Integrating macro- & microbial ecology

A/Prof. Ziggy Marzinelli

THE UNIVERSITY OF SYDNEY

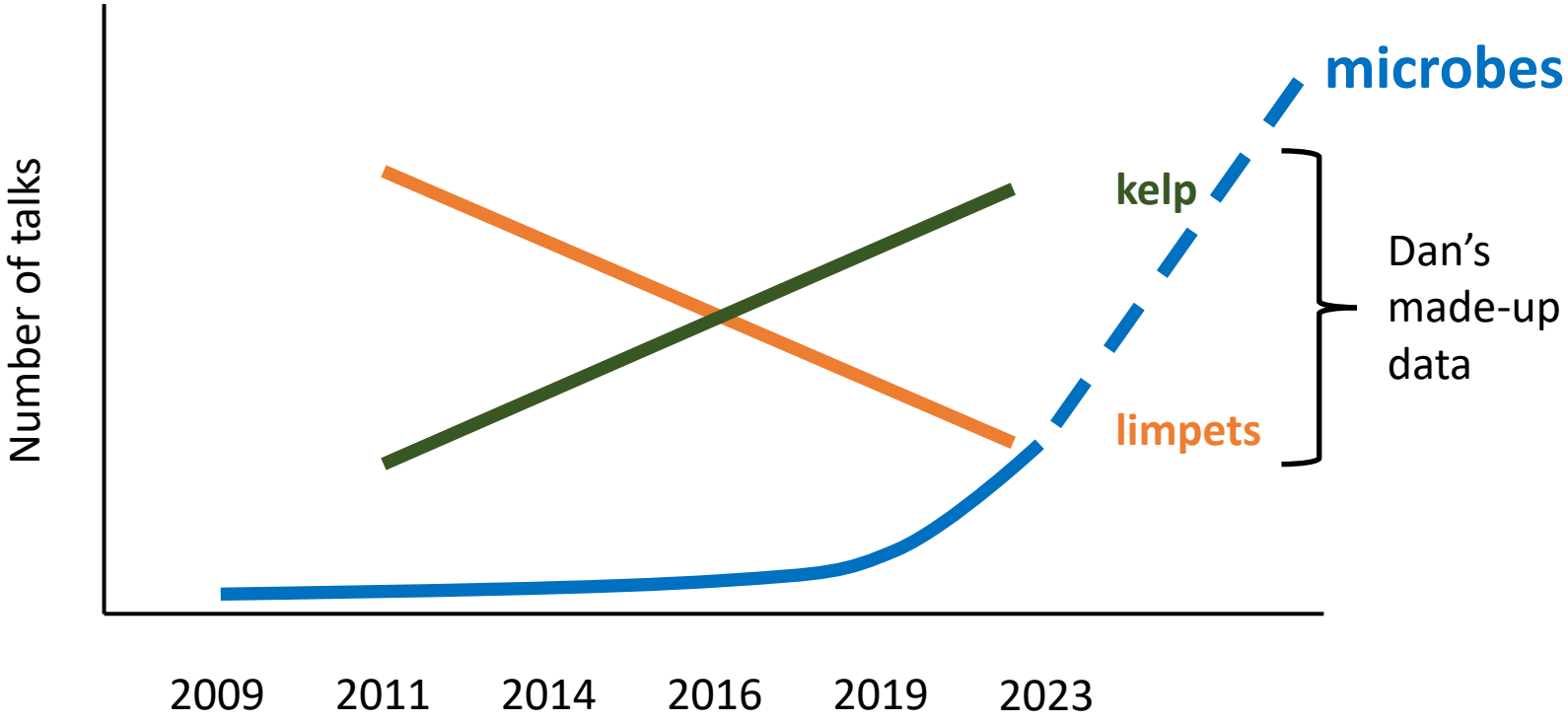
@ZiggyMarzinelli

Credit: NASA/GFSC

Credit: WordPress.com

ITRS 2019 HK
(I think)

ITRS talks through time (according to us)



‘Holobiont’

>50% of cells

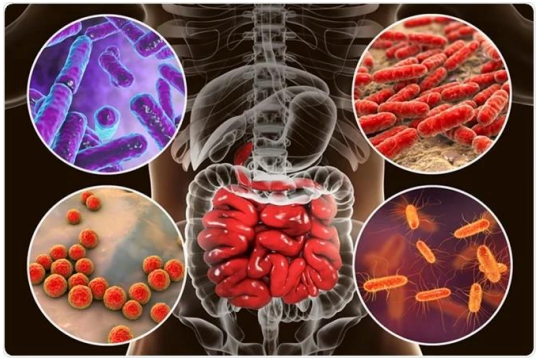
>95% of genes

Gilbert et al. 2018 *Nat. Med*.

‘Holobiont’

Change in environment, diet

Shift / imbalance of gut microbiota



Disease

e.g. inflammatory bowel disease, irritable bowel syndrome, asthma, cardiovascular disease, etc.

Carding et al. 2015 *Microb. Ecol. Health Dis*.

Credit: A. Rae, Quanta Magazine

Where/when…? How?

~~Do~~ changes in microbiomes matter?

What are the implications for managing ecosystems?

The ‘omics’ revolution

Ecology + Microbiology

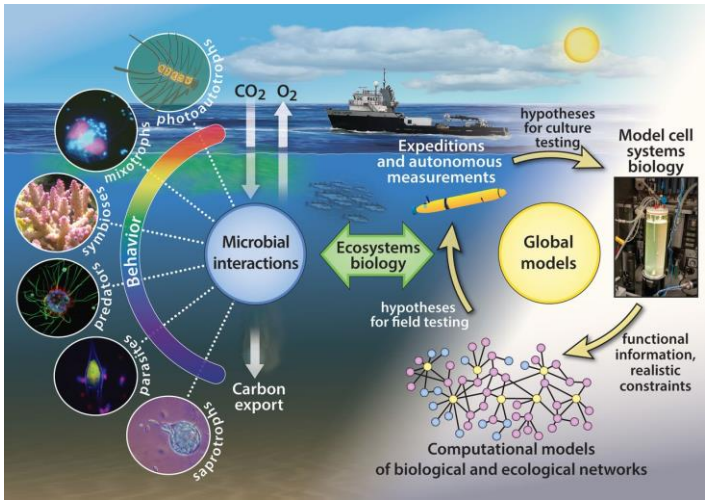
Molecular and computational tools

- 16S rRNA gene/ ITS/ 18S amplicon sequencing
  - [illegible]H, DADA2
- Metagenomics
  - Trimmomatic, metaSPAdes, MetaBAT (MAGs)
- Metatranscriptomics
  - MetaTrans
- Metabolomics, etc.
- Data analysis
  - Distance-based, mGLM, networks

