REEFS
REEF ENVIRONMENTS: ECOSYSTEM, FUNCTION & SOCIETY

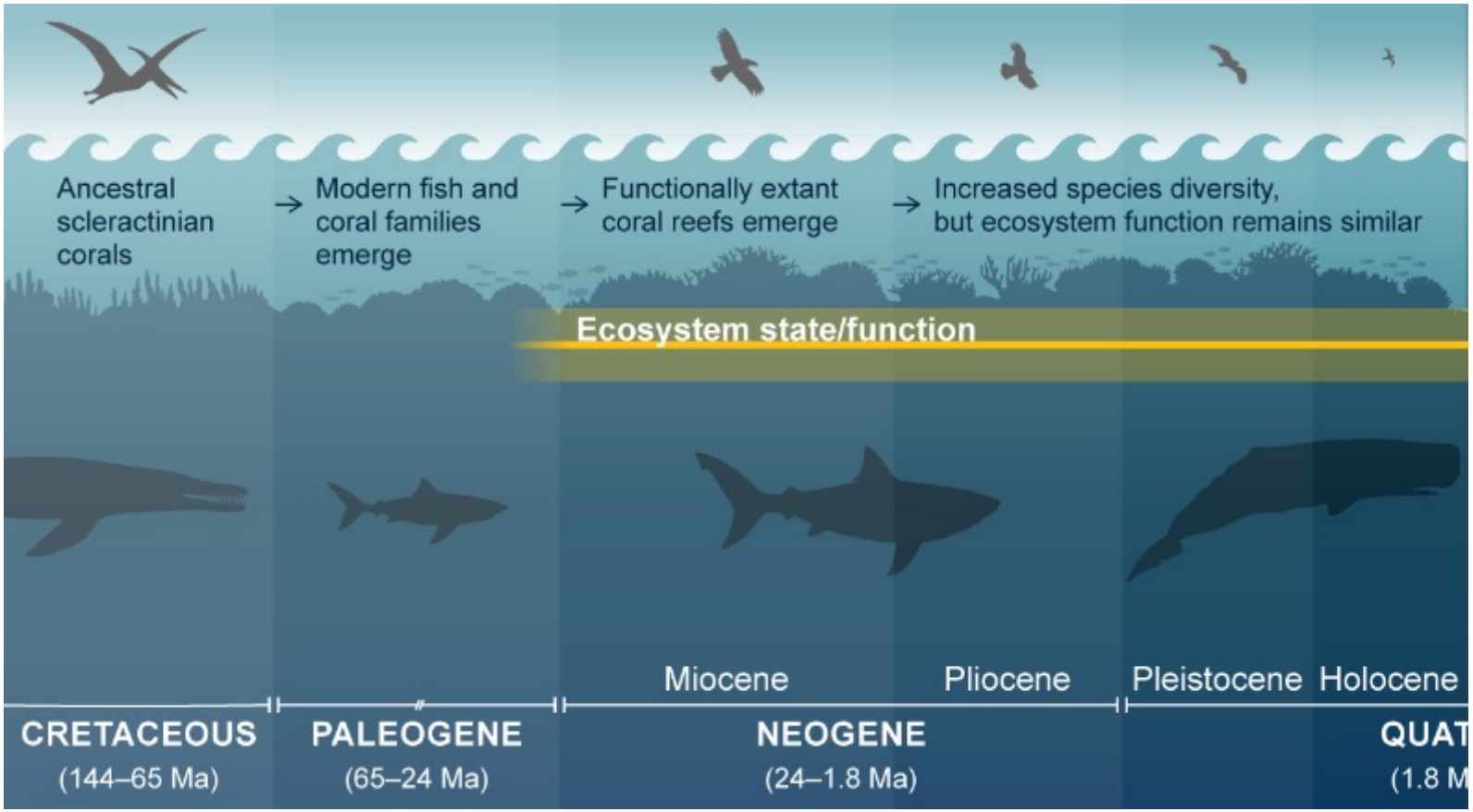
THE ROYAL SOCIETY

Lancaster Environment Centre | Lancaster University

Coral Reefs in a Warming World

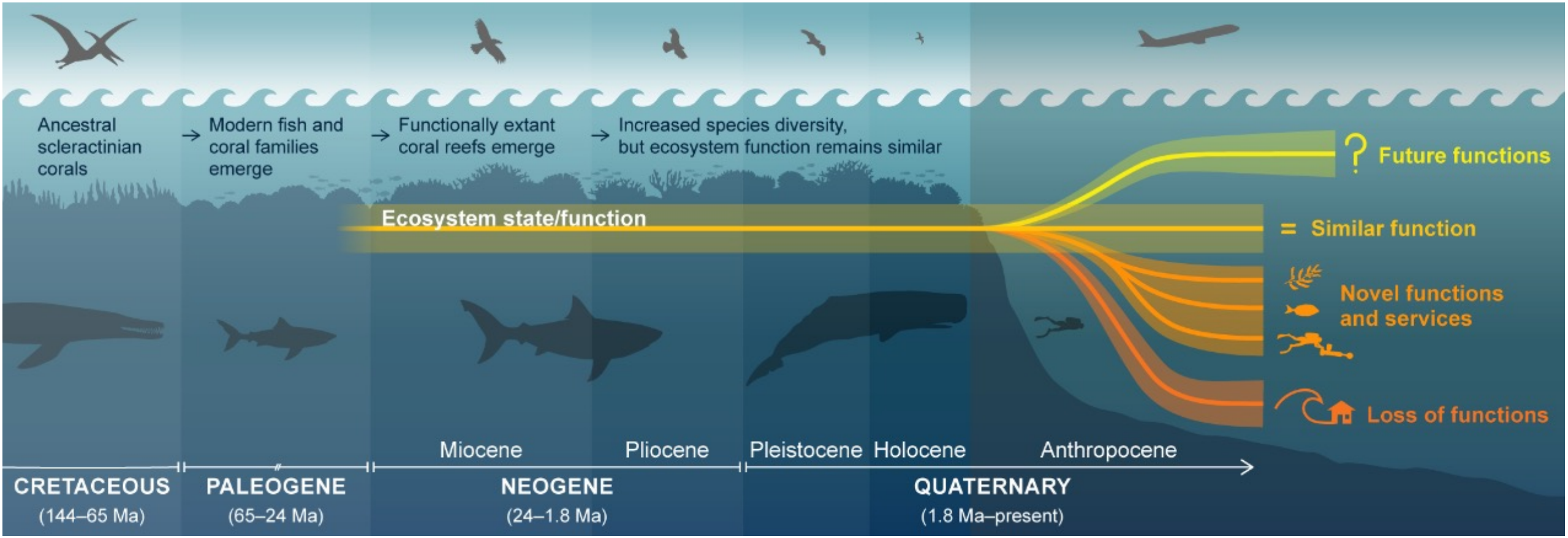
Prof Nick Graham

Uncertain futures in the Anthropocene



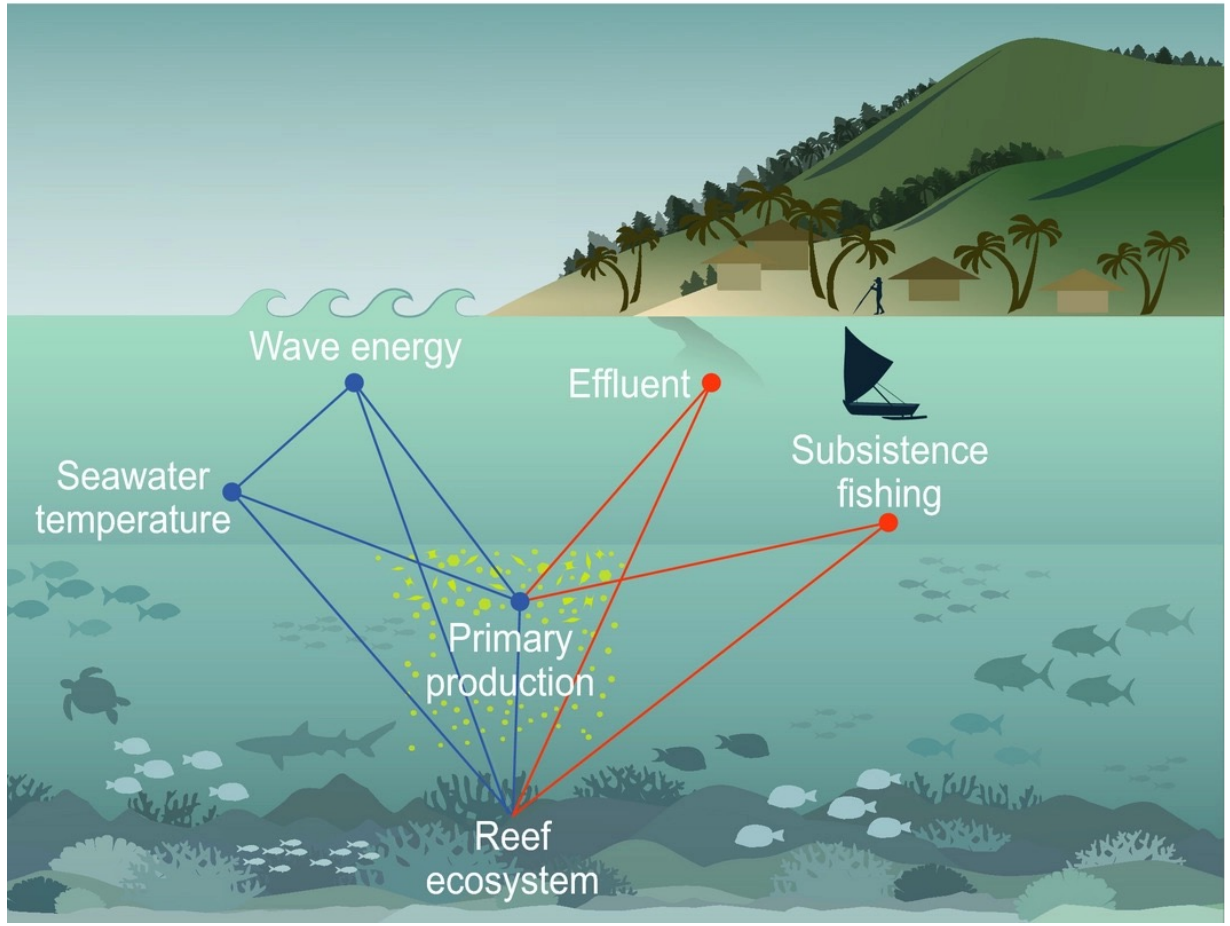
Williams & Graham (2019) Func Ecol

Uncertain futures in the Anthropocene



Williams & Graham (2019) Func Ecol

Human-dominated ecosystems of the Anthropocene



Williams et al. 2019 Func Ecol

Coral reefs are in dire straits

The New York Times | https://www.nytimes.com/2021/10/04/climate/coral-reefs-climate-change.html

Climate Change Is Devastating Coral Reefs Worldwide, Major Report Says

BBC | Home | News | More

Unesco: Great Barrier Reef should be listed as 'in danger'

The Guardian

Sharks 'functionally extinct' at 20% of world's coral reefs as fishing drives global decline

Coral Bleaching

Greg Torda

“Roughly half of the corals on the #GreatBarrierReef died in 18 months (from global warming).”

