Testing Energy Biodiversity Theories on Marine Species

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Introduction

- What are the fundamental factors that drive patterns of biodiversity on Earth?
- Hypotheses that have been validated in the terrestrial environment (Hobi et al 2017; Radeloff et al 2019) should be tested in the oceans

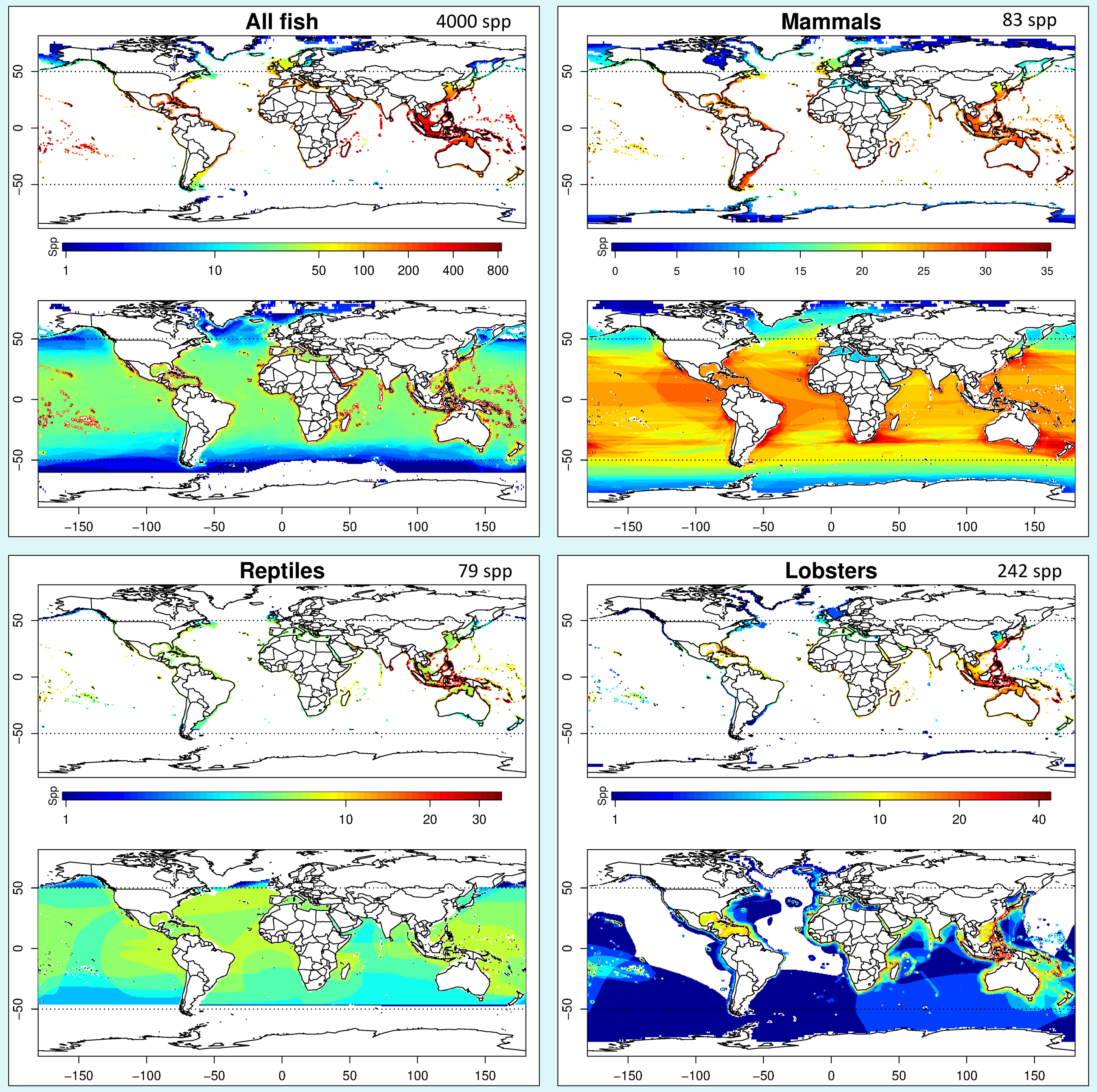
Energy Biodiversity Hypotheses

1. Environmental Stability Hypothesis: lower intra-annual variability of available energy facilitates richness
2. Available Energy Hypothesis: Greater energy availability facilitates species richness
3. Environmental Stress Hypothesis: Higher minimum energy available facilitates higher species richness

To test these hypotheses in the oceans, species richness data and calculations of energy availability were combined

