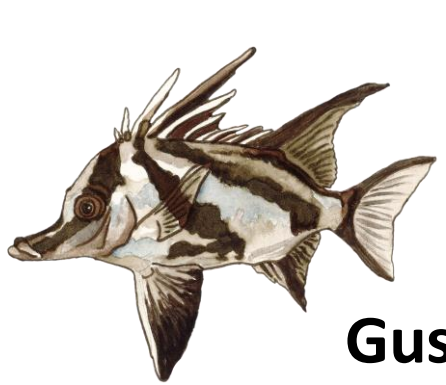
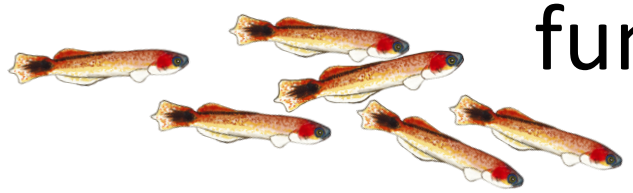
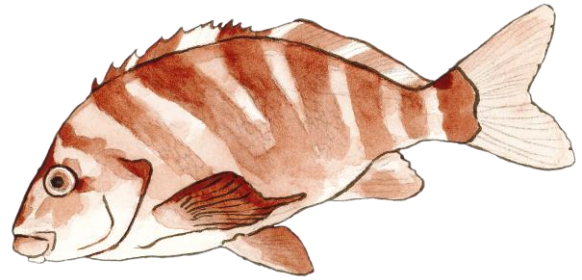
Size based Tasmanian rocky reef model shows importance of benthic production for reef ecosystem functioning







Asta Audzijonyte &

Gustav Delius, Rick Stuart-Smith, Camilla Novaglio, Graham Edgar, Neville Barrett, Julia Blanchard

Institute for Marine and Antarctic Studies &

Centre for Marine Socioecology , University of Tasmania

UNIVERSITY of TASMANIA

IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

CMS CENTRE FOR MARINE SOCIOECOLOGY

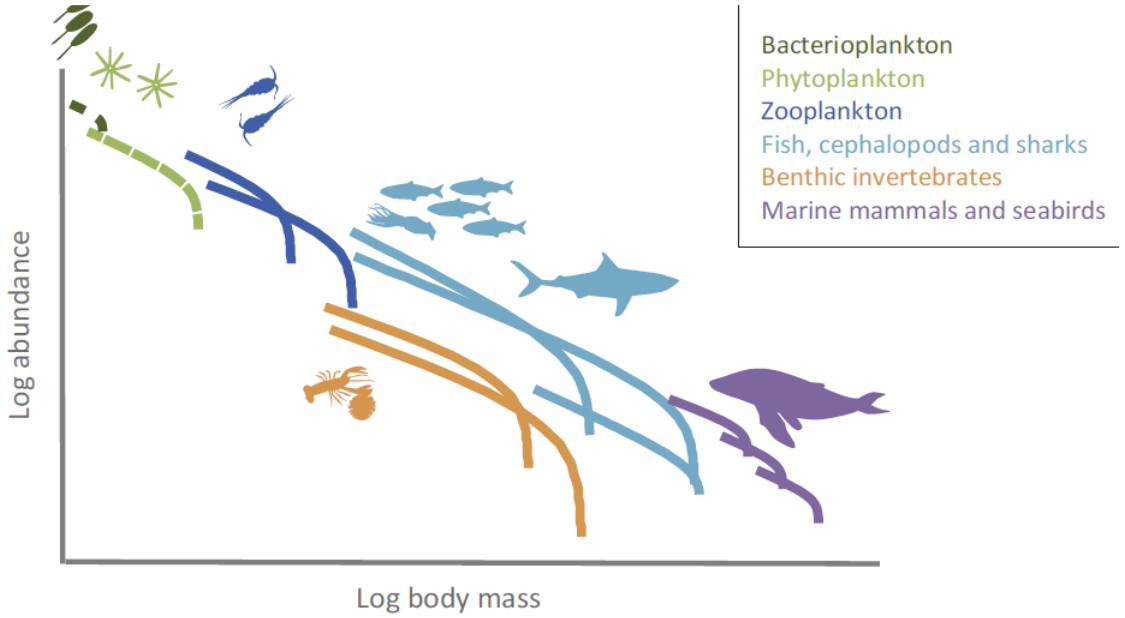
Trends in Ecology & Evolution

Size based models are very useful and increasingly popular

Review

From Bacteria to Whales: Using Functional Size Spectra to Model Marine Ecosystems

Julia L. Blanchard,[1,*] Ryan F. Heneghan,[2] Jason D. Everett,[3,4] Rowan Trebilco,[5] and Anthony J. Richardson[2,6]



How much fish is out there?

