Ocean Bitemap: global and local drivers of shallow water predation intensity

Matt Whalen, Emmett Duffy, Ross Whippo, & the Bitemap Team

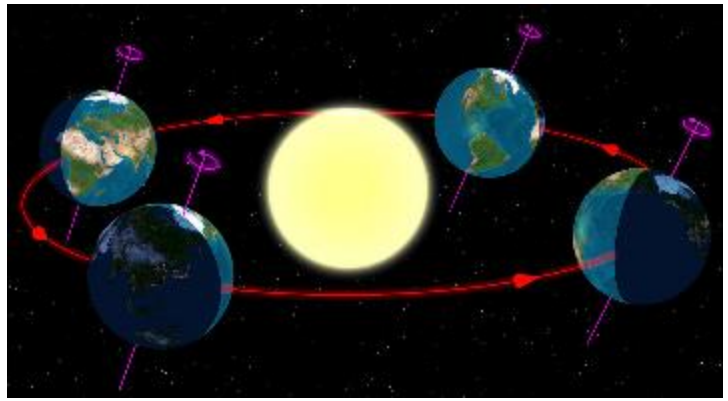
30 March 2018

Benthic Ecology Meeting
Corpus Christi, Texas

Latitudinal gradients:

some of the most studied and celebrated patterns in ecology

Ultimately driven by the Earth's rotation and orbit around the sun

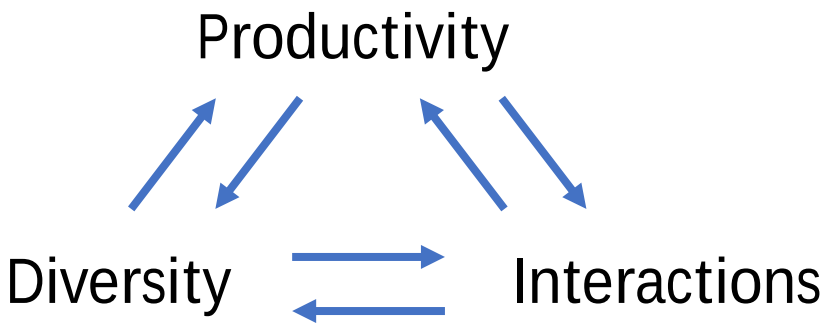


Classic gradients:

- light and temperature
- productivity
- species diversity
- interaction strength

Relationships among important gradients are unclear

causality, directionality, reciprocity

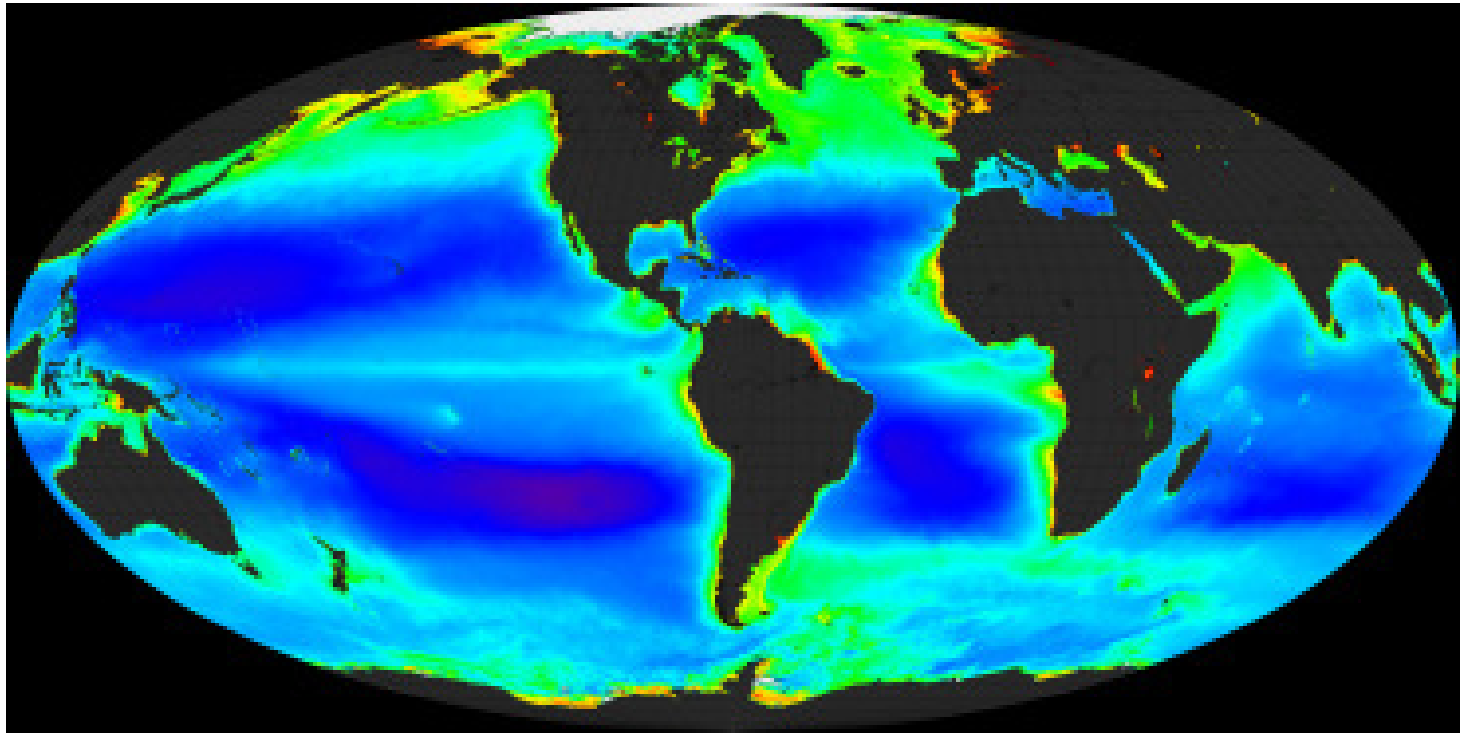


Fundamental constraints on *primary* productivity are relatively well understood, but

Constraints on species interactions and diversity are less well understood (need to invoke ecology and evolution)

We can see primary production from space

Maps of phytoplankton and terrestrial plants help us understand what constrains primary productivity at global and regional levels



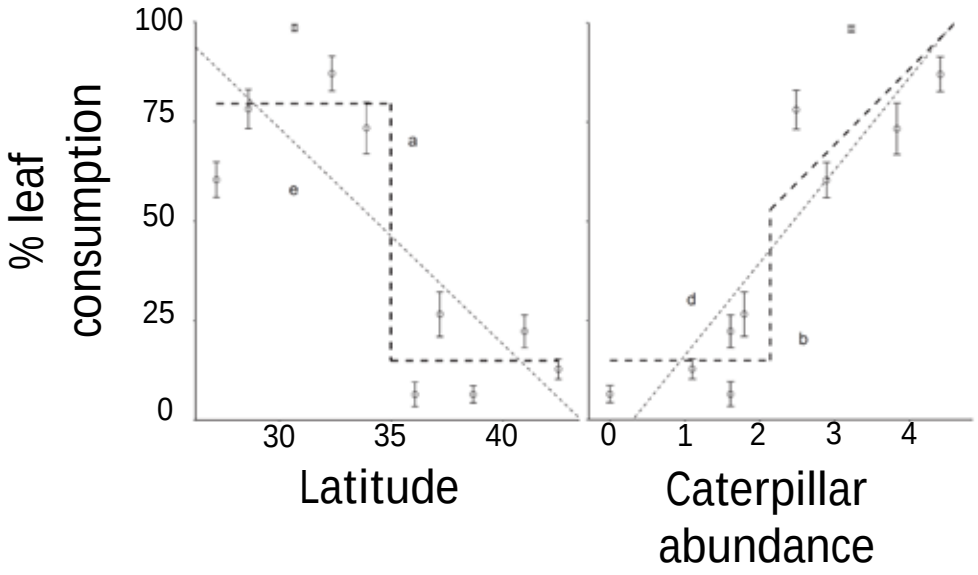
Where does this production go? Do we understand how species interactions funnel energy and materials up food webs?

