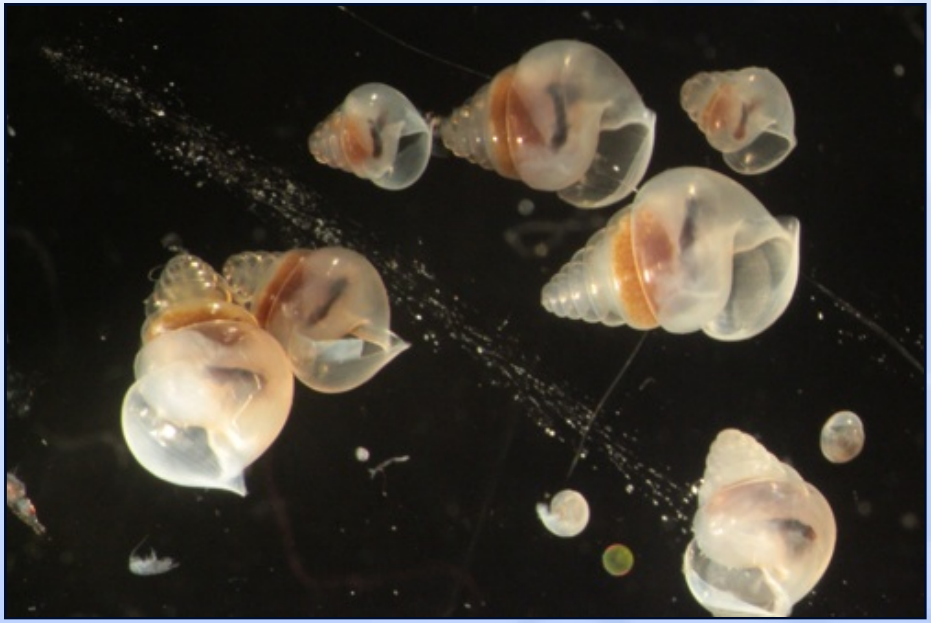
The impacts of ocean acidification on the distribution, abundance, species composition and shell size of thecosome pteropods



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Ocean Acidification

$$CO_{2\,(atm)} \rightleftharpoons CO_{2\,(aq)} + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons 2H^+ + CO_3^{2-}$$

