

Facilitation cascades (FCs) increases biodiversity but can be destroyed by heatwaves

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Terminology: Direct effects vs. indirect ‘inhibition cascades’

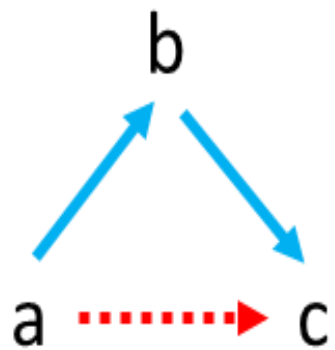
1. Direct effects: 1st species → focal

÷ Inhibition
+ Facilitation

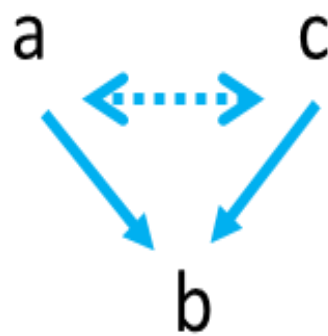
		Organism 1		
		÷	0	+
Organism 2	÷	Competition		
	0	Amensalism/ Biological disturbances	Neutralism	
	+	Consumption, Predation, Grazing, Parasitism	Commensalism/ Habitat-formation	Mutualism

2. Indirect effects (‘cascades’): 1st → 2nd → Focal ; i.e., 1st→ Focal

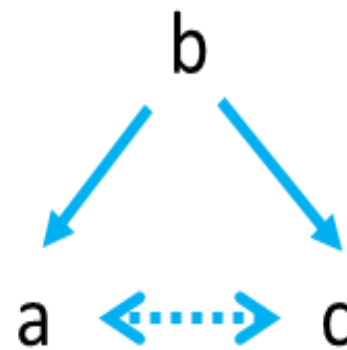
3. Most studies of indirect effects focus on inhibition processes (cascades) (e.g. Wootton 1994)



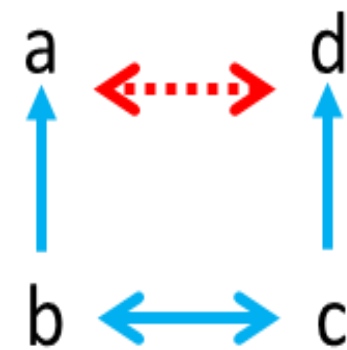
Trophic cascades



Exploitative Competition



Apparent Competition



Mutualism w/interference Competition

Inhibition cascades are ecologically important

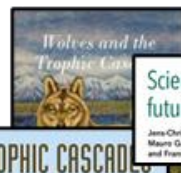
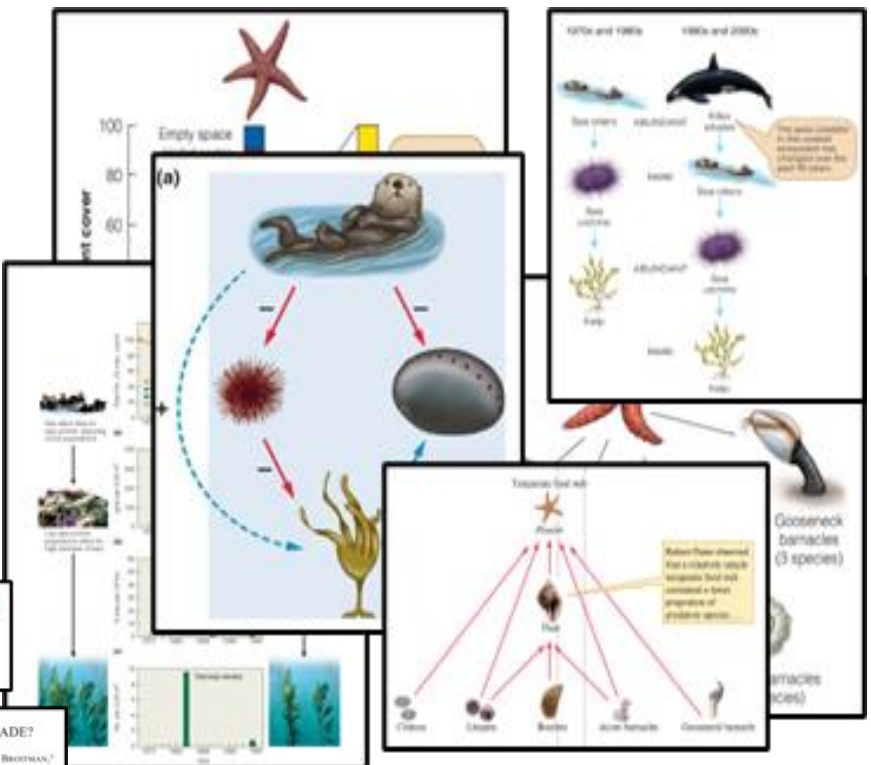
Trophic Cascades in a Formerly Cod-Dominated Ecosystem
Kenneth T. Frank,^{1*} Brian Petrie,¹ Jae S. Ch

Regulation of Keystone Predation by Small Changes in Ocean Temperature
Eric Sanford

Trait-mediated trophic cascade of enemy-free space for nesting hu
Harold F. Greeney,^{1,2,3} M. Rocio Men
R. William Mannan,³ Noel Snyder,⁶ He

Predator diversity dampens trophic cascades
Deborah L. Finke & Robert F. Denno

Climate Change, Keystone Predation, Diversity Loss



Science for a wilder Anthropocene: Synthesis and future directions for trophic rewilding research
Jena Christian Svenning^{1,2}, Pi B. N. Pedersen¹, C. Josh Donlan³, Ramon Egnar⁴, Sarah Feurly⁵, Mauro Galetti⁶, Dennis M. Hansen⁷, Brody Sandif⁸, Christopher J. Sandoni⁹, John W. Terborgh¹⁰, and Frans W. M. Morel¹¹

WHAT DETERMINES THE STRENGTH OF A TROPHIC CASCADE?
E. T. Borer,^{1*} E. W. Scarlson,¹ J. B. Shurin,² K. E. Anderson,³ C. A. Blanchette,⁴ B. Brodtman,⁵ S. D. Cooper,⁶ and B. S. Halpern⁷

A meta-analysis of the freshwater trophic cascade
MICHAEL T. BRETT* AND CHARLES R. GOLDMAN

The world and its shades of green: a meta-analysis on trophic cascades across temperature and precipitation gradients

