Integrated Marine Observing System

State and Trends of Australia's Oceans | Report

4.4 | Ocean acidification and calcifying zooplankton

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Summary

There is no evidence of a decline in calcifying zooplankton at the IMOS National Reference Stations over the past 10 years, suggesting ocean acidification over this time span is unlikely to be having a substantial impact on calcifying zooplankton. However, there is some evidence that calcifying zooplankton might at Maria Island and Yongala be sensitive to the aragonite saturation state at the range of values currently observed.

Key Data Streams

National Reference Stations

State and Trends of Australia's Ocean Report
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Rationale

A consequence of elevated carbon dioxide levels in the atmosphere is that more carbon dioxide dissolves in the ocean. This alters the carbonate balance, releasing more hydrogen ions into the water and lowering pH. There has been a decrease of 0.1 pH units since the Industrial Revolution, representing about a 30% increase in hydrogen ions. This is accompanied by a decrease in the dissolved carbonate ion concentration of the seawater (Doneyet al., 2005). These changes impact the ability of many ocean organisms to grow calcium carbonate structures, increasing maintenance costs, and reducing larval survival and growth (Bednarsek et al., 2019; Waldbusser et al., 2015). Among marine organisms with calcium carbonate shells (calcifiers), those with the aragonite form of calcium carbonate are more susceptible to acidification than those with calcite. The saturation state of both aragonite and calcite is decreasing in ocean waters around Australia. Superimposed on this variability is a strong seasonal cycle, particularly in temperate regions (Lentonet al., 2016).

Methods

To summarise trends in time series of abundance of calcareous groups at the Integrated Marine Observing System (IMOS) National Reference Stations, we plotted sample scores of the first component of a principal components analysis of the abundance time series of a suite of calcareous zooplankton groups (IMOS Australian Ocean Data Network (AODN) dataset: “IMOS National Reference Station (NRS) - Zooplankton Abundance”). The principal components scores can be interpreted as an index of abundance of the community, with a high positive score reflecting high abundances of calcifiers (Edwards & Richardson, 2004; Legendre & Legendre, 2012). Calcareous groups included in this analysis are: echinoderm larvae (starfish and sea urchins that have calcite structures with magnesium, which makes it 30 times more soluble than calcite alone (Raven et al., 2005); bivalve larvae that have shells of aragonite and calcite; several gastropods including Cavoliniids that have aragonite shells, *Limacina* spp. with aragonite shells, and prosobranchs (some which have calcite and others aragonite shells)).

We then corelated the principal component scores with the aragonite saturation state at each national reference station. We calculated aragonite saturation state based on calculations of saturation state made using measurements of total dissolved carbon dioxide and total alkalinity (AODN dataset: “IMOS National Reference Station (NRS) - Salinity, Carbon, Alkalinity, Oxygen and Nutrients (Silicate, Ammonium, Nitrite/Nitrate, Phosphate)”) following best practice recommendations (Dickson, Sabine, & Dore, 2007). If ocean acidification is impacting calcifiers over the time scale of sampling, one would expect a positive relationship between the abundance of calcifiers and the aragonite saturation state is lower.

Results and interpretation

The principal components analysis shows that there is considerable seasonal and inter-annual variation in abundance of calcifying zooplankton (**Figure 1**). Linear trend lines for each National Reference Station and for all stations combined show that there is no overall decline in abundance of calcifiers. There are modest increases in calcifier abundance at Maria Island, Port Hacking and Darwin, and slight declines at Yongala and Kangaroo Island, but no substantial declines.

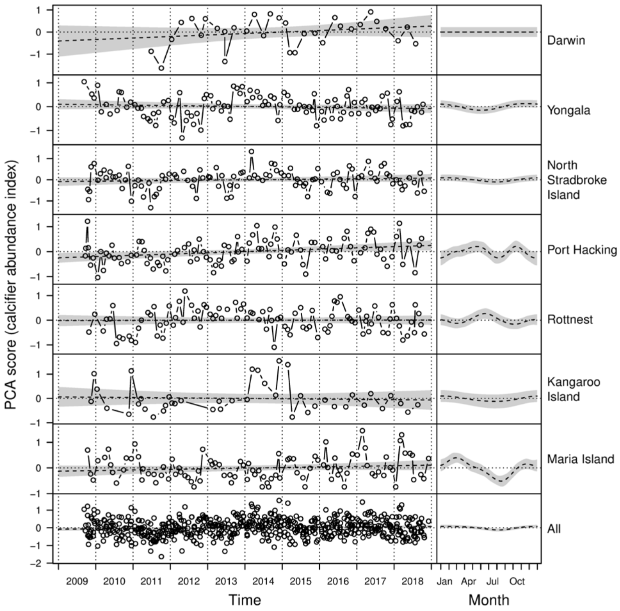

Figure 1. Time series of the scores on the first principal component of calcifying zooplankton (echinoderm larvae, bivalve larvae, Cavoliniid gastropods, and other shelled gastropods) and their seasonal cycles at the National Reference Stations. A linear trend was fitted to each NRS. The bottom plot shows the trend and seasonal cycle of zooplankton calcifiers for all stations combined.