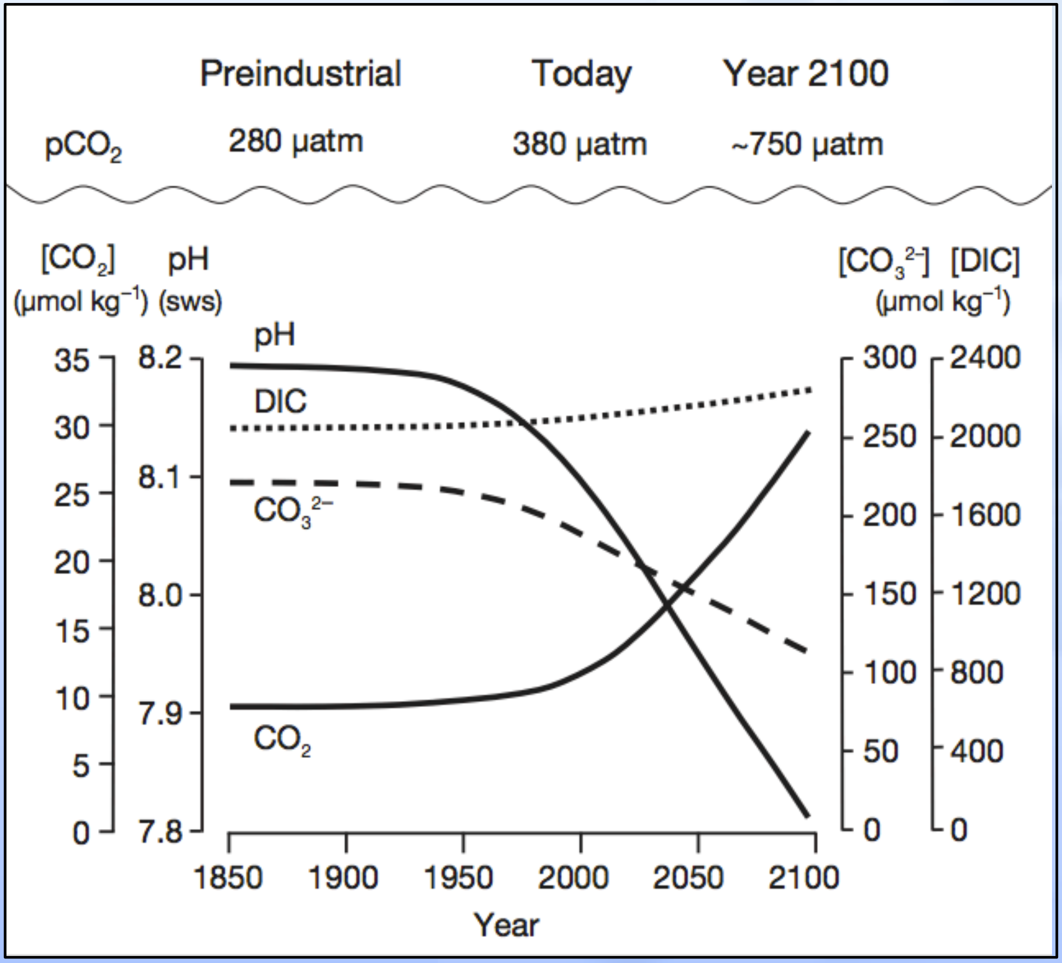


Figure: Rost et al. 2008

Aragonite Saturation State

$$\Omega_{aragonite} = [Ca^{2+}]\,[CO_3^{2-}] / K_{sp\ aragonite}$$

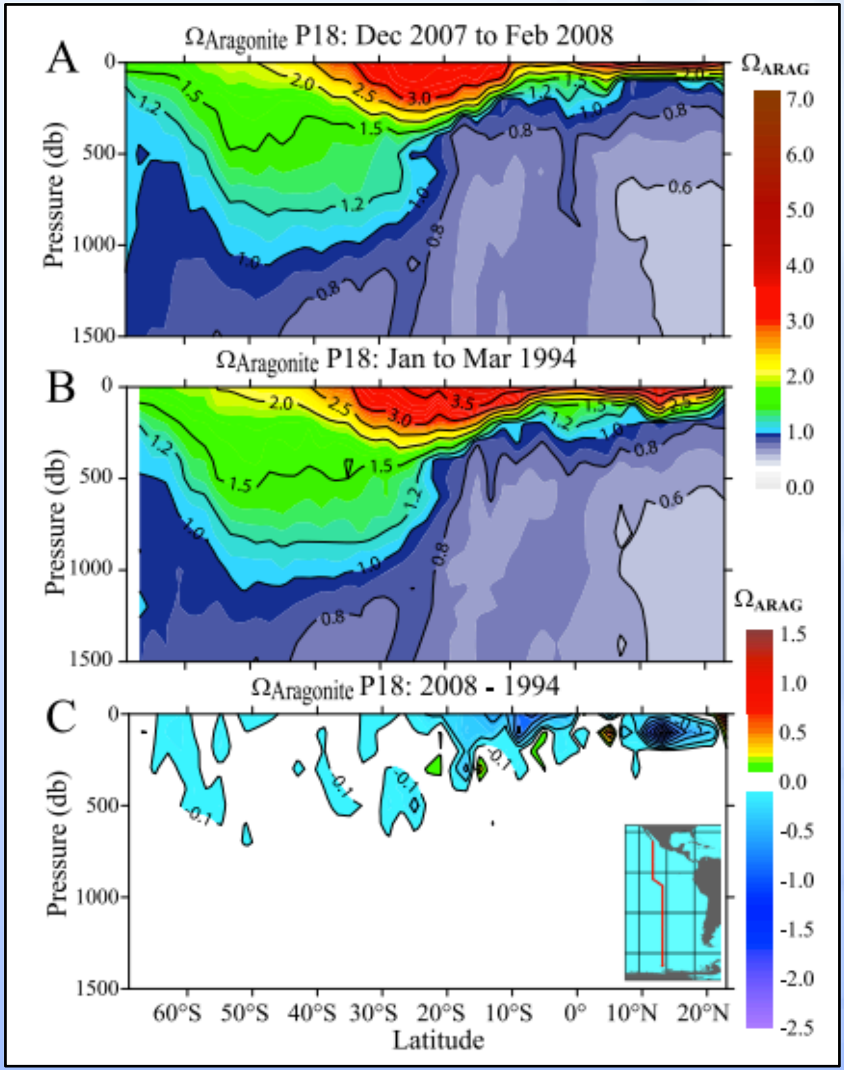


Figure: Feely et al. 2012

Impacts on the Plankton

- Much previous work has focused on coastal species
- Effects of experimentally decreased pH has been variable, depending on species
- Less work done on zooplankton and the open ocean