Prof Terry Hughes

… and of course it's not just the Great Barrier Reef

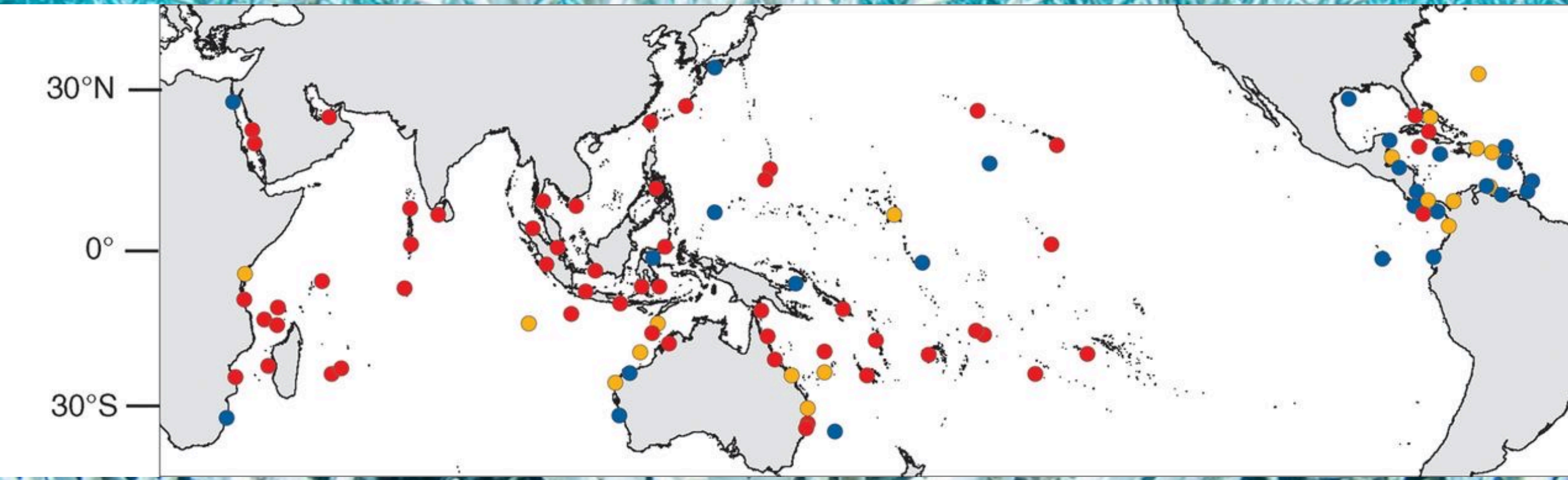
Fiji

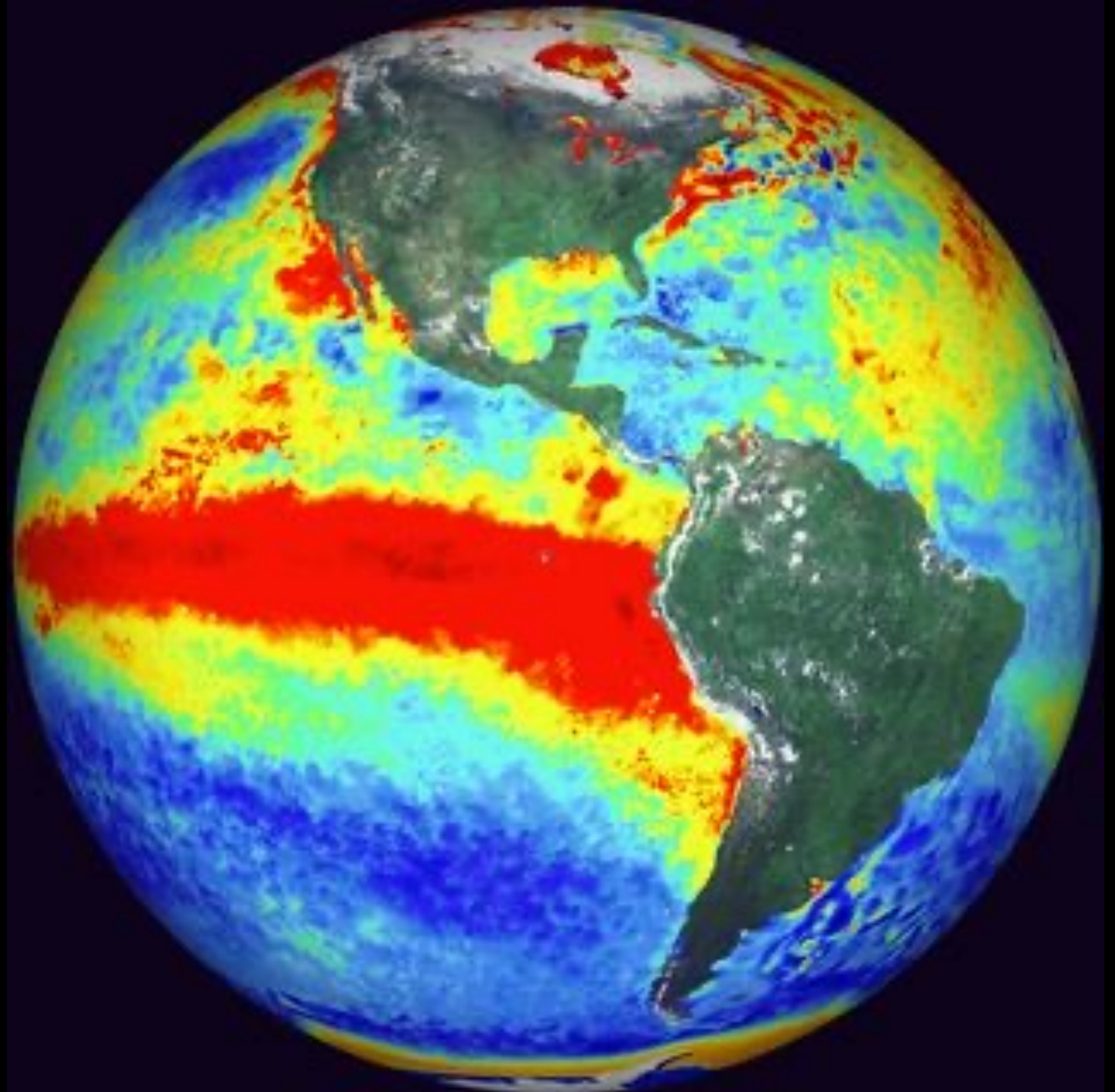
Japan

Maldives

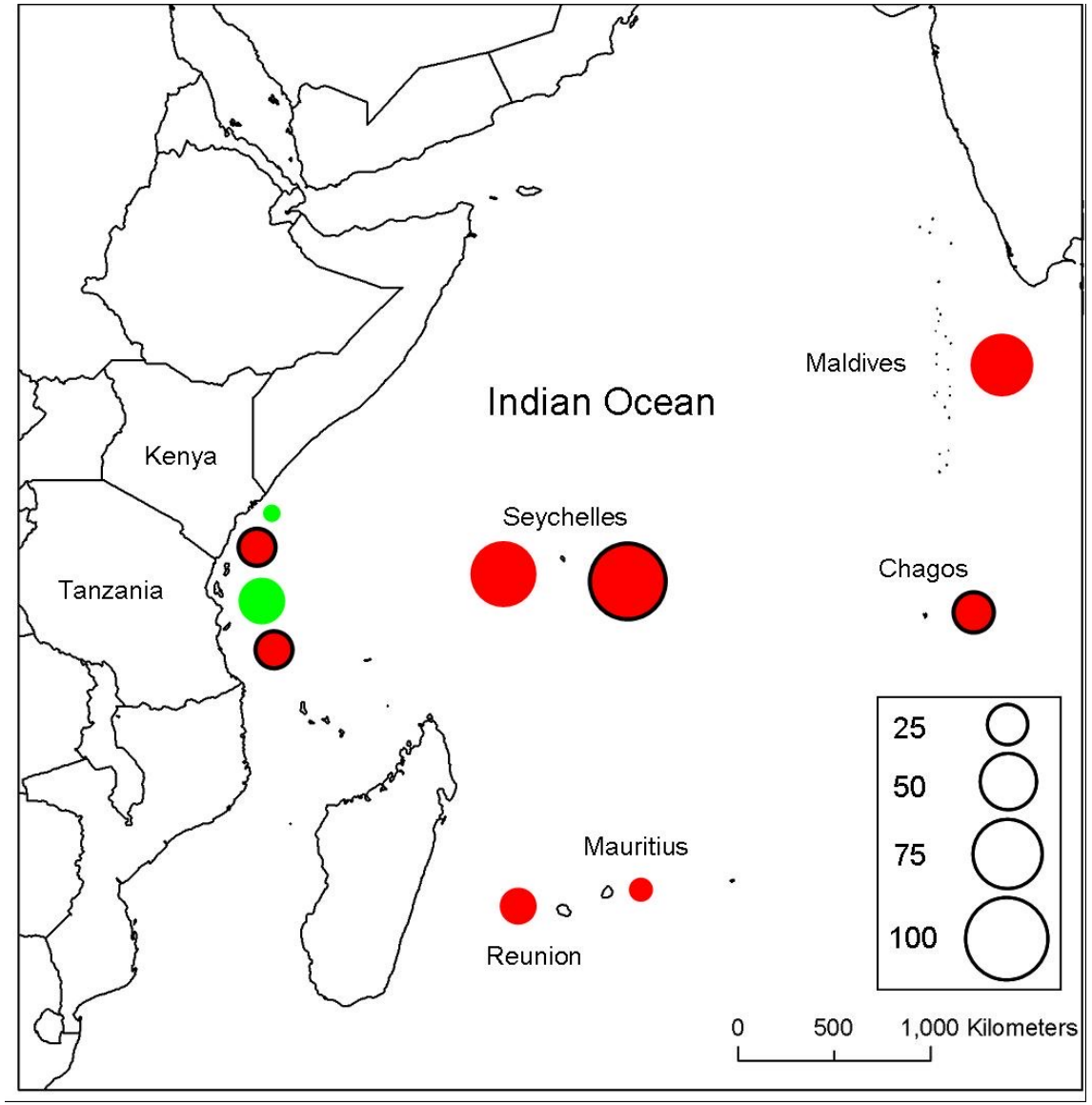
Seychelles

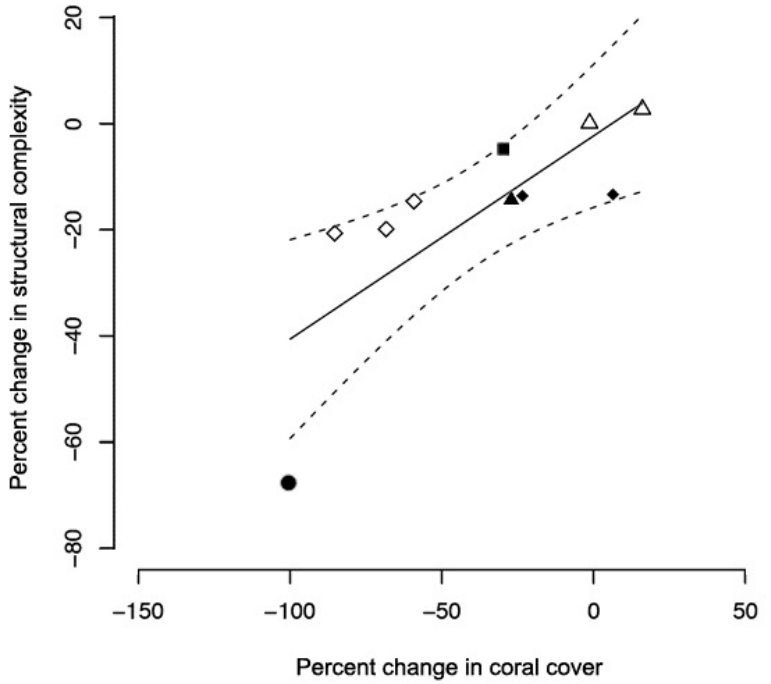
Hughes et al. 2018 Science





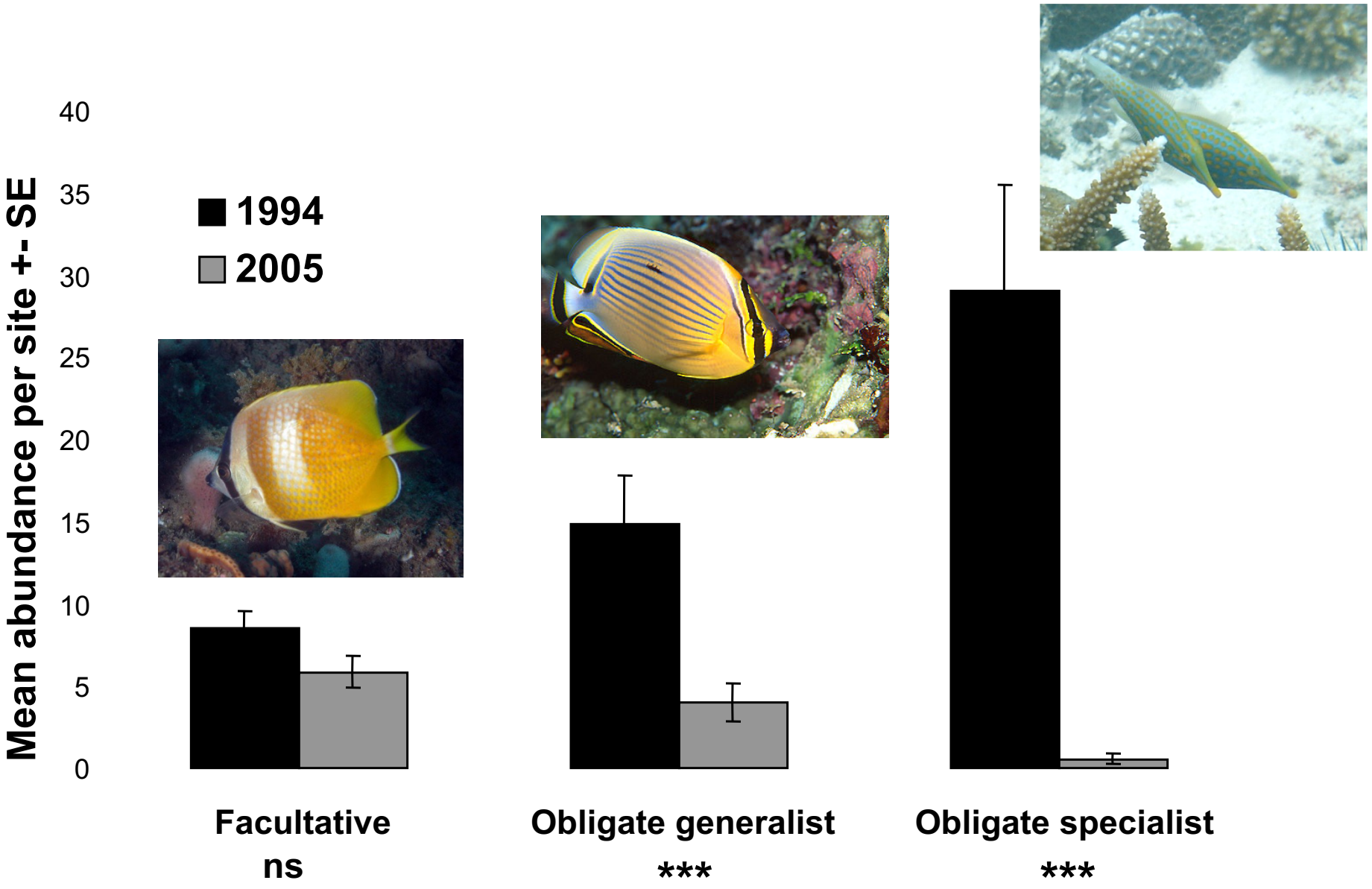
Change in coral cover through 1998



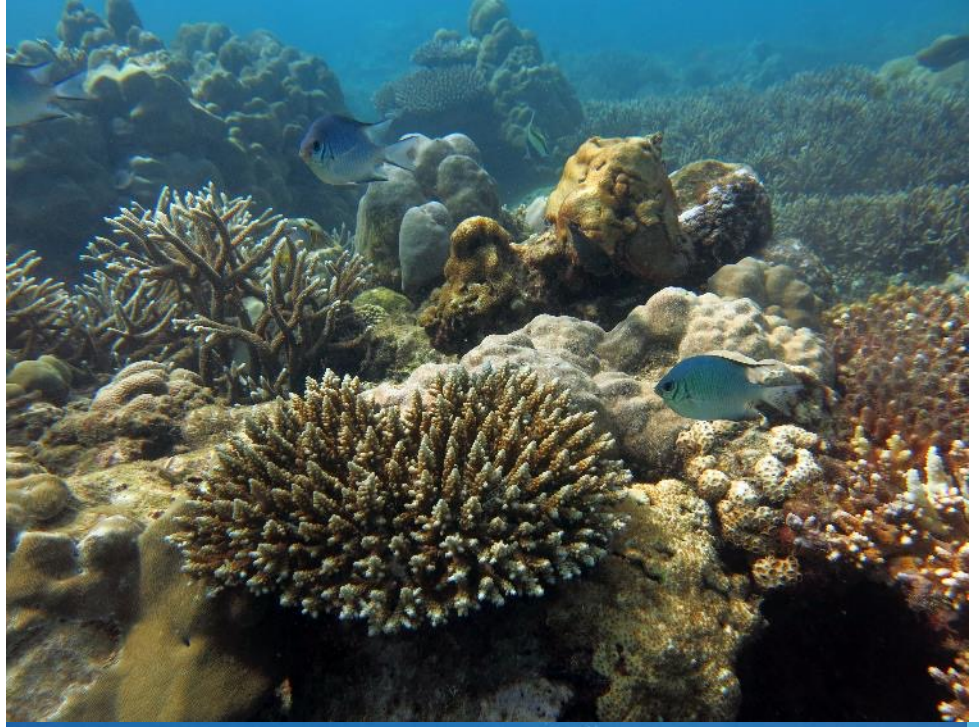


Graham et al. PLOS ONE 2008

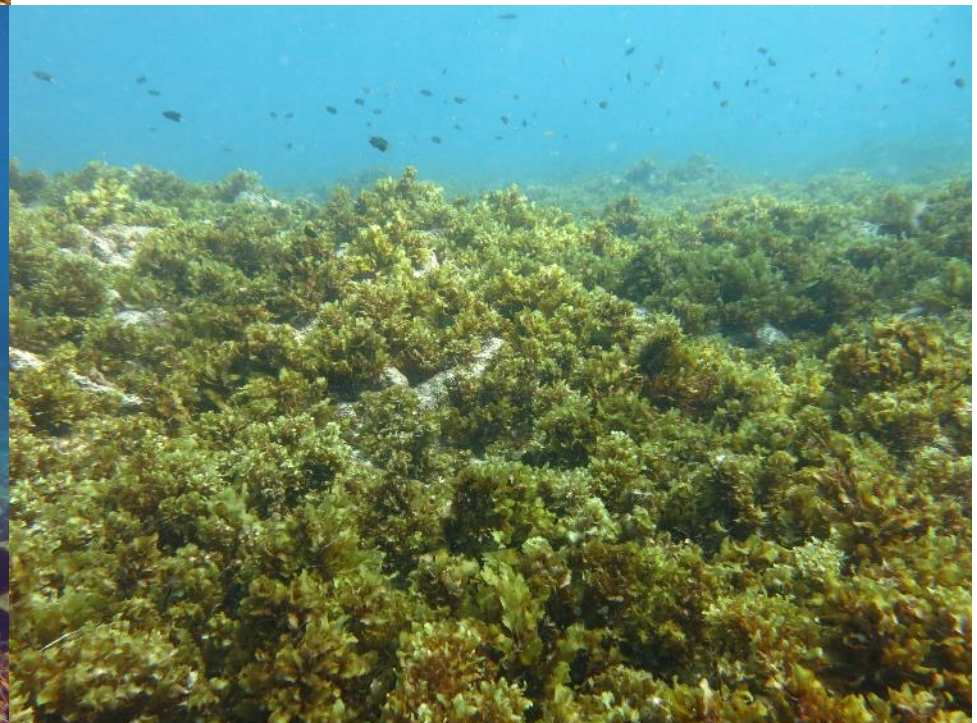
Change in coral-feeding fish abundance



Graham Mar Biol 2007

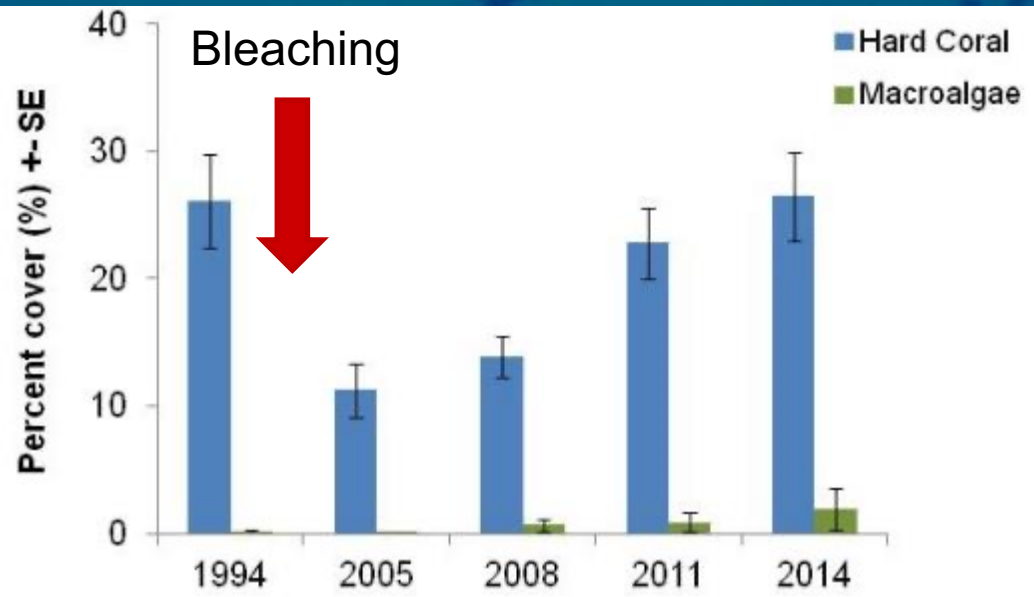


REEF TRAJECTORIES FOLLOWING MAJOR BLEACHING



Benthic communities are changing dramatically

RECOVERY

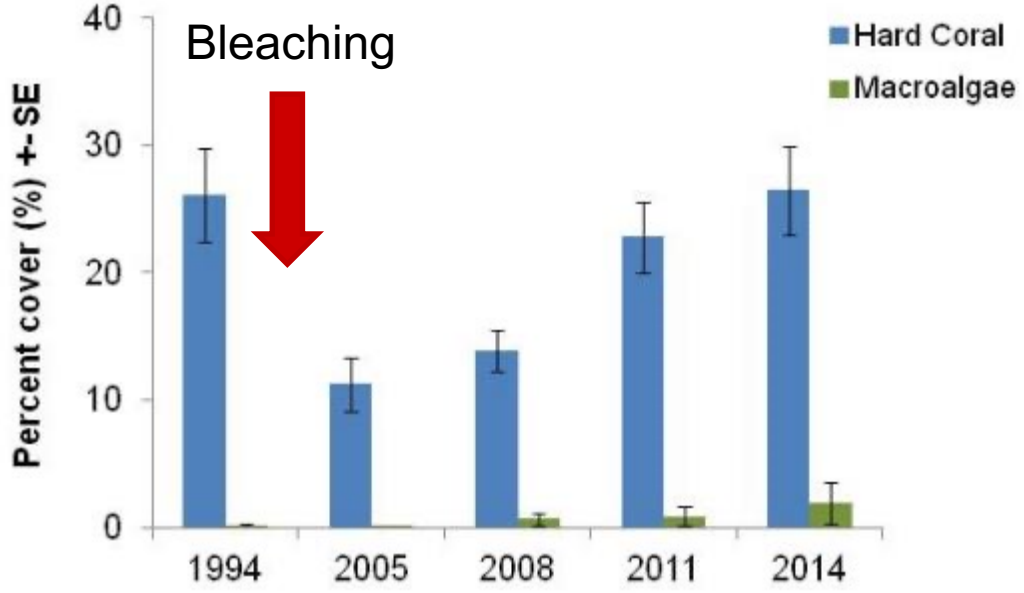


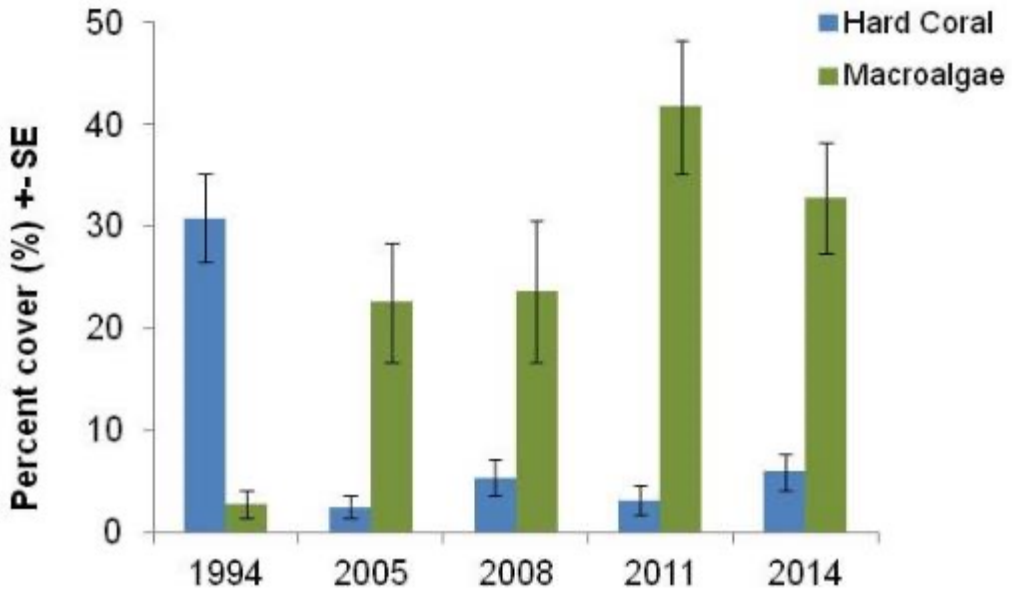
