at this body of work that we now have, and credit for the DWS also needs to be given for this," Prof Adams concludes.

- To access the report, *Assessment of completed ecological water requirement studies for South African estuaries and responses to changes in freshwater inflow* (**Report No. KV 352/15**) contact Publications at Tel: (012) 330-0340; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.



Eutrophic conditions, harmful algal blooms and fish kills affect the aesthetic and recreational value of estuaries which can reduce eco-tourism opportunities. Here, algal blooms at Mhlangankhulu Estuary can be seen.