A cross-ecosystem comparison of the strength of trophic cascades

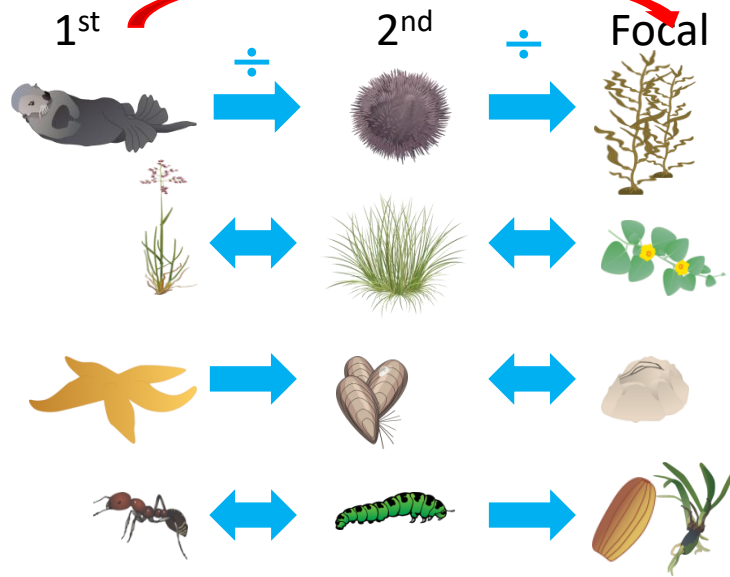
Science & Nature

Teaching & text-books

Books, Meta-analysis & Conservation

Inhibition cascades vs. Facilitation cascades

Indirect Facilitation

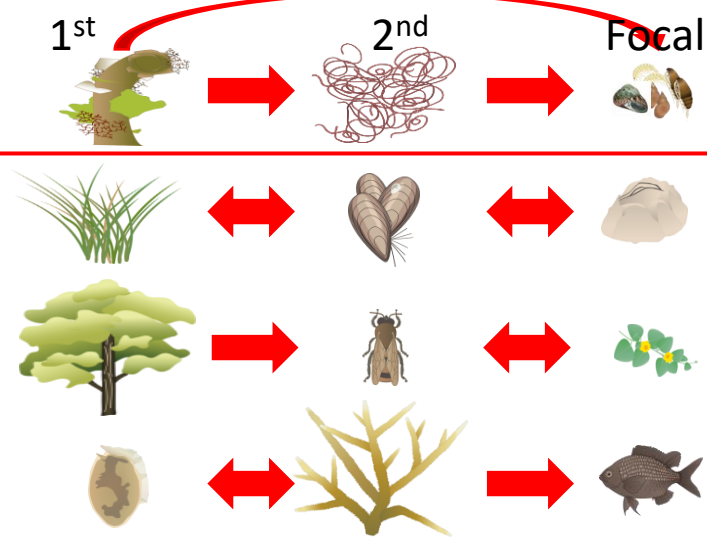


Inhibition cascades

An enemy of my enemy is my friend

1. Cascading Consumption
2. Cascading Competition
3. Keystone consumption
4. Keystone Competition

Indirect Facilitation

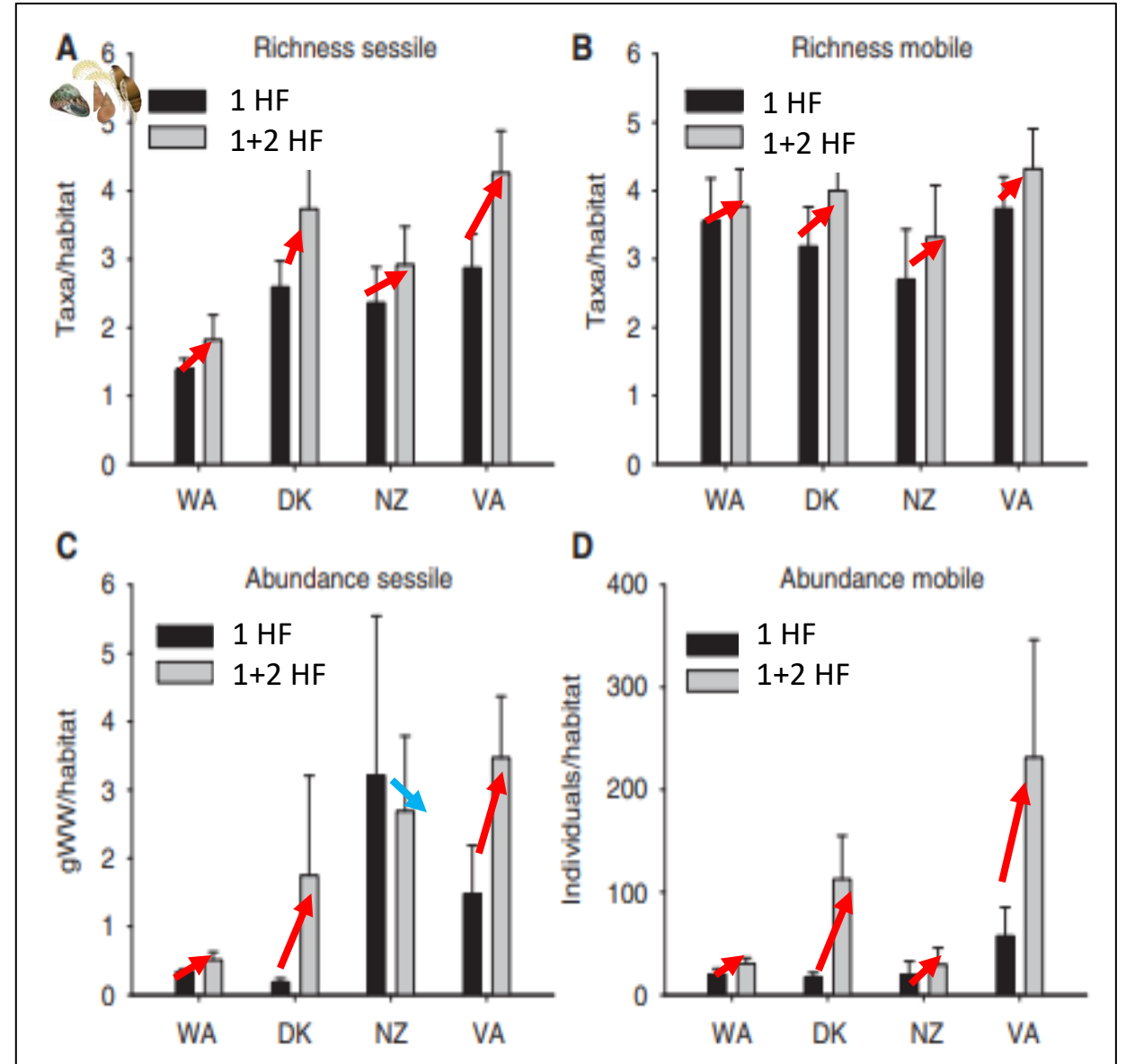
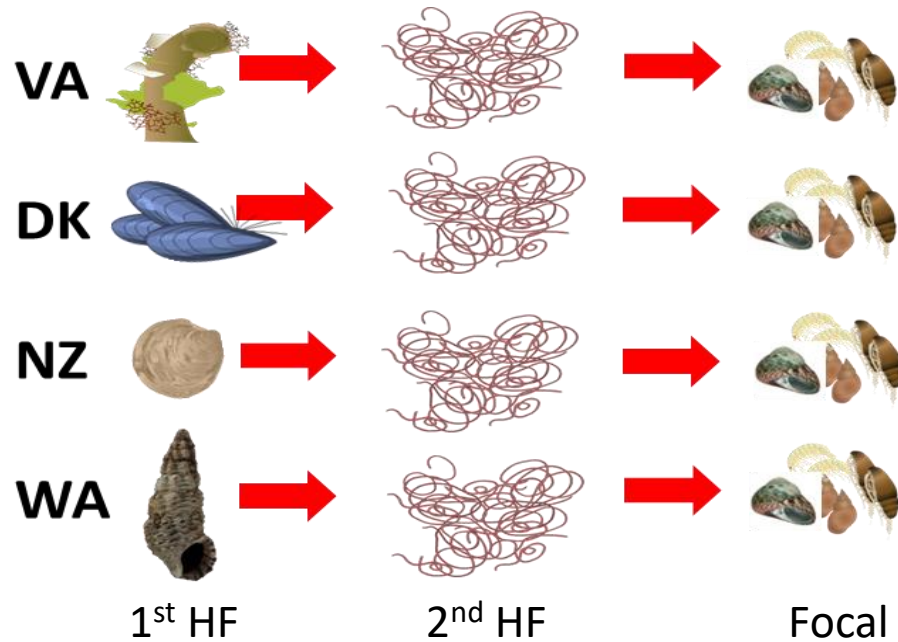


Facilitation cascades

A friend of my friend is my friend

1. Cascading Habitat-formation
2. Cascading Mutualism
3. Keystone Habitat-formation
4. Keystone Mutualism

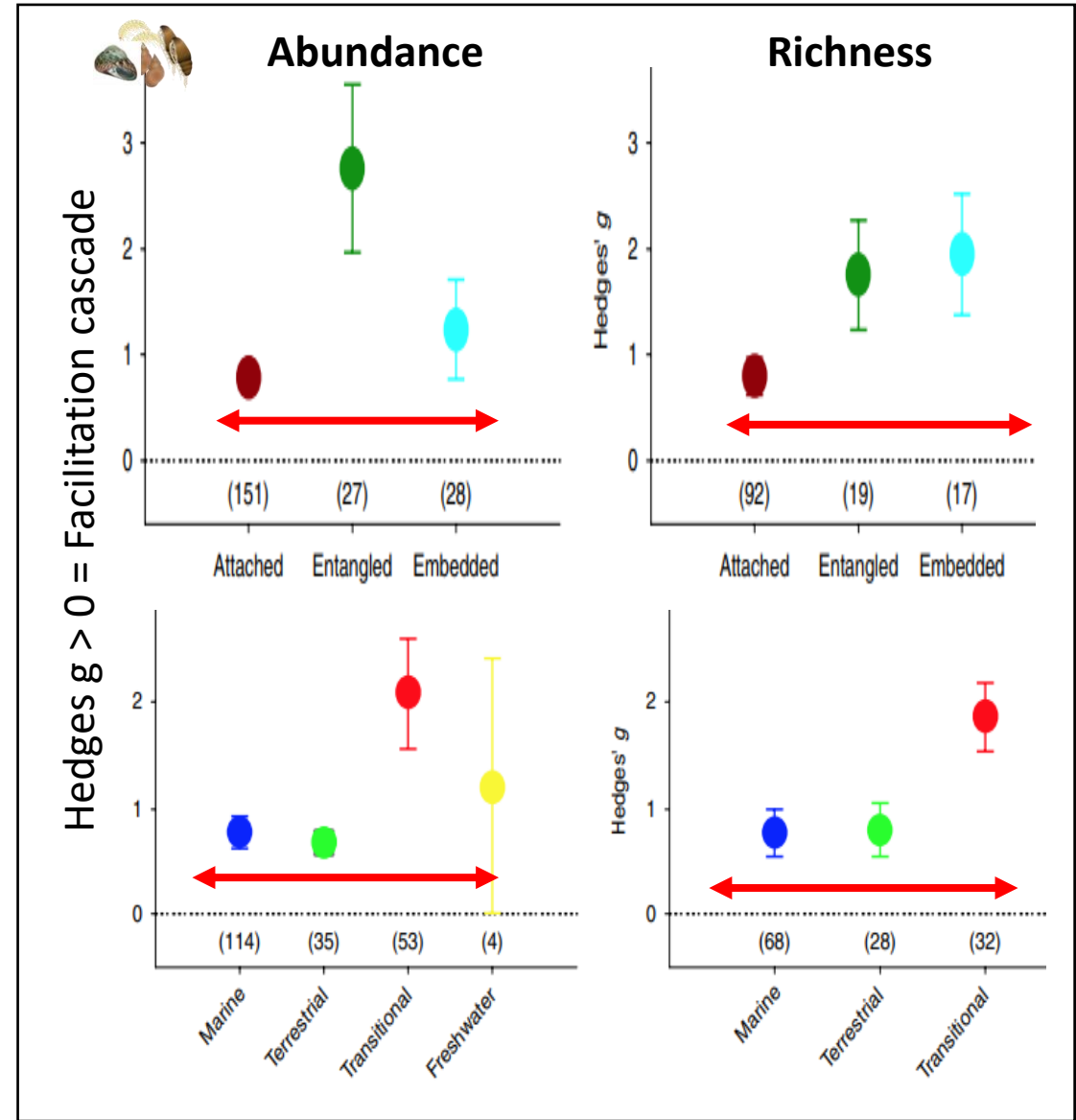
Pattern: FCs increase diversity **across biogenic mini-reefs**