Graham et al. 2015 Nature

Benthic communities are changing dramatically

RECOVERY

REGIME SHIFT





Graham et al. 2015 Nature

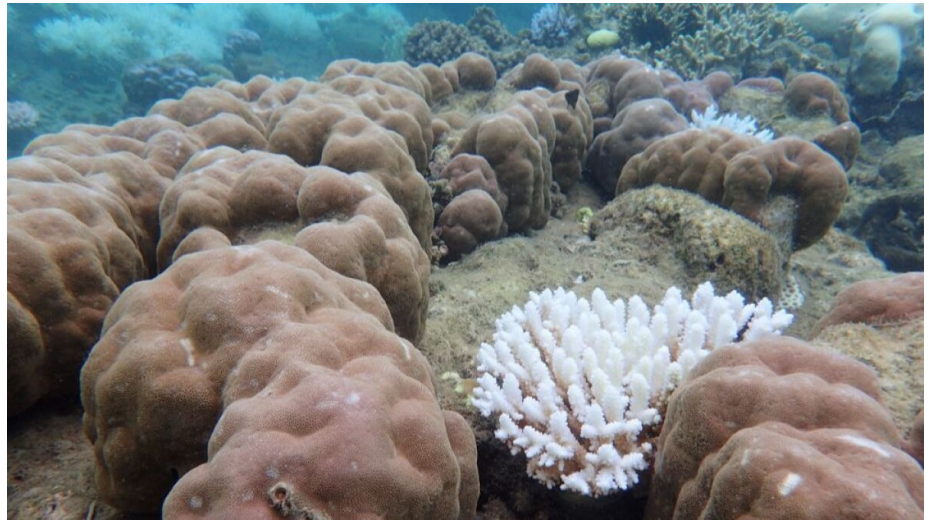
Winners and Losers

ECOLOGY LETTERS

Coral bleaching: the winners and the losers

Y. Loya, K. Sakai, K. Yamazato, Y. Nakano, H. Sambali, R. van Woesik

First published: 20 December 2001 | https://doi.org/10.1046/j.1461-0248.2001.00203.x | Citations: 916



Coral Reefs are Undergoing Transformation

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Environmental Sustainability

Coral reefs as novel ecosystems: embracing new futures

Nicholas AJ Graham[1], Joshua E Cinner[1], Albert V Norström[2] and Magnus Nyström[2]

Guiding coral reef futures in the Anthropocene

