Long-term CPR data and joint species distribution models reveal changes in zooplankton communities in the Southern Ocean

Joel Williams, Nicole Hill, Kerrie Swadling, Scott Foster, Yash Gimonkar
Kaitlin Naughton, Skip Woolley, Philippe Ziegler, Craig Johnson

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Australian Government
Department of Climate Change, Energy, the Environment and Water
Australian Antarctic Division

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CSIRO

British Antarctic Survey

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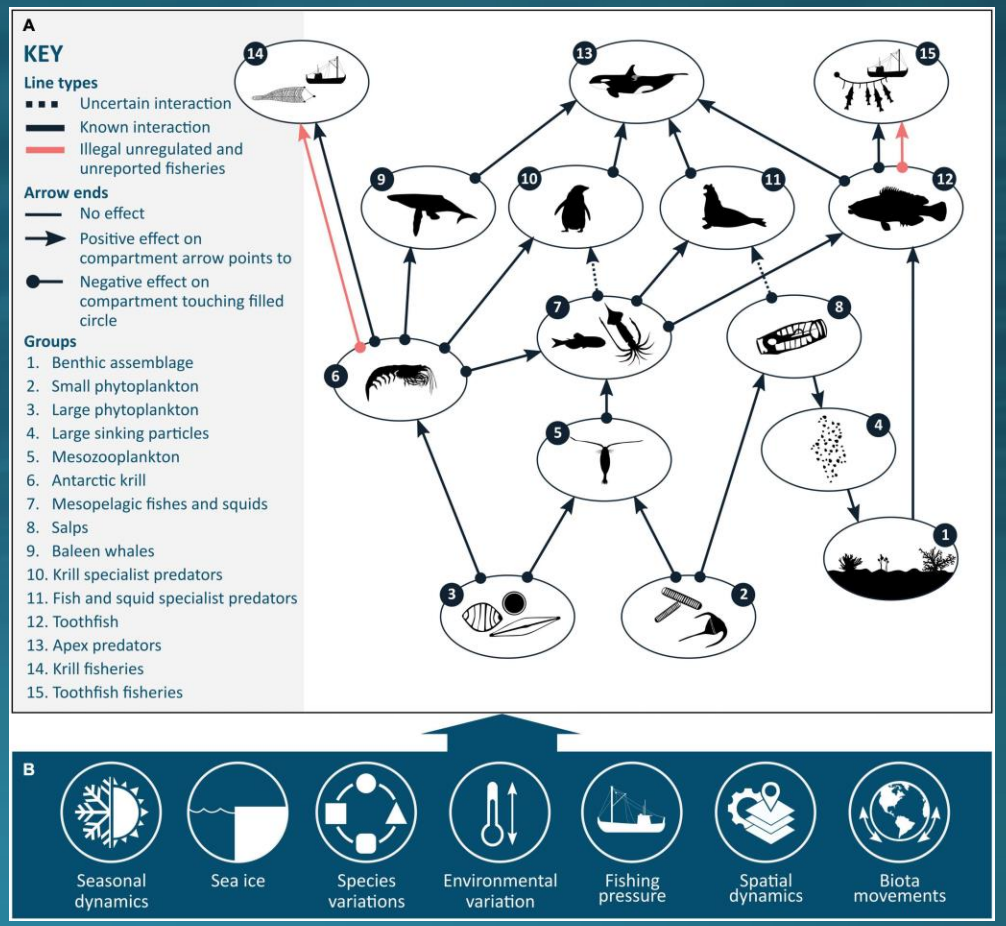
Introduction

- The Southern Ocean
- Climate change
  - Warming water temps.
  - Shifting polar fronts
  - Changing water chemistry
  - Shifting species ranges
- Plankton important food web and ecosystem component.
- particularly susceptible to climate change
- Focus on single species
- Limited understanding of zooplankton at the community level



McCormack et al 2021

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Introduction

Review Article | Open Access | Published: 02 February 2023

Monitoring and modelling marine zooplankton in a changing climate

Lavenia Ratnarajah, Rana Abu-Alhaija, Angus Atkinson, Sonia Batten, Nicholas J. Bax, Kim S. Bernard, Gabrielle Canonico, Astrid Cornils, Jason D. Everett, Maria Grigoratou, Nurul Huda Ahmad Ishak, David Johns, Fabien Lombard, Erik Muxagata, Clare Ostle, Sophie Pitois, Anthony J. Richardson, Katrin Schmidt, Lars Stemmann, Kerrie M. Swadling, Guang Yang & Lidia Yebra

Nature Communications **14**, Article number: 564 (2023) | Cite this article

8737 Accesses | **11** Citations | **79** Altmetric | Metrics

ELSEVIER

Science of The Total Environment

Volume 898, 10 November 2023, 165505

Major declines in NE Atlantic plankton contrast with more stable populations in the rapidly warming North Sea

Matthew M. Holland [a], Arnaud Louchart [b], Luis Felipe Artigas [b], Clare Ostle [c], Angus Atkinson [n], Isabelle Rombouts [d], Carolyn A. Graves [e], Michelle Devlin [e], Birgit Heyden [f], Margarita Machairopoulou [g], Eileen Bresnan [g], Jos Schilder [h], Hans H. Jakobsen [i], Hannah Lloyd-Hartley [j], Paul Tett [k], Mike Best [l], Eric Goberville [m], Abigail McQuatters-Gollop [a]

Show more

Article | Open Access | Published: 23 March 2023

Climate-driven zooplankton shifts cause large-scale declines in food quality for fish

Ryan F. Heneghan, Jason D. Everett, Julia L. Blanchard, Patrick Sykes & Anthony J. Richardson

Nature Climate Change **13**, 470–477 (2023) | Cite this article

5982 Accesses | **4** Citations | **149** Altmetric | Metrics

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Has the Southern Ocean zooplankton assemblage changed in the last 2 decades?

Establish what is driving this change

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Continuous Plankton Recorder (CPR)

- Continuous Plankton Recorder is a standardise method for sampling plankton over large temporal and spatial scales
- Southern Ocean Continuous Plankton Recorder (SO-CPR) Program
  - Established early 1990s
- SO-CPR database
  - Ensure QA/QC
  - Collaborative research
  - Long-term time series data
- Fantastic, species level data, through space and time across the Southern Ocean
- "The project has covered 70% of the Southern Ocean, taken 30,000 samples, identified and mapped 230 species and towed the Recorder for more than 278,000 kilometres." (Hosie, 2010)