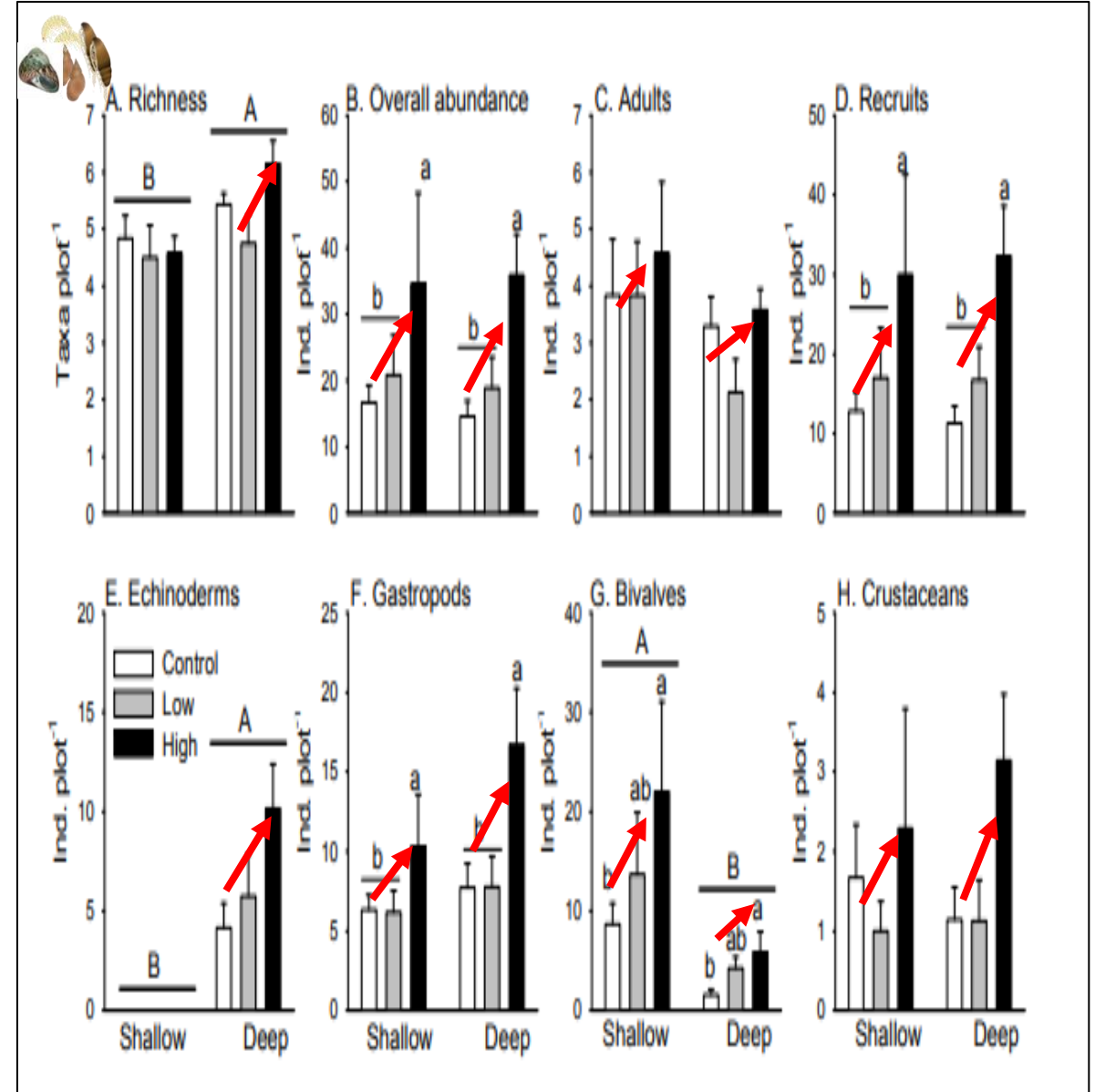
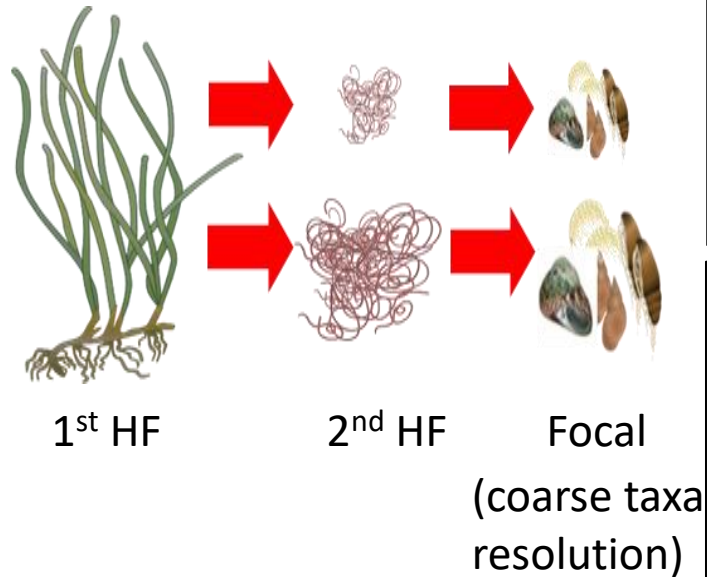
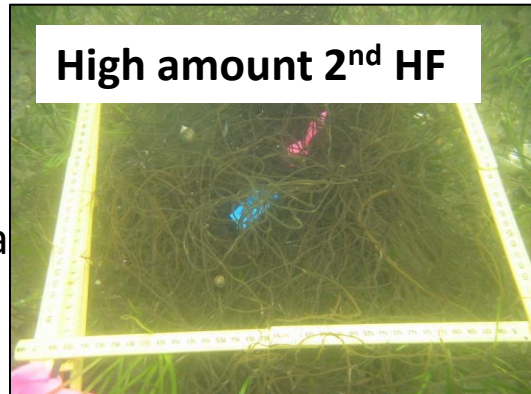
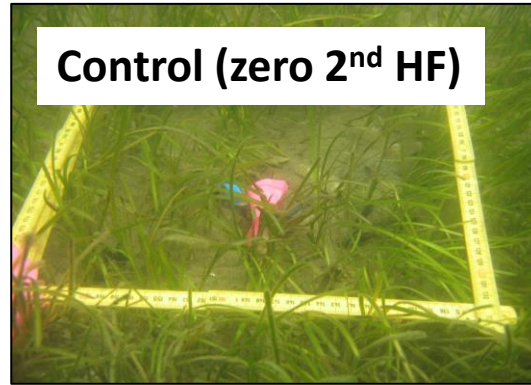
Pattern: FCs increase diversity **across ecosystems**



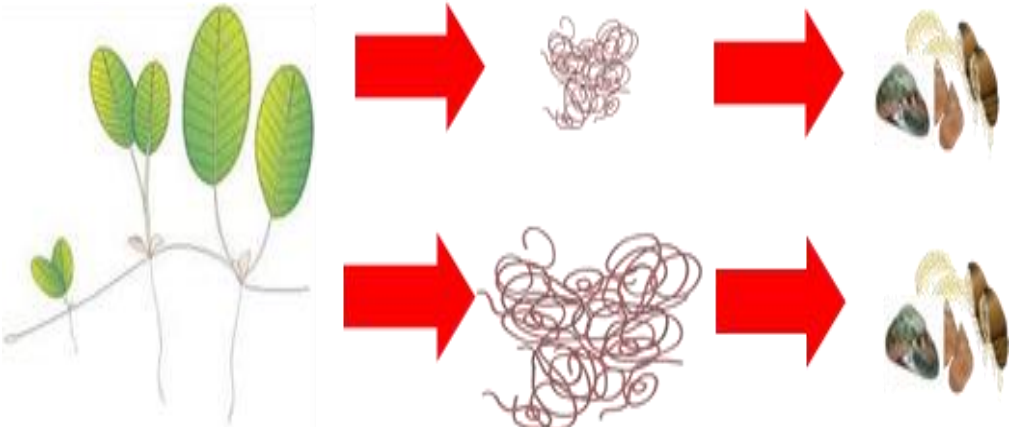
	Freshwater	Terrestrial	Brackish	Marine
Focal	Snail	Bird	Barnacles	Juvenile crabs
1+2 nd HF	Algal filaments (attached)	Mistletoe (attached)	Mussels (embedded)	Seaweed (entangled)
1 st HF	Plant	Tree	Marsh grass	Seagrass



Mechanism: FCs depend on habitat amounts (ADA)



Mechanism: FCs depend on habitat **affinity** (ADA)