Albert V Norström[1a], Magnus Nyström[1], Jean-Baptiste Jouffray[1,2], Carl Folke[1,2,3], Nicholas AJ Graham[4,5], Fredrik Moberg[1], Per Olsson[1], and Gareth J Williams[6,7]

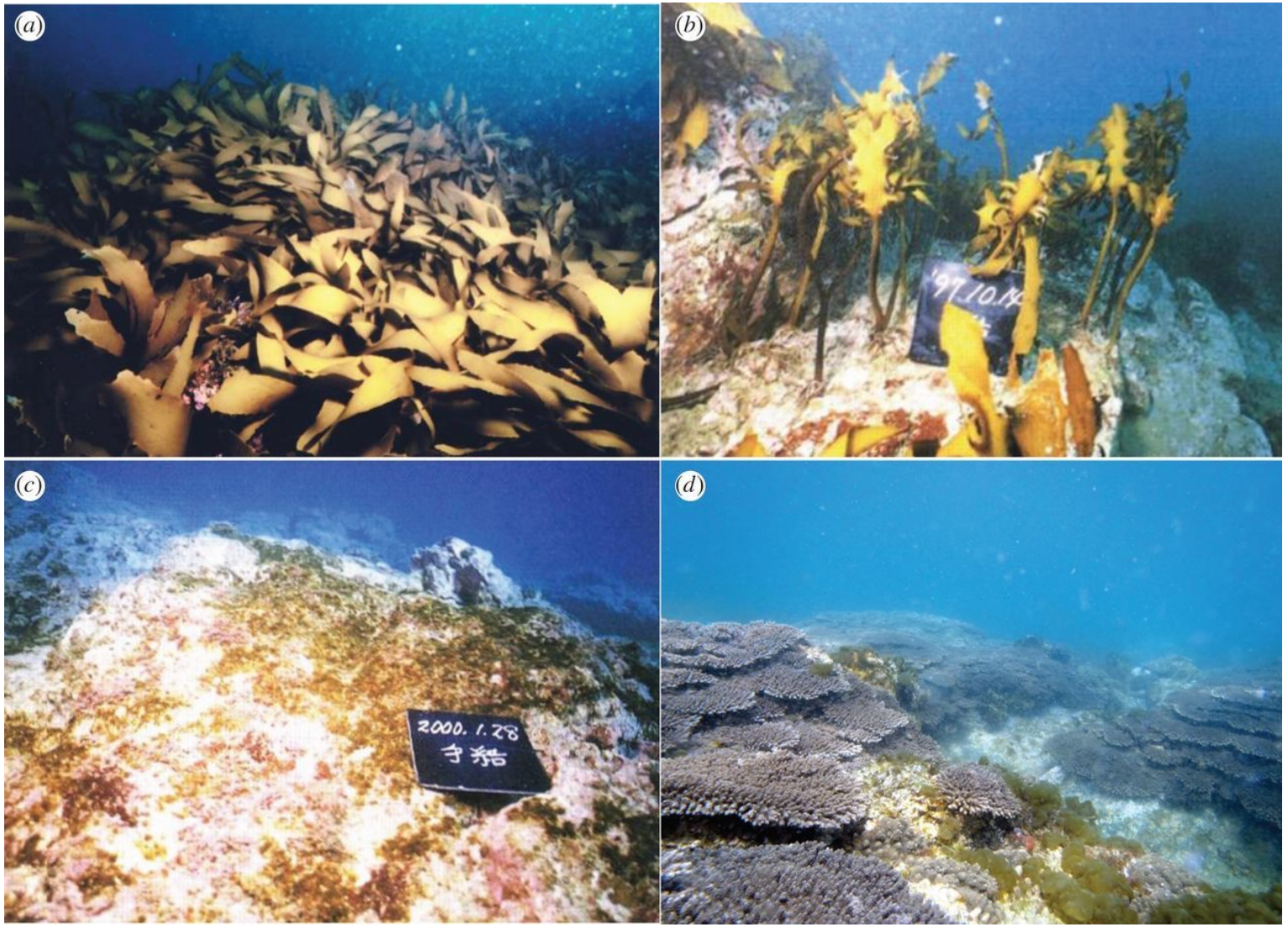
Coral reefs in the Anthropocene

Terry P. Hughes[1], Michele L. Barnes[1], David R. Bellwood[1], Joshua E. Cinner[1], Graeme S. Cumming[1], Jeremy B. C. Jackson[2,3], Joanie Kleypas[4], Ingrid A. van de Leemput[5], Janice M. Lough[1,6], Tiffany H. Morrison[1], Stephen R. Palumbi[7], Egbert H. van Nes[5] & Marten Scheffer[5]

Coral reef ecology in the Anthropocene

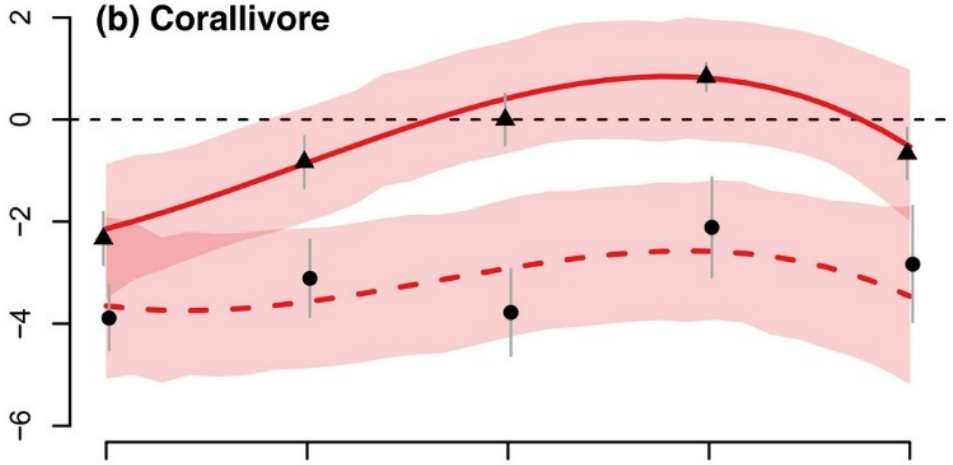
Gareth J. Williams[1] | Nicholas A. J. Graham[2] | Jean-Baptiste Jouffray[3,4] | Albert V. Norström[3] | Magnus Nyström[3] | Jamison M. Gove[5] | Adel Heenan[1] | Lisa M. Wedding[6]

