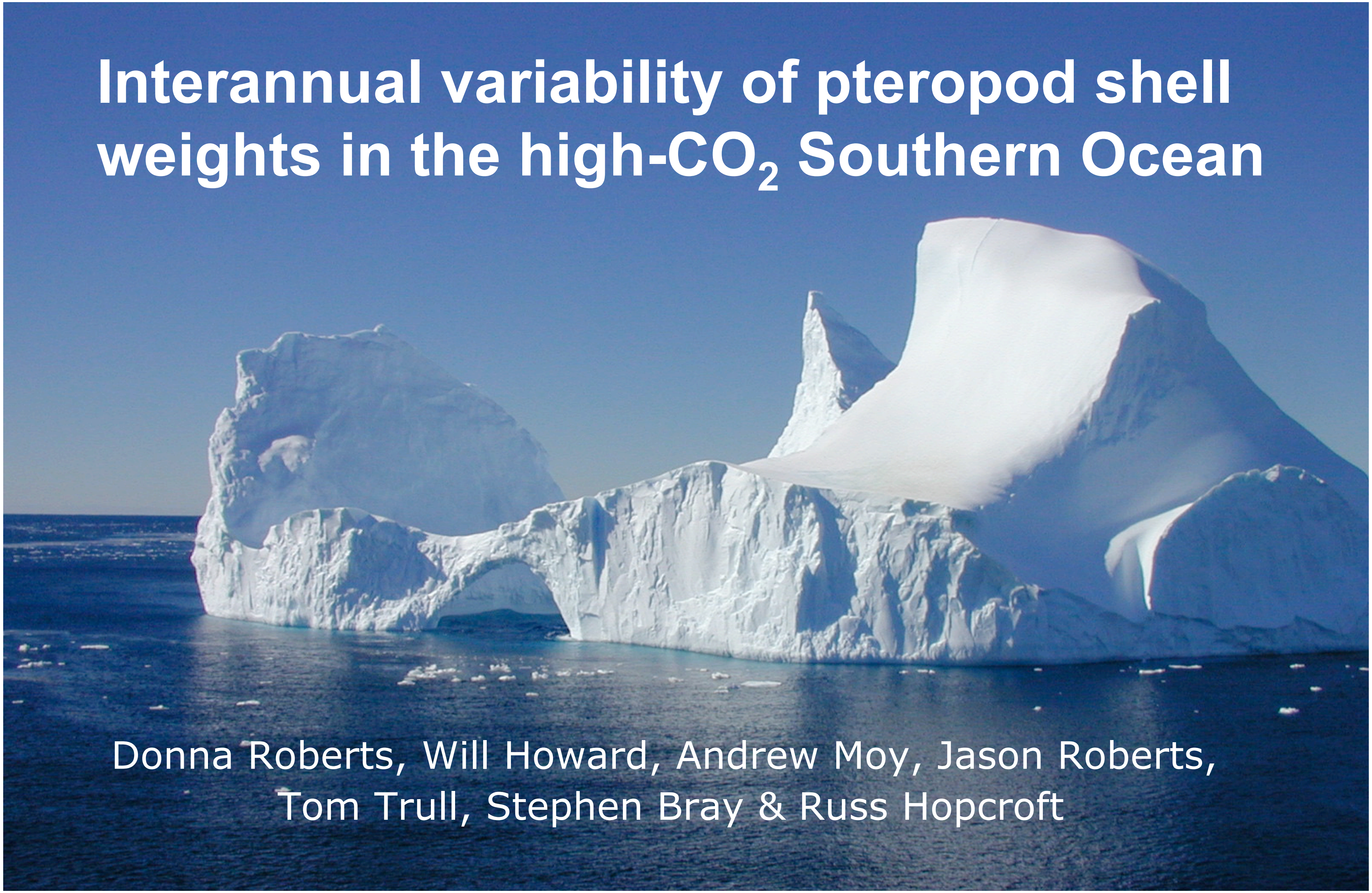
Interannual variability of pteropod shell weights in the high-CO_2 Southern Ocean



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Tom Trull, Stephen Bray & Russ Hopcroft