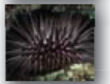
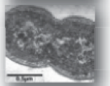
PHYSIOLOGICAL RESPONSE		MAJOR GROUP	# SPECIES STUDIED	RESPONSE TO INCREASING CO_2 a	b	c	d
CALCIFICATION							
		Coccolithophores	4	2	1	1	1
		Planktonic Foraminifera	2	2	–	–	–
		Molluscs	6	5	–	1	–
		Echinoderms	3	2	1	–	–
		Tropical Corals	11	11	–	–	–
		Coralline Red Algae	1	1	1	–	–
PHOTOSYNTHESIS[1]							
		Coccolithophores[2]	2	–	2	2	–
		Prokaryotes	2	–	1	1	–
		Seagrasses	5	–	5	–	–

Figure: Doney et al. 2009

Pteropods – Charismatic Microfauna

- Shell-forming planktonic gastropods aka ‘sea butterflies’
- Thecosome = Shelled
- Little known about their abundance, distribution, movements, and ecological role
- Important as prey item for many commercial fish (e.g., salmon)

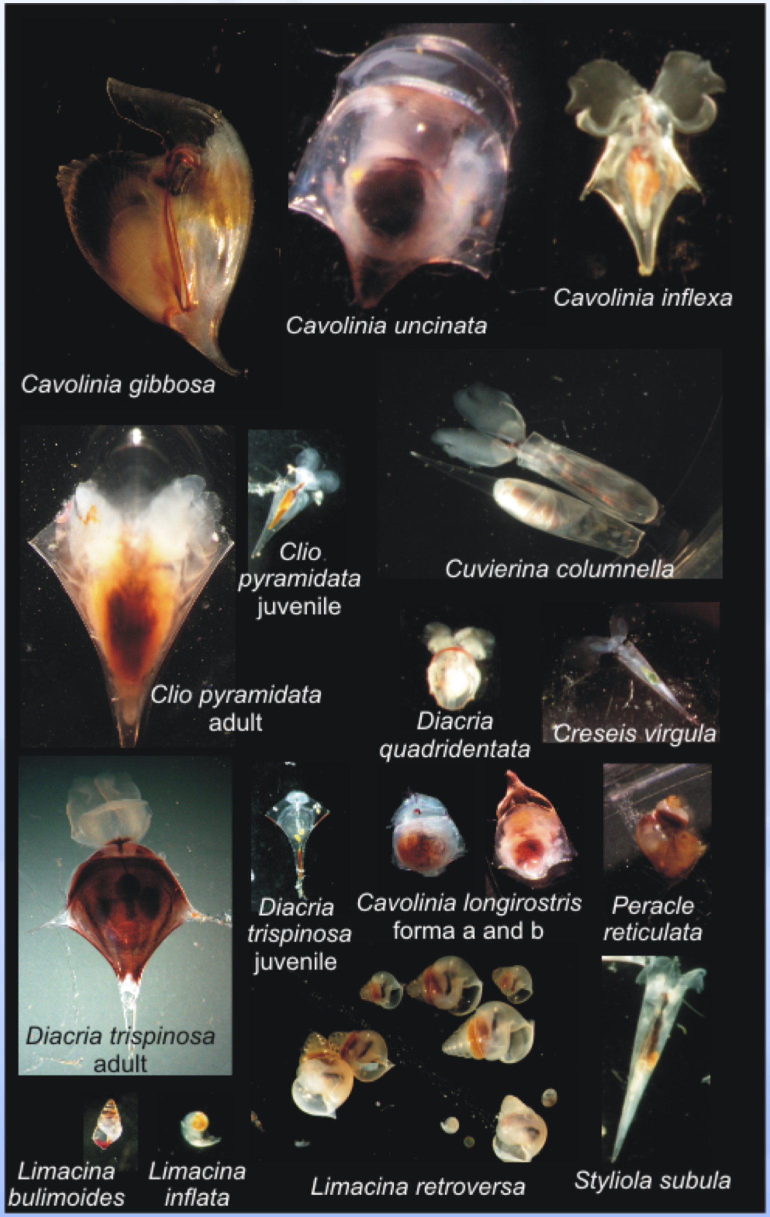


Image courtesy of Amy Maas

Ocean Acidification and Thecosome Pteropods

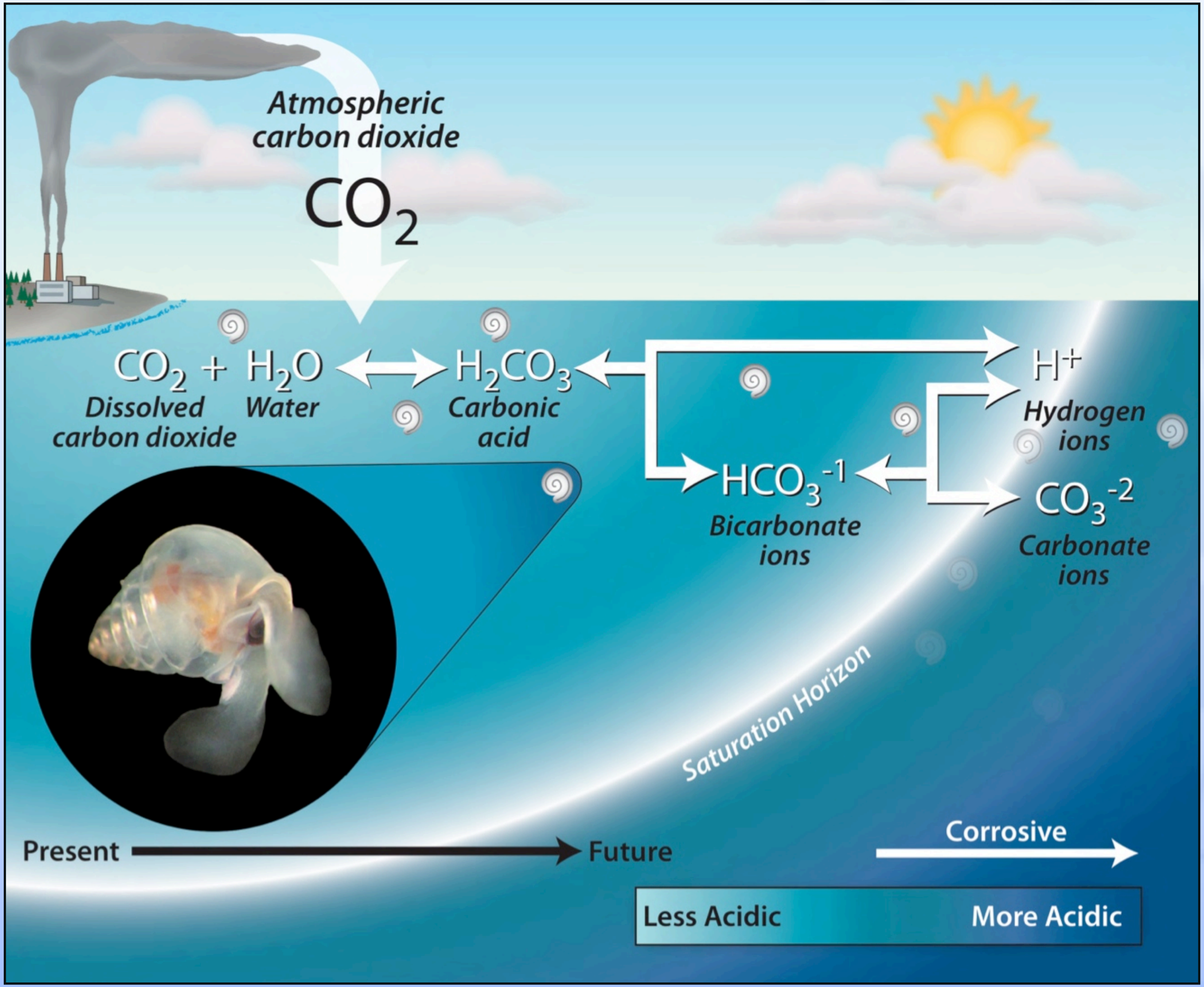
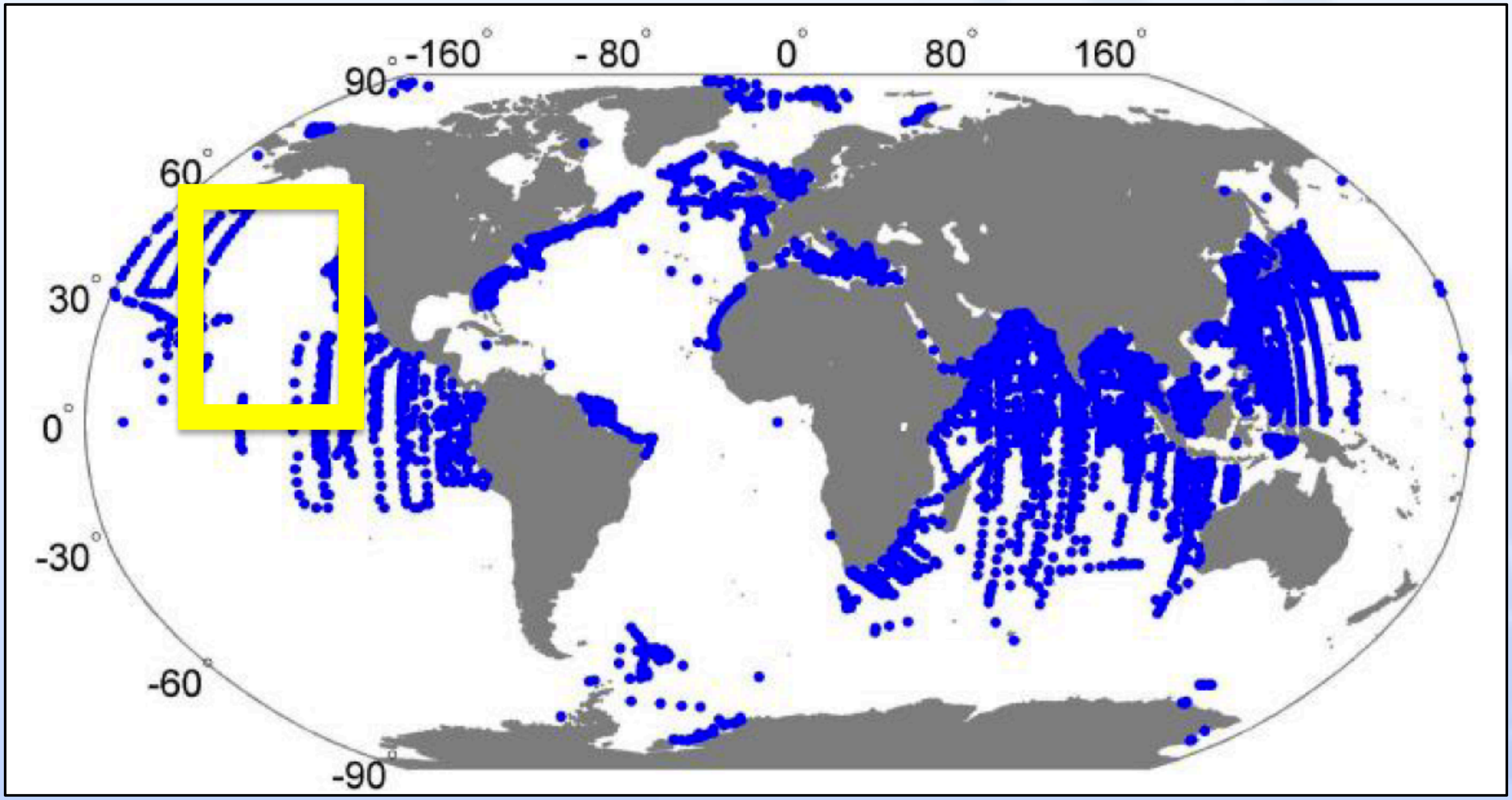


Image courtesy of Gareth Lawson

Geographic Distribution of Pteropods



- highest species diversity in tropical and subtropical regions (Lalli and Gilmer, 1989; Fabry et al., 2008)
- highest abundances found at high latitudes (Lalli and Gilmer, 1989)

Figure: Bednaršek et al. 2012

Research Question

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

Objective

Quantify:

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

of *oceanic thecosome pteropods* in the southeast Pacific.

