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Effects of Ocean Acidification and Warming on Salish Sea Kelps: a Meta-analysis

Miranda Roethler

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Effects of Ocean Acidification and Warming on Salish Sea Kelps: A Meta-analysis

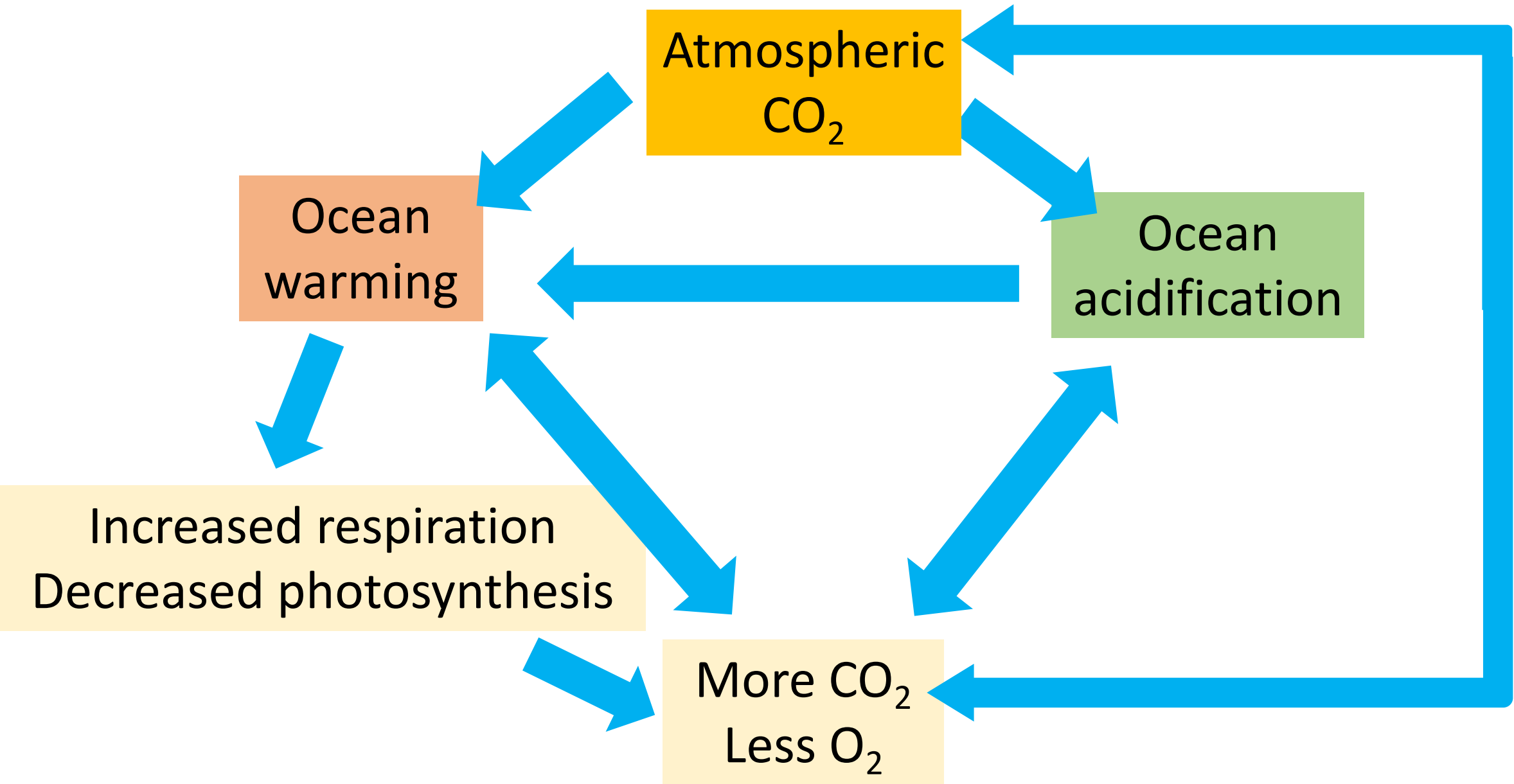
Miranda Roethler

Advisor: Dr. Jacqueline Padilla-Gamiño
Salish Sea Ecosystem Conference 2022














An underwater photograph showing a dense kelp forest on the left and a sandy seabed on the right. The kelp has long, thin blades and dark stalks. The water is clear and blue-green. The seabed is covered in fine sand and small rocks. A small, light-colored fish is visible near the bottom right.

**How vulnerable are Salish Sea
kelps to climate change?**



Why meta-analysis?



Review of the literature



Combine data from
multiple studies

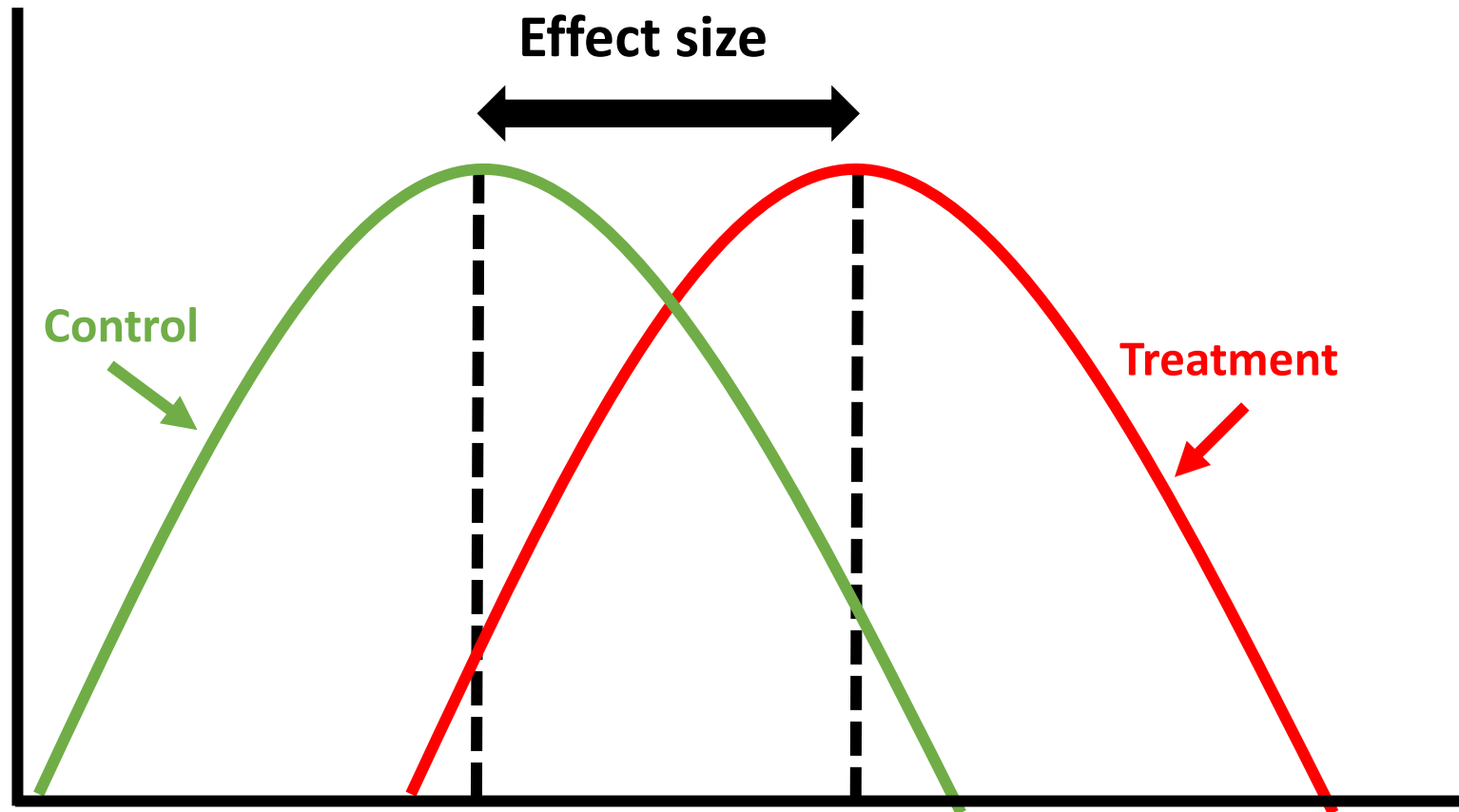


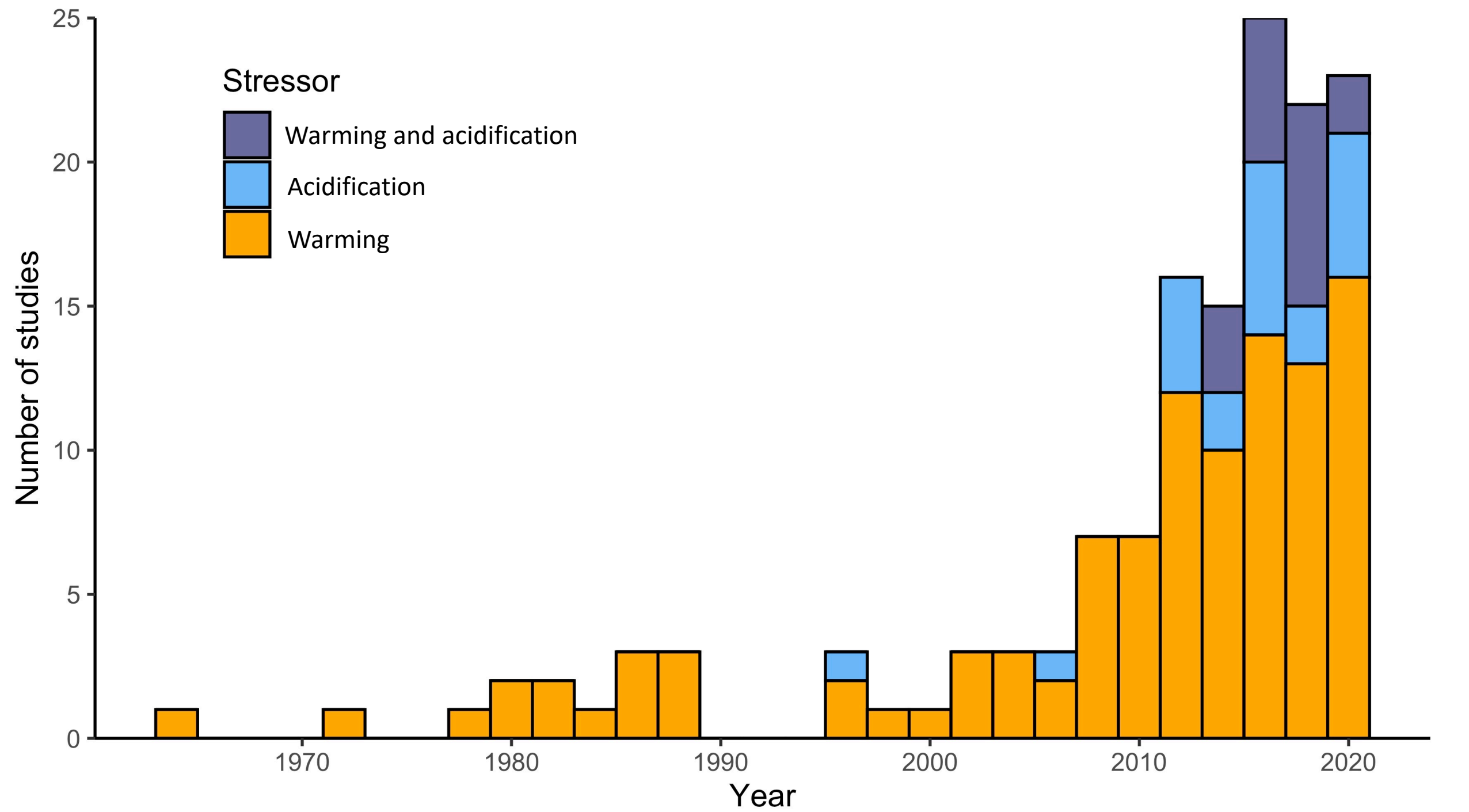
General trends



Knowledge gaps

How does a meta-analysis work?





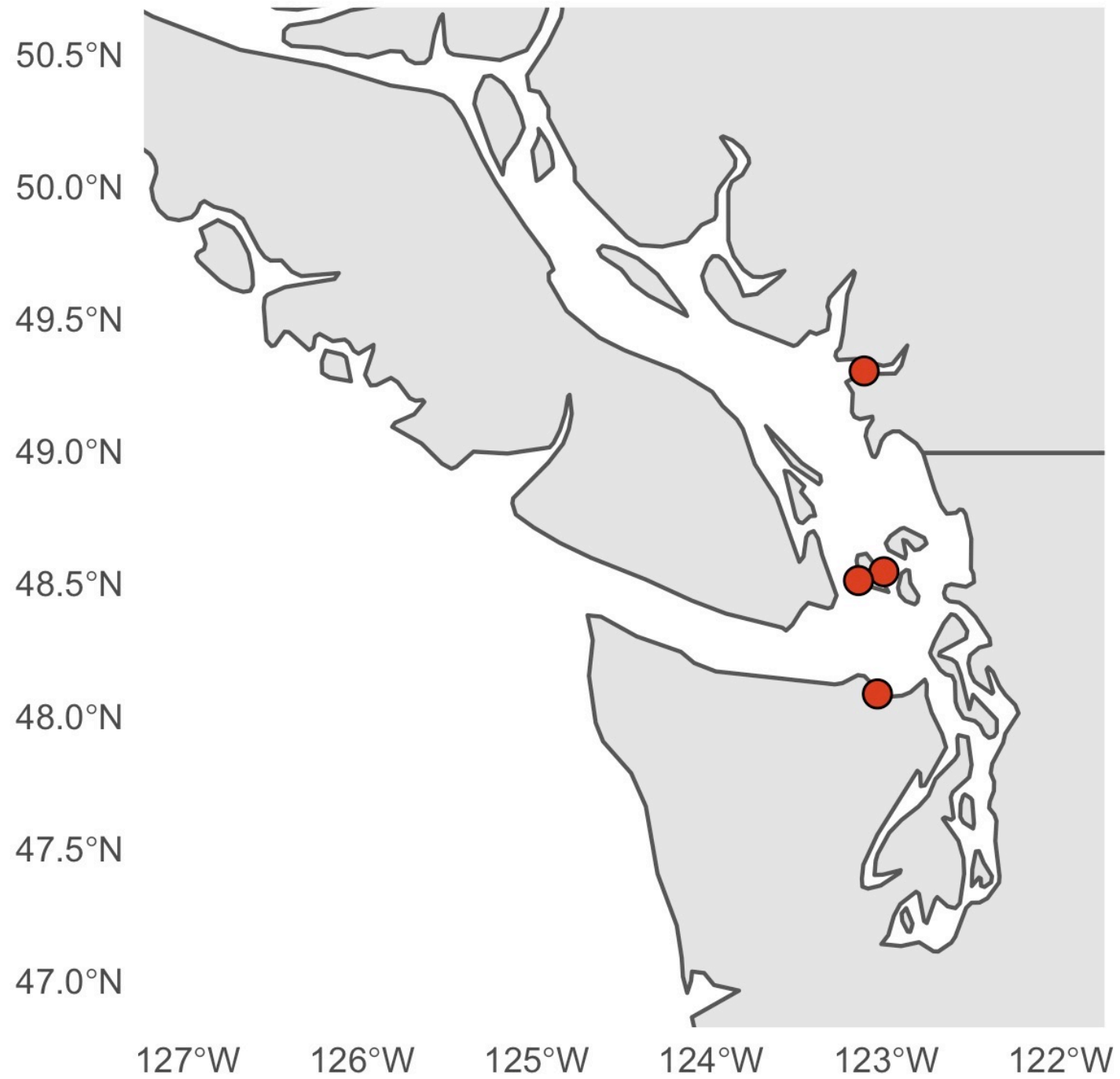


Our questions

- How vulnerable are **Salish Sea kelps** compared to the rest of the world?
- How do **warming and acidification** affect kelp, separately and combined?
- Is vulnerability the same across all **species and life stages**?