Reefs on the move

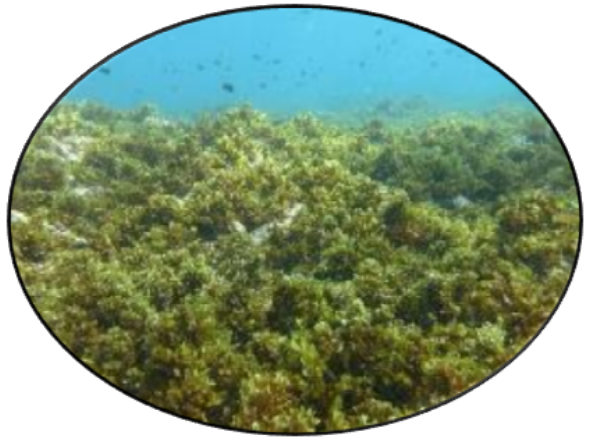


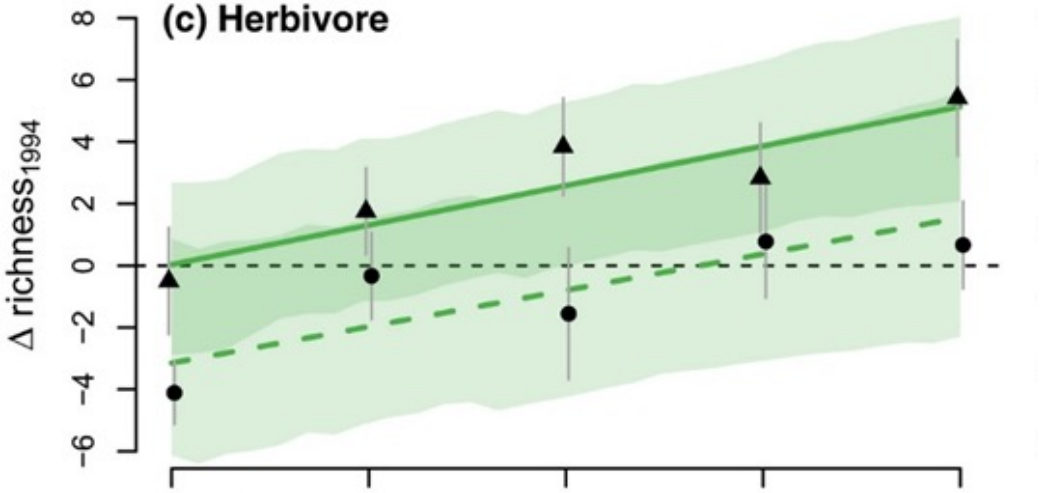
Verges et al. 2004 Proc B

Fish communities are changing dramatically



Francois Libert



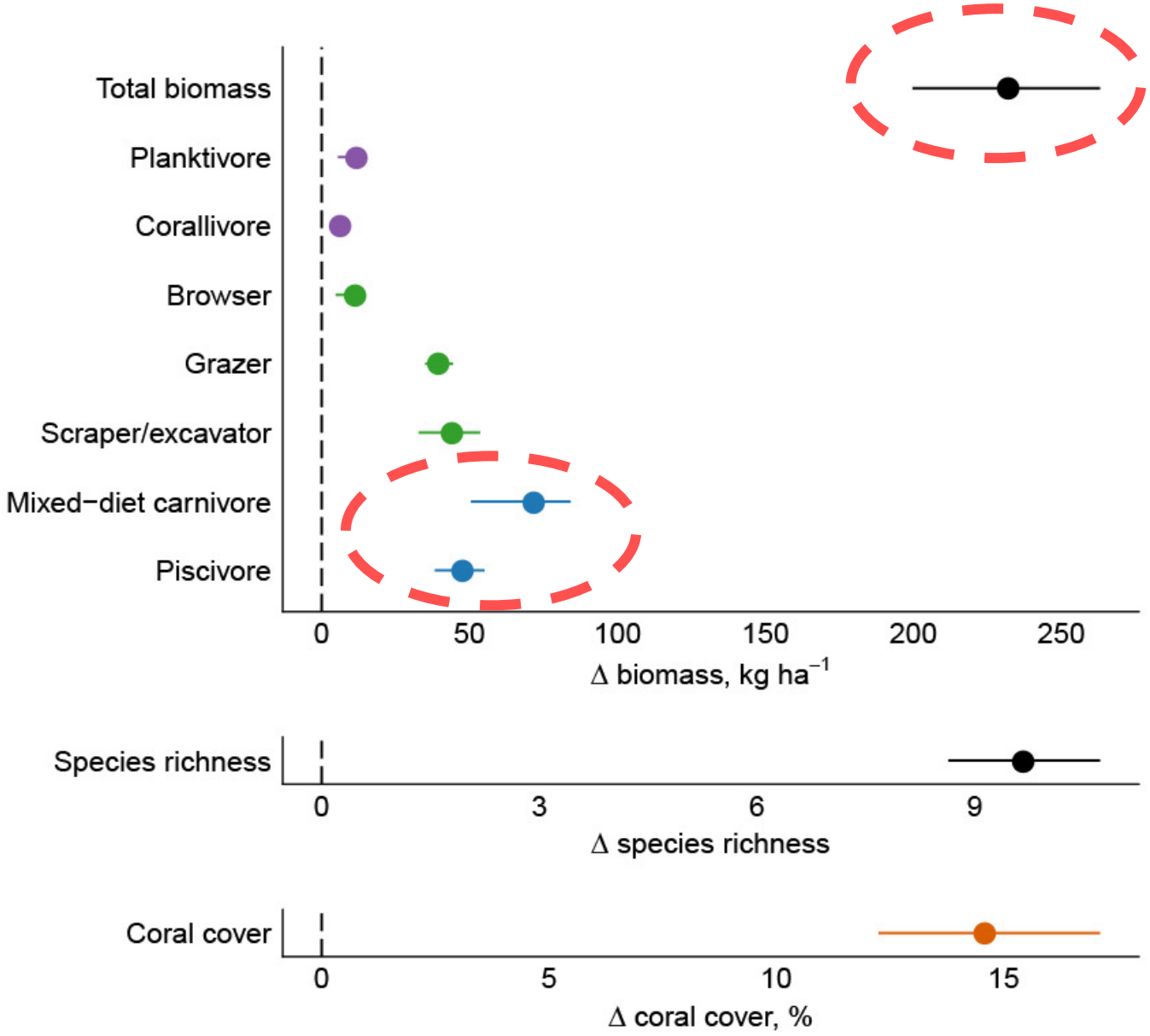


Robinson et al. 2019 GCB

Reef management

Marine Protected Areas – expectations based on decades of work

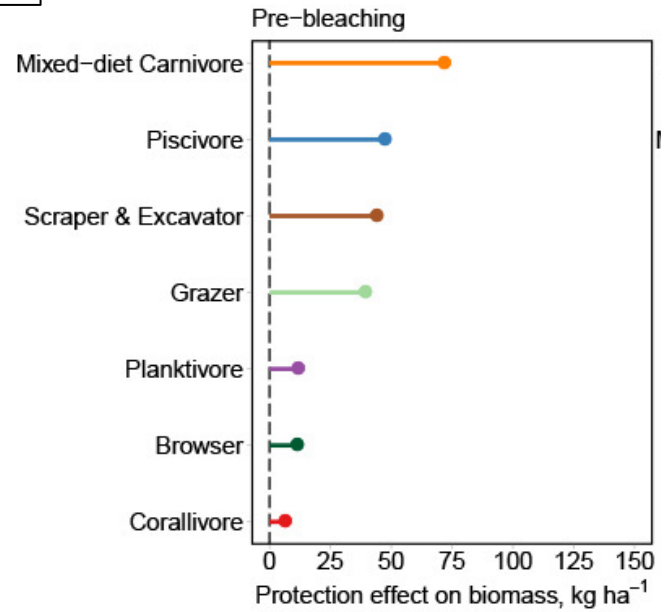
- Seychelles MPA effects 1994 (pre-bleaching)