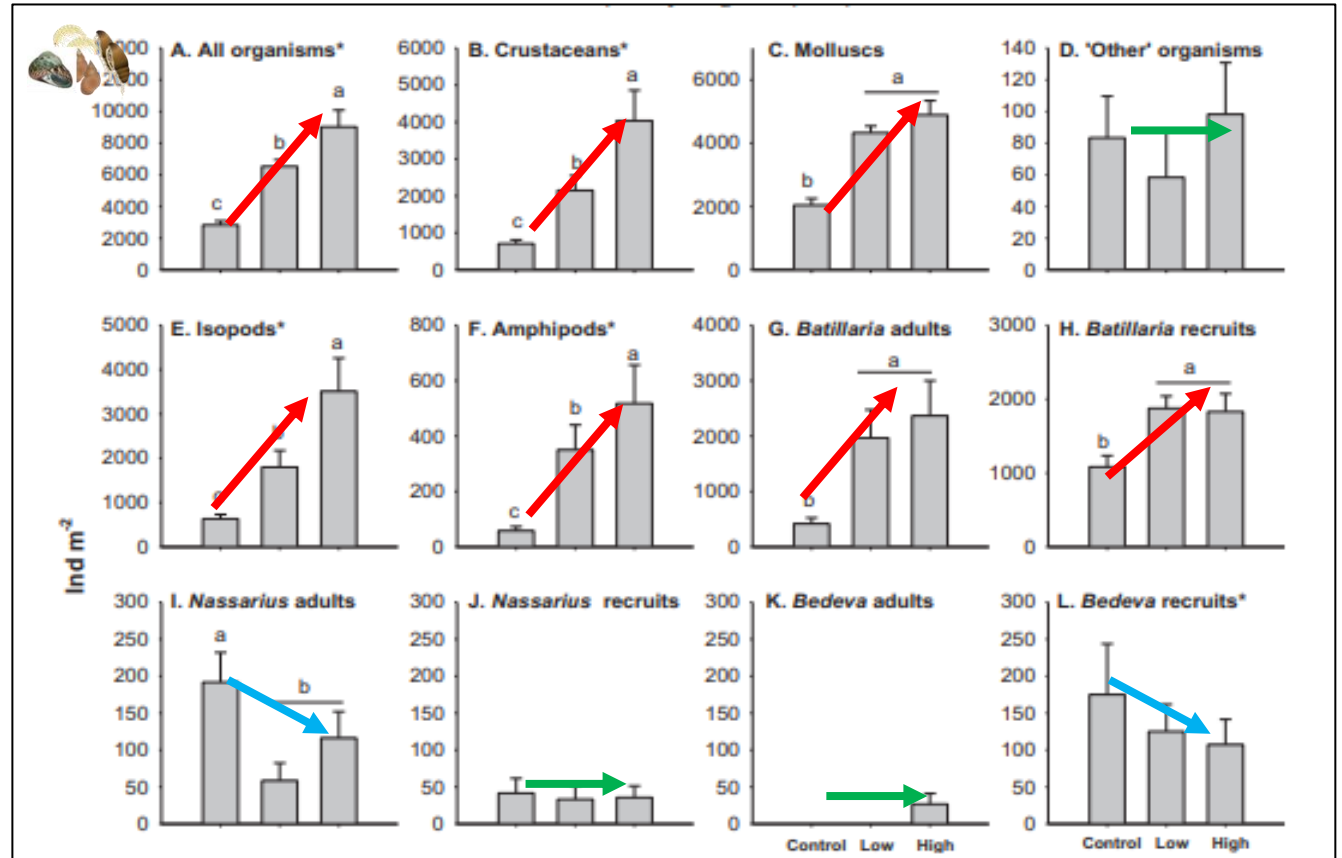


1st HF

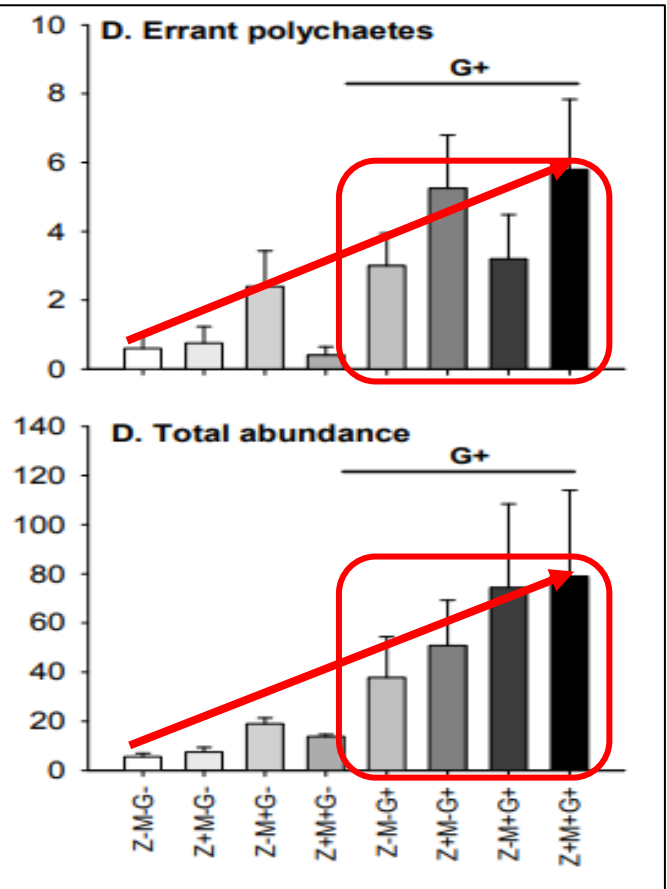
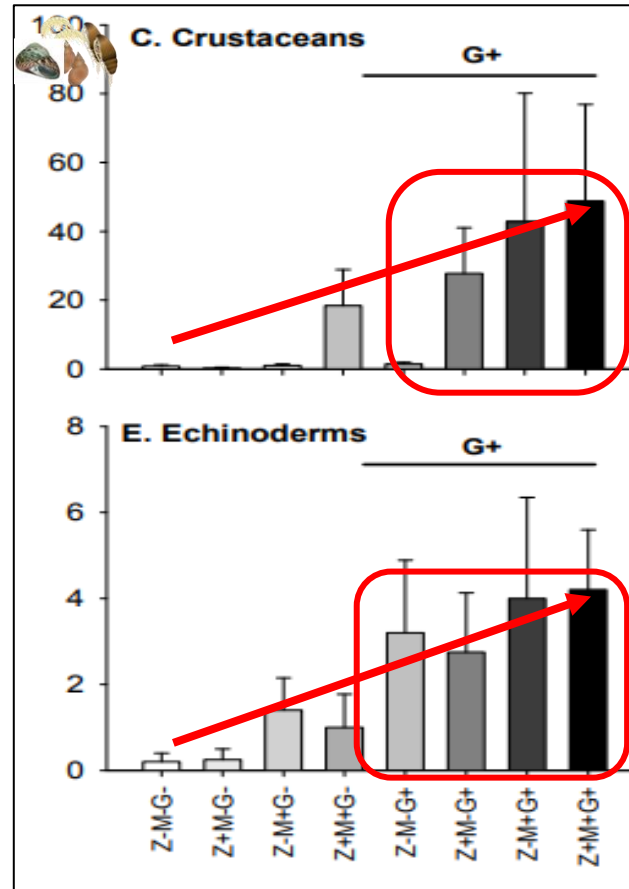
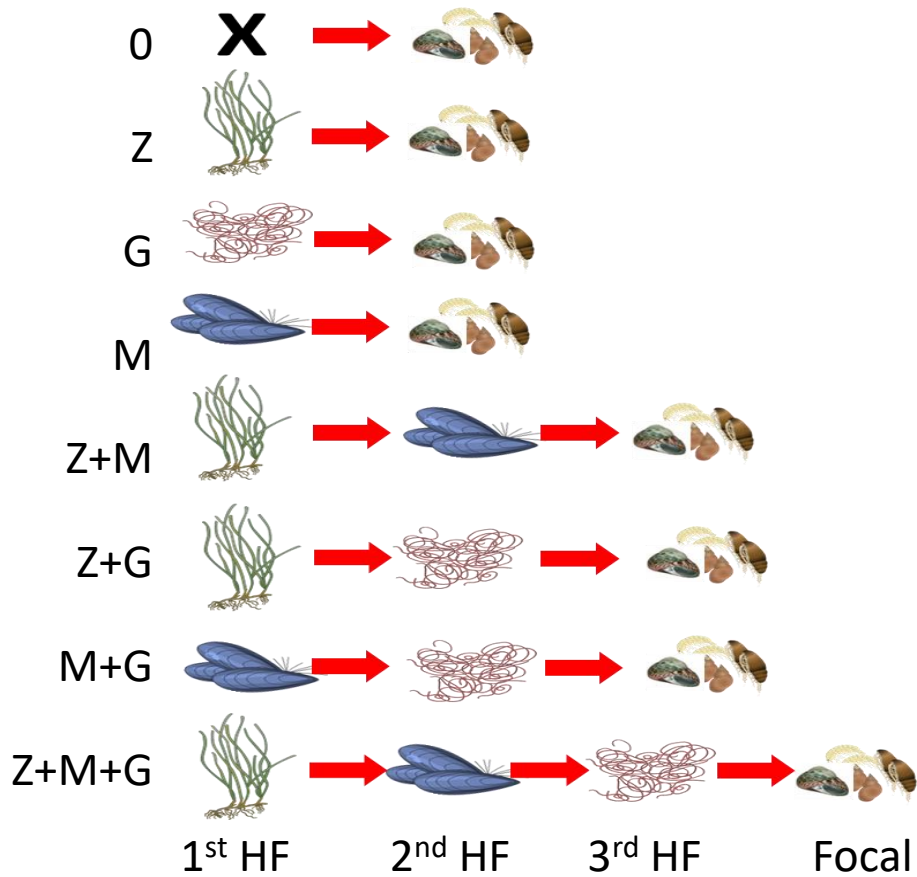
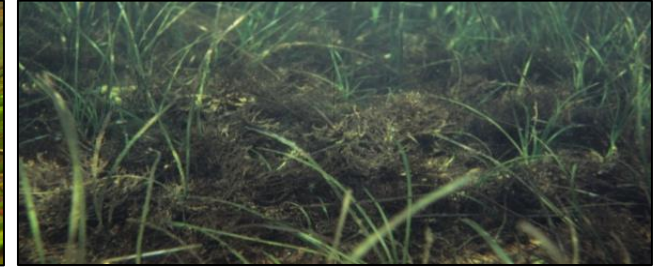
2nd HF

Focal

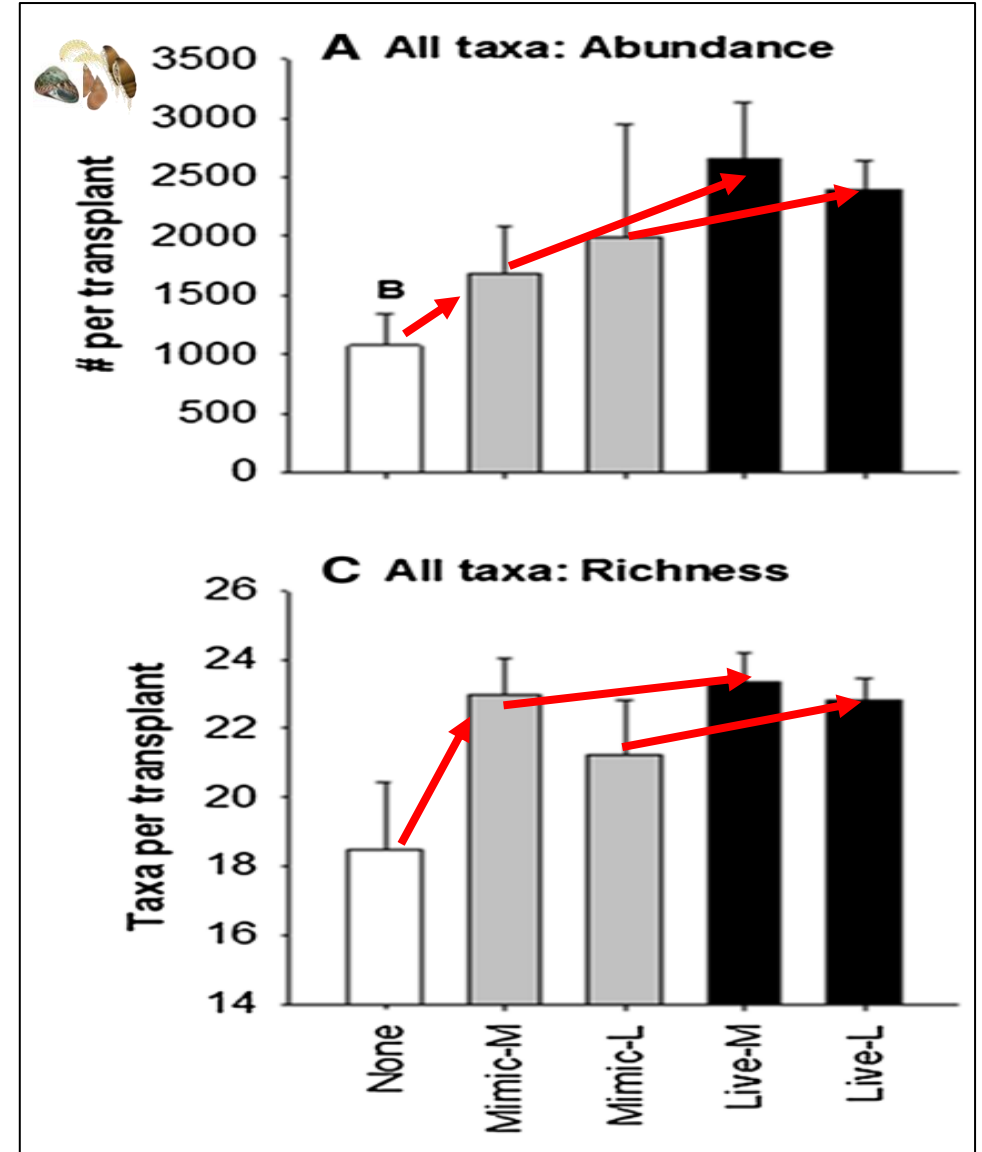
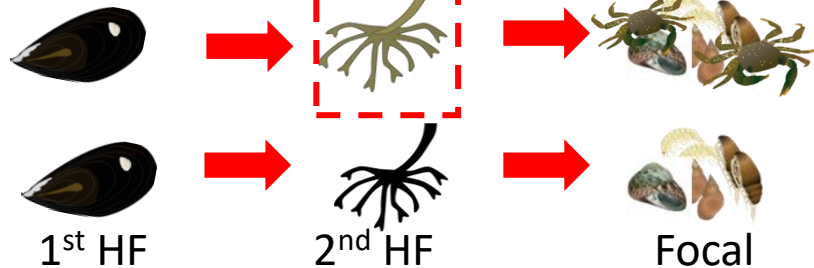
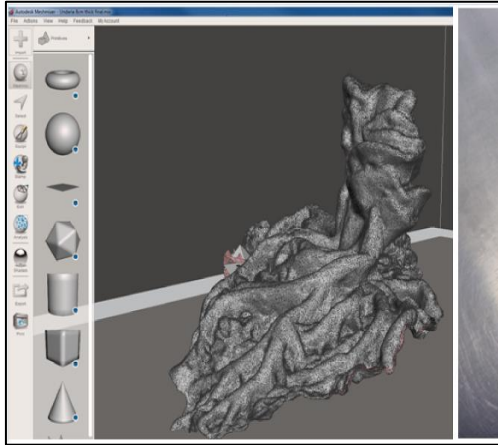
(but now with species ID)



