Environmental controls on temporal and spatial patterns in pteropod abundance along the Western Antarctic Peninsula

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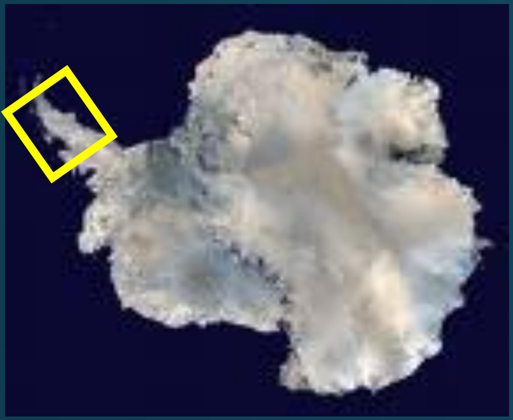
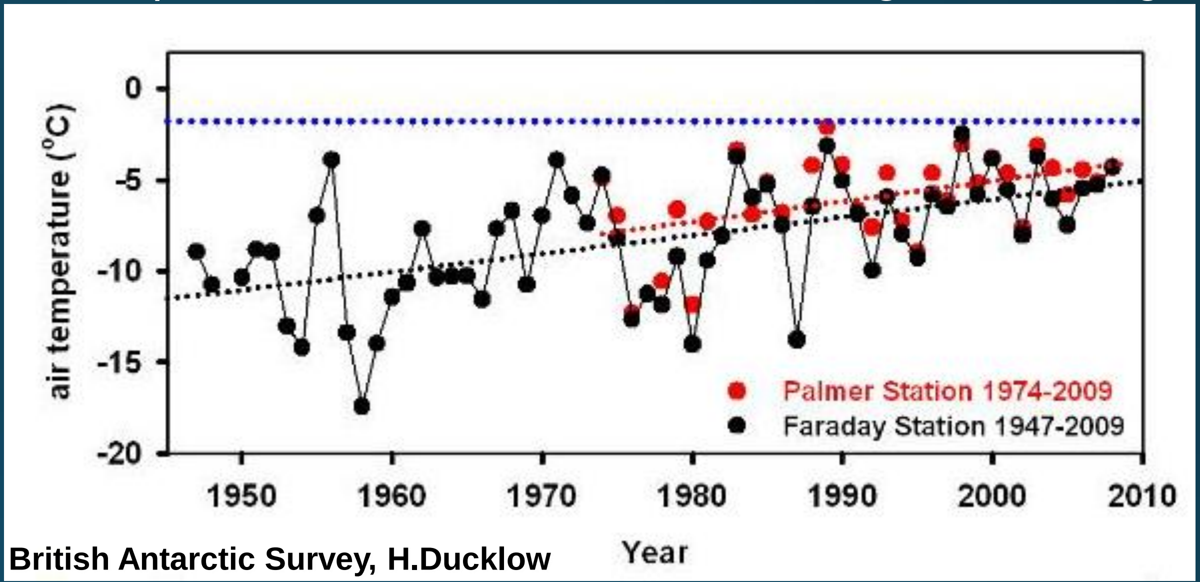
Warming in the Western Antarctic Peninsula

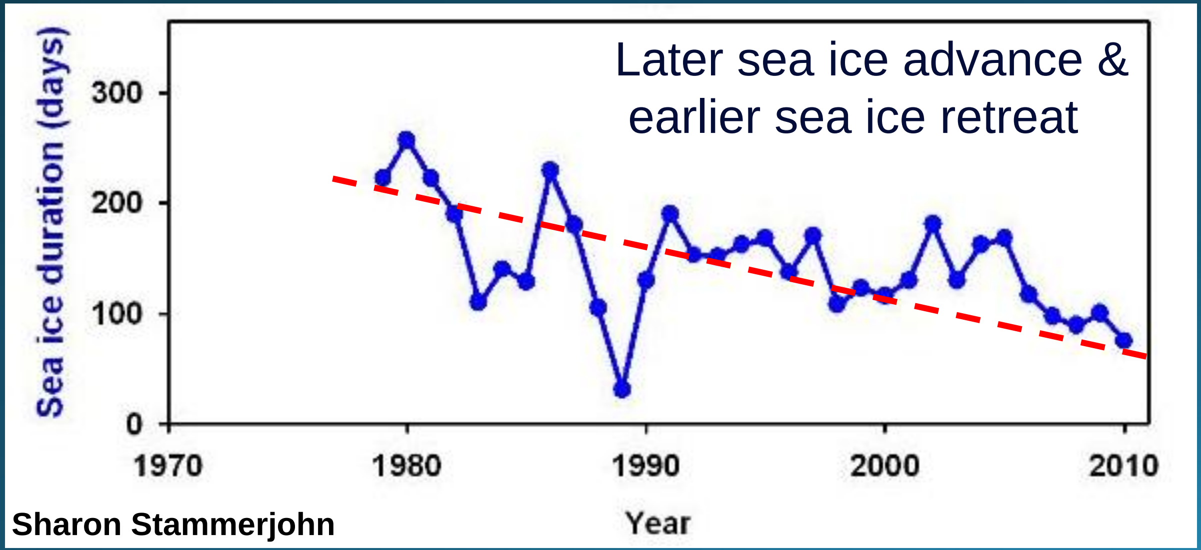


Average winter (June-Aug.) temperature
+1.1°C per decade: 7°C since 1950: 5x global average



