The impacts of ocean acidification on the geographic distribution, abundance, species composition and shell size of oceanic thecosome pteropods in the southeast Pacific

SEA Semester
Environmental Studies in Woods Hole & at Sea

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Background

What is ocean acidification? The absorption of anthropogenic carbon dioxide (CO_2) by the oceans reduces pH and the concentration of carbonate ion (CO_3^{2-}) (Doney et al., 2009). Surface pH has decreased from 8.2 to 8.1 since pre-industrial times (Rost et al., 2008). Many physiological processes are sensitive to pH. Organisms that form calcium carbonate ($CaCO_3$) shells may be particularly at risk.

What are thecosome pteropods? Thecosome pteropods are shell-forming planktonic gastropods, commonly referred to as 'sea butterflies.'

Where are they found? Pteropods are widely distributed and abundant in coastal and open ocean pelagic ecosystems of the world's oceans (Figure 2; Lalli and Gilmer, 1989). They are primarily found between approximately 40° S and 40° N (Be and Gilmer, 1977).

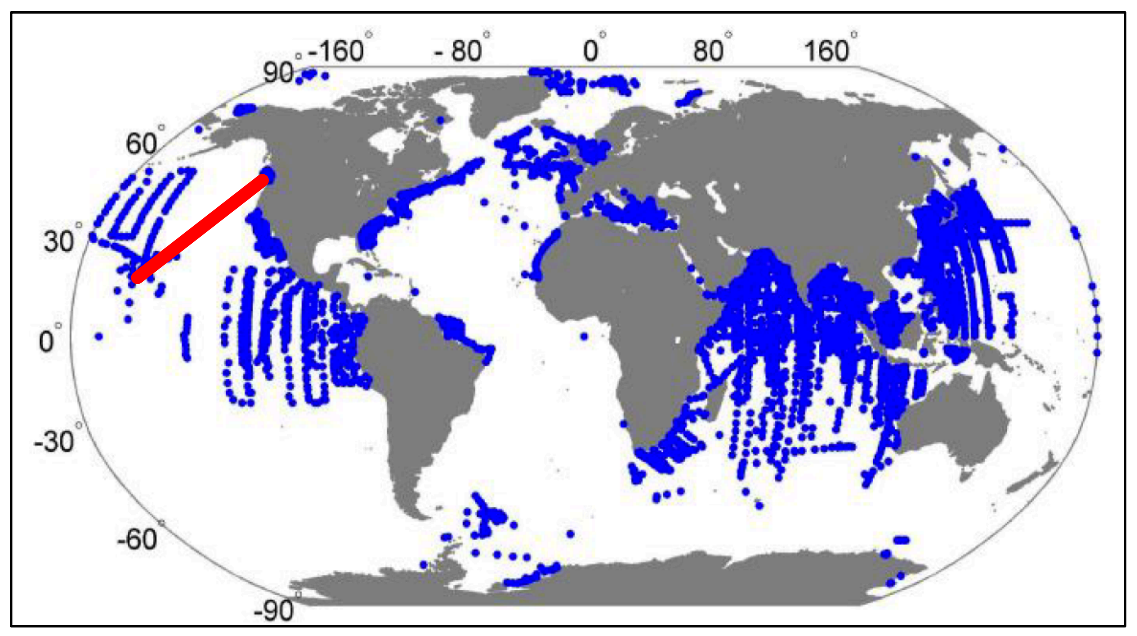

Figure 1. Cruise track (red) and global distribution of pteropod observations (blue) (modified from Bednaršek et al., 2012).

How will ocean acidification affect thecosome pteropods?
Pteropods are sensitive to ocean acidification due to their aragonite shells. Future changes are expected to strongly impact their calcification rates and susceptibility to dissolution (Orr et al., 2005). The extent to which pteropods are affected largely depends upon the aragonite saturation state ($\Omega_{aragonite}$). Shell formation generally occurs where $\Omega_{aragonite} > 1.0$ where as dissolution occurs when $\Omega_{aragnoite} < 1.0$ (Doney et al., 2009). Less is known about the potential changes in horizontal and vertical distribution, abundance, and species composition of thecosome pteropods that may accompany ocean acidification.