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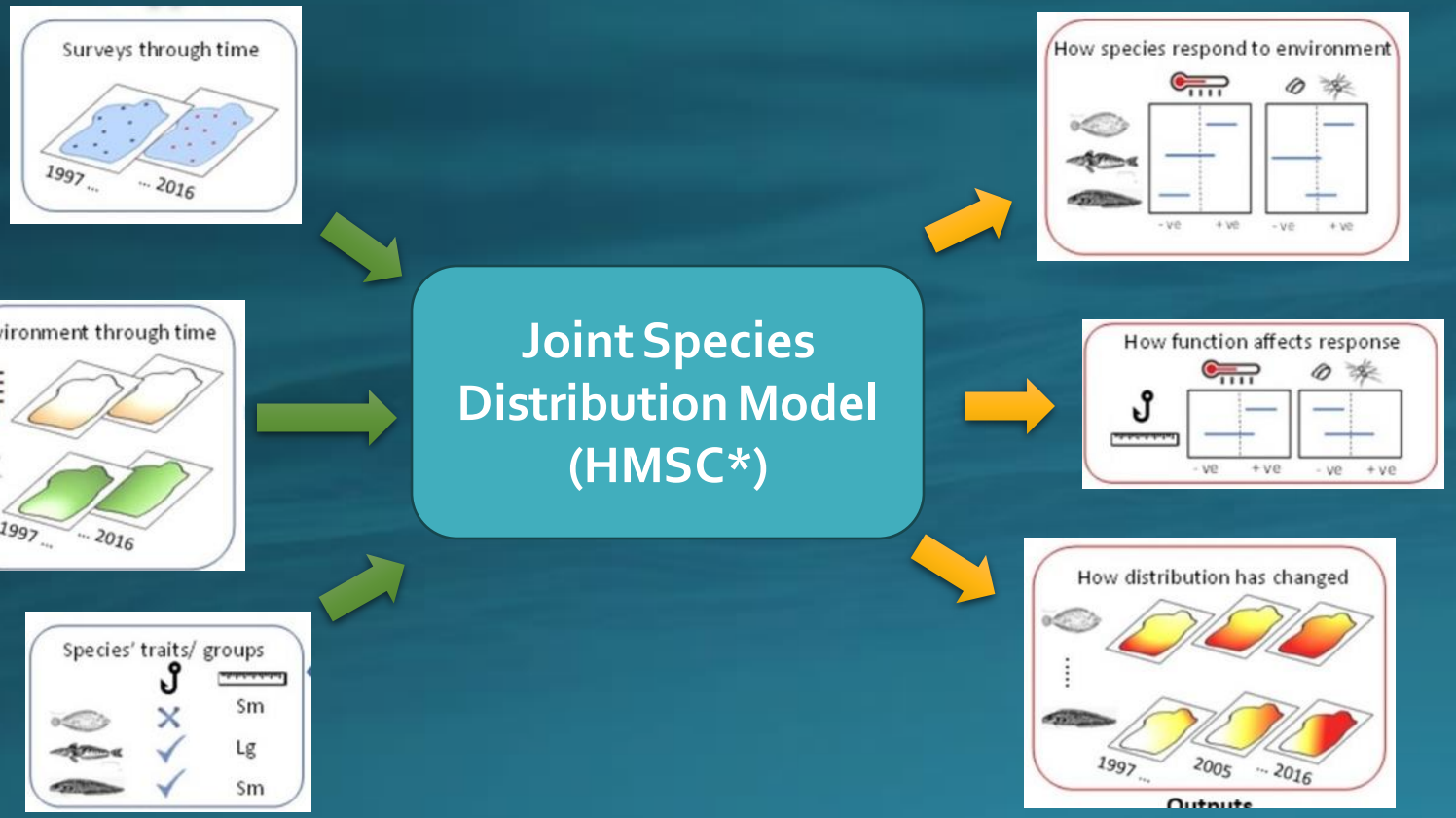
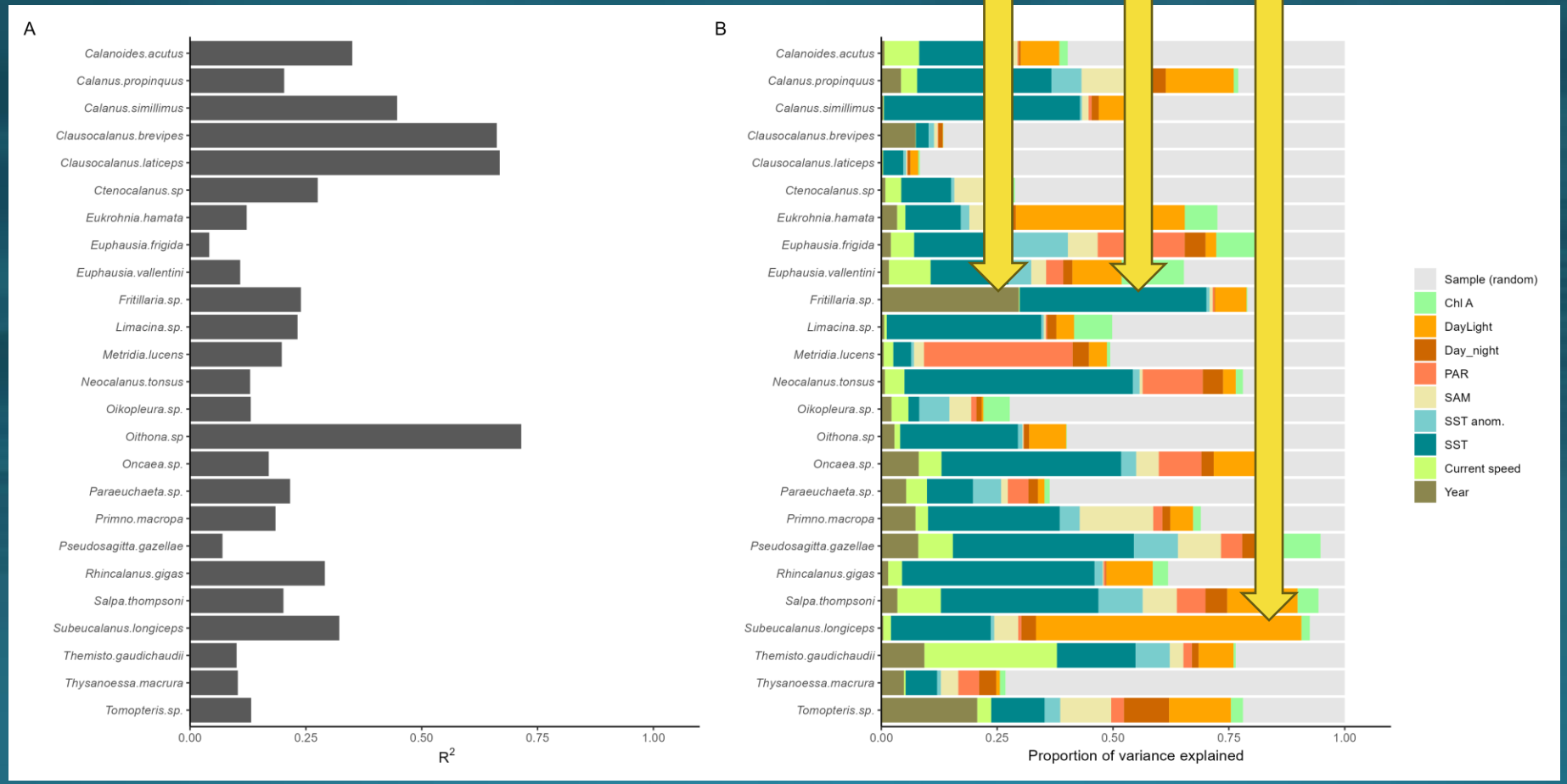
Data Analysis



- **Hierarchical modelling of species communities (HMSC, R package)**
- Multivariate hierarchical generalised linear mixed model fitted with Bayesian inference
- CPR segments aggregated to 20nm
- Years 2003 – 2016
- Environmental variables:
  - Year, day/night, PAR, day length
  - SST, SST anom., Chl A, SAM
  - FESOM surface currents
- Spatial random factors
- Hurdle model: presence/absence & abundance conditional presence

Variance Partitioning



Year

SST

Daylight

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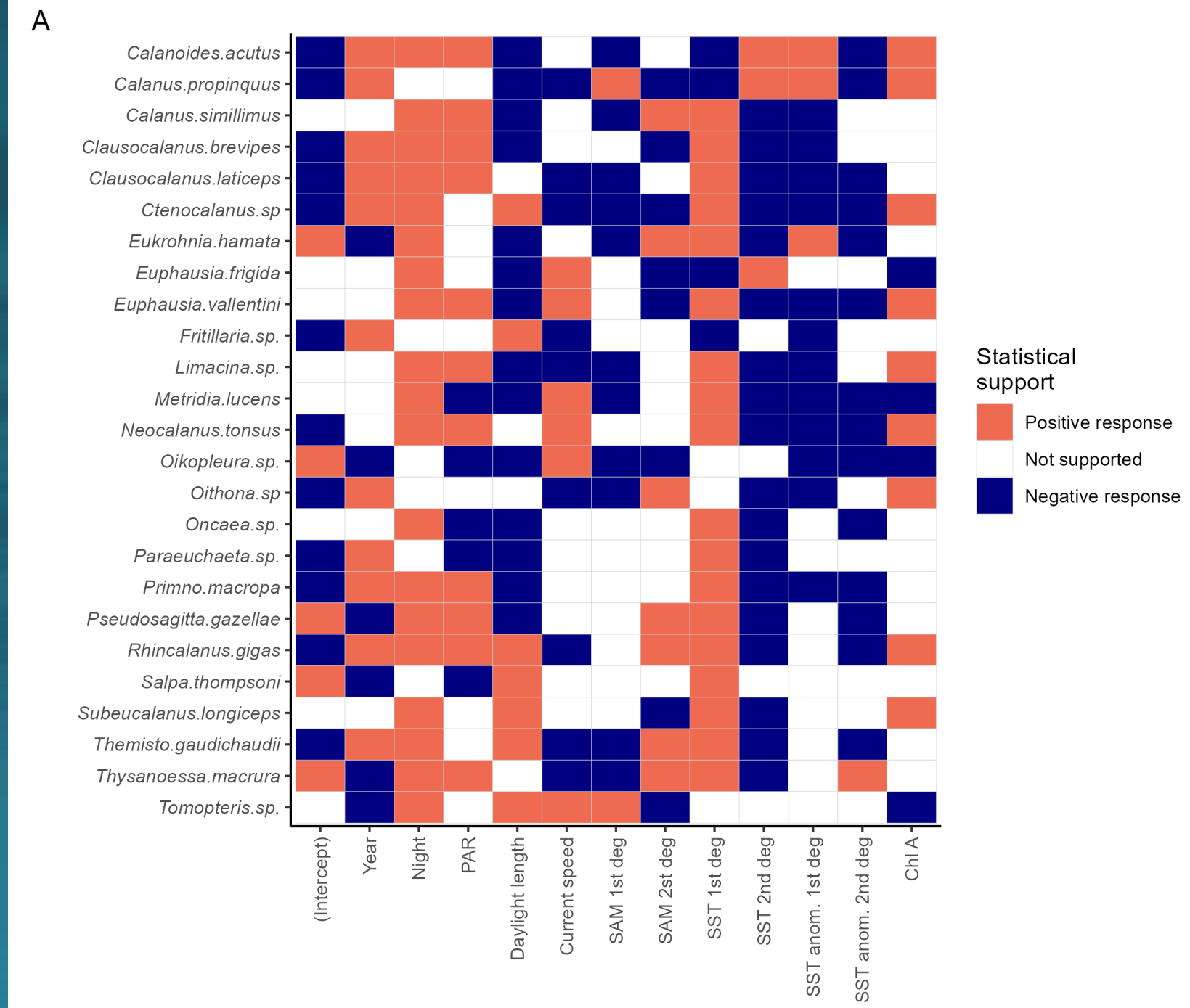
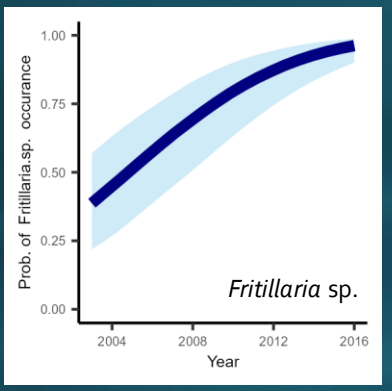
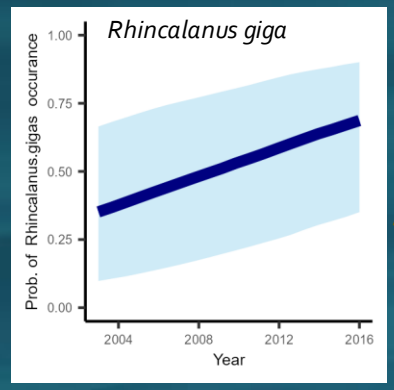
Beta Plots