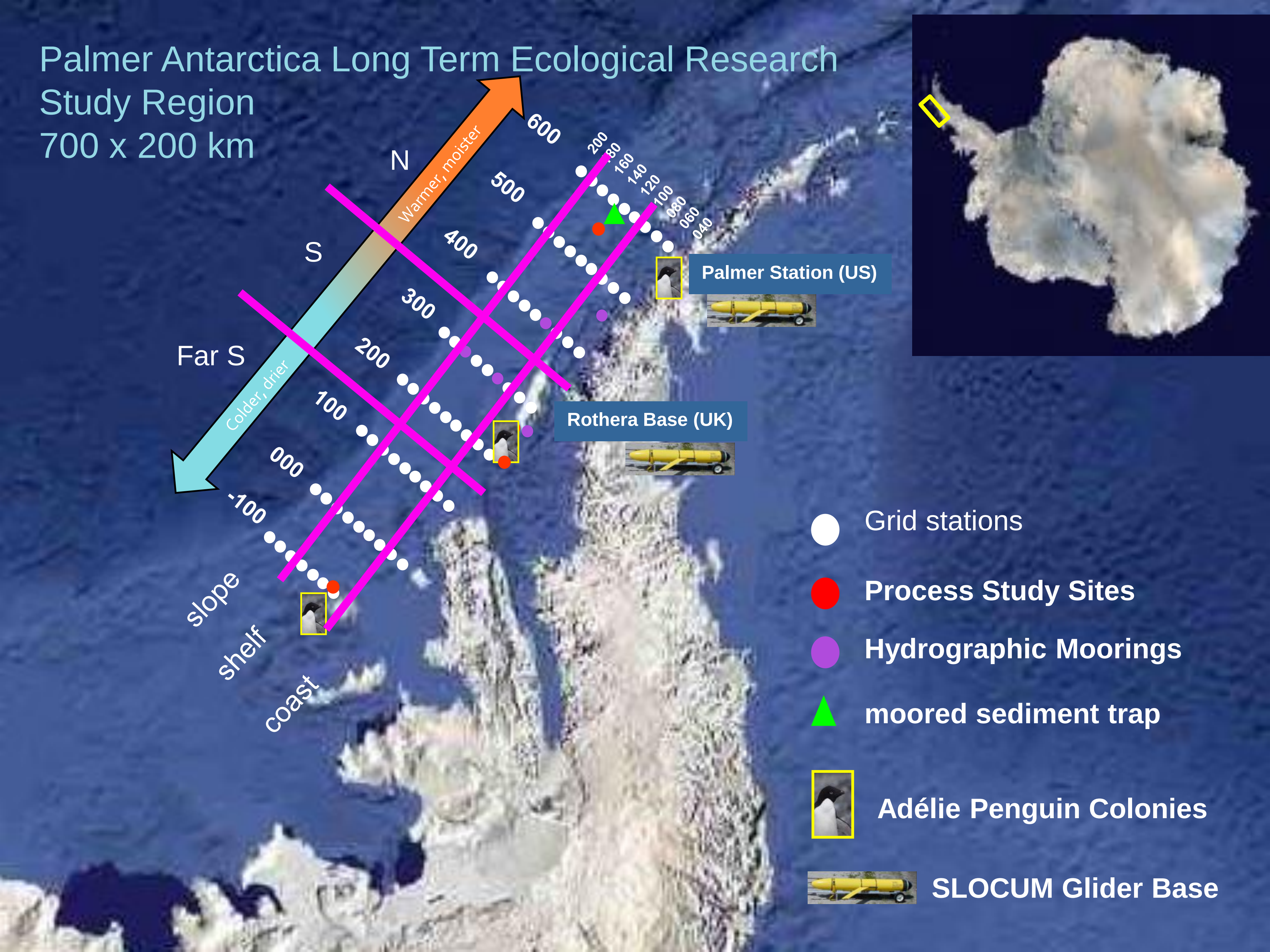
British Antarctic Survey, H.Ducklow

Sea ice declining



Sharon Stammerjohn

3 month decrease
in sea ice season
since 1970



Palmer Antarctica Long Term Ecological Research
Study Region
700 x 200 km
N
S
Far S
Warmer, moister
Colder, drier
600
500
400
300
200
100
000
-100
200
180
160
140
120
100
080
060
040
slope
shelf
coast
Palmer Station (US)
Rothera Base (UK)
Grid stations
Process Study Sites
Hydrographic Moorings
moored sediment trap
Adélie Penguin Colonies
SLOCUM Glider Base

Macrozooplankton collection


salps
Salpa thompsoni


krill
Euphausia superba


Limacina helicina

Thecosome= shell


Clio pyramidata


Clione antarctica

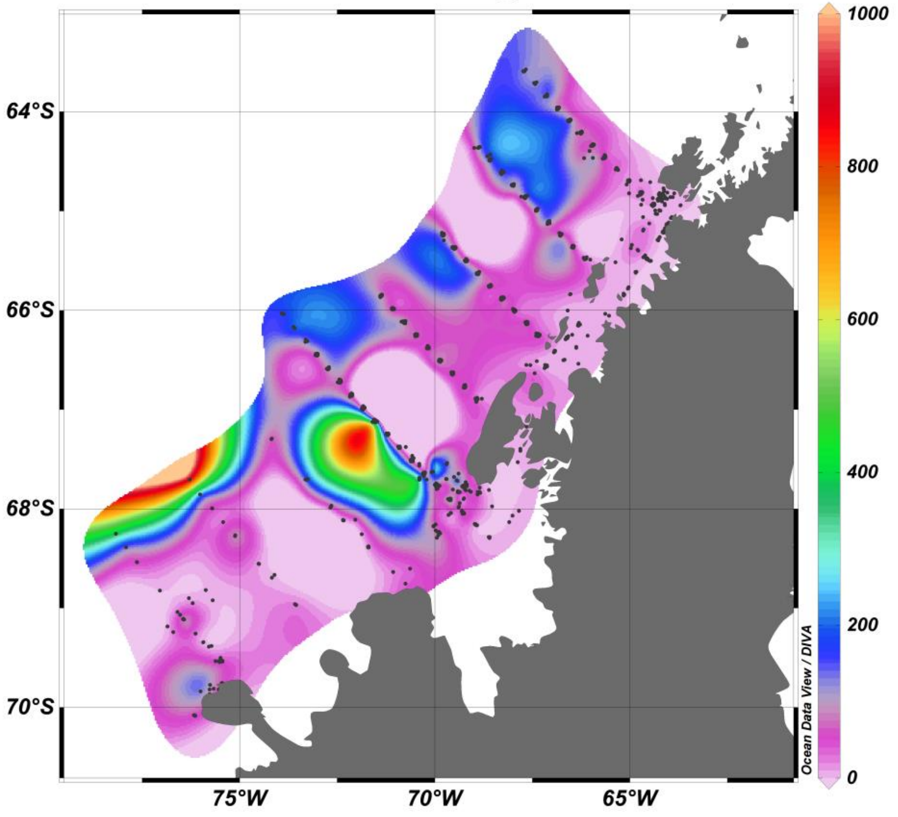
Gymnosome= no shell


Spongiobranchea australis

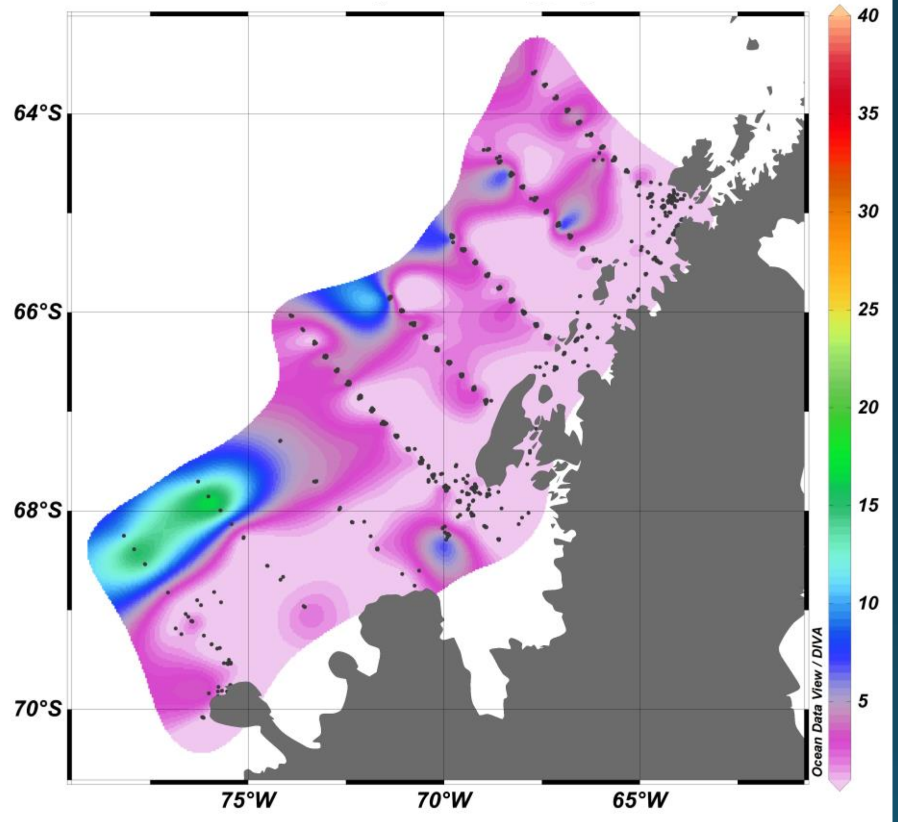
Photos: A. McDonnell, L. Madin, M. Gleiber, R. Hopcroft, and J. Stone