Antarctic Climate & Ecosystems
Cooperative Research Centre

Australian Government
Department of Climate Change

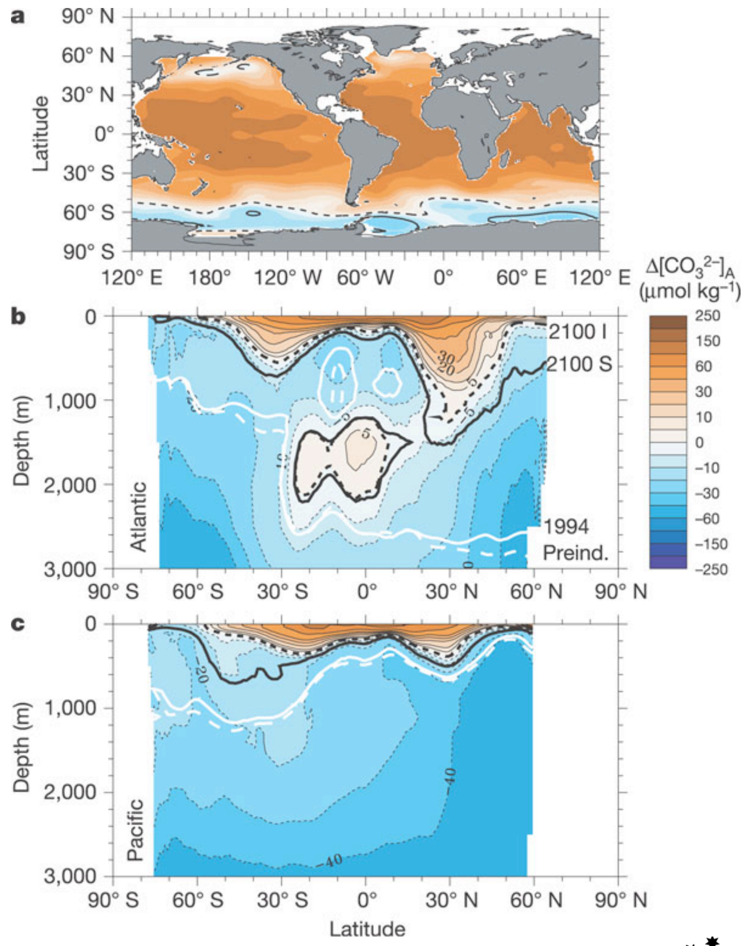
Motivation for Research Project

- **Atmospheric CO_2 ⇑**

- **Ocean pH ⇓**
- **$[CO_3^{2-}]$ ⇓**

  - models suggest polar regions will experience $[CO_3^{2-}]$ below those favourable for aragonite precipitation first [1]

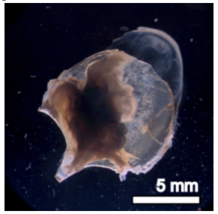
  - Southern Ocean a good place to look for impacts of ocean acidification on aragonite calcifiers



[1] Orr et al. 2005. Nature: 437

Southern Ocean shelled pteropods: now

SAZ-SENSE Voyage
44-54°S 140-155°E
17 Jan - 20 Feb 2007

1


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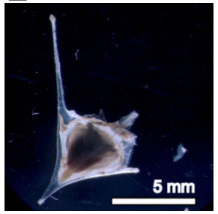

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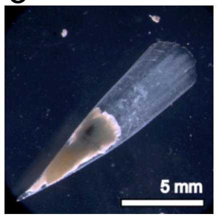

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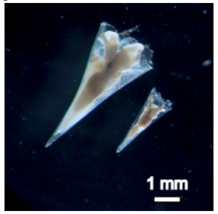

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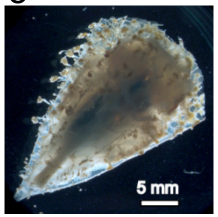

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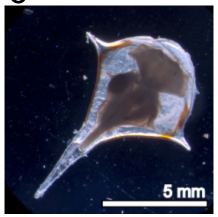

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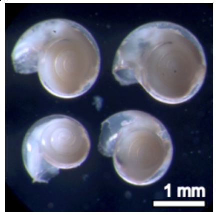

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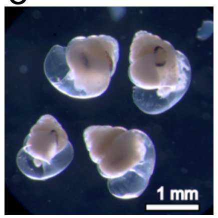
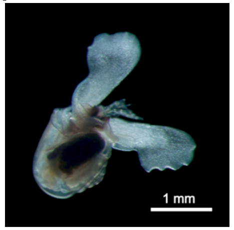


9


1. *Cavolinia tridentata* f. *atlantica*
2. *Clio cuspidata*
3. *Clio pyramidata* f. *antarctica*
4. *Clio pyramidata* f. *sulcata*
5. *Clio balantium (recurva)*
6. *Diacria rampali*
7. *Limacina helicina antarctica*
8. *Limacina retroversa australis*
9. *Peracle* cf. *valdiviae*