A
Calanoides.acutus
Calanus.propinquus
Calanus.simillimus
Clausocalanus.brevipes
Clausocalanus.laticeps
Ctenocalanus.sp
Eukrohnia.hamata
Euphausia.frigida
Euphausia.vallentini
Fritillaria.sp.
Limacina.sp.
Metridia.lucens
Neocalanus.tonsus
Oikopleura.sp.
Oithona.sp
Oncaea.sp.
Paraeuchaeta.sp.
Primno.macropa
Pseudosagitta.gazellae
Rhincalanus.gigas
Salpa.thompsoni
Subeucalanus.longiceps
Themisto.gaudichaudii
Thysanoessa.macrura
Tomopteris.sp.
(Intercept)
Year
Night
PAR
Daylight length
Current speed
SAM 1st deg
SAM 2st deg
SST 1st deg
SST 2nd deg
SST anom. 1st deg
SST anom. 2nd deg
Chl A
Statistical support
Positive response
Not supported
Negative response

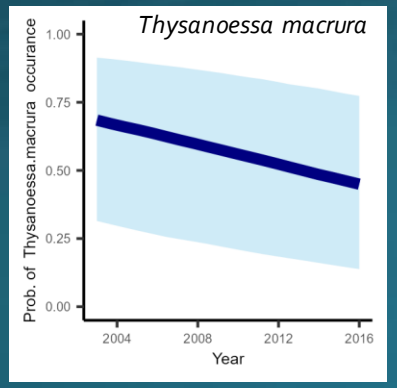
Beta Plots

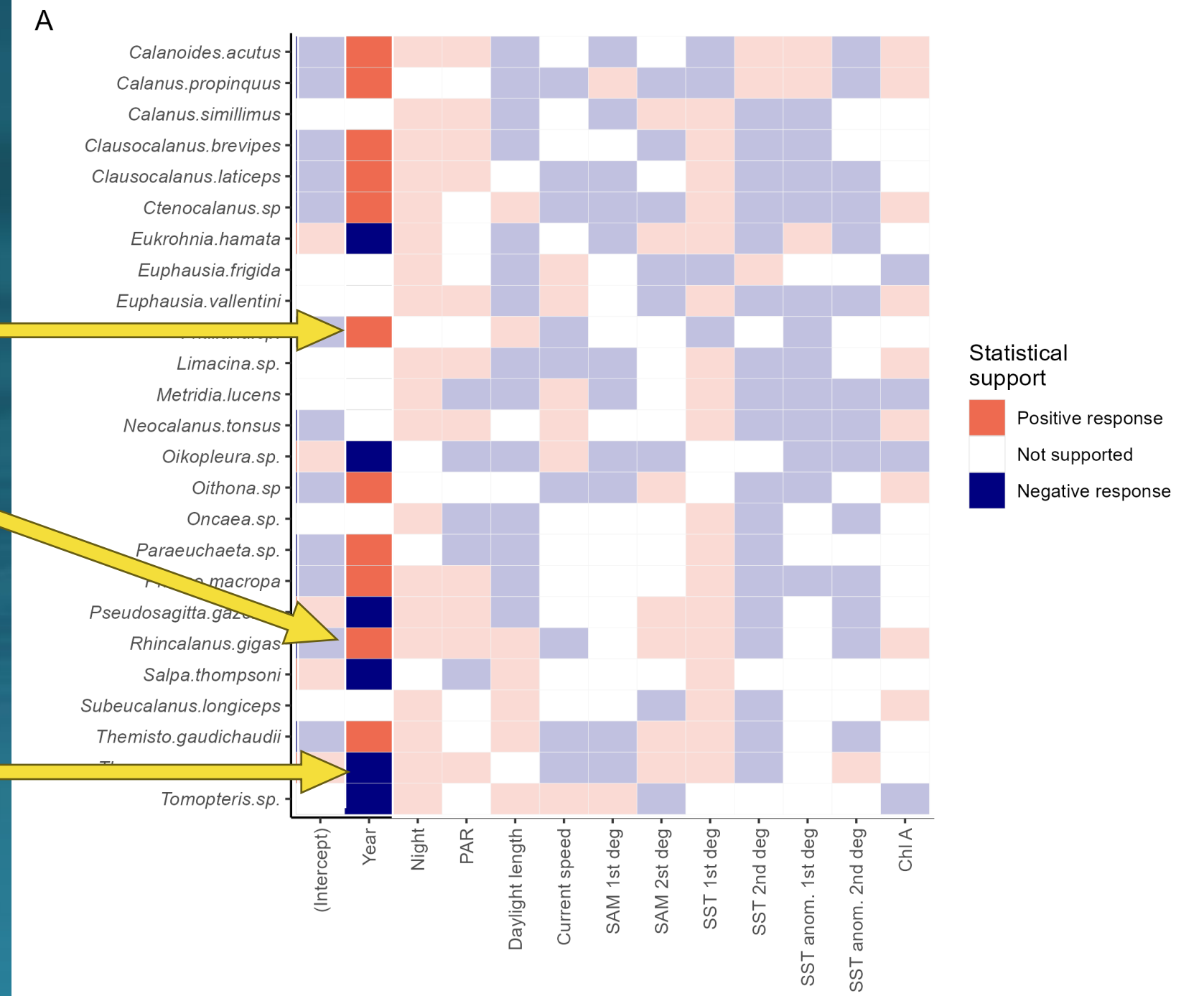
Winners?

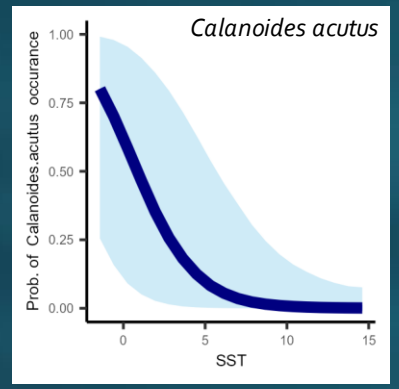


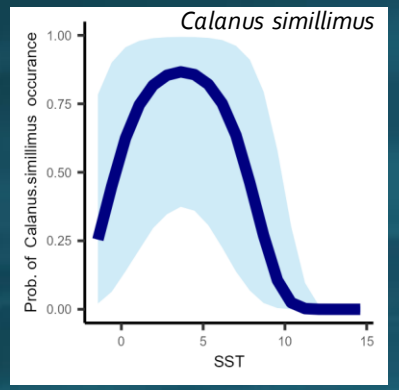


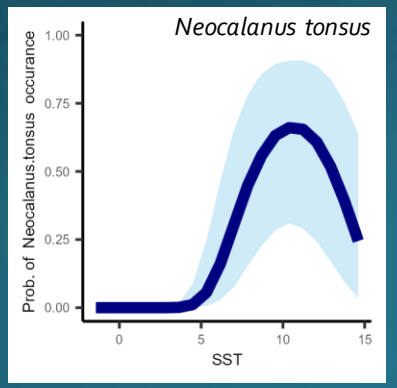
Losers?






Calanoides acutus
Prob. of Calanoides.acutus occurance
1.00
0.75
0.50
0.25
0.00
0
5
10
15
SST


Calanus simillimus
Prob. of Calanus.simillimus occurance
1.00
0.75
0.50
0.25
0.00
0
5
10
15
SST


