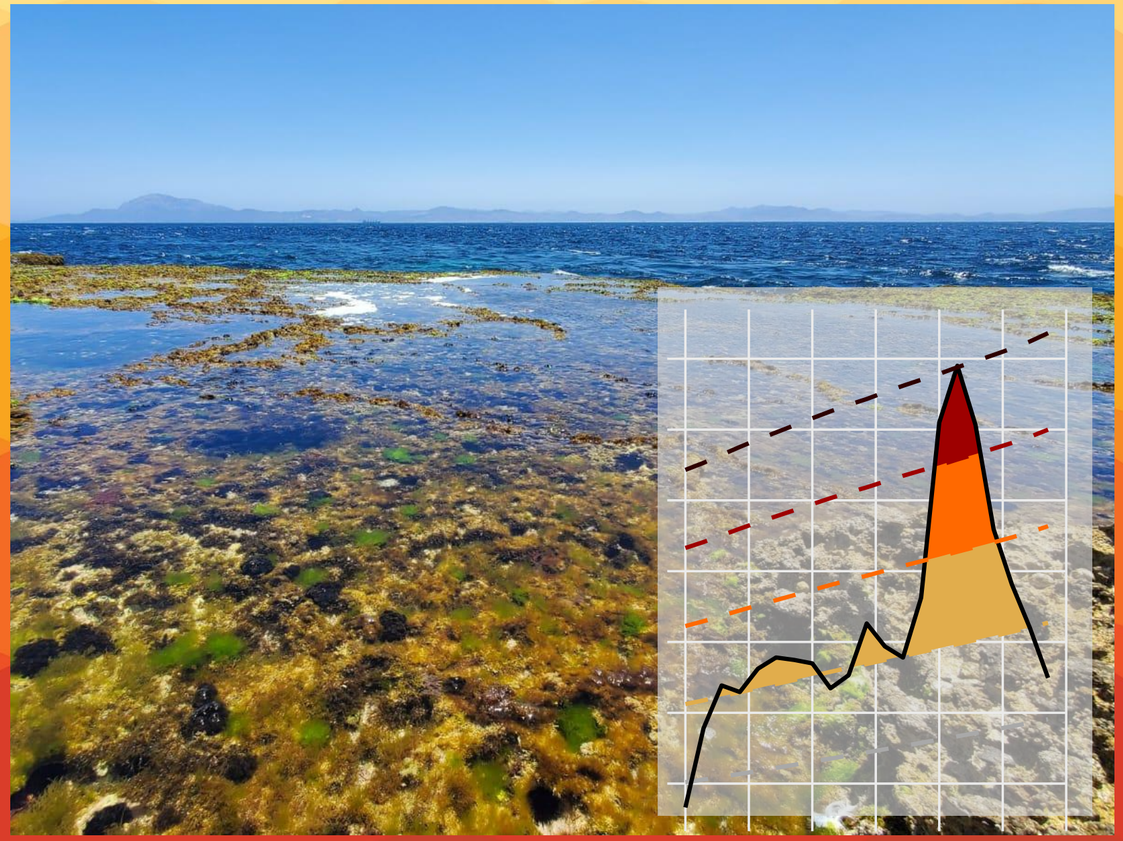
University of New Hampshire

Ecological Forecasting Initiative
UNDERSTAND · MANAGE · CONSERVE

ONE OCEAN SCIENCE CONGRESS
NICE FRANCE 3-6 June 2025

FORECASTING THE IMPACTS OF MARINE HEATWAVES ON HABITAT-FORMING INVERTEBRATE SPECIES



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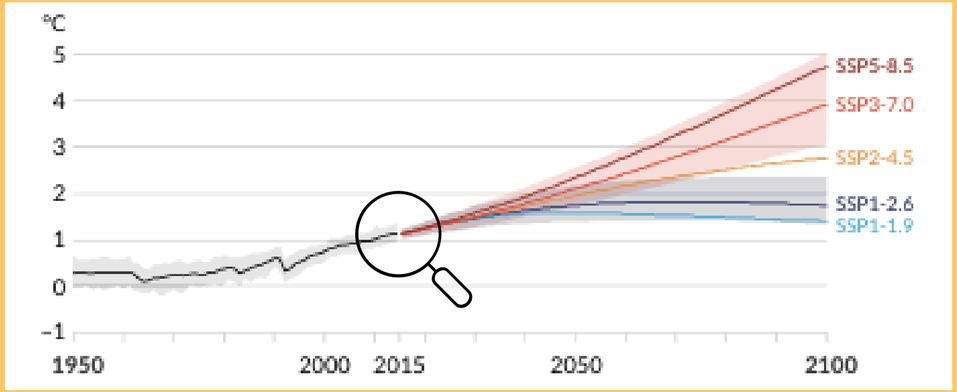
One Ocean Science Congress
4 June 2025Marine Biodiversity Observation and Monitoring - Session T3-6