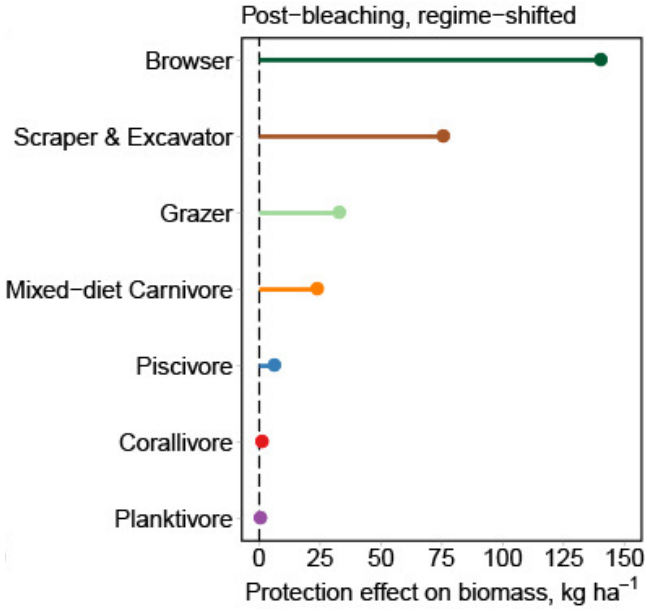
Graham et al. 2020 Nature Comms

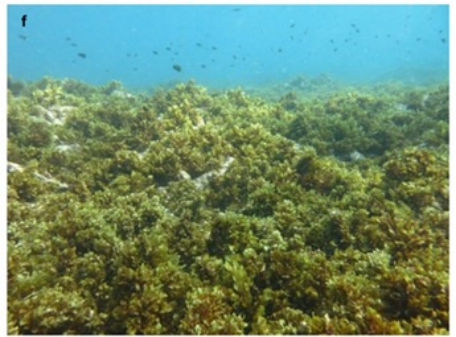
Changing role of marine protected areas

Before climate-induced regime shift



After climate-induced regime shift

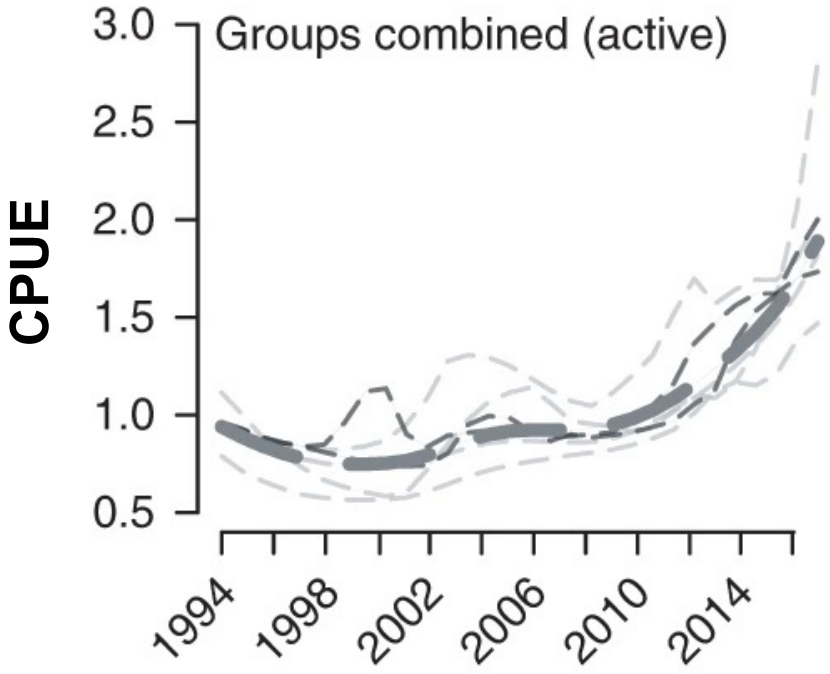


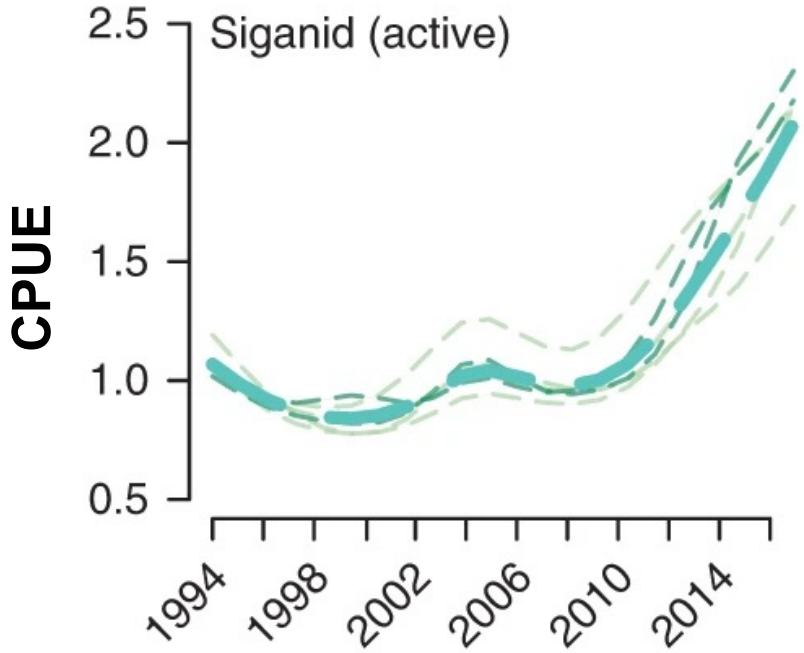


Graham et al. 2020 Nature Comms

Fisheries

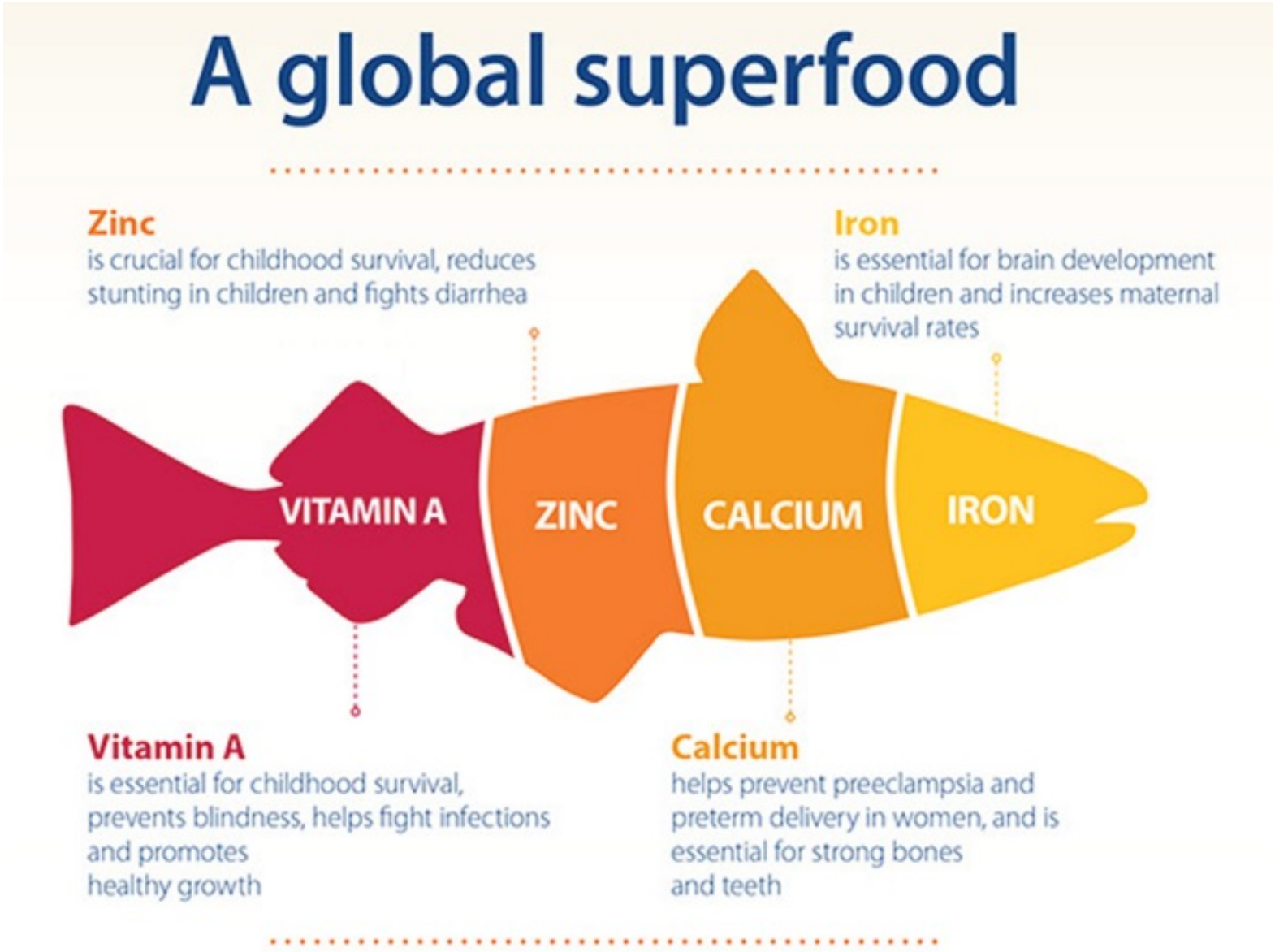
Fisheries following coral loss





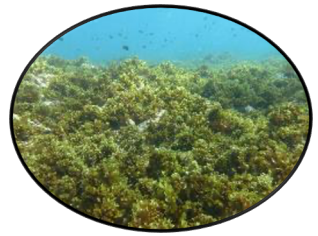
Robinson et al. Nature Eco Evo (2019)

