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Influence of a western boundary current on cross shelf patterns in zooplankton

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Abstract

Western boundary currents are recognized to influence continental shelf waters through a variety of physical mechanisms. Despite this, understanding of how western boundary curretns influence the biota on the continental shelf is limited. Zooplankton are the basis for many ecosystems on the continental shelf yet it is largely unknown how the east Australian current influences the coastal waters and the zooplankton they contain. By combining 4 targeted cross-shelf transects from inshore to off the continent shelf in Australia with an analysis of satellite derived sea surface temperature, we show that there is a regularly occurring EAC driven inshore – offshore temperature gradient on the continental shelf of eastern Australia which corresponds to changes in the zooplankton community. Zooplankton biomass, abundance and geometric mean size generally declined with increasing distance from the coast and depth when the EAC was influencing the coastal water on the continental shelf through uplift of cooler nutrient rich water. This cooler water also had a steeper normalized biomass size spectrum slope, signifying that this is highly productive water. This highly productive band of inner shelf water may be contributing the consistently high yield from fisheries in this region. This influence of the EAC on continental shelf zooplankton is likely reflected in other western boundary current regions where the fast flowing currents influence water on the continental shelf though uplift of colder water.

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Sections to include:

1. Importance of Zooplankton and previous research on continental shelf/coastal oceans
2. Continental shelf processes (including EAC influences)

Western boundary currents (WBCs) are fast-flowing currents which transport warm salty water from low latitudes poleward. At a more local scale, WBCs interact with the continental shelfs to generate eddies, fronts and upwelling. These features increase mixing across the continental shelf (REFS). By increasing mixing and upwelling on the continental shelf, WBCs are likely contributing to production through the supply of nutrients normally found in the cooler deeper water.

The importance of zooplankton to coastal ecosystems is increasingly being recognized. Zooplankton have been shown to be the basis for up to XXX % of biomass in these ecosystems (REFS). BAIRD papers on modelling here

Size structure short intro here

Insert Zoe White work etc here

Zooplankton are not uniformly distributed in the ocean. Their distribution is the result of a number of factors including physical mechanism such as transport and retention, biological factors including prey availability and predator abundance as well as behavior of the zooplankton (Huntley 2000). While there are no previous studies which investigate the depth stratified patterns of zooplankton on the continental shelf, it has previously been observed that zooplankton are not distributed uniformly across continental shelf with oceanographic features a key factor in these distributions. In the southeast Atlantic it was shown that the zooplankton community on the continental shelf had higher biomass and a steeper NBSS slope compared to the offshore oceanic stations which were typically more vertically stratified (Marcolin et al 2013).

INSERT VAN DROMME

The East Australian Current (EAC) is a baroclinic jet which forms between 10 and 20 °S when the South Equatorial Current diverges against the Australian coast. It flows south at approximately x – x m s-1 flowing the continental shelf until the majority of the EAC separates from the coast at approximately X °S and continues to flow eastward as the EAC eastern extension. The remaining portion of the EAC continues to flow south along the coast as part of the EAC southern extension generating a large eddy field. Along the continental shelf, particularly in the where the continental shelf narrows, the EAC had significant impact on shelf circulation. Current driven bottom friction leads to Ekman transport in the bottom boundary layer, moving cooler denser water up the slope, resulting in uplift of isotherms and upwelling. These upwelling events have been shown to bring nutrient rich water into the euphotic zone, increasing primary productivity (Rossi 2014) and controlling vertical phytoplankton abundance, composition and distribution (Ambrect 2014/15). Phytoplankton and nutrients are a key energy source for zooplankton and it is highly likely that the variable EAC is influencing zooplankton communities similar to the phytoplankton communities. Despite this there is little information on how western boundary currents influence patterns of zooplankton on the continental shelf and no analyses in the EAC region investigating the zooplankton community.

Aims:

1. Investigate cross shelf and depth stratified (wrong word?) patterns of zooplankton in eastern Australia
2. Identify the temporal stability of any observed patterns.