Predicting Biodiversity under a variable future

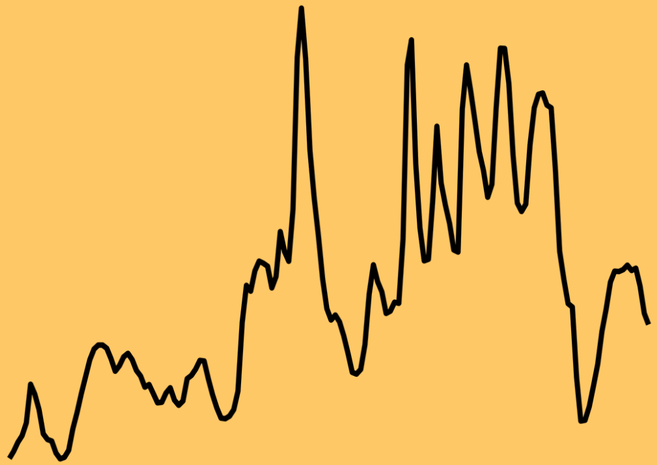
Climate change is pushing global mean temperature upwards over decadal scales.

We see extreme temperature events happening on much quicker time scales – pulses occurring minutes to months.

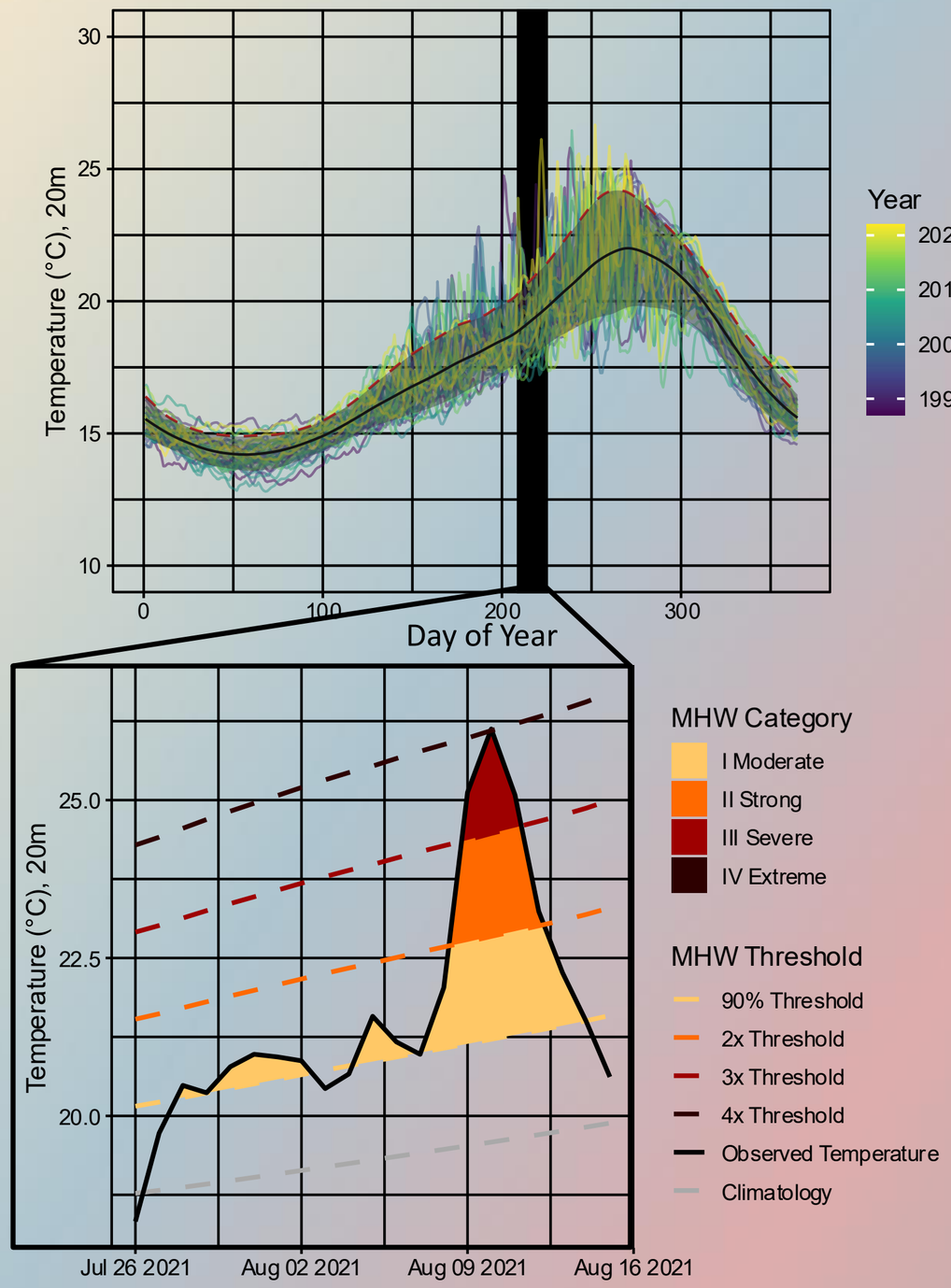
This variability is over the scale at which many animals operate!



