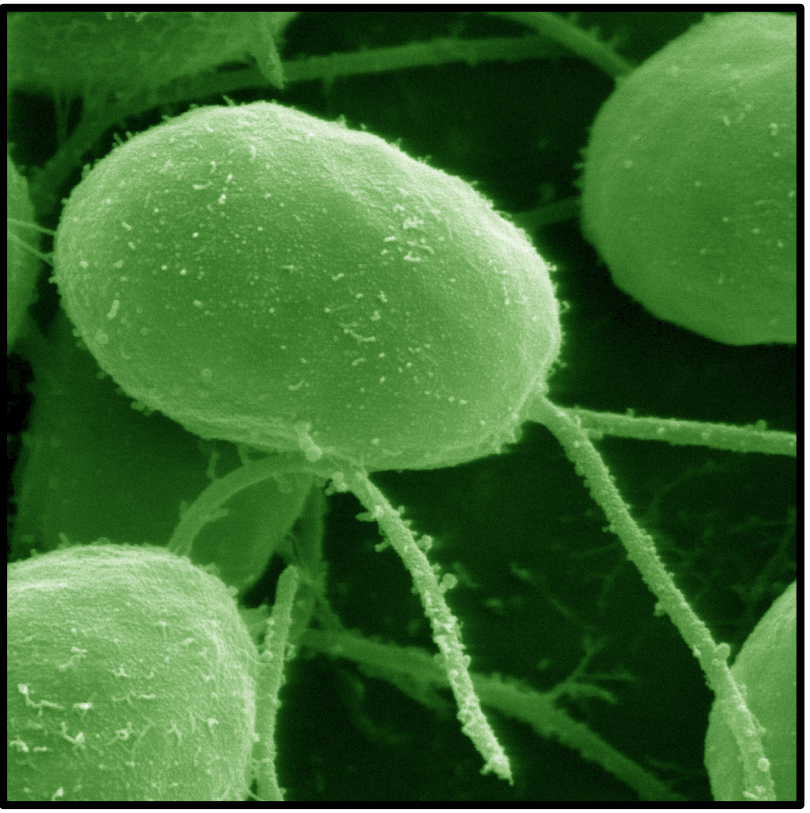
Towards a mechanistic understanding of biodiversity change: from cells to ecosystems and human well-being



Joey Bernhardt
University of Guelph
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“When the tide goes out, the table is set”

Chief Leah George-Wilson,
Tsleil-Waututh


"When the tide goes out, the table is set"
Ecosystem
Human well-being
Change
Changing, living coastal system
Chief Leah George-Wilson, Tsleil-Waututh

Bernhardt and Leslie, 2013, *Annual Review of Marine Science*
Singh, Hilmi, **Bernhardt** et al. 2019, *People and Nature*

Fishers in Madagascar (Credit: artush)

Climate change is pushing the Sustainable Development Goals further out of reach

Bernhardt and Leslie, 2013, *Annual Review of Marine Science*
Singh, Hilmi, **Bernhardt** et al. 2019, *People and Nature*

Fishers in Madagascar (Credit: artush)

How do living systems, across scales, respond to environmental change?

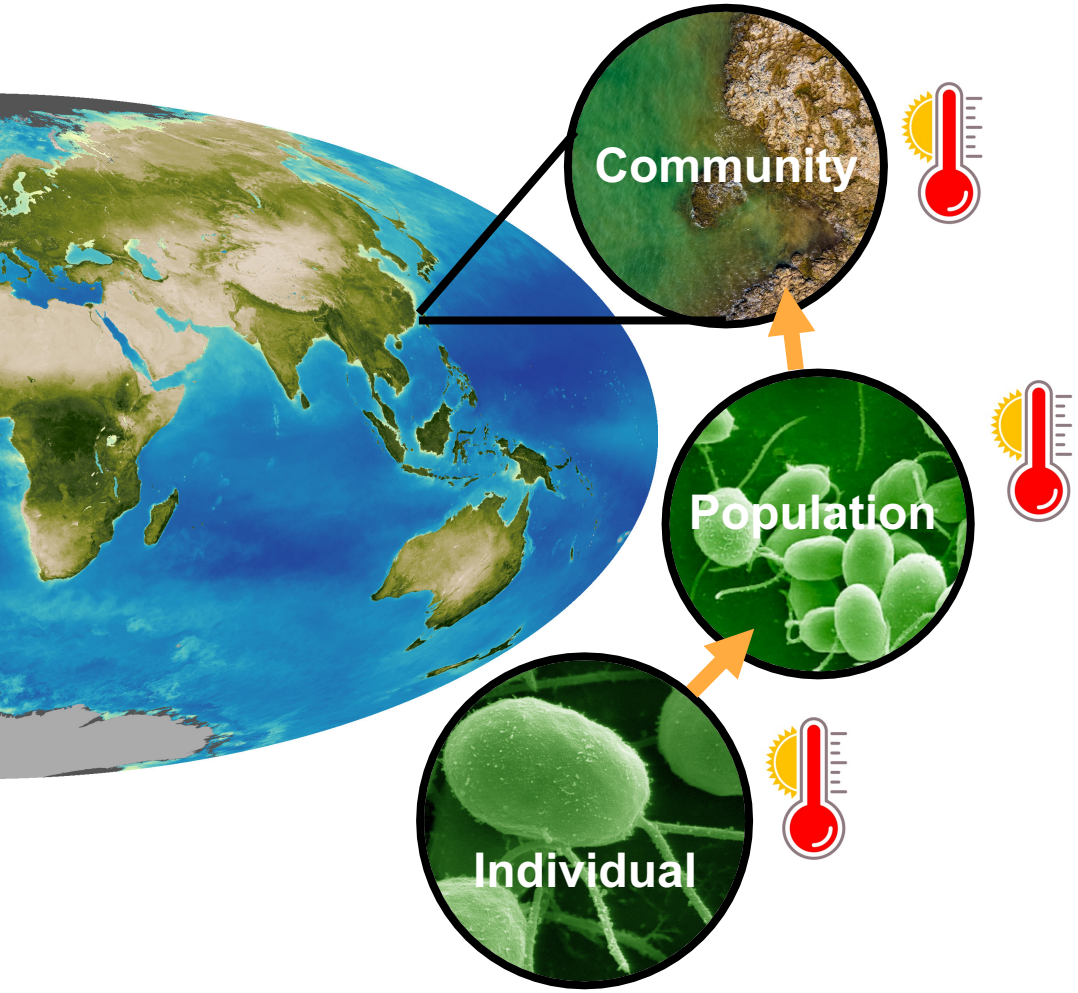
How do living systems, across scales, respond to environmental change?