Gradients in herbivory and predation:

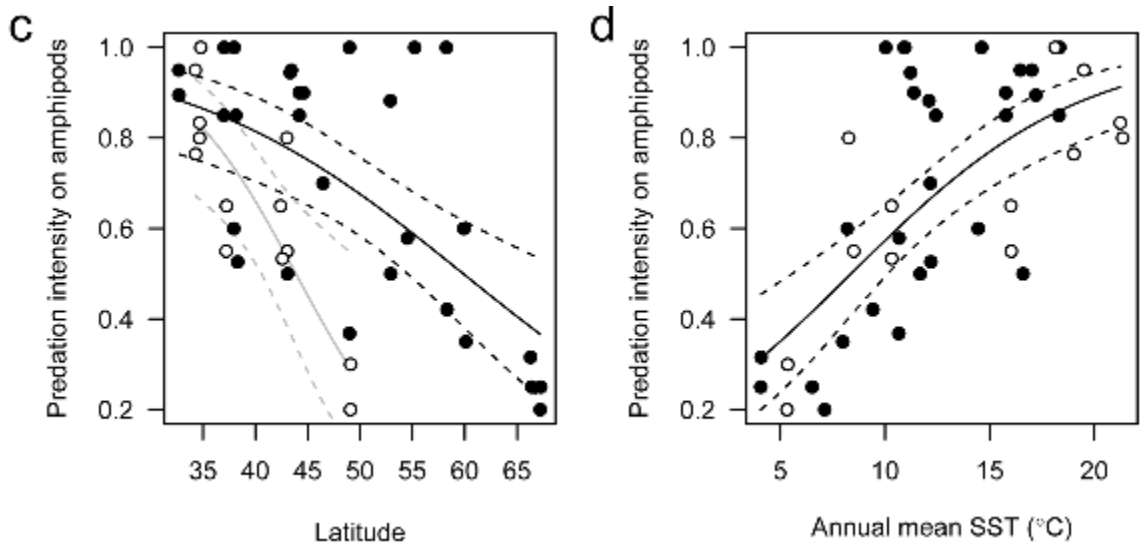
Evidence for increasing species interactions toward equator

Sometimes, non-linear patterns evident

Caterpillars eating leaves on trees



Predation on amphipods ~ Latitude or Temperature



Baskett & Schemske 2018 Ecol Lett

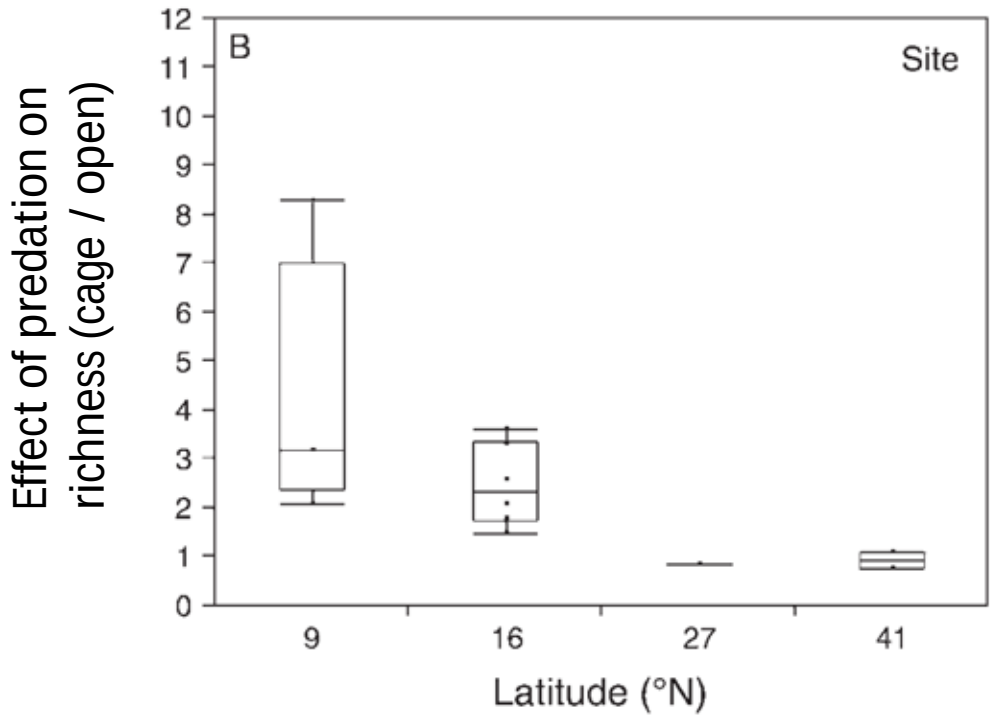
Reynolds et al 2018 Ecology

Gradients in predation:

Evidence for increasing species interactions toward equator

Evidence from marine systems:

- Amy Freestone: predation influences coexistence



Freestone et al 2011 Ecology

Gradients that signal species interactions:

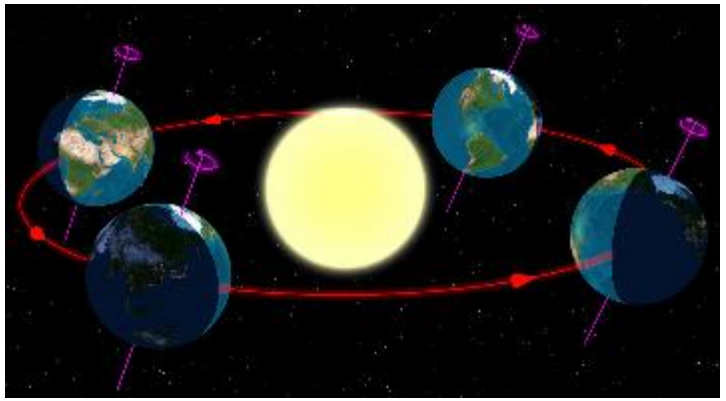
- Gastropod morphology: bigger, thicker shells with more ornamentation in tropics
- Invertebrate body size decreases with latitude: predation or temperature/oxygen

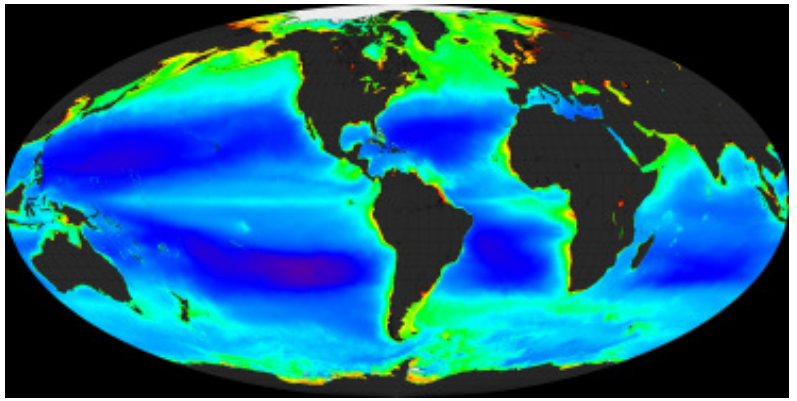
How do we get a reliable estimate of predation intensity across the globe, given differences in prey communities?

Bitemap: a globally resolved map of predation intensity using standardized methods

Consumption is what moves energy and materials through food webs, so measuring consumption across space will tell us about trophic transfer