Credit: W. Crochot

Marine systems

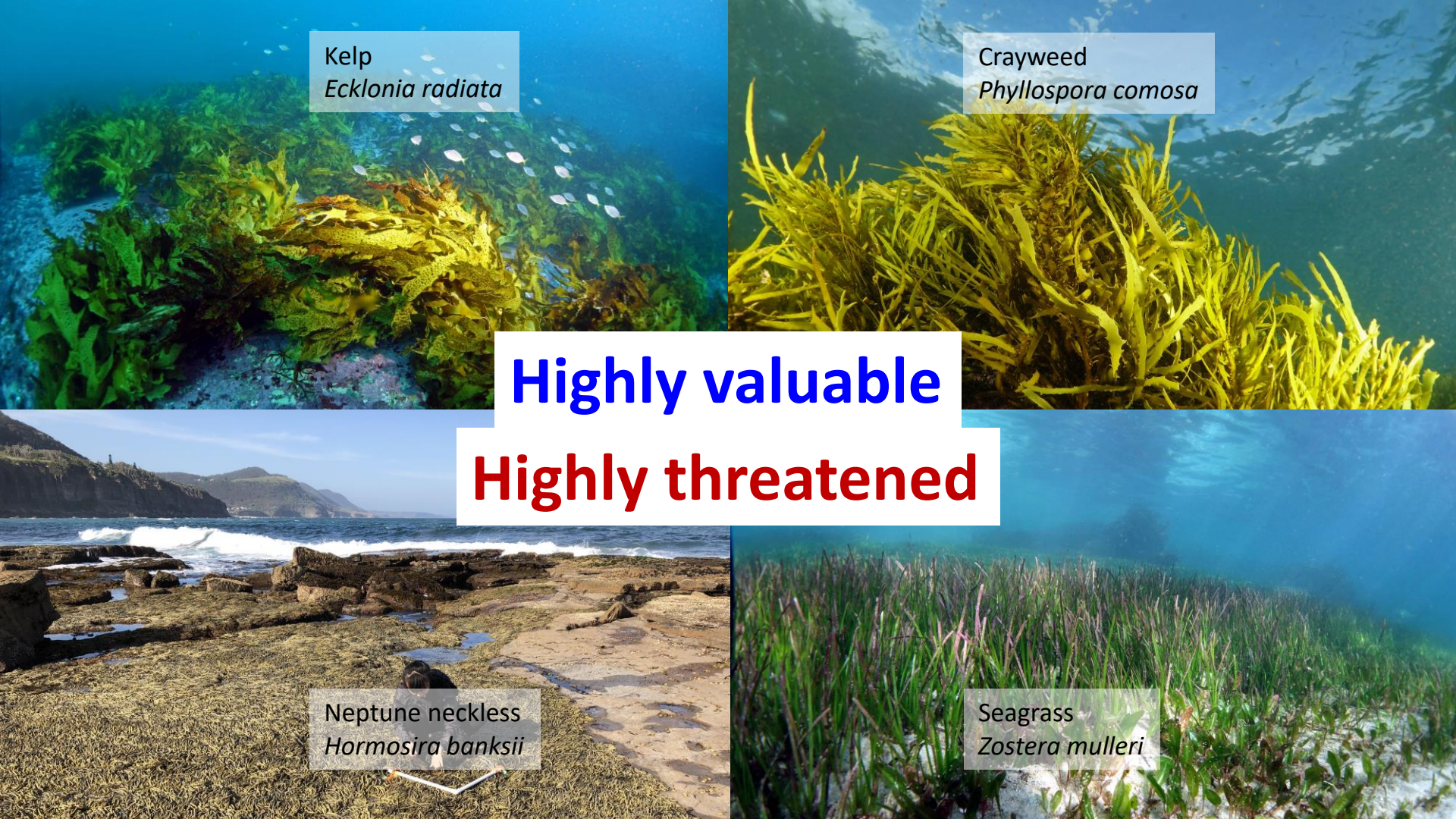
Open ocean



Worden et al. 2015 *Science*

Coastal habitat-formers??

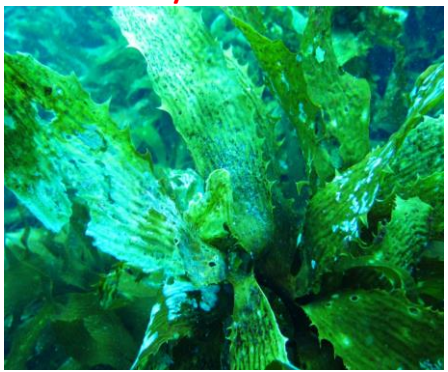
Marzinelli et al. 2015 *Environ. Microbiol.*;
Thompson et al. 2017 *Nature*; Trevathan-Tackett et al. 2019 *Nature Eco. Evo*.

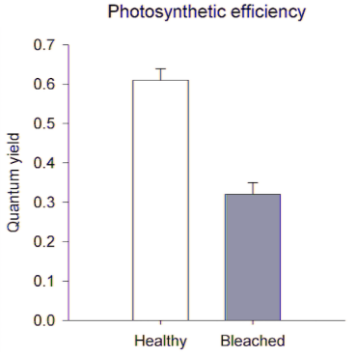

Kelp
Ecklonia radiata
Crayweed
Phyllospora comosa
Highly valuable
Highly threatened
Neptune neckless
Hormosira banksii
Seagrass
Zostera mulleri

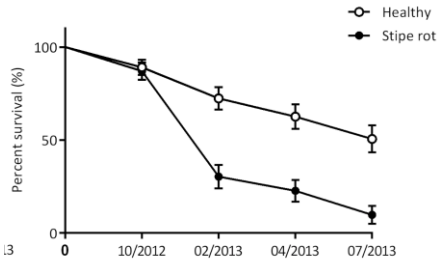
Host-microbe interactions & environmental change