LIFE
BELOW WATER

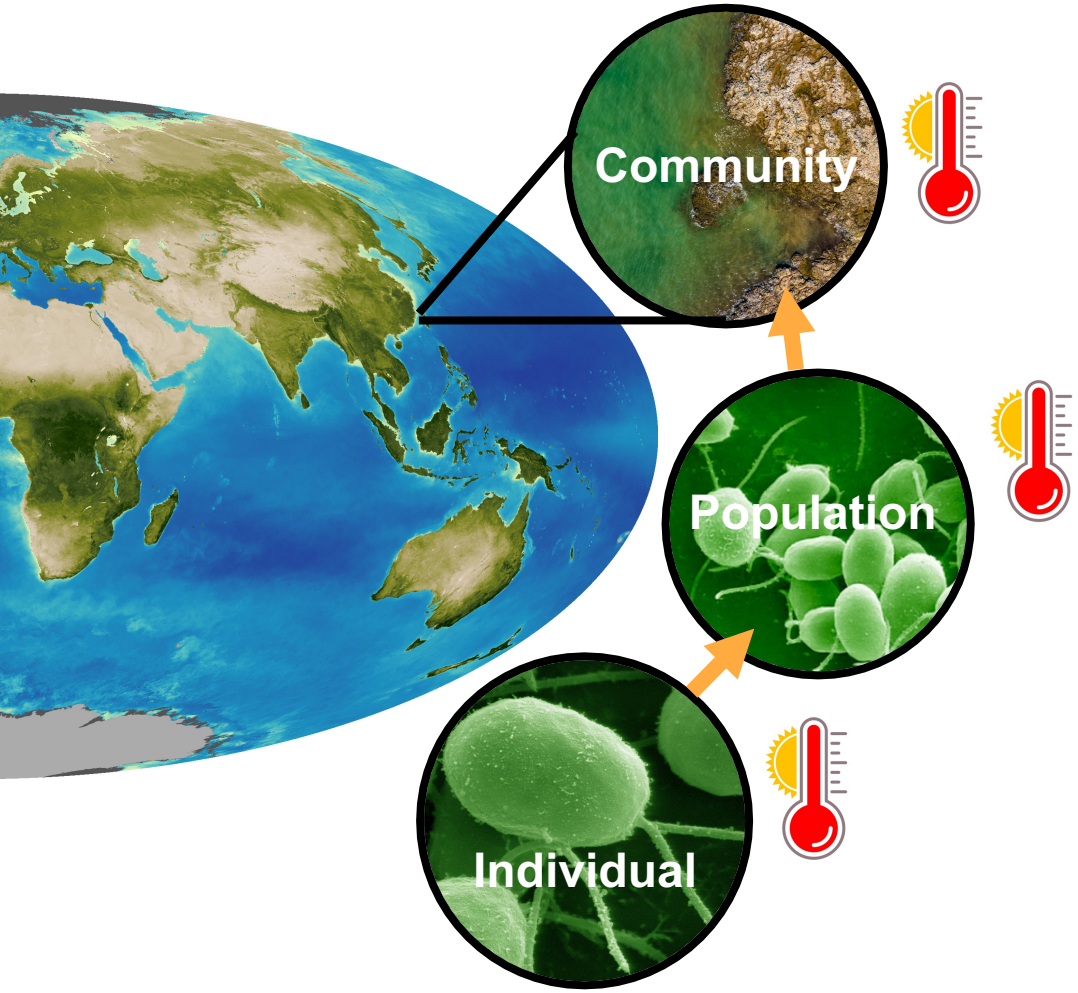
Mechanistic understanding of biodiversity change in aquatic systems

ZERO
HUNGER

Consequences of ecological change for seafood & human nutrition

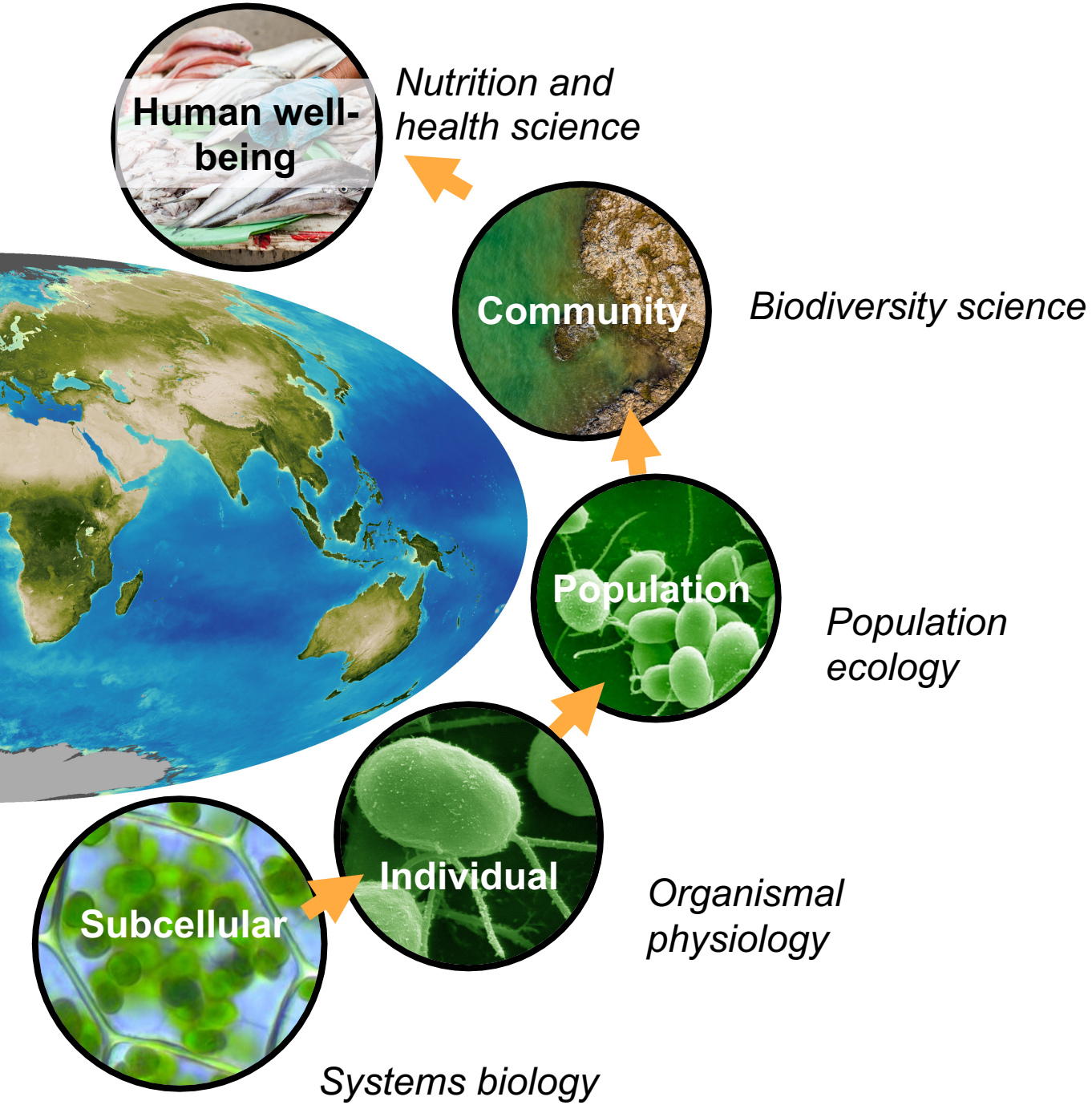


Mechanistic understanding of biodiversity *change* in ecology:



Mechanistic understanding of biodiversity *change* in ecology:

Connect understanding of processes operating at **another scale**



Mechanistic understanding of biodiversity *change* in ecology:

Connect understanding of processes operating at **another scale**

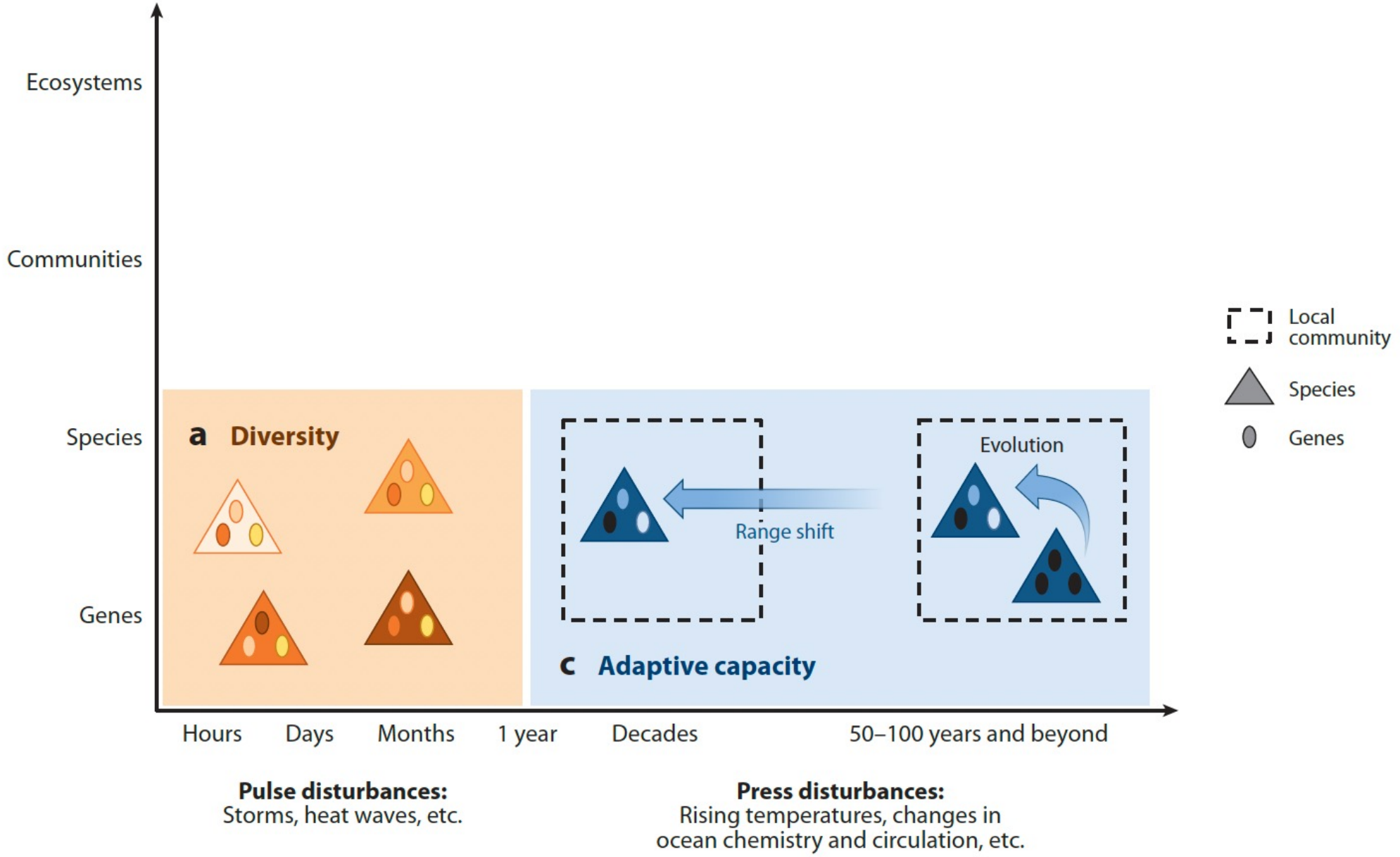
From cells to human well-being

Biodiversity at multiple scales enhances resilience

(The capacity of a system to maintain functioning, structure, and feedbacks in the face of environmental change)

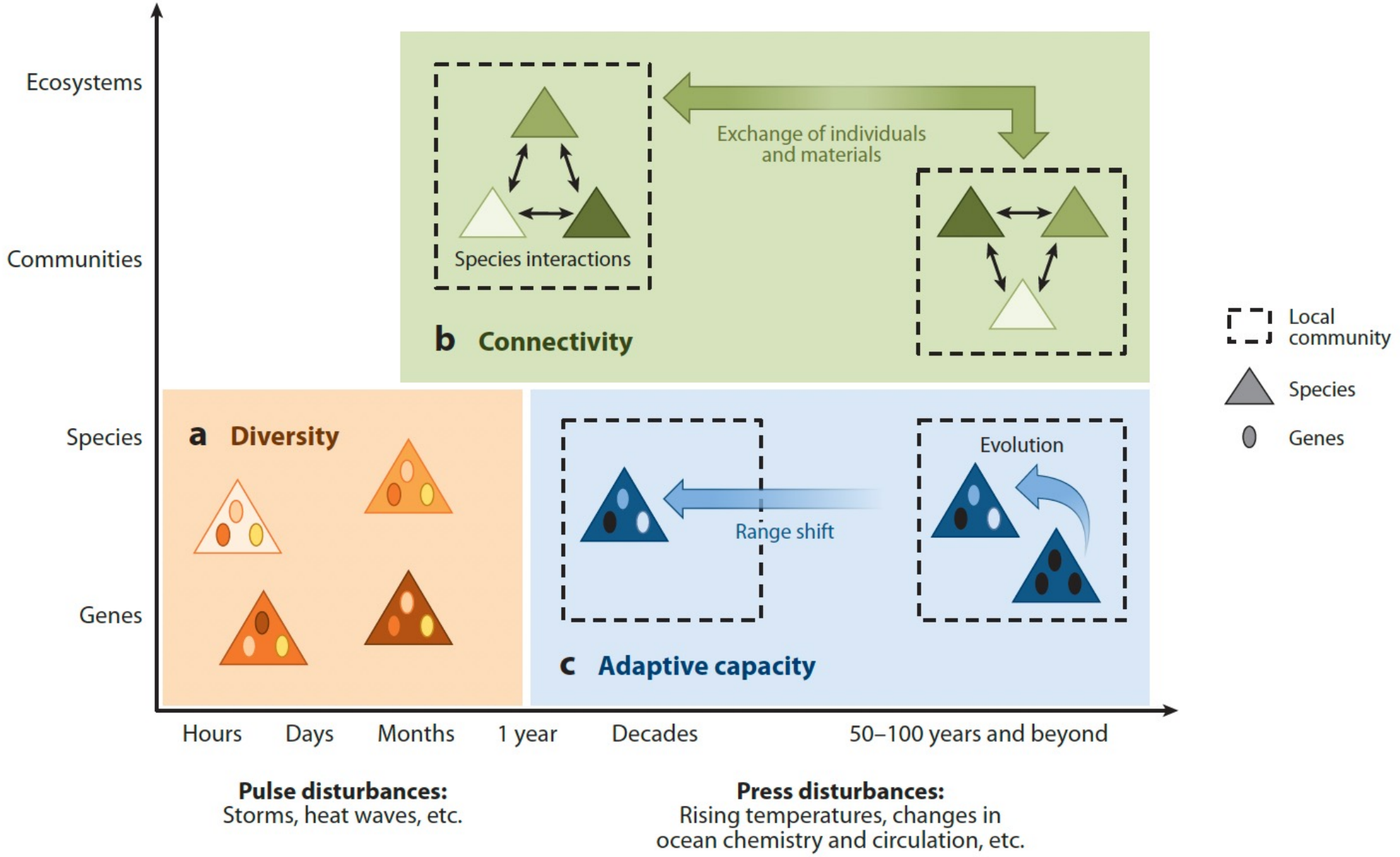
Biodiversity is critical for human well-being