Abiotic Factors

Correlate these quantities with:

- **latitude**
- **temperature**
- **surface water pH**
- **dissolved inorganic carbon (DIC)**
- **alkalinity**
- **aragonite saturation state**

Hypotheses

H1. Species composition will vary with:

- latitude
- sea surface temperature
- pH
- alkalinity
- DIC
- aragonite saturation state

Species-specific relationships are expected.

Hypotheses

H2. Abundance ↓ with:

- ↓ latitudes
- ↑ sea surface temperatures
- ↓ pH
- ↓ alkalinity
- ↑ DIC
- ↓ aragonite saturation state

Hypotheses

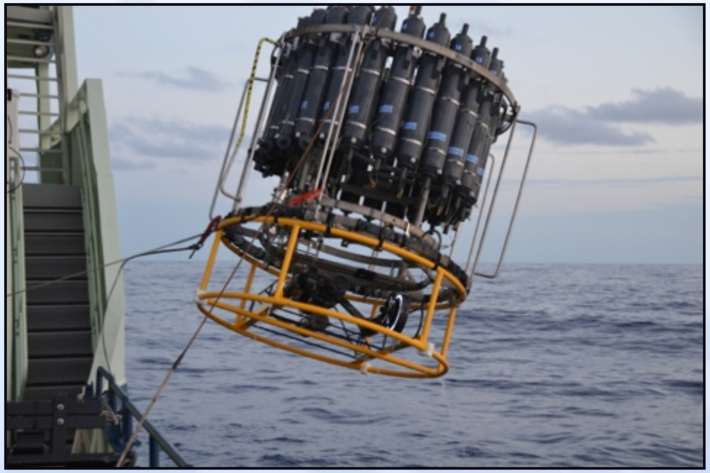
H3. Shell size ↑ with:

- ↓ latitudes
- ↑ sea surface temperatures
- ↑ pH
- ↑ alkalinity
- ↓ DIC
- ↑ aragonite saturation state

H4. Biomass will vary with all abiotic factors similarly to shell size.

Sampling Methods

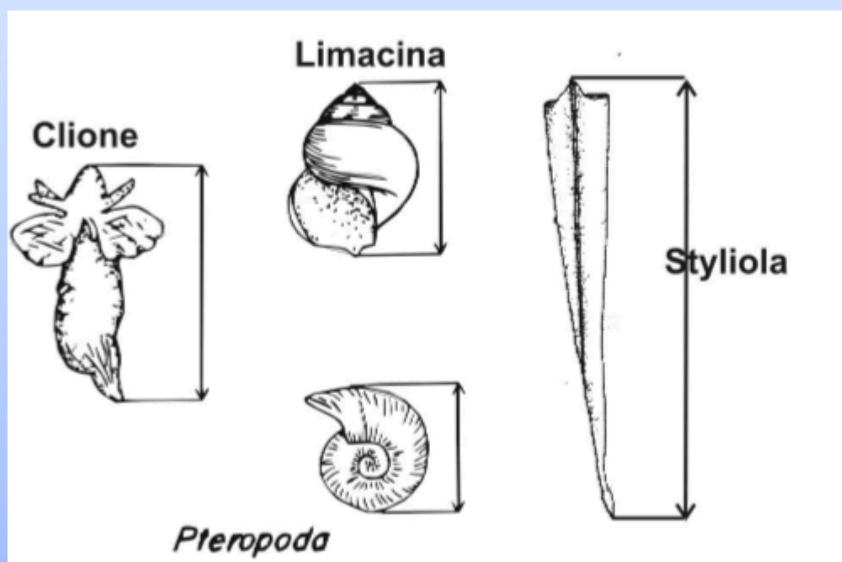
- Conductivity-Temperature-Depth (CTD) to characterize temperature, salinity
- Niskin bottle sampling to measure pH, DIC, alkalinity
- 333 µm-mesh Neuston net to collect pteropods in surface waters
- possible use of mesh meter nets to sample deeper (to 75 m)