Neocalanus tonsus
Prob. of Neocalanus.tonsus occurance
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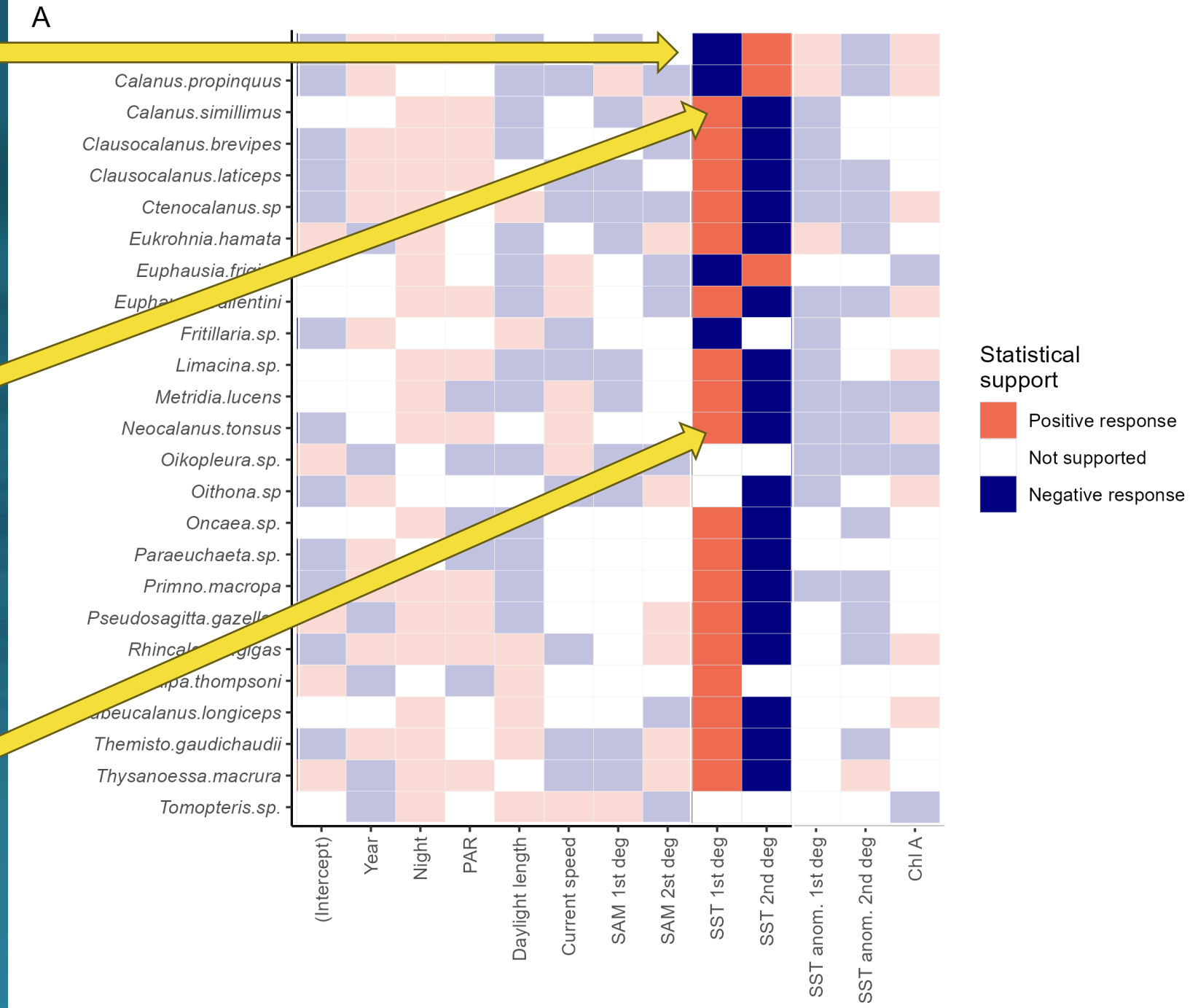
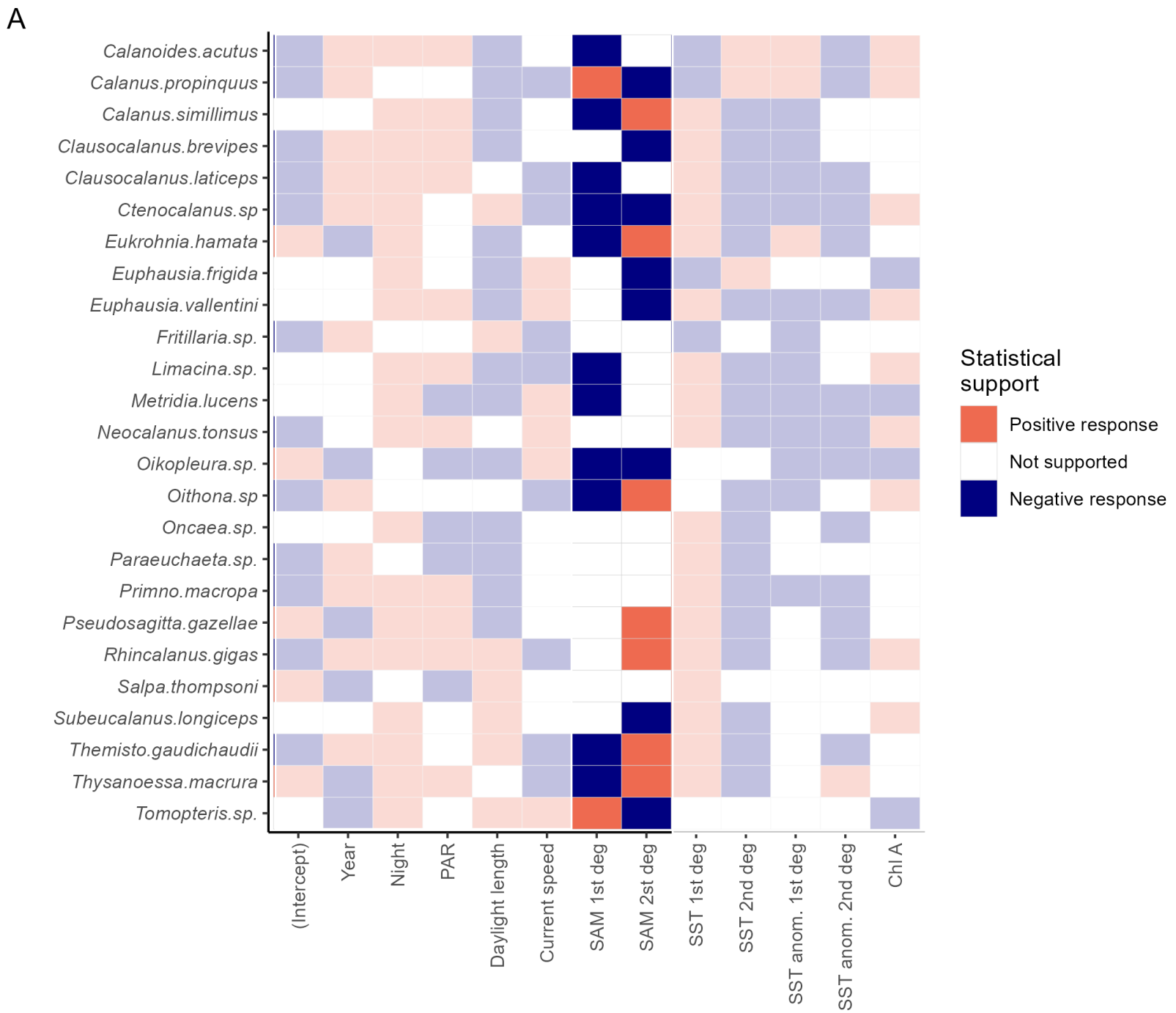
0.75
0.50
0.25
0.00
0
5
10
15
SST


A
Calanus.propinquus
Calanus.simillimus
Clausocalanus.brevipes
Clausocalanus.laticeps
Ctenocalanus.sp
Eukrohnia.hamata
Euphausia.frici
Euphausia.lentini
Fritillaria.sp.
Limacina.sp.
Metridia.lucens
Neocalanus.tonsus
Oikopleura.sp.
Oithona.sp
Oncaea.sp.
Paraeuchaeta.sp.
Primno.macropa
Pseudosagitta.gazelle
Rhincalanus.gigas
Scolecithricella.thompsoni
Scolecithrichaeta.longiceps
Themisto.gaudichaudii
Thysanoessa.macrura
Tomopteris.sp.
(Intercept)
Year
Night
PAR
Daylight length
Current speed
SAM 1st deg
SAM 2st deg
SST 1st deg
SST 2nd deg
SST anom. 1st deg
SST anom. 2nd deg
Chl A
Statistical support
Positive response
Not supported
Negative response