Biodiversity enhances resilience across scales



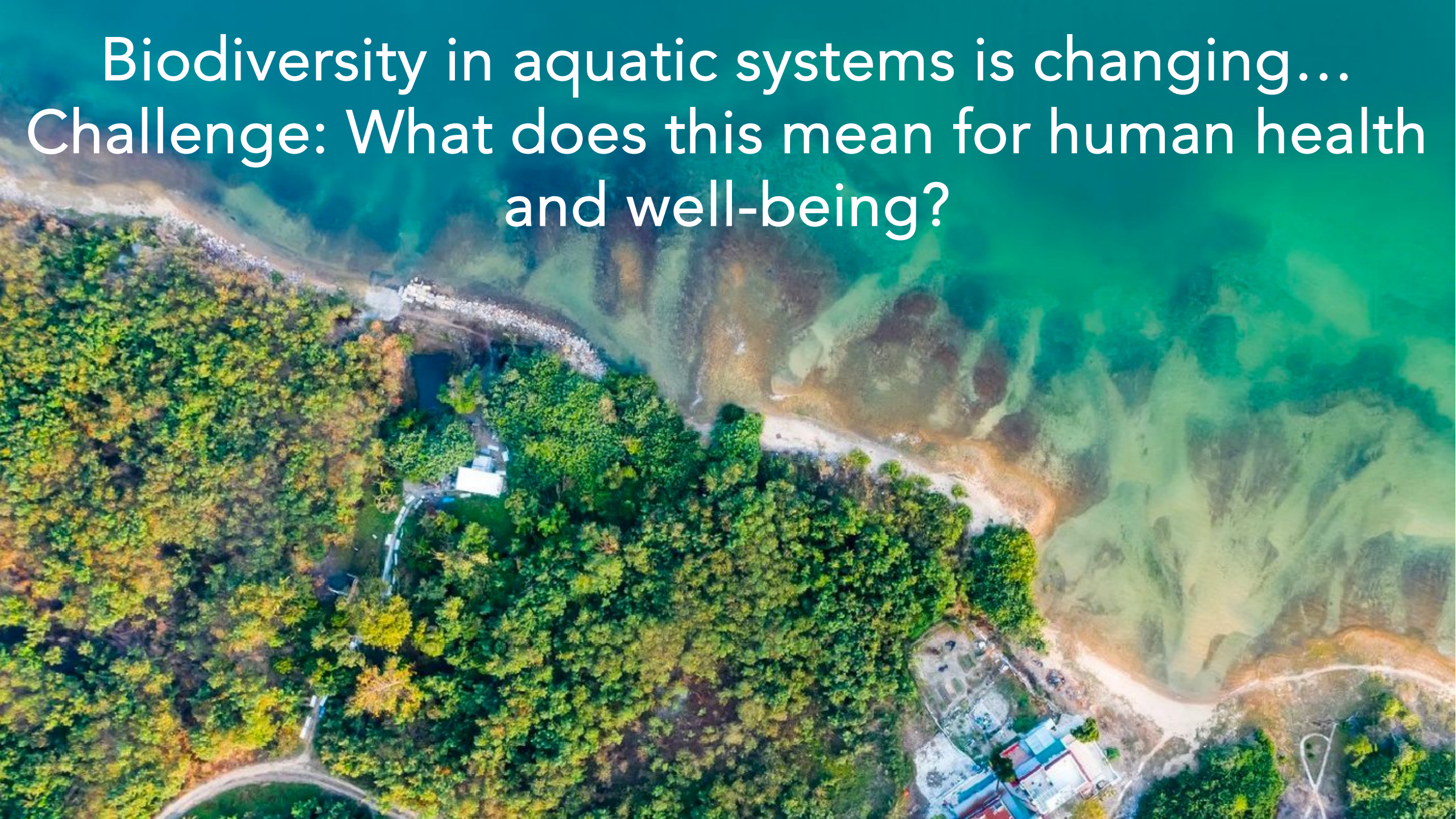
Bernhardt and Leslie 2013

Biodiversity enhances resilience across scales



Bernhardt and Leslie 2013

Biodiversity in aquatic systems is changing…
Challenge: What does this mean for human health and well-being?



Biodiversity increases ecosystem functioning

For coexistence, species differ in resource niches & complementarity in resource use

Tilman et al 1997 *PNAS*; Cardinale et al. 2012, *Nature*

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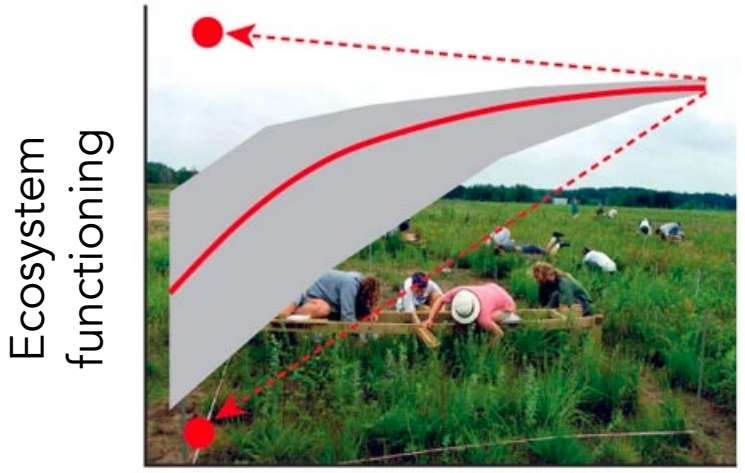
Biodiversity leads to increased functioning

$$Y = aS^b$$



Tilman et al 1997 *PNAS*; Cardinale et al. 2012, *Nature*

Biodiversity increases ecosystem functioning

For coexistence, species differ in resource niches & complementarity in resource use

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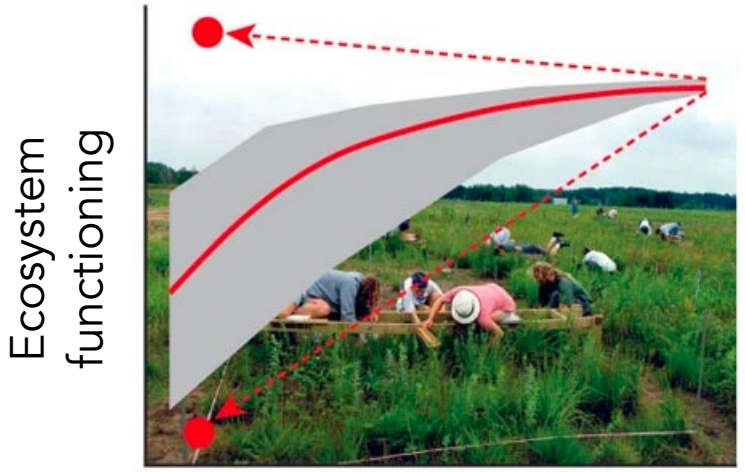


→ Ecosystem services

Yield

Few robust links to human health and well-being

Tilman et al 1997 *PNAS*; Cardinale et al. 2012, *Nature*

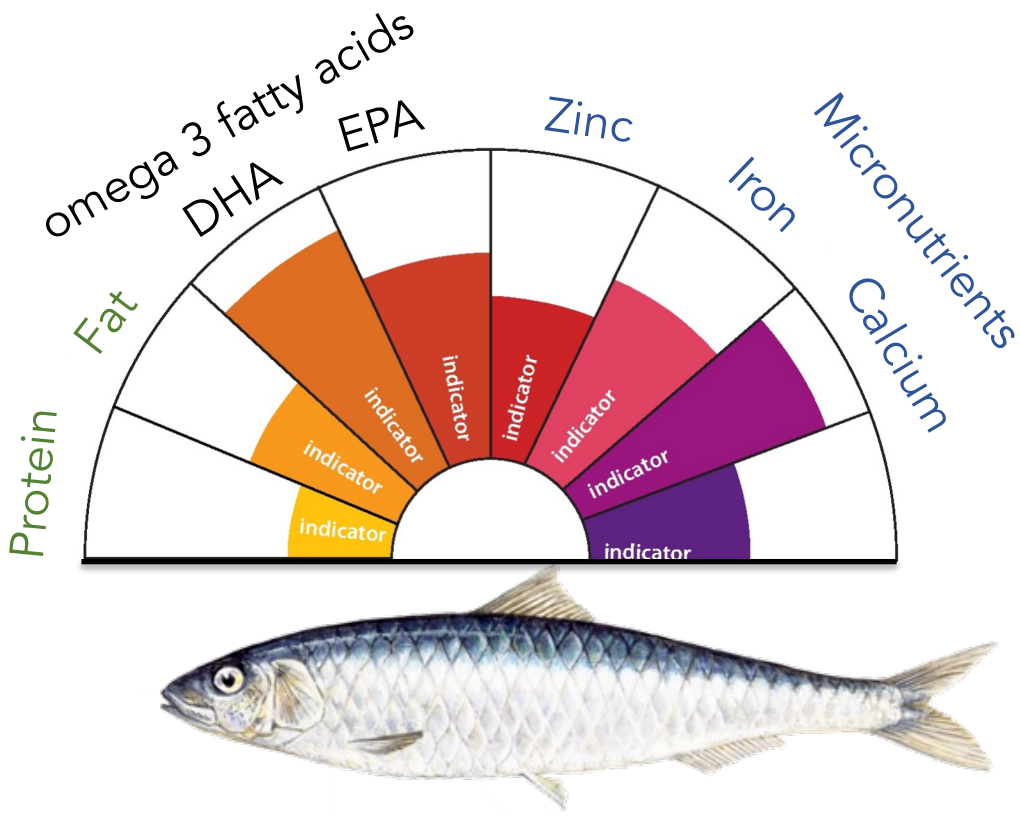
Total biomass yields are not predictive of health benefits:

Higher fish consumption, but *lower micronutrient intake (hidden hunger),* due to diet switch to low biodiversity seafood diet

(1990) Bangladesh (2010)

Bogard et al. 2015, Thilsted et al. 2016

Human health benefits from seafood: Not just a matter of yields



Recommended dietary allowance (RDA)

Nutrition Facts
Valeur nutritive
Per 114 g / par 114 g

Amount / Teneur	% Daily Value / % valeur quotidienne
Calories / Calories 196	
Fat / Lipides 8 g	**1** %
Saturated / saturés 2 g	
Omega-3 / oméga-3 2 g	
Cholesterol / Cholestérol 43 mg	
Sodium / Sodium 58 mg	**2** %
Carbohydrate / Glucides 0 g	**0** %
Fibre / Fibres 0 g	**0** %
Sugars / Sucres 0 g	
Protein / Protéines 29 g	
Vitamin A / Vitamine A	1 %
Vitamin C / Vitamine C	2 %
Calcium / Calcium	2 %
Iron / Fer	5 %