Salish Sea kelps





Negative effect of treatment

Warming

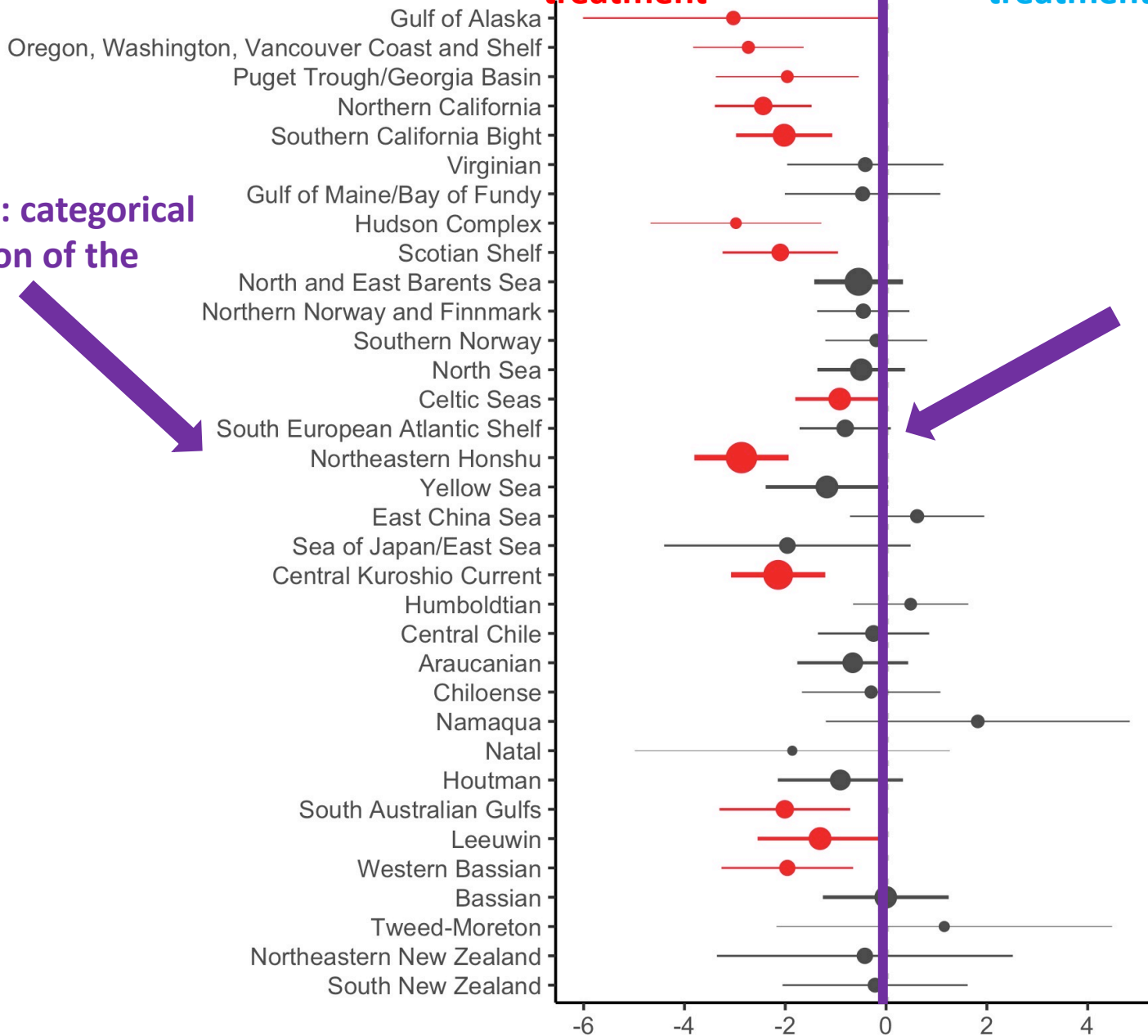
Positive effect of treatment

Y-axis: categorical division of the data

Ecoregion

Zero-line

X-axis: Effect size

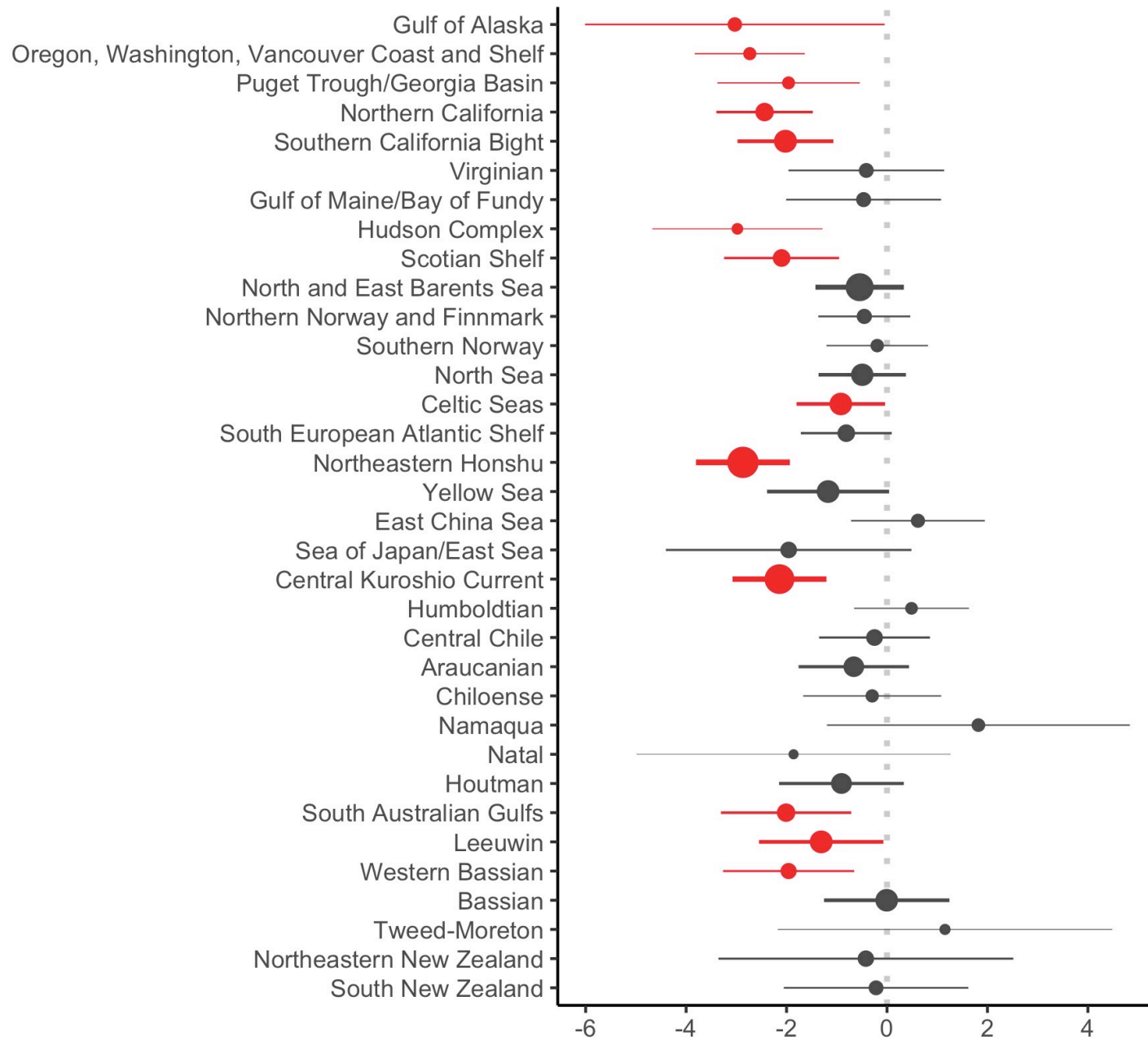


Ecoregion

Warming

Effect direction

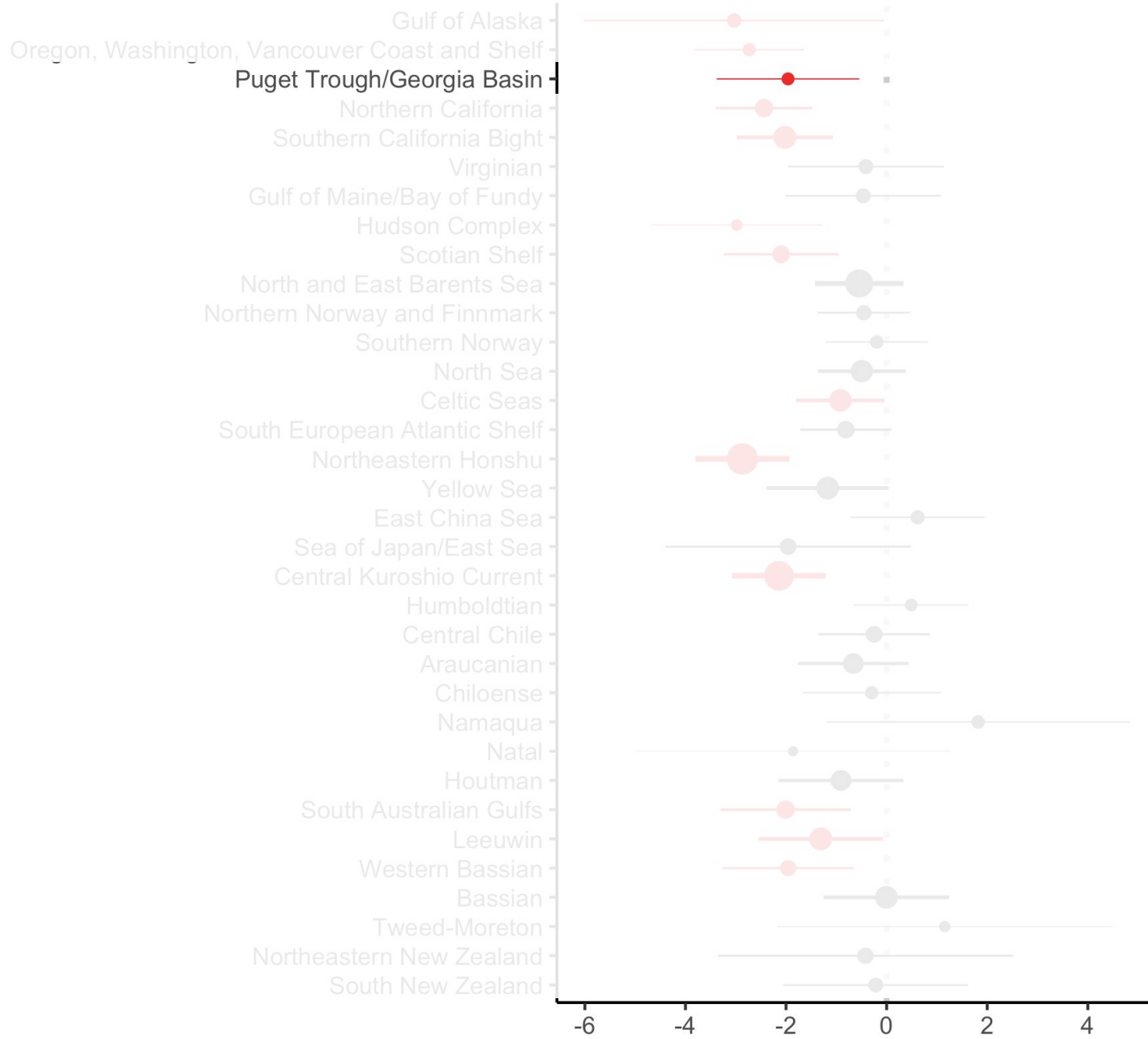
- Positive
- No effect
- Negative

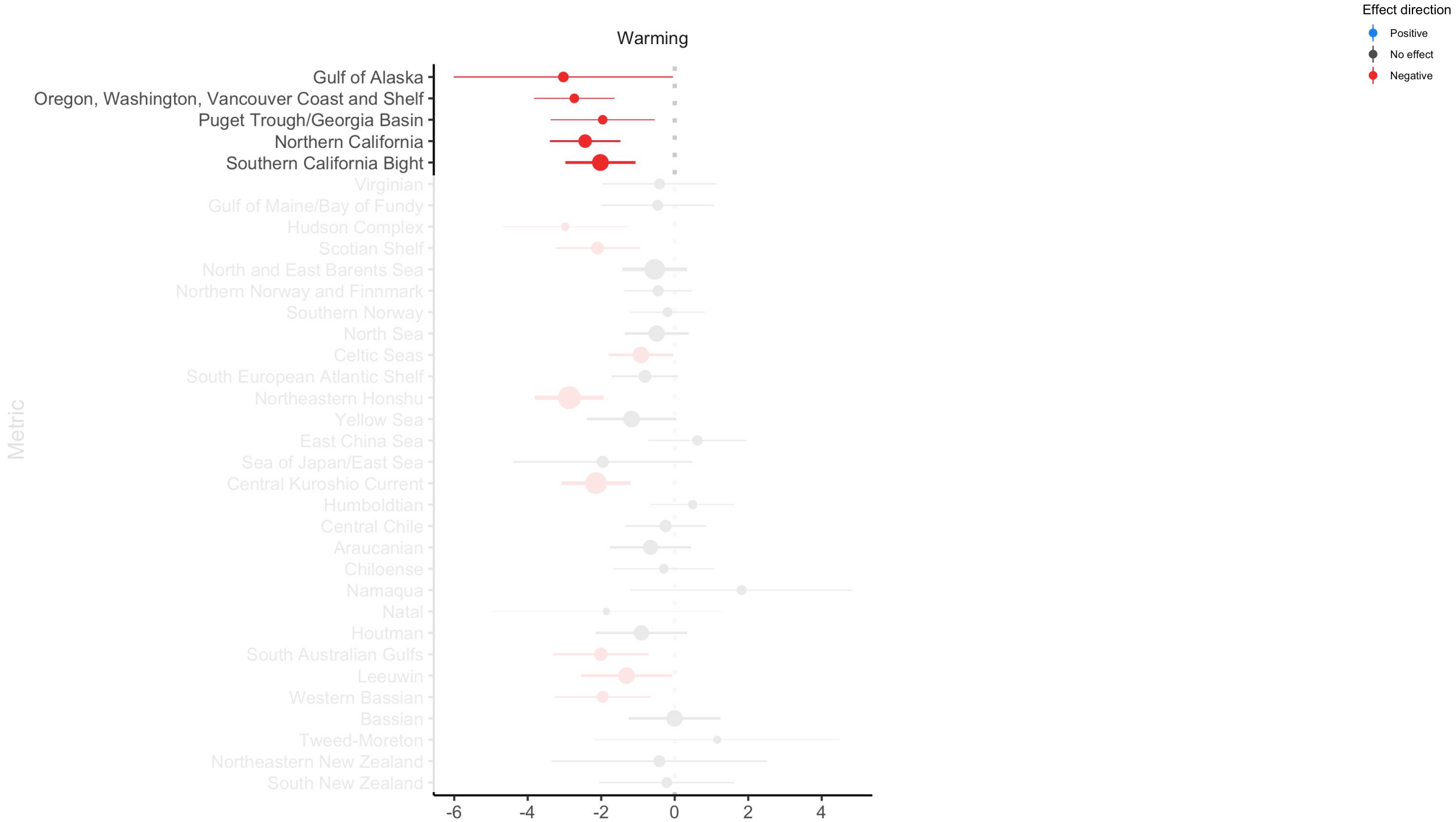


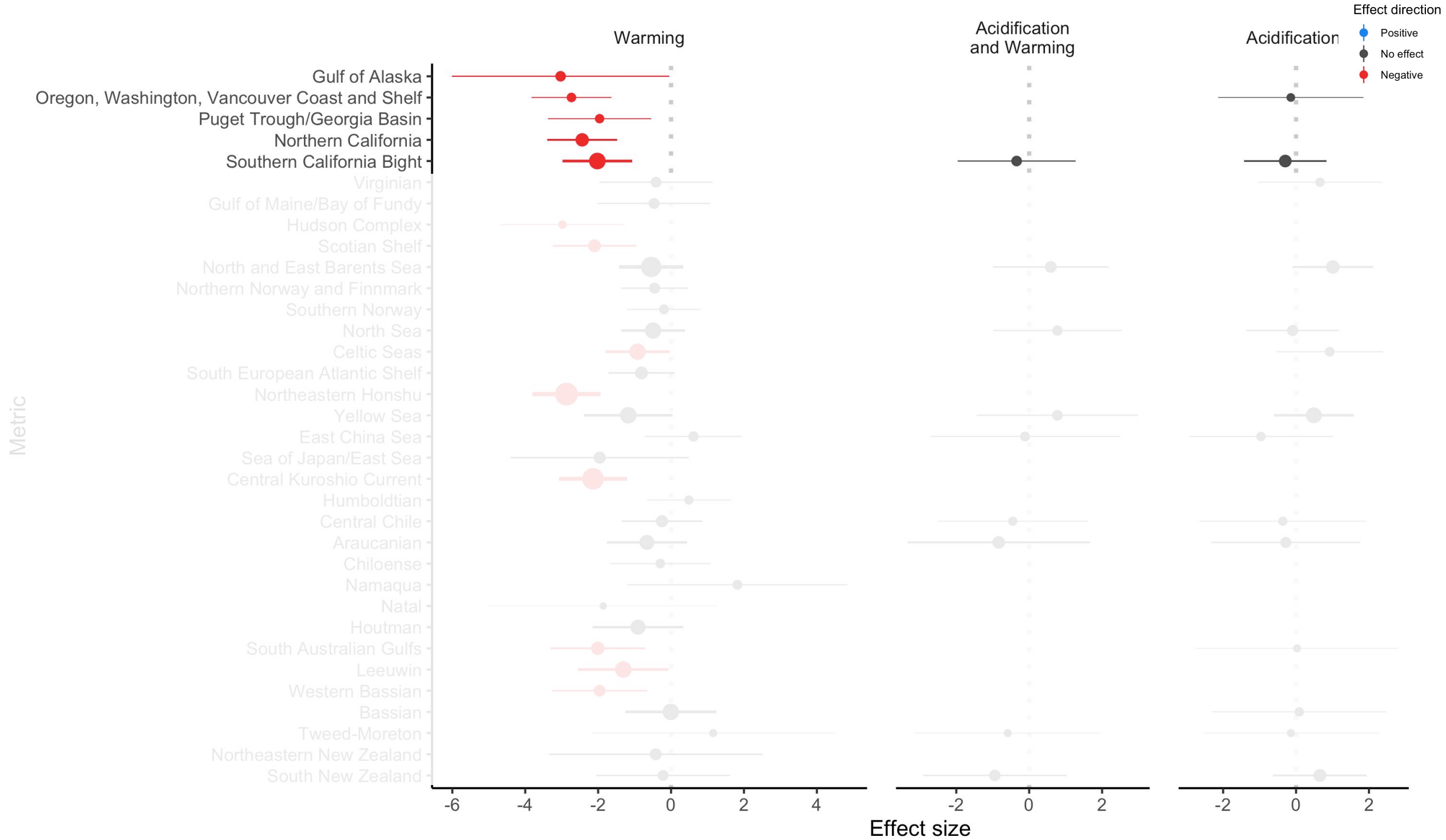
Warming

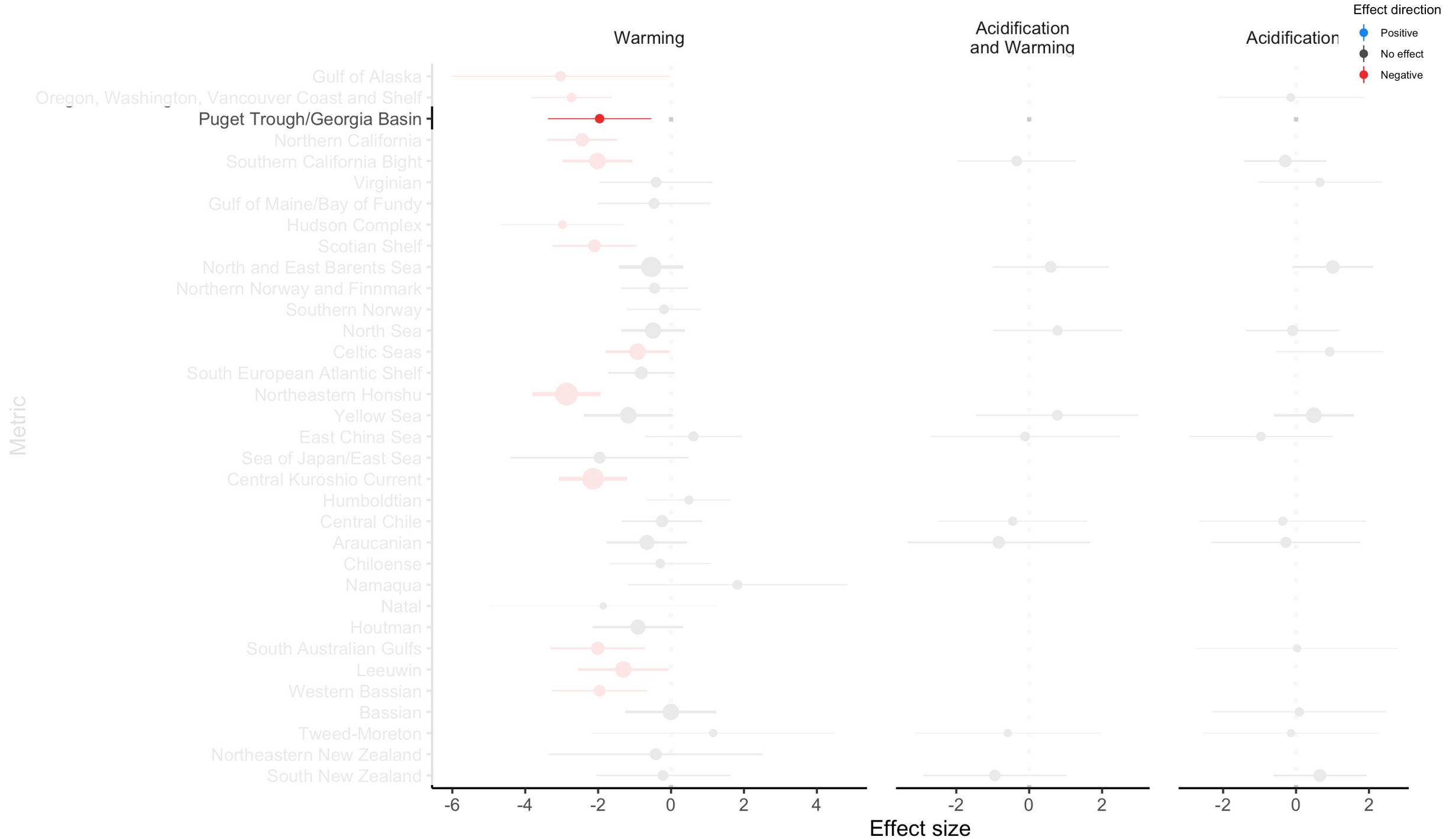
Effect direction
Positive
No effect
Negative

