



# Resilience of intertidal habitats under multiple stressors: insights from a global meta-analysis

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## Introduction

Intertidal ecosystems are dynamic and ecologically primary systems, yet their resilience to multiple interacting stressors remains understudied<sup>1,2,3</sup>. This study presents a global meta-analysis of peer-reviewed research to identify and compare the main drivers of intertidal community resilience evaluating their relative importance for resistance, recovery and reorganization.

## Materials and methods

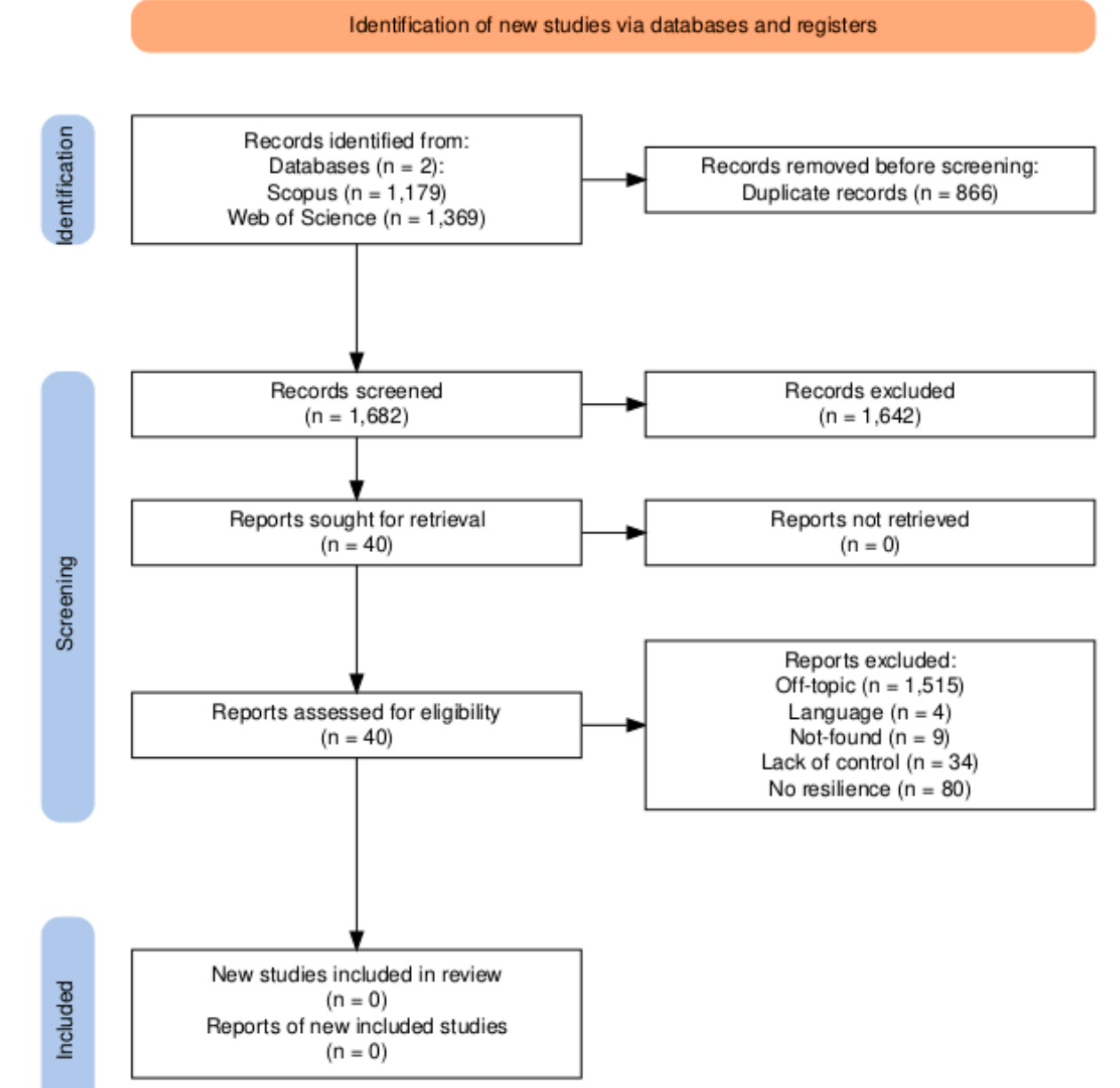
### Main research question

How do the effects of single versus multiple stressors on intertidal community resilience vary across different phylogenetic groups and geographic regions?