Long-term distribution climatology

L.helicina abundance (1000 m^3)

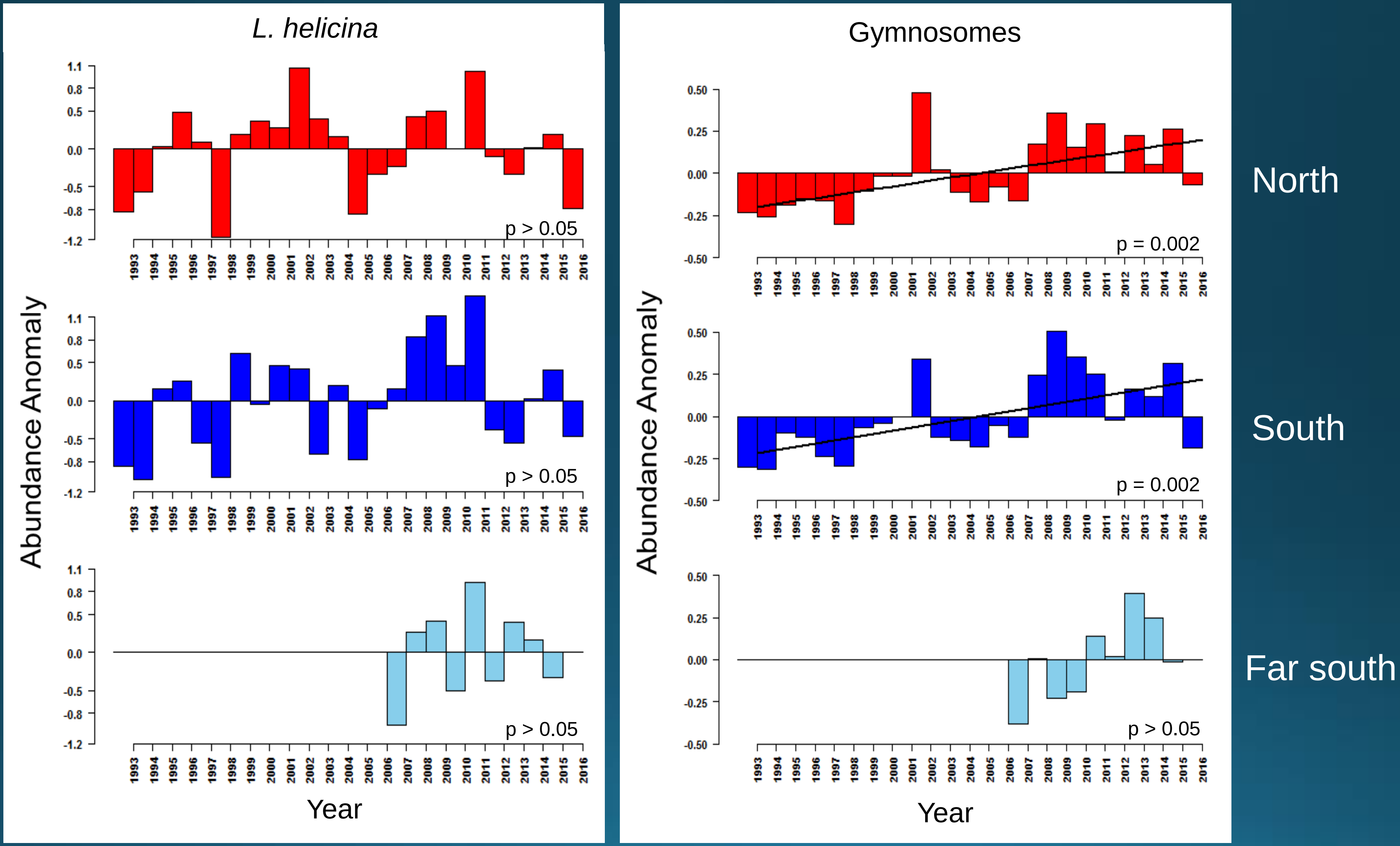


Gymnosome abundance (1000 m^3)