Marine species richness

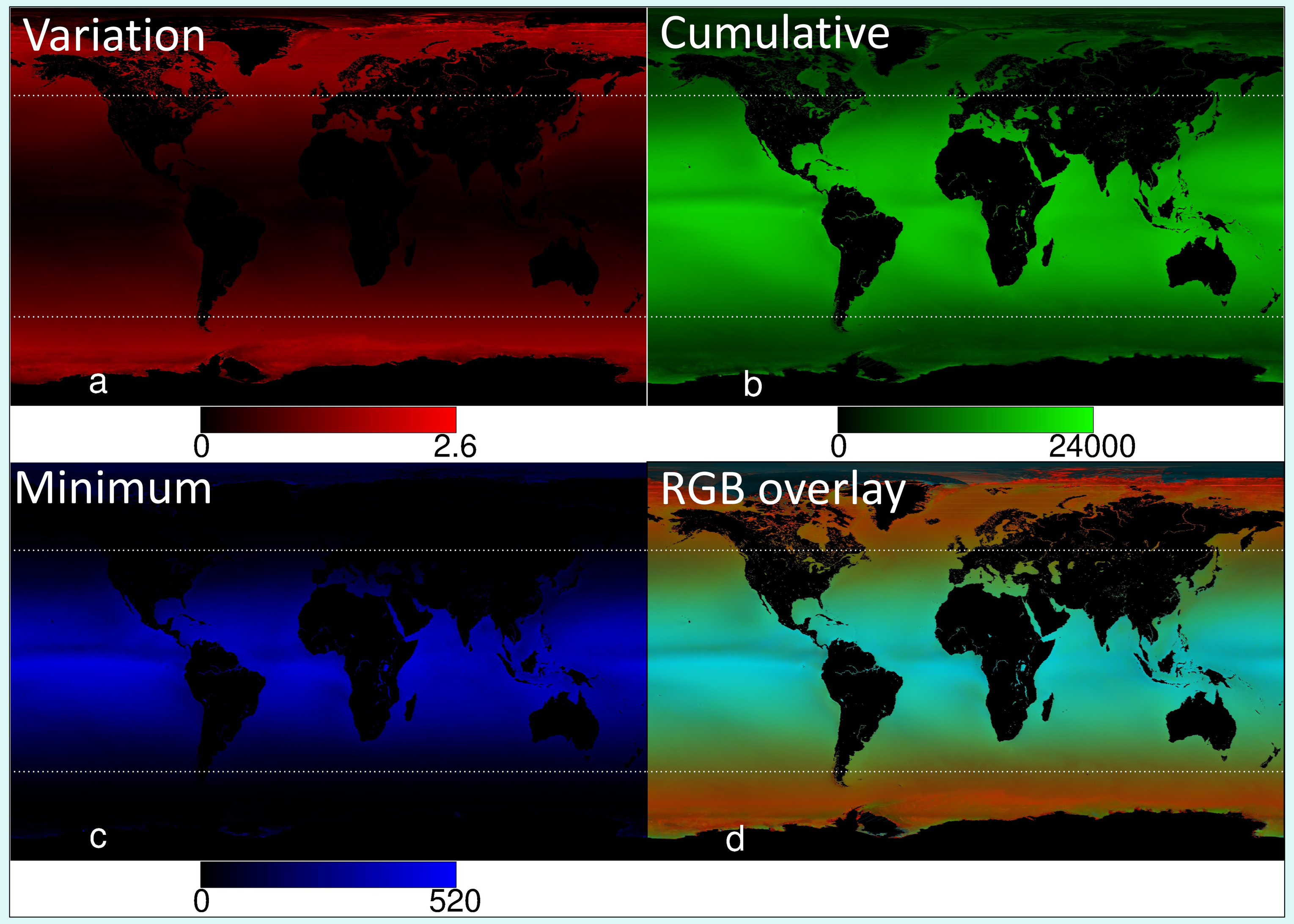
- Expert-defined ranges
- Separated by spatial region:
  - Coastal (<200 m bathymetry)
  - Offshore (>200 m bathymetry)
    - 5% sample with spatial buffer used for offshore regressions
- Fish separated by preferred habitat:
  - All-fish, Pelagic, Demersal, Reef