### Search string

(intertidal OR tidal) AND (resilience OR resistance OR recovery OR compensation\* OR buffer\*) AND (anthropogenic OR climat\* OR warming OR "global warming" OR "climate change").

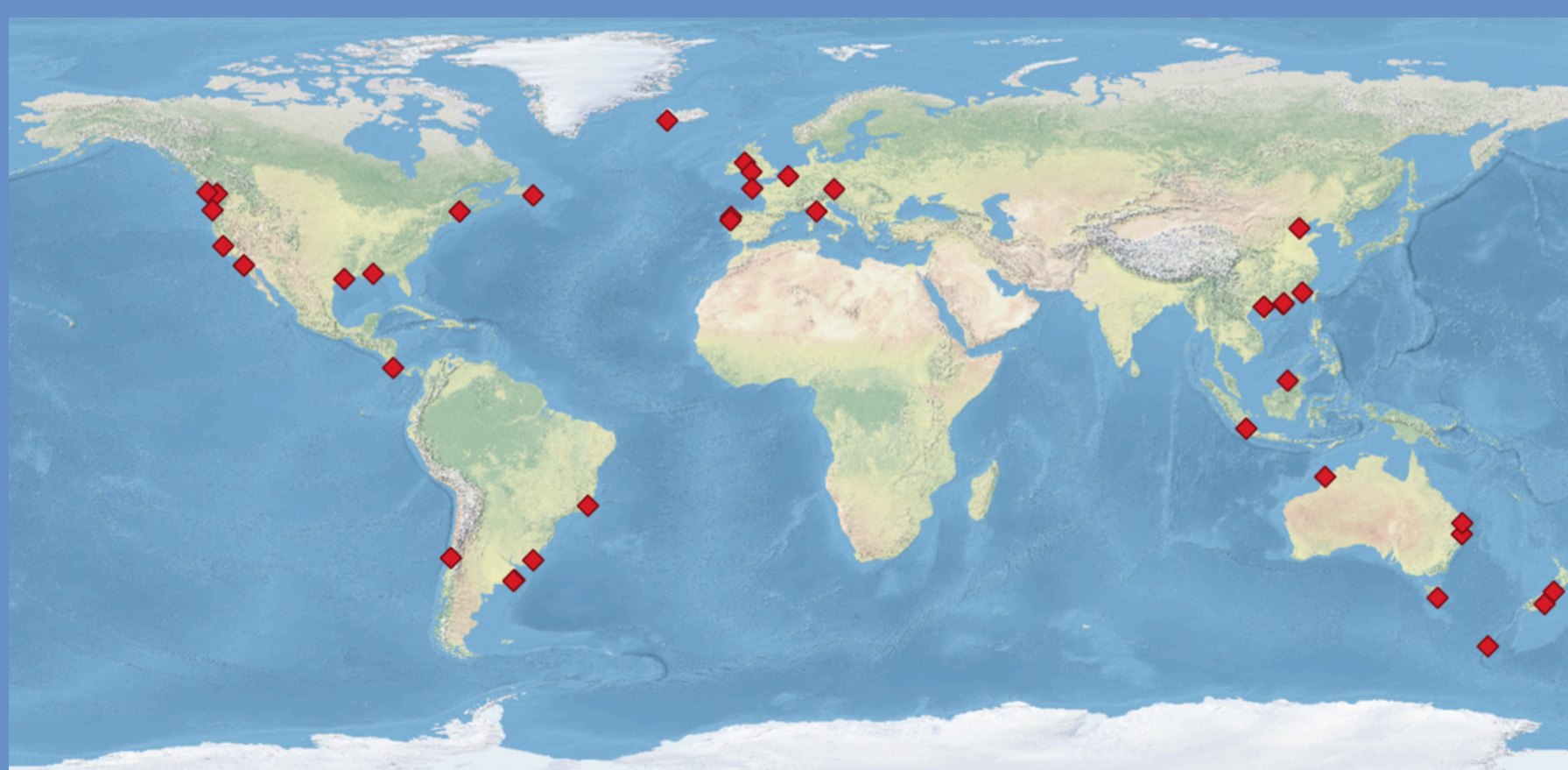
### PRISMA flow diagram



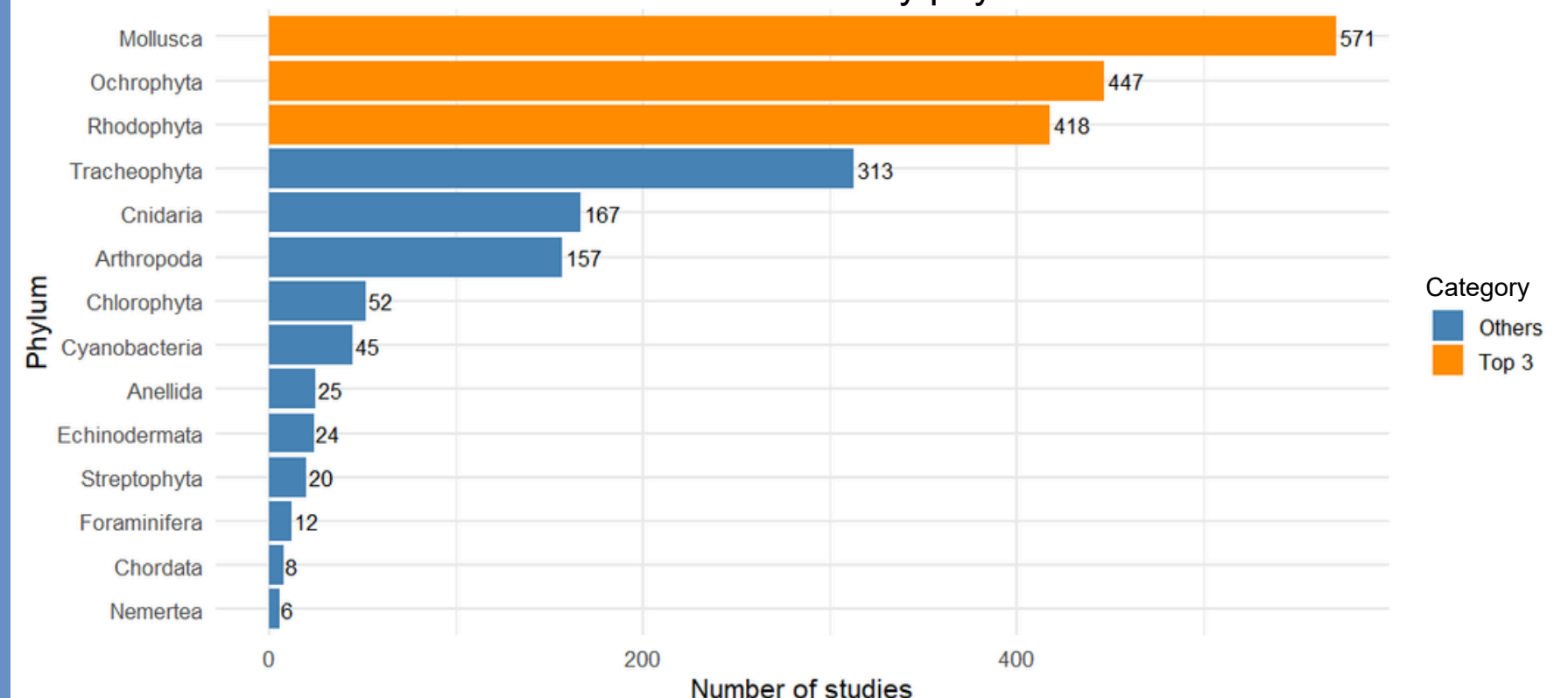
This study examines global patterns in marine intertidal environments. Four study design were considered: outdoor experiments, field experiments, surveys and laboratory experiments. Ecological responses were evaluated starting from the individual to the population and the community levels. Stressors were also considered in terms of number (single or multiple), nature (biotic or abiotic) and duration.