Need to reach nutritional targets for a range of nutrients simultaneously

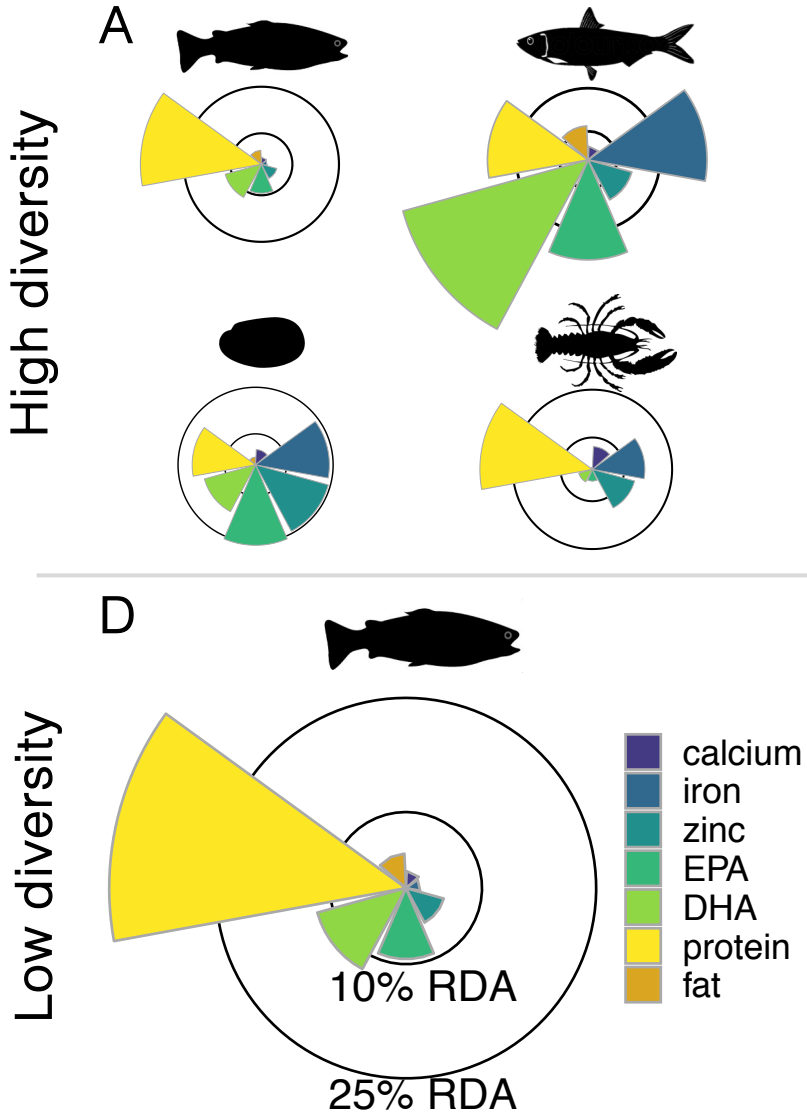
Seafood biodiversity benefit hypothesis:

a. Species richness enhances nutritional benefits

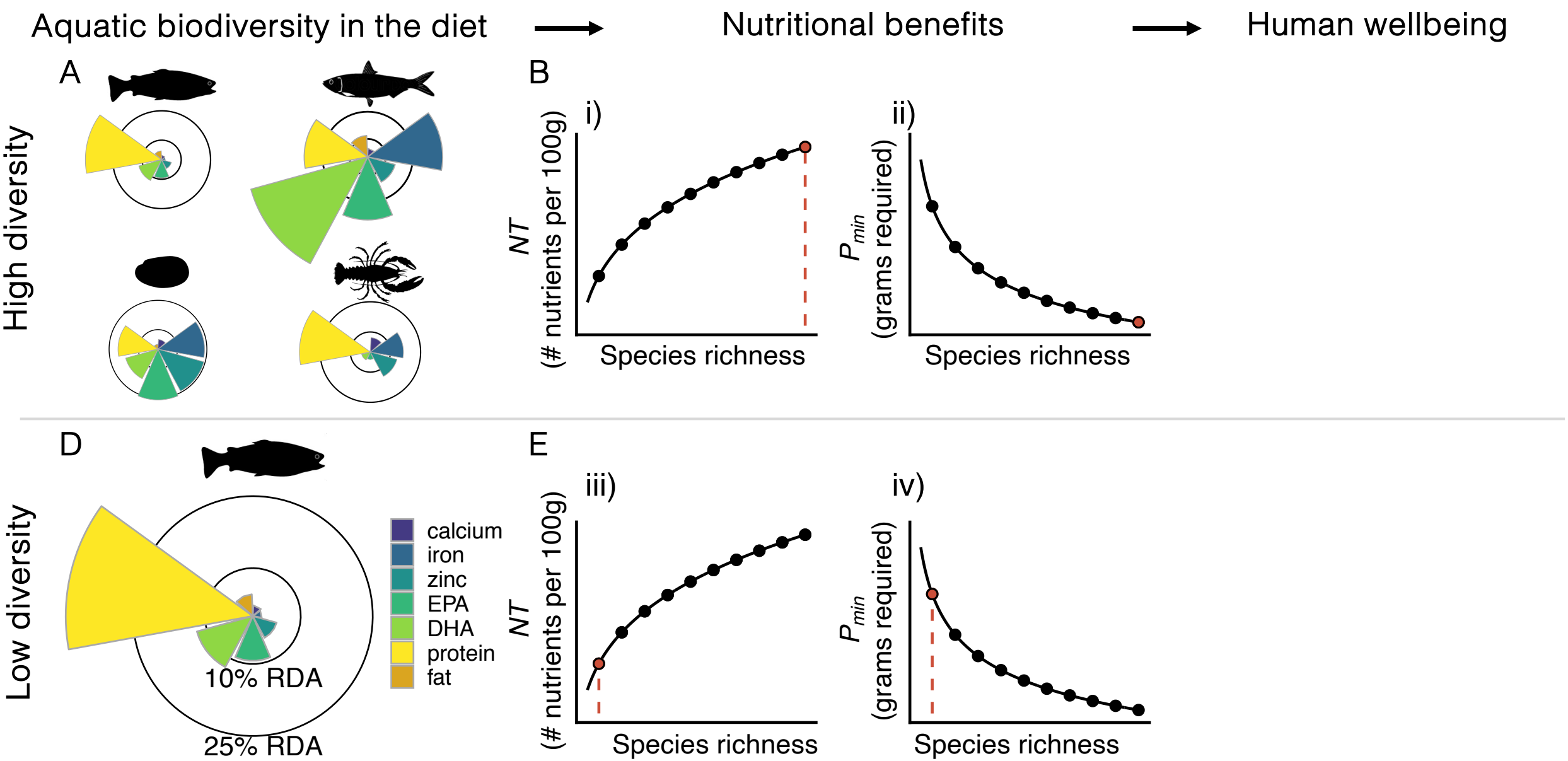
b. Ecological functional diversity is positively associated with nutrient diversity, and therefore increased nutritional benefits