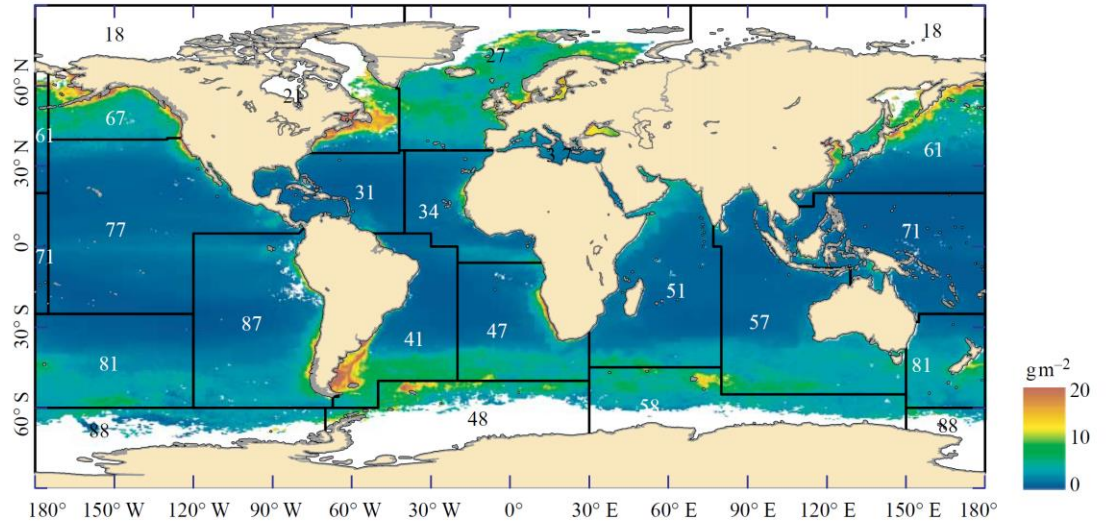
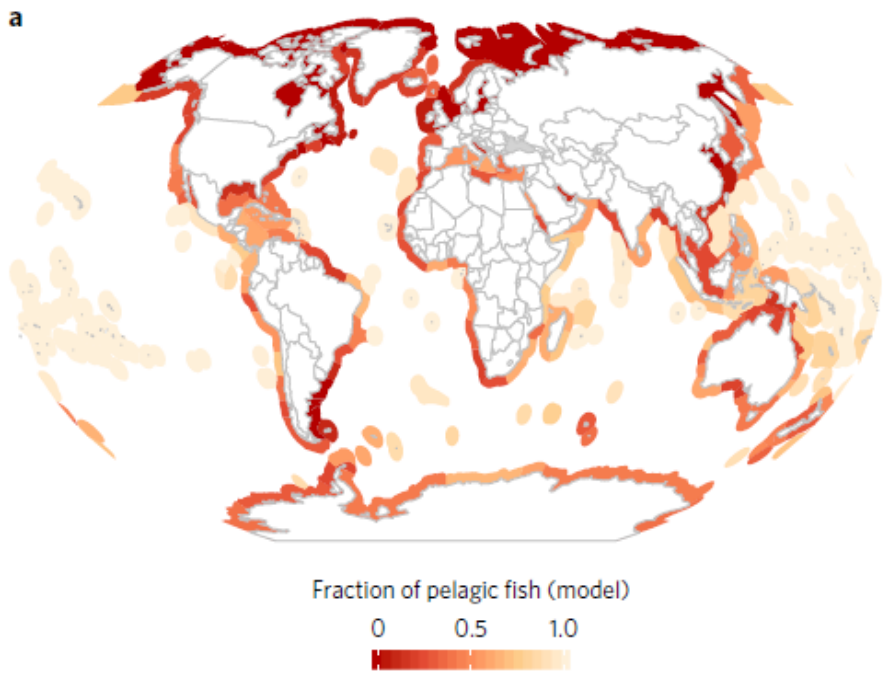
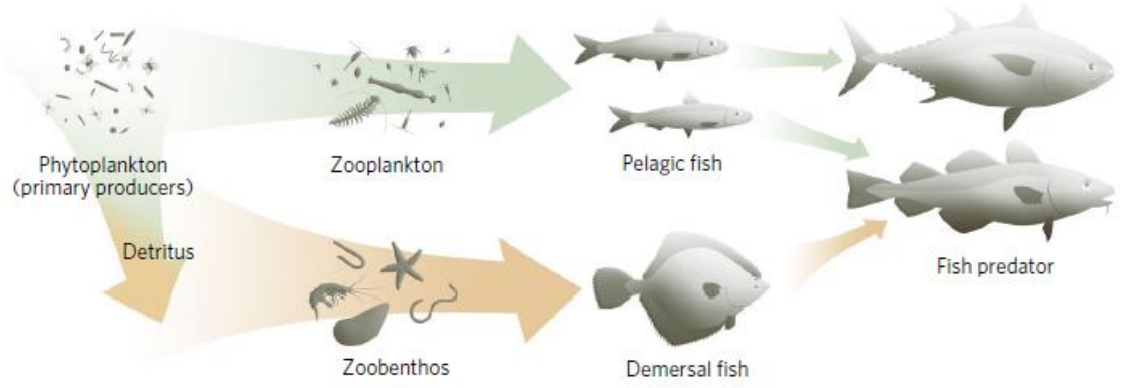


Figure 3. The distribution of teleost biomass. The overlays show the FAO fishing areas and their corresponding codes (see electronic supplementary material for further details). PP estimates were not available for the areas shown in white.