A
Calanoides.acutus
Calanus.propinquus
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Ctenocalanus.sp
Eukrohnia.hamata
Euphausia.frigida
Euphausia.vallentini
Fritillaria.sp.
Limacina.sp.
Metridia.lucens
Neocalanus.tonsus
Oikopleura.sp.
Oithona.sp
Oncaea.sp.
Paraeuchaeta.sp.
Primno.macropa
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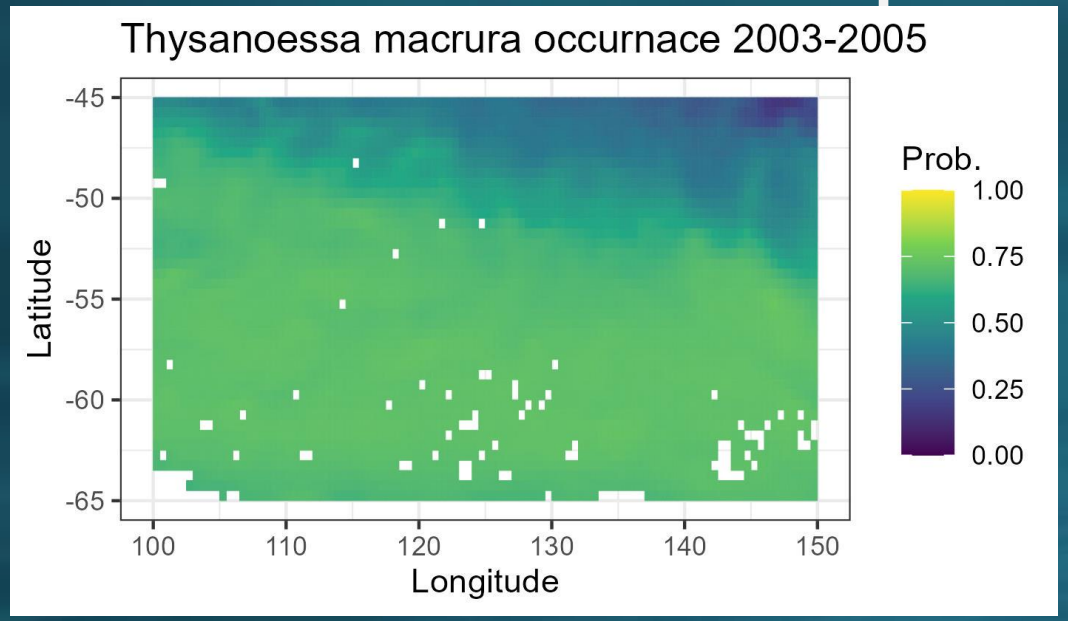
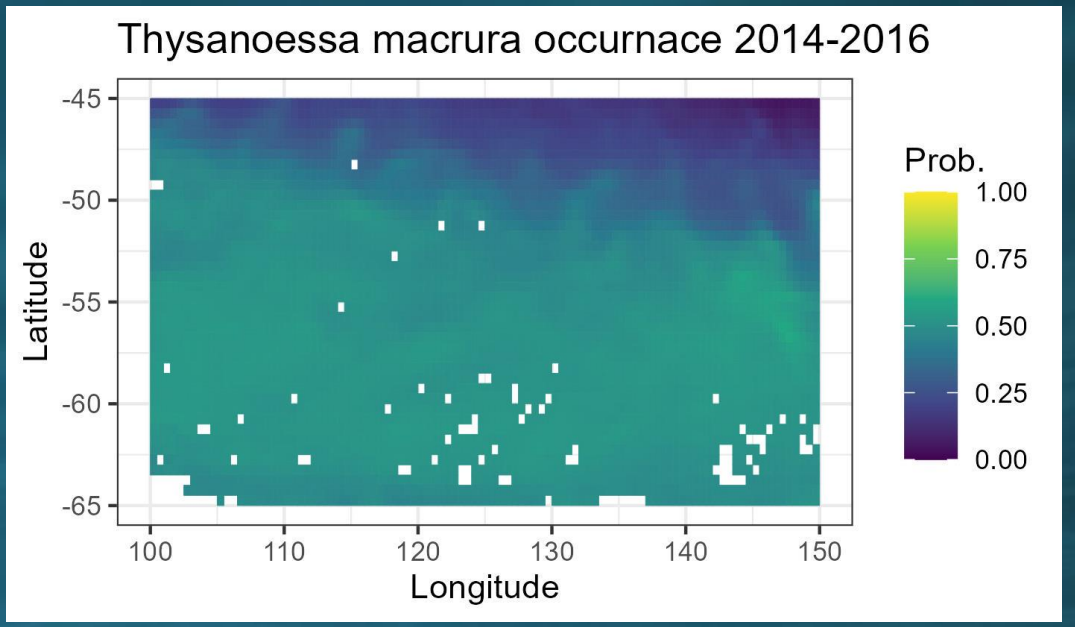
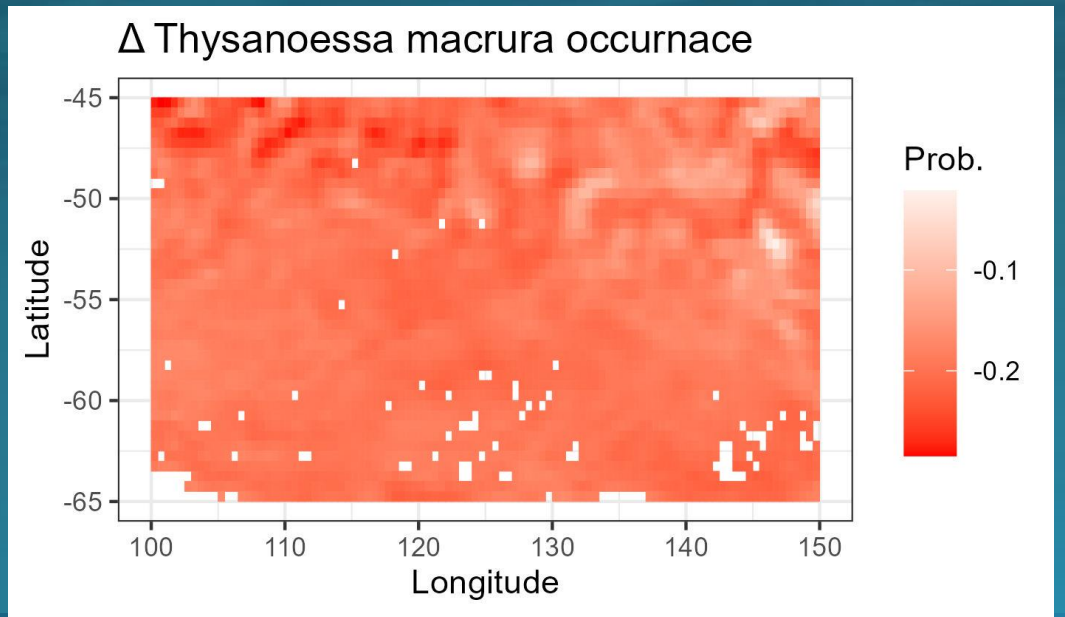
(Intercept)
Year
Night
PAR
Daylight length
Current speed
SAM 1st deg
SAM 2st deg
SST 1st deg
SST 2nd deg
SST anom. 1st deg
SST anom. 2nd deg
Chl A
Statistical support
Positive response
Not supported
Negative response

Predictive maps: *Thysanoessa macrura*







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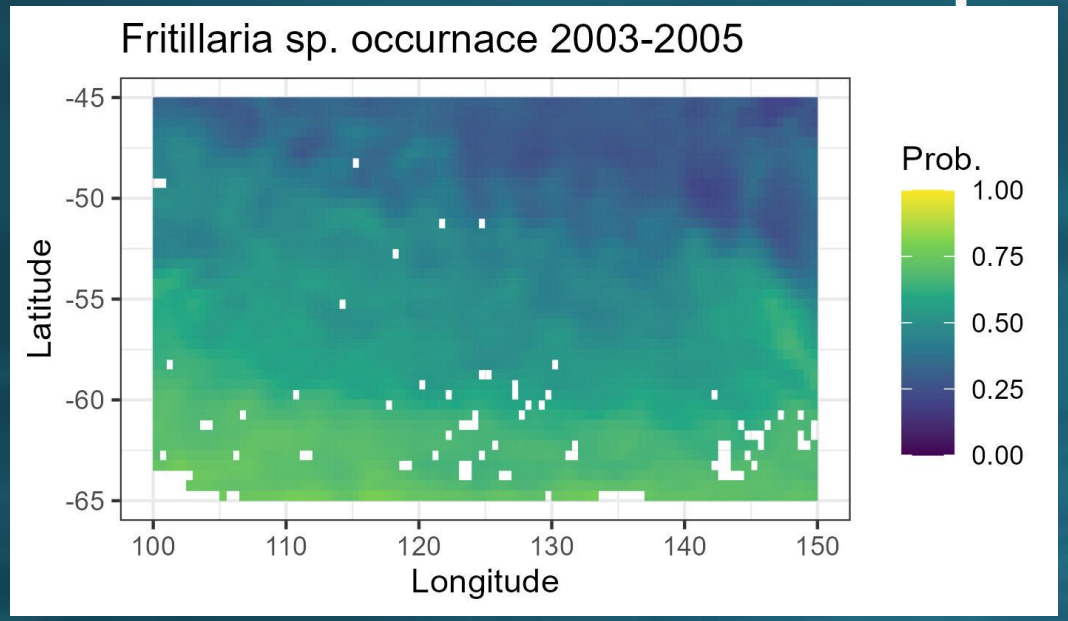
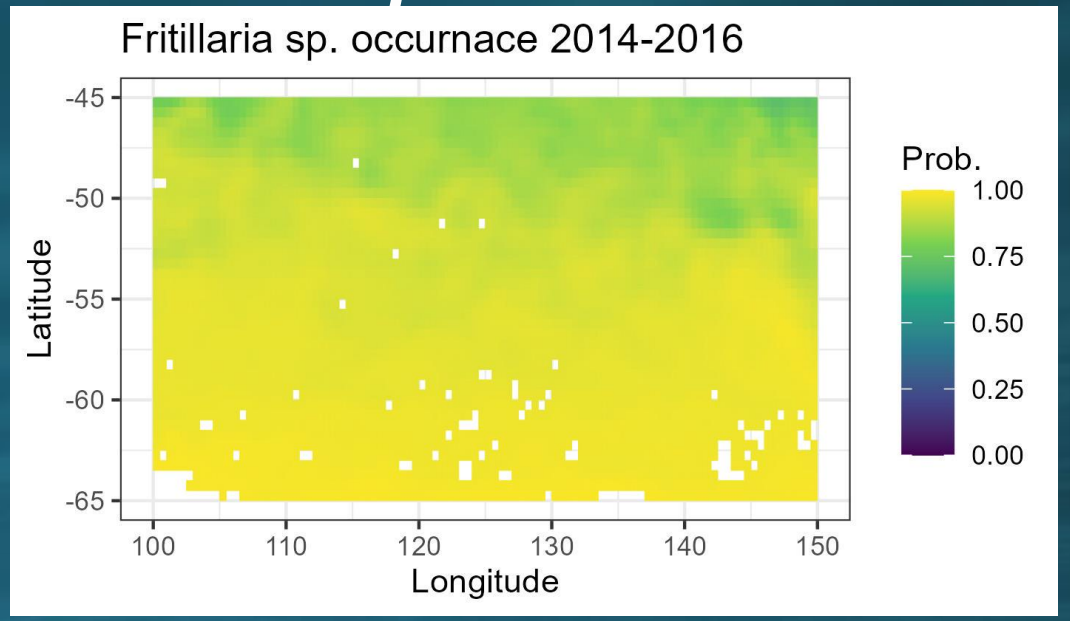
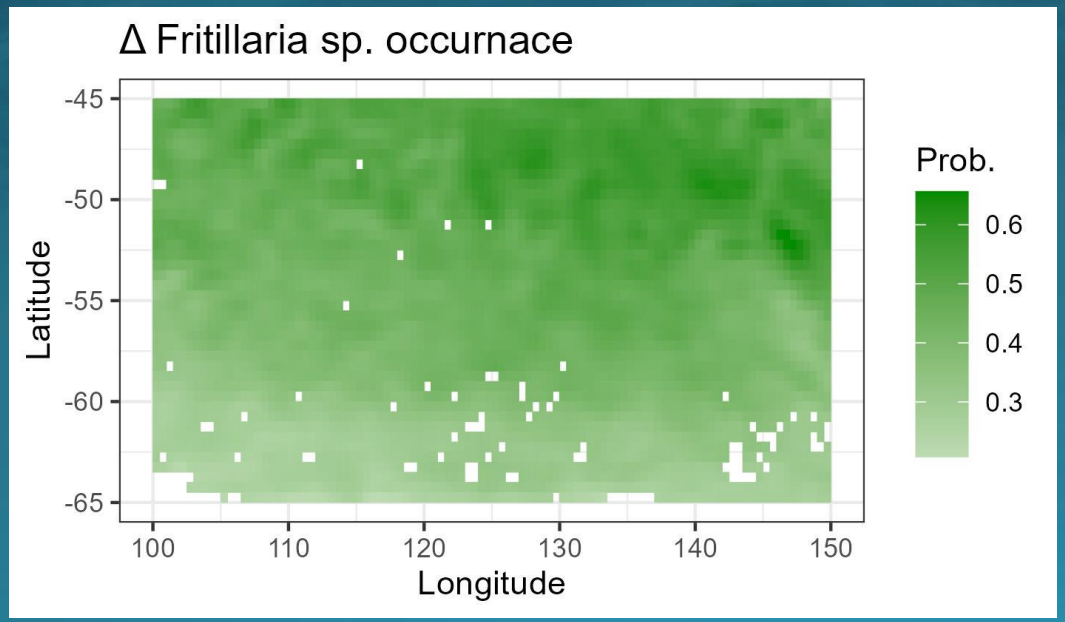
Predictive maps: *Fritillaria sp.*