IPCC RCP Global mean temperature projections



Jentsch et al. 2007, van de Pol et al. 2017, Latimer and Zuckerberg 2019, Jackson et al. 2021, IPCC 2021 (PC).



Marine Heatwaves (MHWs)

- Extreme events occurring in the marine systems, driven by oceanic and atmospheric processes.
- How to define? One approach – **statistical analysis of historic temperatures.**
- Temperature exceeds 90th percentile of 30-year historical time series
- Describes what is extreme for a given location - but is this what is extreme for organisms?

Hobday et al. 2016; 2018

The ultimate ecological impact: Mass Mortaltiy Events

Intertidal Bivalves, Salish Sea, US and Canada, 2021

Raymond et al. 2022

Subtidal Gorgonians, Mediterranean Sea, 2003 & 2018

Garrabou et al. 2022

Intertidal Kelp, New Zealand, 2018

Thomsen et al. 2019

Forecasting Goals: 1) Predict when conditions cause mass mortality events, and 2) what the extent of damage resulting from these events

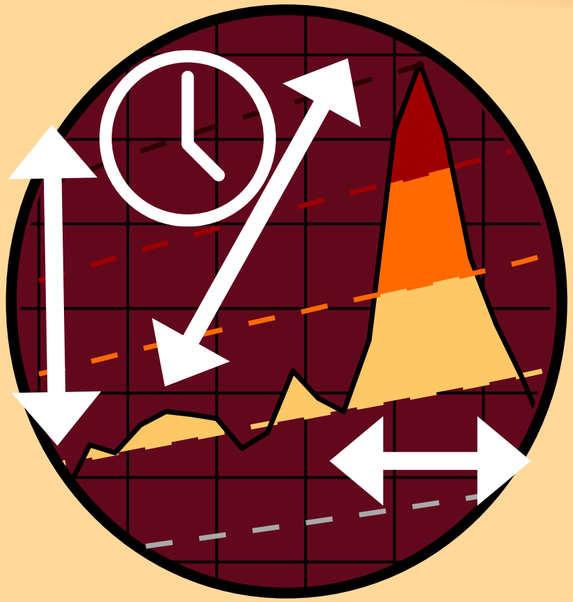
Statistical Lens

Duration

Magnitude

Seasonal Timing

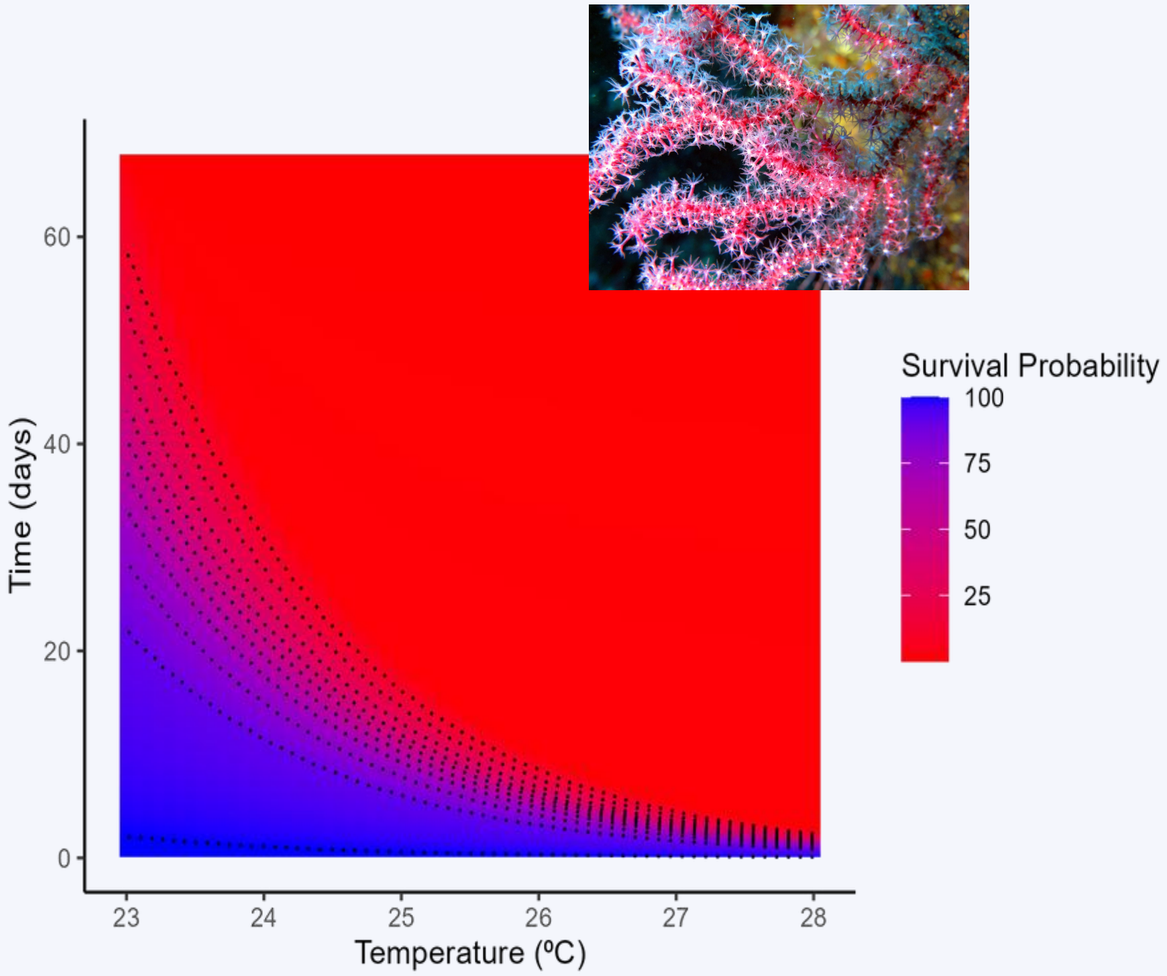
Ramp Rate



...many other time series metrics

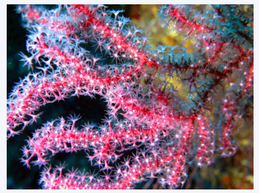
A Biological Approach:
Thermal Tolerance Landscapes

- Important to consider exposure **duration** when measuring thermal tolerance - temperature as a dose.
- Time to death follows a log-linear pattern across taxa.
- Create a **continuous landscape** of survival probability
- We constructed a TTL for the gorgonian *Paramuricea clavata*

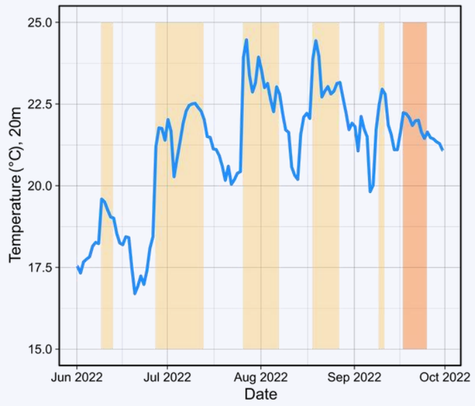


Rezende et al. 2014, Pairaud et al. 2014,
Gomez-Gras et al. 2021

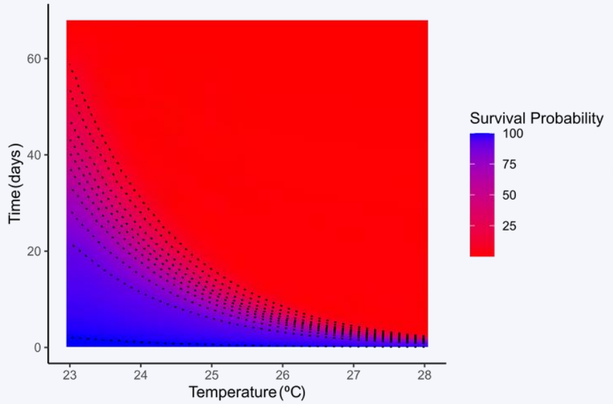
A Biological Approach: From Model to Prediction