Jennings et al. 2008: Proceedings B

Why are fisheries dominated by large pelagic predators (tunas) or large benthic predators (cod)?





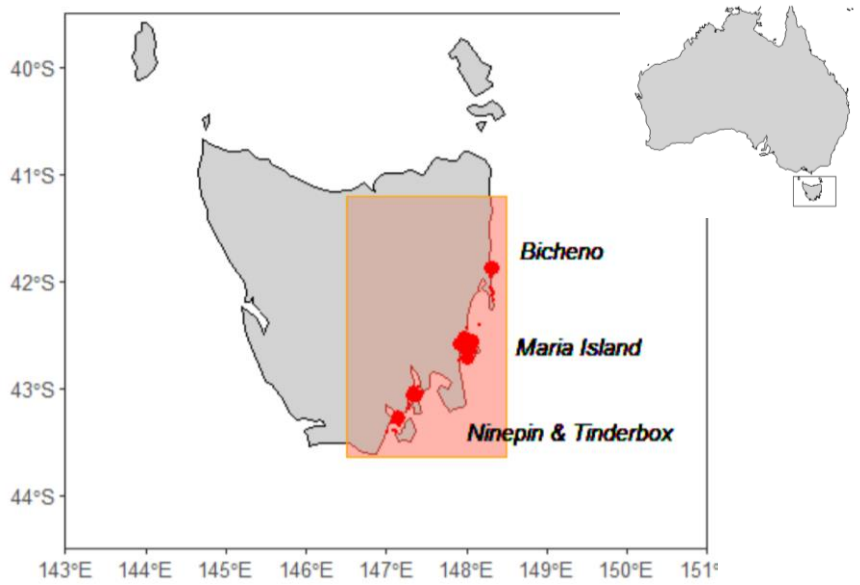
nature ecology & evolution
ARTICLES
https://doi.org/10.1038/s41559-017-0388-z

Global patterns in marine predatory fish

P. Daniël van Denderen[1*], Martin Lindegren[1], Brian R. MacKenzie[1], Reg A. Watson[2,3] and Ken H. Andersen[1]

Size based models for coastal ecosystems with high complexity

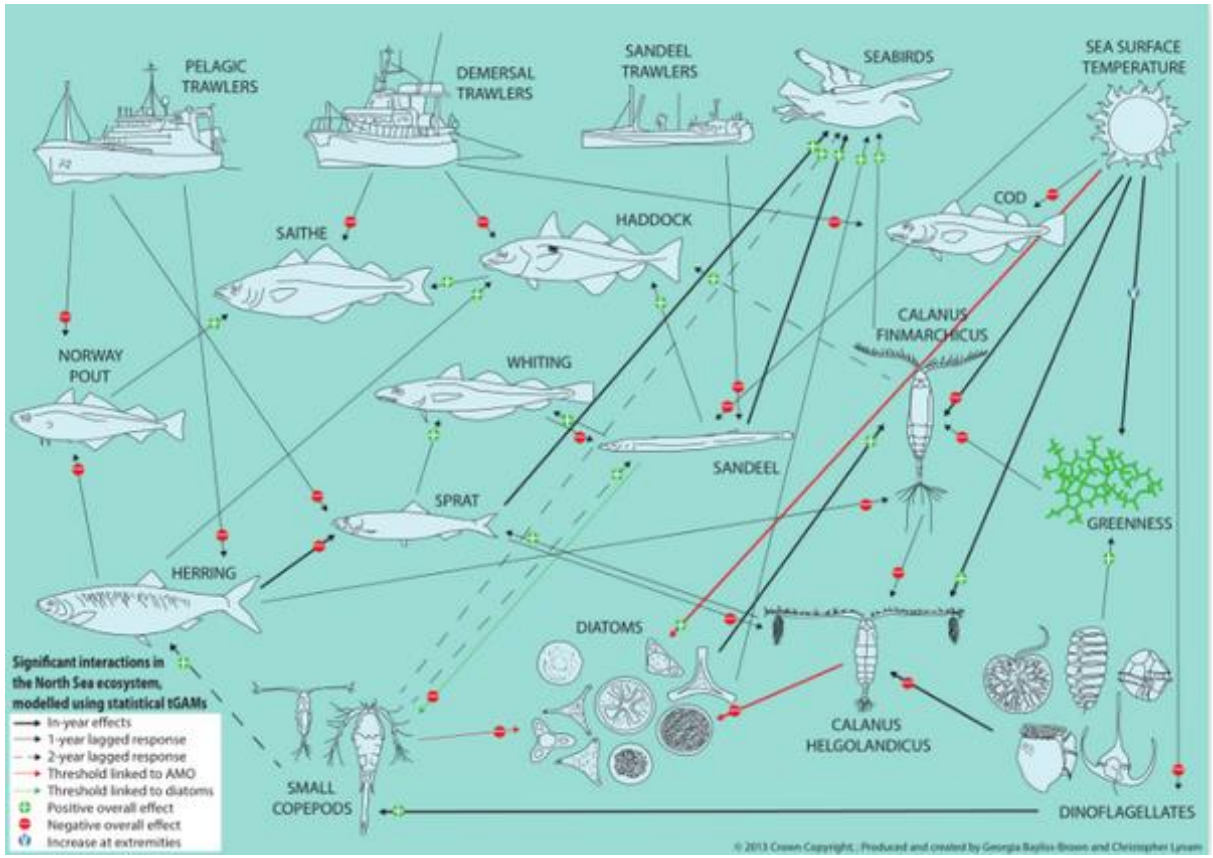
Photography by Rick Stuart-Smith
www.mostlyfish.com