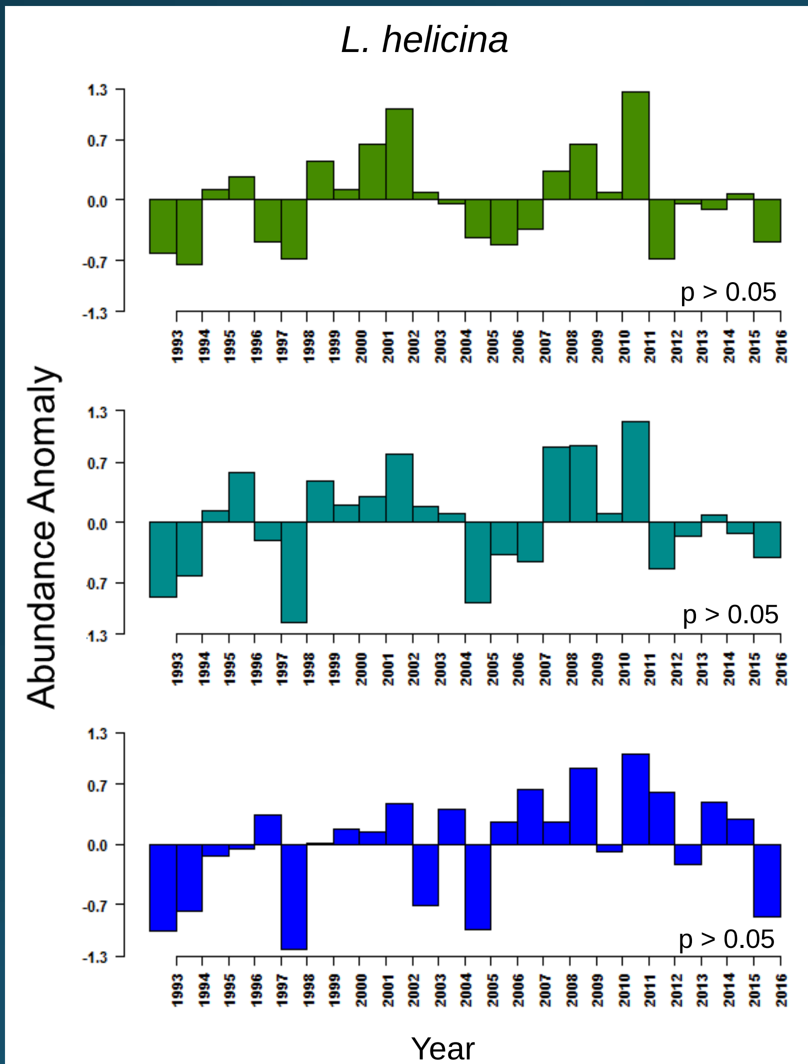


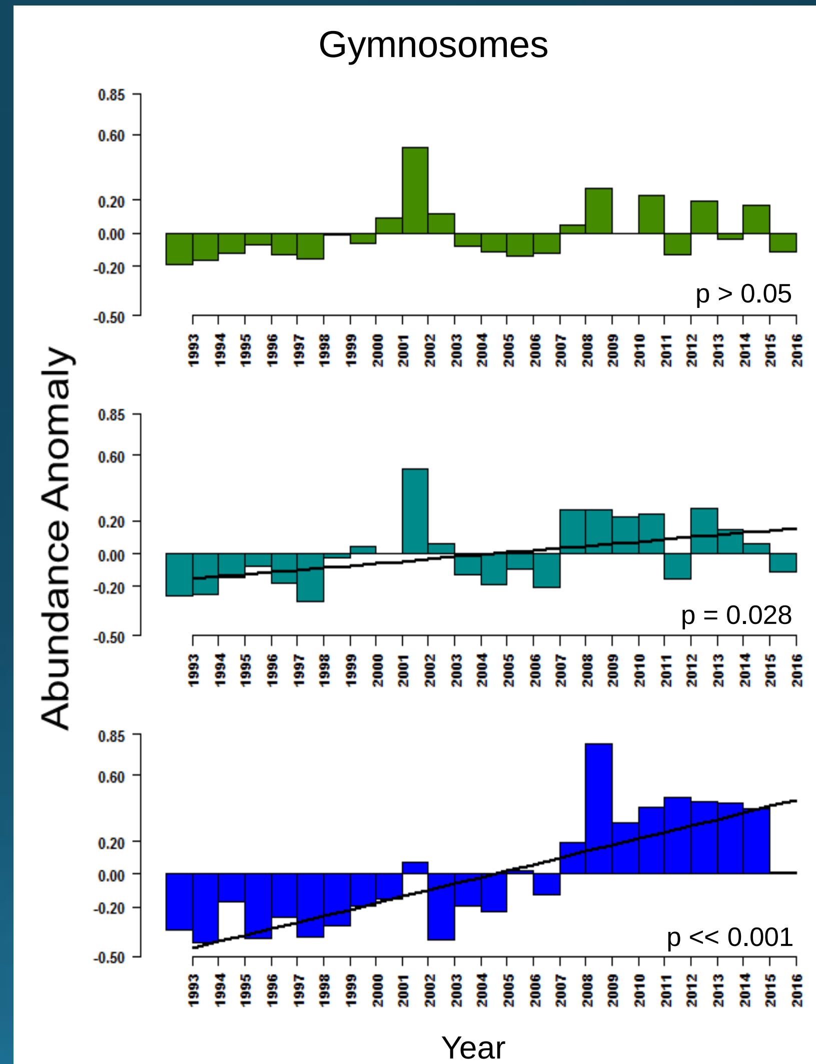
Abundance average 1993-2016

Pteropod abundance: north – south gradient



Pteropod abundance: Coastal – shelf – slope gradient



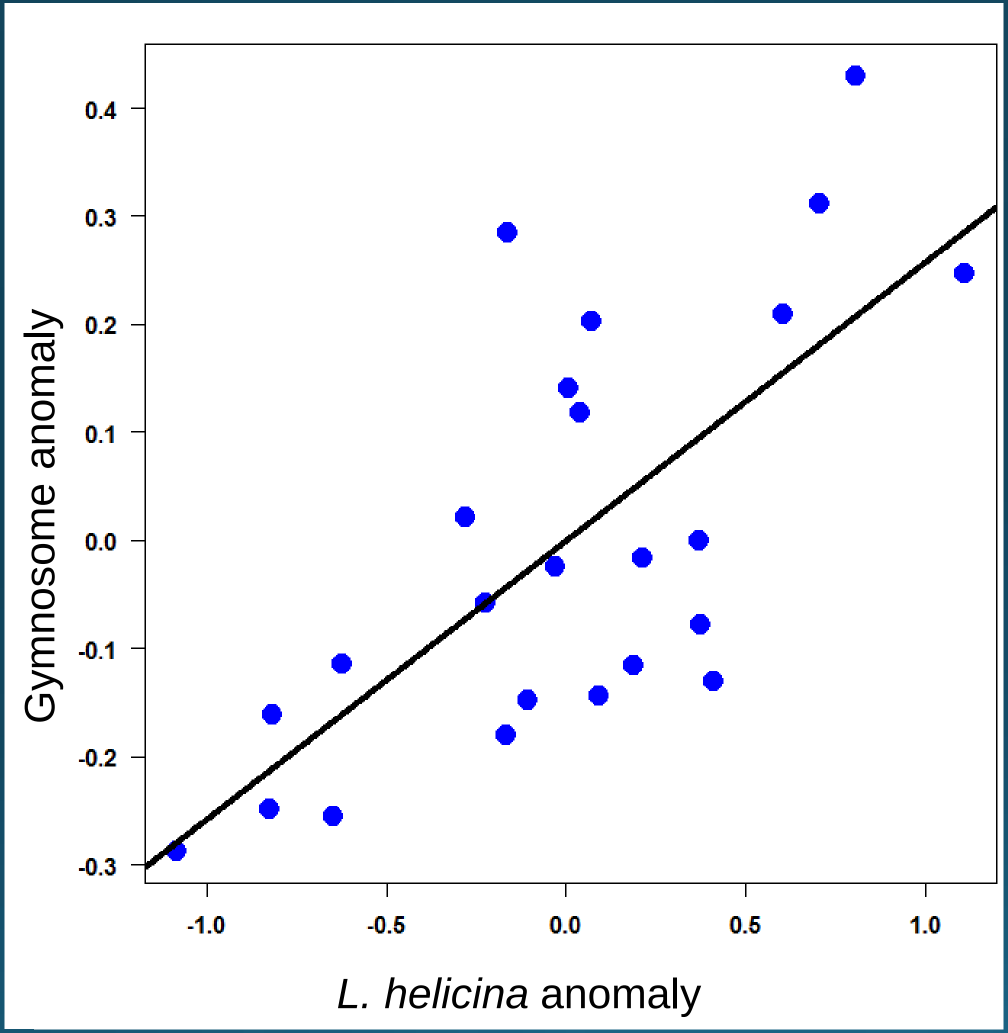


Coast

Shelf

Slope

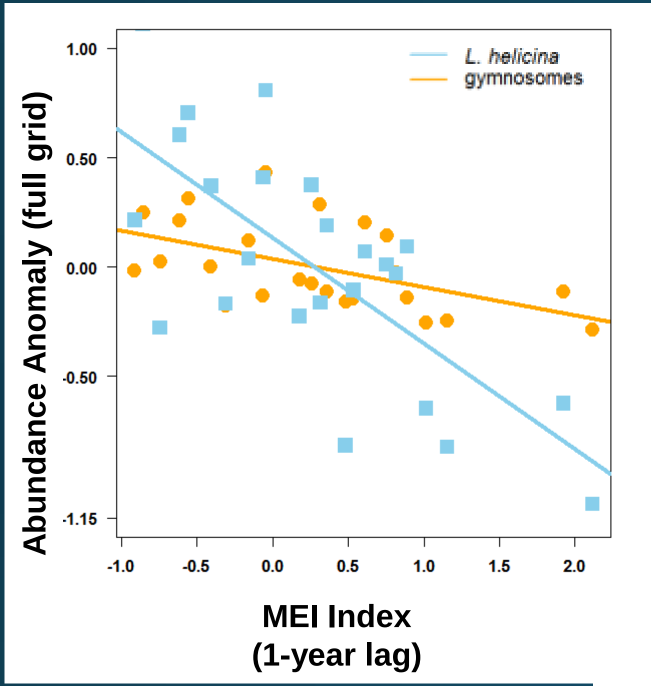
L. helicina vs. gymnosome abundance