Field Body Temperature



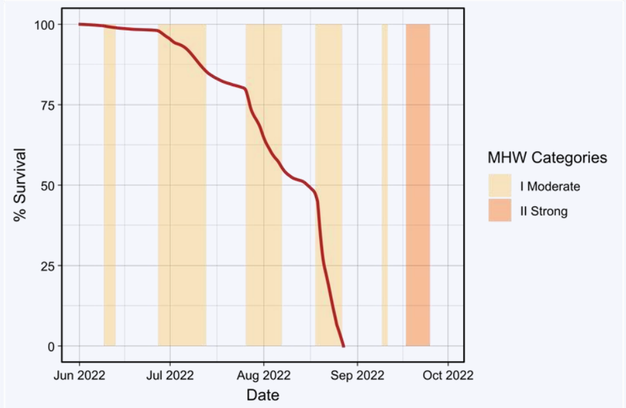
Thermal Tolerance Landscape



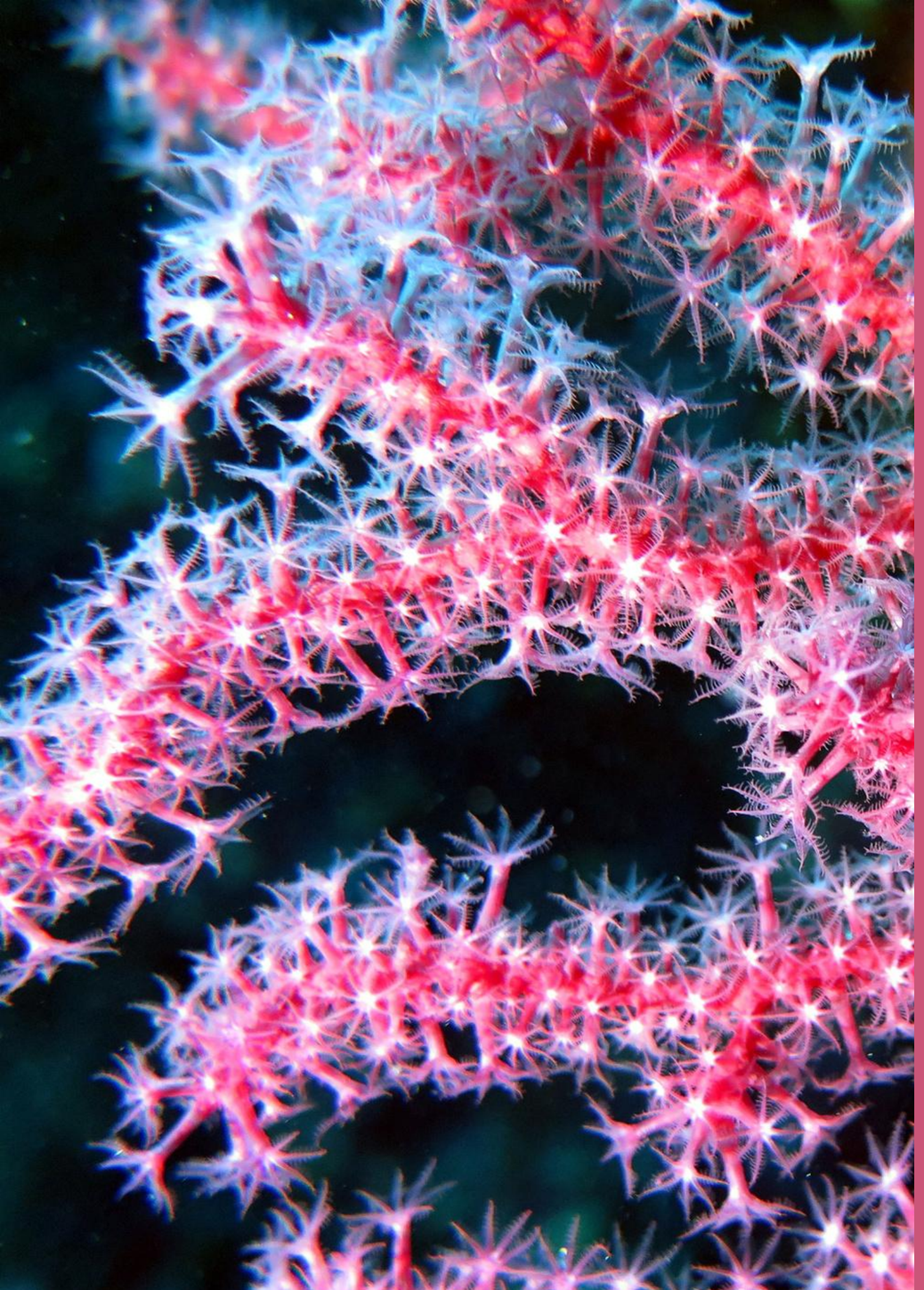
Dynamic Tolerance Algorithm

(Rezende et al. 2020, Rezende and Carter 2024)