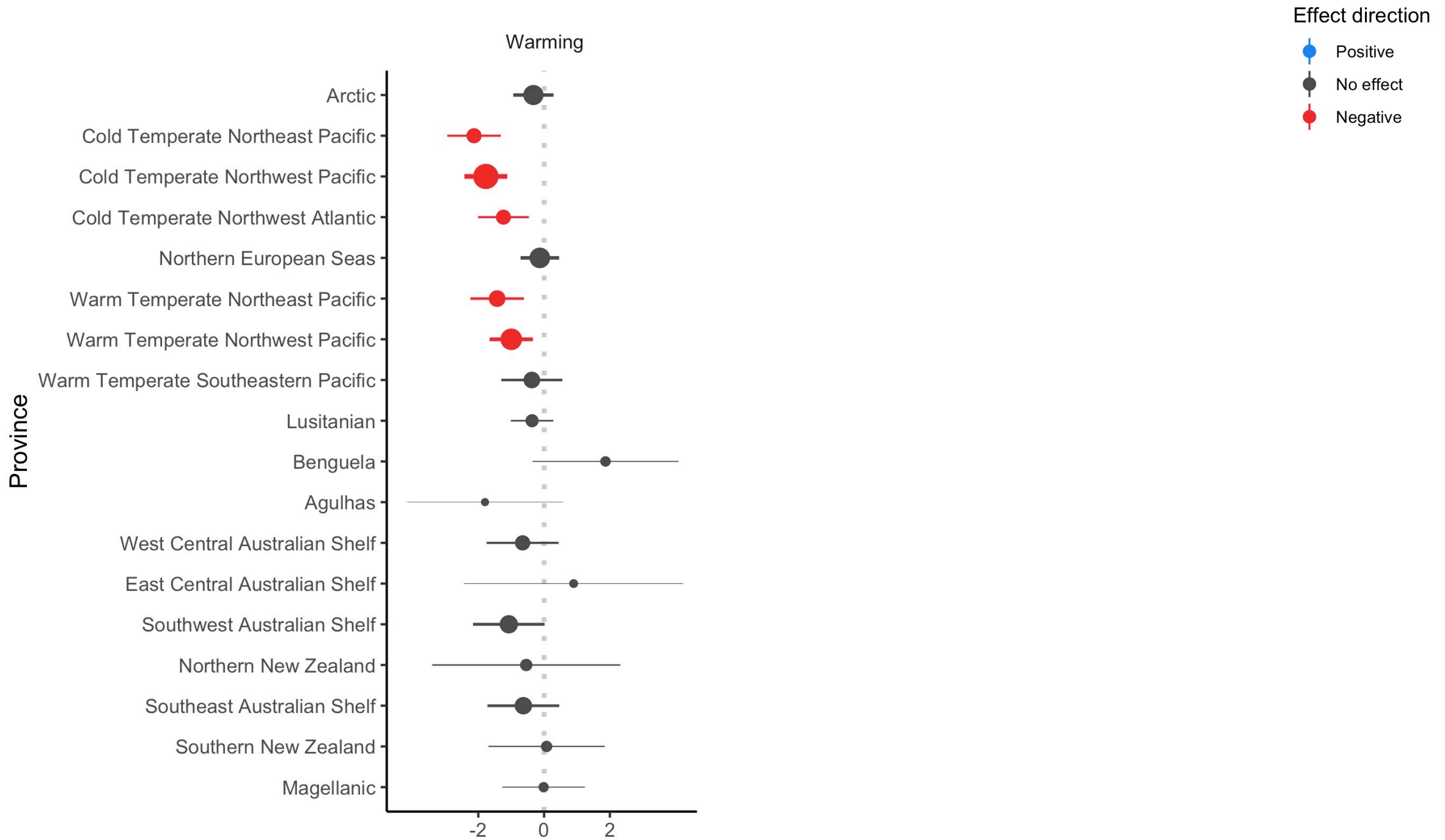
Metric





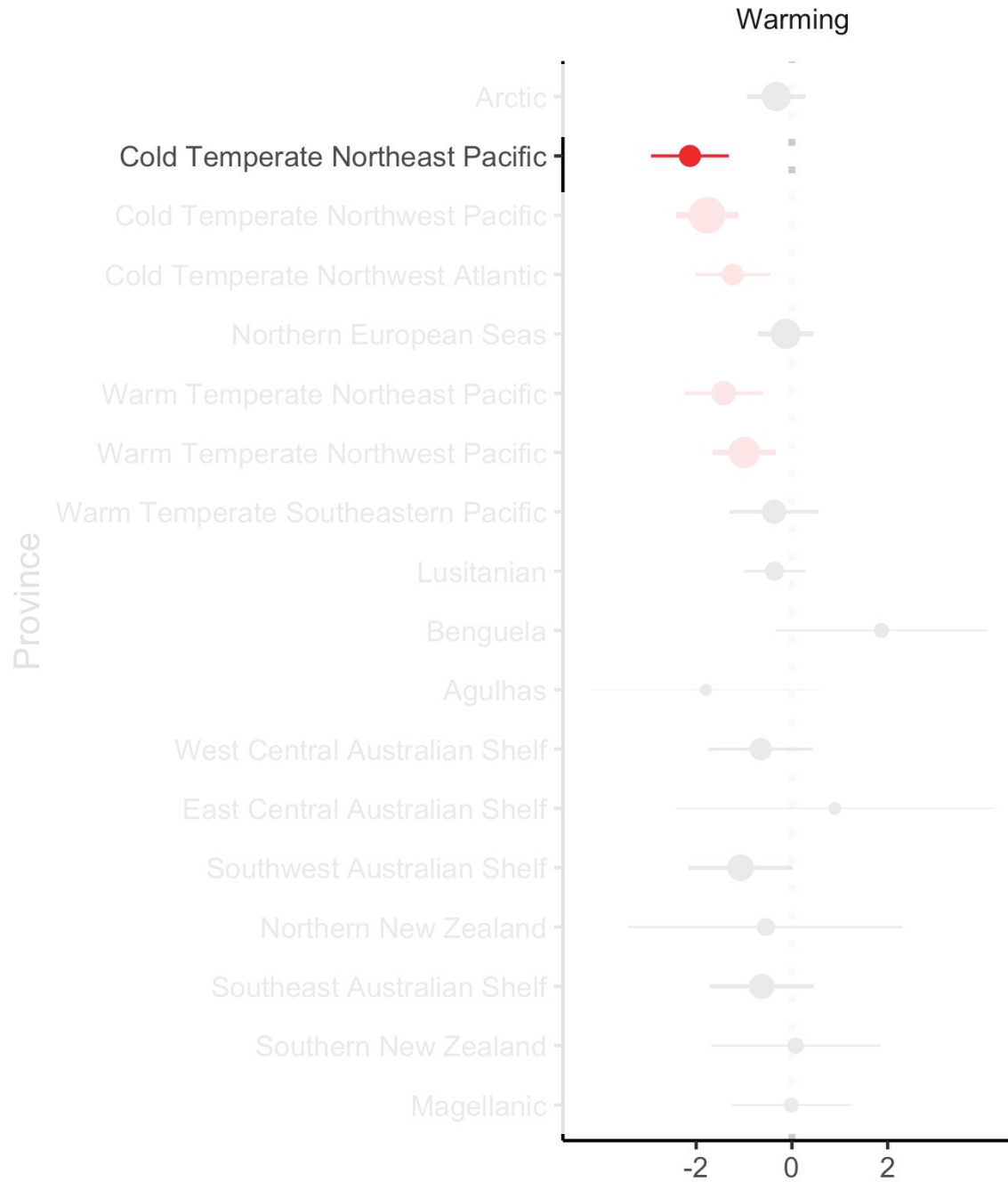


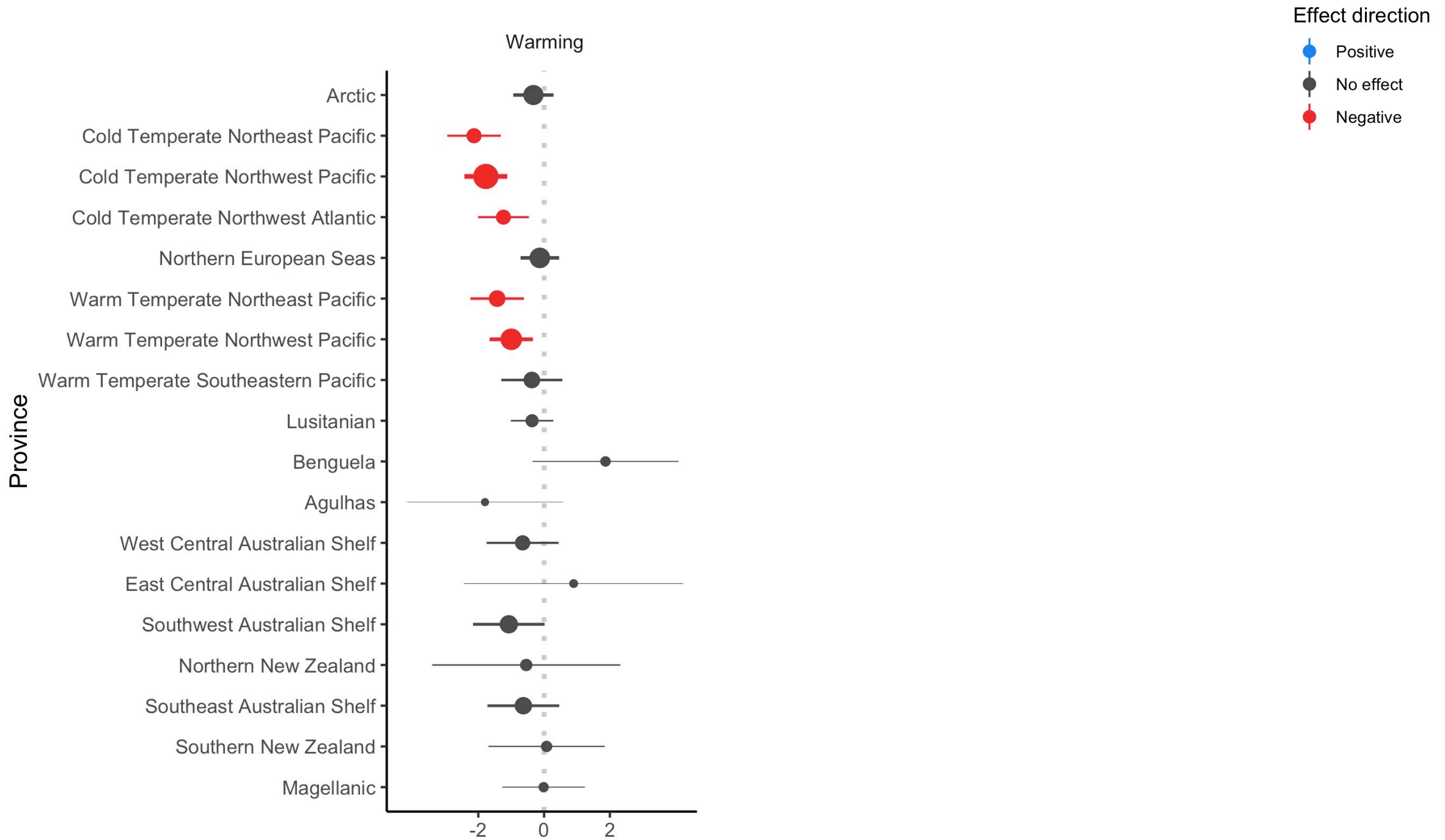


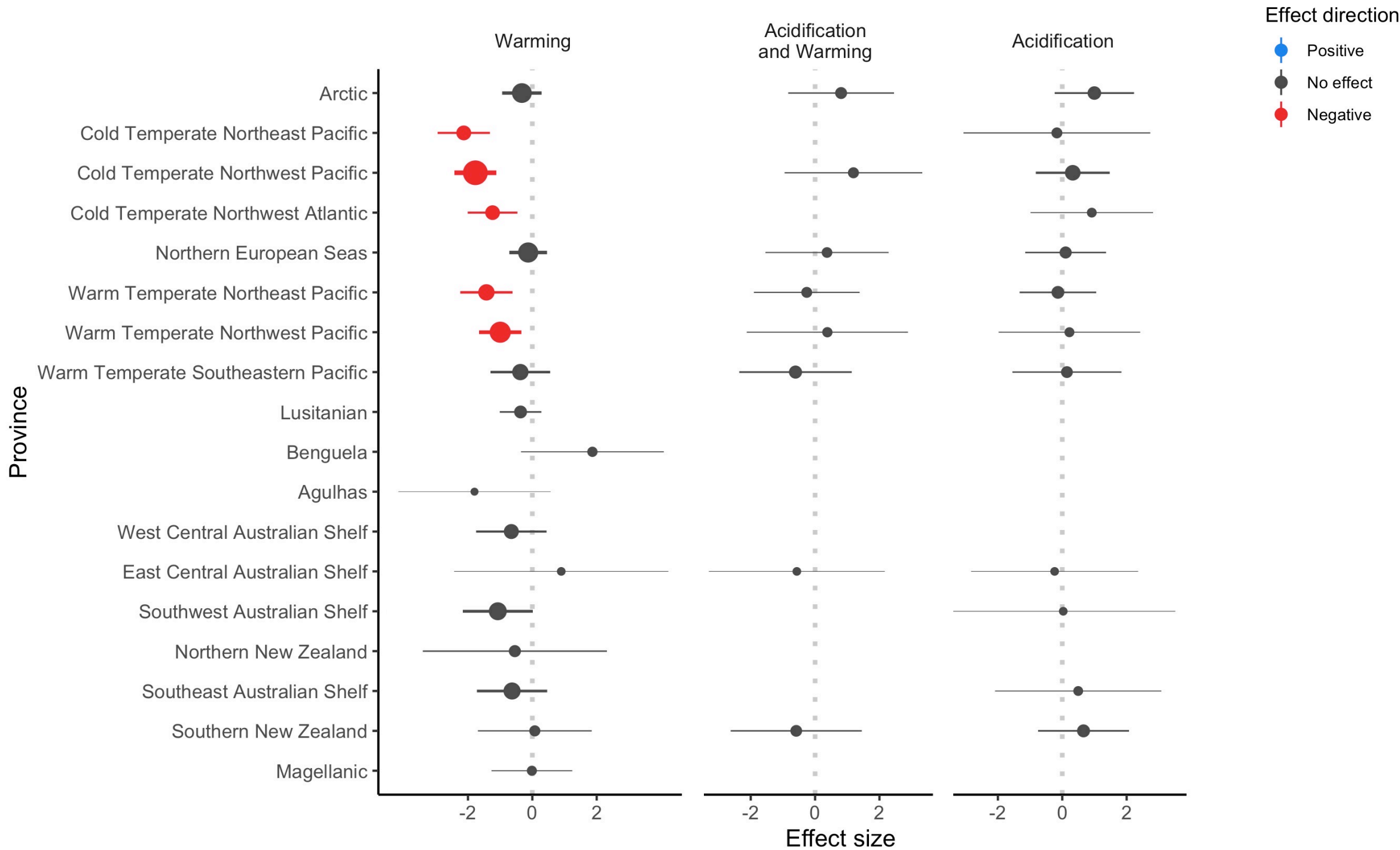


Effect direction

- Positive
- No effect
- Negative

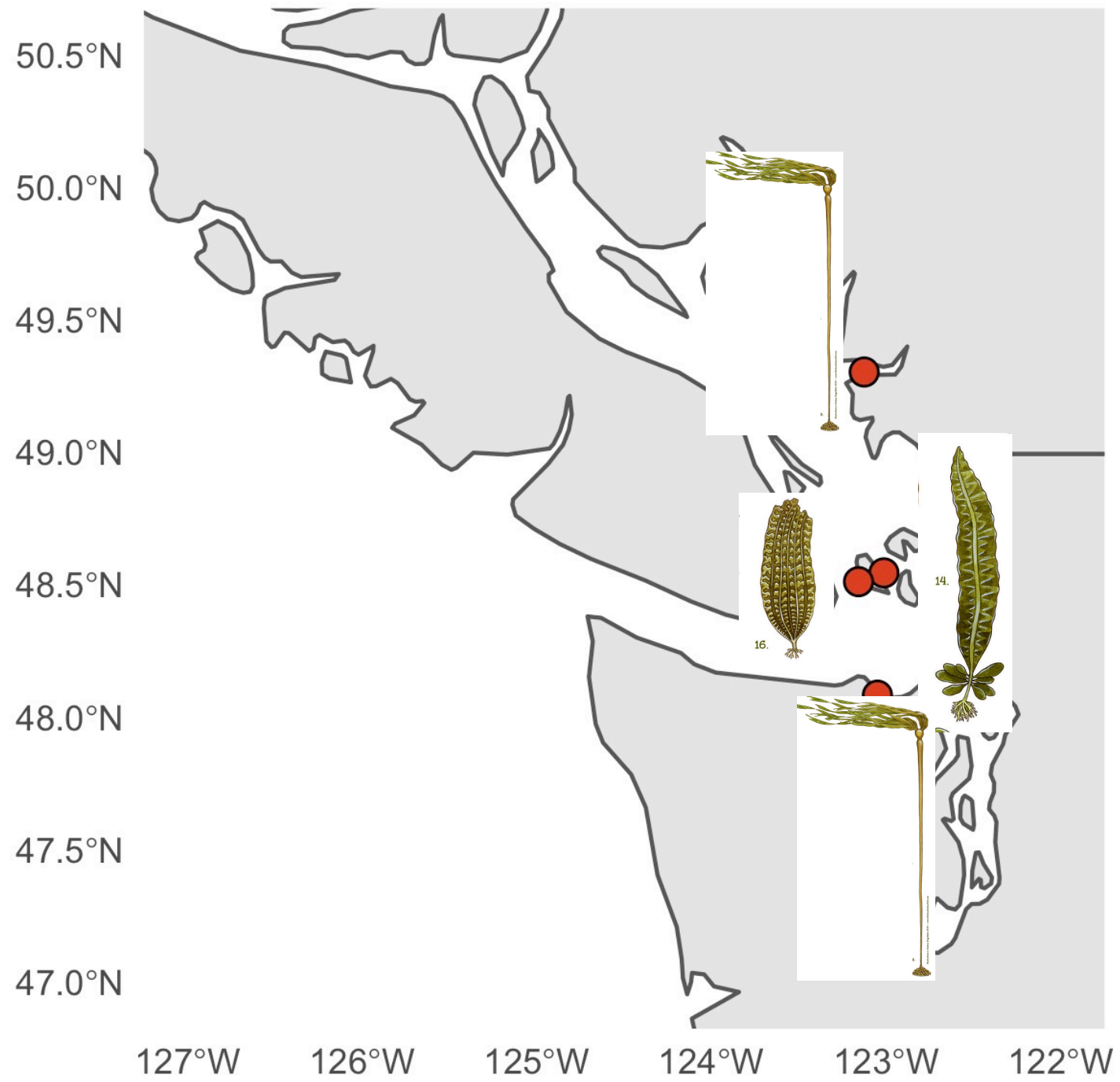




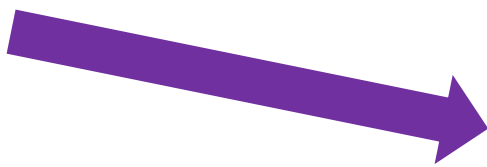




Species

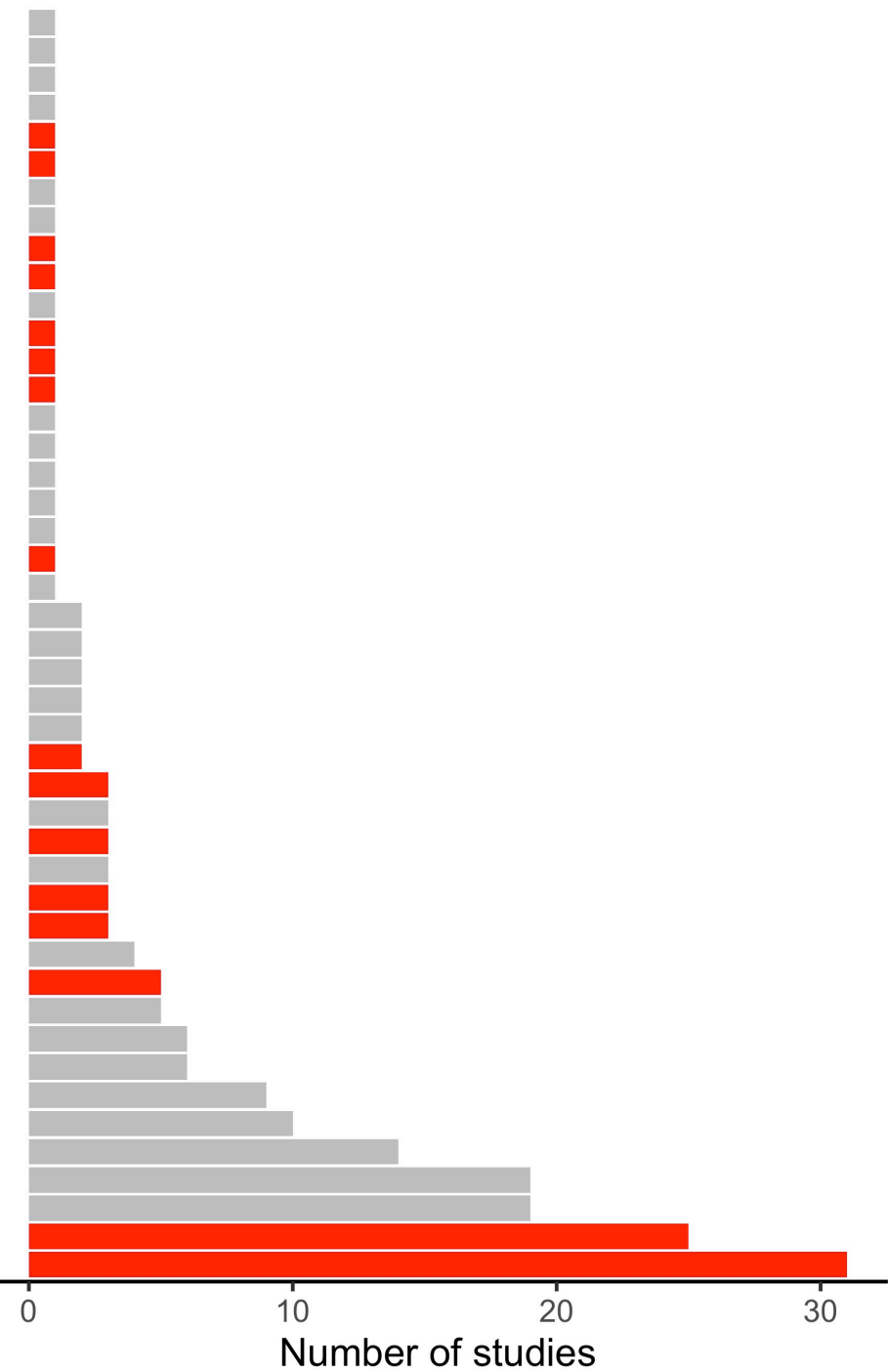


12.

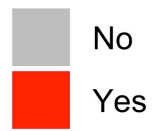


Species

- Saccharina sculpera*
- Saccharina longicuris*
- Saccharina angustissima*
- Saccharina angustata*
- Postelsia palmaeformis*
- Lessoniopsis littoralis*
- Lessonia variegata*
- Lessonia corrugata*
- Laminaria sinclairii*
- Laminaria setchellii*
- Laminaria farlowii*
- Laminaria ephemera*
- Hedophyllum sessile*
- Hedophyllum nigripes*
- Hedophyllum dentigerum*
- Eualaria fistulosa*
- Eisenia bicyclis*
- Ecklonia stolonifera*
- Ecklonia biruncinata*