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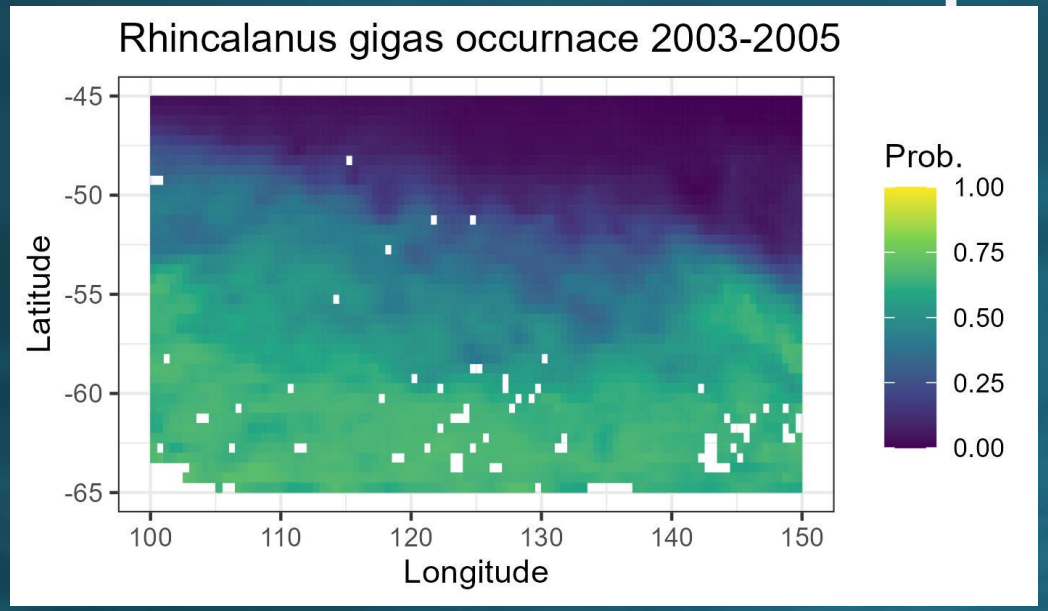
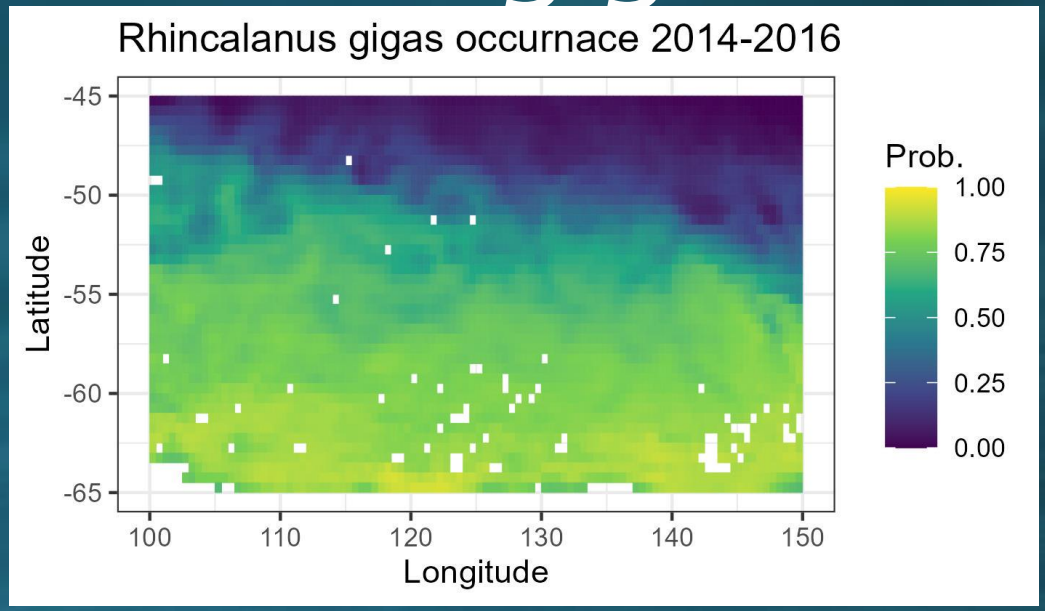
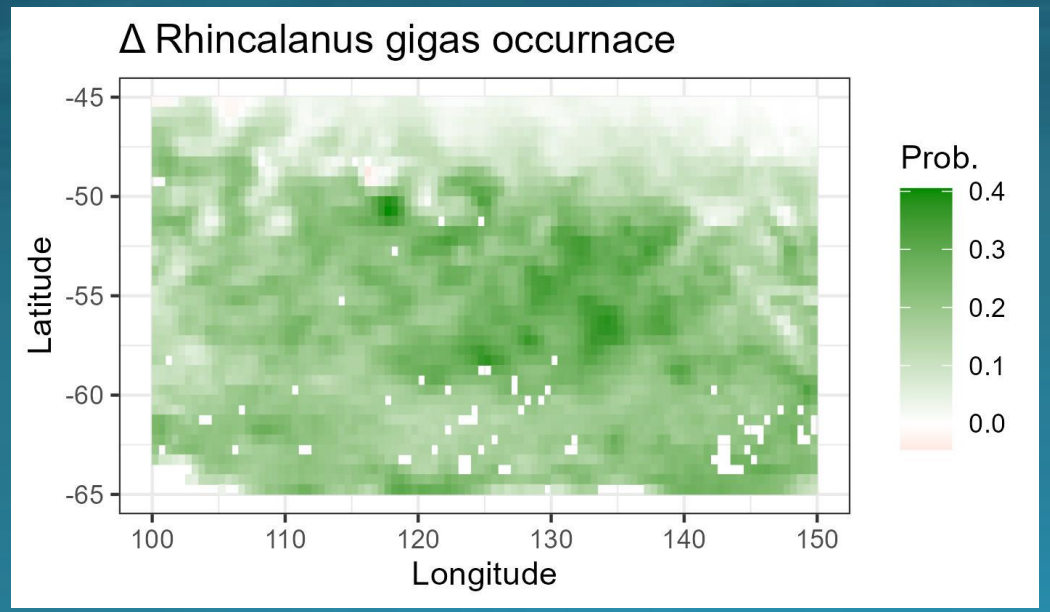
Predictive maps: *Rhincalanus gigas*