CEAMARC Voyage
62-67°S 138-146°E
23 Jan - 16 Feb 2008

1


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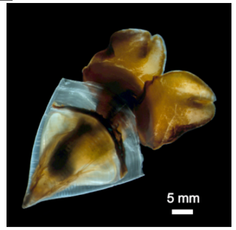
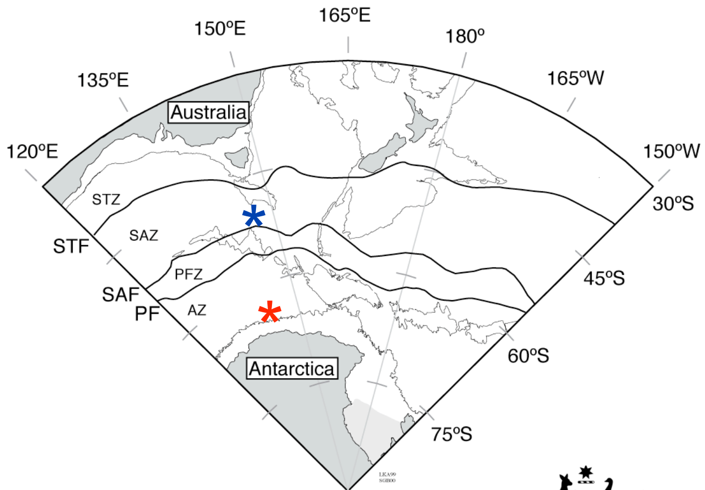


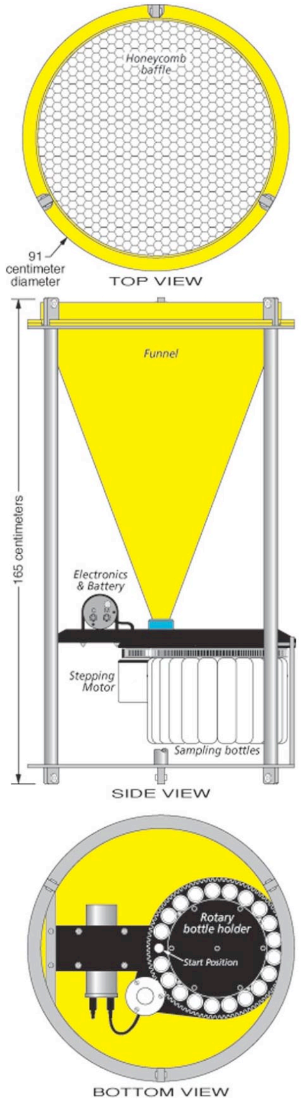
1. *Limacina helicina antarctica*
2. *Clio balantium*

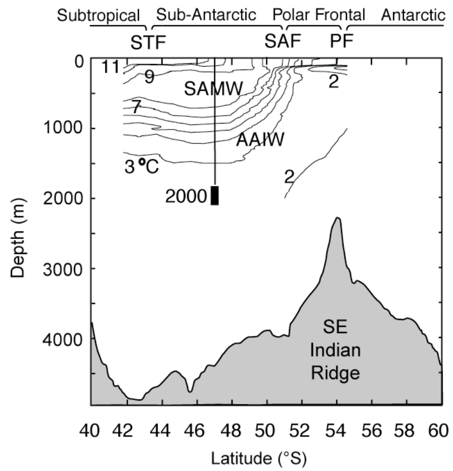


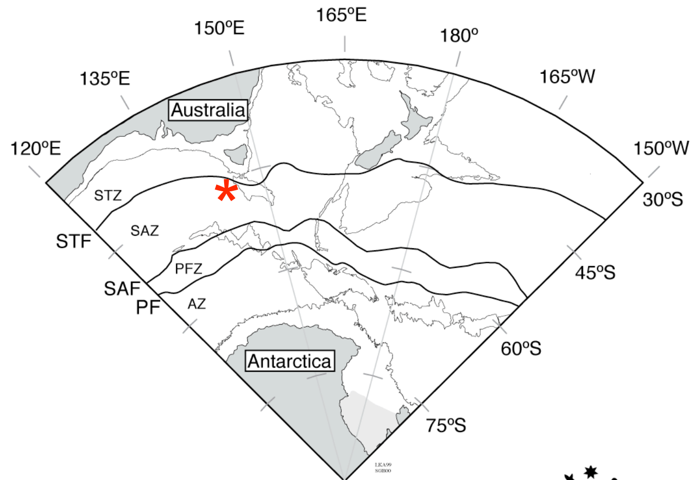
Southern Ocean shelled pteropods: past

- Sediment Traps
  - 47°S
  - 142°E
  - 2000 m trap
  - 4500 m water
  - 1997/98 - 2005/06