Warmer waters and/or urban

Lower survival/ performance

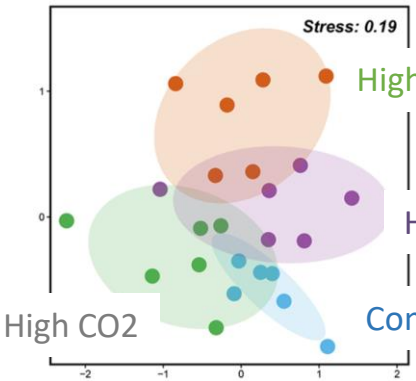


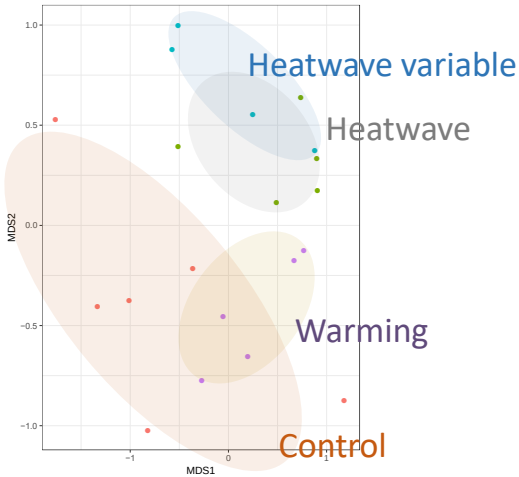


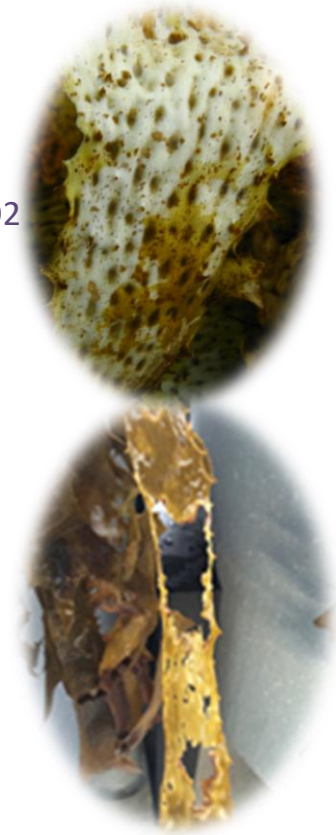


Marzinelli et al. 2015 *Env. Microbiol.*; Campbell & Marzinelli et al. In rev. *Ecology*

~ 10,000 ASV (= Amplicon Seq. Variants)

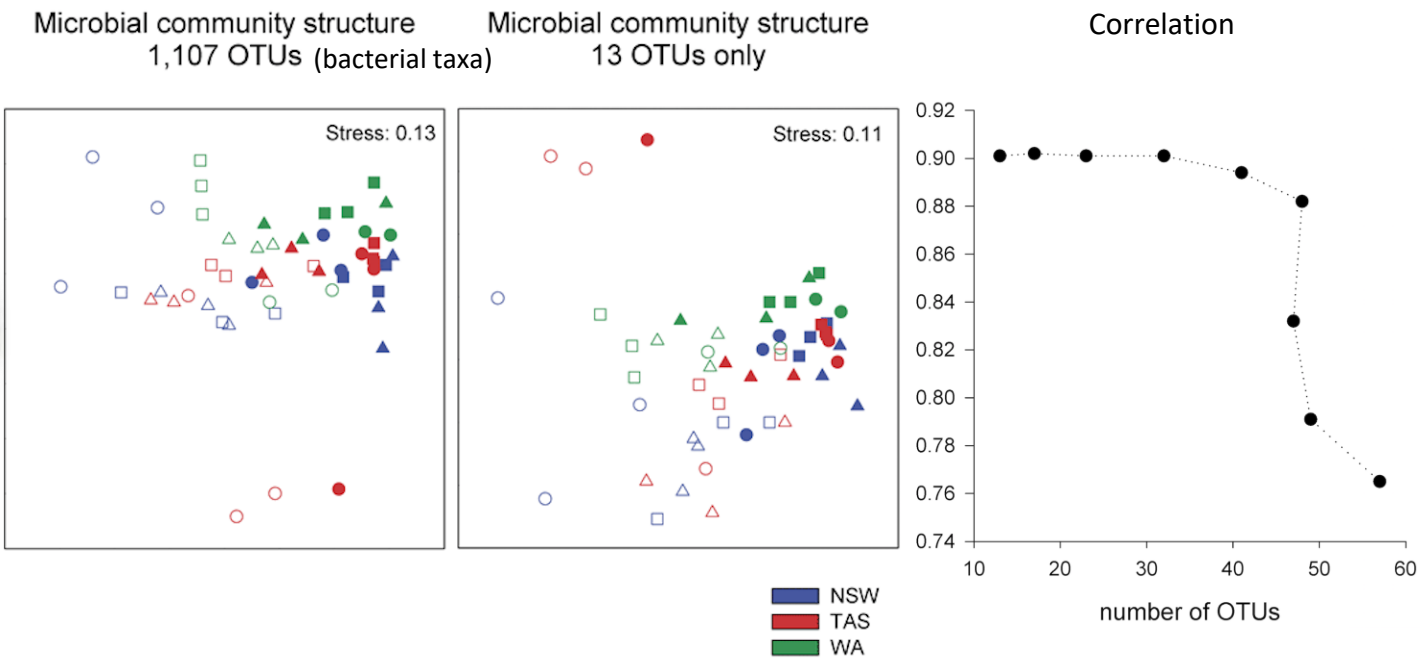






Marzinelli et al. 2018 *Nature Biof. Microb.*; Qiu et al. 2019 *Proc R Soc B*; Castro et al. In rev. *Molec. Ecol.*

Cause-effect: thousands, but high redundancy

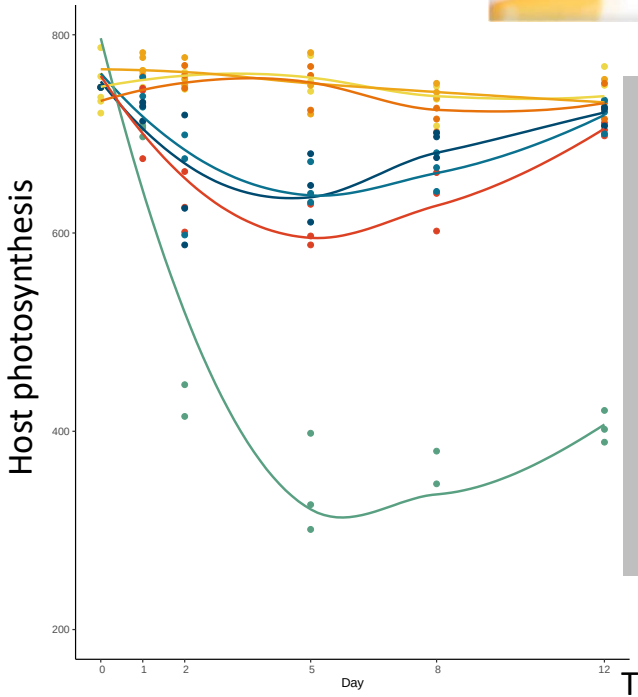


Same for functional genes (e.g. nutrient transport, sugar and phlorotannin degradation, stress responses)

Marzinelli et al. 2015 *Environ. Microbiol.*; Song et al. 2021 *ISME-J*

Cause-effect: removal/disturbance + inoculation

Alex McGrath



Undisturbed microbiota (Control)
Procedural control
Undisturbed microbiota + "harmless" *Vibrio*