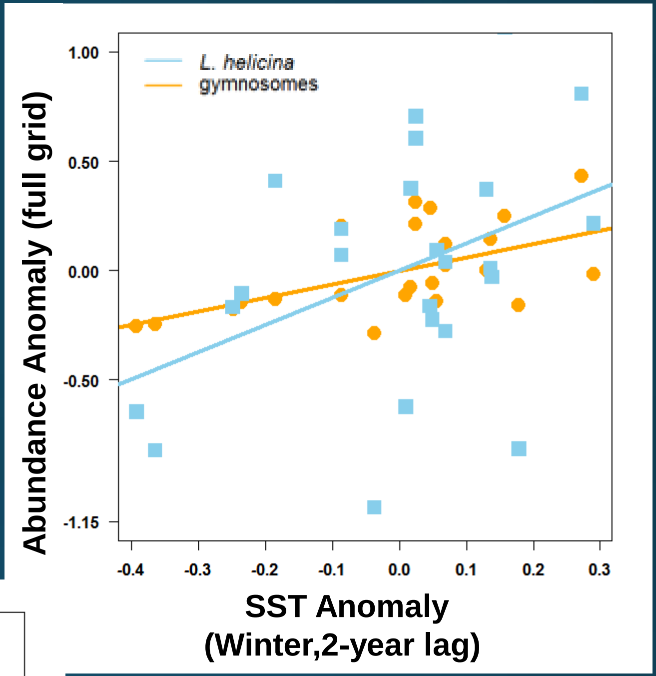


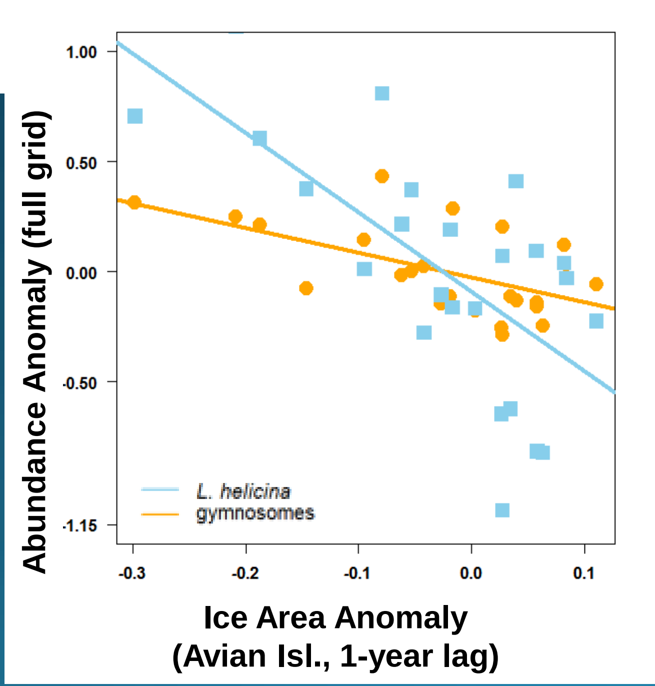
Adjusted R^2: 0.47
$p << 0.001$

(predator)

Environmental controls of pteropod abundance

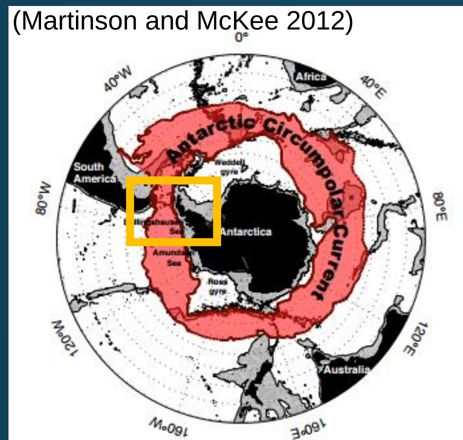


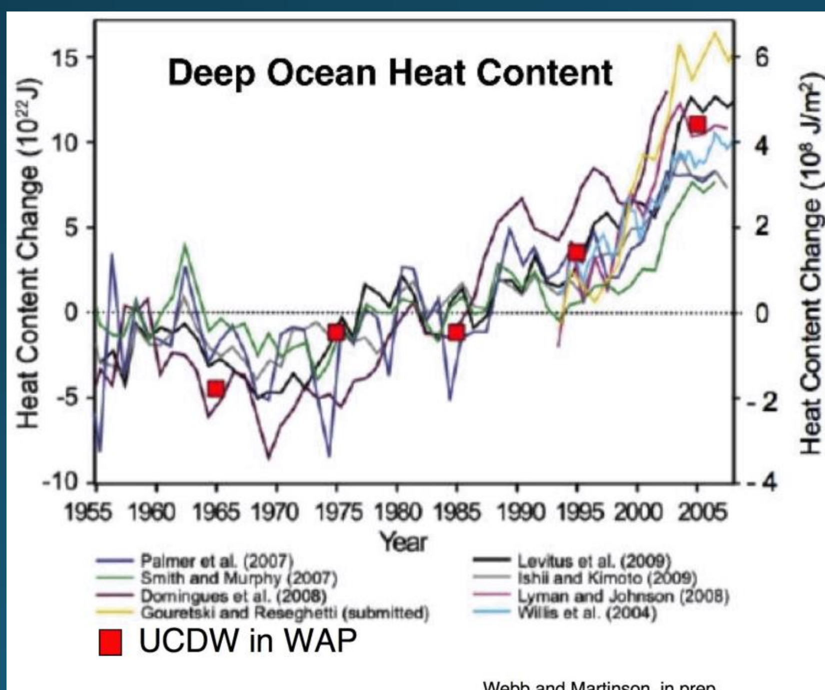




$p < 0.05$ for all

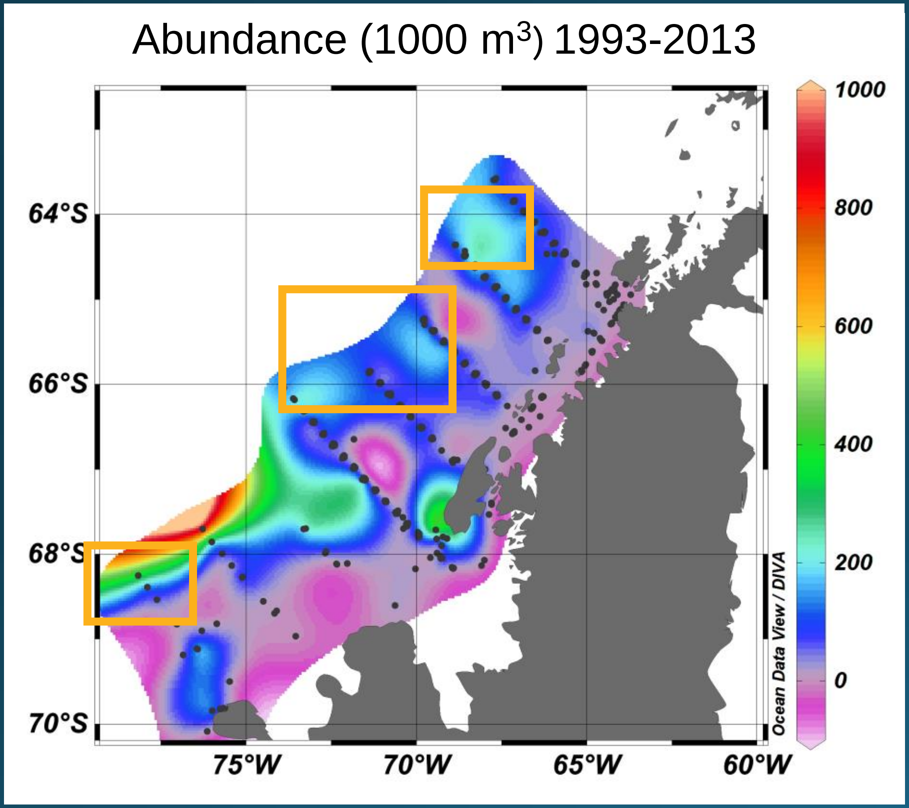
Increase of Upper Circumpolar Deepwater (UCDW) on WAP shelf