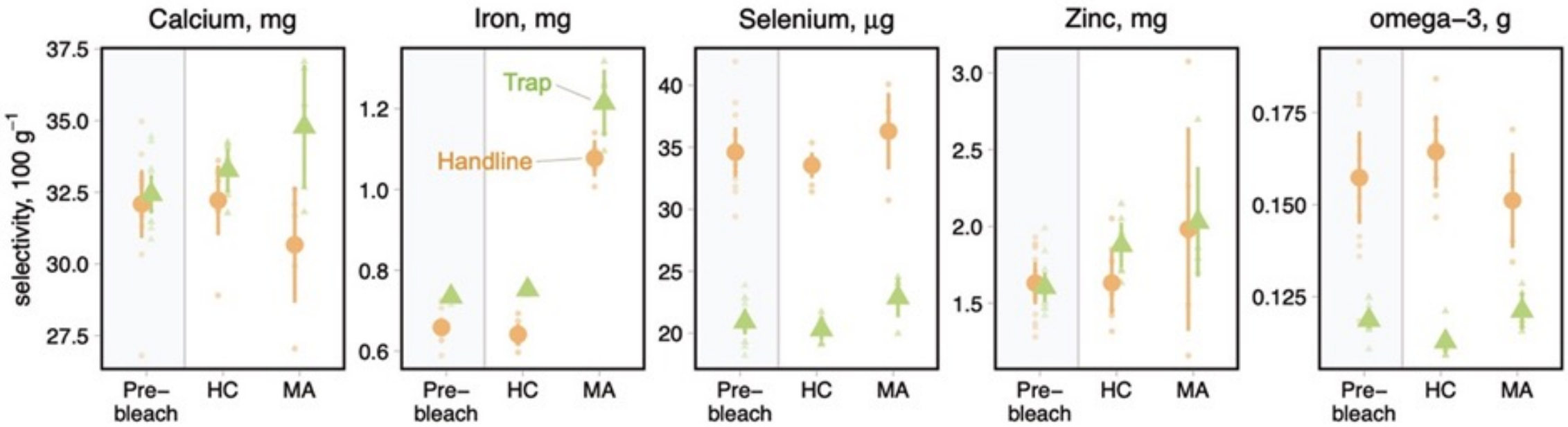
Food security



Fish are packed dense with nutrients

Pathways of nutrient change in reef fisheries

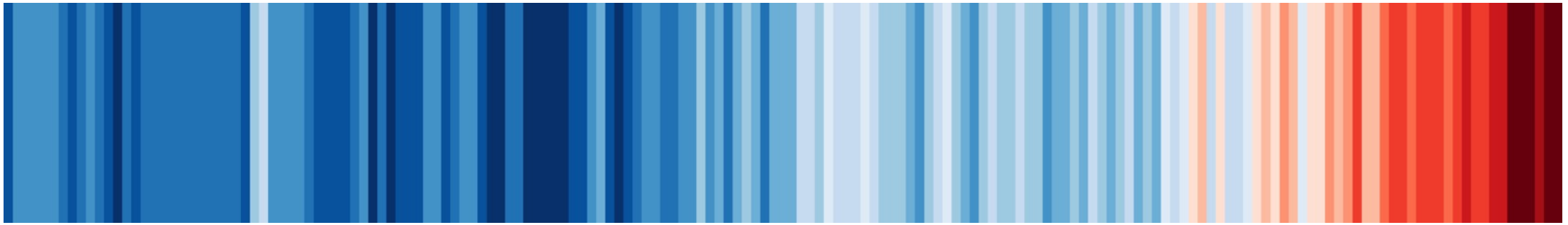




- Catch potential of micronutrients increased, particularly for zinc and iron

Robinson et al. 2022 One Earth

Global and local action is critical for coral reef futures



<1.5 C

Manage fisheries

Improve water quality

Nutrients are not always bad for coral reefs

High nitrogen, low phosphorus

- ✓ Slower growth
- ✓ Bleaches easier

High nitrogen AND phosphorus

- ✓ Faster growth
- ✓ Bleaches at higher threshold

D'Angelo & Wiedenmann 2014 Curr Opin Env Sust

Seabird nutrient subsidies

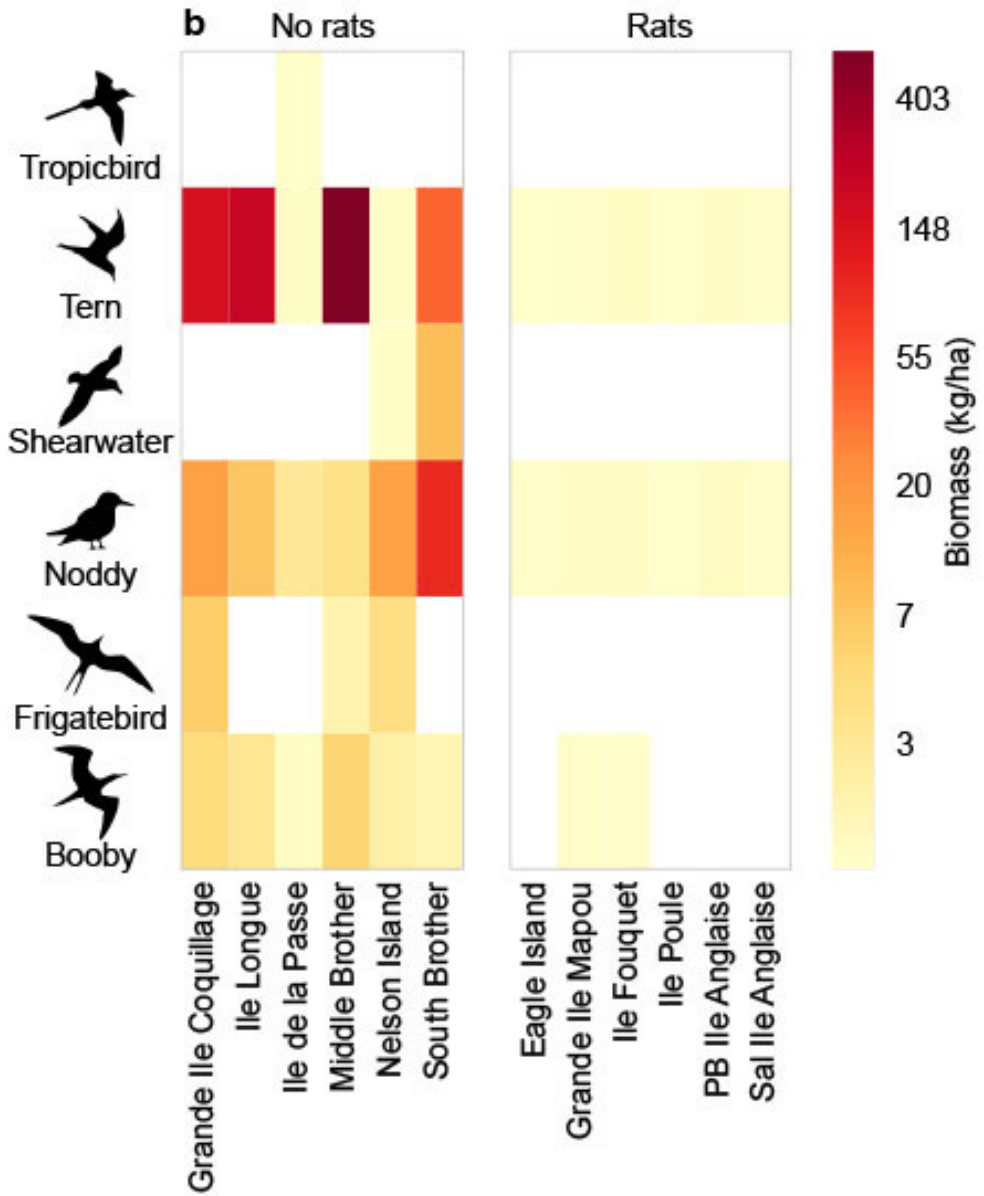
INVASIVE RATS

Rat-free islands

Rat-infested islands

Seabirds bring nutrients from open ocean

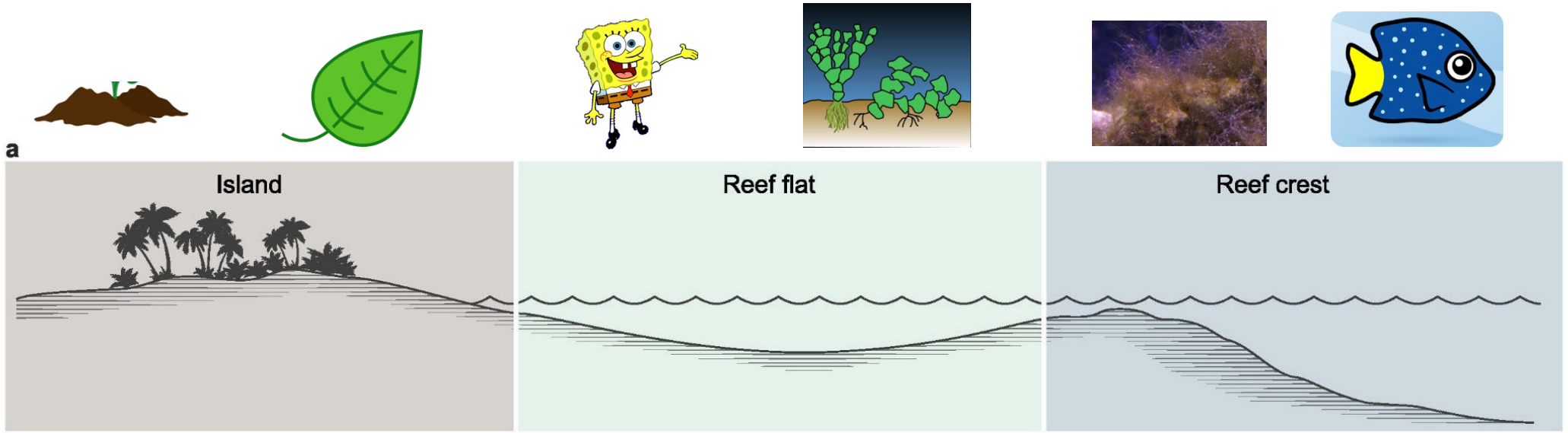
Seabirds & nutrients higher on rat-free islands

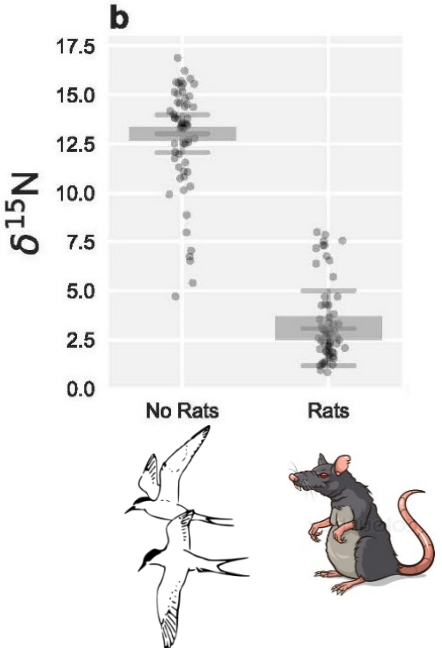


- 750 times more seabirds on islands with no rats
- 250 times more nitrogen input on islands with no rats