  - each cup (21) treated with dense, buffered, biocide solution and open from 5 - 60 days

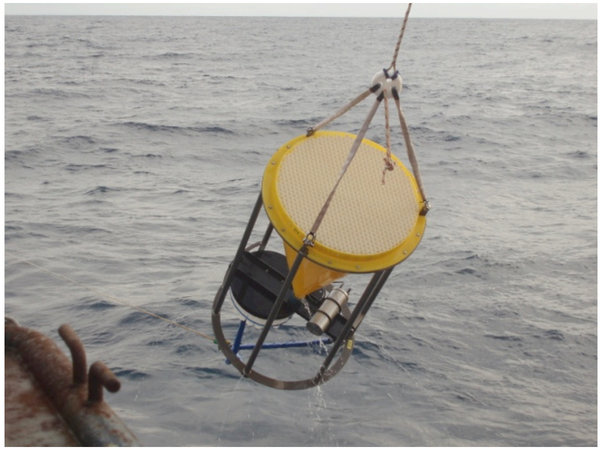






Southern Ocean shelled pteropods: past

- How will we measure calcification response in Southern Ocean pteropods?
  - Foram shell weights ⇓ as surface water $[CO_3^{2-}]$ ⇓ [1]
  - Pteropod shell weights?

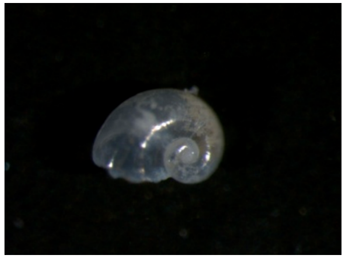


- recovered 5 traps in 9 years at 47°S
- extracted 150µm - 1mm size fraction
- dissolved organics in buffered 3% H_2O_2
- identified whole pteropod shells
- batch weighed discrete taxa per cup (microbalance precision = 0.1µg)
- accounted for non-uniform trap intervals

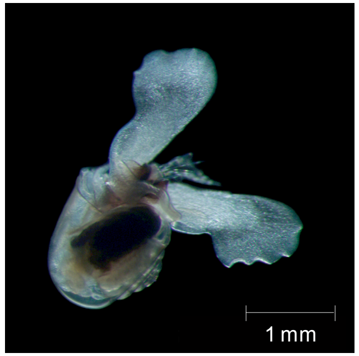
[1] Barker & Elderfield. 2002. Science: 297

Southern Ocean shelled pteropods: past

- Sediment Trap Pteropods
  - *Limacina helicina antarctica (66%)*
  - *Limacina inflata (14%)*
  - *Clio (pyramidata, sulcata, cuspidata)**(10%)
  - *Limacina retroversa australis (2%)*

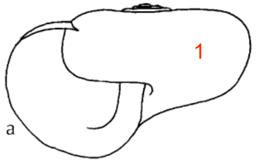


Southern Ocean shelled pteropods: past

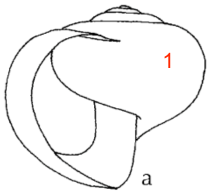


- Limacina helicina antarctica
  - Antarctic coast <---> Subtropical Front

  - forma *antarctica*
    - Antarctic waters
    - Antarctic coast <---> Polar Front
    - 'cold' morphotype (25%)