- Dictyoneurum reticulatum*
- Alaria crassifolia*
- Undaria undarioides*
- Laminaria japonica*
- Ecklonia radicata*
- Ecklonia maxima*
- Ecklonia arborea*
- Agarum clathratum*
- Pterygophora californica*
- Lessonia trabeculata*
- Egrecia menziesii*
- Ecklonia cava*
- Costaria costata*
- Alaria marginata*
- Lessonia nigrescens*
- Nereocystis luetkeana*
- Laminaria solidungula*
- Laminaria ochroleuca*
- Laminaria hyperborea*
- Alaria esculenta*
- Ecklonia radiata*
- Saccharina japonica*
- Undaria pinnatifida*
- Laminaria digitata*
- Macrocystis pyrifera*
- Saccharina latissima*



Present in Washington?



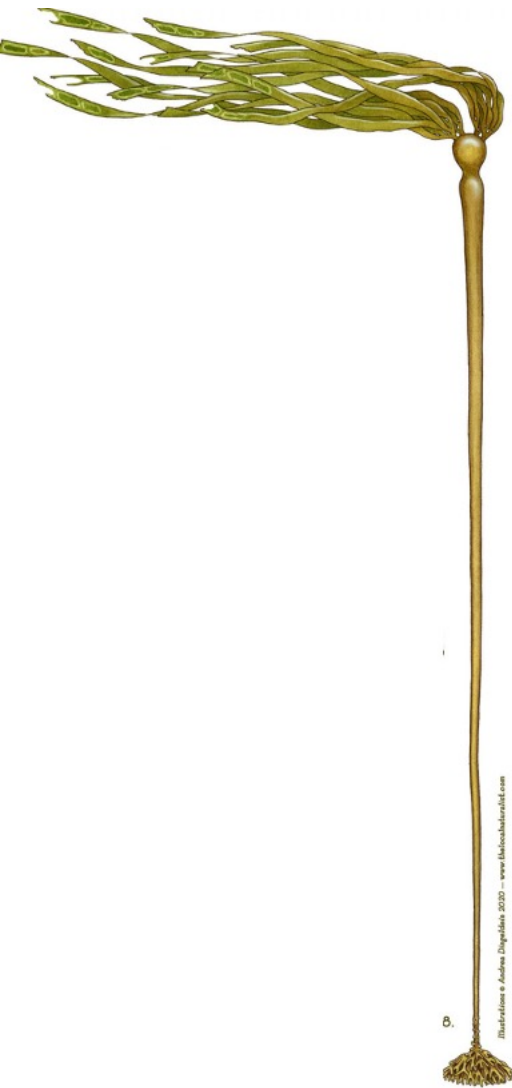
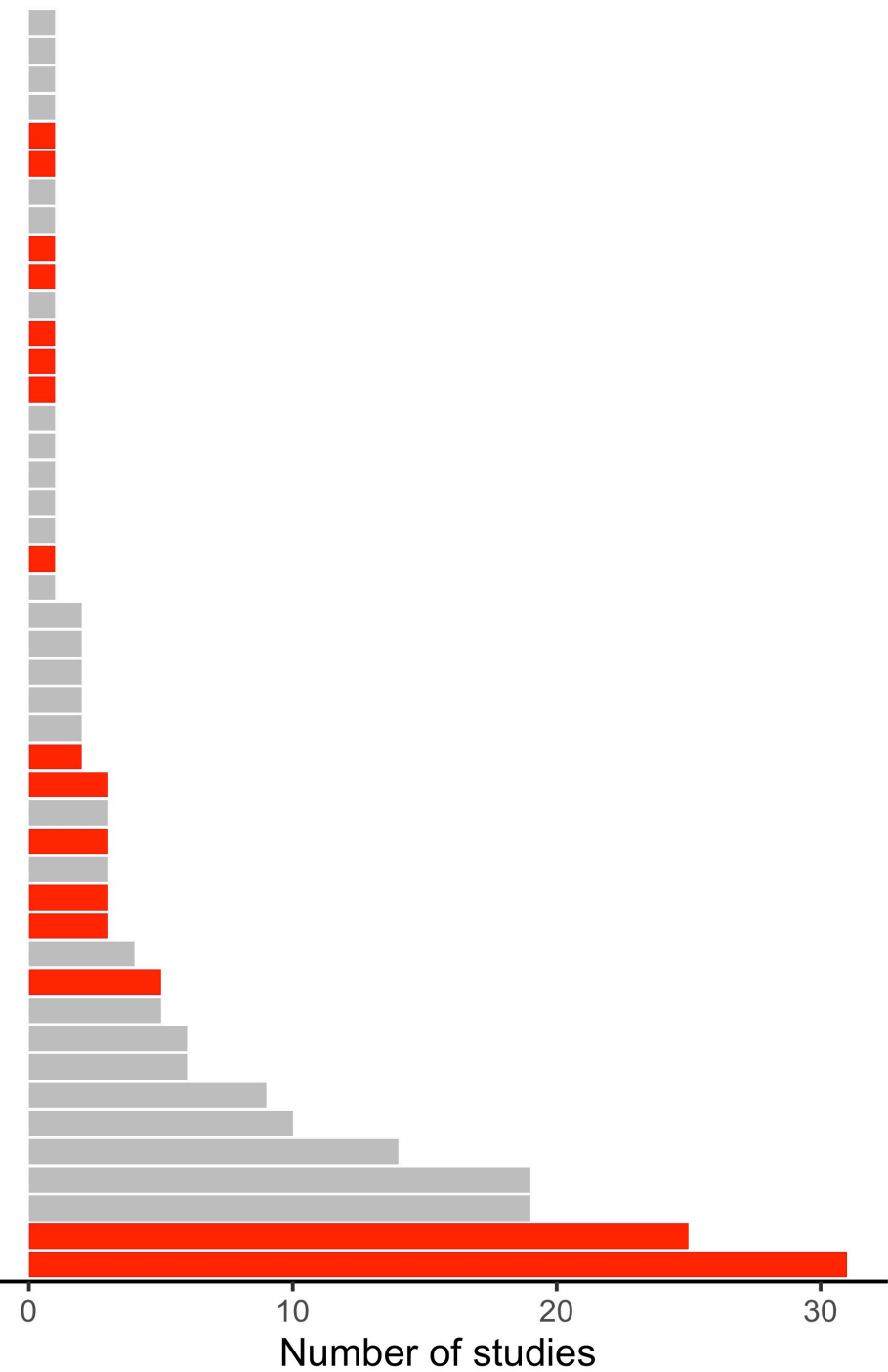


Illustration © Andrea Dagnelie 2020 - www.Macochakra.com



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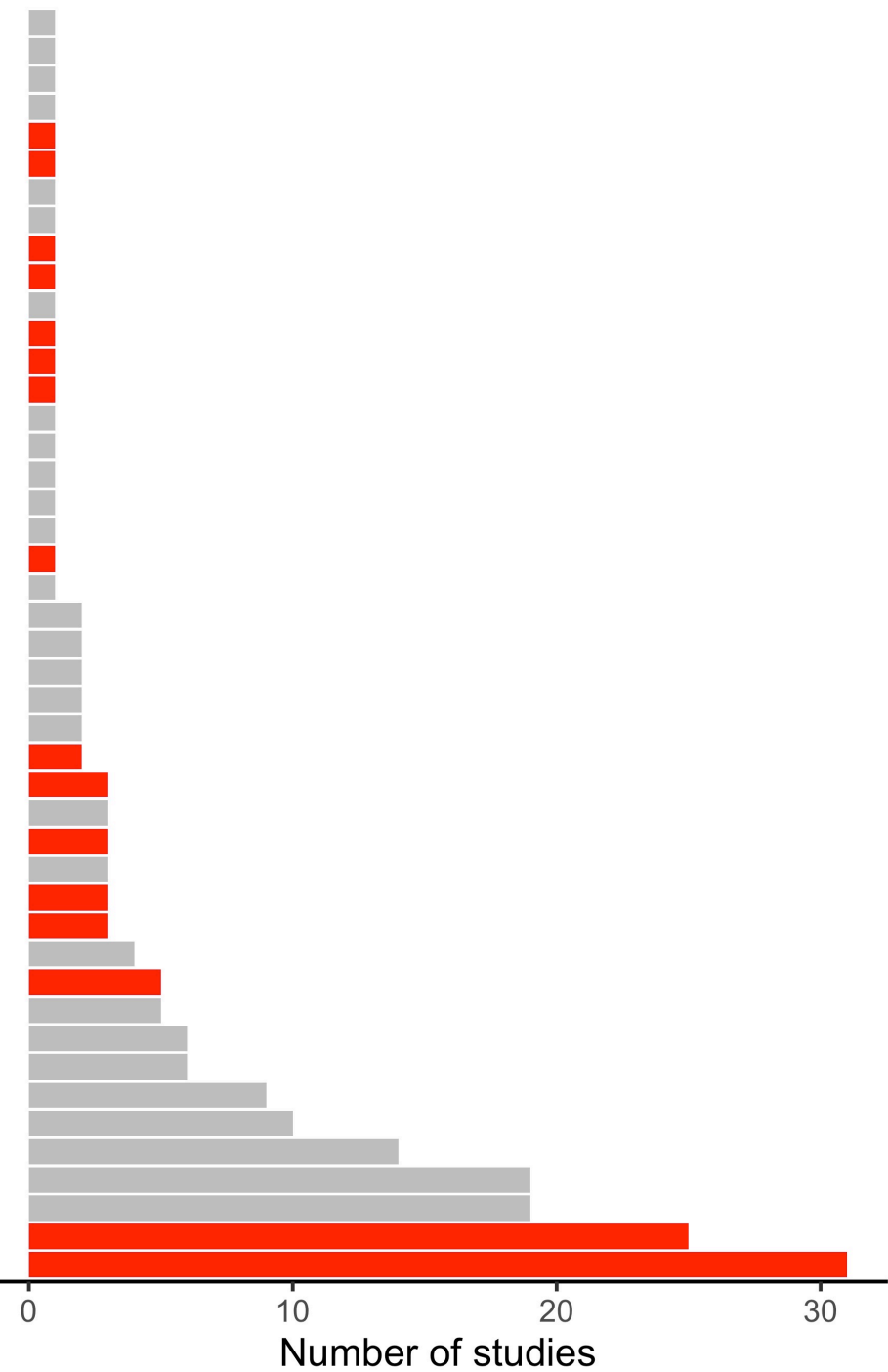
Present in Washington?
 No (Grey)
 Yes (Red)

