BRIEFING NOTE SERIES

MONITORING COASTAL PH VARIABILITY AND THE IMPACTS OF FUTURE OCEAN ACIDIFICATION ON COASTAL SPECIES

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Objective – A briefing note aims to provide a concise outcome based synopsis of recent research or expert opinion that may inform decision making and activities by authorities, NGOs and NPOs. The briefing note series complements the academic peer reviewed literature published by SAIAB.

1) OBJECTIVE OF BRIEFING NOTE

Ocean acidification (OA) is a global concern, which is a consequence of consistently increasing atmospheric carbon dioxide (CO_2) concentrations. As such, it has been termed as the "evil twin" of global climate change. Globally, at the current rate of atmospheric CO_2 emissions, it is estimated that seawater pH will decrease by 0.3–0.4 units (from a current average of 8.1) by the end of the century.

Decreases in seawater pH and carbonate ions may have severe negative consequences for many marine organisms. The decline in pH and simultaneous chemical changes in seawater associated with ocean acidification affect marine organisms in different ways, with ocean acidification and associated chemical changes having varying effects on both calcifying (invertebrates) and non-calcifying (fish) marine organisms. The conditions predicted for the open ocean by the end of the century (which are used in most experimental studies to infer impacts) may not, however, reflect what is going to happen in coastal regions. Coastal environments are known for their generally variable conditions, including variability in pH, and understanding this variability is important for assessing organism responses to future conditions. The African continent is also behind in efforts to monitor local acidification in coastal regions, where most marine organisms and resources occur.

The objective of this briefing note is to highlight recent research that has been conducted by SAIAB researchers on local pH and carbonate chemistry in Algoa Bay, as well as laboratory-based experimental studies on coastal species. This information will improve our understanding of local ocean acidification and its impacts and is important to inform management and adaptation strategies.

2) KEY ISSUES/FINDINGS

- Variability in pH and associated carbonate chemistry parameters were monitored along the shoreline and offshore waters (at the 30 m depth contour) of Algoa Bay, with pH ranges of up to ~0.5 - 0.6 units recorded over relatively small spatial (10 km) and temporal (daily) scales.
- Higher average pH (and high daily variability) was recorded around a macroalgal-dominated reef in the bay. Macroalgae and seagrass can raise pH on a local scale by taking up carbon through photosynthesis. This highlights the role that macroalgae and seagrass, that serve as nursery habitats for many marine fish species, may play in providing a refuge from acidification by offering higher average (> 8.2) pH levels.
- Due to their exposure to variable pH conditions (spatially and temporally), it would be expected that coastal species may be tolerant to low pH conditions. However research has shown a different response in three coastal fish species. The marine estuarine dependent dusky kob (*Argyrosomus japonicus*) showed low tolerance to low pH treatments (~7.78) in their early life stages in laboratory experiments, with pH affecting their metabolism, growth rate and skeletogenesis. Similarly, in the laboratory, the marine red roman (*Chrysoblephus laticeps*), showed metabolic depression and reduced growth in low pH treatments (~7.63) in their preflexion stages. Conversely, the marine estuarine opportunist blacktail (*Diplodus capensis*), which is found in estuaries and rocky coastal areas in it's early-life stages, showed behavioural and physiological tolerance to pH treatments as low as 7.2 in their later larval stages.
- These results highlight the strong species-specific response to future conditions.
- These findings highlight the need to understand the response of different species and different life stages to future acidification in coastal environments, especially those that are important resources or provide key ecological functions (keystone species).
- Pressures associated with ocean acidification on marine organisms are not acting in isolation and other climate factors as well as exploitation and overfishing will have interacting impacts on marine resources.

- It is essential to improve our understanding of local ocean acidification and its impacts on marine organisms, together with co-occurring stressors, to inform management strategies.

3) KEY PROCESSES THAT THE FINDINGS MAY INFLUENCE

Understanding local pH and carbonate chemistry conditions, particularly in coastal habitats, is important for assessing and predicting future scenarios and the impacts these may have on important coastal species. Identifying potential OA hotspots and refuges is also necessary to inform protected area management. Further experimental studies on key species and marine resources are necessary in order to predict the impact of future ocean acidification on coastal ecosystems, by identifying vulnerable and tolerant species. This understanding will contribute to addressing the Sustainable Development Goals Target 14.3, which aims to "minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels" and also aligns with the UN Decade for Ocean Science where "Ocean Acidification Research for Sustainability" is highlighted as a decade action. The most recently published Intergovernmental Panel on Climate Change (IPCC) report (Climate Change 2022: Impacts, Adaptation and Vulnerability) highlights the ongoing acidification occurring in the world's oceans and its impacts on marine biota.

4) KEY PAPERS FOR CONSIDERATION BY SAIAB & OTHERs

Duncan MI, Bates AE, James NC, Potts WM. 2019. Exploitation may influence the climate resilience of fish populations through removing high performance metabolic phenotypes. *Scientific Reports* https://doi.org/10.1038/s41598-019-47395-y

Edworthy C, Potts WM, Dupont S, Duncan MI, Bornman TG, James NC. *in prep*. Coastal pH and carbonate chemistry variability in a temperate South African embayment.

Edworthy C, 2021. Coastal pH variability and the eco-physiological and behavioural response of a coastal fish species in light of future ocean acidification. PhD Thesis, Rhodes University.

Erasmus, B. 2018. Effects of CO_2-induced ocean acidification on the early development, growth, survival and skeletogenesis of the estuarine-dependant sciaenid, Argyrosomus japonicus. MSc Thesis, Rhodes University.

IPCC, 2022: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H-O Pörtner, DC Roberts, M Tignor, ES Poloczanska, K Mintenbeck, A Alegría, M Craig, S Langsdorf, S Löschke, V Möller, A Okem, B Rama (eds). Cambridge University Press. *In Press*.

Mpopetsi, PP. 2018. Towards defining the tipping point of tolerance to CO_2-induced ocean acidification for the growth, development and metabolism of larval dusky kob *Argyrosomus japonicus* (Pisces: Sciaenidae). MSc Thesis, Rhodes University.

Muller C, Childs A-R, James NC, Potts WM. 2021. Effects of experimental ocean acidification on the larval morphology and metabolism of a temperate Sparid, *Chrysoblephus laticeps*. *Oceans 2*(1), 26-40. https://doi.org/10.3390/oceans2010002

Tilbrook, B., Jewett, E. B., DeGrandpre, M. D., Hernandez-Ayon, J. M., Feely, R. A., Gledhill, D. 768 K., et al. (2019). An enhanced ocean acidification observing network: from people to technology 769 to data synthesis and information exchange. *Front. Mar. Sci.* 6. 770. https://doi.org/10.3389/fmars.2019.00337

5) LIST OF ENTITIES

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