Abiotic gradients → Primary production → Predation, fisheries production



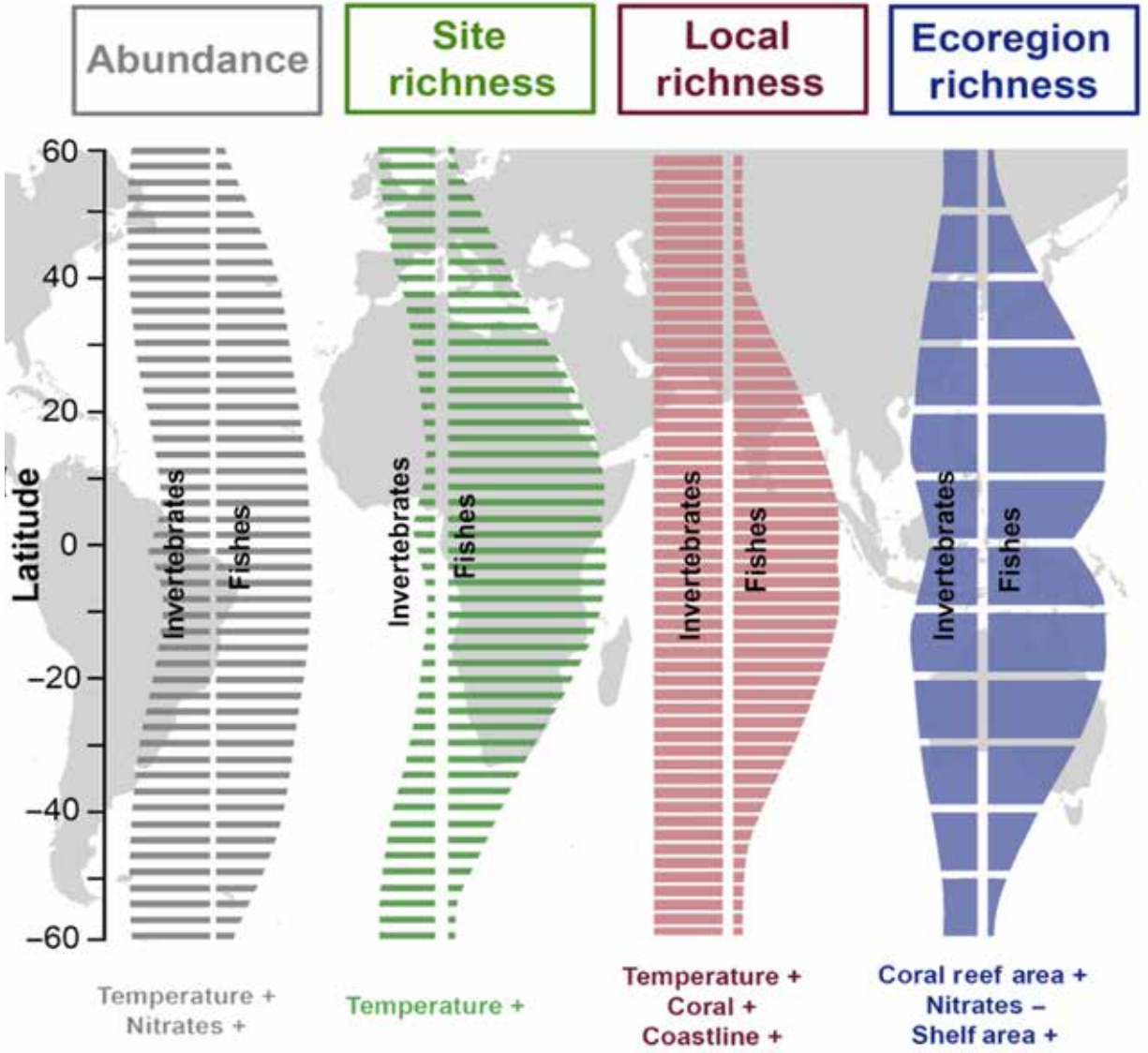


Bitemap: what should it look like?

Perhaps predation rates should mirror patterns of fish abundance and diversity

Predation likely influenced directly by temperature as consumption is a temperature-dependent process

Hypothesis: monotonic increase in predation pressure with decreasing latitude / mean temperature



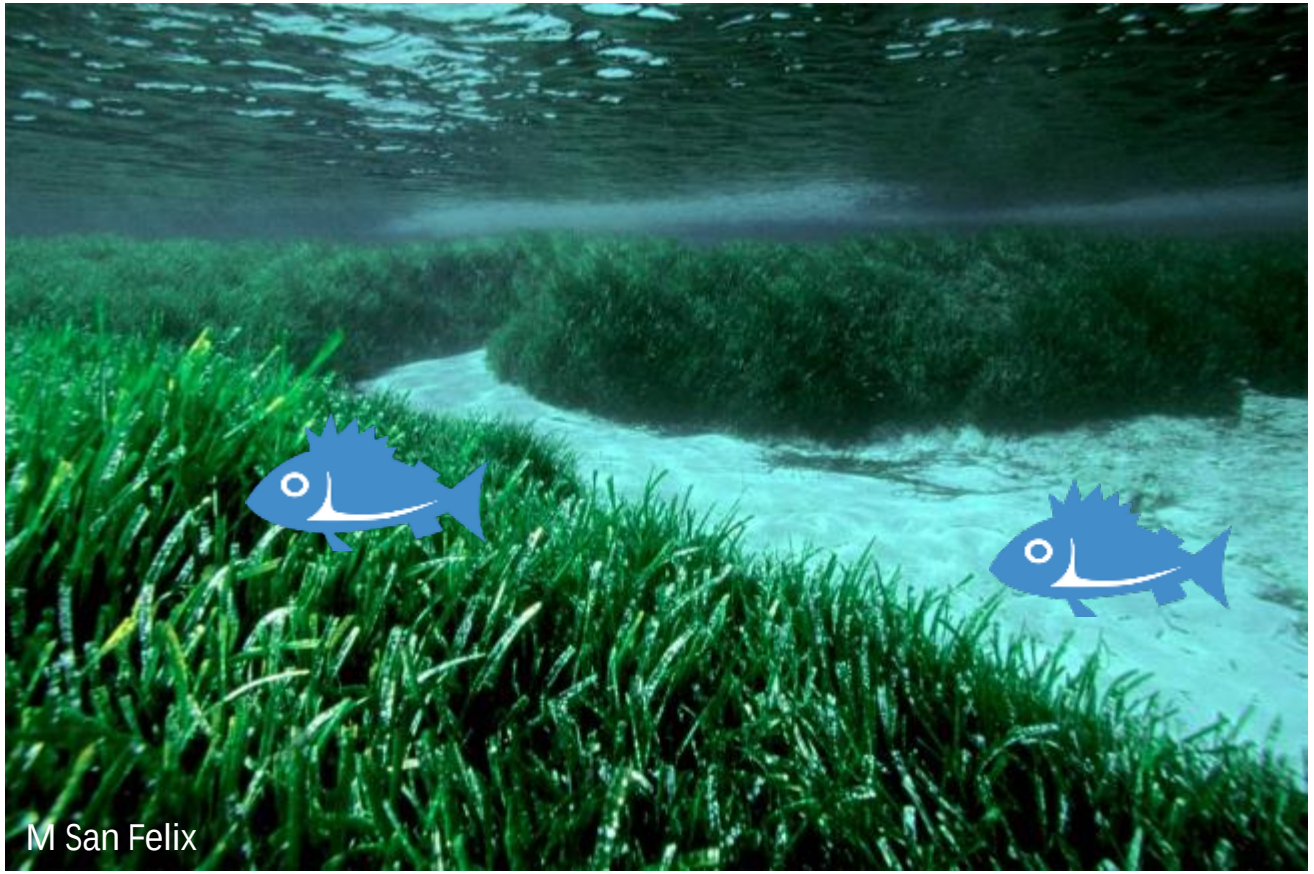
Edgar et al 2017 Sci Adv

Bitemap: what should it look like? Influence of physical structure?

Effect of physical structure on predation can be difficult to predict.

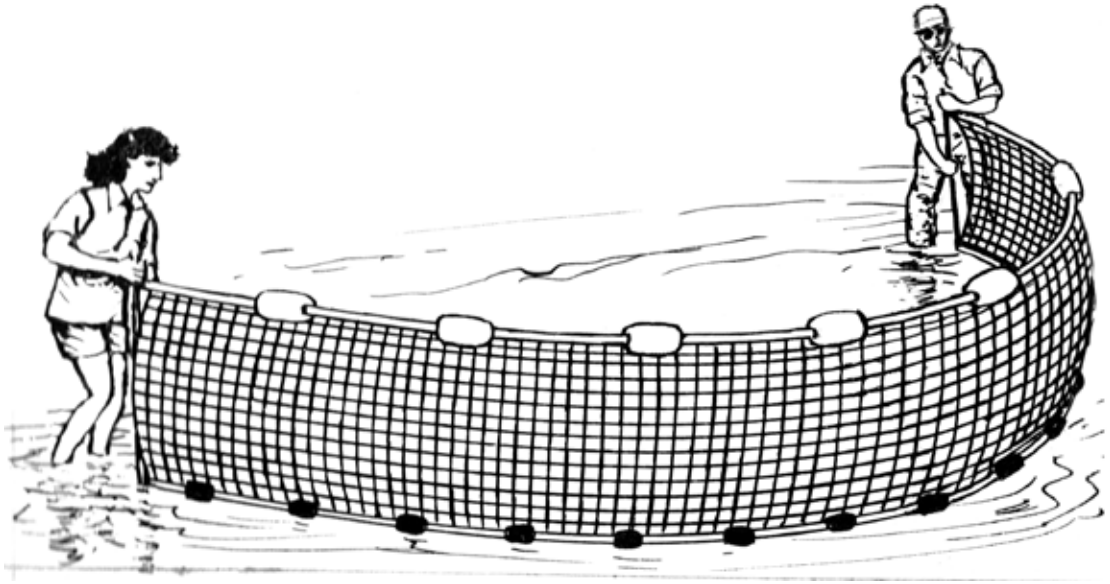
Predation can be *lower* or *higher* in vegetated habitats like seagrasses, but this is complicated by a number of factors:

- density of vegetation
- predator/prey composition
- body size + other functional traits of predators and prey



Methods: Squidpops + Predator surveys

Duffy et al 2015 PLoS ONE



Squidpops

- 25 squidpops each in seagrass and unvegetated habitats
- repeated three times
- presence/absence of squid measured at 1 and 24 hours
- exponential decay of squidpops over time as *predation rate*
  - GLMMs on rates (logit link)

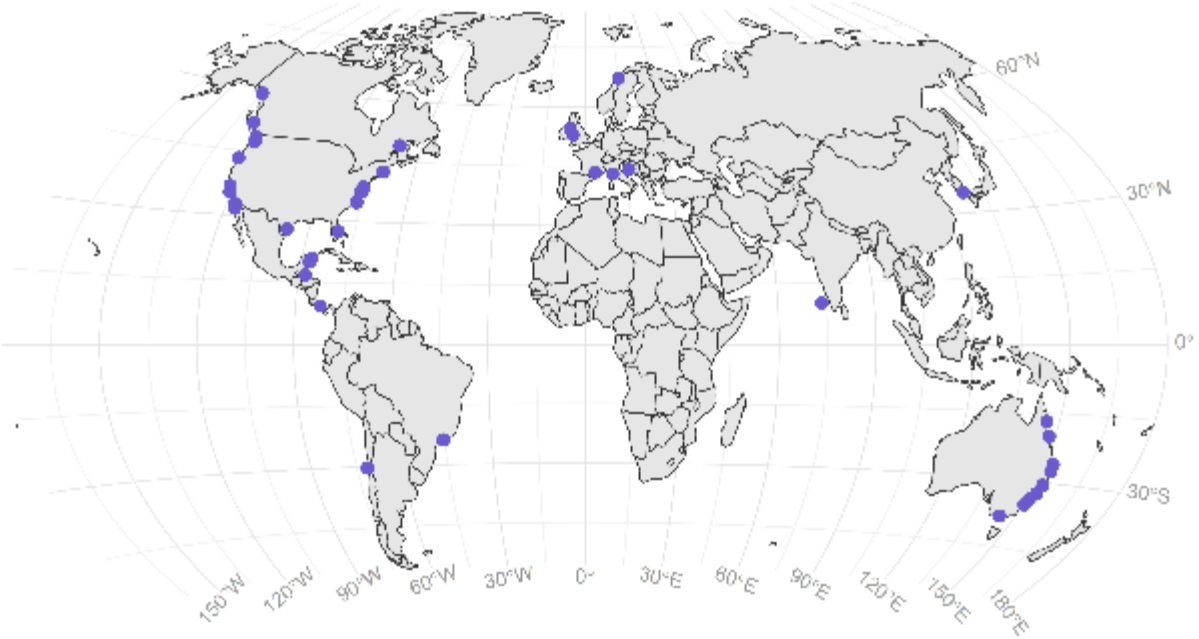
Predator surveys

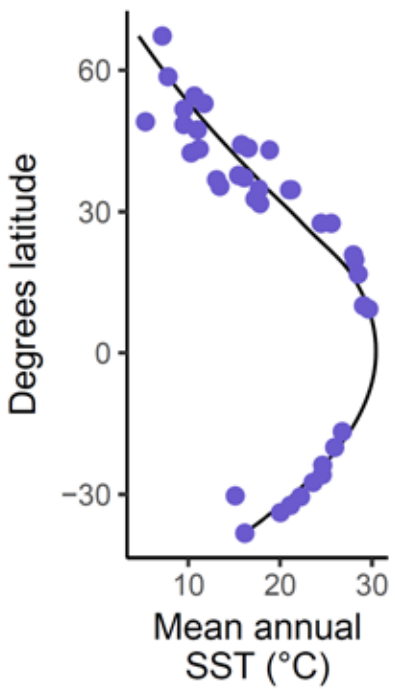
- coupled seining and/or video
- predator abundance, biomass, diversity FROM SEINES
- use traits to select taxa

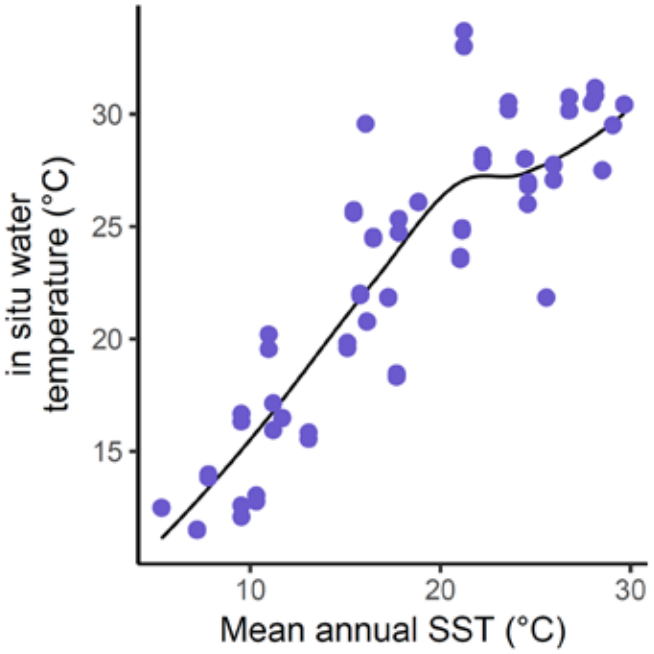
Bitemap: 2016 and 2017 efforts

40 sites across 105 degrees of latitude

- seagrass vs unvegetated habitat (n=37)
- strong gradients in temperature (annual mean and instantaneous)
- 14 species of seagrass (dominated by *Zostera*, 4 species max at one site)