Number of studies



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- Saccharina sculpera*
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- Saccharina angustata*
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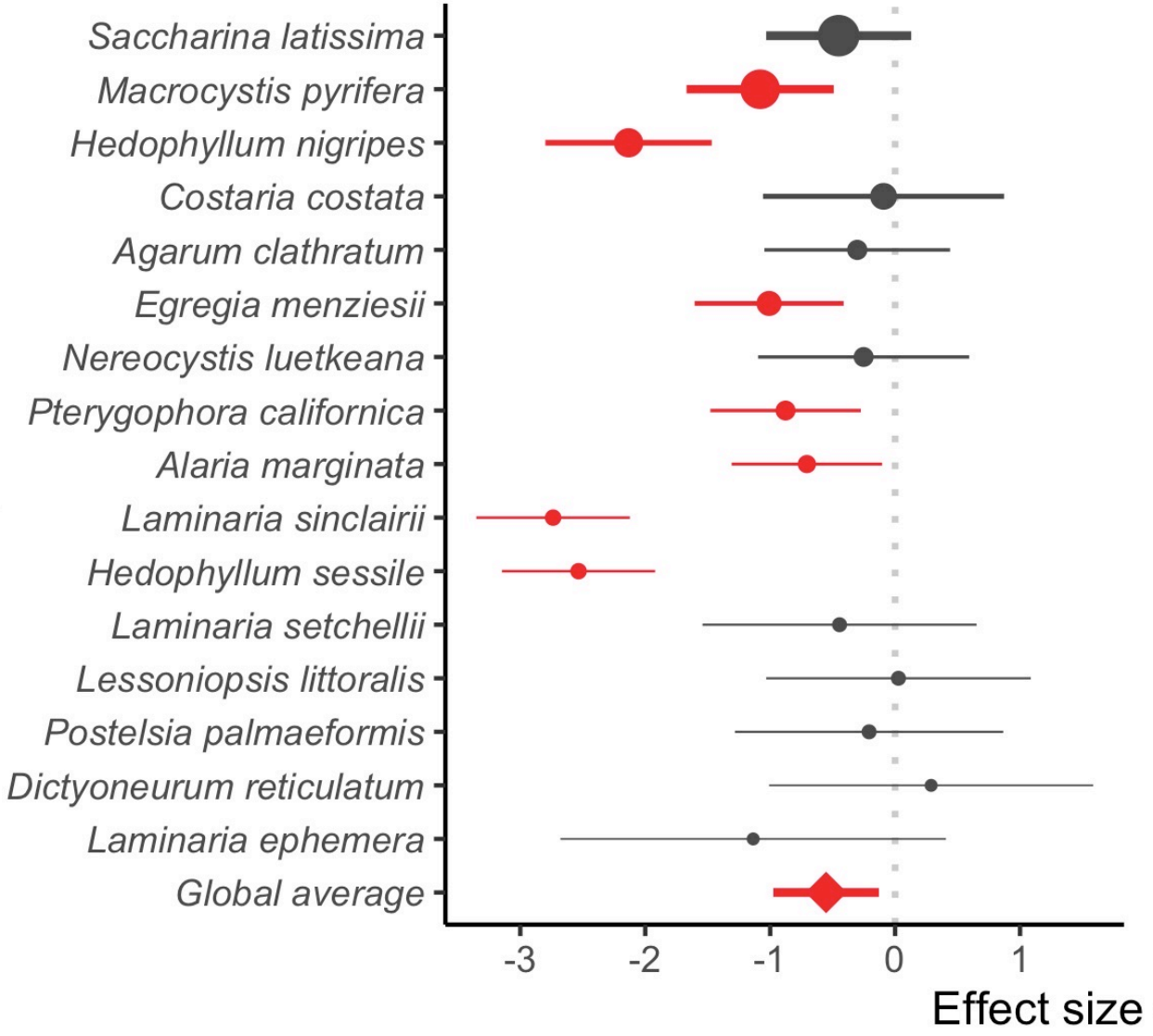
Present in Washington?
 No
 Yes