Tilman et al. 1997, Loreau and Hector 2001, Cardinale et al. 2012

Aquatic biodiversity in the diet → Nutritional benefits → Human wellbeing



Bernhardt and O'Connor, *PNAS*, 2021



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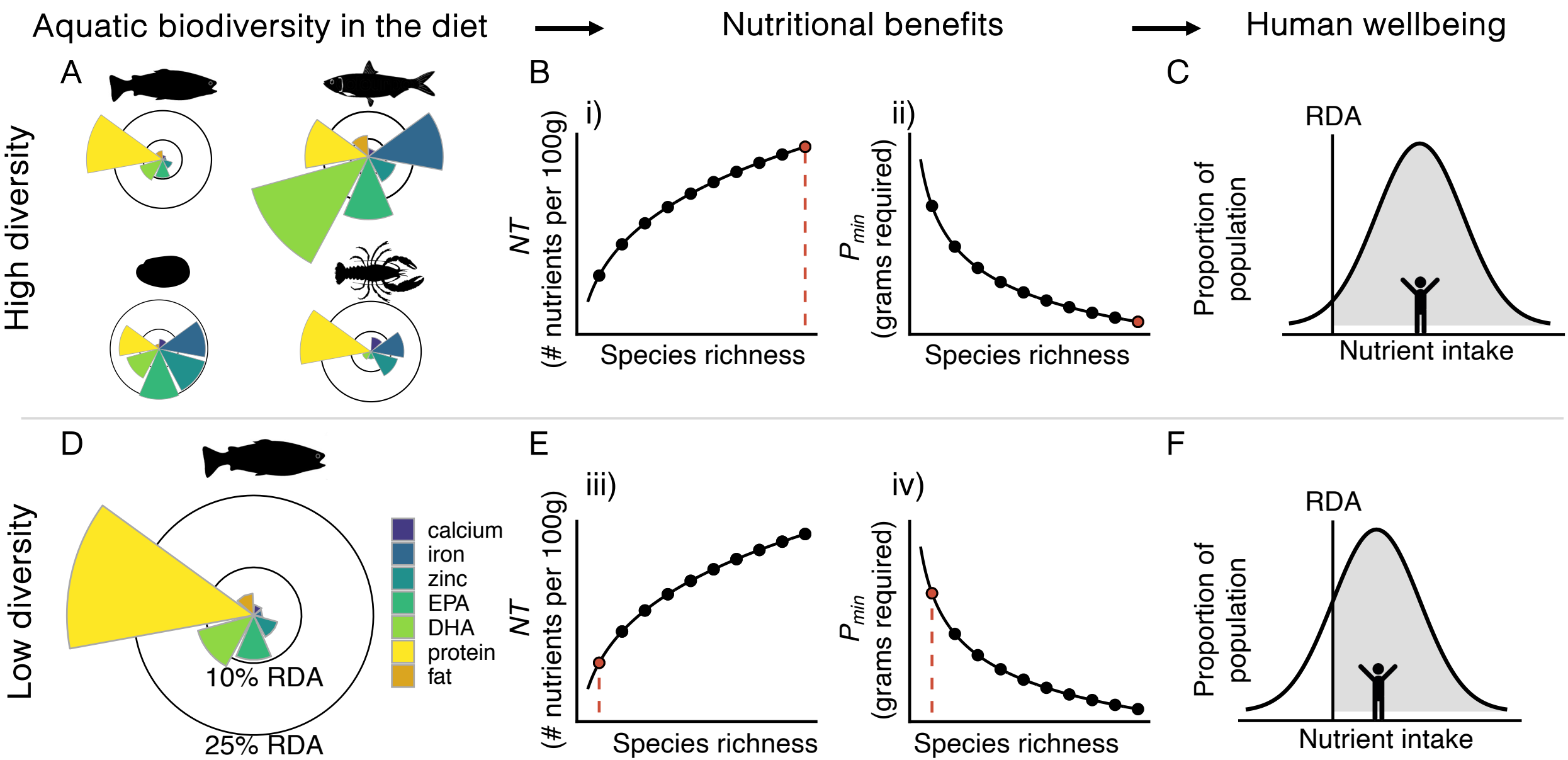
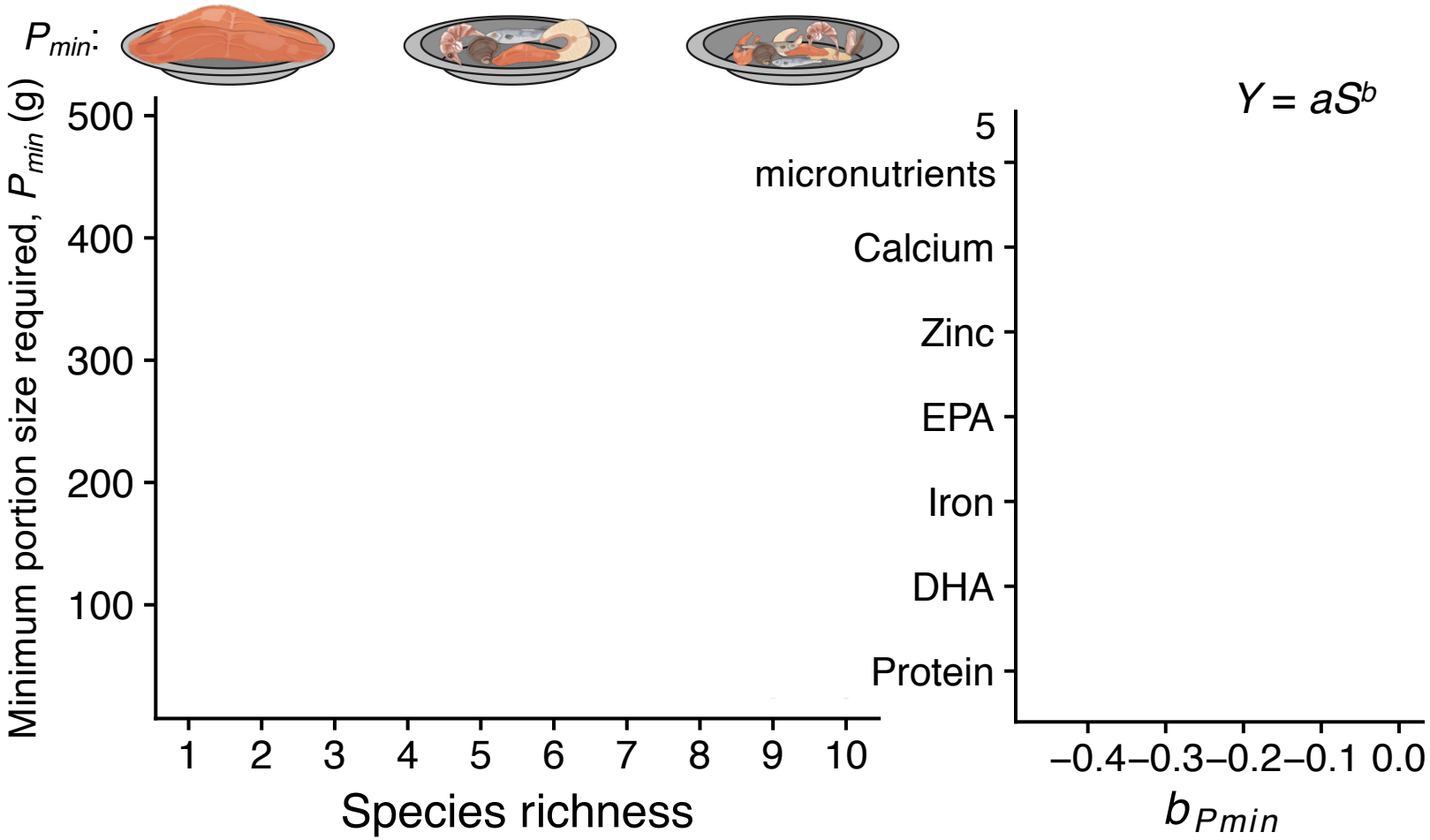