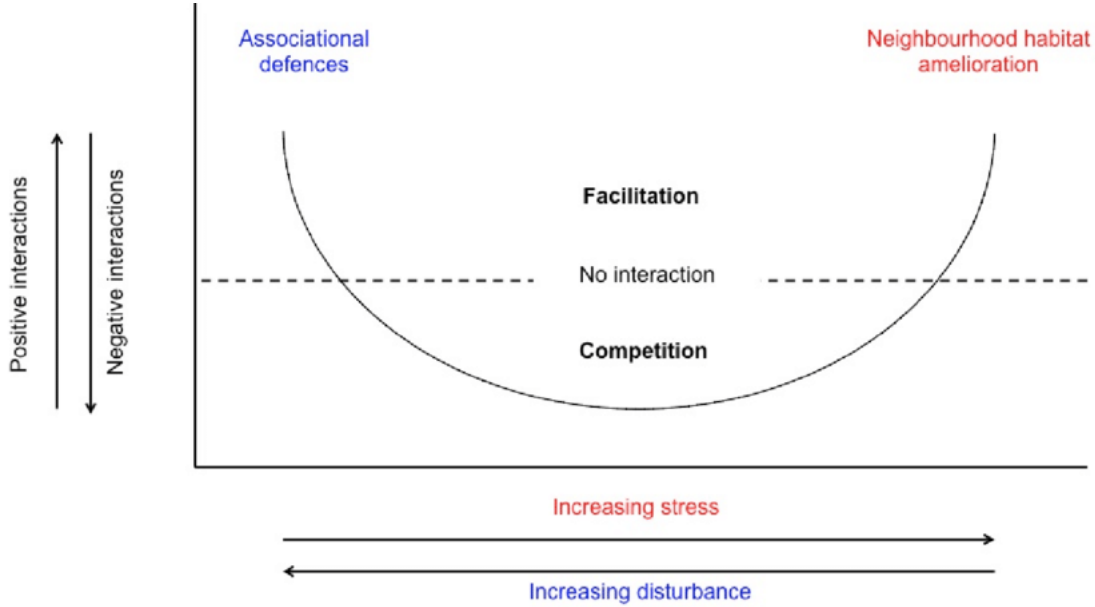
Disturbed microbiota
Disturbed microbiota + "harmless" *Vibrio*
Undisturbed microbiota + "bad" *Vibrio*

Disturbed microbiota + "bad" *Vibrio*

McGrath et al. In prep.

Where/when?