2 Materials and Methods

2.1 Voyage details

The cruise took place at the beginning of the austral spring, in September 2004. At this time, the EAC had separated from the coast at approximately 31°S and formed a large pool of water at 33°S, 155°E, creating a counter-clockwise rotating warm core eddy (Fig X).

2.2 Sampling

Five sections were sampled along constant latitude transects roughly perpendicular to the north NSW coast over a 6 day period in September 2004 using a CTD and a towed device called the Bunyip (a highly modified SeaSoar). During the CTD transects, florescence, temperature, salinity and oxygen were electronically measured, and nutrients (NO3, PO4, Si) and bottle oxygen taken at the surface, and, total depth of water allowing, at depths of 25, 50, 75, 100, 150, 200, 250, 400 and 500 m. Filtered particulate matter samples were taken at the surface of each of the CTD stations. The Bunyip varied between the 10 and 120 m, and sampled temperature, salinity, and, using an optical plankton counter, the size distribution of particulate matter. Further sampling during this period using towed plankton nets will be reported in later publications. The shelf sampling was interrupted on the 8-10th September to undertake a wake study around North Solitary Island (29°55'S 153°23'E) which will be reported elsewhere. All times reported are local (Sydney) Australian eastern Standard Time.

2.2.1 Transects

Diamond Head Section (31°45'S). The Bunyip undertook a transect between 1953-2201 on the 6th September in an easterly direction, followed by net tows in a westward direction. A CTD transect was then undertaken in a easterly direction on the 7th September from 0437-0838.

North Solitary Island Section (30°00'S). The Bunyip undertook a transect between 2134 on the 7th September and 0013 on the 8th in an easterly direction, followed by net tows in a westward direction. A CTD transect was then undertaken in an easterly direction on the 8th September from 1340 -2314.

Evans Head Section (29°00'S). A Bunyip transect was undertaken in an easterly direction from 1048-1243 on the 11th September. A CTD transect followed in a westward direction from 1317-2044 on the 11th September, and finally net tows.

Cape Byron Section (28°38'S). A Bunyip transect was undertaken in an easterly direction from 0805-1006 on the 12th September. No other sampling was undertaken at Cape Byron.

2.3 Chlorophyll analysis (IS THIS NEEDED?)

Water sampled for Chl a analysis was filtered through a 47 mm diameter, 1.2 µm glass fibre filter under low vacuum within 30 minutes of collection. Filters were then folded, blotted dry, wrapped in aluminium foil and stored at -20°C until analysis. Chl a concentration was calculated using the method of Jeffery and Humphrey (1975). The calibration curve of the CTD fluorometers is shown in Fig. 2 of Baird et al. (in prep.), where Fl = 4.66 [Chl a] +52.66, r2 = 0.73. Chl a is converted to phytoplankton biomass using 1 mmol N = 1.59 mg Chl a (Fasham et al., 1990).

2.4 Optical plankton counter

The optical plankton counter was mounted on the Bunyip, a CSIRO customised towed device. The optical plankton counter (OPC) is a Focal Technologies Corporation Model OPC-2T with a sampling aperture of 2 x 10 cm. The OPC records equivalent spherical diameters of particles that pass through the instrument in a 0.5 s interval. The particle sizes are recorded digitally into 4096 bins, corresponding within the operating range of the instrument to bins with a 5 and 15 µm width. (not sure here?)

The volume of flow through the sample region is based on distance measured, averaged over a 6 s interval. The choice of time interval is a trade-off between a larger time period to obtain a higher particle count to accurately obtain the estimate of the size distribution, and a shorter time period to provide better spatial resolution. The spatial averaging is along the instrument trajectory. As the instrument moves vertically at approximately 1 m s-1, a long period averaging most affects vertical resolution. A 6 s interval provides the best resolution of spatial distribution of size distribution of the Tasman Sea waters with a biomass of ≈ 1-10 mmol N m-3. The biomass in the Coral Sea waters is so low that no sensible size-distribution data can be spatially resolved. Instead, size-distribution is averaged for the all Coral Sea water in a particular transect.

3 Data, or a descriptive heading about data

4 Results, or a descriptive heading about the results

5 Conclusions

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Acknowledgments, Samples, and Data

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References

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