Bernhardt and O'Connor, *PNAS,* 2021

Benefits of biodiversity for micronutrients and fatty acids, not protein



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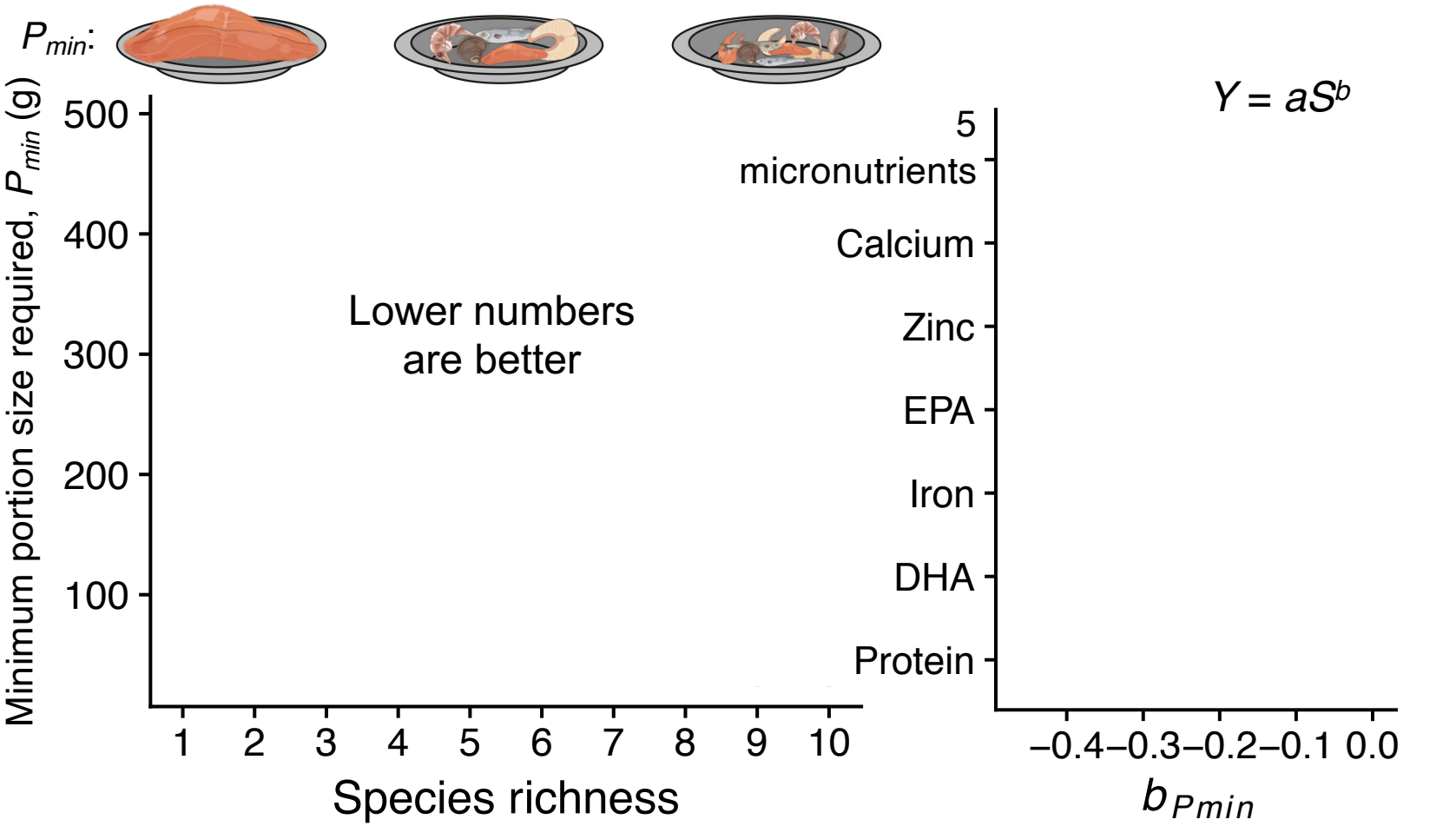

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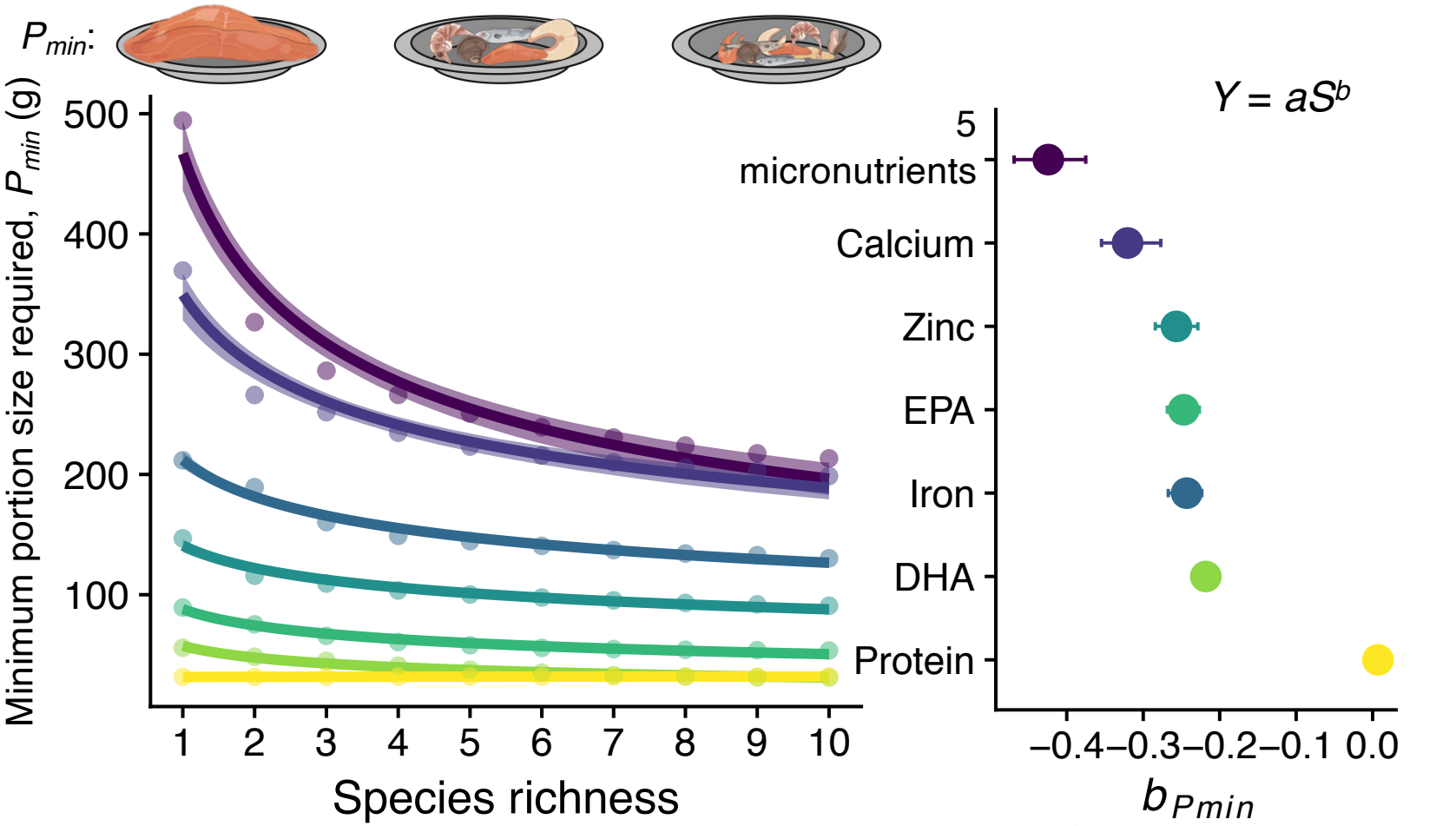
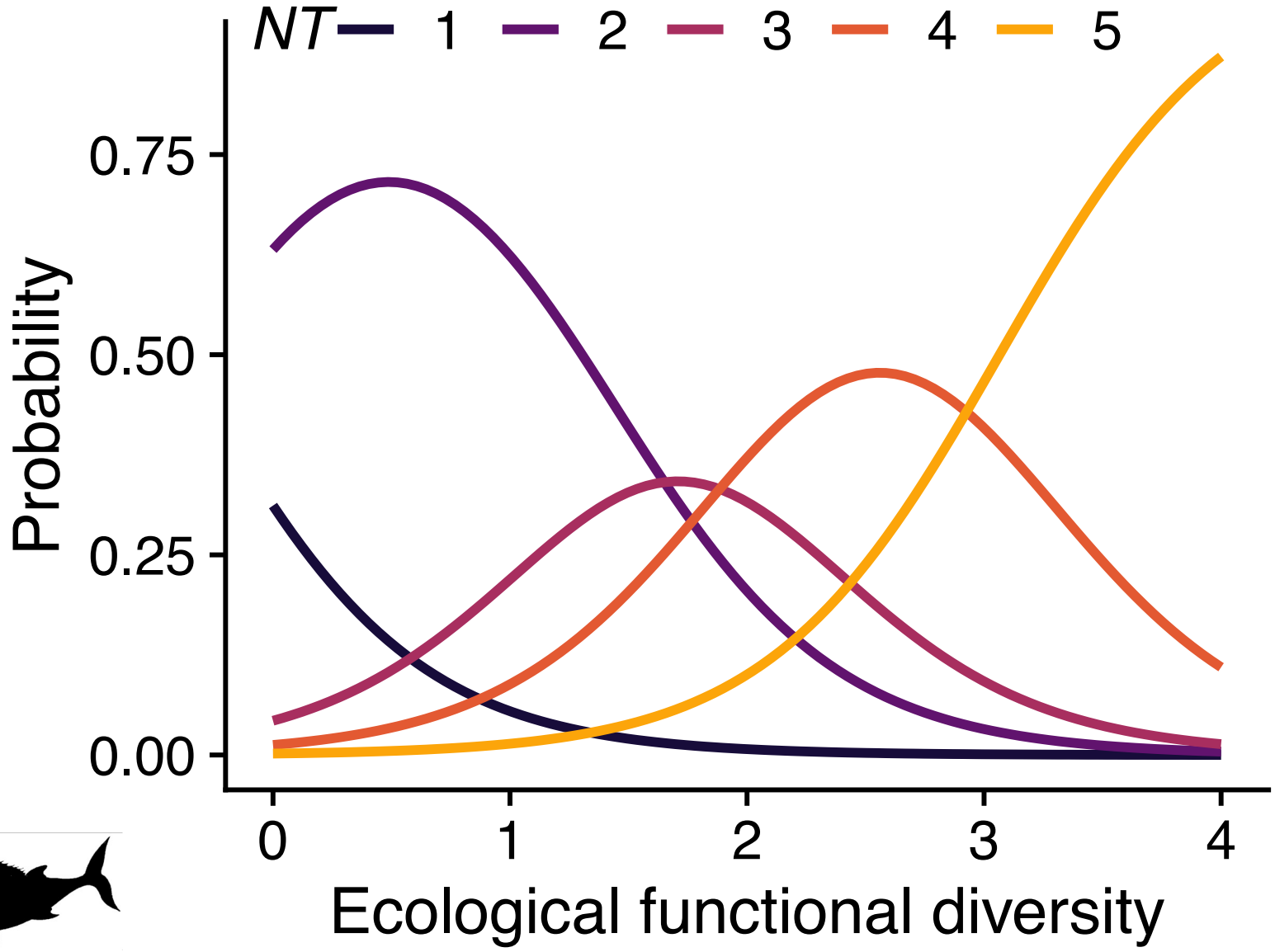
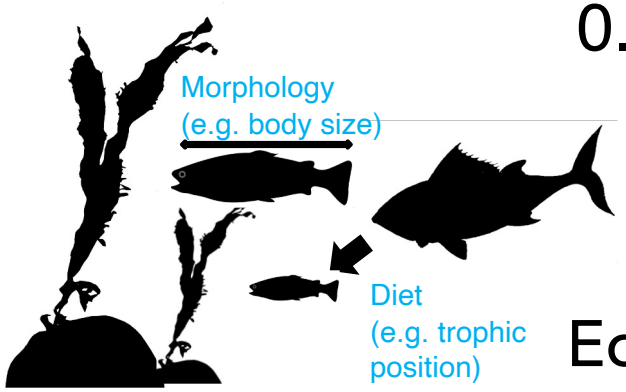