Effect direction

- Positive
- No effect
- Negative

Warming

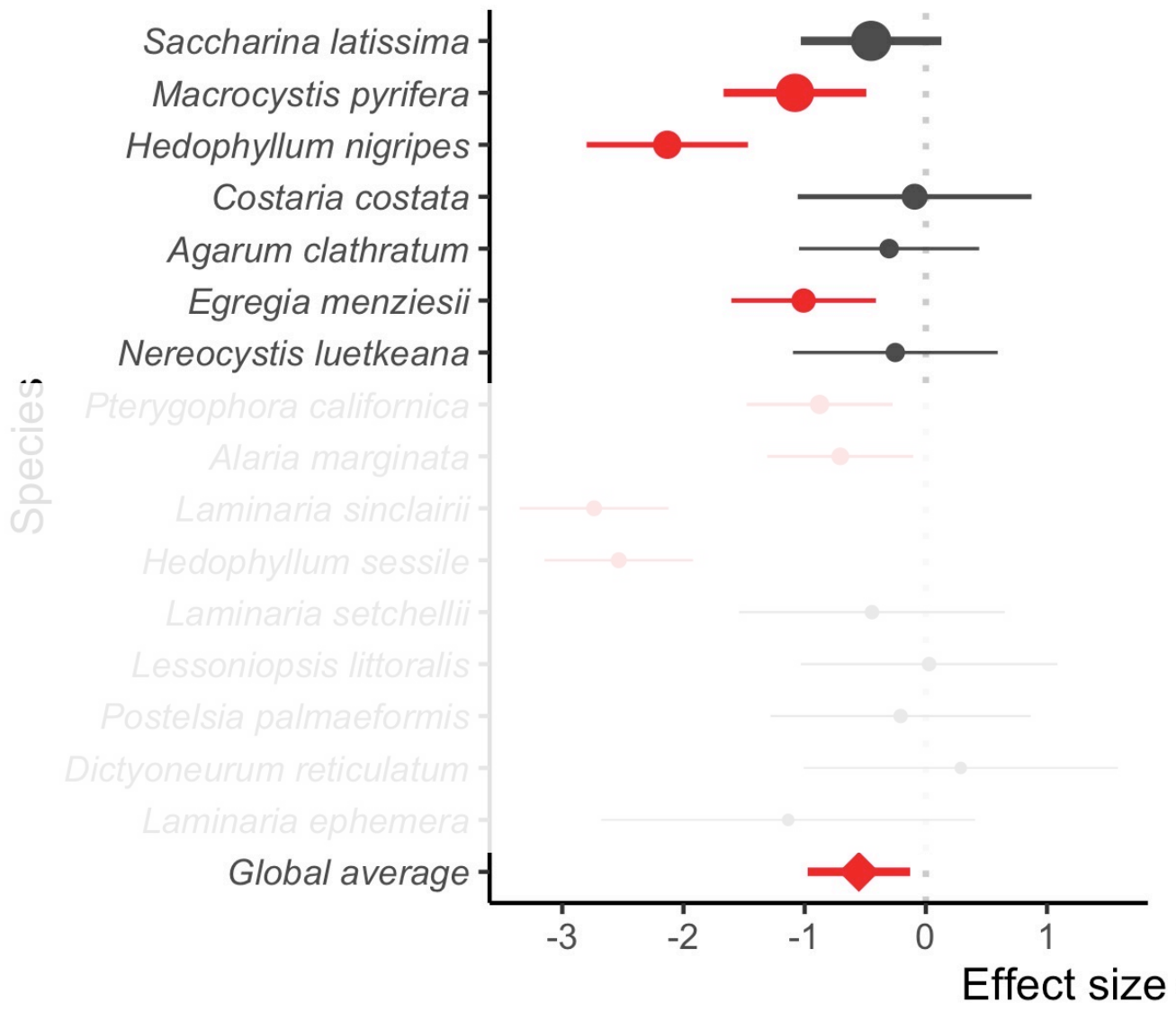
Species



Effect direction

- Positive
- No effect
- Negative

Warming



Effect direction

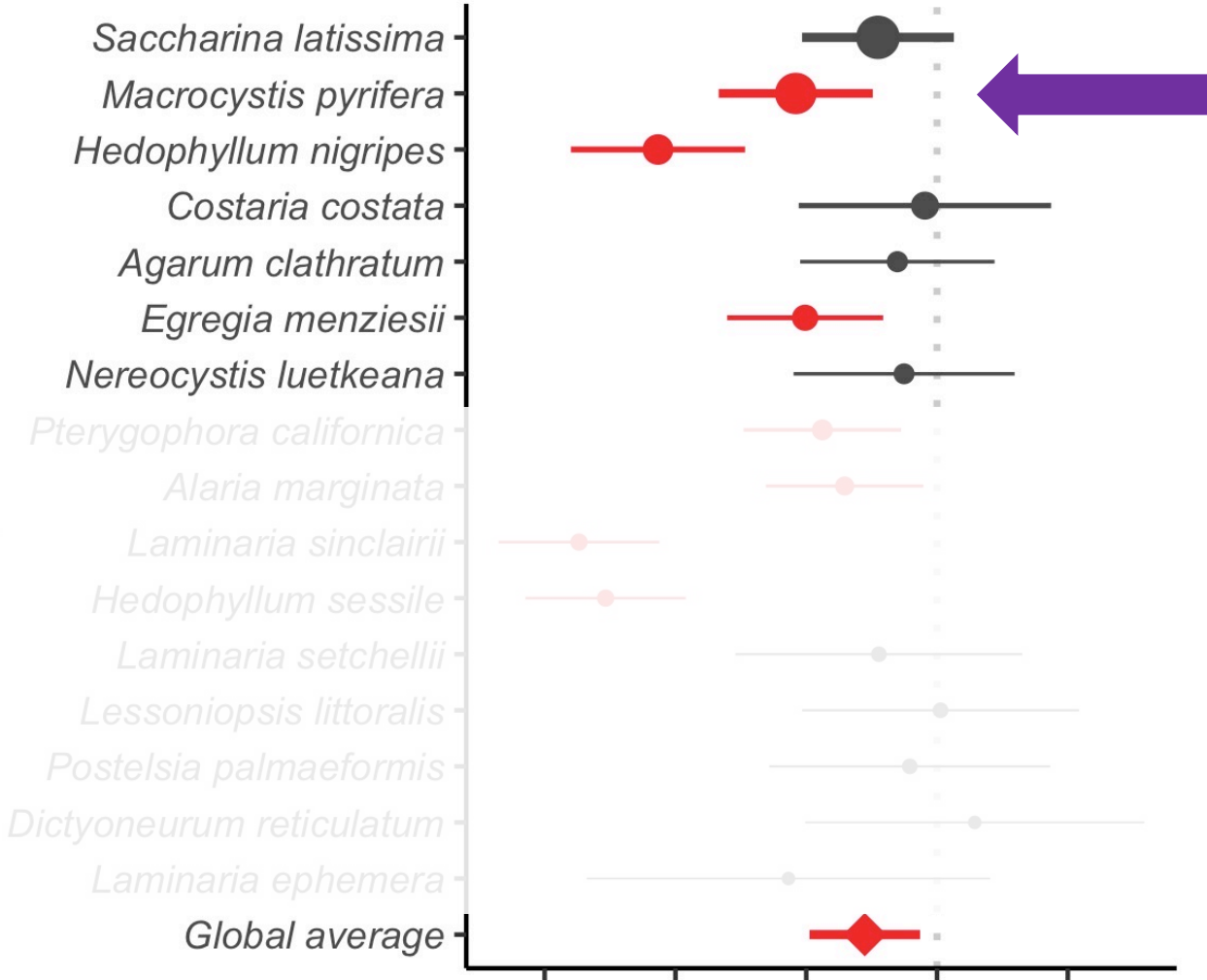
- Positive
- No effect
- Negative

Warming



Effect size

Species

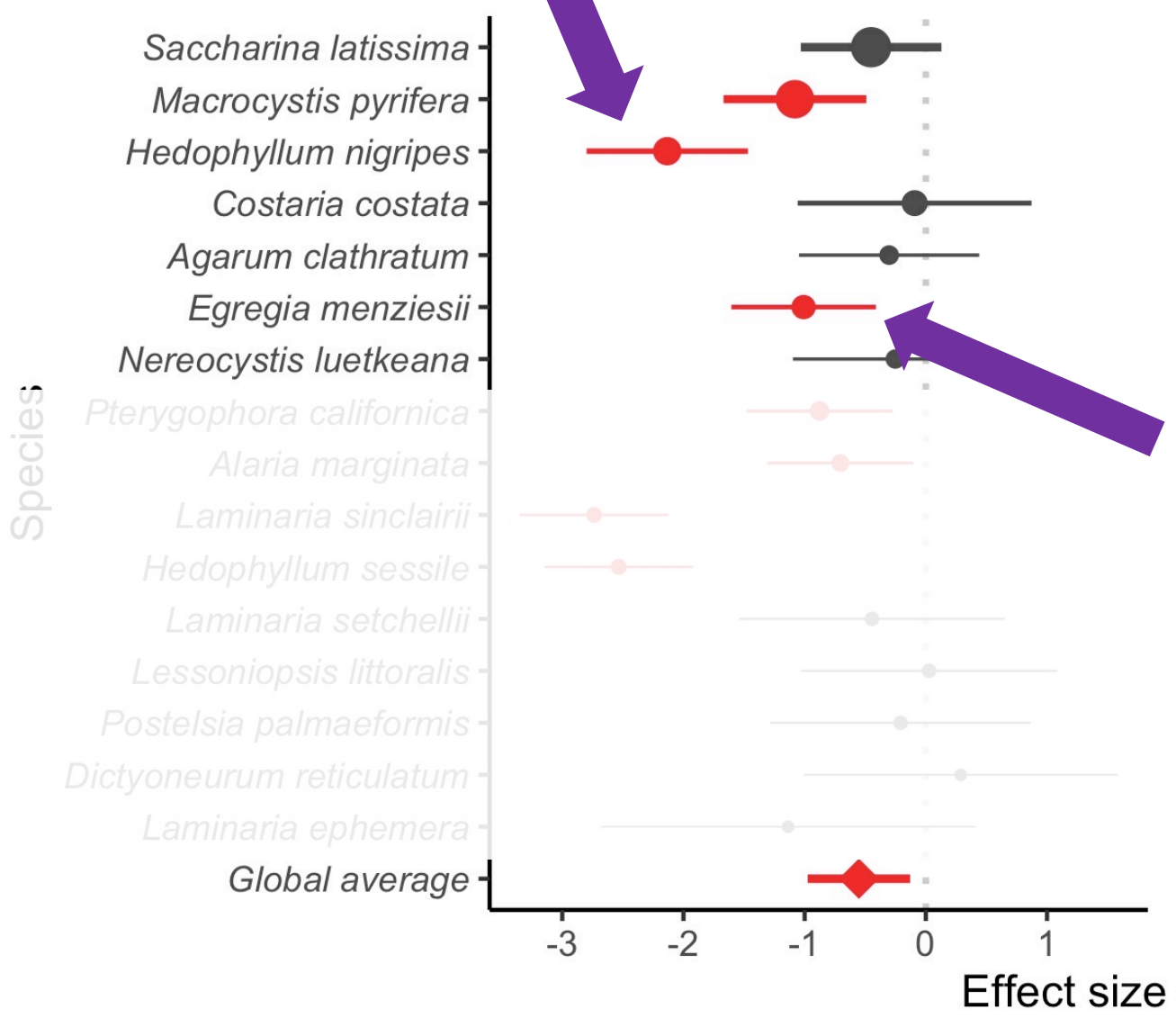


Effect direction

- Positive
- No effect
- Negative



Warming

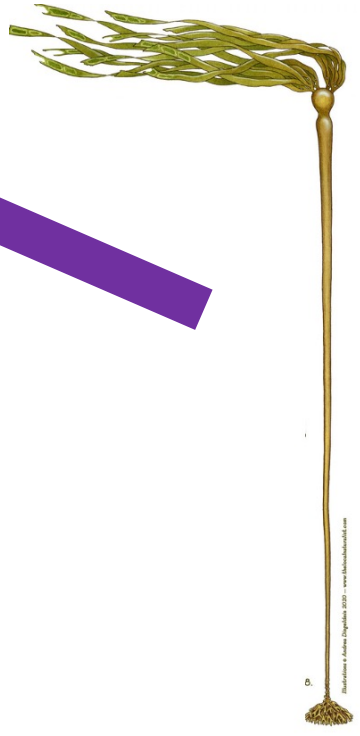


Effect direction

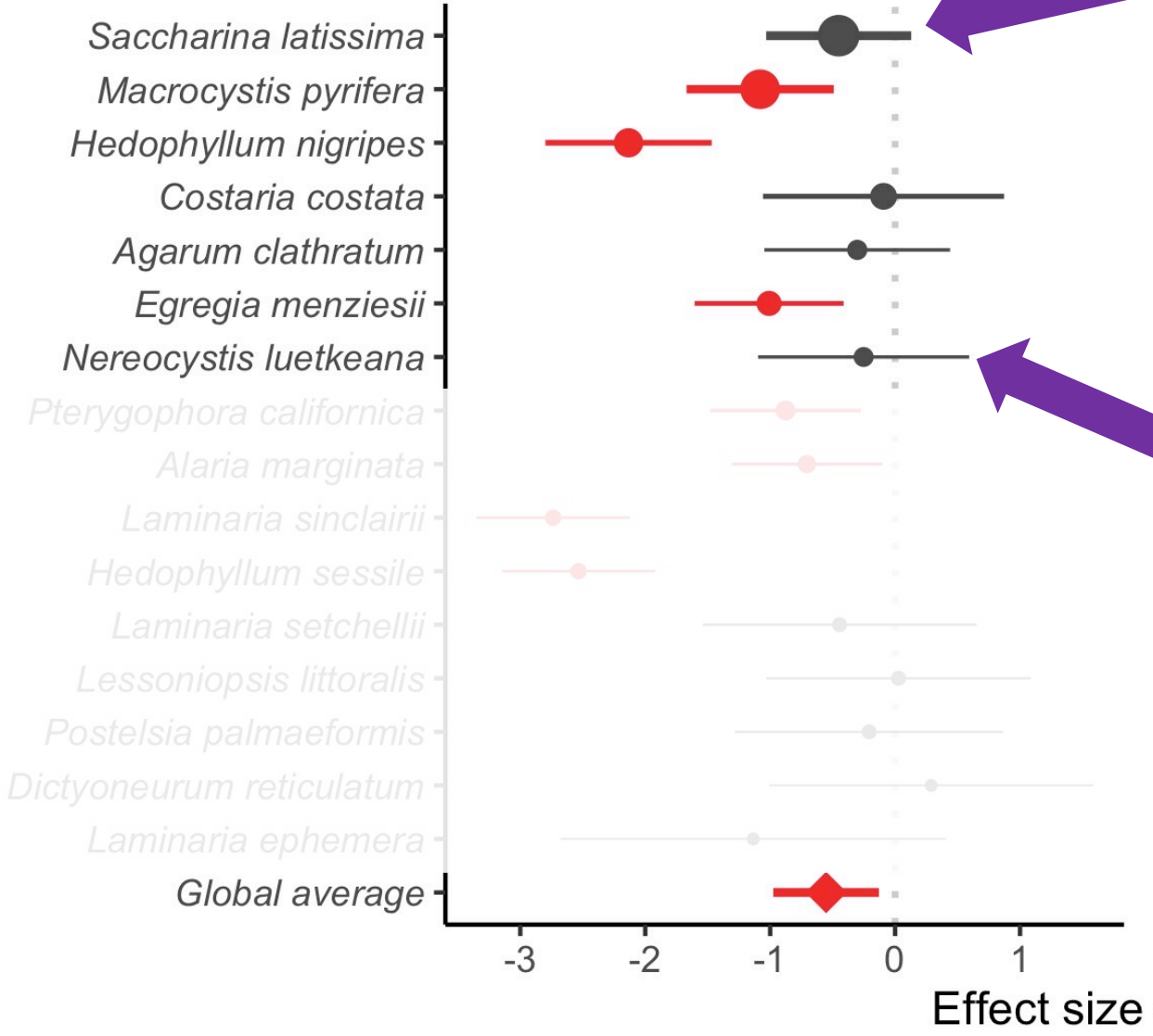
- Positive
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- Negative

Warming

12.