Large copepod

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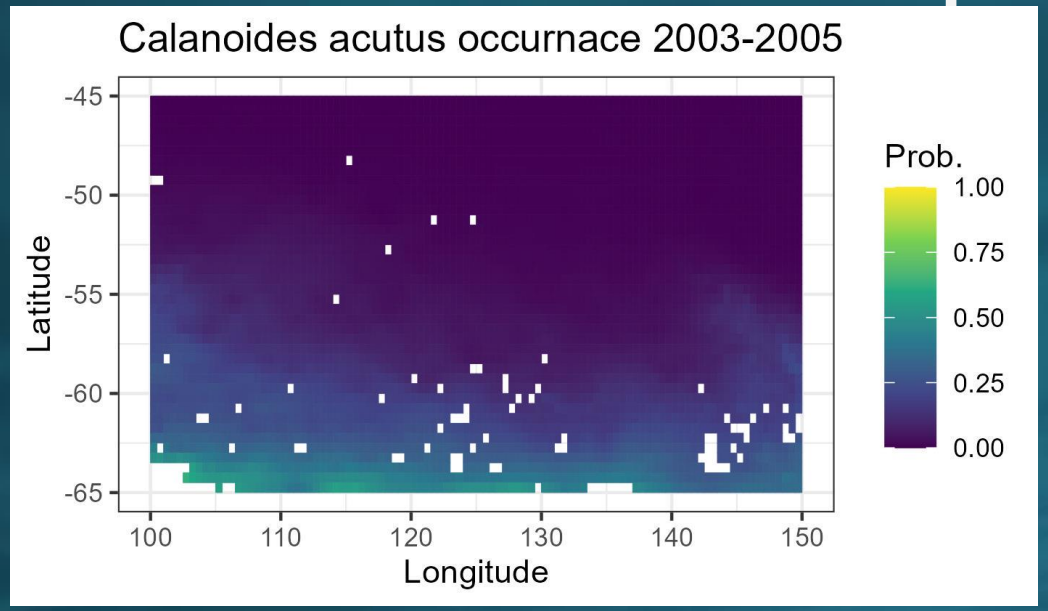
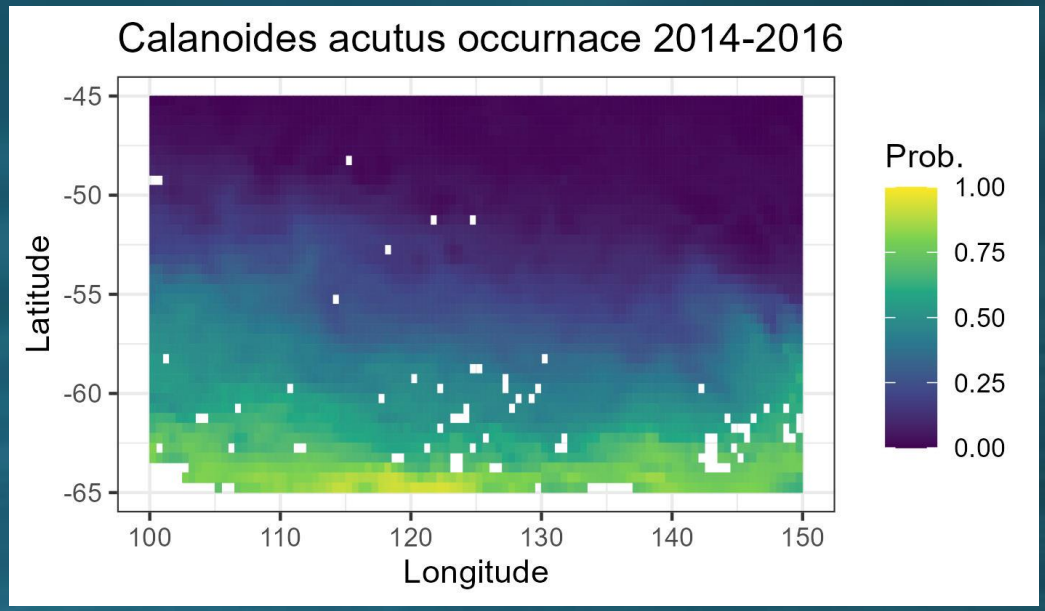
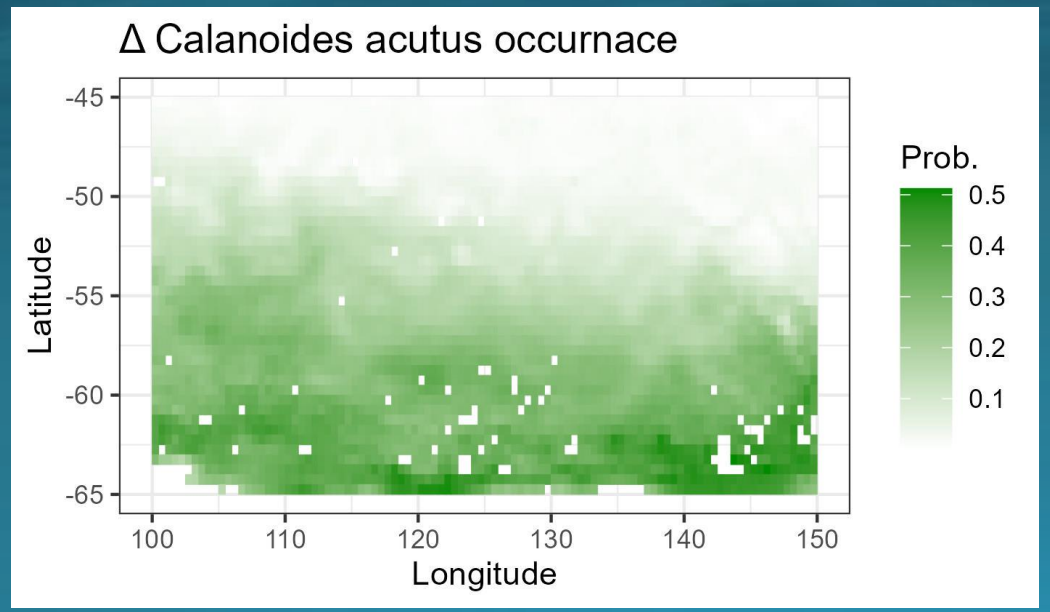
Predictive maps: *Calanoides acutus*







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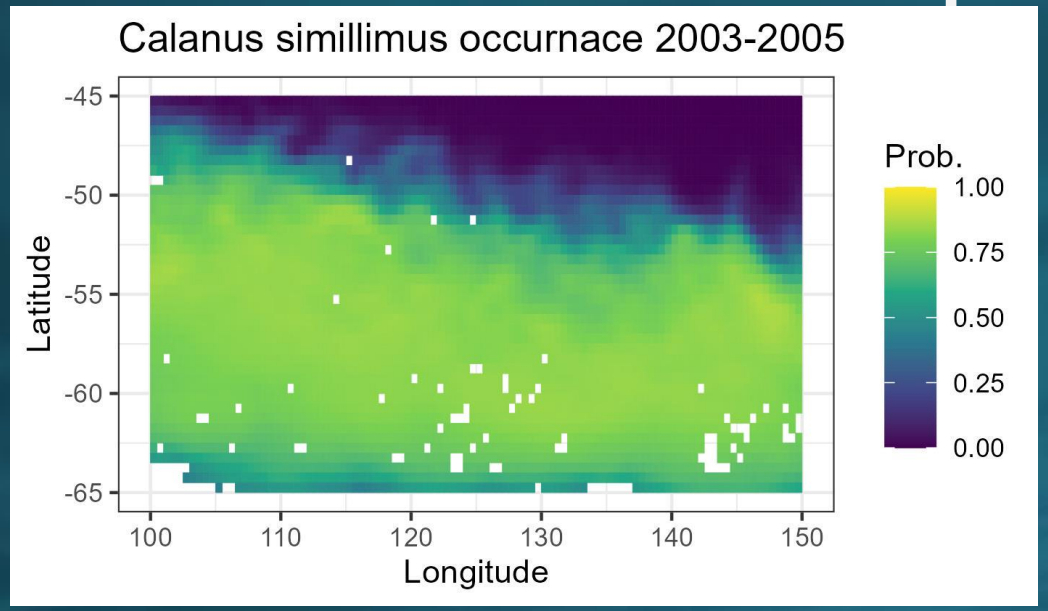
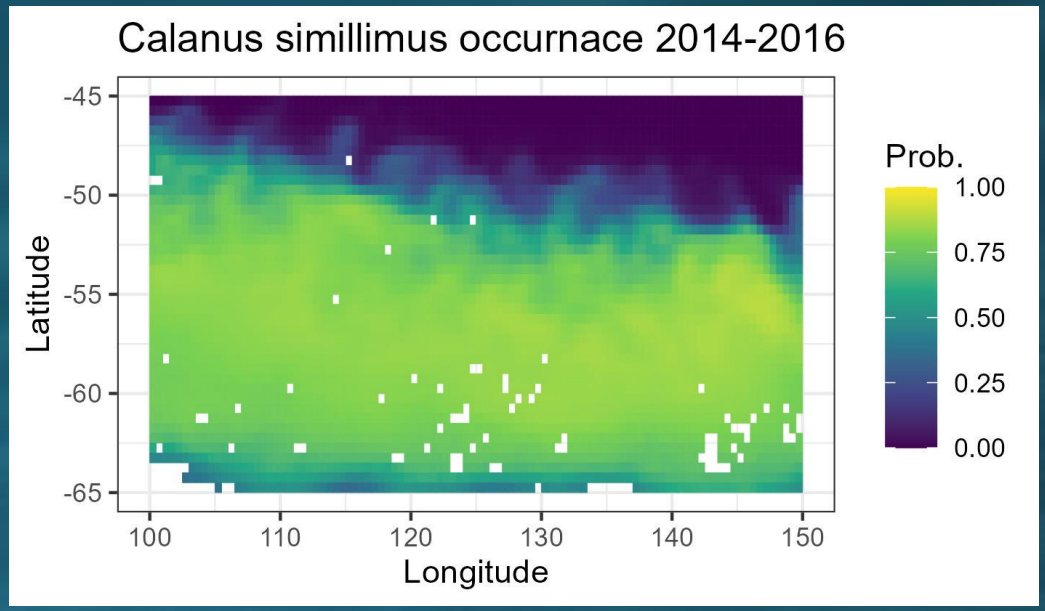
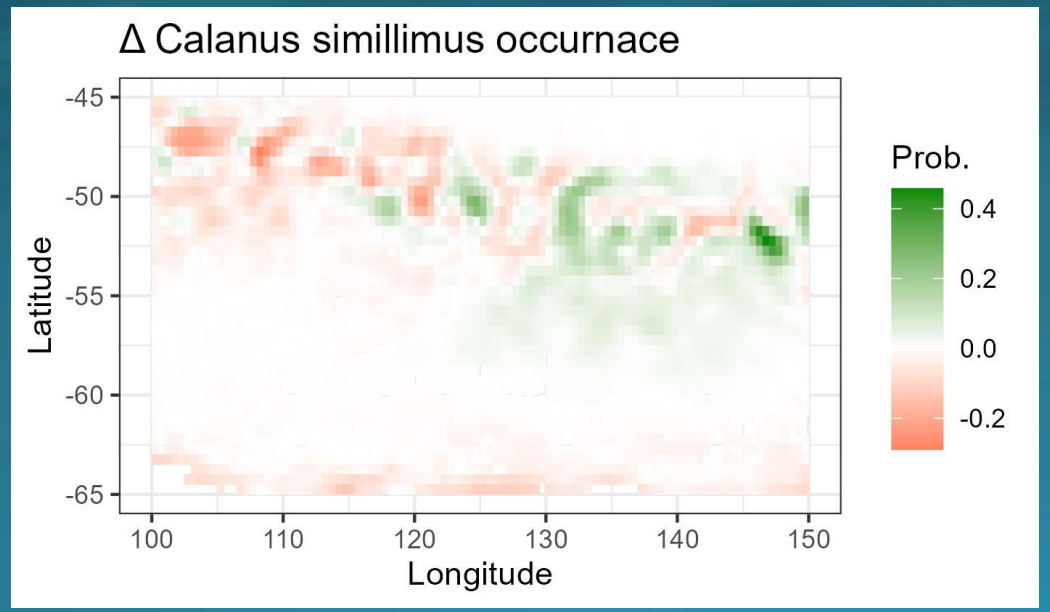
Predictive maps: *Calanus simillimus*