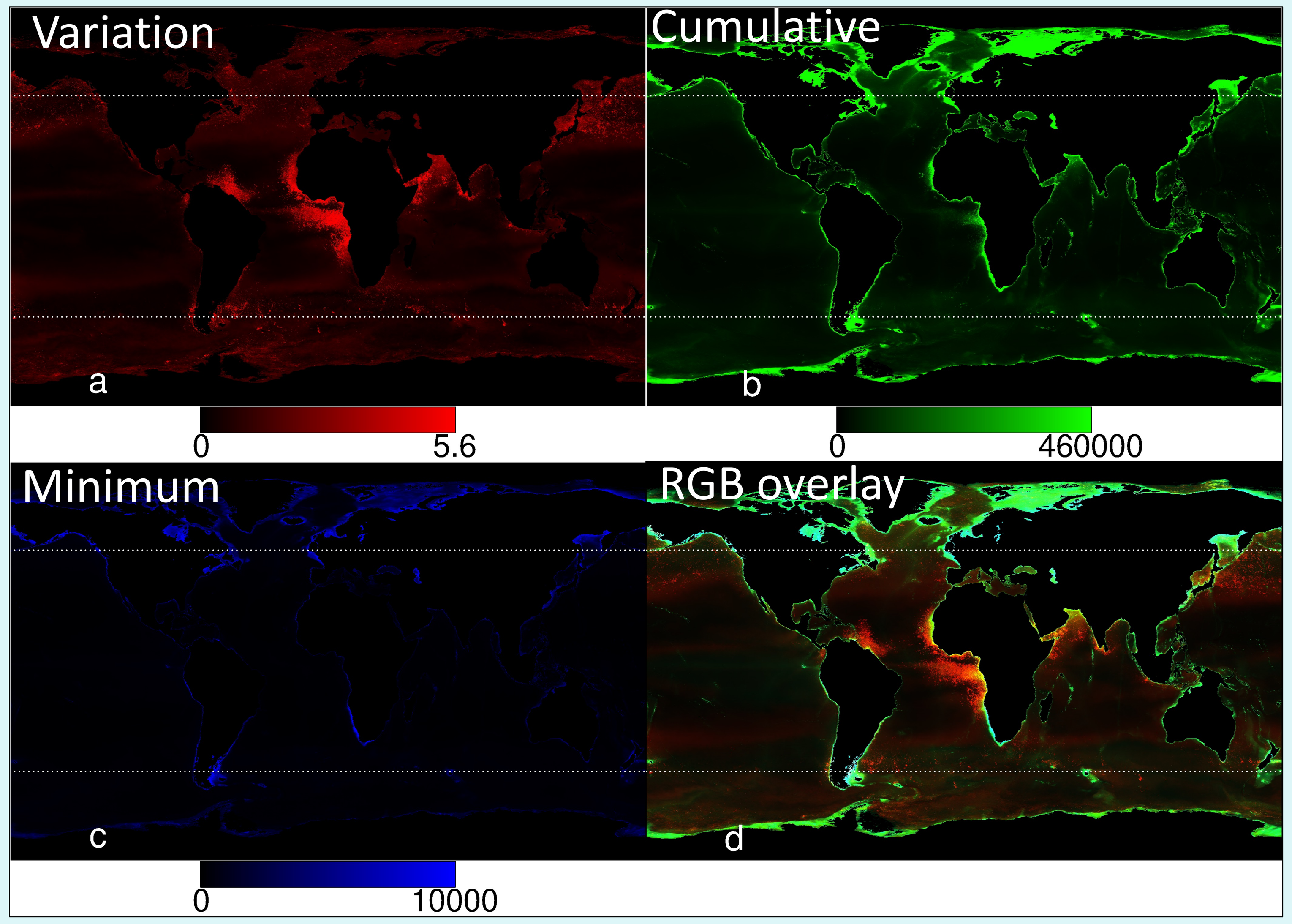
Energy proxies

- MODIS Aqua satellite data used to calculate energy proxies:
  - Radiative: PAR, SST
  - Metabolic: Chlorophyll, Primary productivity (VGPM), benthic POC
- Coefficient of variation, cumulative, and minimum energy over an average year energy curve (2003-2019)
- Excluded polar points (> 50 and < -50 latitude) due to satellite measurement limitations

Radiative example: PAR (E m^{-2})



Metabolic example: Benthic POC (mg m^{-2})