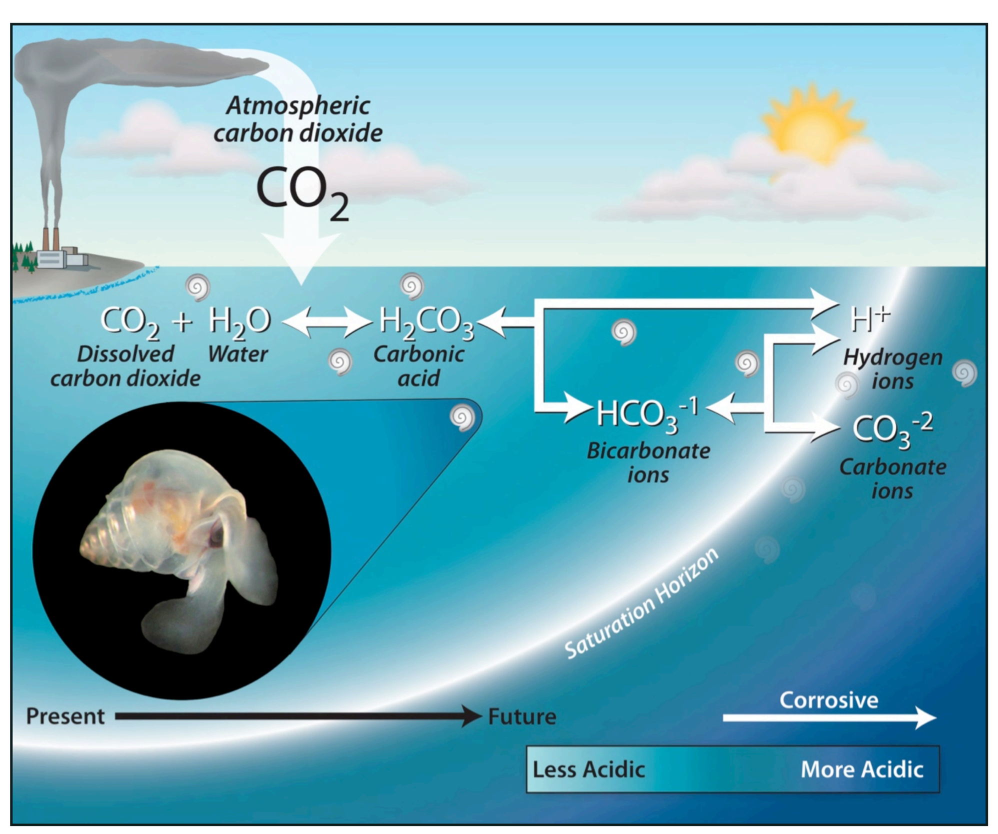

Figure 2. The impact of ocean acidification on thecosome pteropods. Courtesy of Gareth Lawson.

Research Question

How will continued ***ocean acidification*** impact the ecology and role of ***oceanic thecosome pteropods*** within the pelagic ecosystem?

Objective

Quantify the:

- **geographic distribution**
- **numerical abundance**
- **species composition**
- **shell size**
- **biomass**

of *oceanic thecosome pteropods* in the southeast Pacific.

Correlate these quantities with:

- **latitude**
- **SST**
- **pH at 0, 50 & 150 m**
- **DIC**
- **TA**
- **$\Omega_{aragonite}$**

Hypotheses

H1. Pteropod species composition will vary with all quantities. Species-specific relationships are expected.
H2. Abundance ↓ with: ↓ latitude, ↑ SST, ↓ pH, ↓ TA, ↑ DIC, ↓ $\Omega_{aragonite}$
H3. Shell size ↑ with: ↓ latitude, ↑ SST, ↑ pH, ↑ TA, ↓ DIC, ↑ $\Omega_{aragonite}$
H4. Biomass will vary with all abiotic factors similarly to shell size.

Methods

A 46-day cruise to the southeast Pacific will be conducted from November 5 to December 20, 2013 on the SVV *Robert C. Seamans* sailing out of San Diego, CA and into Papeete, Tahiti. Regular sampling stations will occur twice daily, at ca. 10:00 (LAT), and 22:00 (LAT), and will involve:

- SST and SSS measurements with a CTD from 0 to 150 m
- pH and TA measurements with Niskin bottle samples at 0, 50 and 150 m
- pteropod collection with 333 µm-mesh Neuston net at the surface

Pteropods will also be collected every four days at night using a 333 µm-mesh meter net towed obliquely to sample the top 150 m of the water column. DIC and $\Omega_{aragonite}$ will also be calculated. The number of pteropods collected will be counted to determine numerical abundance. Species of the pteropods will be determined using a key provided by A. Maas. Pteropod shell size will be measured using the method described by Little and Copley (2003). Length-to-wet weight conversion equations will be used to calculate total biomass (Table 1).

Table 1. Length-to-weight conversion equations for different geometric shapes. L represents length (mm) and WW represents wet weight (mg) (modified from Little and Copley, 2003).

Shape	Example Pteropod Taxon	Size-weight relationship
Triangular/Pyramidal	Cavolinia spp., Diacria spp.	$WW = 0.2152*L^{2.293}$
Round/Cylindrical/Globular	Limacina spp.	$WW = 0.000194*L^{2.5473}$
Cone/Needle/Bottle	Hyalocylis spp., Styliola spp.,	$WW = \pi*L^{3*3/25}$

Acknowledgements

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