## Preliminary results

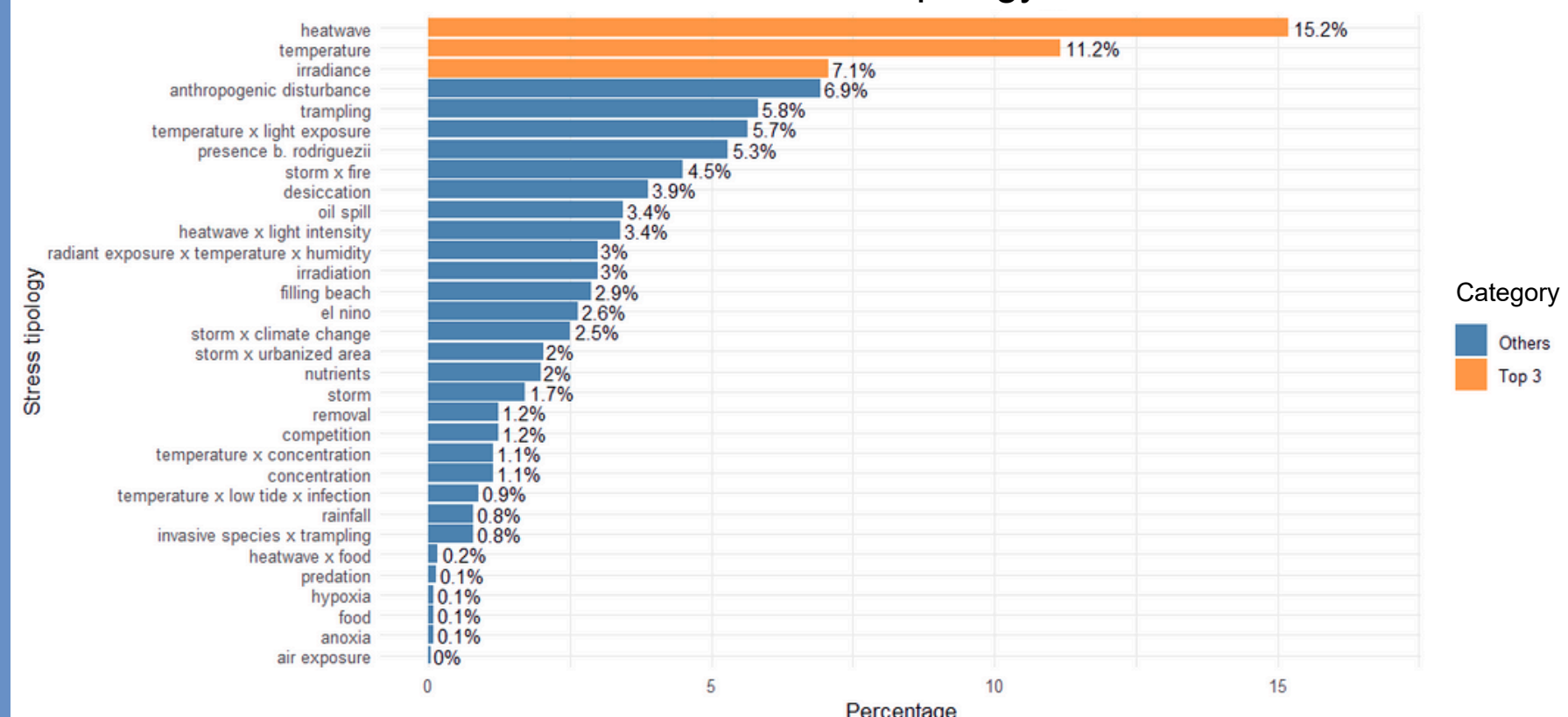
### Geographical distribution of resilience studies