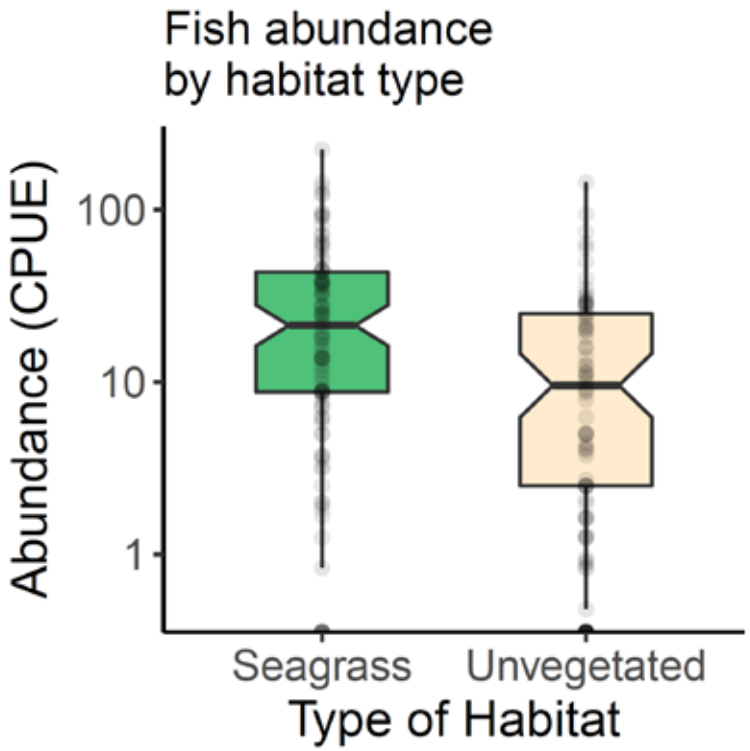


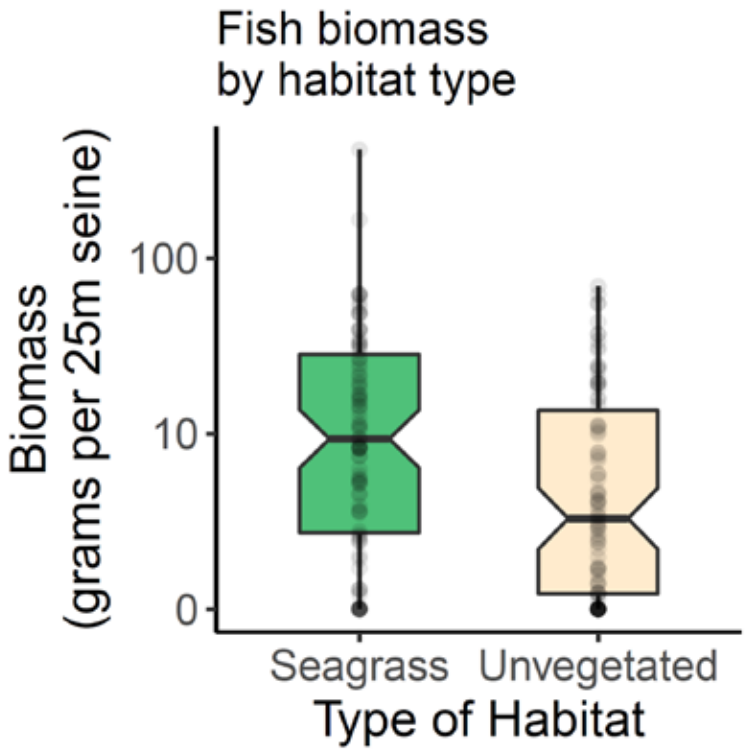


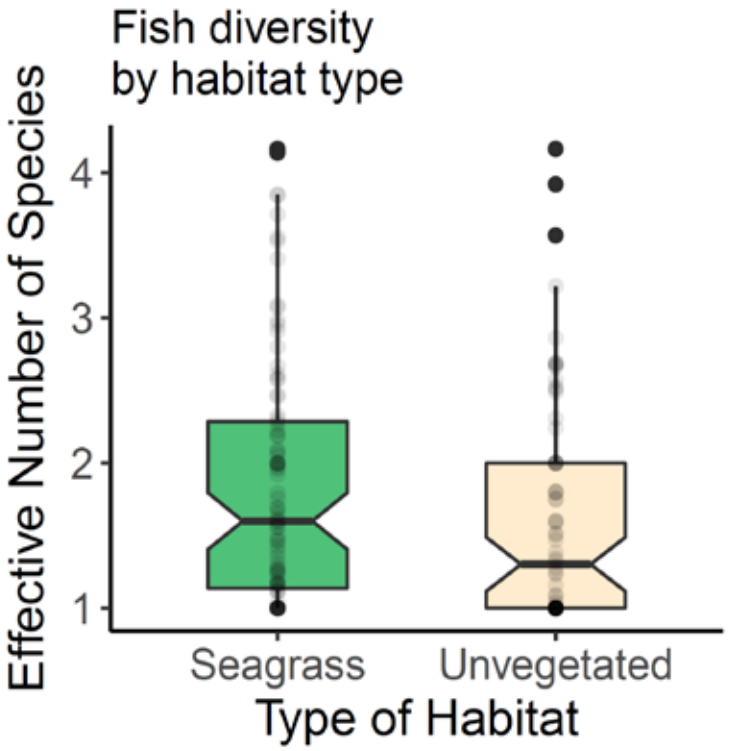


Mediterranean *Posidonia* bed
Lisandro Benedetti-Cecchi

Fish abundance, biomass, and diversity all higher in seagrass, on average

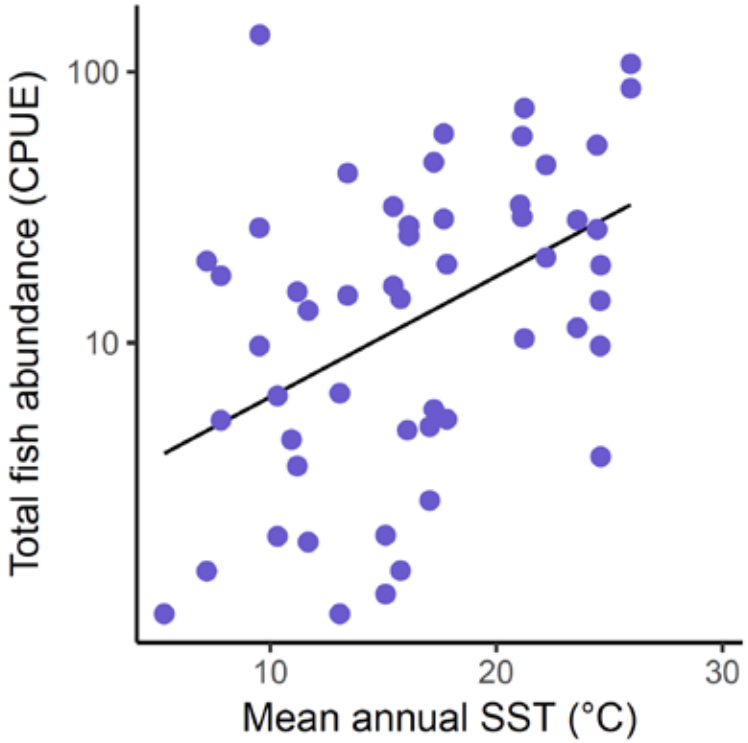


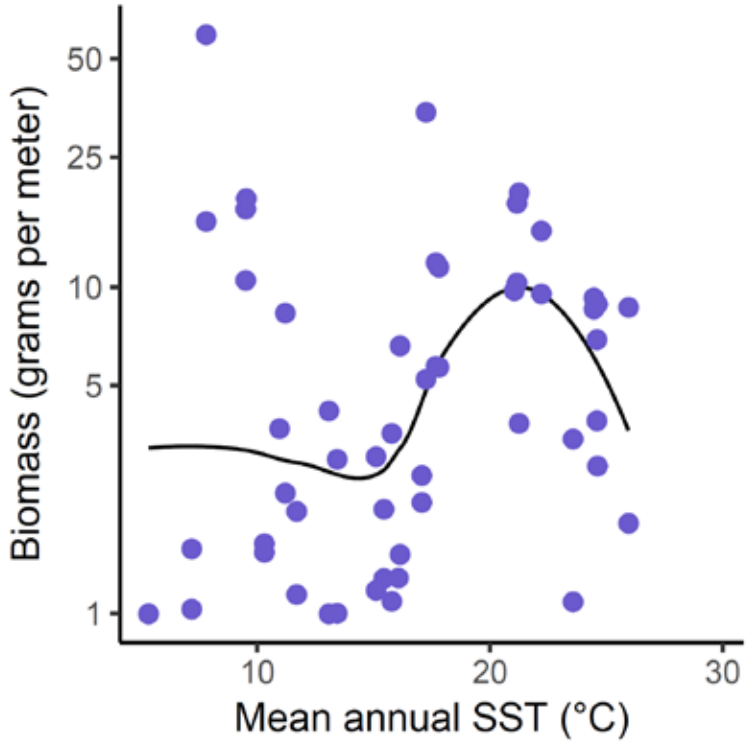