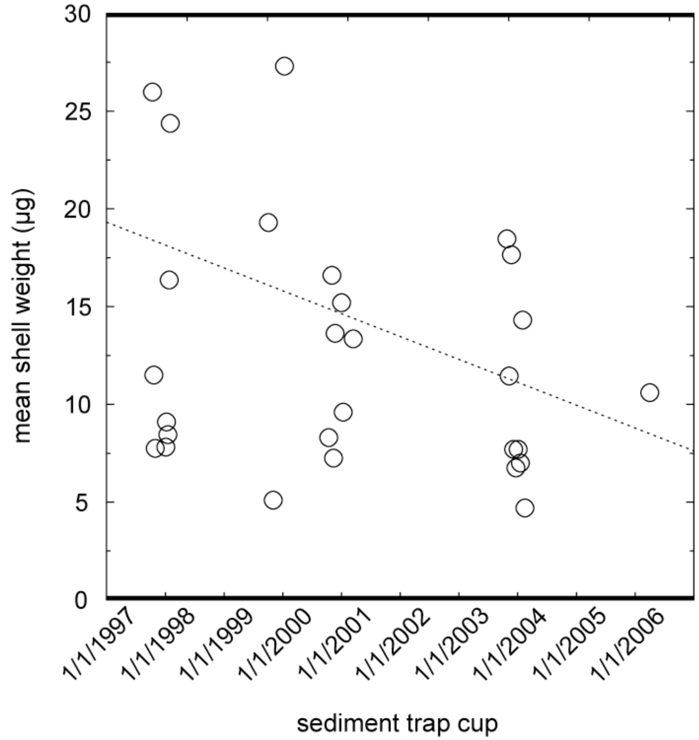
  - forma *rangi*
    - Subantarctic waters
    - Polar Front <---> Subtropical Front
    - 'warm' morphotype (41%)

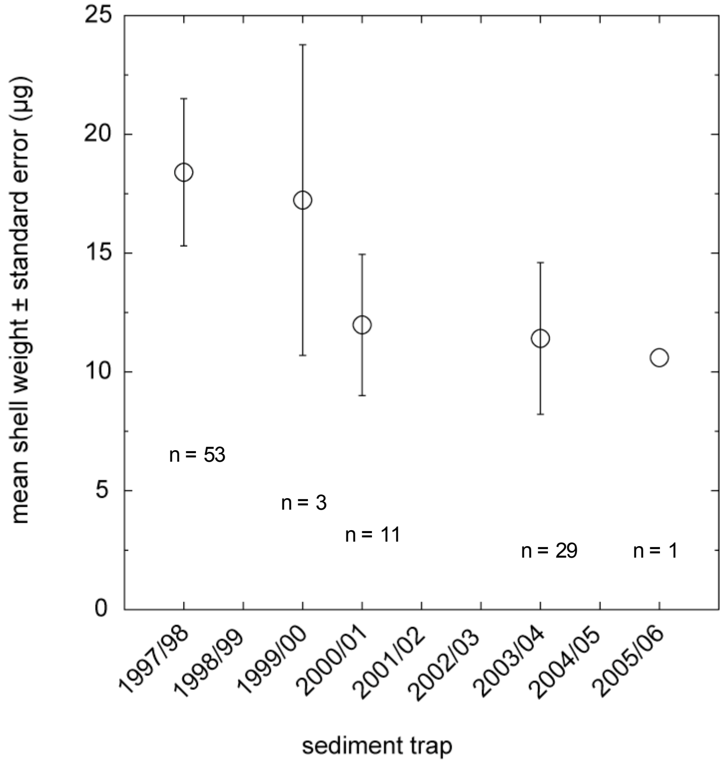


[1] van der Spoel & Dadon. 1999. Pteropoda: Boltovskoy (ed) South Atlantic Zooplankton