How are coastal ecosystems different?

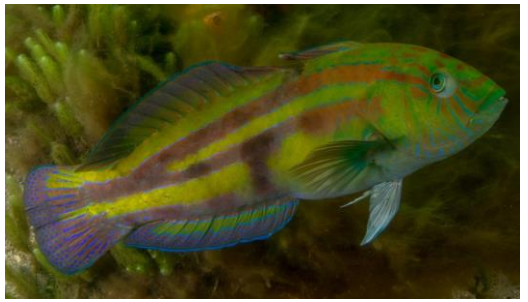
1. Importance of both pelagic and benthic production

2. In pelagic systems most species seem to eat each other ("big fish eat small fish"), and the largest species typically are predators (except whales)



Significant interactions in the North Sea ecosystem modelled using statistical tGAMS
Georgia Bayliss Brown

Most coastal fish don’t eat each other!







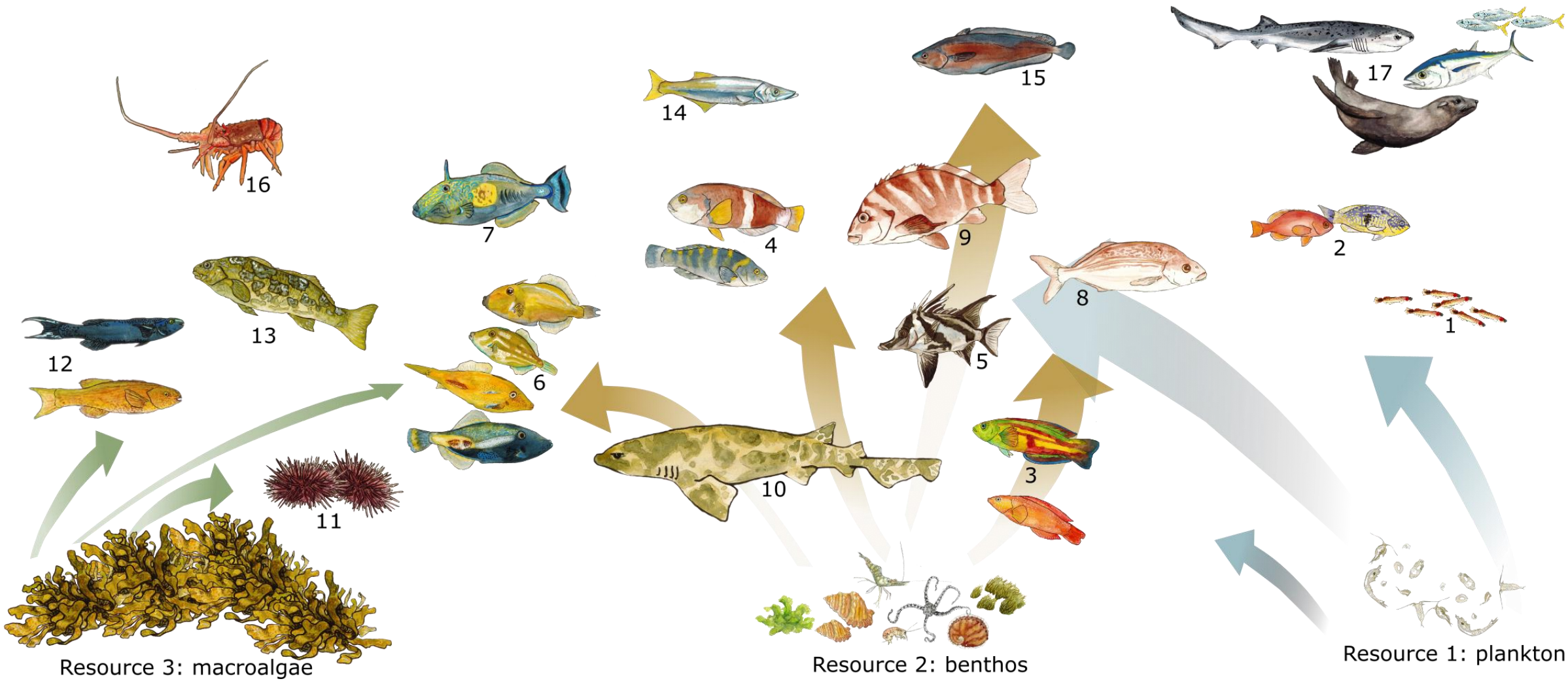





Largest fishes typically are not predators

3. For pelagic systems **predator-prey mass ratio (PPMR)** is often assumed to be around 100 or 1000, but is much higher in coastal species

Coghlan et al. 2022: community level realised PPMR values of **15-30K**


16
14
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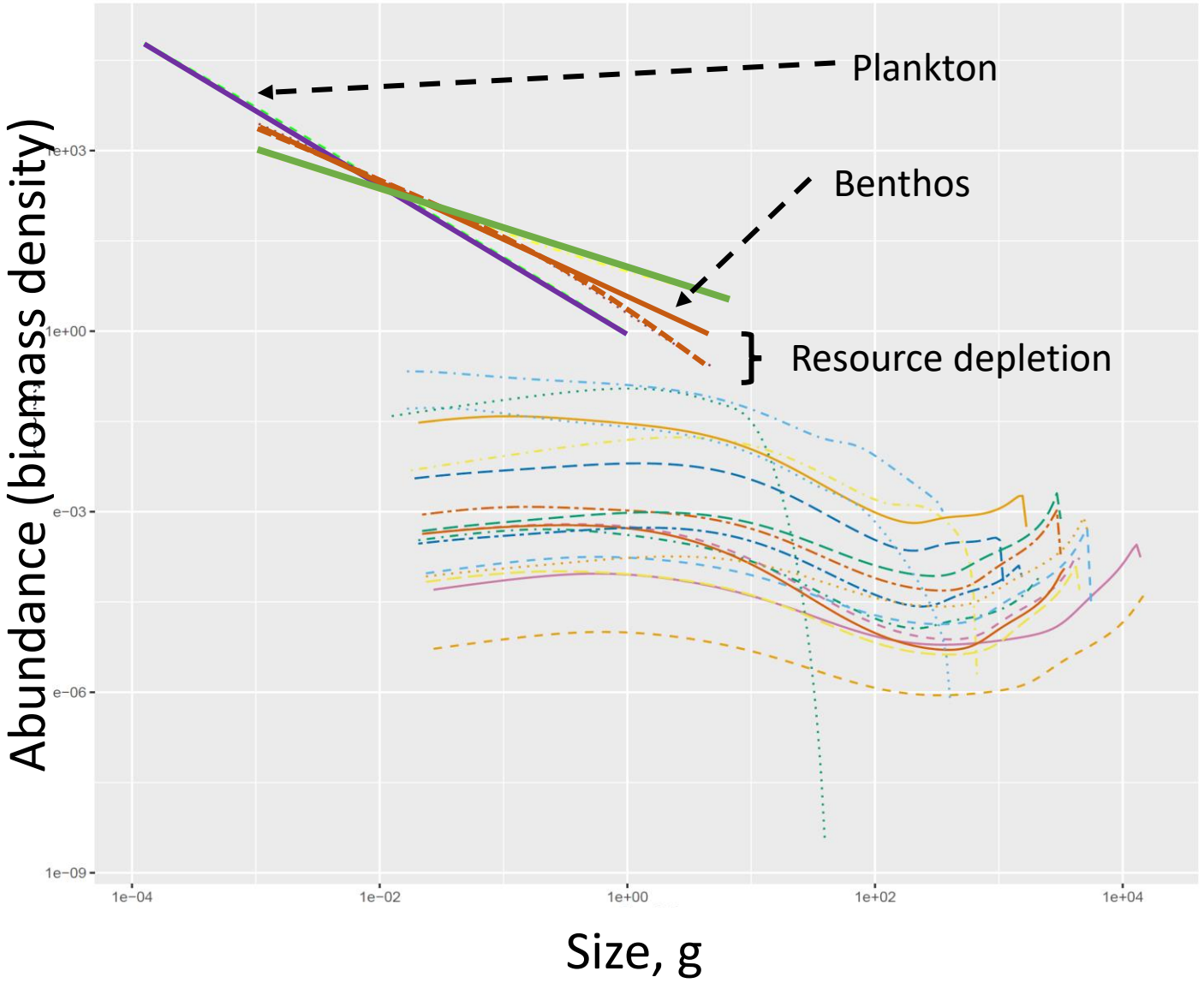
3
11
Resource 3: macroalgae
Resource 2: benthos
Resource 1: plankton