Fish abundance increases with annual mean temperature

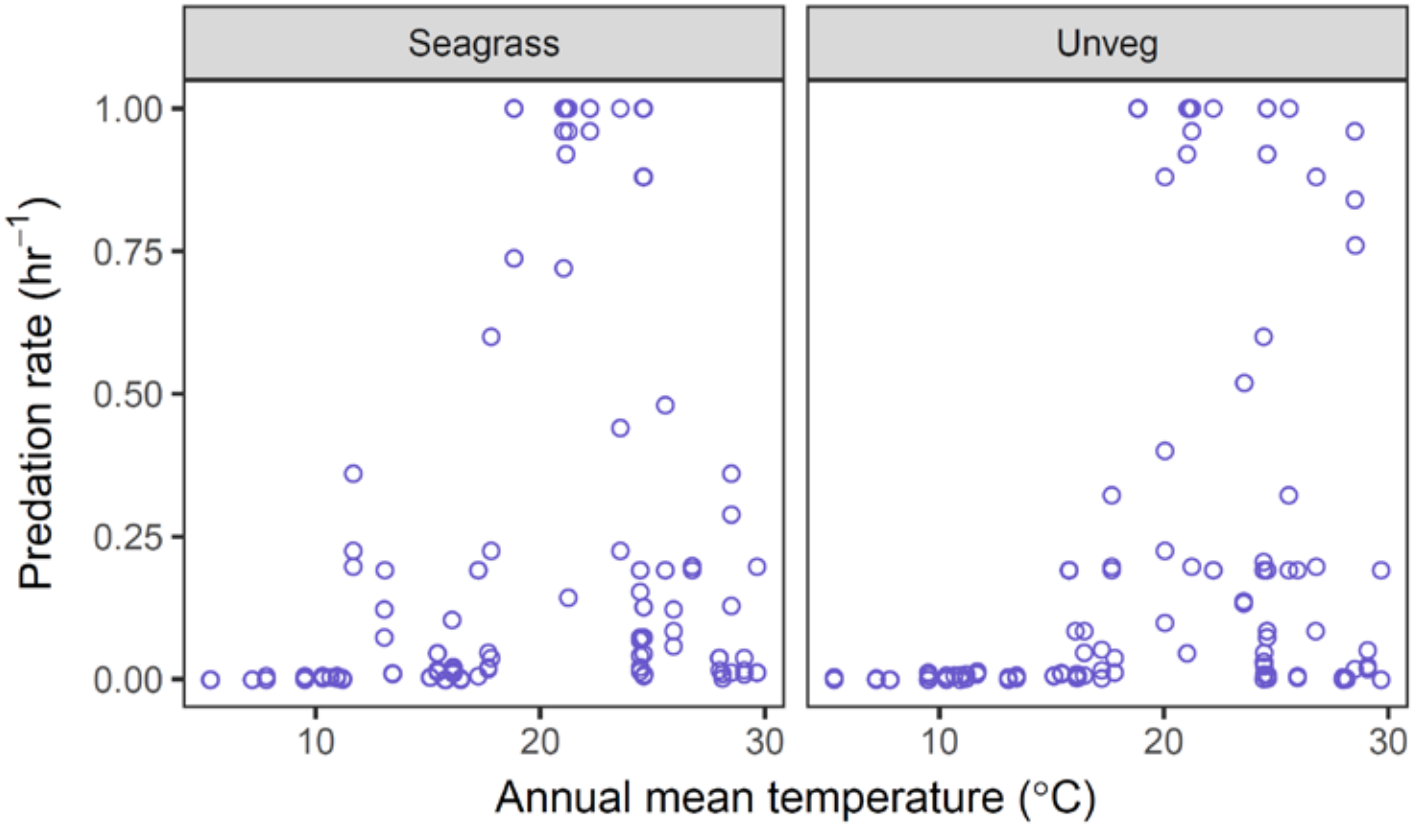
But, fish biomass declines at highest temperatures





Note: both abundance and biomass on a log scale

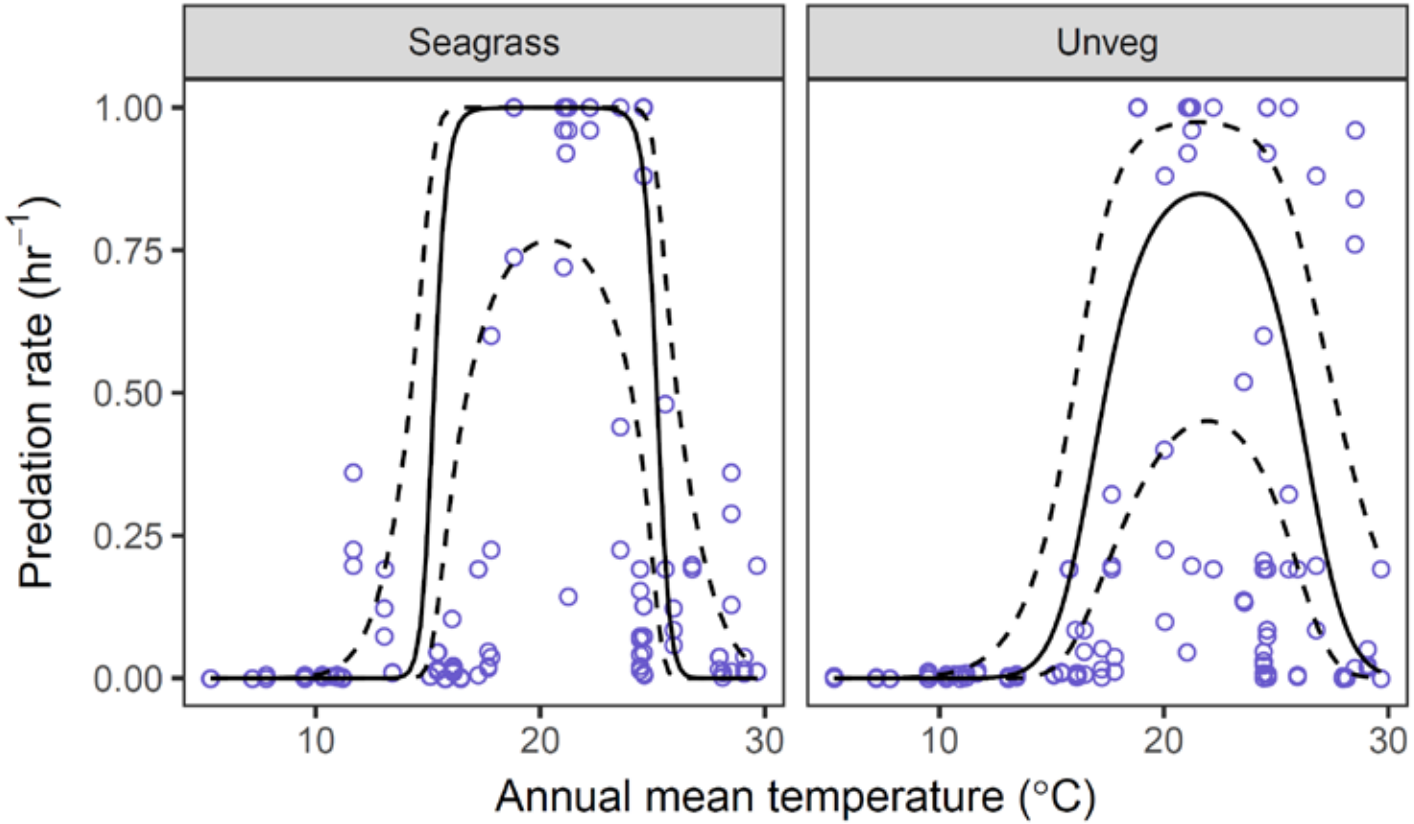
Apparent drop in predation rate at lowest latitudes/average temps