Survival Prediction



Rezende et al. 2020, Villeneuve and White 2024

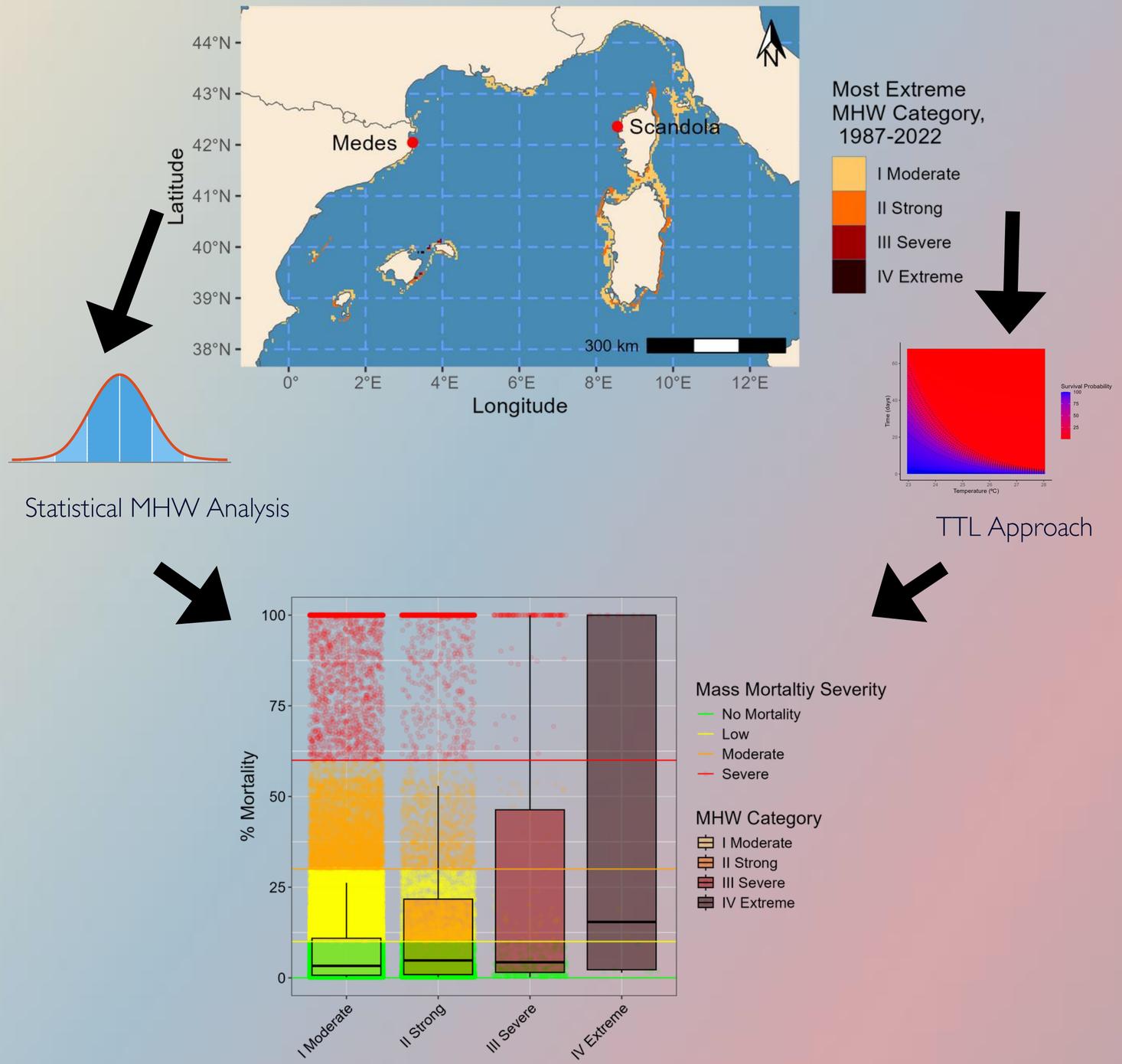


Case Study: *Paramuricea clavata* in the western Mediterannean

1. Does *P. clavata* mass mortality severity follow MHW severity?

2. Are forecasts made by thermal tolerance landscapes accurate?

Statistical MHWs do not describe Mass Mortality Event Severity

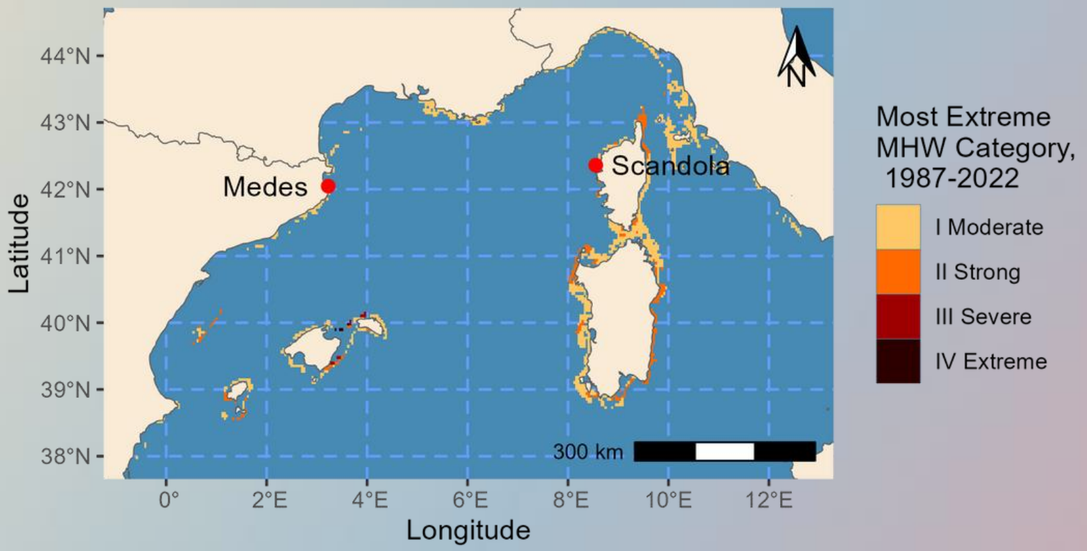


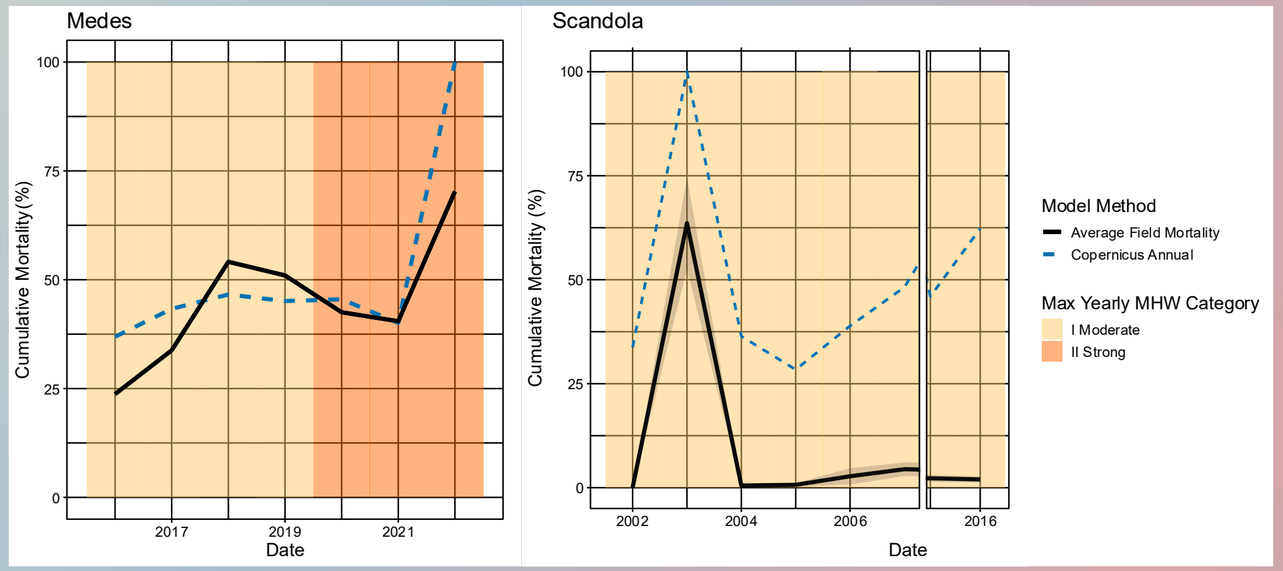
Method:

We modeled mortality of *P. clavata* across the western Mediterranean between 1987 and 2022 using remote-sensed water temperature at 20m.