Limacina helicina antarctica f. *antarctica*

- Shell weight change



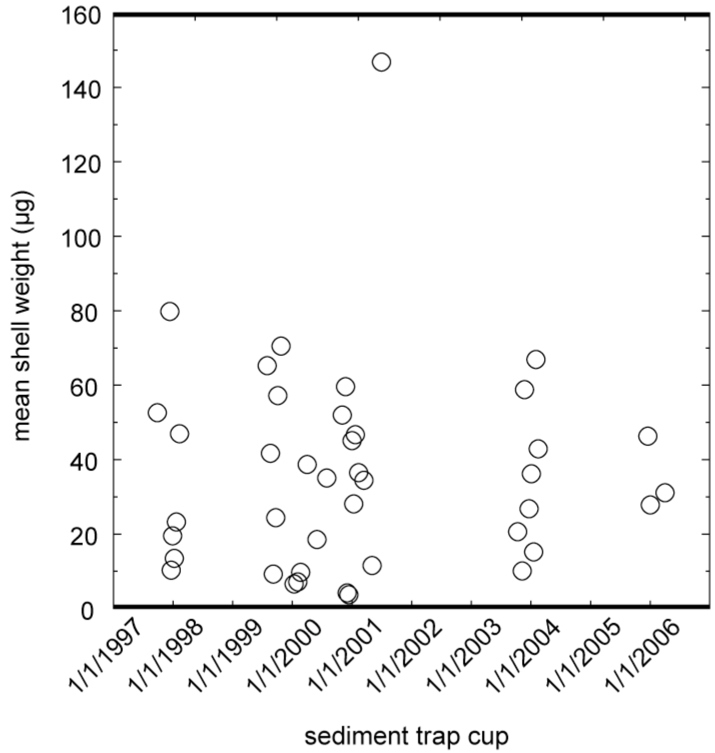


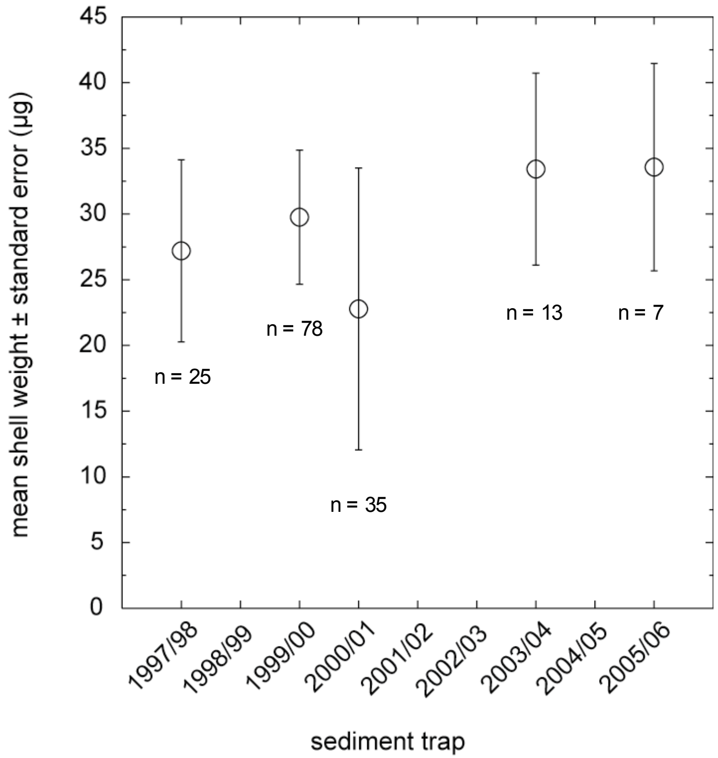
Linear rate (P=0.02)
-1.17 ± 0.47 µg yr^{-1}