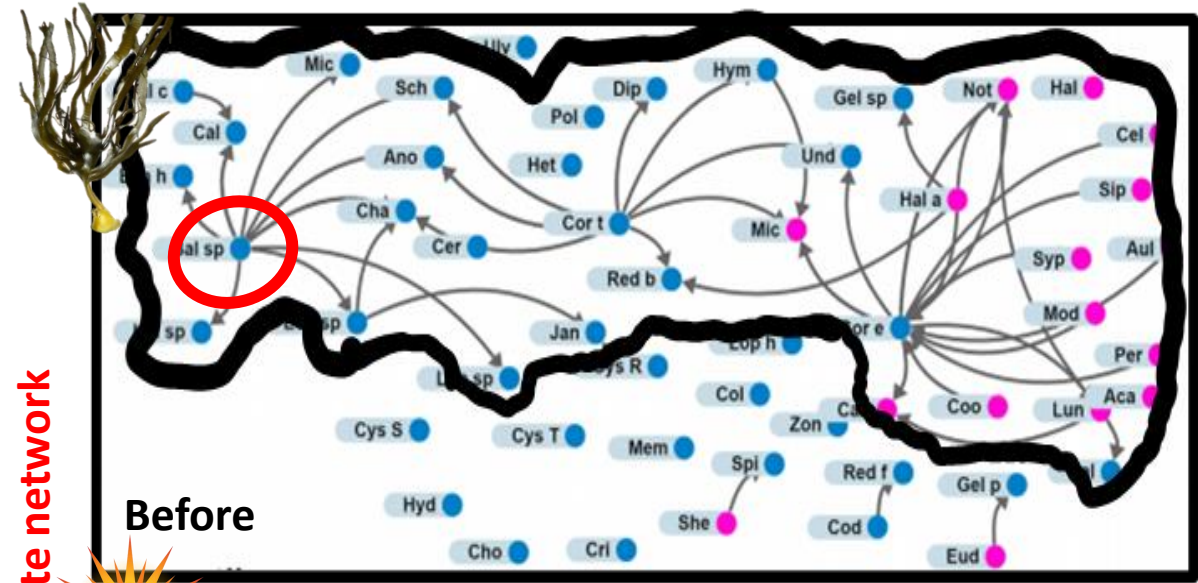
Mechanism: FCs depend on different morphologies (ADA)



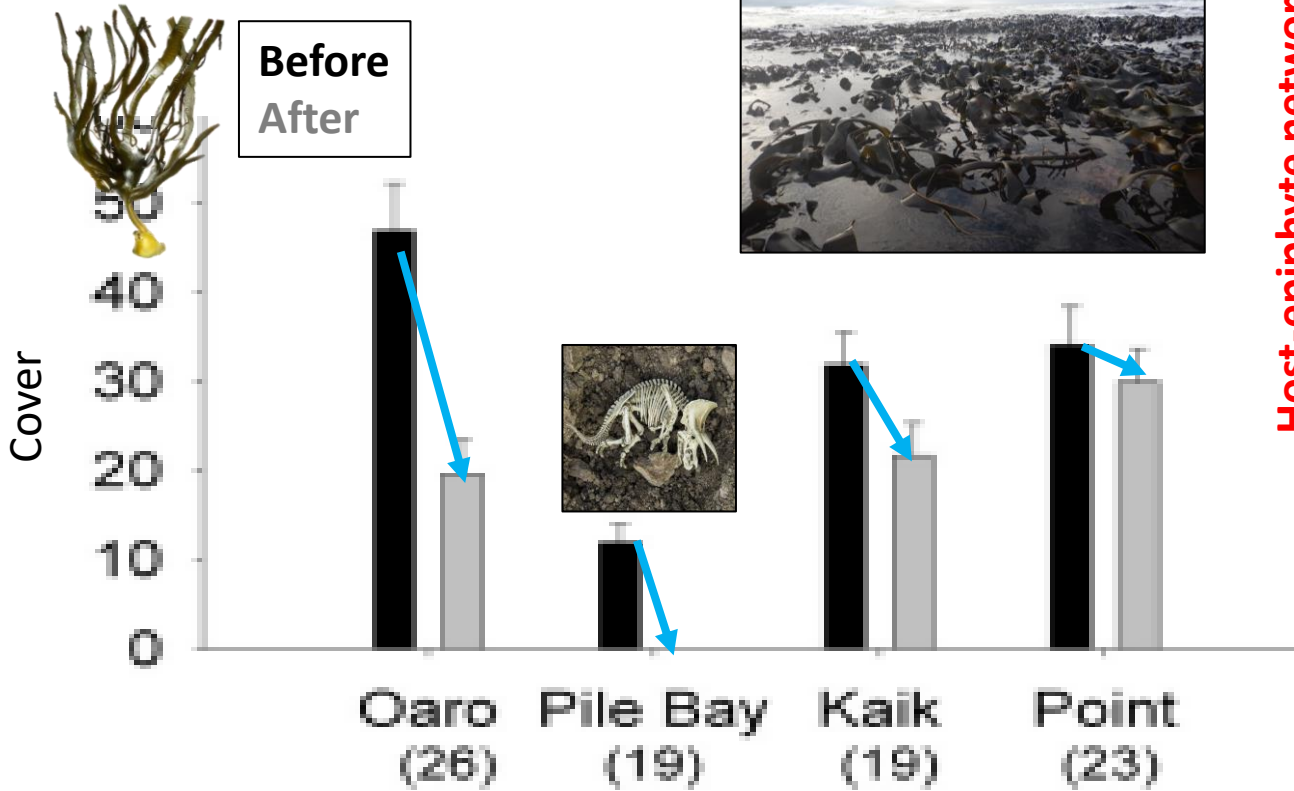
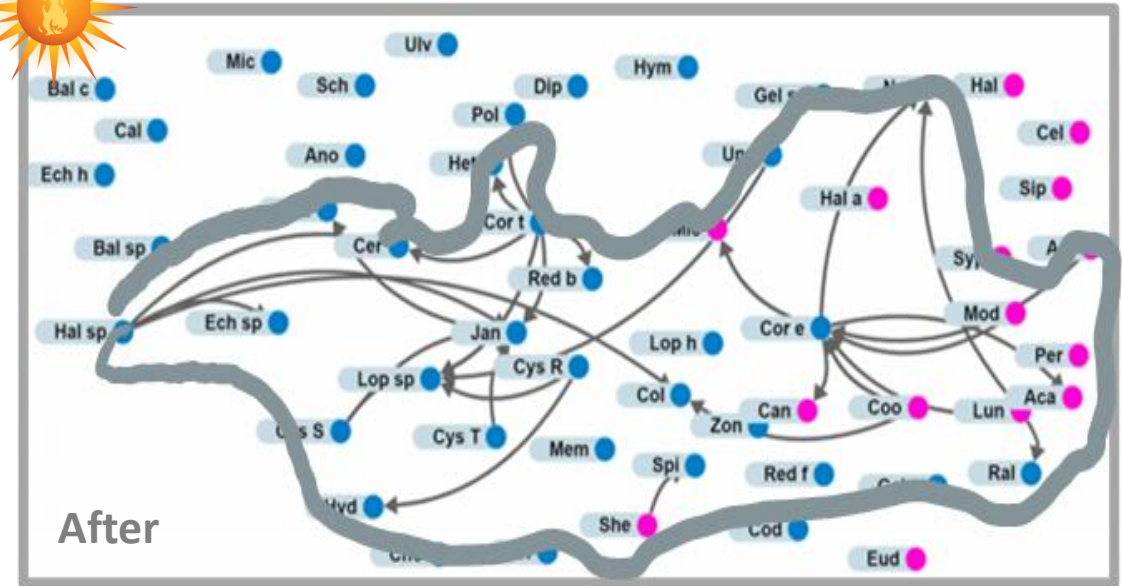
Mechanism: FCs depend on different functions (ADA)



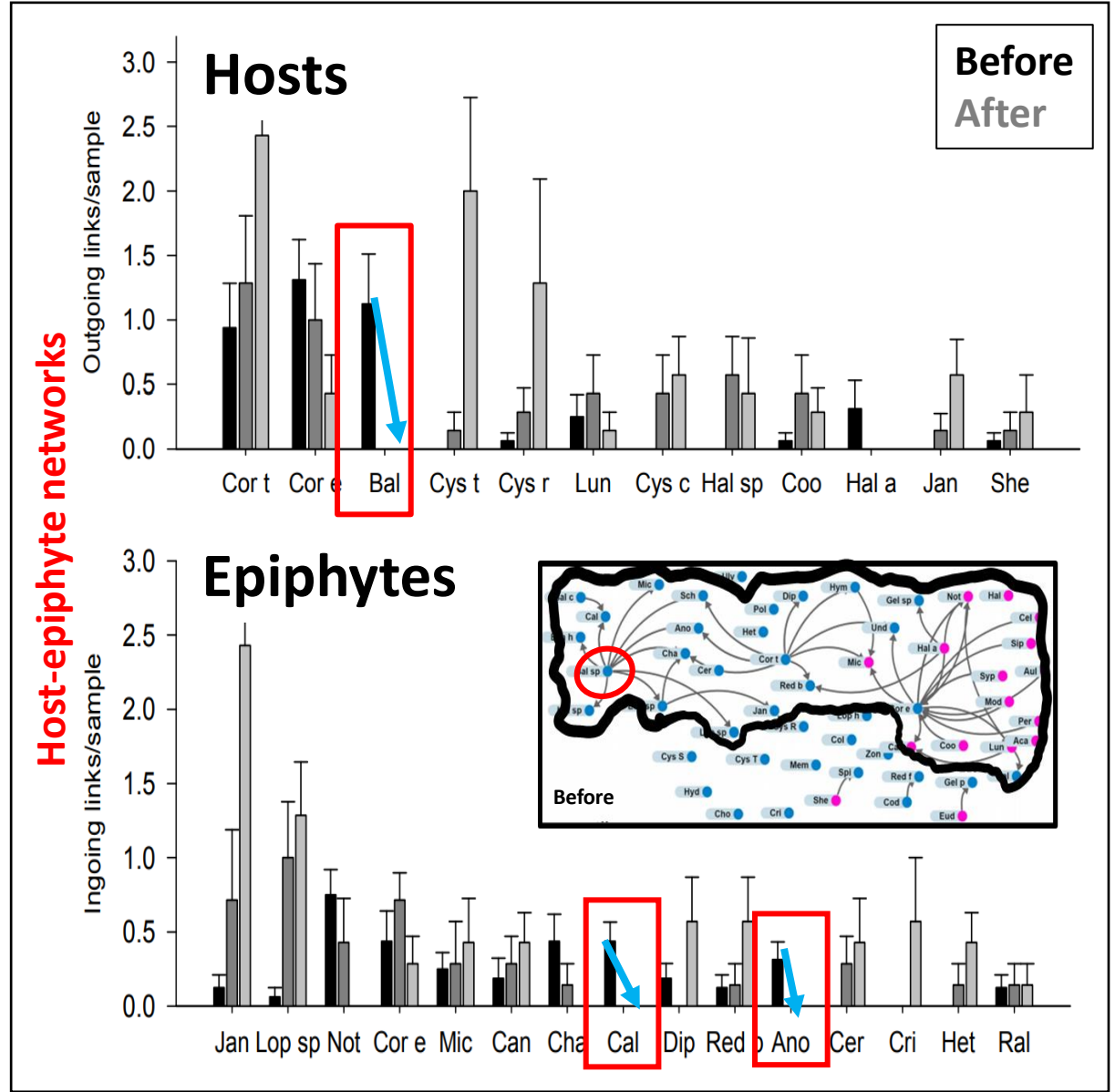
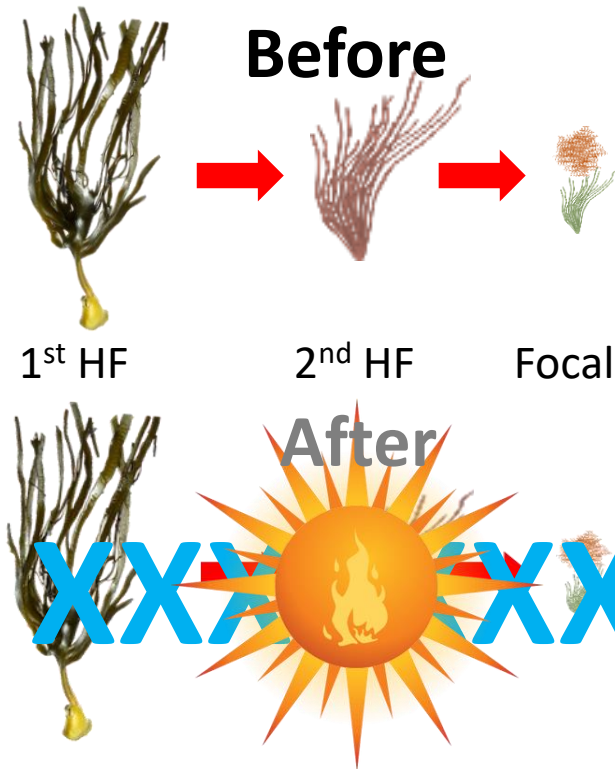
FCs can be **destroyed** by heatwaves



Host-epiphyte network



FCs can be **destroyed by** heatwaves



To sum up...