There is strong seasonality in calcifier abundance at some stations. Warmer more tropical stations (Darwin, Yongala, North Stradbroke Island) have little seasonality, but colder-water stations (especially Maria Island, Rottnest and Kangaroo Island) are strongly seasonal. There is a clear spring and autumn bloom in calcifiers in Port Hacking, and a summer and autumn peak in Maria Island.

Calcifier abundance does not appear to be related to the range of aragonite saturation states observed at most National Reference Stations (**Figure 2**). However, there are significant positive relationships between the abundance of calcifiers (the first principal component) and the aragonite saturation state for Maria Island (r=0.34, p=0.007) and Yongala (r=0.32, p=0.001). This is likely to be a consequence of seasonal changes in aragonite saturation and calcifiers, but it could suggest that calcifiers in those regions might be sensitive to changes in aragonite saturation state. However, seasonal increases in temperature and saturation state coincide, so disentangling impacts of both is difficult.

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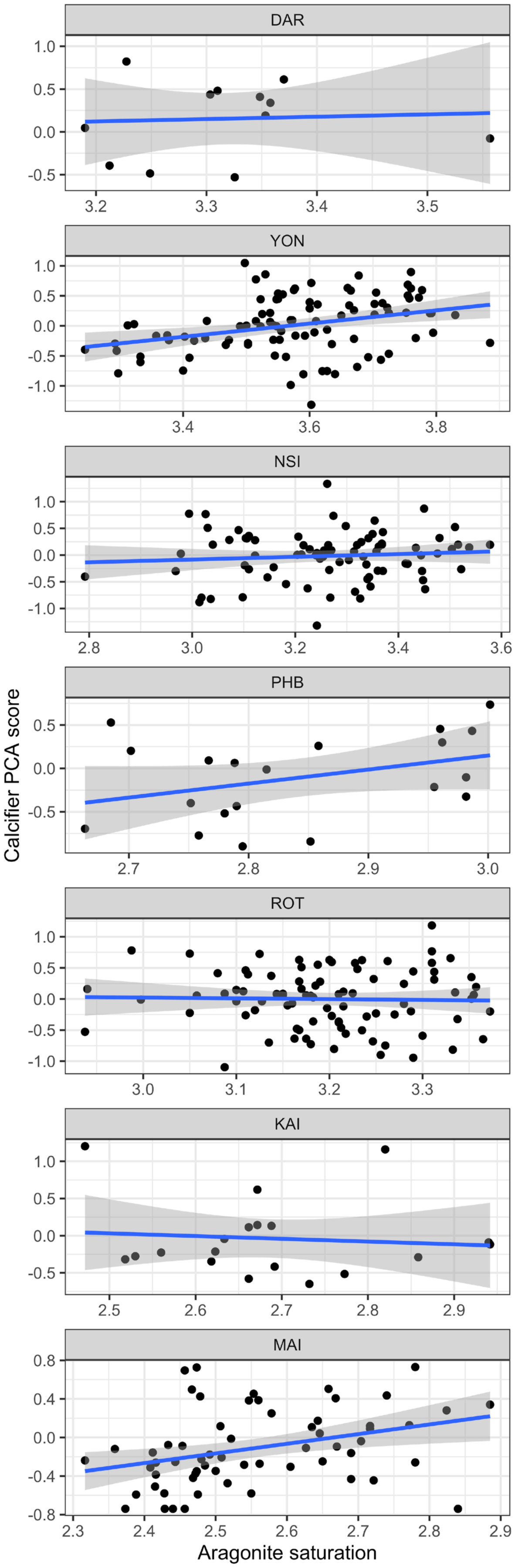

Figure 2. The relationship between the first principal component of calcifiers (echinoderm larvae, bivalve larvae, Cavoliniid gastropods, and other shelled gastropods) and the aragonite saturation state at the National Reference Stations.

Implications for people and ecosystems

There is no evidence of a decline in calcifying zooplankton at the IMOS National Reference Stations over the past 10 years. This suggests that ocean acidification over this time span is unlikely to be having a substantial impact on calcifying zooplankton. However, there is some evidence that at Maria Island and at Yongala that calcifiers might be sensitive to the aragonite saturation state at the range of values currently observed. It is also not clear if the changes that have occurred since the 1870s in the Australian region (Lenton et al., 2016) may have already impacted on zooplankton abundance. As the seawater aragonite saturation state continues to decrease in the future, the IMOS network is well placed to provide an early warning system of the impact of ocean acidification on calcifying zooplankton and other species.

Acknowledgements

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Data Sources

IMOS National Reference Stations.
http://imos.org.au/facilities/nationalmooringnetwork/nrs/

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