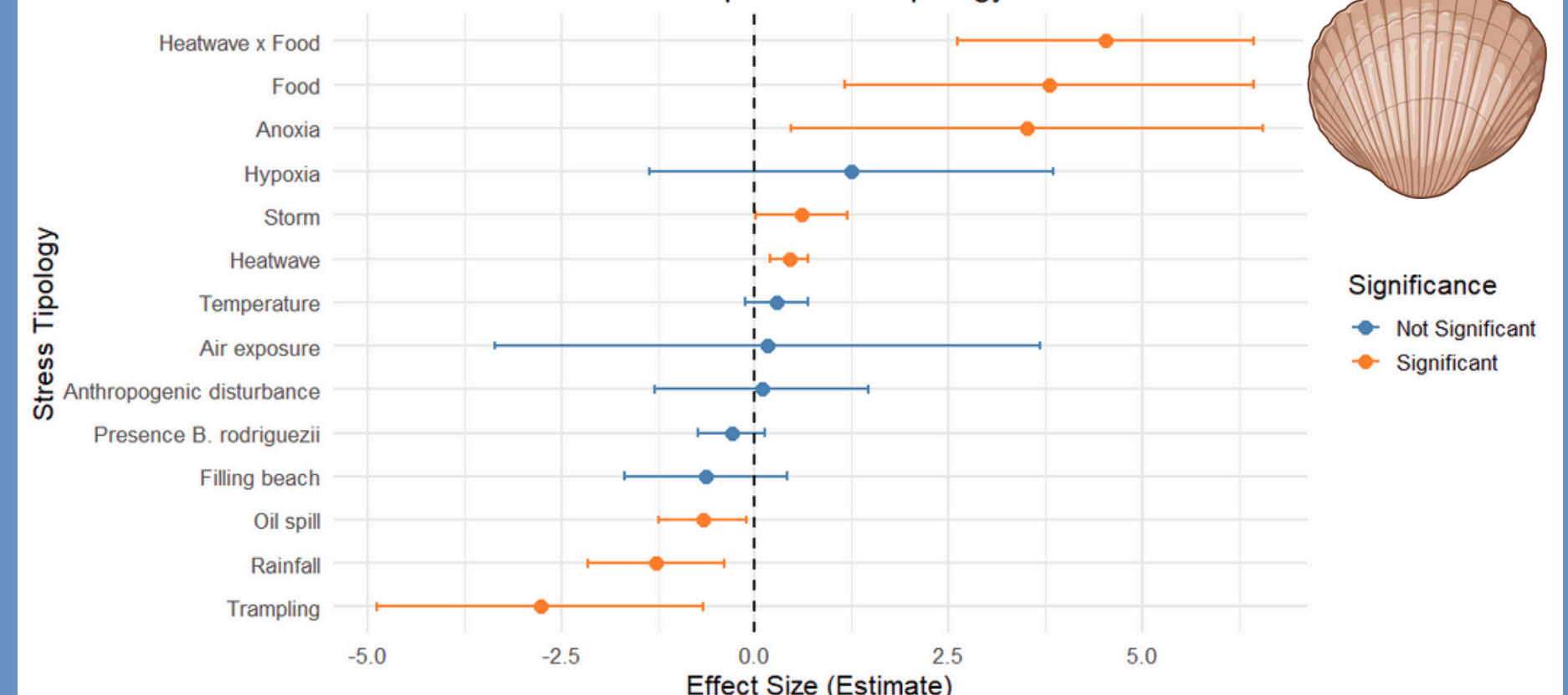
### Distribution of studies by phylum



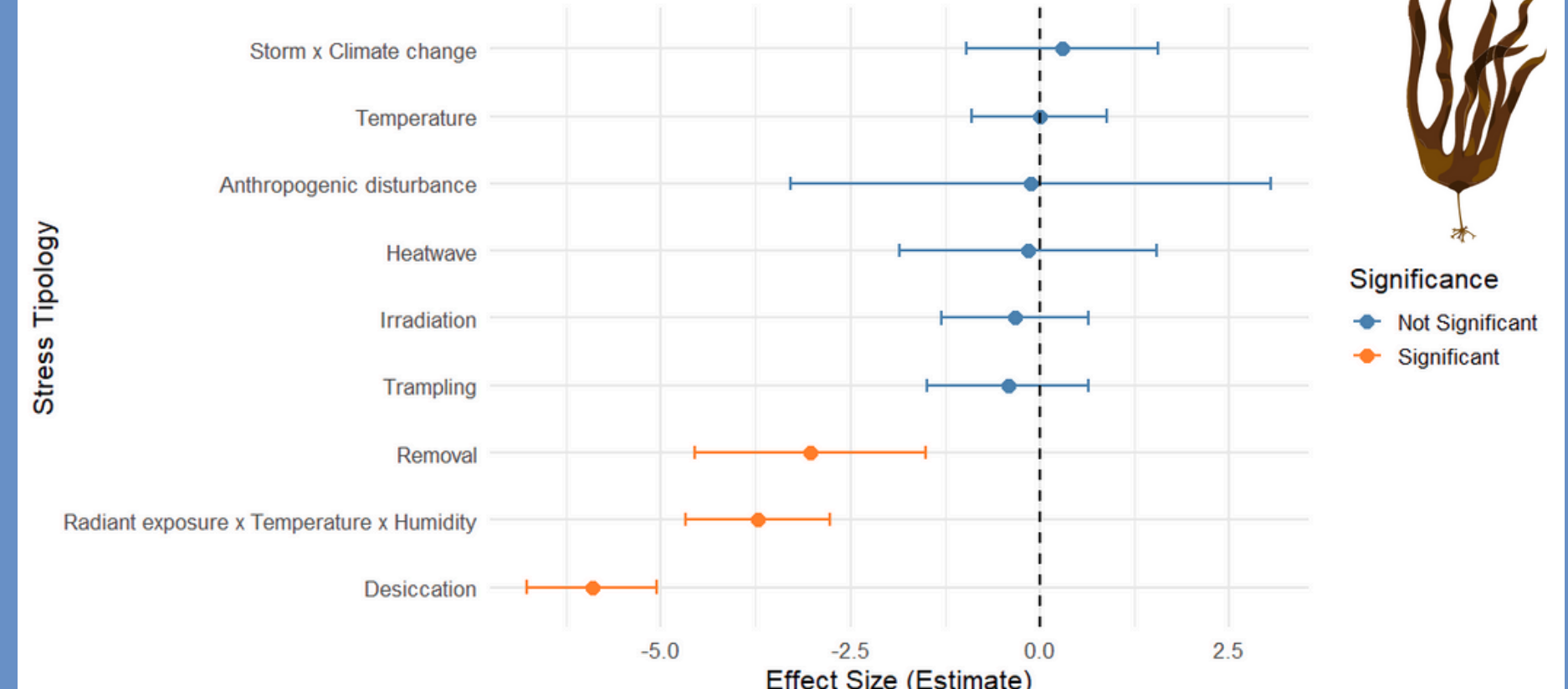
### Distribution of stressor typology



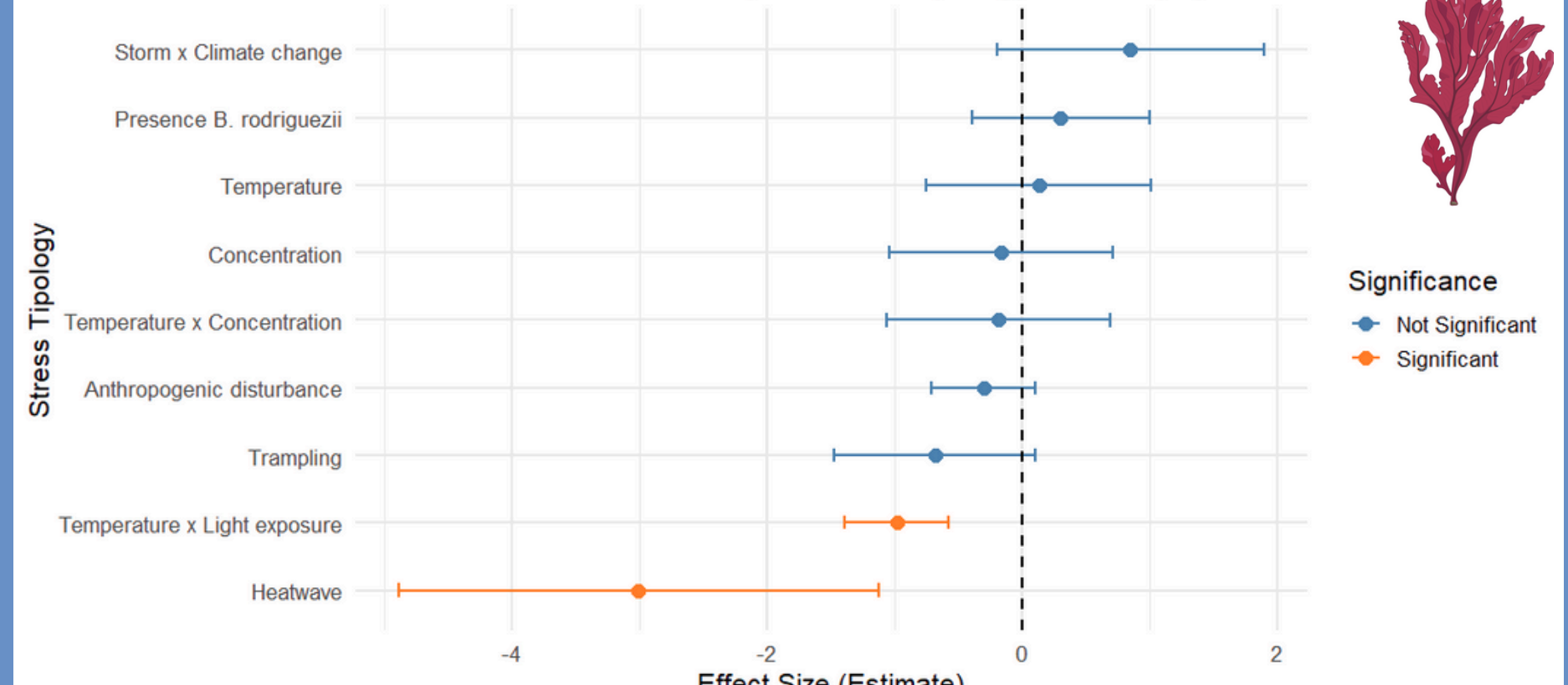
### Forest Plot of Effect Sizes per Stress Typology - Mollusca



### Forest Plot of Effect Sizes per Stress Typology - Ochrophyta



### Forest Plot of Effect Sizes per Stress Typology - Rhodophyta

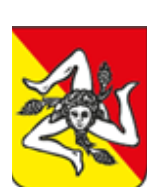


## Emerging patterns

- ⚡ Significant effects vary across phyla, with multiple stressors showing stronger impacts than single stressors.
- 🌱 Responses are heterogeneous among groups, indicating that resilience is phylum or species-specific and strongly dependent on the type of stressor.
- ⚙️ Once confirmed, these patterns could inform targeted management approaches that account for species-specific resilience mechanisms.

## References

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- Crain, C. M., Kroeker, K., & Halpern, B. S. (2008). Interactive and cumulative effects of multiple human stressors in marine systems. *Ecology Letters*, 11(12), 1304–1315. <https://doi.org/10.1111/j.1461-0248.2008.01253.x>



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