ADA Adler (1878–1946)
Danish classical scholar
'greatest woman philologist'



1. **FCs** are repeated facilitation processes.
2. **FCs** can be common and strong.
3. **FCs** can control diversity via 'ADA' [Amount – Difference – Affinity].
4. **FCs** can be destroyed by heatwaves.
- ...**FCs** can be better understood with your help....

Thank you for your attention - and thanks to collaborators, students and funding agencies



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DANMARKS FRIE
FORSKNINGSFOND

MARSDEN FUND

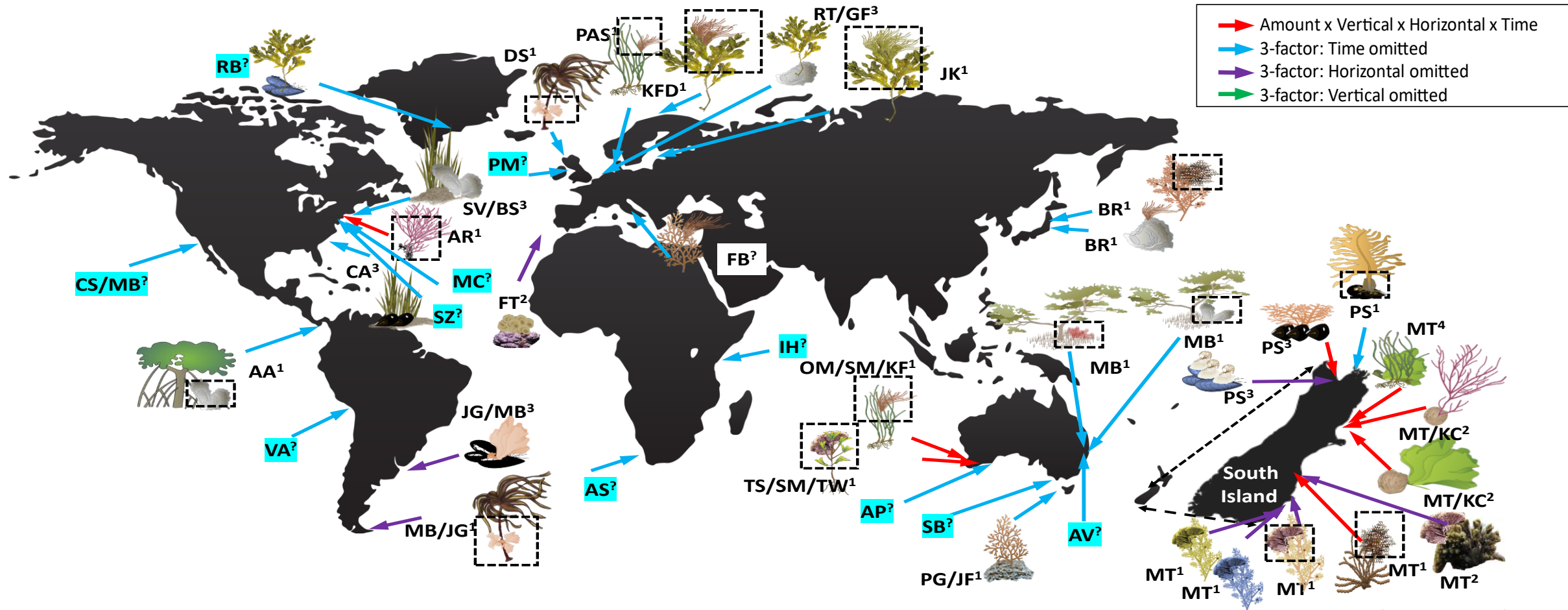
TE PŪTEA RANGAHAU
A MARSDEN



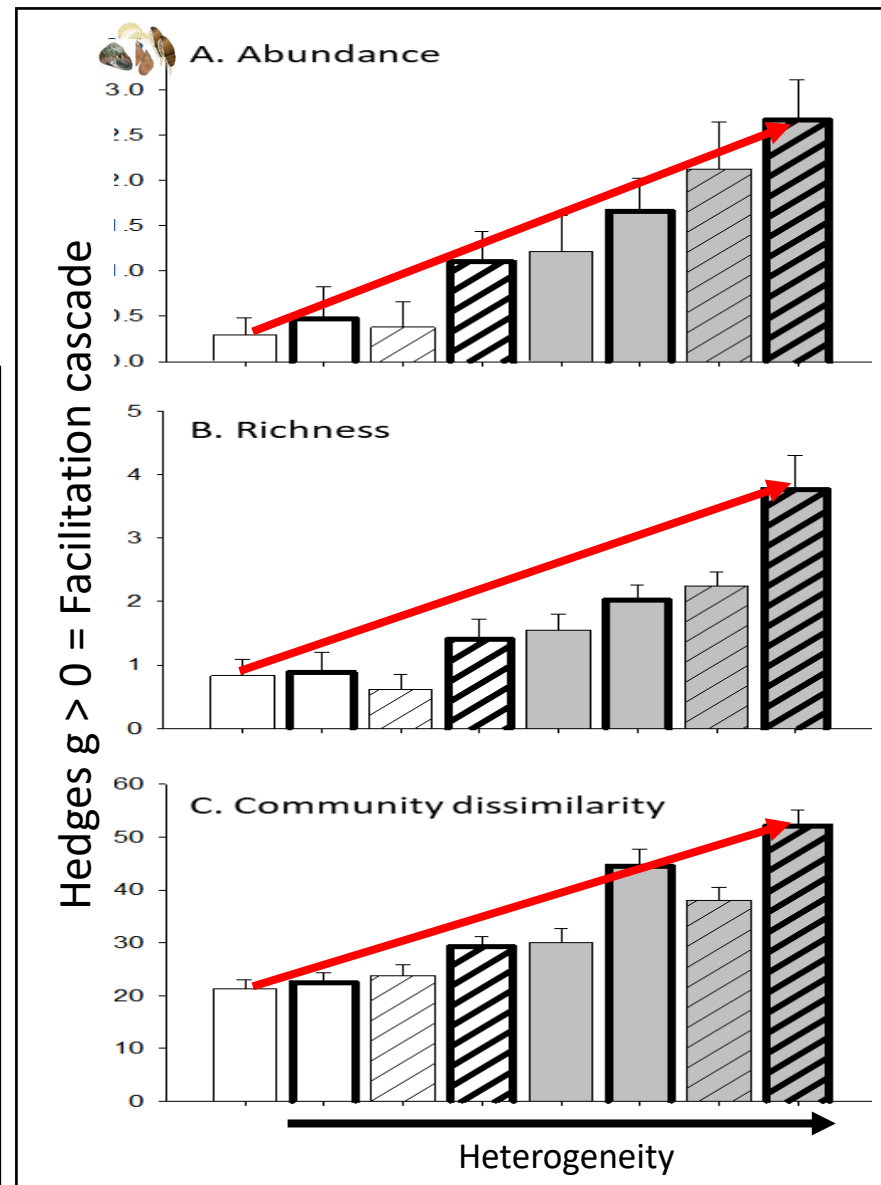
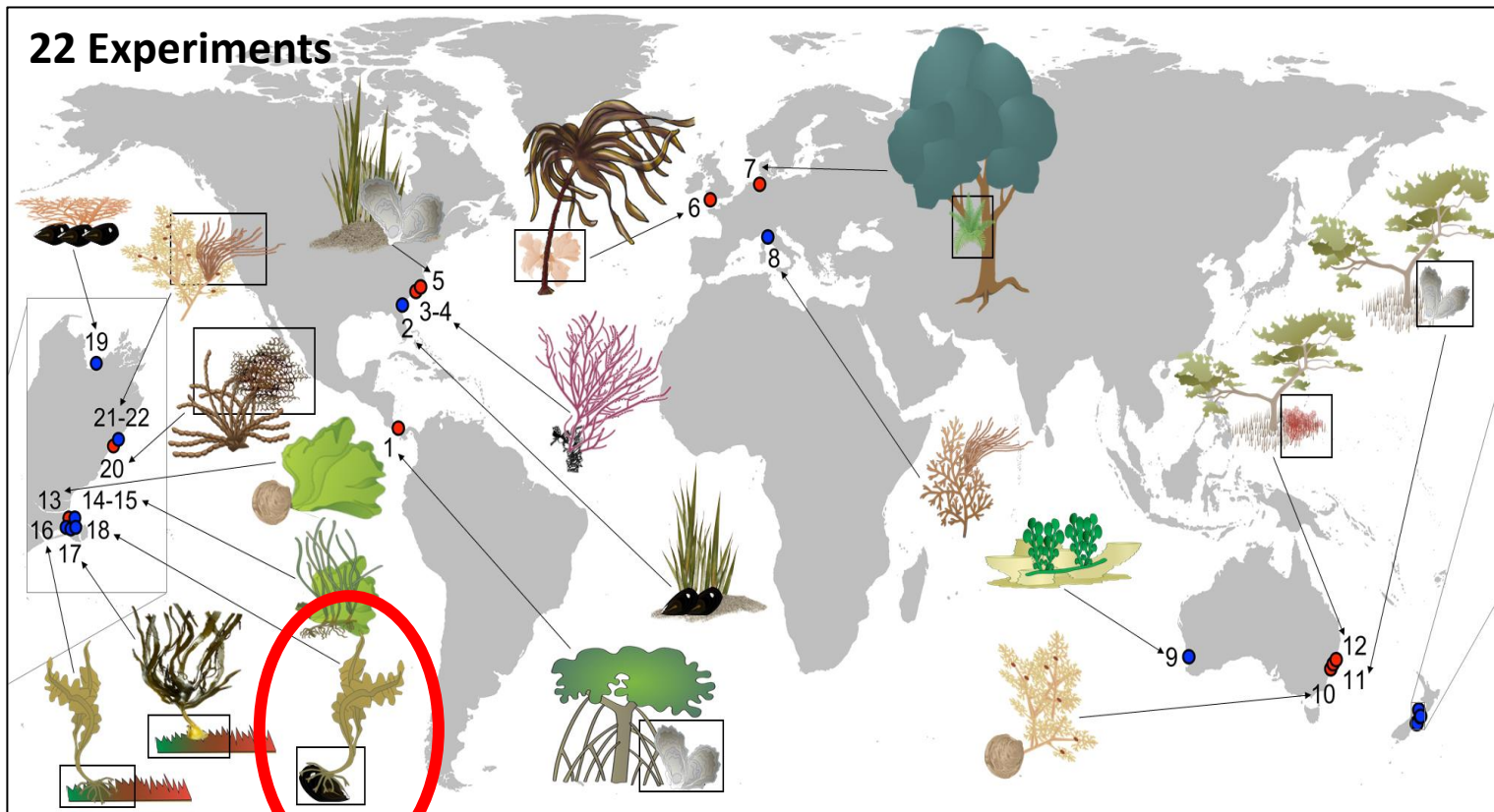
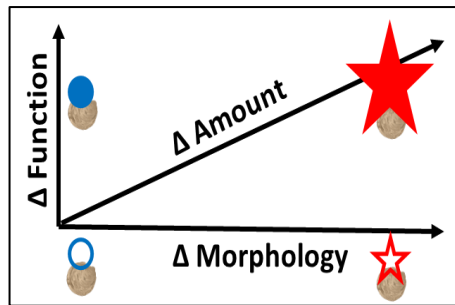
FCs can be better understood with your help (for co-authorship😊)