reduction in calcification
≈ 35%

Limacina helicina antarctica f. *rangi*

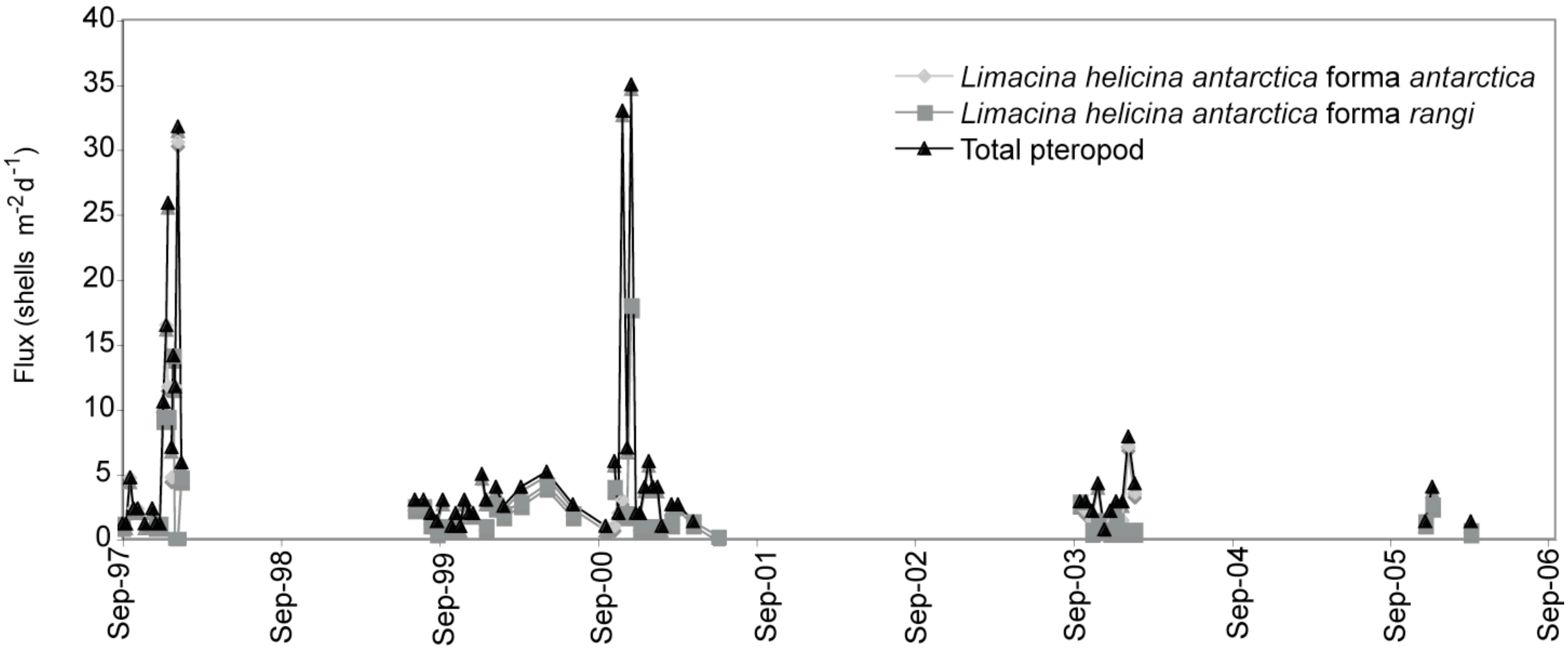
- No shell weight change





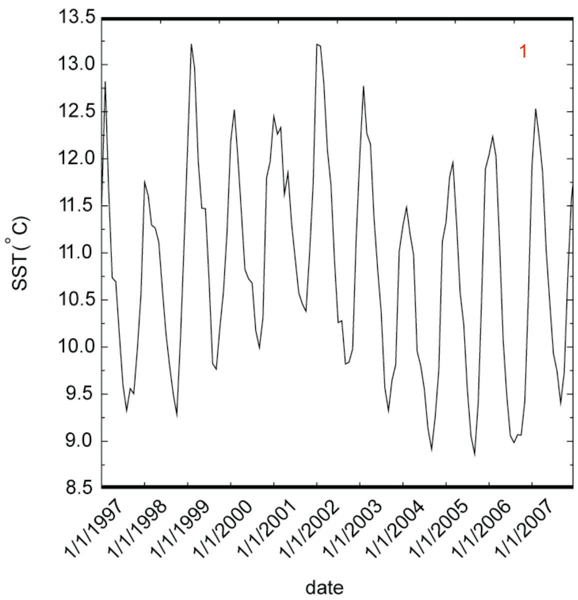
Southern Ocean pteropod flux

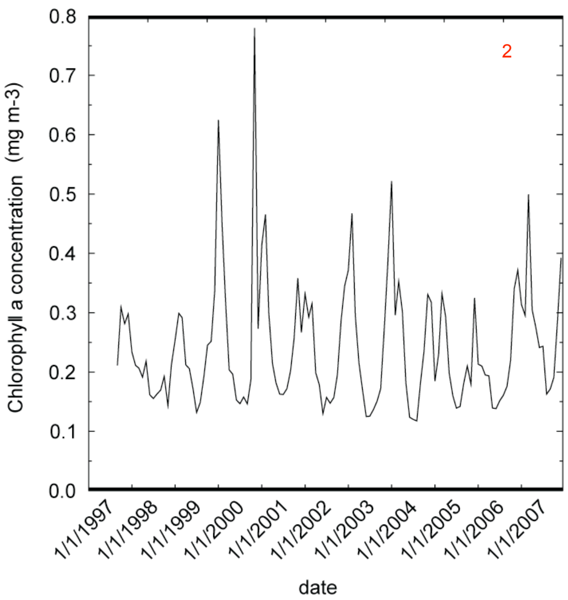
- Shell flux to sediment traps

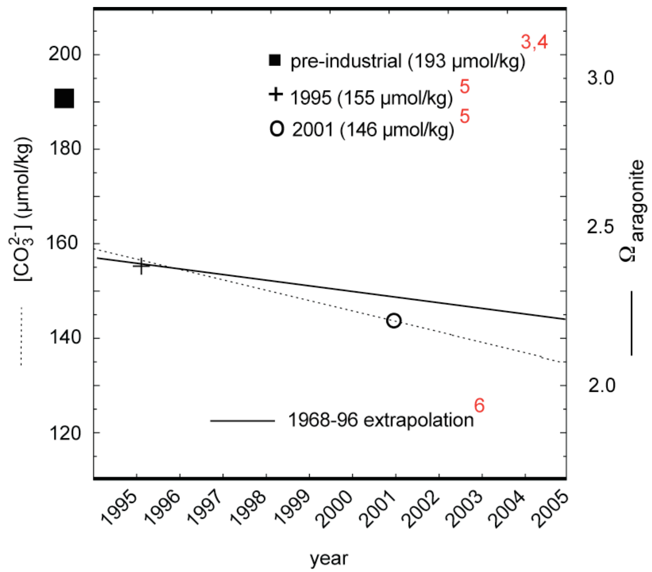


Causal mechanism(s)?

- physical
  - sea surface temperature
- ecological
  - primary production
- biogeochemical
  - carbonate ion availability







* ~25% drop in [CO_3^{2-}] from pre-ind'l

** ~5% drop in [CO_3^{2-}] past decade

[1] Smith & Reynolds. 2004. J. Climate:17
[2] SeaWiFS. 2008. NASA
[3] Feely et al. 2004. Science: 305
[4] Sabine et al. 2004. Science: 305
[5] CLIVAR/WOCE SR3 voyages
[6] McNeil et al. 2001. JGR: 106

Hypotheses

- The reduction in carbonate ion in the Subantarctic Southern Ocean is affecting *Limacina helicina antarctica* forma *antarctica*'s ability to calcify

- forma *antarctica* is morphologically and ecologically distinct from forma *rangi* and we propose they have distinct physiological responses to calcification