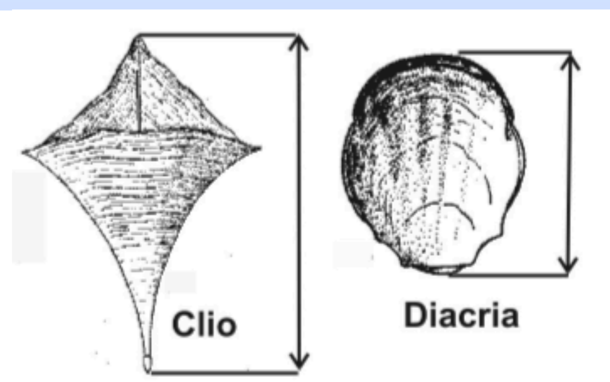


Images courtesy of Gareth Lawson

Shell Size and Biomass

SPECIES	Group	Equation source	Conversion	Equation name	Equation (size-weight relationship)	Equation (Davis and Wiebe, 1985)	
Limacina spp.	Round/cylindrical/ globular	GLOBEC	Diameter→DW		$WW = 0.000194\times L^{2.5473}$	WW→DW	$WW\times 0.28$
Clione spp.	Barell/oval-shaped (naked)	GLOBEC	Length→WW	Pteropod (naked: Clione)	$WW = 10^{(2.533\times\log(L)-3.89095)\times 10^3}$	WW→DW	$WW\times 0.28$
Styliola spp.	Cone/needle/ tube/bottle-shaped	GLOBEC	Length→WW	Pteropod (cone-shaped: Styliola)	$WW = PI\times L^{3\times 3/25}$	WW→DW	$WW\times 0.28$
Clio spp.	Triangular/ pyramidal	GLOBEC	Length→WW	Pteropod (Clio)	$WW = 0.2152\times L^{2.293}$	WW→DW	$WW\times 0.28$
Diacria spp.	Triangular/ pyramidal	GLOBEC	Length→WW	Pteropod (Clio)	$WW = 0.2152\times L^{2.293}$	WW→DW	$WW\times 0.28$
Thecosomata	Shelled	Davis and Wiebe (1985)	Length→WW		$WW = 0.2152\times L^{2.293}$	WW→DW	$WW\times 0.28$
Gymnosomata	Naked	Davis and Wiebe (1985)	Length→WW		$WW = 10^{(2.533\times\log(L)-3.89095)\times 10^3}$	WW→DW	$WW\times 0.28$
Pteropoda	Shelled	Davis and Wiebe (1985)	Length→WW		$WW = 0.2152\times L^{2.293}$	WW→DW	$WW\times 0.28$





Figures: Bednaršek et al. 2012; Little and Copley 2003

References

Bednaršek, N., J. Možina, M. Vogt, C. O'Brien, and G.A. Tarling. 2012. The global distribution of pteropods and their contribution to carbonate and carbon biomass in the modern ocean. Earth System Science Data. 4: 167-186.

Doney, S.C., V.J. Fabry, R.A. Feely, and J.A. Kleypas. 2009. Ocean Acidfication: The Other CO_2 Problem. Annual Review of Marine Science. 1: 169-192.

Fabry, V.J., B. A. Seibel, R.A. Feely and J.C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. Ices Journal of Marine Science. 65 (3): 414-432.