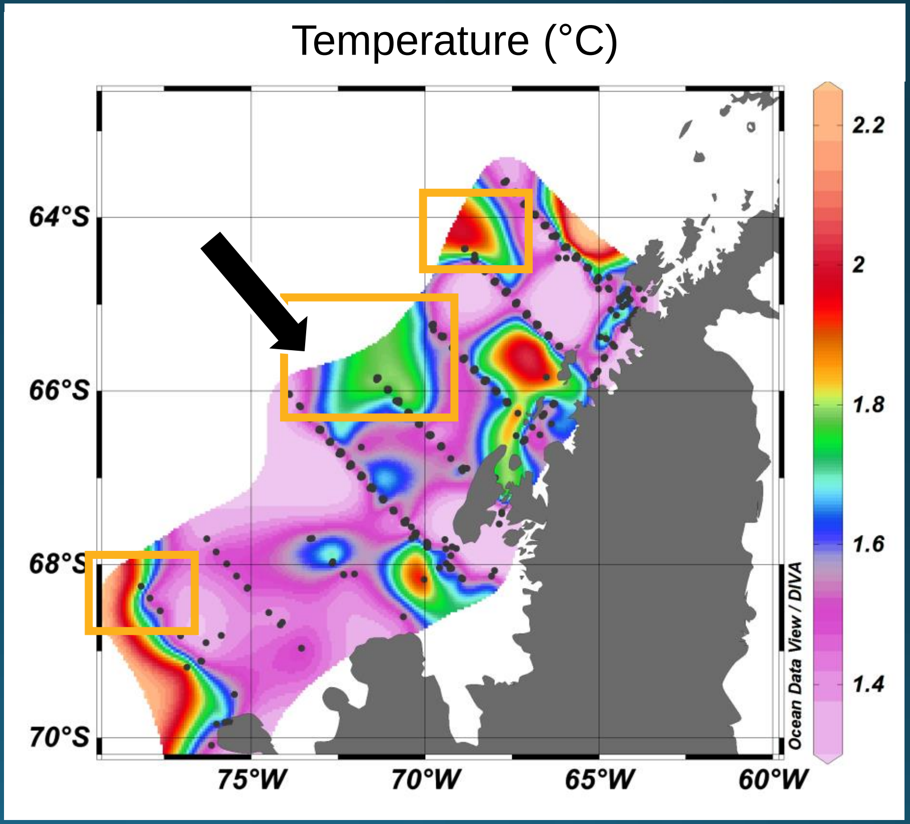




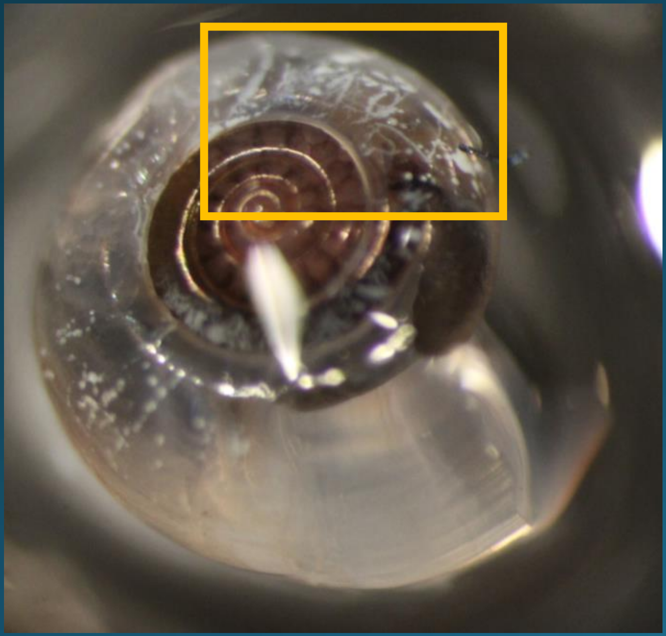
- Characterized by warm temperatures (Tmax > 1.6°C) and high nutrient, CO_2 levels
- 150m below the surface of the Antarctic Circumpolar Current (ACC)
- Floods onto the continental shelf at Marguerite Trough roughly four times each month (Martinson and McKee 2012)

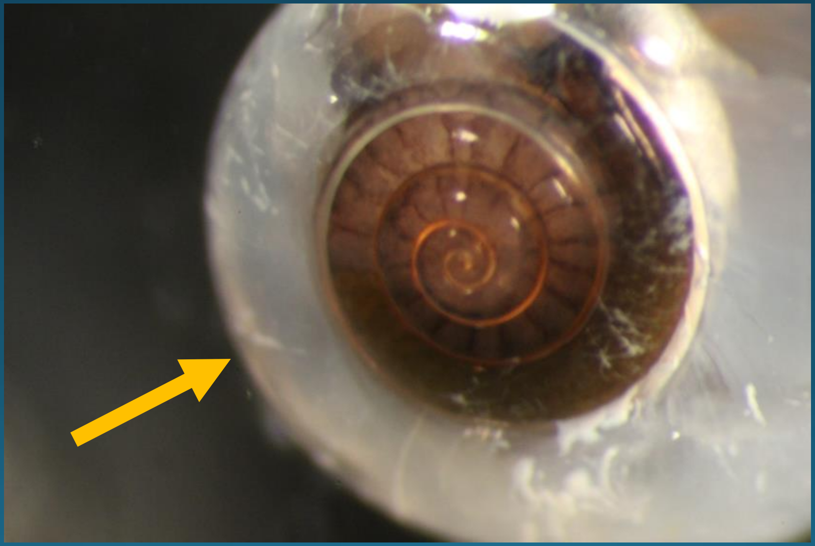
L. helicina abundance increase near UCDW