Apparent drop in predation rate at lowest latitudes/average temps

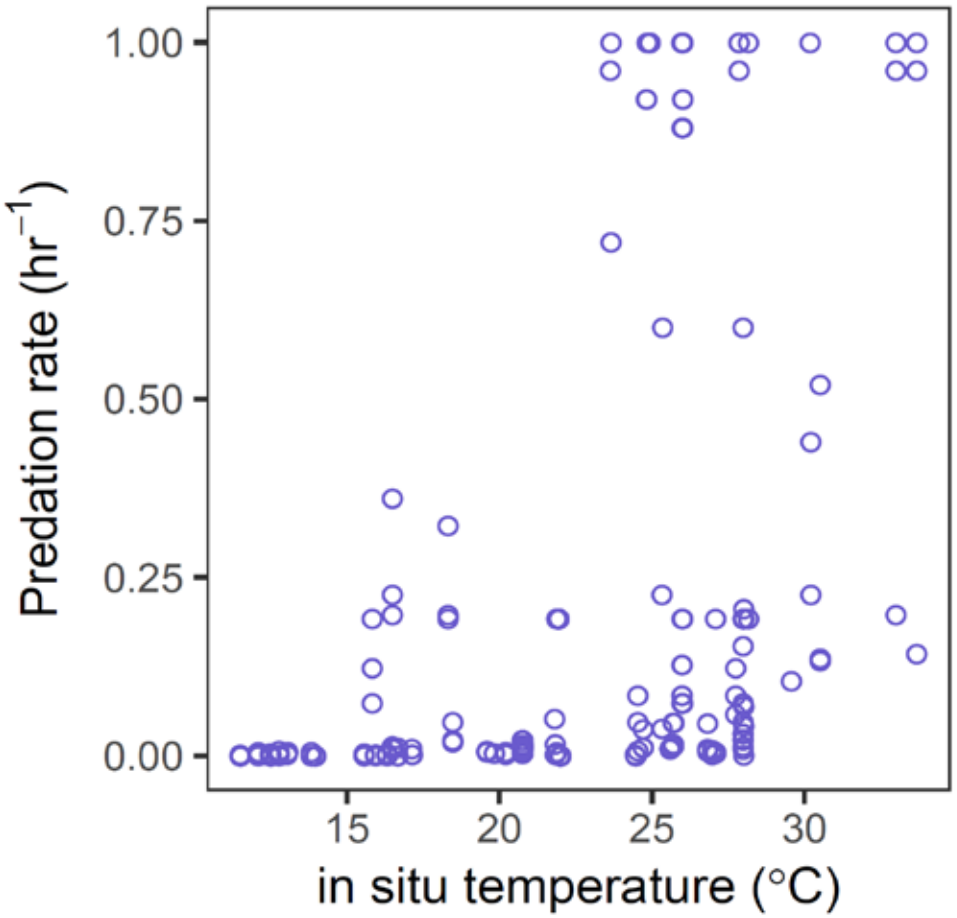
Model comparison: AIC supports quadratric effect of mean annual SST

Modest influence of vegetation at this scale (slightly higher in seagrass, on average)



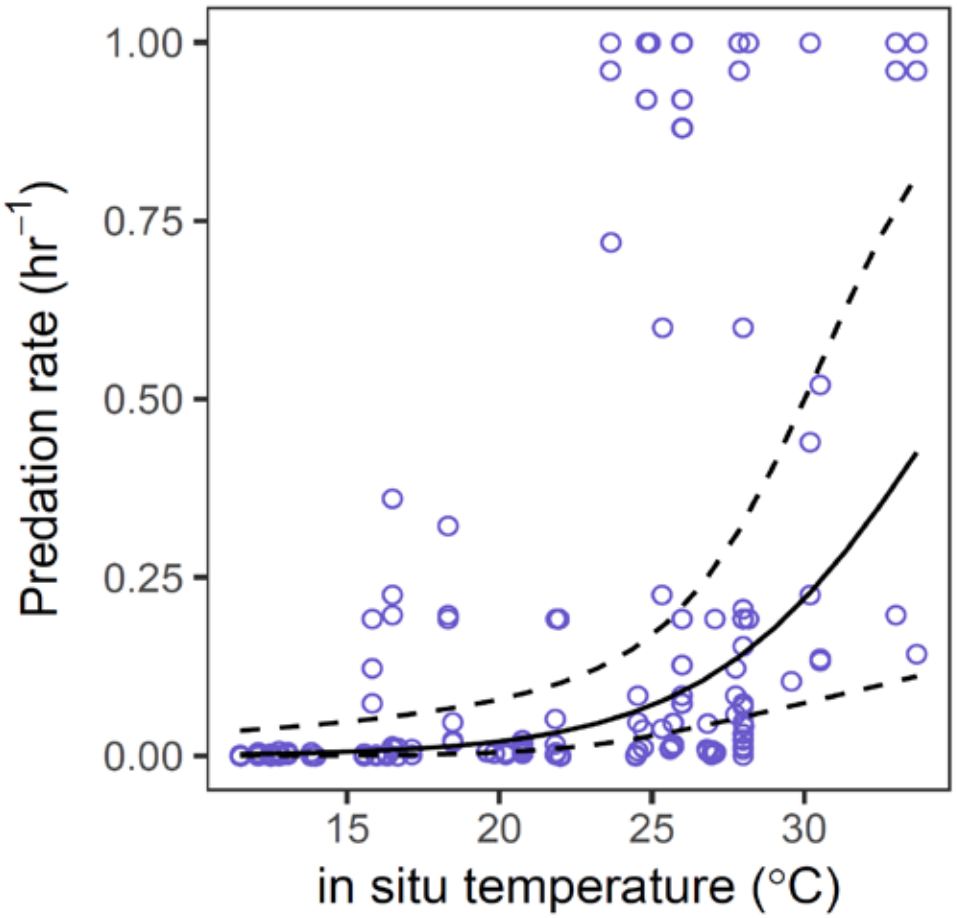
In situ (measured) temperature showed monotonic pattern

Predation rate on squidpops increases with temperature and biomass (additively)



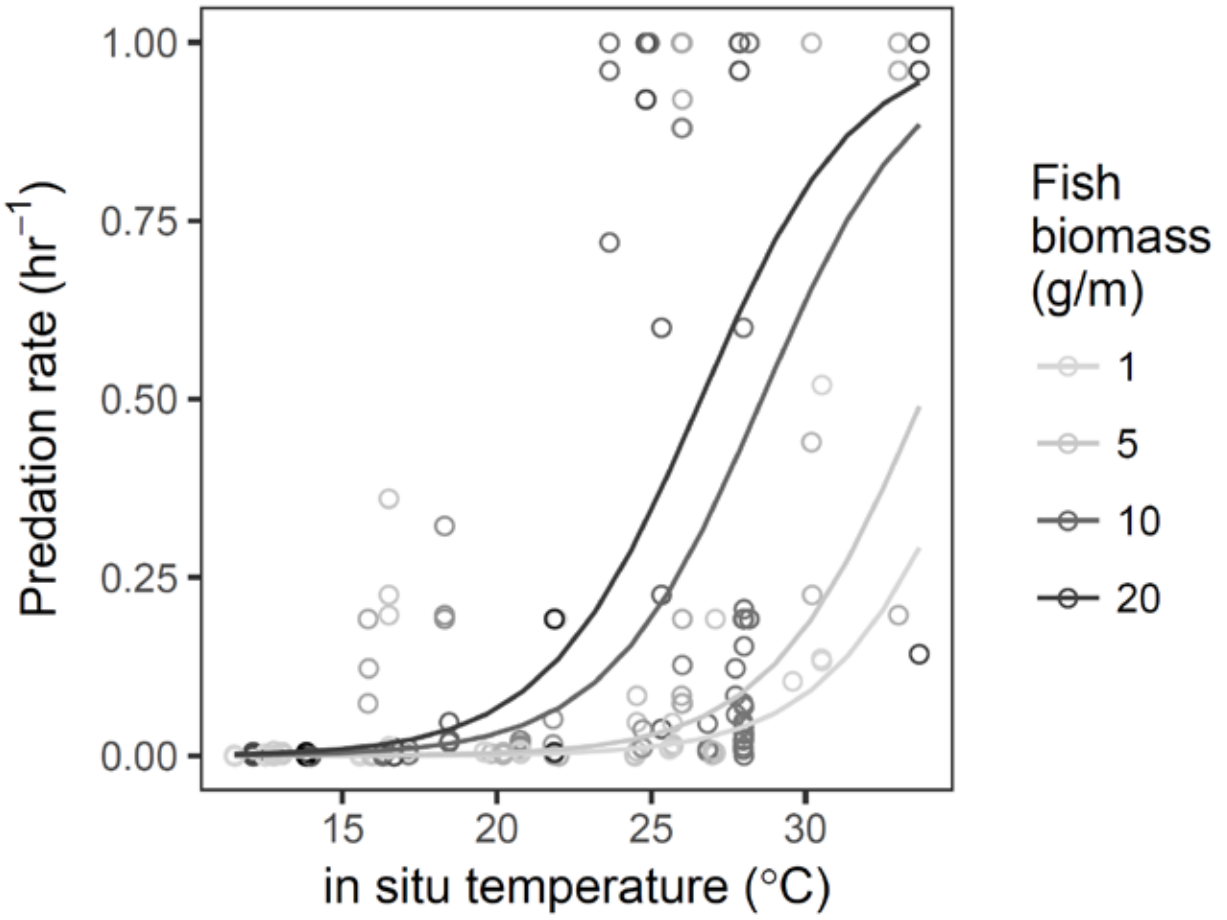
In situ (measured) temperature showed monotonic pattern