"Community ecology is a mess with so much contingency that useful generalizations are hard to find" (J Lawton 1999. Are there general laws in ecology? Oikos: 177-192) **...Well - lets sample spatiotemporal contingency in coastal ecosystems systematically...**

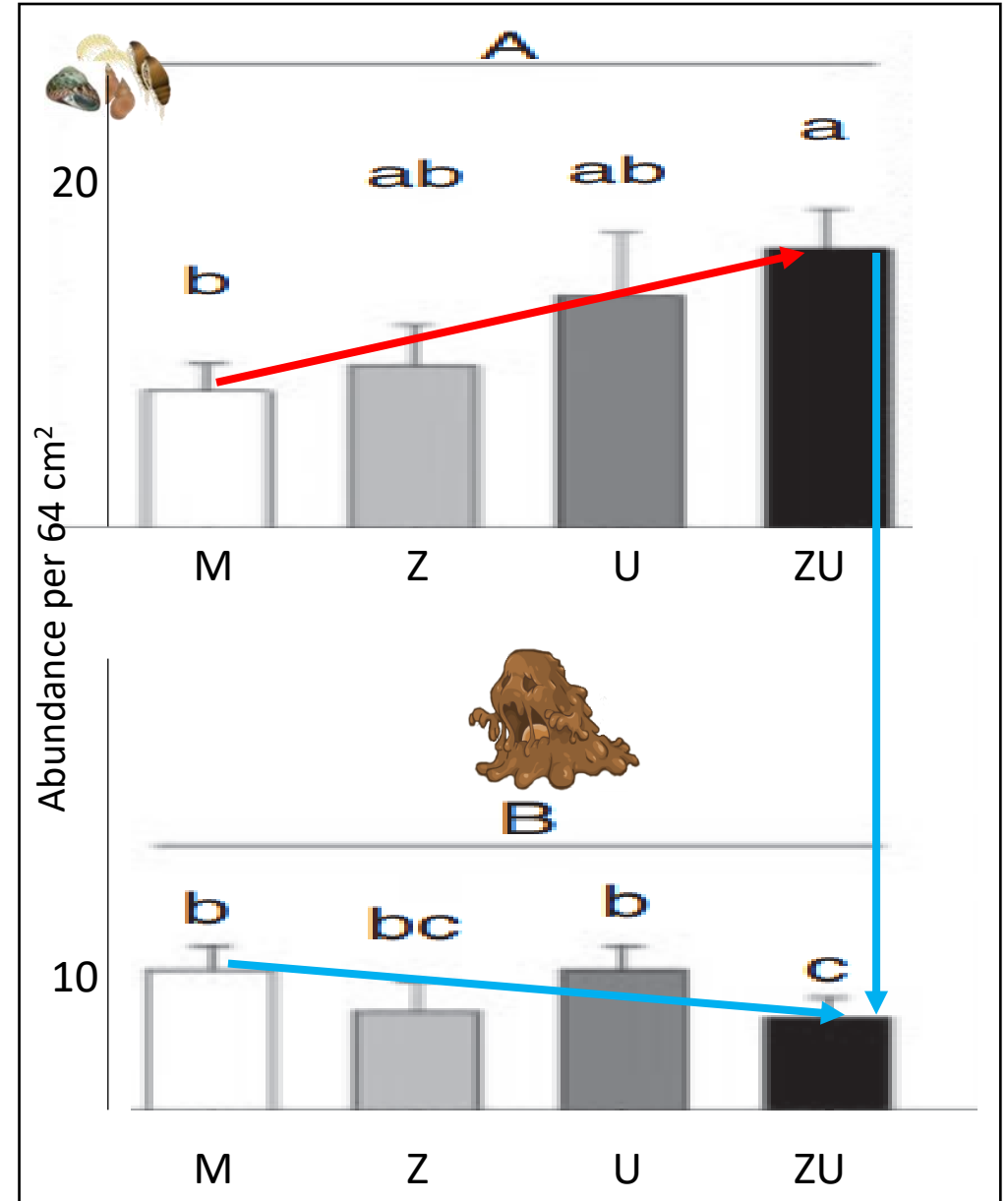
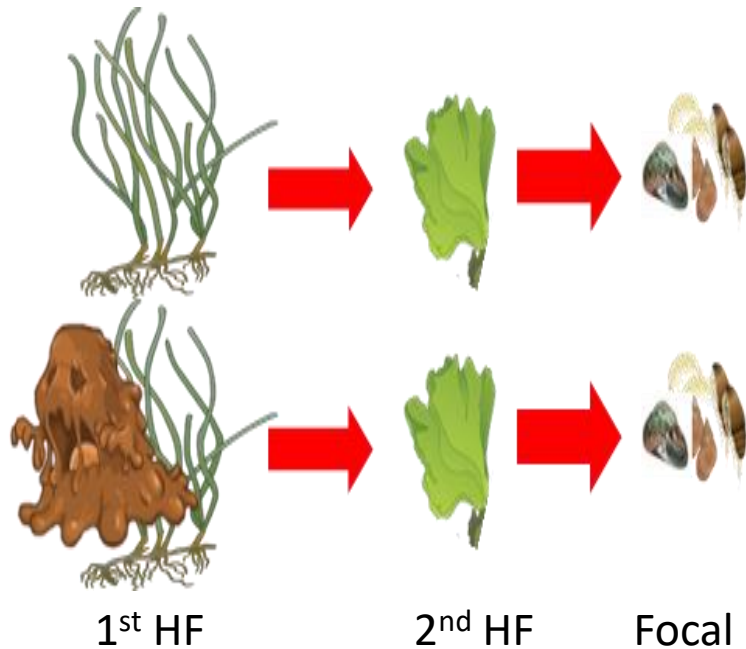
Test 3-4 crossed factors: **Amounts** x **Vertical** (e.g. depth) x **Horizontal** (e.g. latitude) x **Time** (e.g. season) x Replicates = 48-72 samples



Mechanism₁₋₃: FCs depend on 'heterogeneity' (ADA)



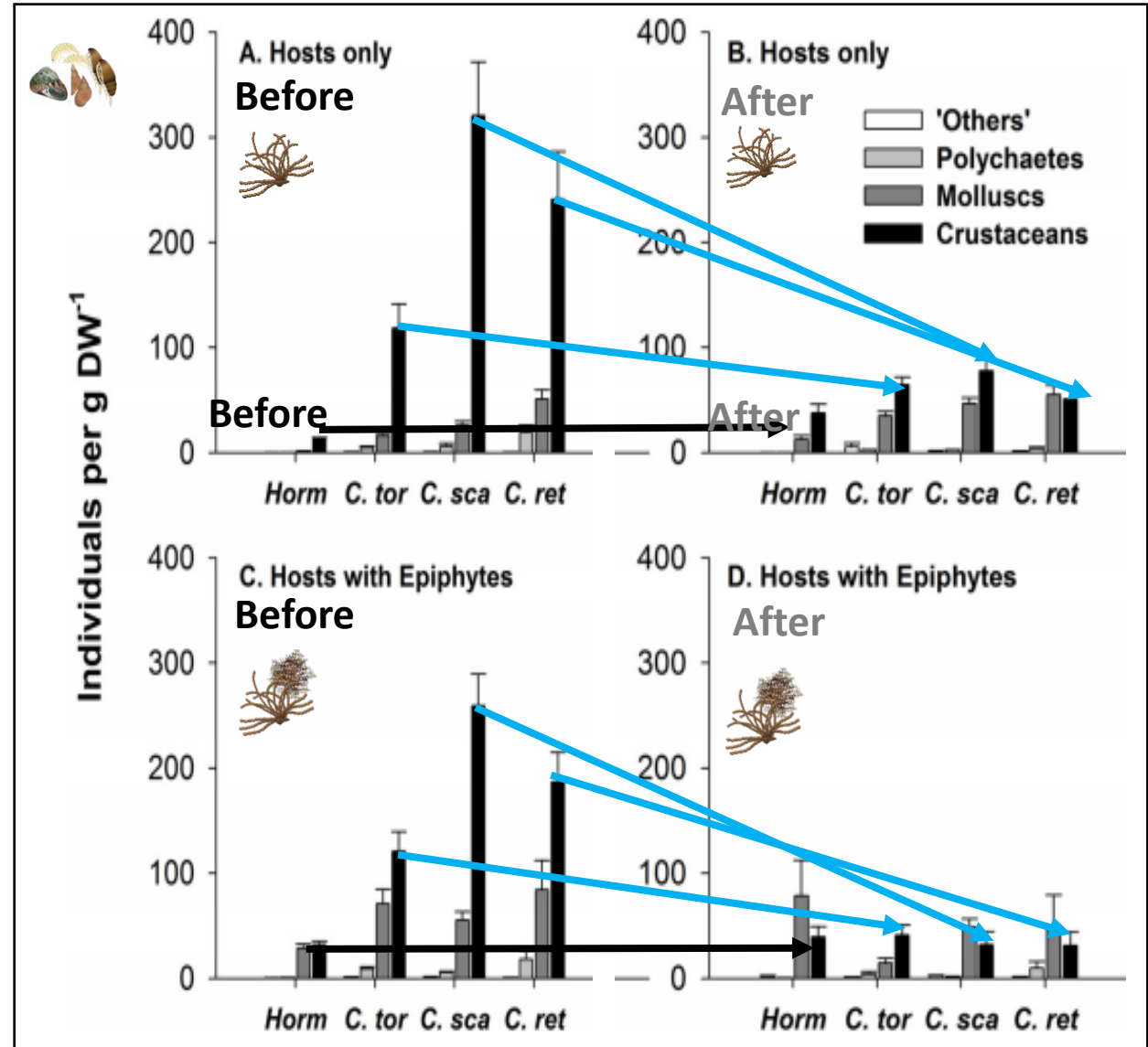
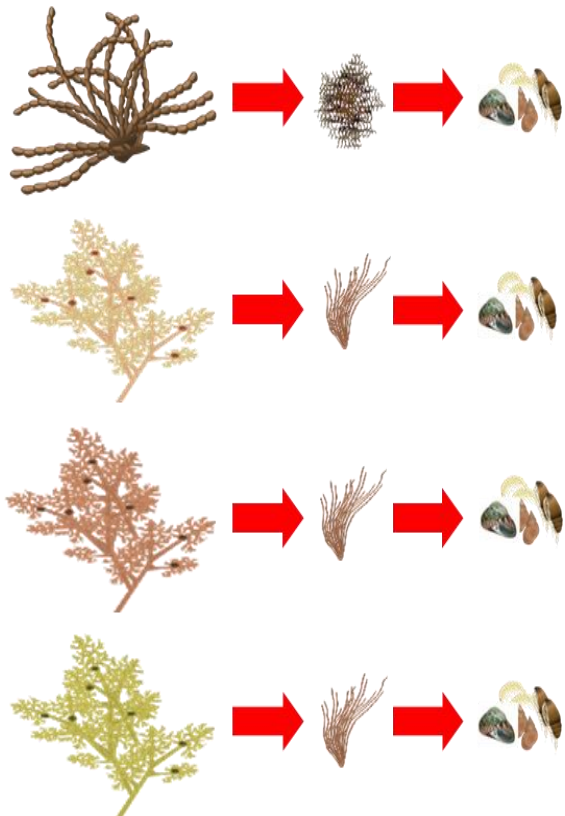
FCs can be **destroyed by** pollution