Ocean Acidification in the Southern Ocean

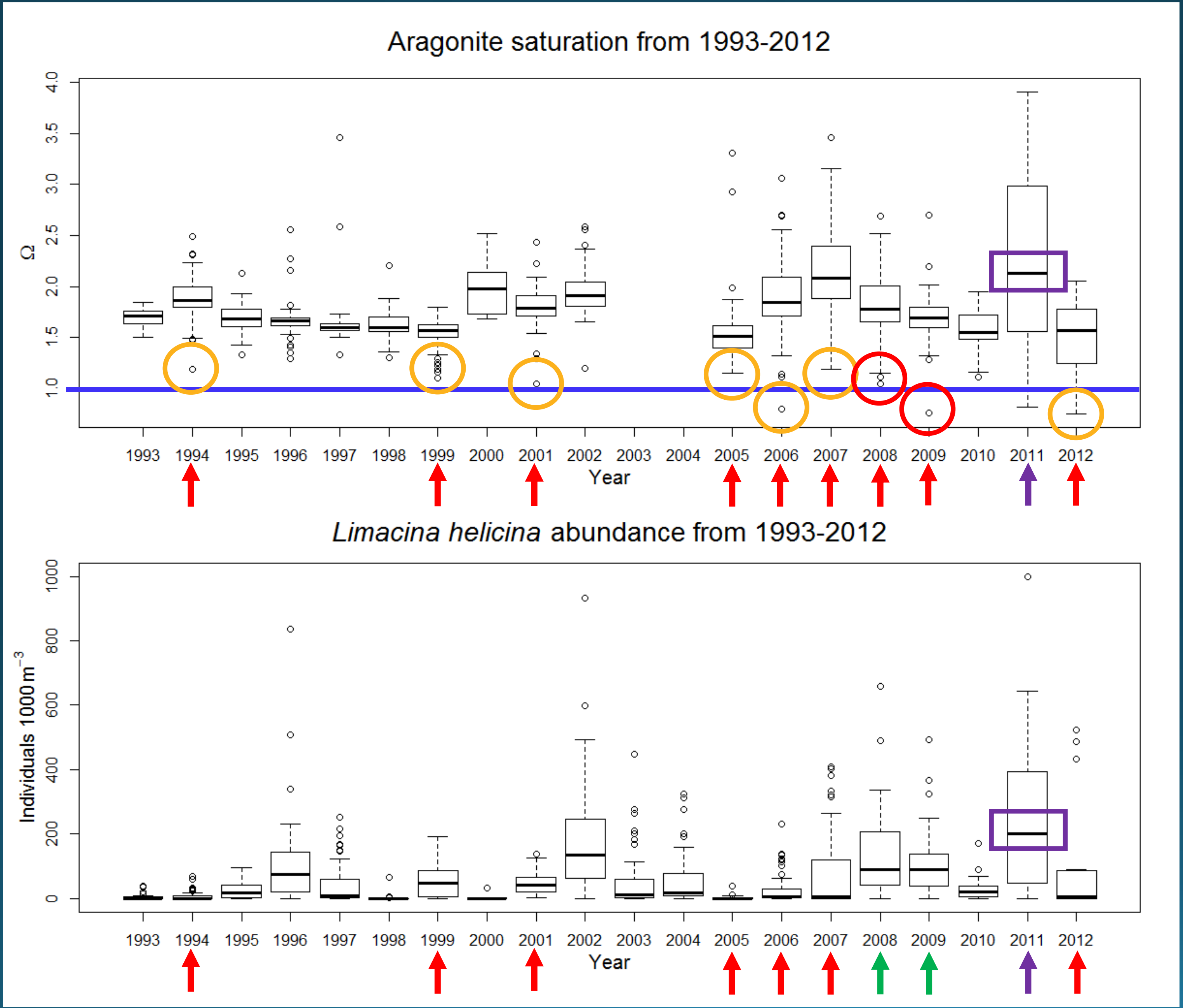




L. helicina collected from PAL LTER study

(Doney 2006, Bednarsek et al. 2014; Comeau et al. 2012; Lischka et al. 2011)

Aragonite saturation and *L. helicina* abundance



Summary and Conclusions

- Evident offshore distribution of pteropods and indication of increasing abundance in south and slope regions overtime
  - Range shifts and hotspots → future work
- Strong predator-prey dynamic between *L. helicina* and gymnosomes
- Weak MEI, low ice, high SST years favor pteropod abundance
- *L. helicina* may prefer warmer, ice free waters possibly due to timing and propagation of the spring bloom as ice melts through the season
- No clear relationship between *L. helicina* abundance and distribution with carbonate parameters
  - Time-series mismatch → future work

Acknowledgements

Zooplankton ecology lab

PAL LTER scientists and collaborators

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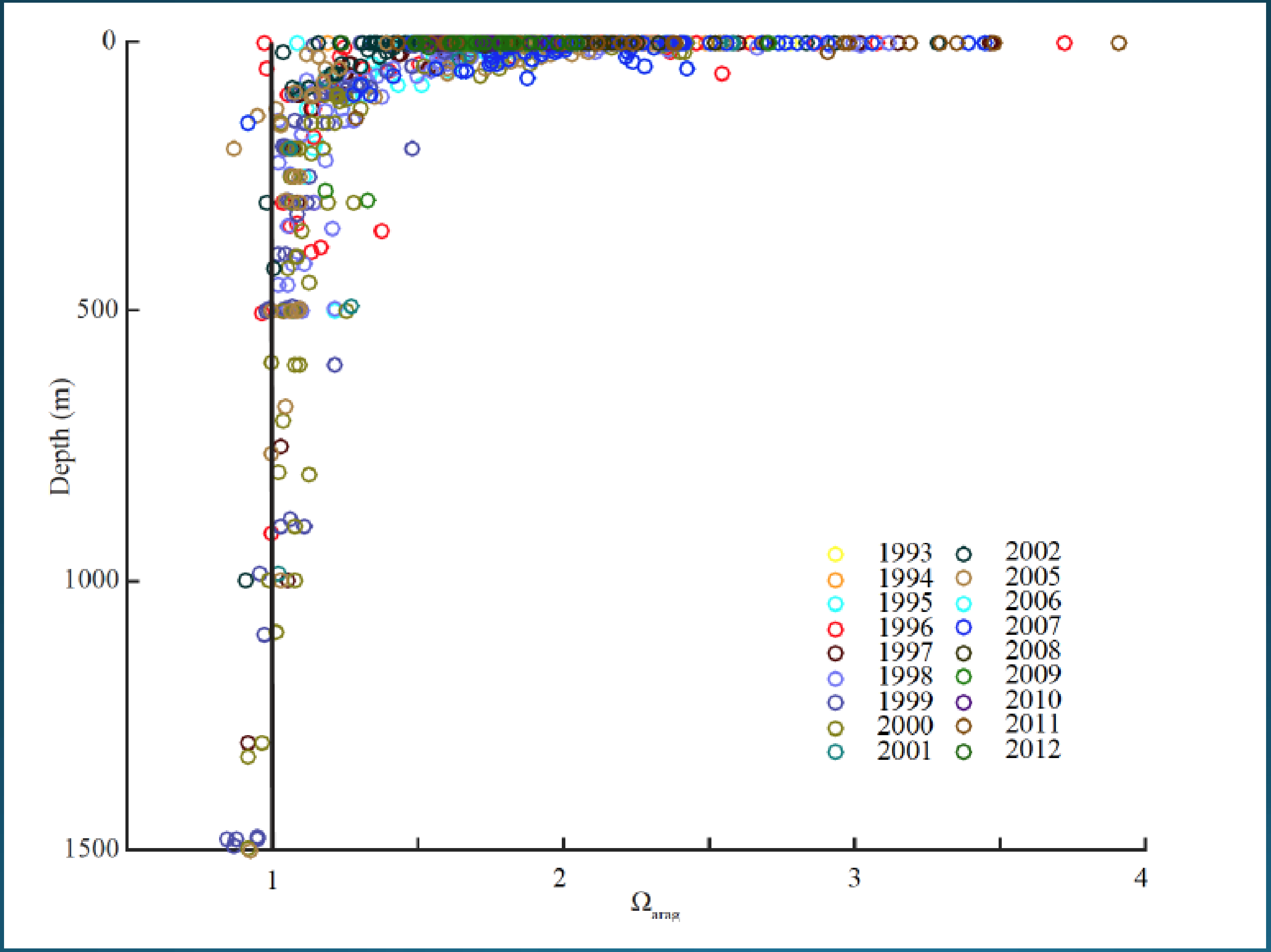
Evidence of aragonite (Ω) undersaturation