Predation rate on squidpops increases with temperature and biomass (additively)

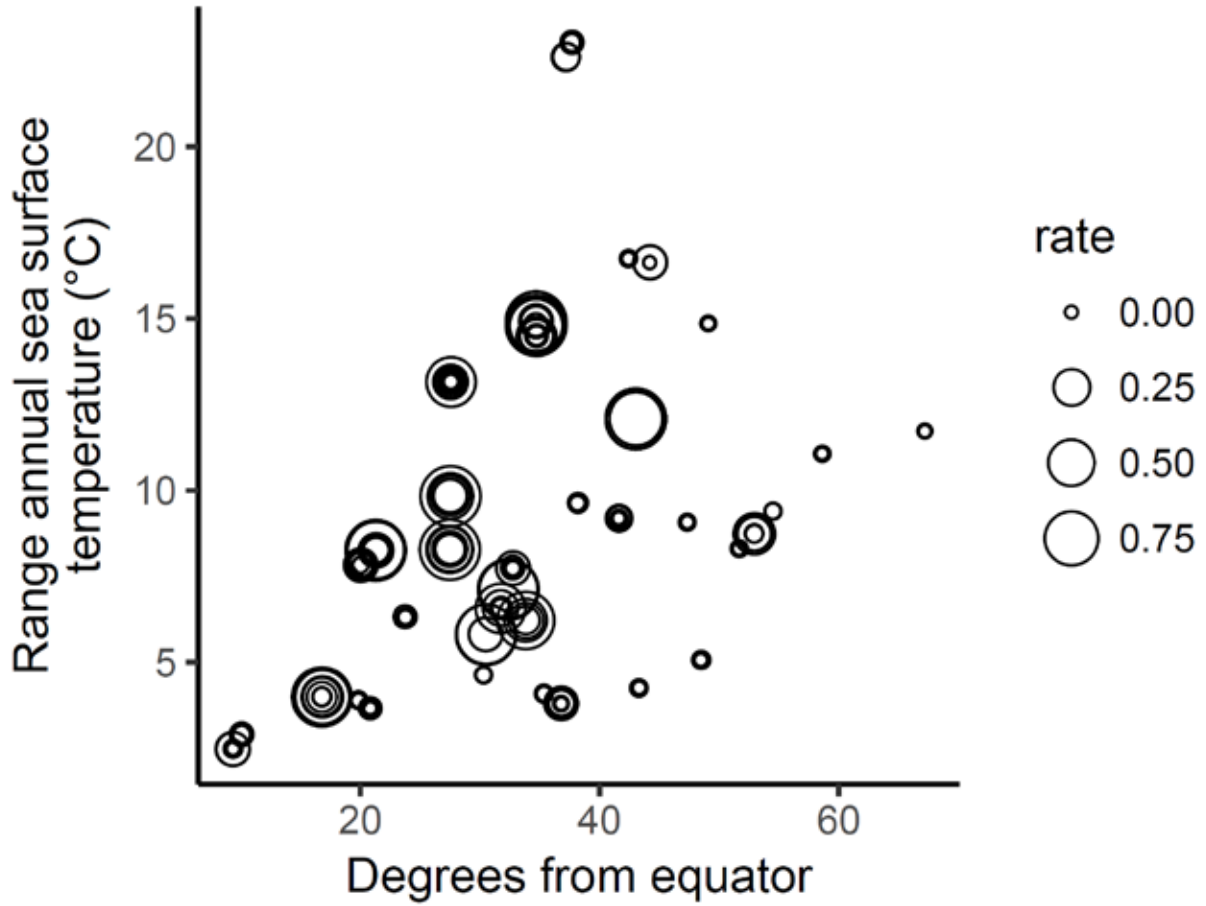


In situ (measured) temperature showed monotonic pattern

Predation rate on squidpops increases with temperature and biomass (additively)

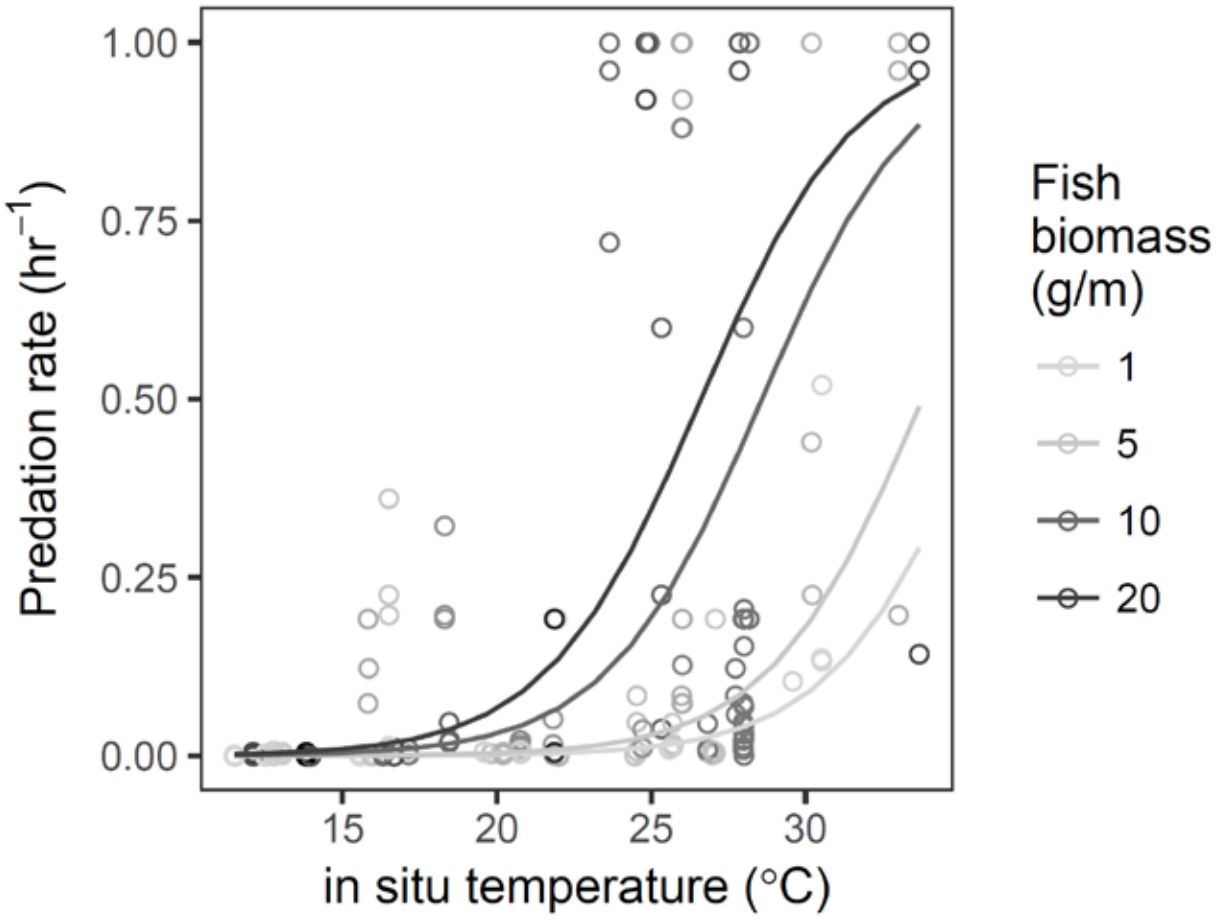


Not a clear relationship between long-term range in SST and predation



In situ (measured) temperature showed monotonic pattern

Predation rate on squidpops increases with temperature and biomass (additively)



Conclusions

- Predation rates are influenced by global-scale gradients in temperature, but it does not appear to be monotonic when consider annual means
  - *the most tropical sites did not have the highest predation rates*

- Predation is influenced by local conditions
  - predation tended to be higher in seagrass habitats
  - abundance, diversity, and *biomass* of predators explain habitat result

- Relative importance of temperature is slightly stronger, but predator biomass adds explanatory value

Acknowledgements

We thank all of the PIs, technicians, and students around the world who made this work possible and continue to collaborate on this project

Funding for this work provided by MarineGEO and the Hakai Institute

MarineGEO
THE TENNENBAUM
MARINE OBSERVATORIES NETWORK

Hakai
Science on the Coastal Margin