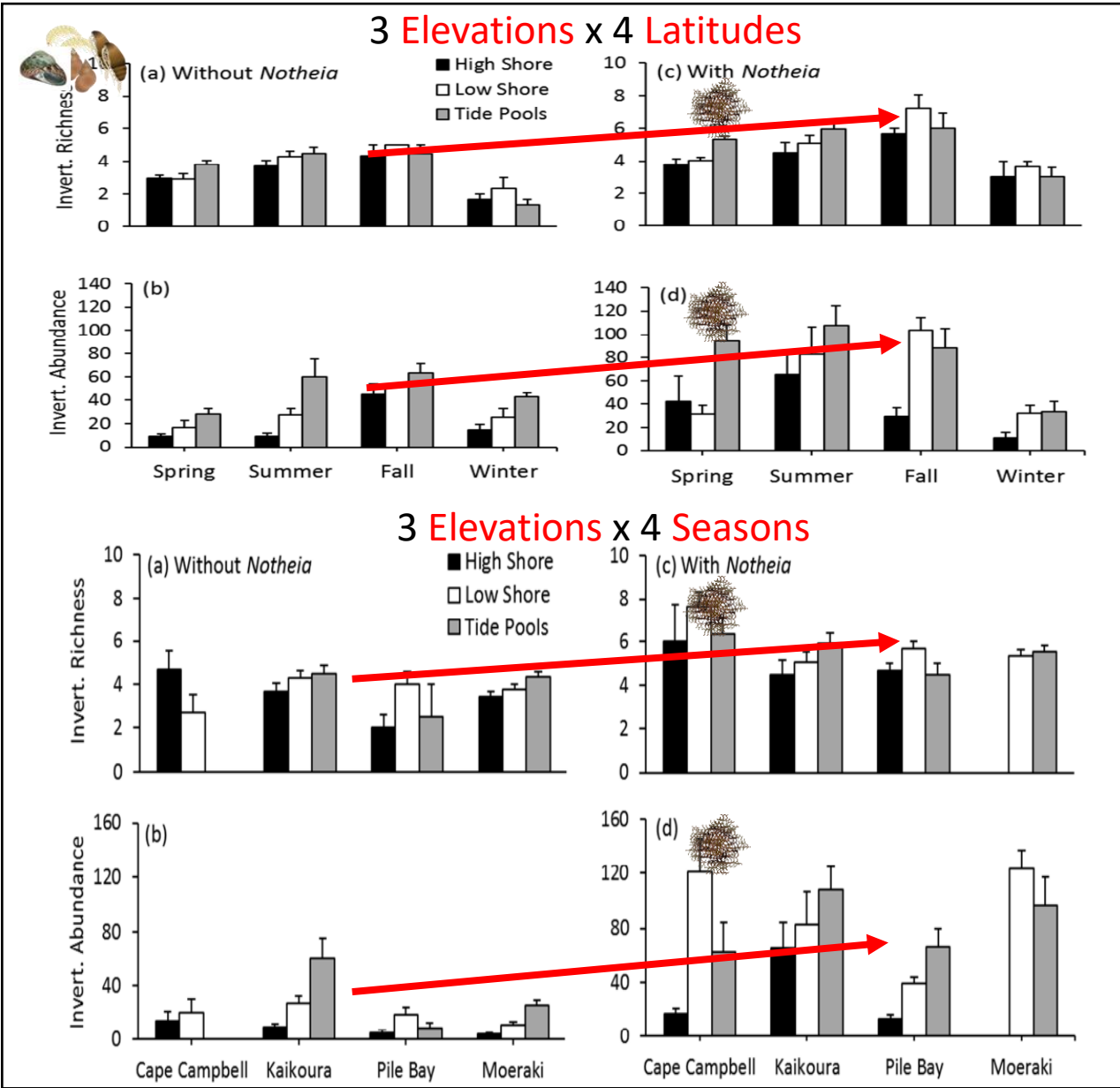
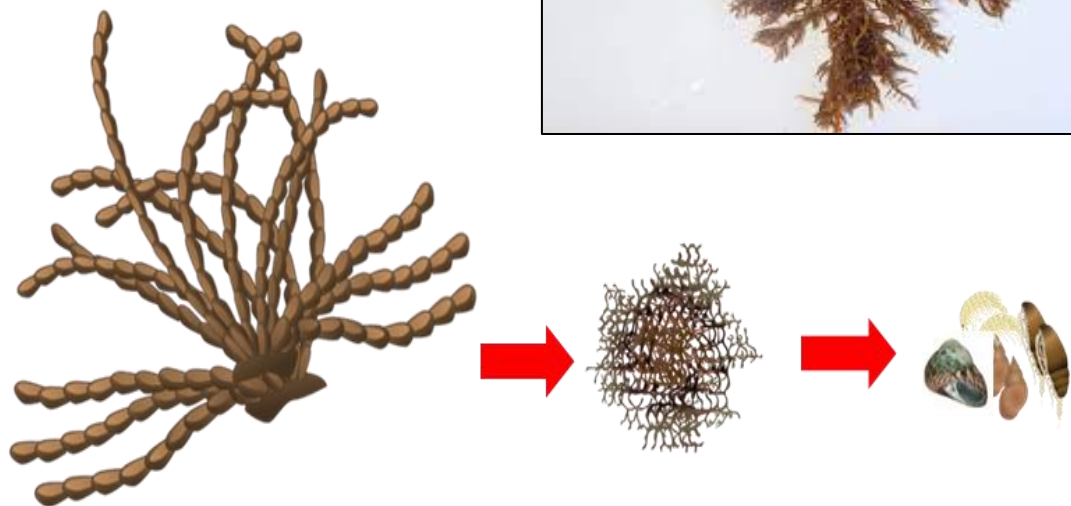
FCs can be **destroyed by nature** – seismic uplift



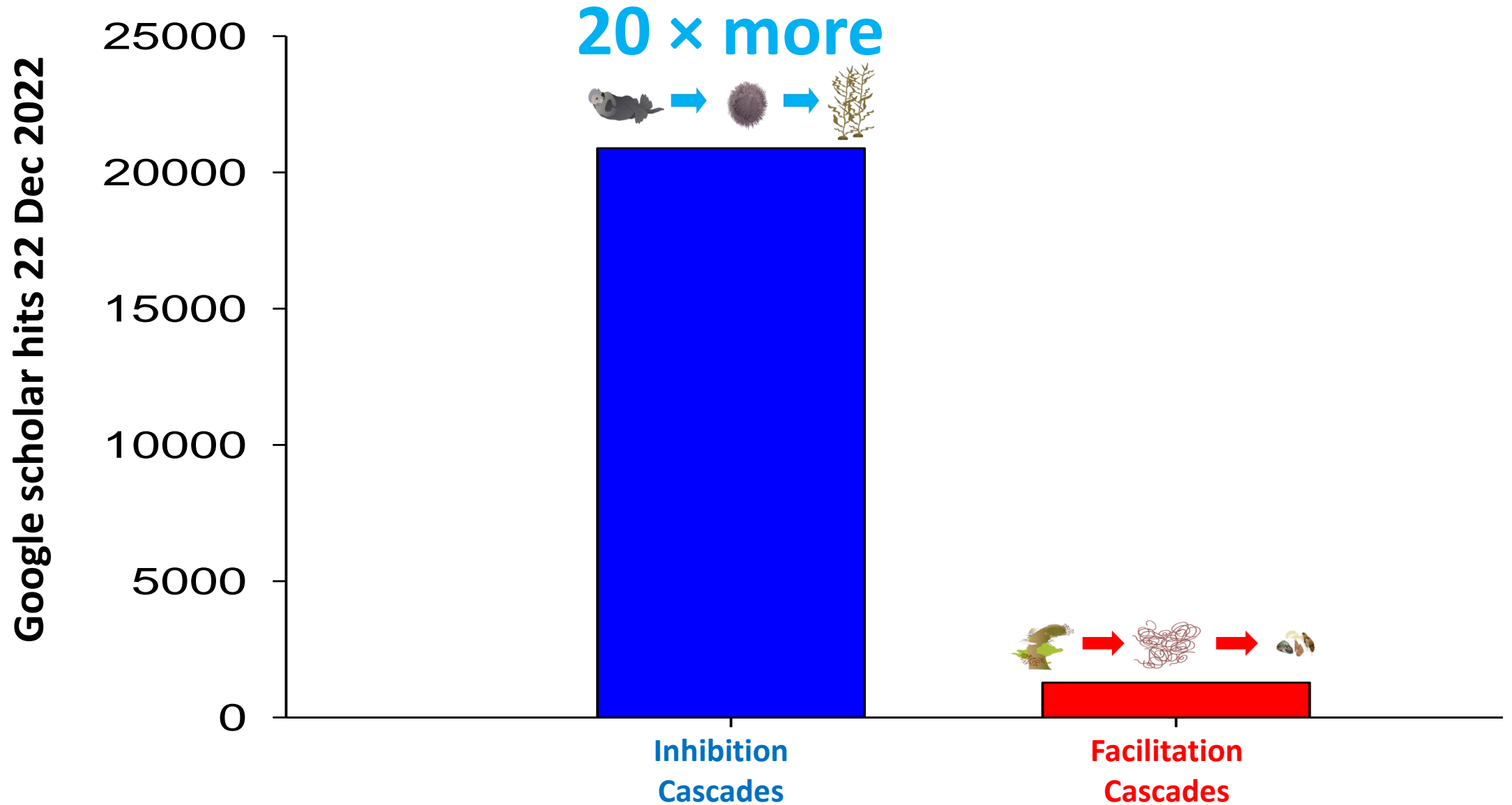
Kaikoura 2016 earthquake



Pattern₂: FCs increase diversity across rocky shore gradients



Inhibition vs. Facilitation cascades (FCs)



FCs increase diversity in attachment networks