Species



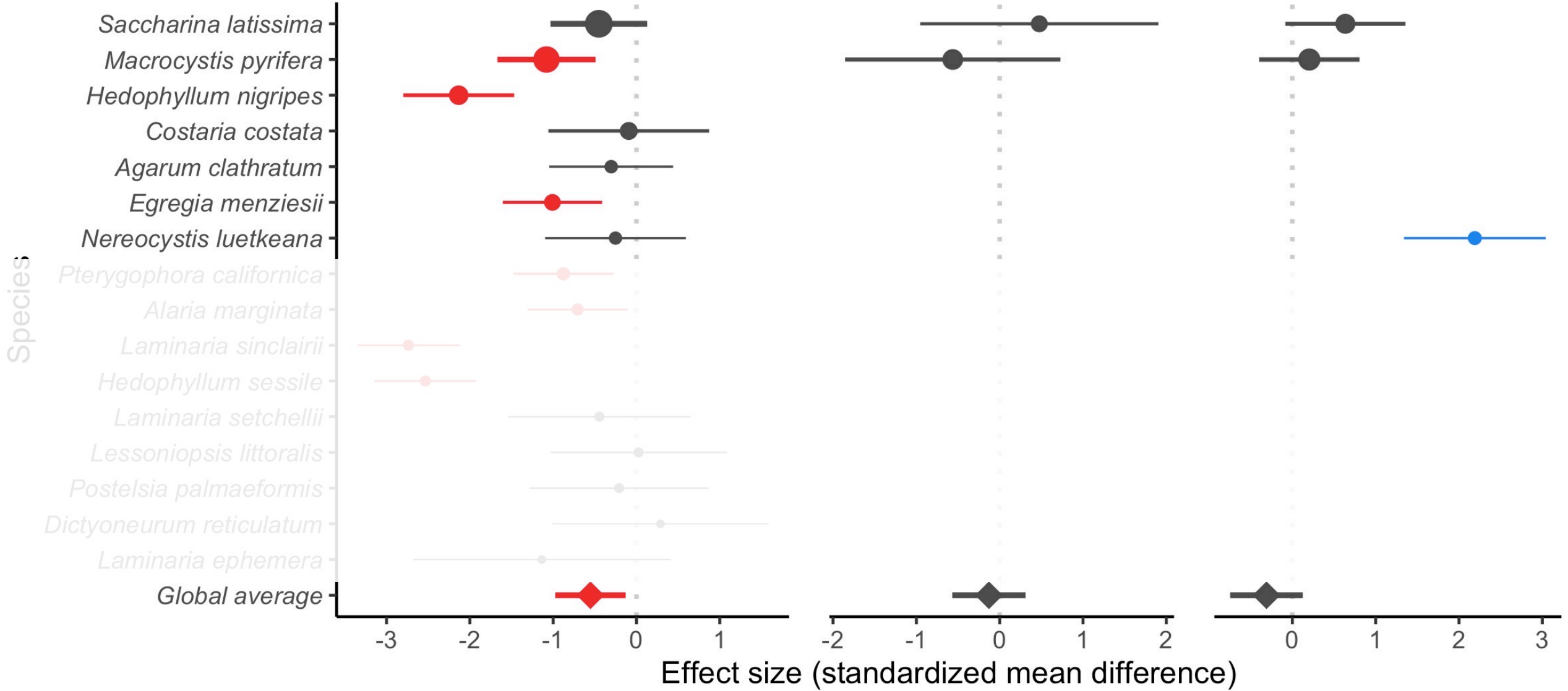
Effect direction

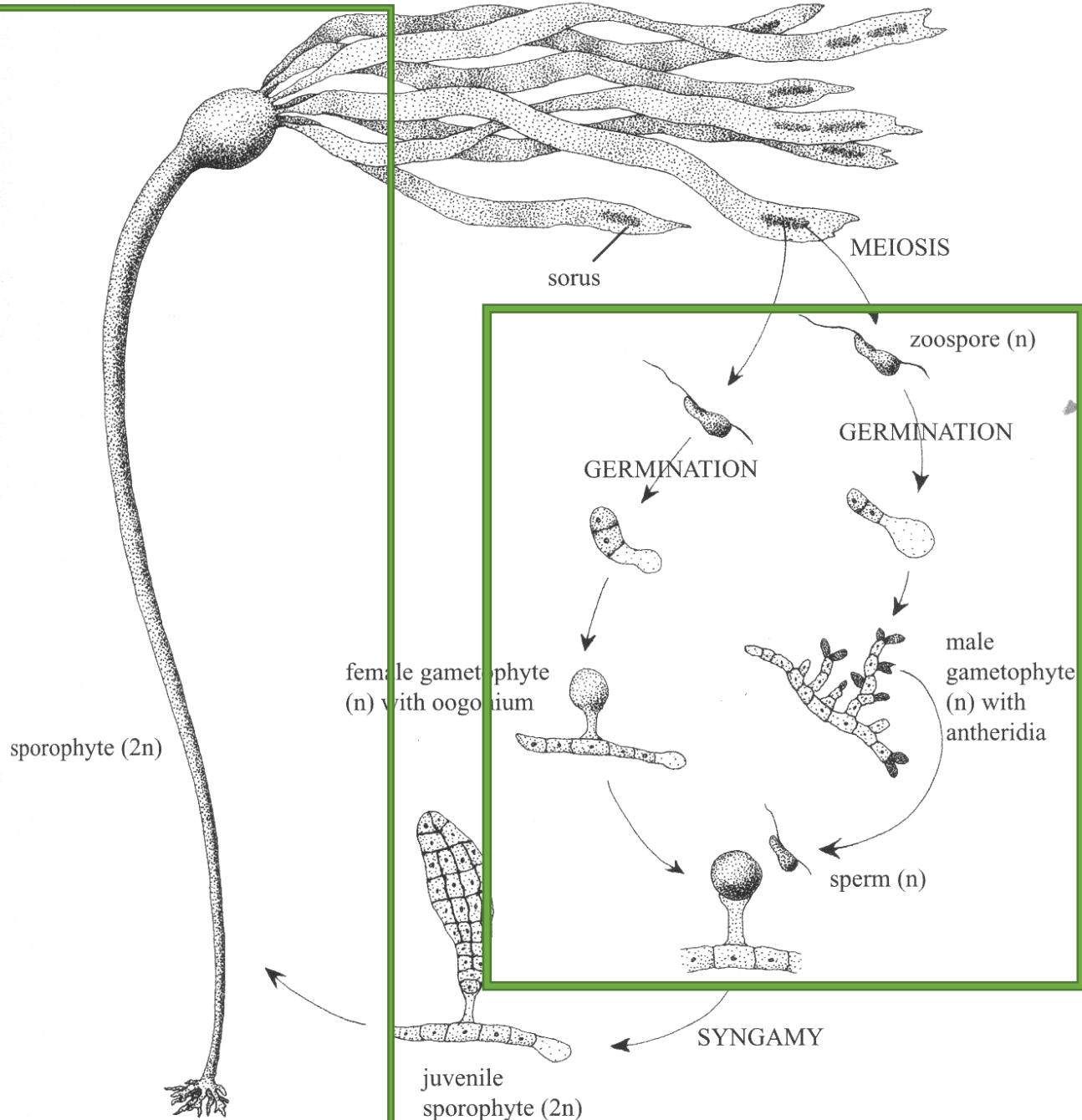
- Positive
- No effect
- Negative

Warming

Acidification
and Warming

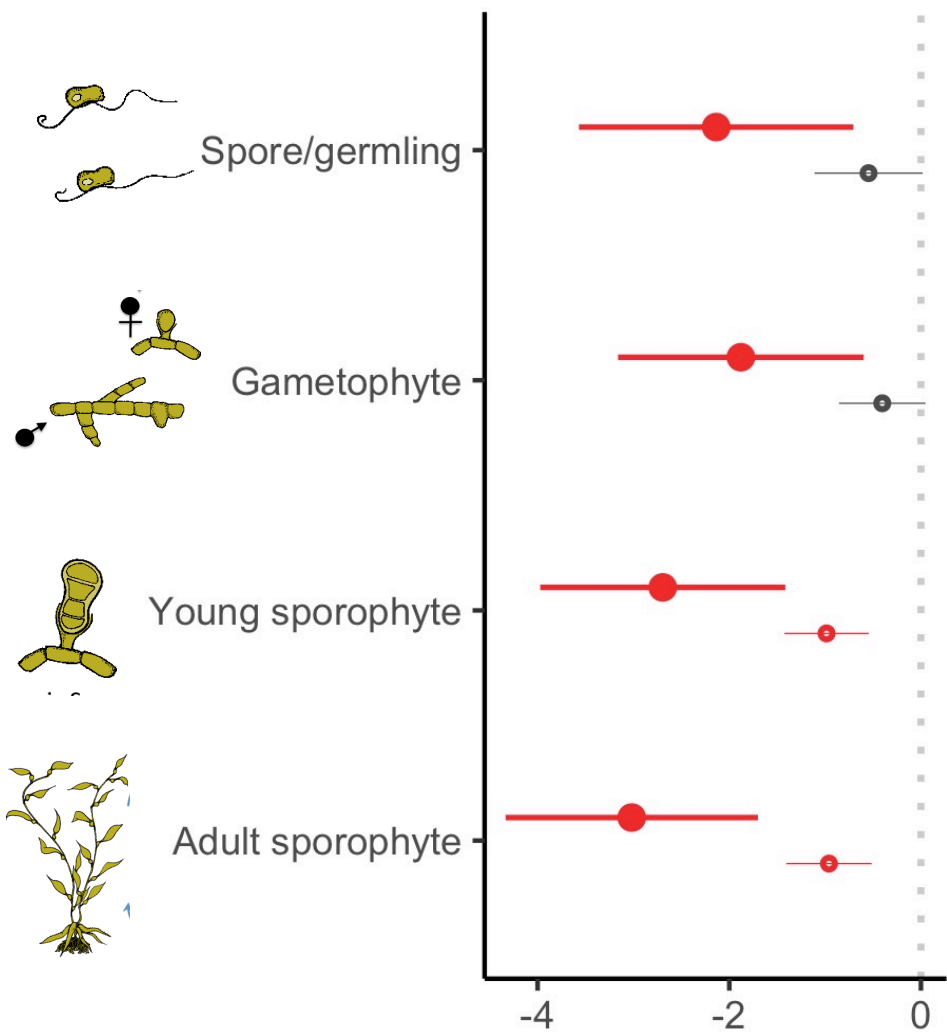
Acidification





Life stages

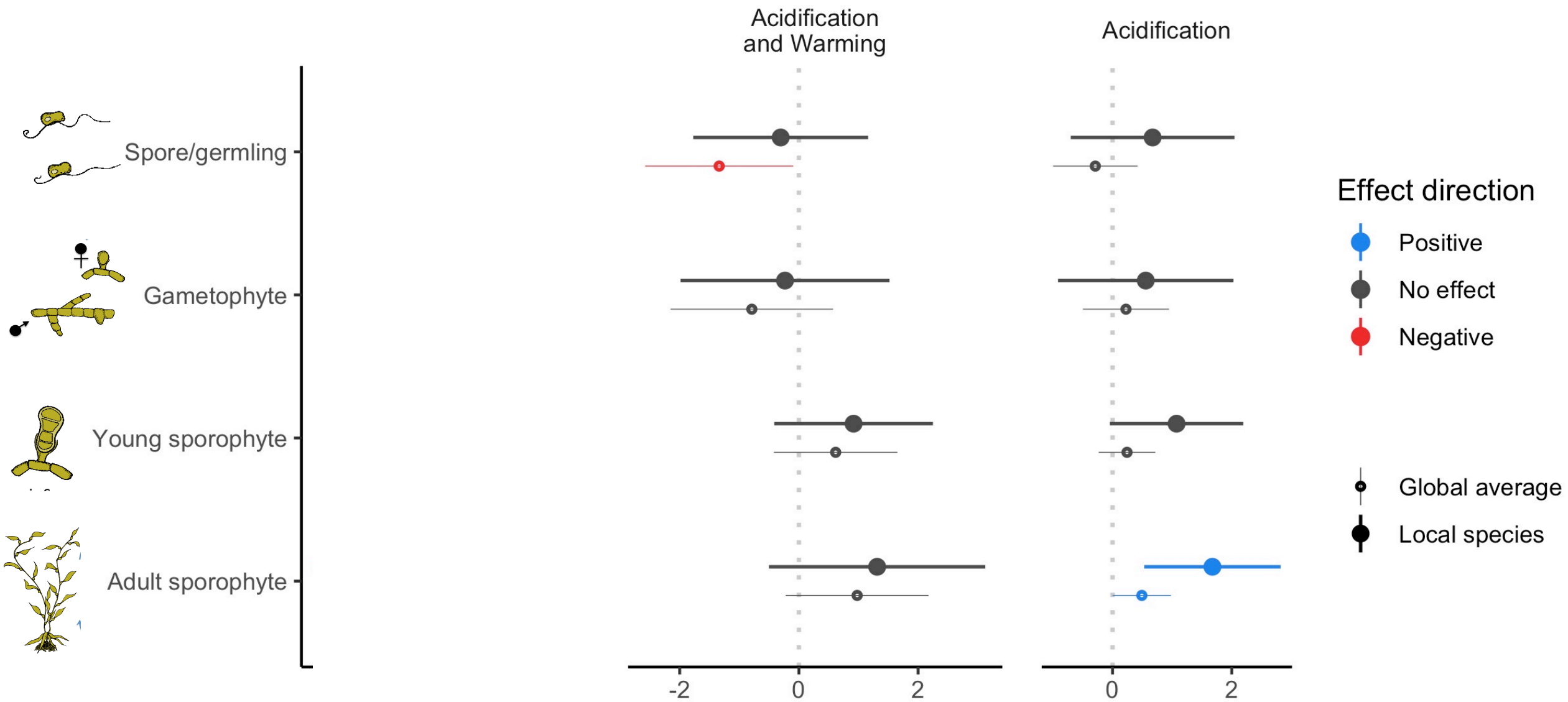
Warming

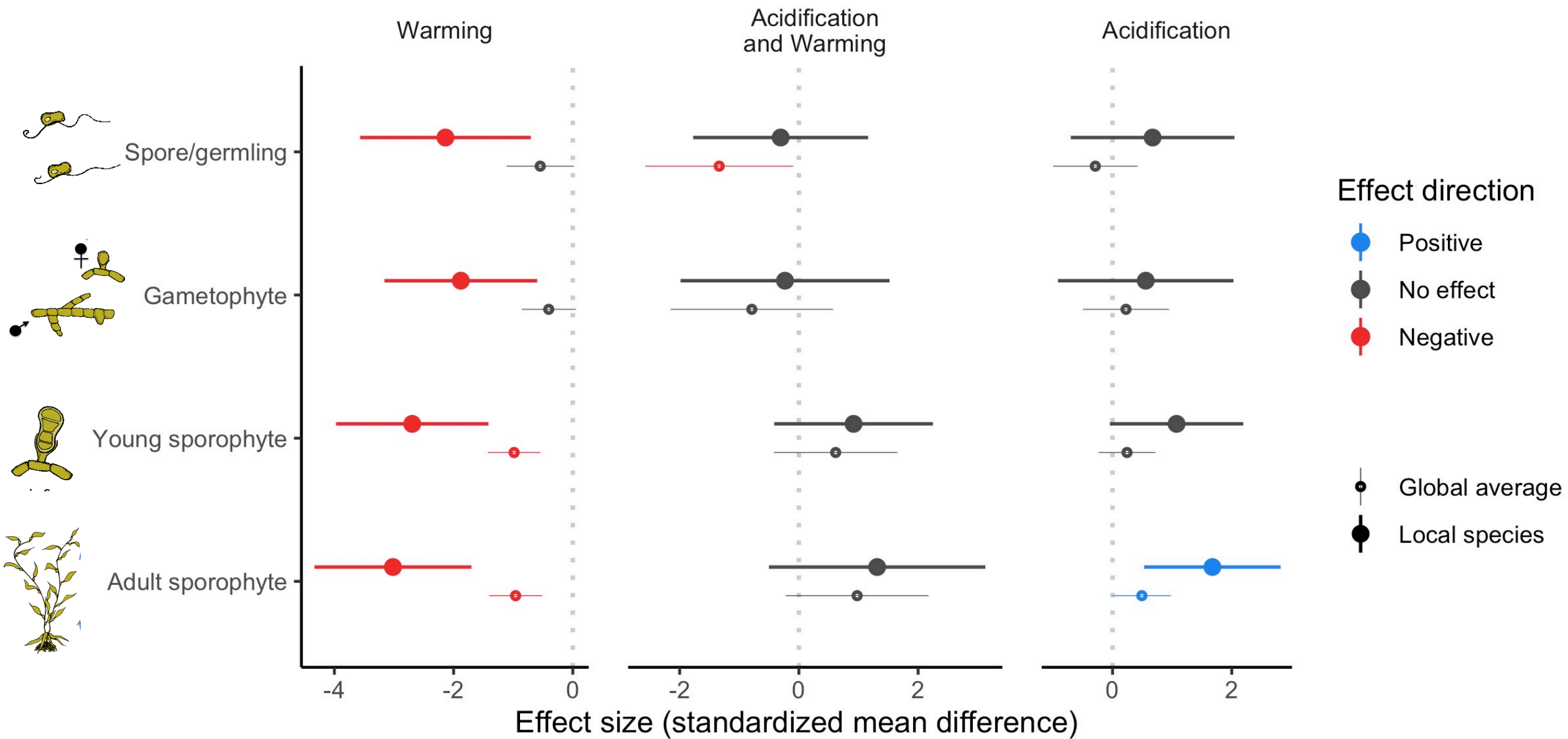


Effect direction

- Positive
- No effect
- Negative

- Global average
- Local species

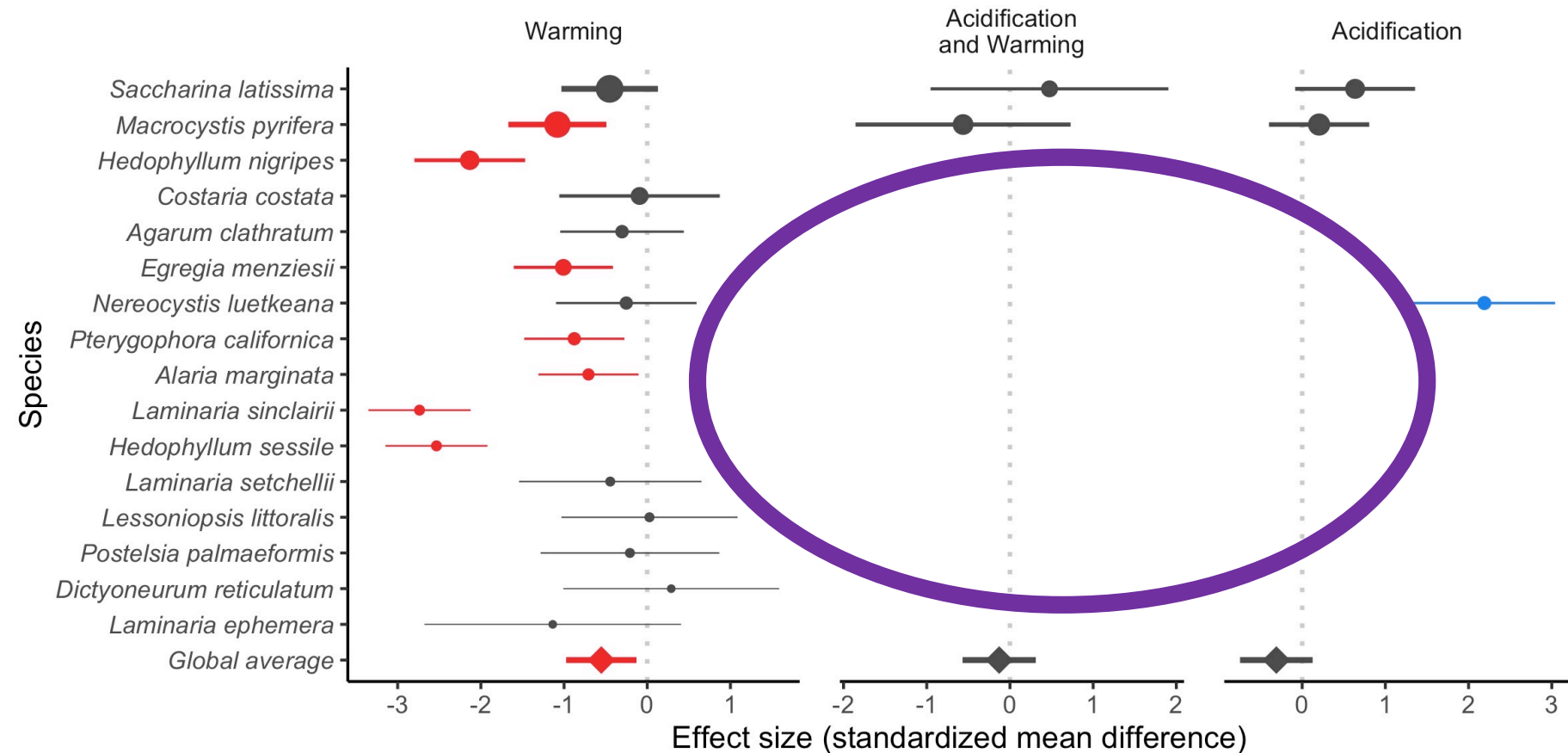






Big takeaways