Result:

Little overlap between statistical and biological categories of severity





Modeled Mass Mortality matches field mortaltiy at some sites

Method

We compared observed field mortality at Medes Islands, ES, and Scandola MPA, FR against modeled mortality.

Result

Good fit of modeled and observed survival at Medes. Local adaptation may be responsible for overprediction at Scandola.

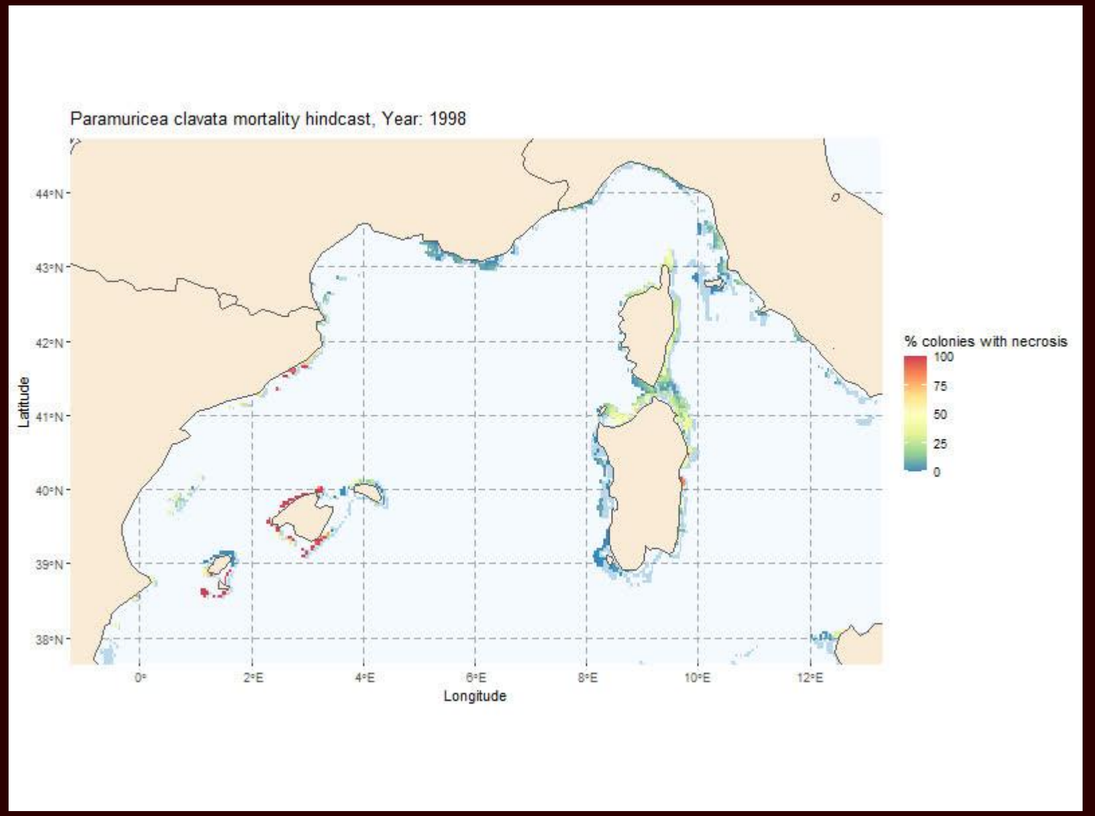
Rovira et al. 2024, Gómez-Gras et al. 2021