Adapting size spectrum models for coastal ecosystems: multiple resources



Add two additional background resource spectra: benthos & macroalgae

https://github.com/sizespectrum/mizerMR

pkgdown/favicon	Use mizer style on website	last year
tests	Renamed `plotResource()` into `plotResourceLevel()` as in main mizer.	4 months ago
.Rbuildignore	Wrote a README outlining the plan. Some more work. Not yet functional.	last year
DESCRIPTION	Renamed `plotResource()` into `plotResourceLevel()` as in main mizer.	4 months ago
LICENSE.md	Package skeleton. Not functional yet.	last year
NAMESPACE	Renamed `plotResource()` into `plotResourceLevel()` as in main mizer.	4 months ago
NEWS.md	Renamed `plotResource()` into `plotResourceLevel()` as in main mizer.	4 months ago
README.Rmd	Make clear that this package is about size-structured resources. Addi...	last year
README.md	updated package description	10 months ago
_pkgdown.yml	Make clear that this package is about size-structured resources. Addi...	last year
mizerMR.Rproj	Package skeleton. Not functional yet.	last year

Contributors 3

- gustavdelius Gustav W Delius
- baldrech Romain Forestier
- astaaudzi Asta Audzi

Languages

- R 100.0%

README.md

mizerMR

lifecycle experimental

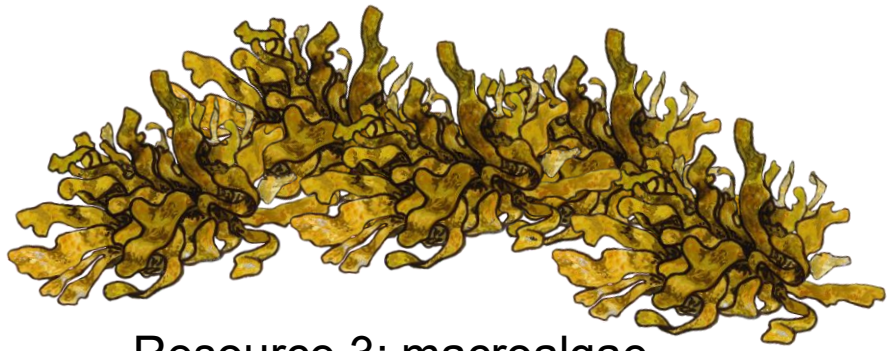
This extension package for mizer allows you to work with multiple size-structured background resources in the same way in which you work with multiple species in mizer. Modelled species can have different preferences for different resources, defined though maximum availability of resource available to species, in a similar way as setting species interaction matrix. Each background resource can have different minimum and maximum sizes, and different size spectrum slopes (lambda) or abundances (kappa). This allows the user to reproduce emergent onto-genetic dietary shifts, where a species feed in a plankton spectrum when it is small, then switches to benthic spectrum, and later to other fish species.

Installation

```
remotes::install_github("sizespectrum/mizerMR")
library(mizerMR)
```