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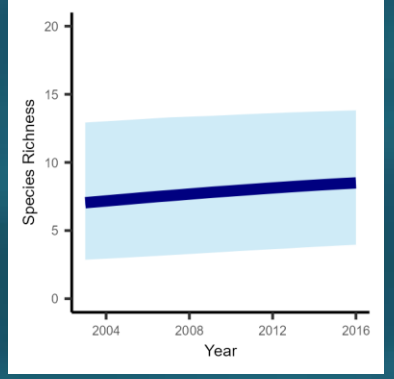
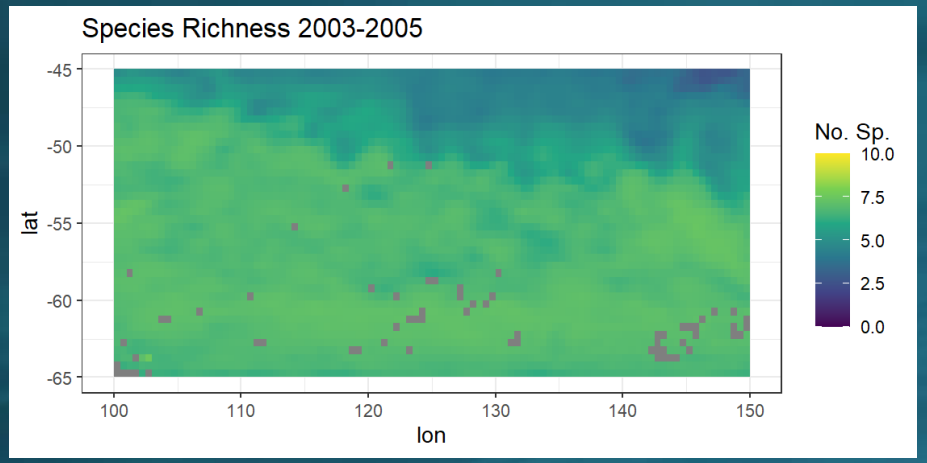
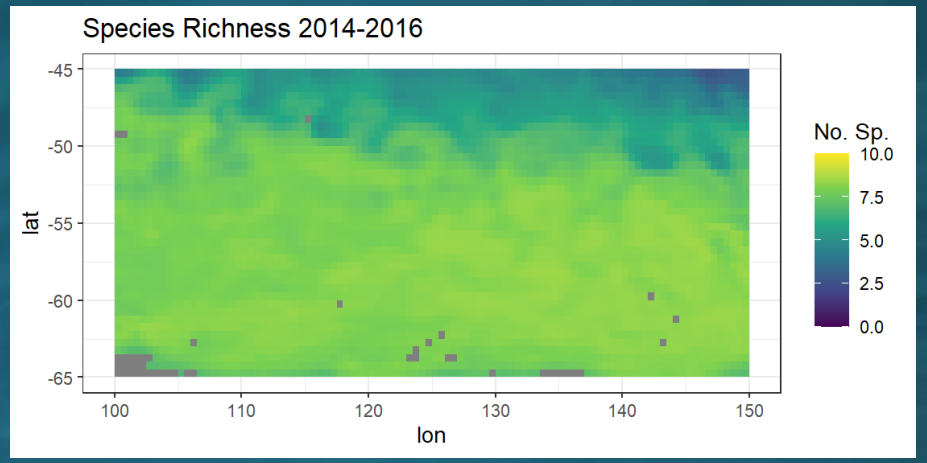
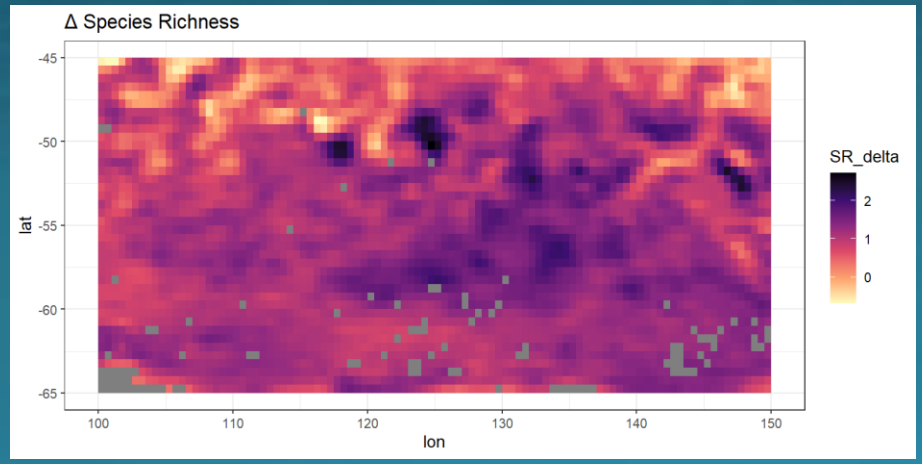
Species richness predictions









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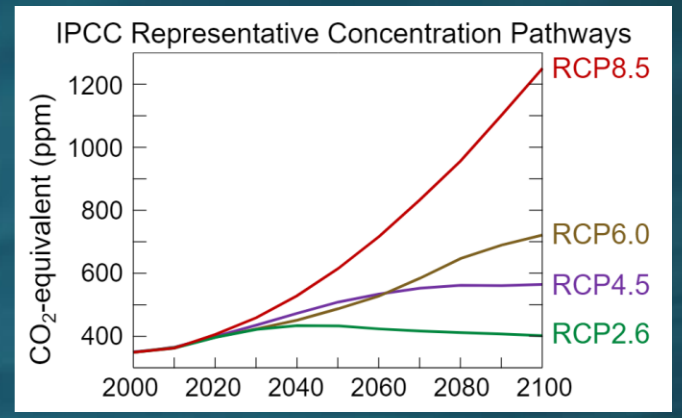
Conclusions

- Zooplankton community of Southern Ocean is changing
- Some winners, some losers
- Evidence that changing SST and ocean currents driving change
- It is complex, **highly patchy**, missing pieces, species biology also important
- Long-term monitoring data is vital
- CCAMLR and resources managers
- Improved ecosystem knowledge
- There are large gaps in the data = areas of uncertainty
- Help influence future voyages to fill knowledge and spatial gaps

What next?

- Identify biodiversity hotspots and coldspots
- Where should we be sampling?
- Incorporate species traits
  - Size, Family
- Future predictions to 2100:
  - RCP4.5 and 8.5
- Interactive data dashboard



Continuous Plankton Recorder (CPR)

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Thank you

More information: joel.williams@utas.edu.au
Twitter: @joelfishecology

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