Bernhardt and O’Connor, *PNAS*, 2021

Nutritional benefits are associated with ecological trait diversity

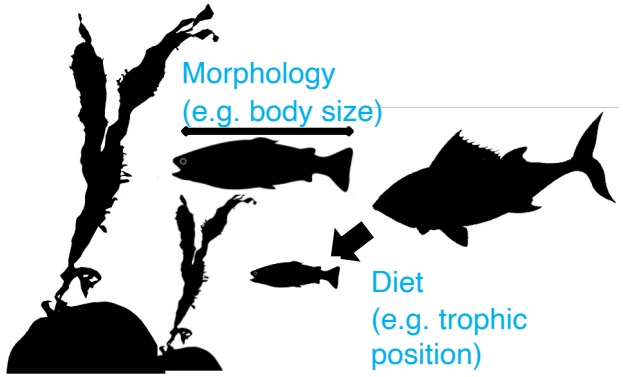




Ecological traits

Bernhardt and O'Connor, *PNAS*, 2021

Processes that maintain biodiversity (competition, predation)



Ecological traits

Benefits to human health

Summary

*Biodiversity is critical for micronutrients, not for protein.

Biodiversity is essential to meet nutritional requirements efficiently.

*Similar patterns at local scales, also for contaminants (methylmercury, lead, cadmium, arsenic)

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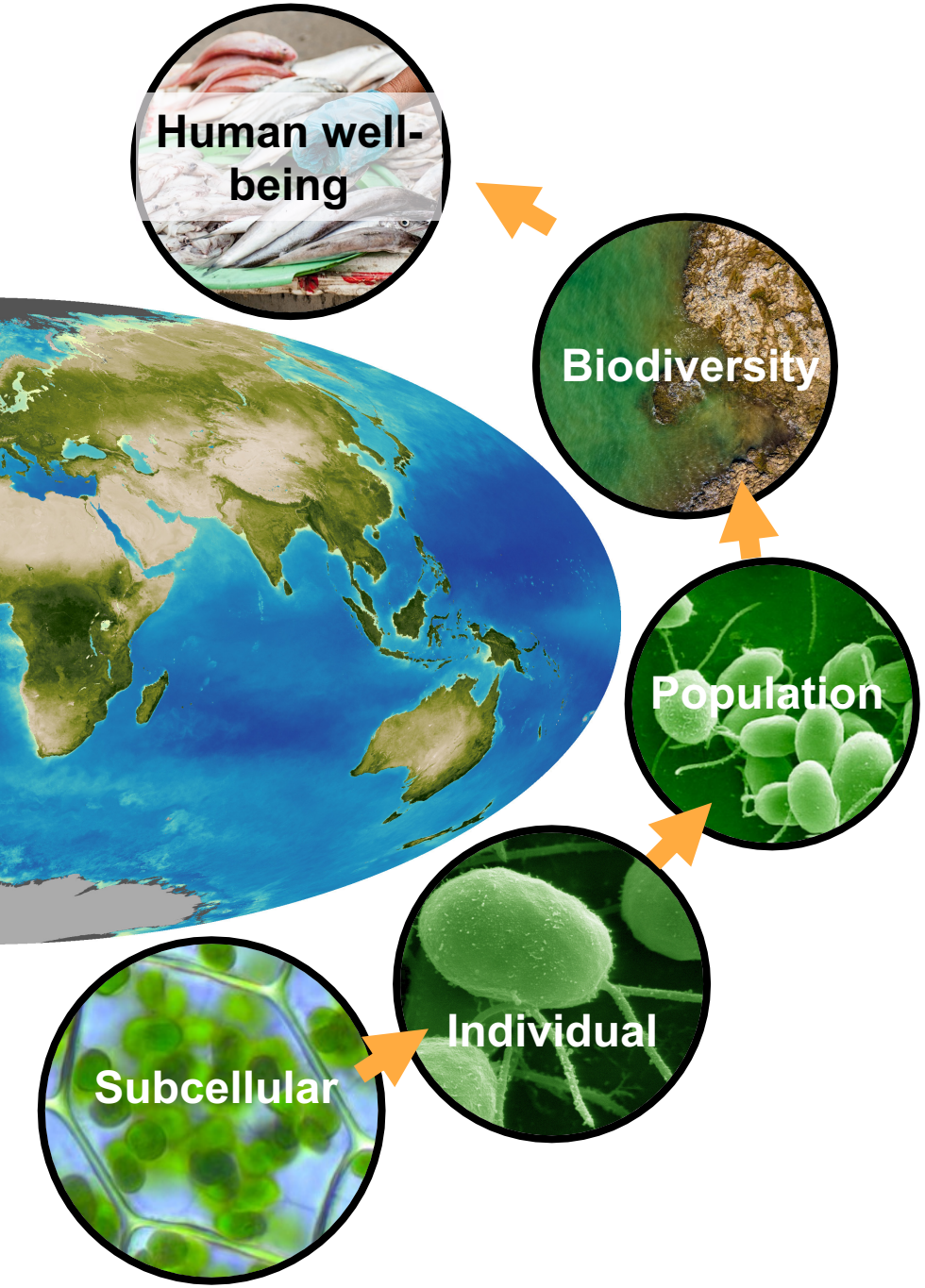

Challenge: Understanding the causes and consequences of biodiversity change, and consequences to human well-being.

Approach: Develop and test theoretical frameworks that allow us to relate processes at one scale to outcomes at another scale.

Common metabolic mechanisms → general understanding of change in living systems.

Thank you!

bernhardtlab.org | @joeybernhardt

NSERC CRSNG

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NEREUS PROGRAM
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