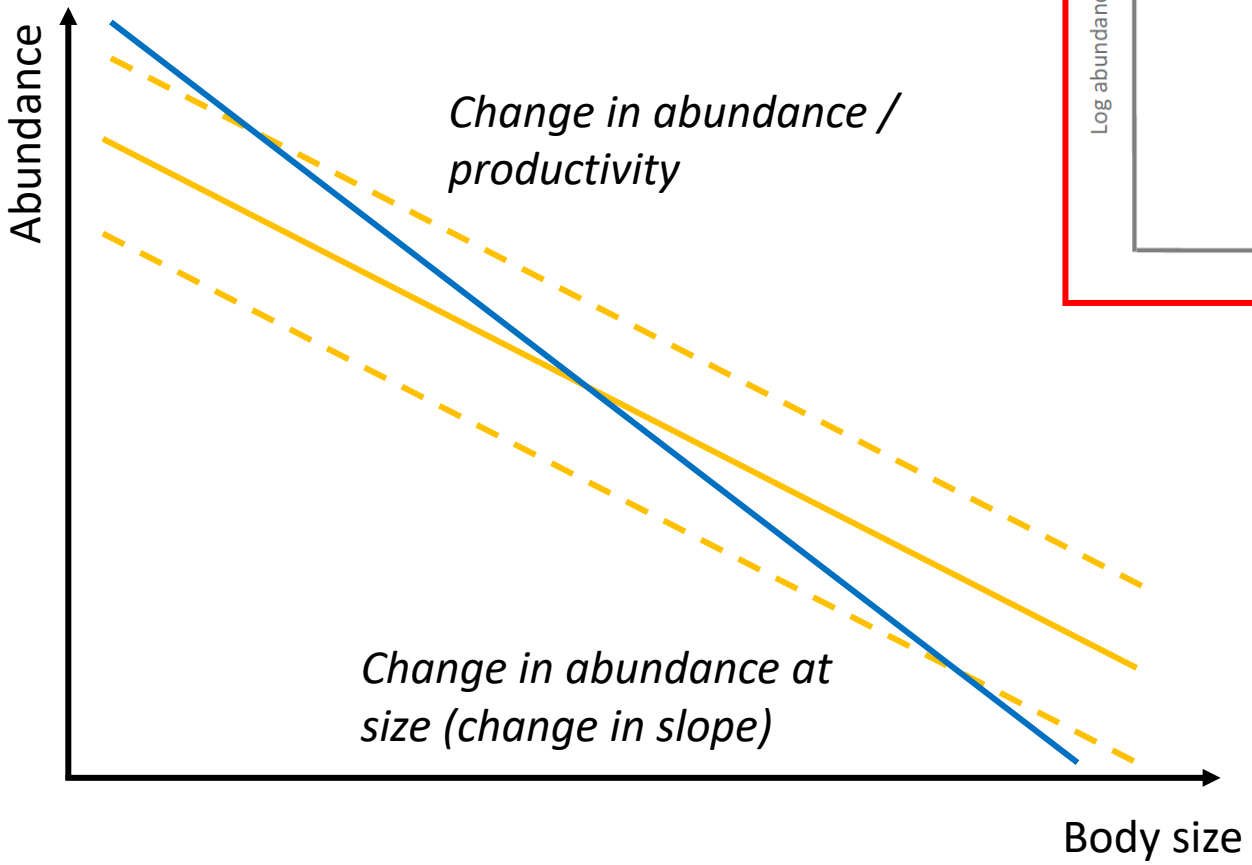
Resource 1: plankton

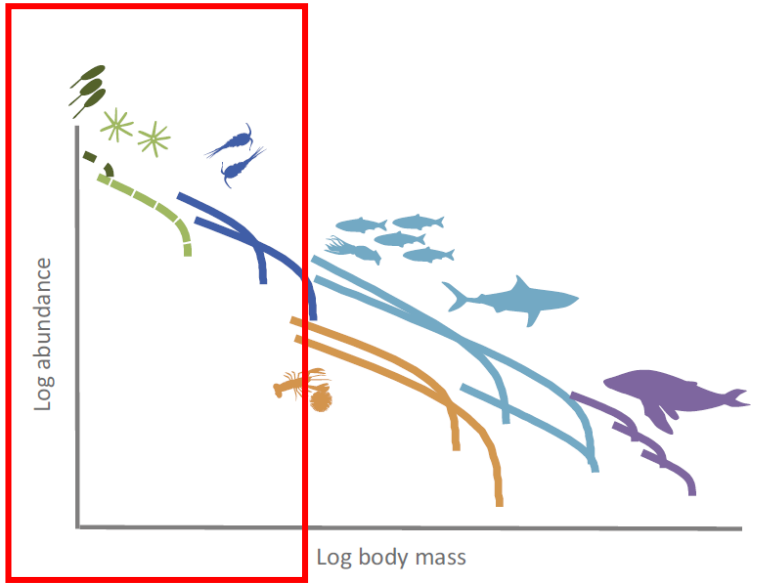
Resource 2: benthos



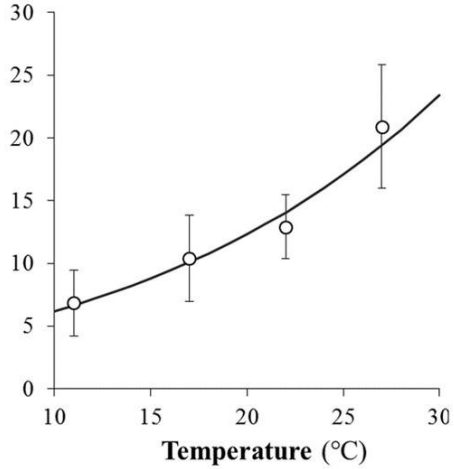
Resource 3: macroalgae

Climate change impacts: role of productivity & temperature





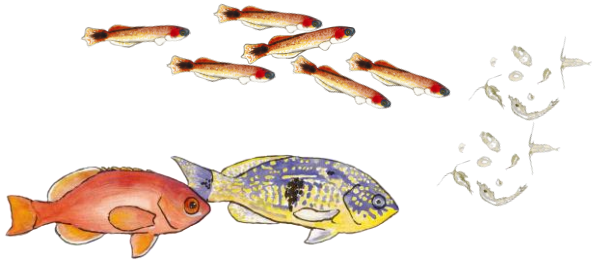
Blanchard et al. 2017 TREE