- our results provide a benchmark* against which future calcification change in Southern Ocean pteropods may be measured

- our results have implications for intra-specific calcification responses** to changing ocean chemistry (cf.[1,2])

* our challenge is to find pre-industrial pteropods: not as easy to source as forams or coccoliths in the Southern Ocean

** we recommend separating forma *antarctica* from forma *rangi* in future experiments

[1] Cubillos et al. 2007. MEPS: 348

[2] Fabry. 2008. Science: 320

Conclusions

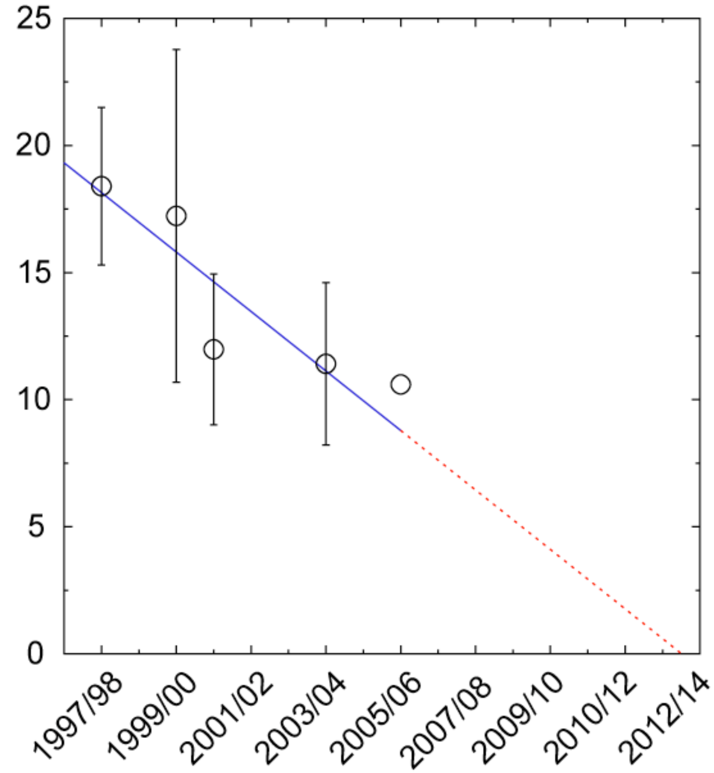
- Pteropods are important indicators of calcification in the Southern Ocean

- The rate of shell weight change in forma *antarctica* is not of trivial concern:

South of the Antarctic Polar Front pteropods* sometimes dominate the export flux of calcium carbonate [1]

[1] Collier et al. 2000. Deep-Sea Res. II: 47

* *Limacina helicina antarctica* forma *antarctica*



-1.17 ± 0.47 μg yr^{-1} ------------>

Thanks

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