Graham et al. 2018 Nature

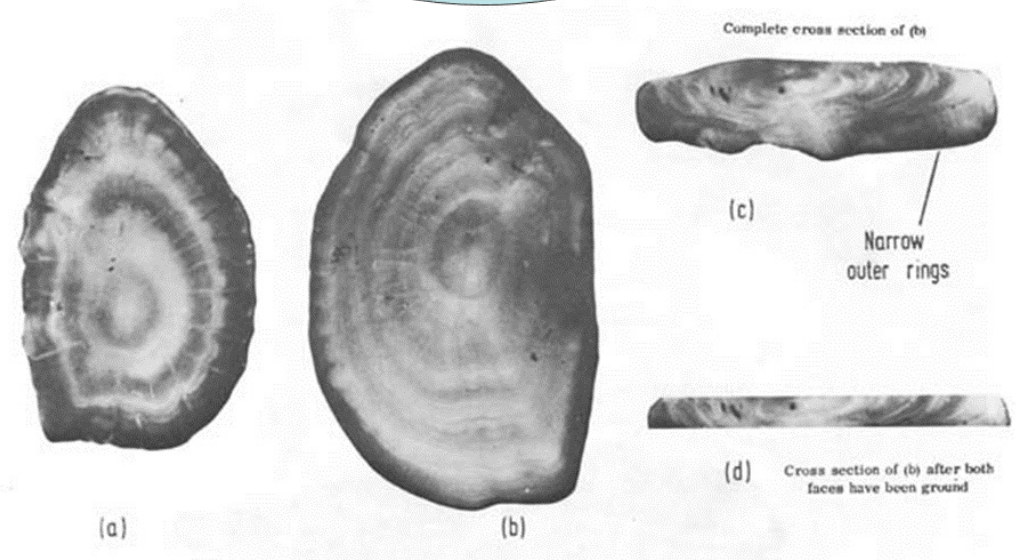
Huge nutrient subsidy

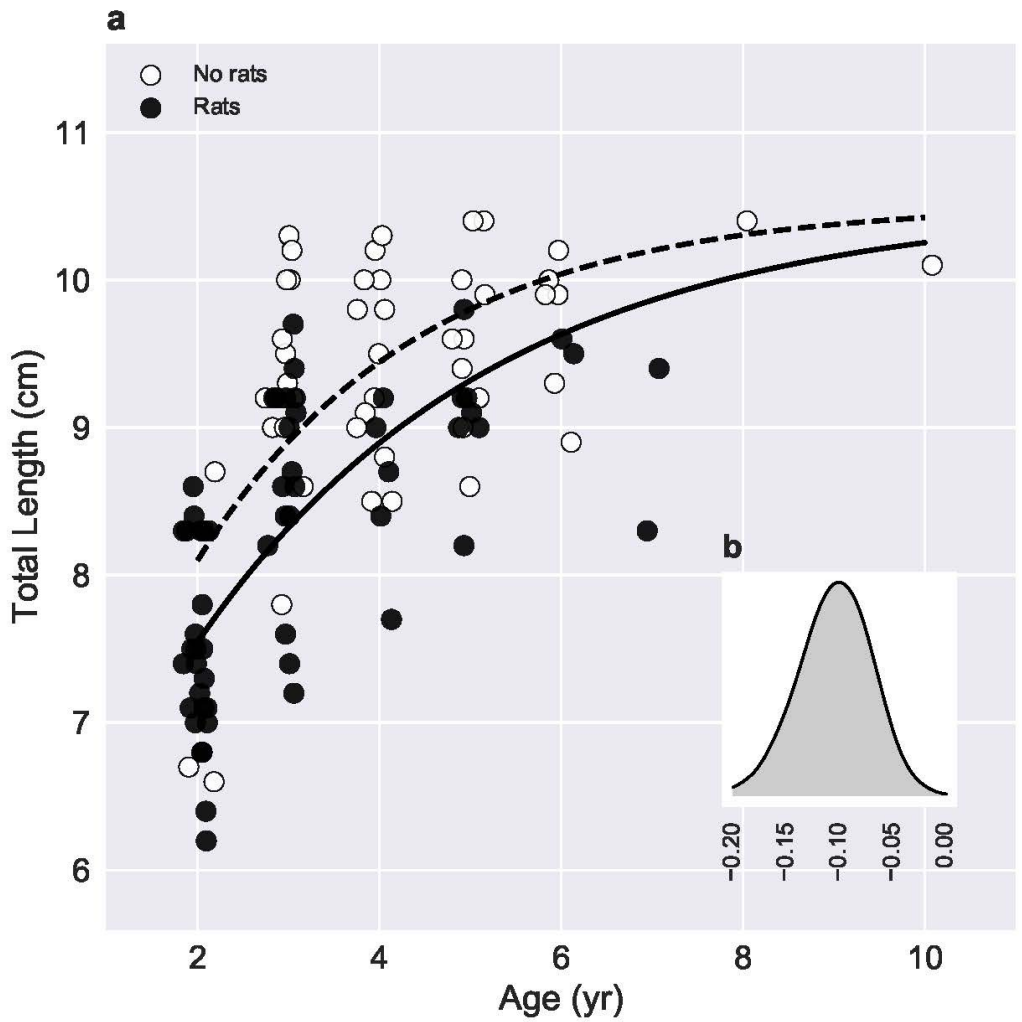




Graham et al. 2018 Nature

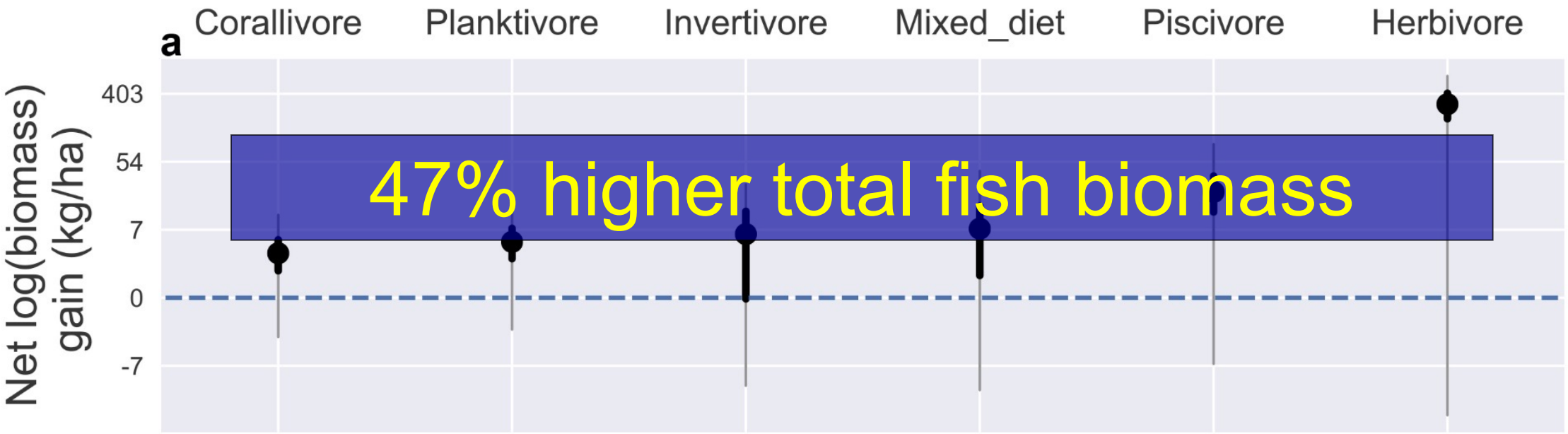
Fish grow faster with seabird nutrient subsidies

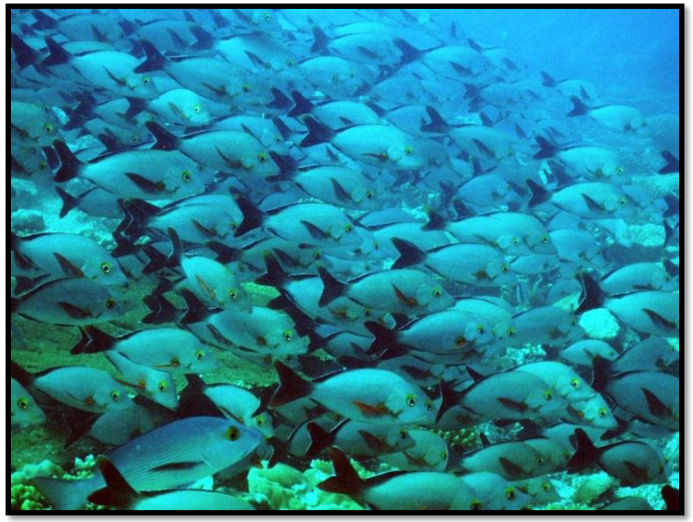




Graham et al. 2018 Nature

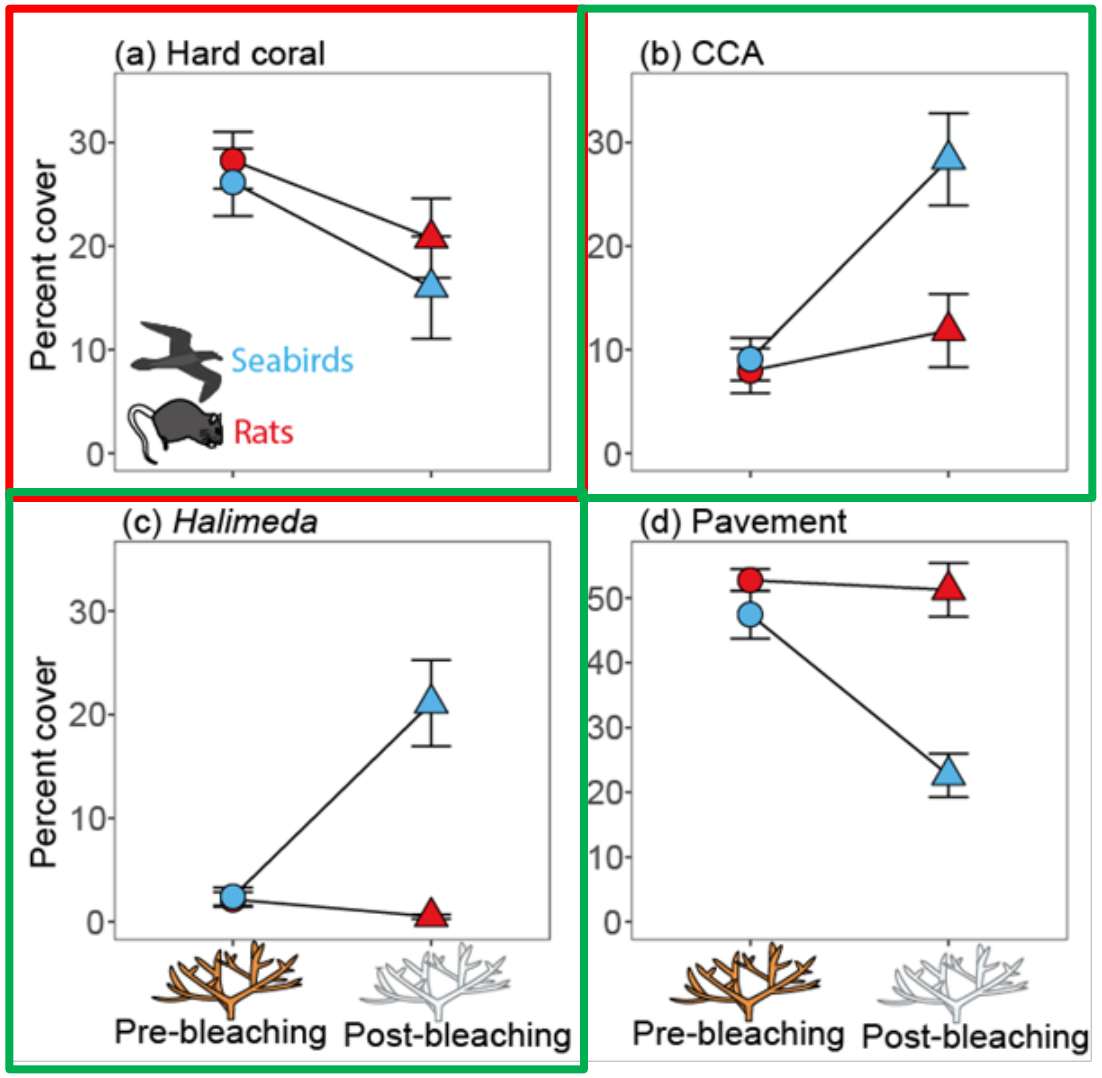
Fish biomass higher with seabird nutrient subsidy





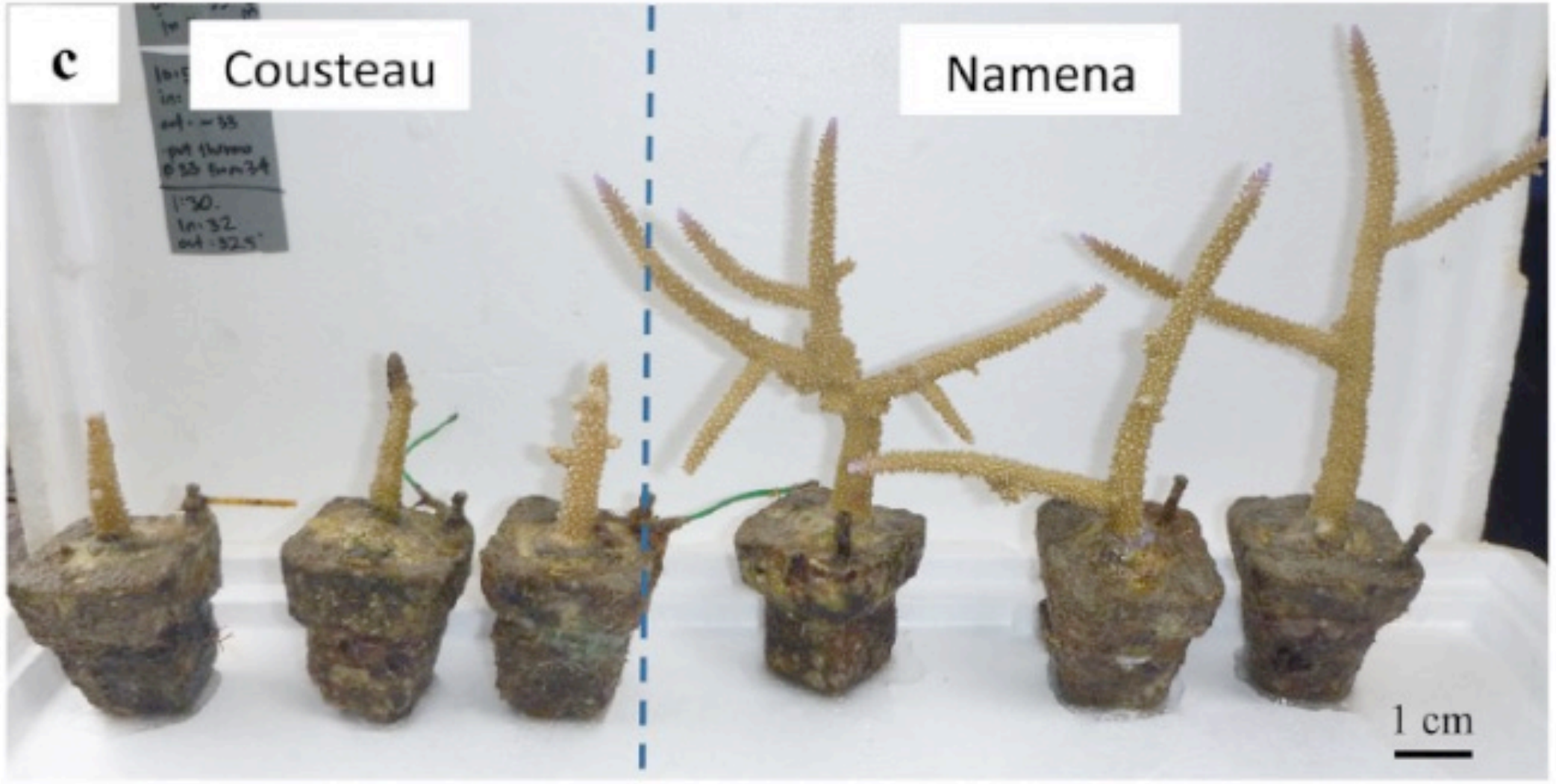
Graham et al. 2018 Nature

Reef responses to coral bleaching



Benkwitt, Wilson & Graham GCB (2019)

Seabird nutrients enhance coral growth FOUR times !!



Savage 2019 Sci Reports

- Coral reefs are undergoing profound change.
- Scientific understanding and management needs to keep pace and be adaptive.
- Cutting carbon emissions and reducing local pressures is essential
- Reinstating ecosystem connections, and natural energy flows also important

THE ROYAL SOCIETY

fondation bertarelli

SEYCHELLES FISHING AUTHORITY

Seychelles National Parks Authority

Thank You !

fsbi
An International Society for Fish Biology

Australian Government
Australian Research Council

LEVERHULME TRUST

NATURE SEYCHELLES