- Effect of multiple stressors largely unknown



Big takeaways

- Effect of multiple stressors largely unknown
- Salish Sea kelps could be in trouble



Big takeaways

- Effect of multiple stressors largely unknown
- Salish Sea kelps could be in trouble
- Knowledge gap in understory kelps



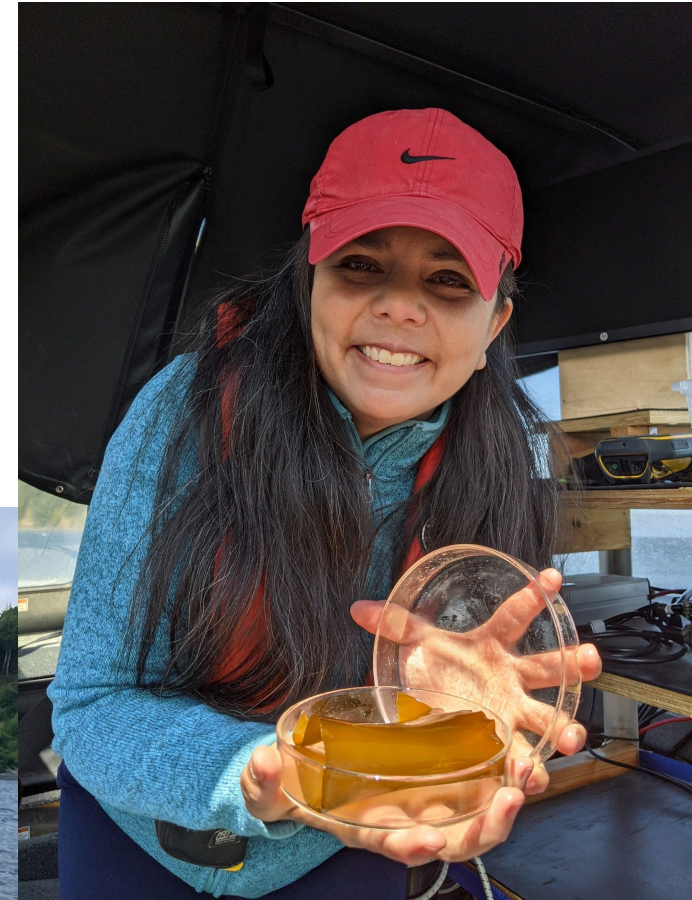


Image credit Dr. Padilla-Gamiño

Thank you!

Dr. Cinde Donoghue

**Washington
Department of
Natural Resources**

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