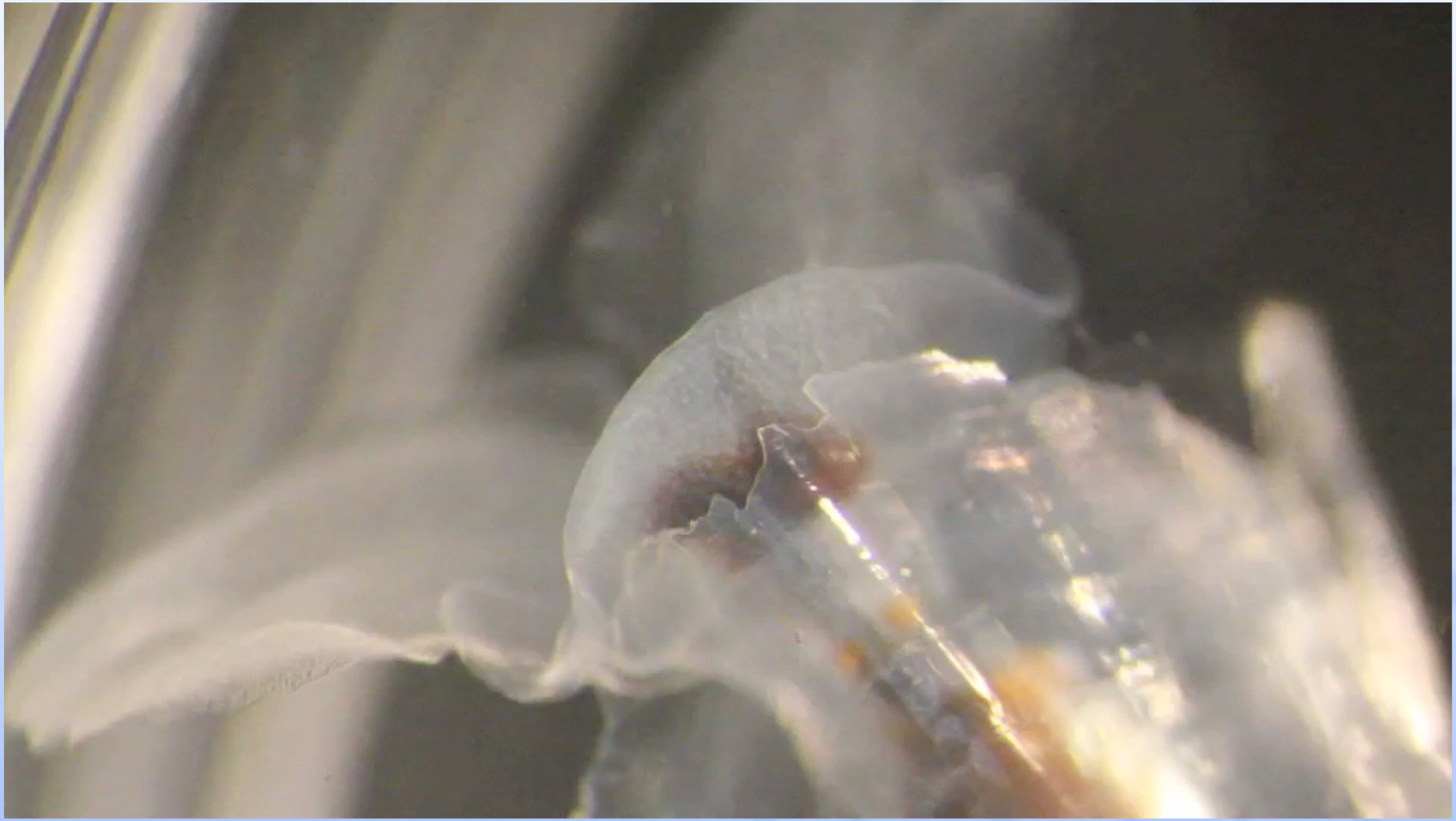
Feely, R.A., C.L.. Sabine, R.H. Byrne, F.J. Millero, A.G. Dickson, R. Wanninkhof, A. Murata, L. A. Miller, and D. Greeley. 2012. Decadal changes in the aragonite and calcite saturation state of the Pacific Ocean. Global Biogeochemical Cycles. 26: 1-15.

Lalli, C.M., and R.W. Gilmer. 1989. Pelagic snails: the biology of holoplanktonic gastropod molluscs. Stanford University Press: Stanford, California.

Little, W.S., and N.J. Copley. 2003. WHOI Silhouette DIGITIZER, Version 1.0, Users Guide. WHOI Technical Report: Woods Hole Oceanographic Institution.

Rost, B., I. Zondervan, and D. Wolf-Gladrow. 2008. Sensitivity of phytoplankton to future changes in ocean carbonate chemistry: current knowledge, contradictions and research directions. Marine Ecology Progress Series. 373: 227-237.

Questions?



Video courtesy of Nancy Copley and Alex Bergen