Stress gradient model

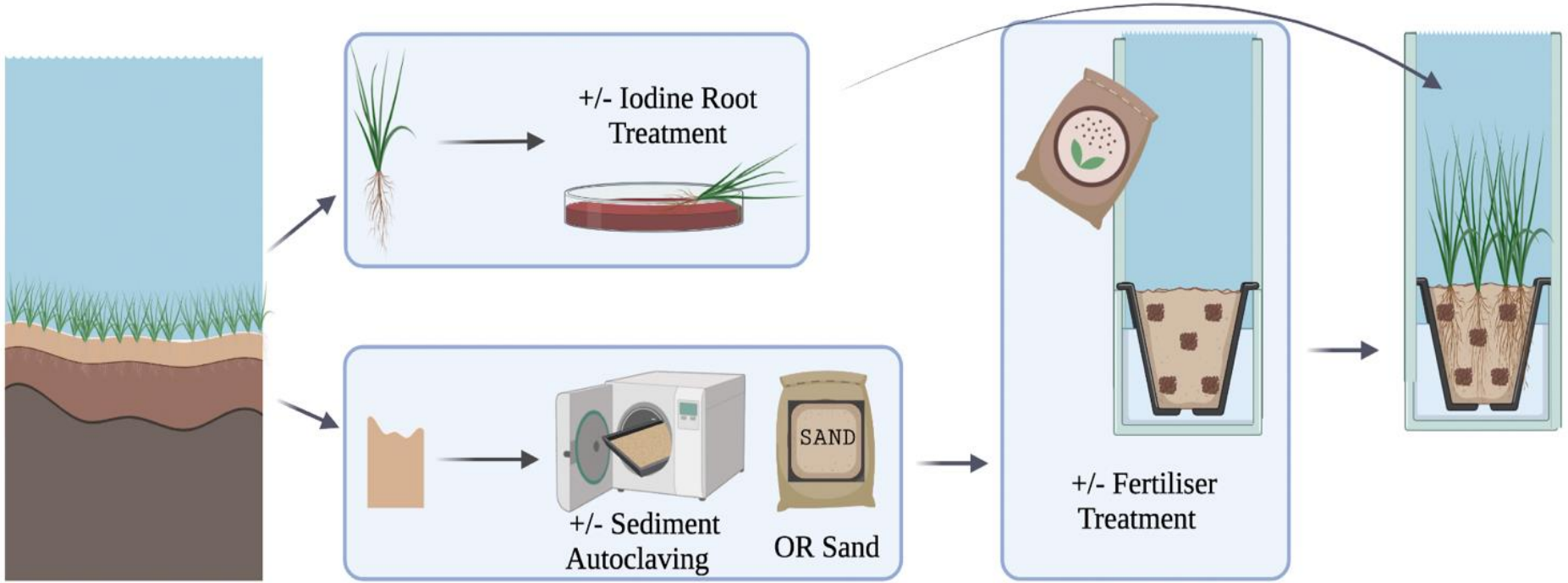


Bertness & Callaway 1994 *TREE*

Where/when? Plant-sediment interactions

Credit: CWR University & Los Alamos

Where/when? Plant-sediment interactions

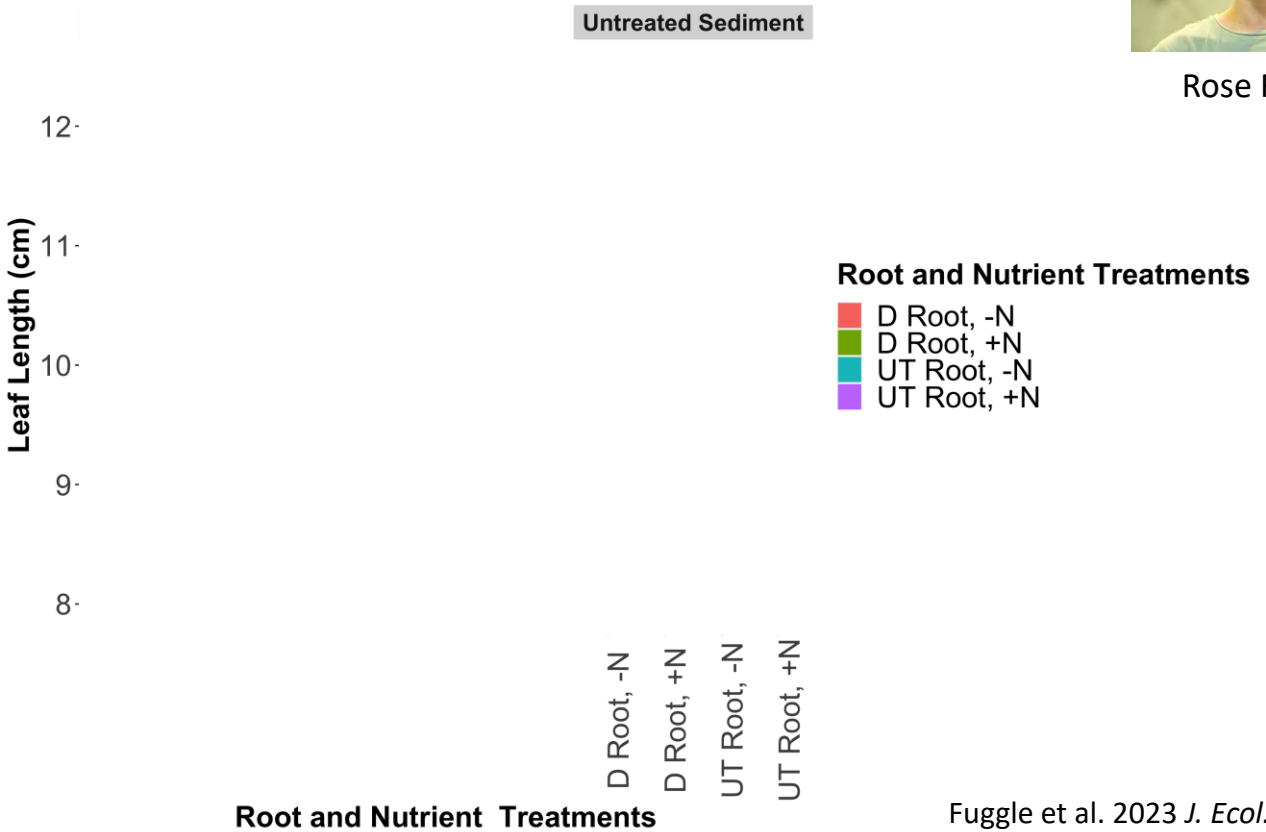


Fuggle et al. 2023 *J. Ecol.* In press

Where/when? Plant-sediment interactions

Rose Fuggle

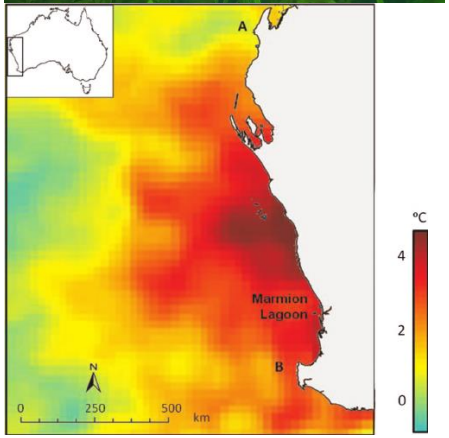
High N ->
anoxia, sulphides ->
Enrichment of
sulphide oxidising &
denitrifying bugs
(e.g. Beggiatoaceae
Candidatus thiopilula)