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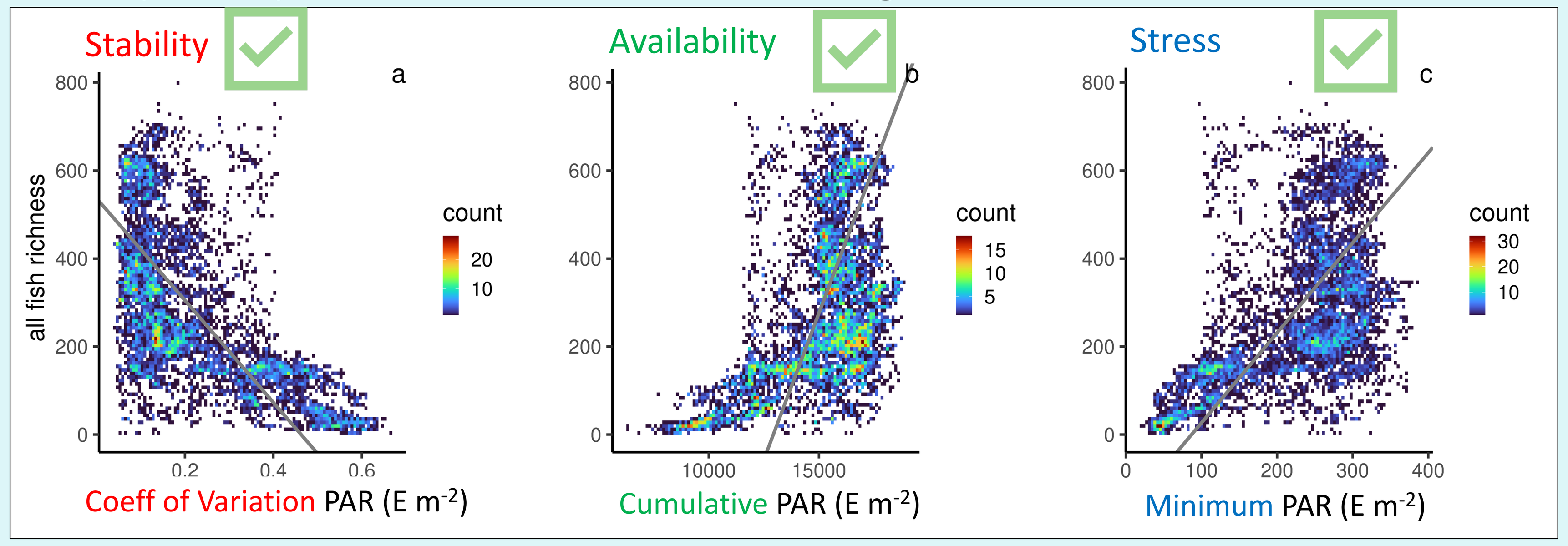
References

- Hobi, Martina L., Maxim Dubinin, Catherine H. Graham, Nicholas C. Coops, Murray K. Clayton, Anna M. Pidgeon, and Volker C. Radeloff. 2017. "A Comparison of Dynamic Habitat Indices Derived from Different MODIS Products as Predictors of Avian Species Richness." *Remote Sensing of Environment* 195 (June): 142–52. https://doi.org/10.1016/j.rse.2017.04.018.
- Radeloff, V. C., M. Dubinin, N. C. Coops, A. M. Allen, T. M. Brooks, M. K. Clayton, G. C. Costa, et al. 2019. "The Dynamic Habitat Indices (DHIs) from MODIS and Global Biodiversity." *Remote Sensing of Environment* 222 (March): 204–14. https://doi.org/10.1016/j.rse.2018.12.009.

2D density plots and model II regressions

- Pixel matched energy indices and fish richness data
- Model II regressions (Ranged Major Axis, p < 0.01)
- Correlation coefficient (r) with parametric p value < 0.01
- Considered sign (+/-) and significance of regressions

PAR (E m^{-2}) and all fish in coastal region



Regression results summary

Coastal

Fish:

	Energy	Stability	Availability	Stress
All fish	Radiative	✓	✓	✓
	Metabolic	✓	✗	✗
Pelagic fish	Radiative	✓	✓	✓
	Metabolic	✗	✓	✗
Demersal fish	Radiative	✗	✗	✗
	Metabolic	✗	✓	✓
Reef	Radiative	✓	✓	✓
	Metabolic	✓	✗	✗

Mammals:

Energy	Stability	Availability	Stress
Radiative	✓	✓	✓
Metabolic	✓	✓	✓

Reptiles:

Energy	Stability	Availability	Stress
Radiative	✓	✓	✓
Metabolic	✓	✗	✗

Lobsters:

Energy	Stability	Availability	Stress
Radiative	✓	✓	✓
Metabolic	✓	✗	✓

Offshore

Fish:

	Energy	Stability	Availability	Stress
All fish	Radiative	✓	✓	✓
	Metabolic	✗	✗	✓
Pelagic fish	Radiative	✓	✓	✓
	Metabolic	✗	✗	✗
Demersal fish	Radiative	✓	✓	✓
	Metabolic	✗	✓	✓

Mammals:

Energy	Stability	Availability	Stress
Radiative	✓	✓	✓
Metabolic	✗	✗	✗

Reptiles:

Energy	Stability	Availability	Stress
Radiative	✓	✓	✓
Metabolic	✓	✗	✗

Lobsters:

Energy	Stability	Availability	Stress
Radiative	✓	✓	✓
Metabolic	✗	✓	✓

Results show that the biodiversity energy hypotheses are broadly applicable to marine species