Hauri et al. 2015, Biogeosciences Discussion

Anomaly Calculation

For each pteropod group and year in the time series, the abundance anomaly was calculated using this formula:

$$A'_y = \log_{10}[\bar{A}_y / \bar{A}]$$

$\bar{A}_y$ is the mean abundance of year y, $\bar{A}$ Type equation here.and is the mean of the yearly means.
(O’Brien et al. 2008, ICES zooplankton status report 2006/2007)

*Stepwise linear regression models, with data in annual anomaly form for the full grid, were used to assess the relative importance of the environmental and climate parameters (sea ice, SAM/MEI, primary productivity, biomass, SST)

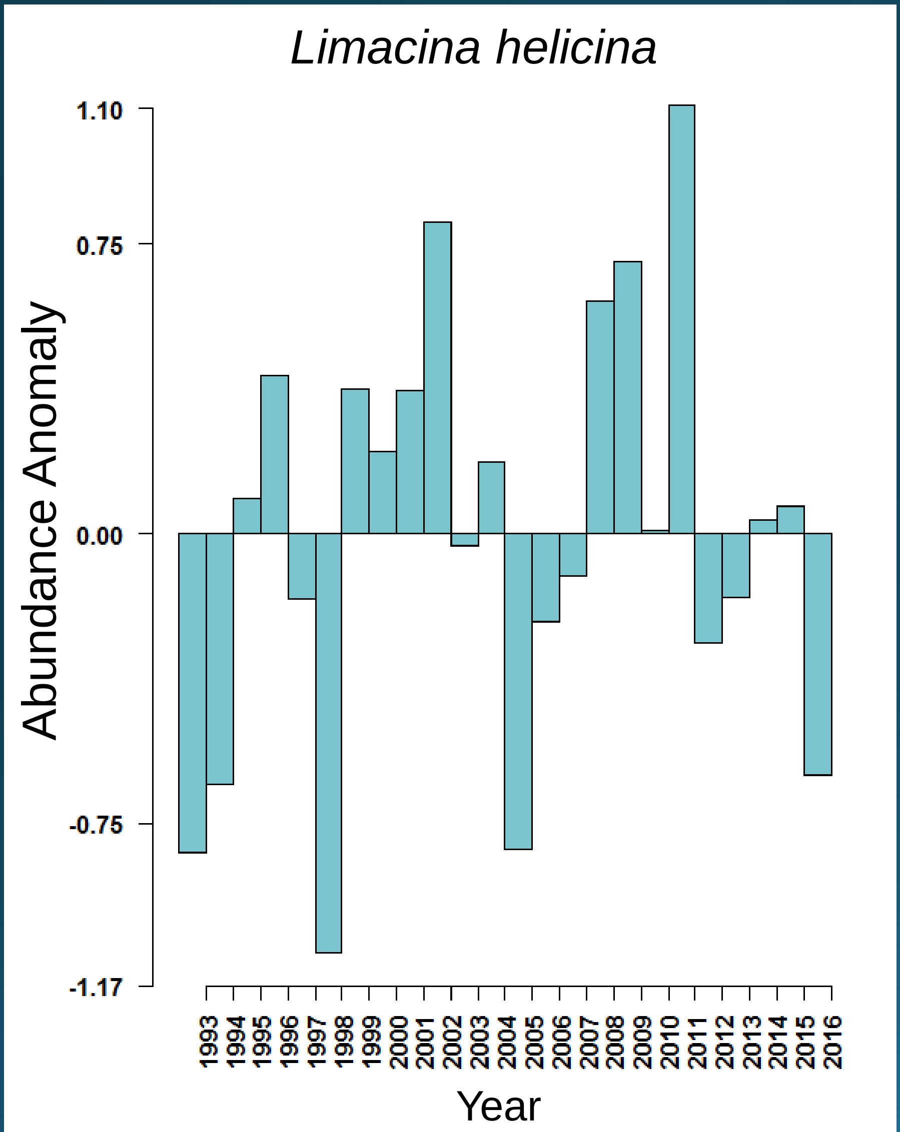
Macrozooplankton collection

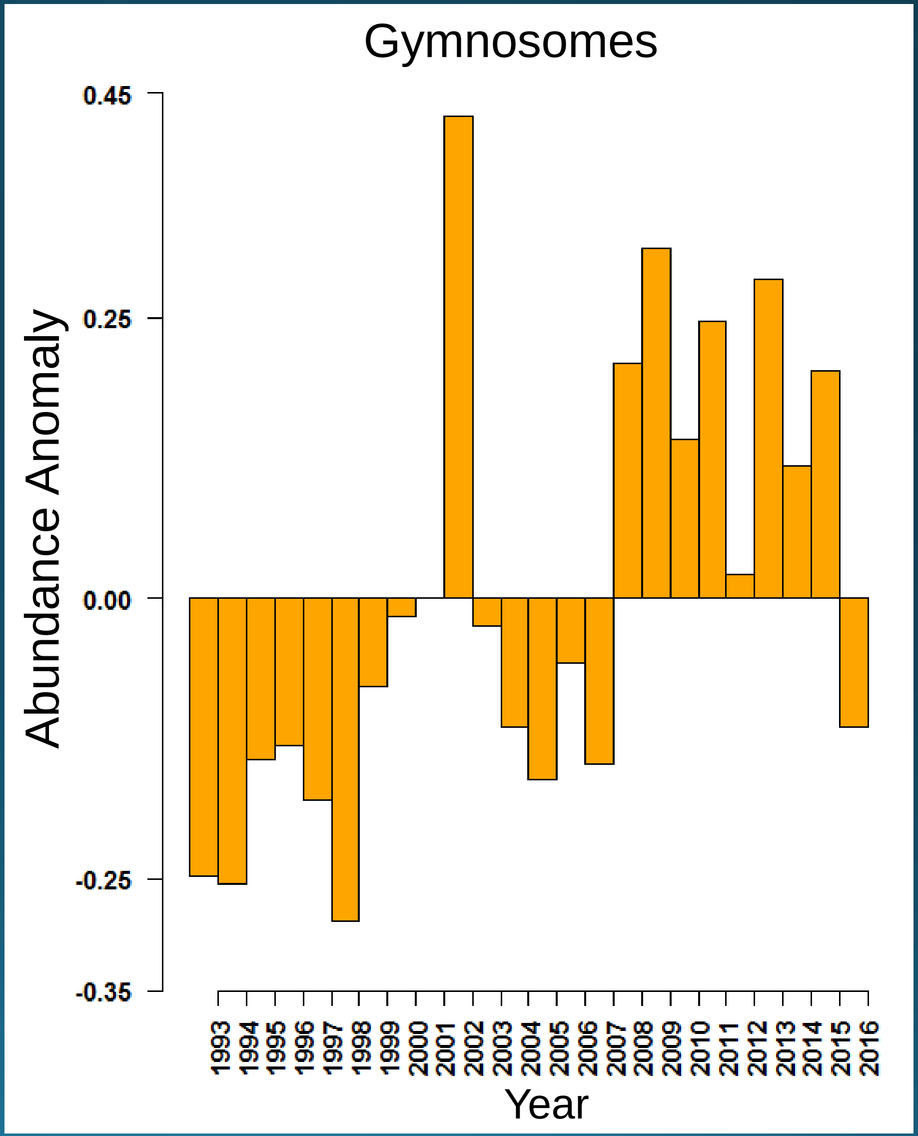
R/V *Laurence M. Gould*

2 m^2 frame,
700 µm mesh
upper 120 m

Sort and count on ship

Long-term trends in abundance





Steinberg et al. 2015, DSR I, updated

$p = 0.002$