Fuggle et al. 2023 *J. Ecol.* In press

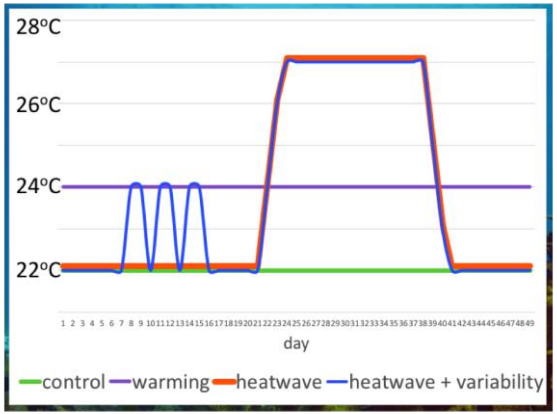
How? Ecological interactions

How? Ecological interactions



Wernberg et al. 2016 *Science*

Temperature treatments

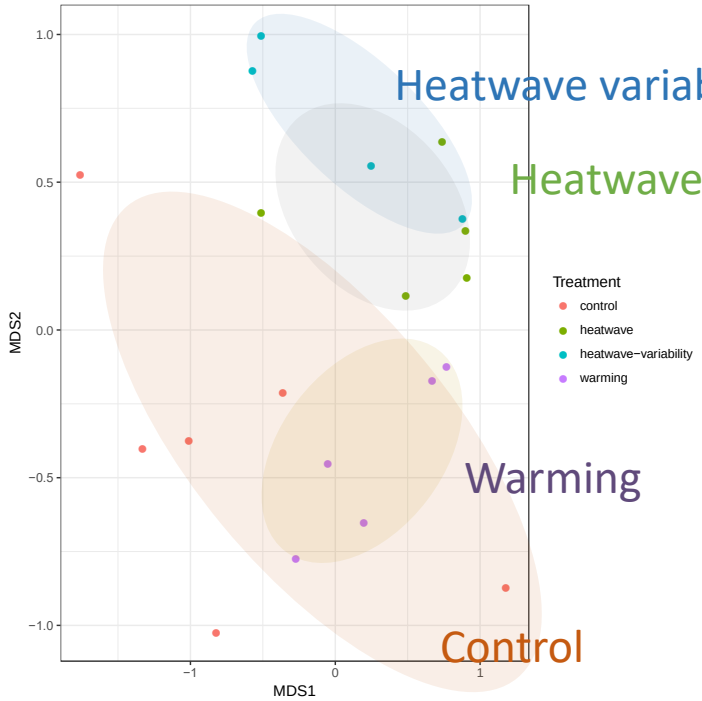


Straub et al. 2022 *J. Phycol.*; Castro et al. in rev. *Molecular Ecology*

How? Ecological interactions

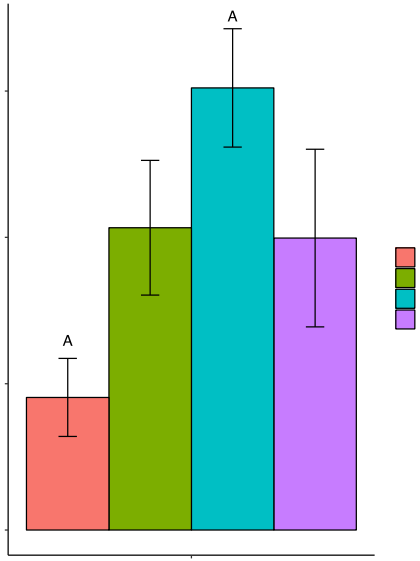
Kelp

Microbial community structure



Sea-urchin

Tripneustes gratilla



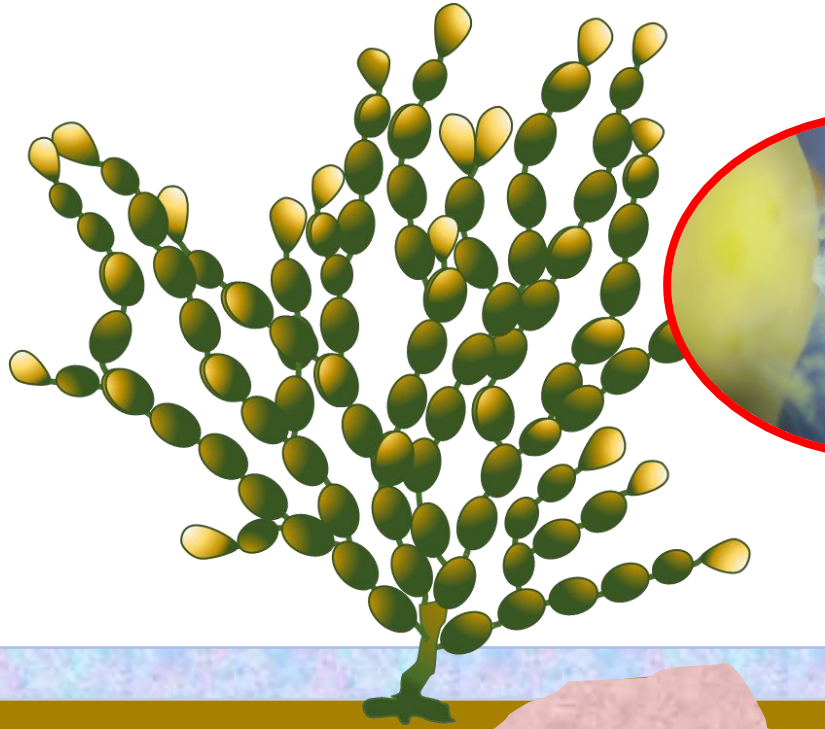
No effects on
C, N, chem. def.

Louise Castro

Castro et al. In rev. *Molecular Ecology*

How? Ecological processes?

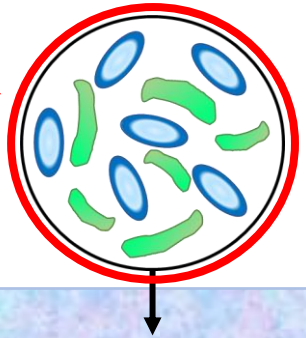
How? Ecological processes?



Alex McGrath

Seb Vadillo

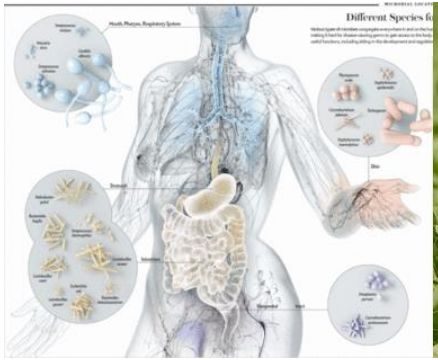
recruitment ?



Host-microbiome interactions & management

How does this new perspective change the way we would manage systems now and into the future?

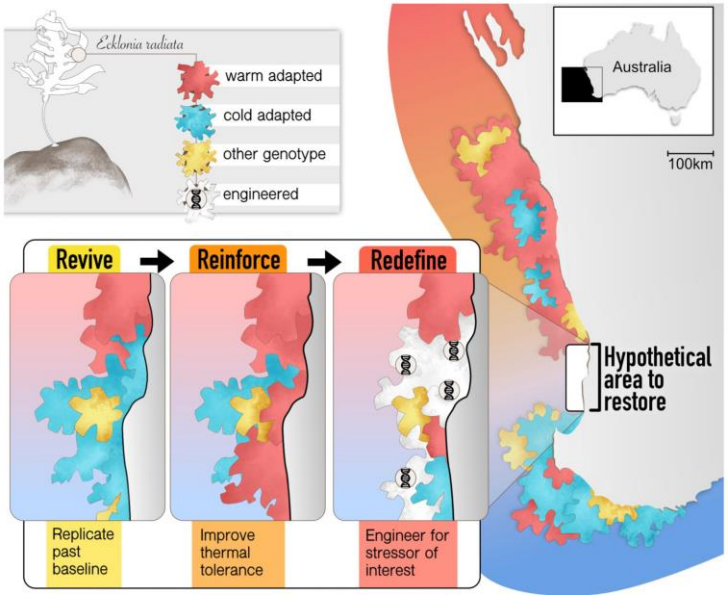
- Diagnosis/prognosis
- Intervention: rehabilitation & resilience



Future-proofing -> Host genotype

Restore or Redefine: Future Trajectories for Restoration

Melinda Ann Coleman[1,2,3], Georgina Wood[4,5], Karen Filbee-Dexter[3,6], Antoine J. P. Minne[3], Hugh Douglas Goold[7,8], Adriana Vergés[4,5], Ezequiel Miguel Marzinelli[5,9,10], Peter David Steinberg[4,5,10] and Thomas Wernberg[3,11]*



Coleman et al. 2020 *Front. Mar. Sci*.

‘Holobiont’

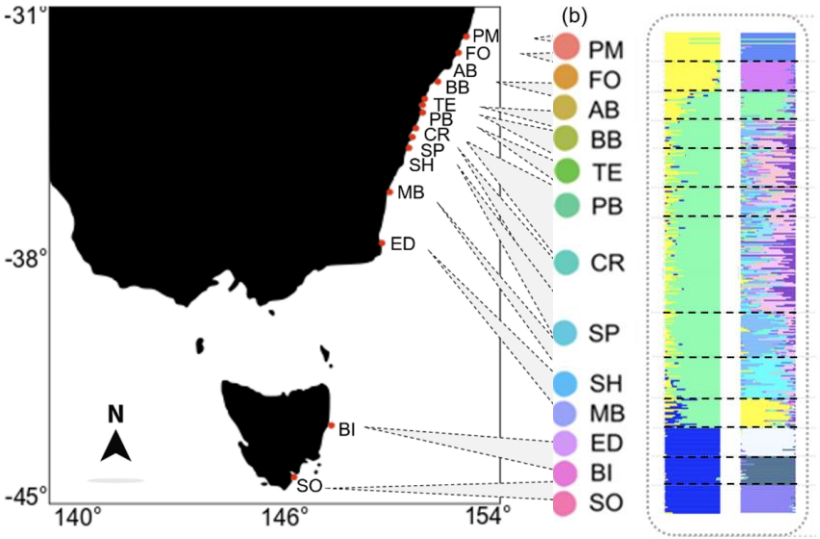
>50% of cells

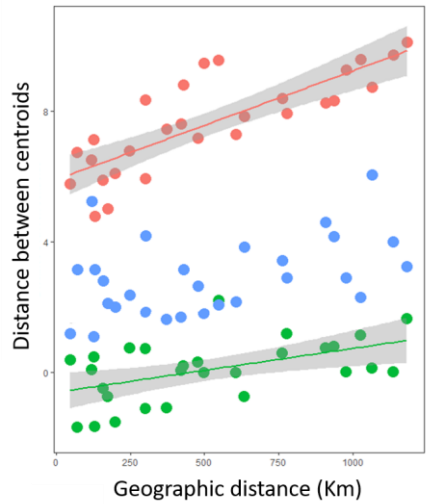
>95% of genes

Gilbert et al. 2018 *Nat. Med*.

Future-proofing -> Host genotype + microbiome?