Towards Operational Forecasts of Extreme Event Impacts

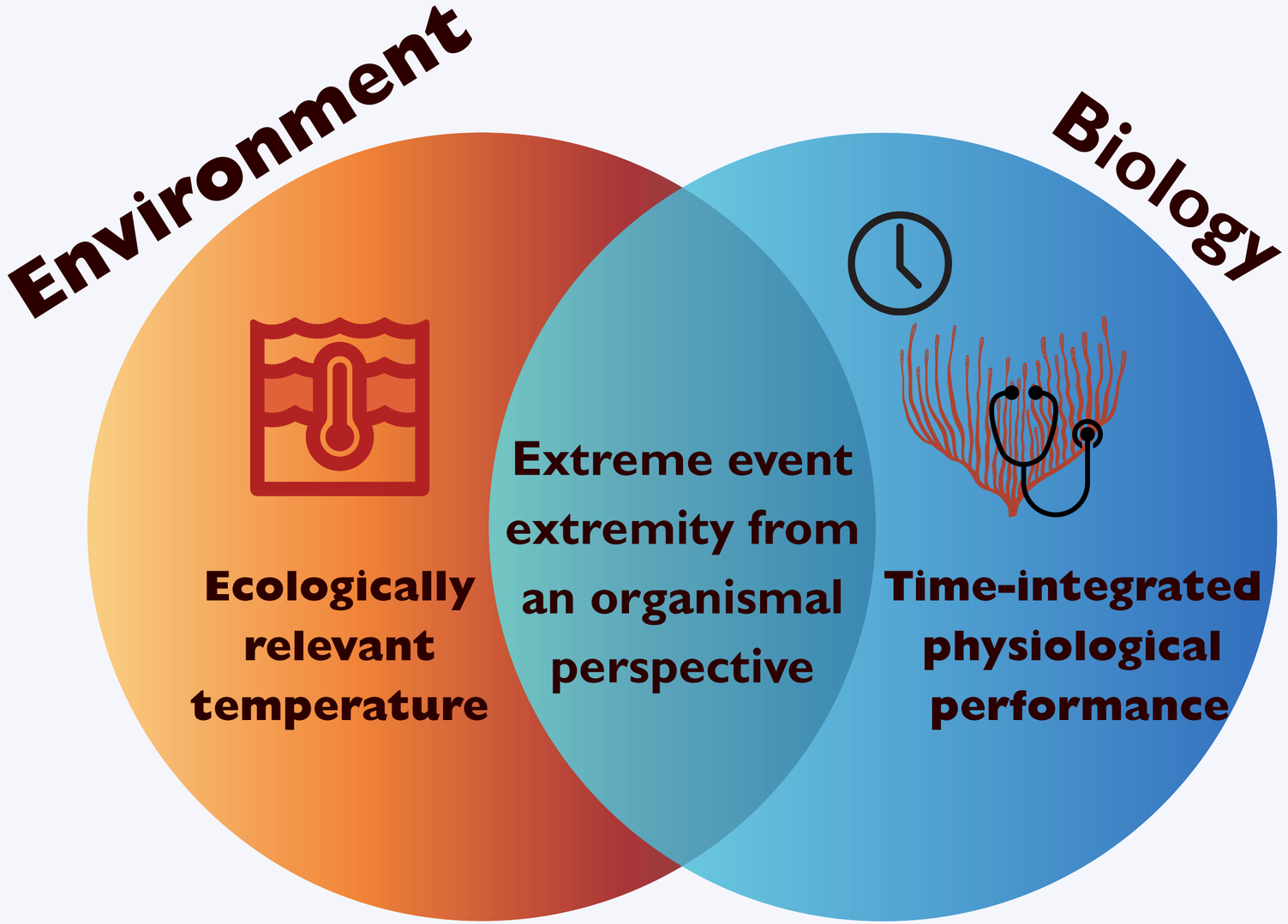
Models that use time provide better predictions

Remote monitoring of hard-to-survey areas

Oceanographic forecasts can yield mortality forecasts



Key Takeaways



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Bibliography