George Wood





genotype

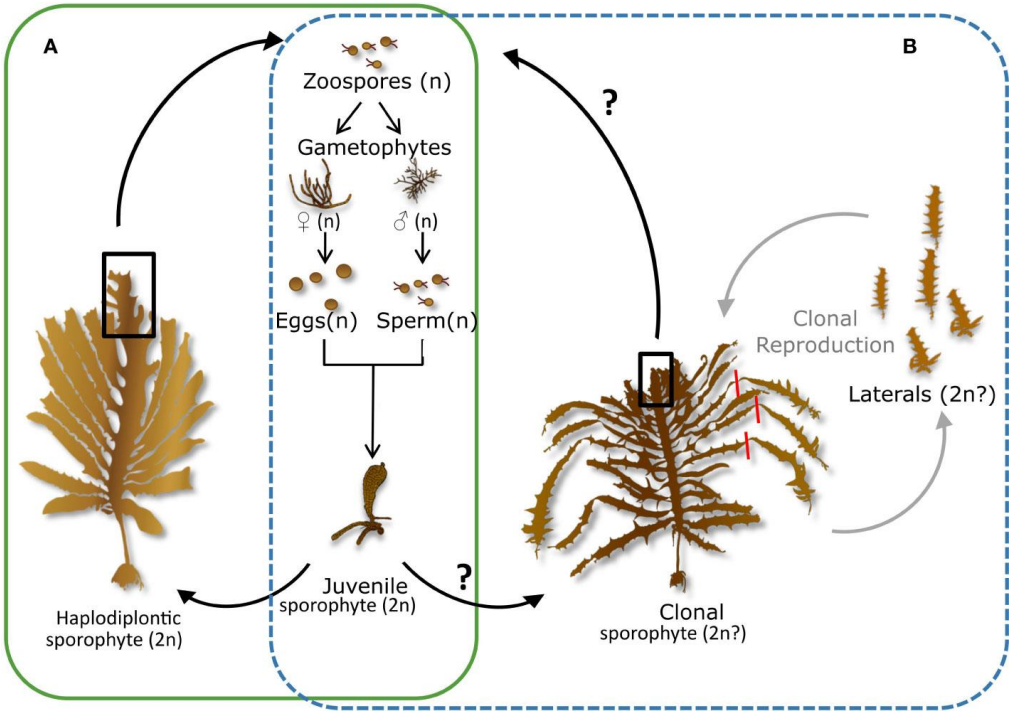
microbes

phenotype

Wood et al. 2021 *Global Change Biol.;* Wood et al. 2022 *Molecular Ecology*

Kelp clones vs unique genotypes vs diff. morphs in same environment

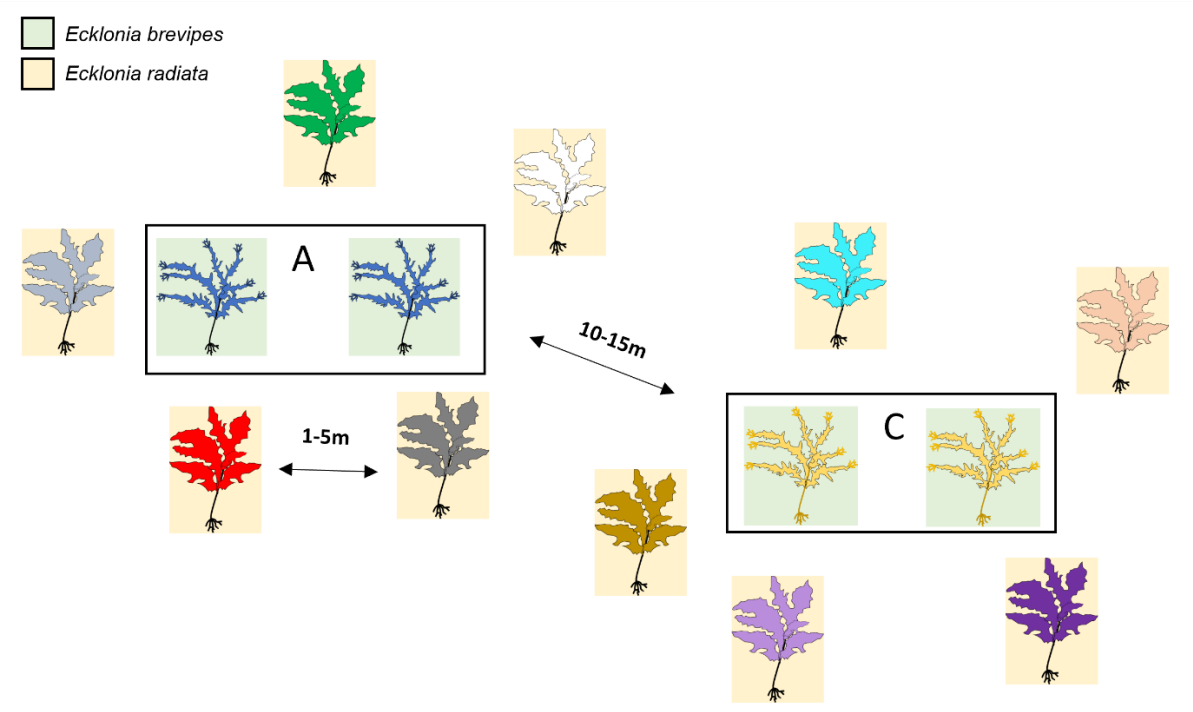
Ecklonia radiata
sexual reproduction



Ecklonia brevipes
sexual +
clonal reproduction

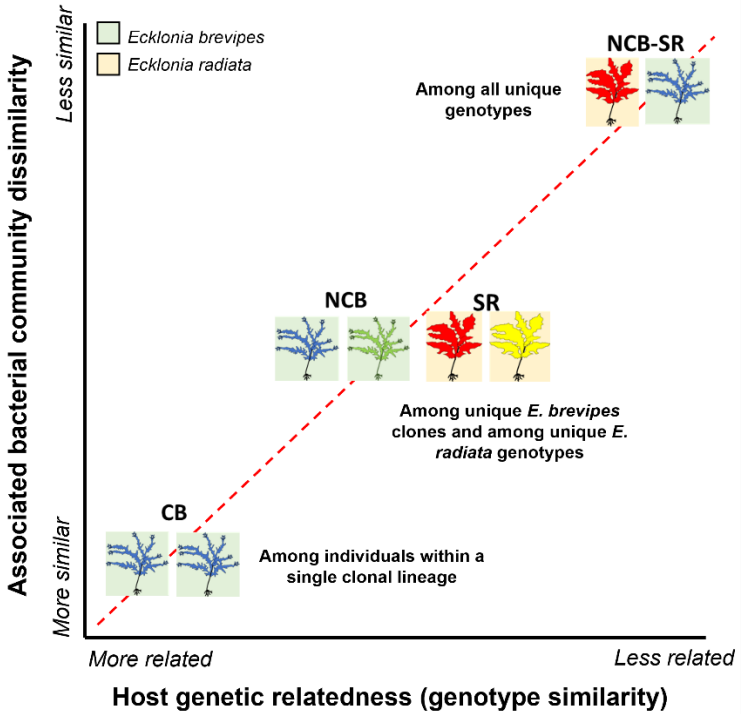
Coleman & Wernberg 2018 *Aquat. Bot.;* Vranken et al. 2022 *Front. Mar. Sci.*

Kelp clones vs unique genotypes vs diff. morphs in same environment



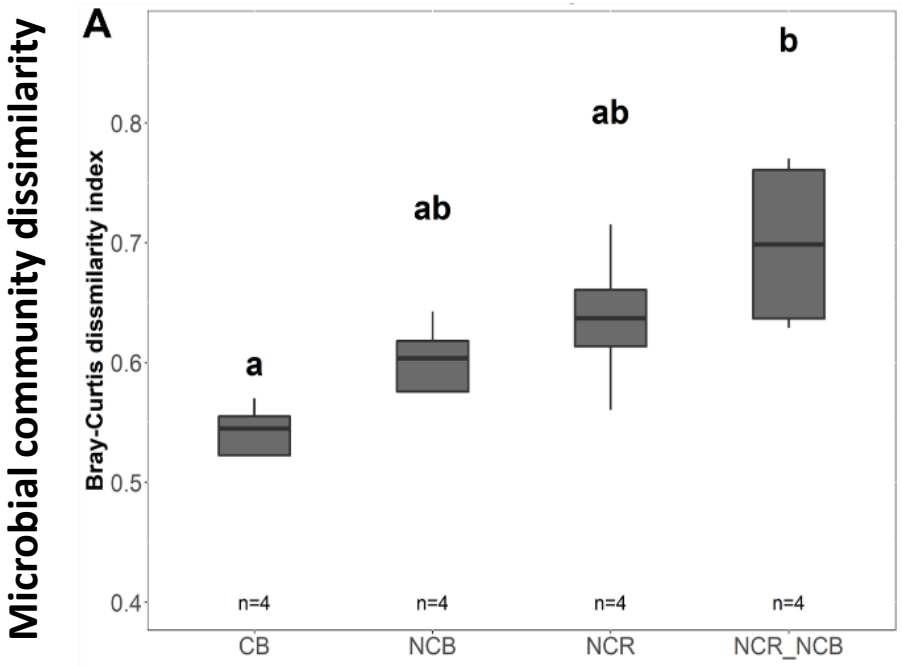
Vranken et al. 2022 *Front. Mar. Sci.*; Vadillo et al. In rev. *Molecular Ecology*

Kelp clones vs unique genotypes vs diff. morphs in same environment



Vadillo et al. In rev. *Molecular Ecology*

Kelp clones vs unique genotypes vs diff. morphs in same environment



Same for predicted function

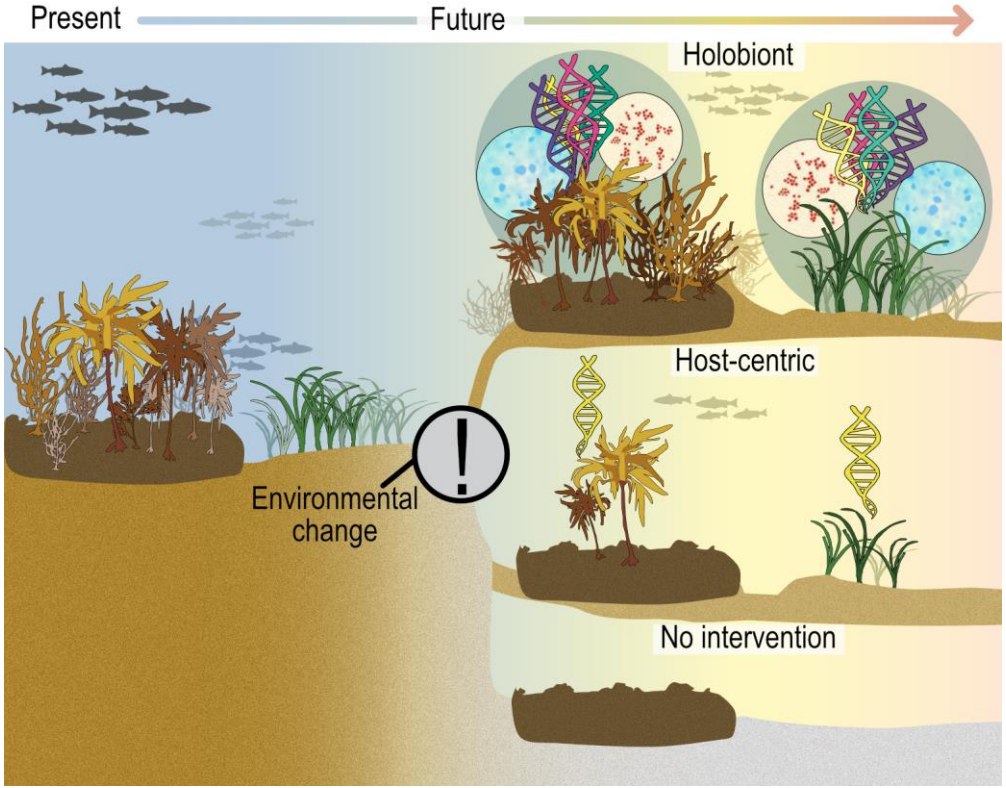
Clones brevipes

Non-clones radiata brevipes

radiata vs brevipes

Vadillo et al. In rev. *Molecular Ecology*

Future-proofing -> Host genotype + microbiome



The Super Coral

PERSPECTIVE

Building coral reef resilience through assisted evolution

Madeleine J. H. van Oppen[a,1], James K. Oliver[a], Hollie M. Putnam[b], and Ruth D. Gates[b]
[a]Australian Institute of Marine Science, Townsville MC, QLD 4810, Australia; and [b]Hawaii Institute of Marine Biology,

GLOBAL CHANGE

Coral microbiome dynamics, functions and design in a changing world

Madeleine J. H. van Oppen[1,2]* and Linda L. Blackall[1]

Conclusion and future directions

- **Integrating ecology and microbiology**
  - Role of microbes in ecosystem function
  - New tools for management

- **Enhancing resilience into the future**
  - Host genotype + microbiome (and life-stage)
  - Mediating macro-macro interactions, e.g. invasion, herbivory
  - Phase-shifts: host-associated vs “habitat-associated” microbiomes
  - Links to animal and human health

Collaborators, students, volunteers:
Peter Steinberg, Torsten Thomas, Mel Coleman, Suhelen Egan, Adriana Vergés, Paul Gribben, Alex Campbell, Thomas Wernberg,
Kim Lema, George Wood, Alex McGrath, Seb Vadillo, Sandra Straub, Sofie Vranken, Louise Castro, Rose Fuggle, Renske Jongen

Lim-Sutton

NSW GOVERNMENT

NSW Environmental TRUST

earth microbiome project

Recreational Fishing Trusts

NSW GOVERNMENT Department of Primary Industries

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Australian Government
Australian Research Council

sims sydney institute of marine science


AFA
10