Temperature scaling of metabolism and intake

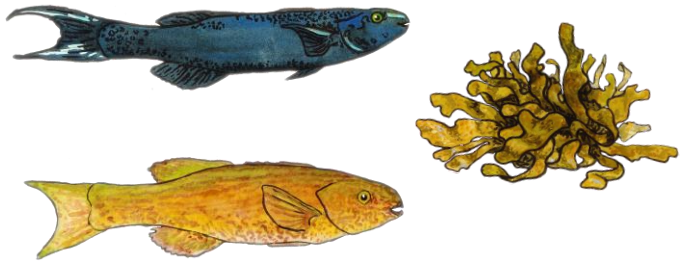
Parameter uncertainty evaluation – approximate Bayesian computation style

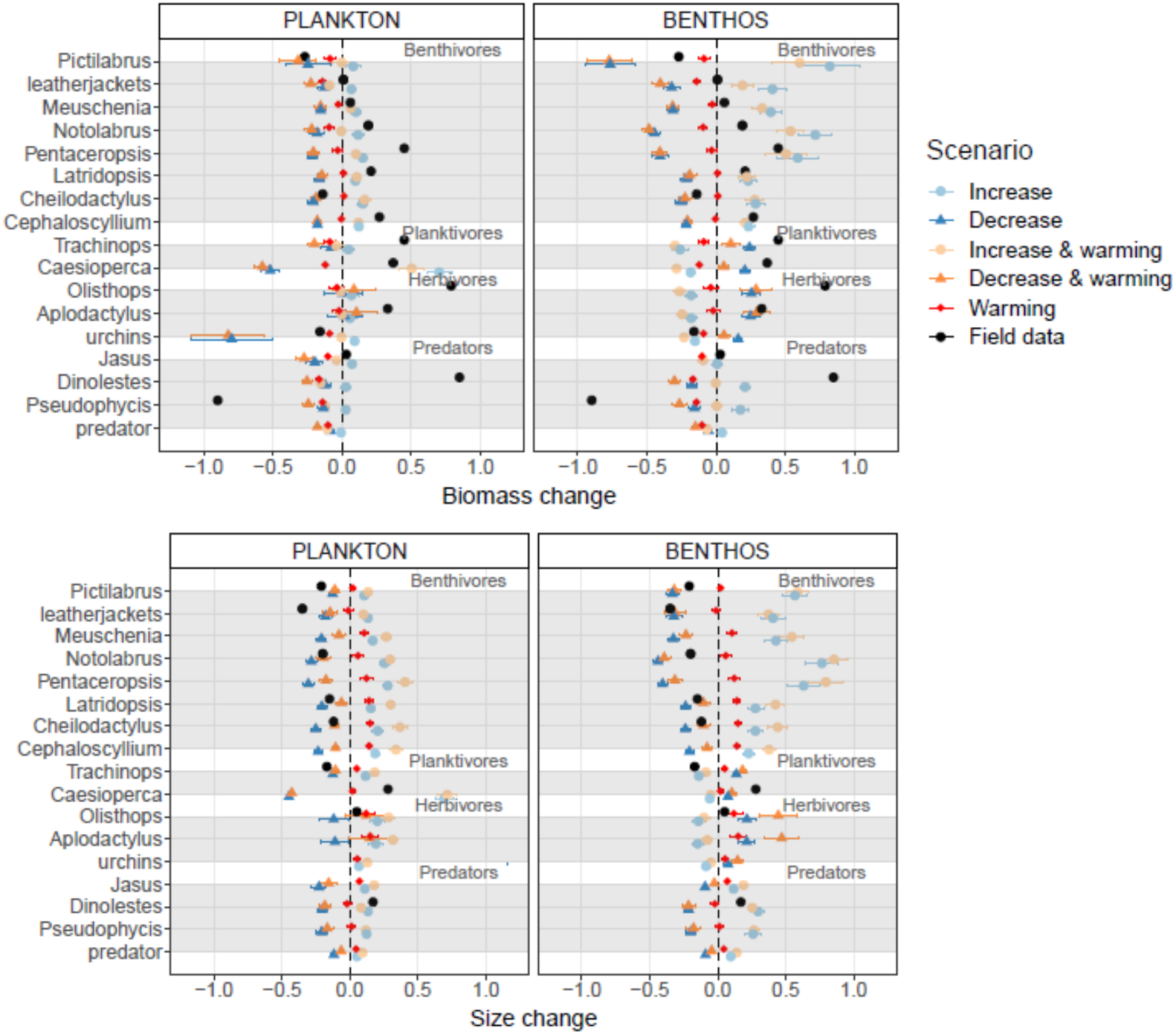
- ***37 uncertain parameters*** *defining species interactions and recruitment*



- ***2.2mln.*** *parameter combinations tested against emergent model properties*

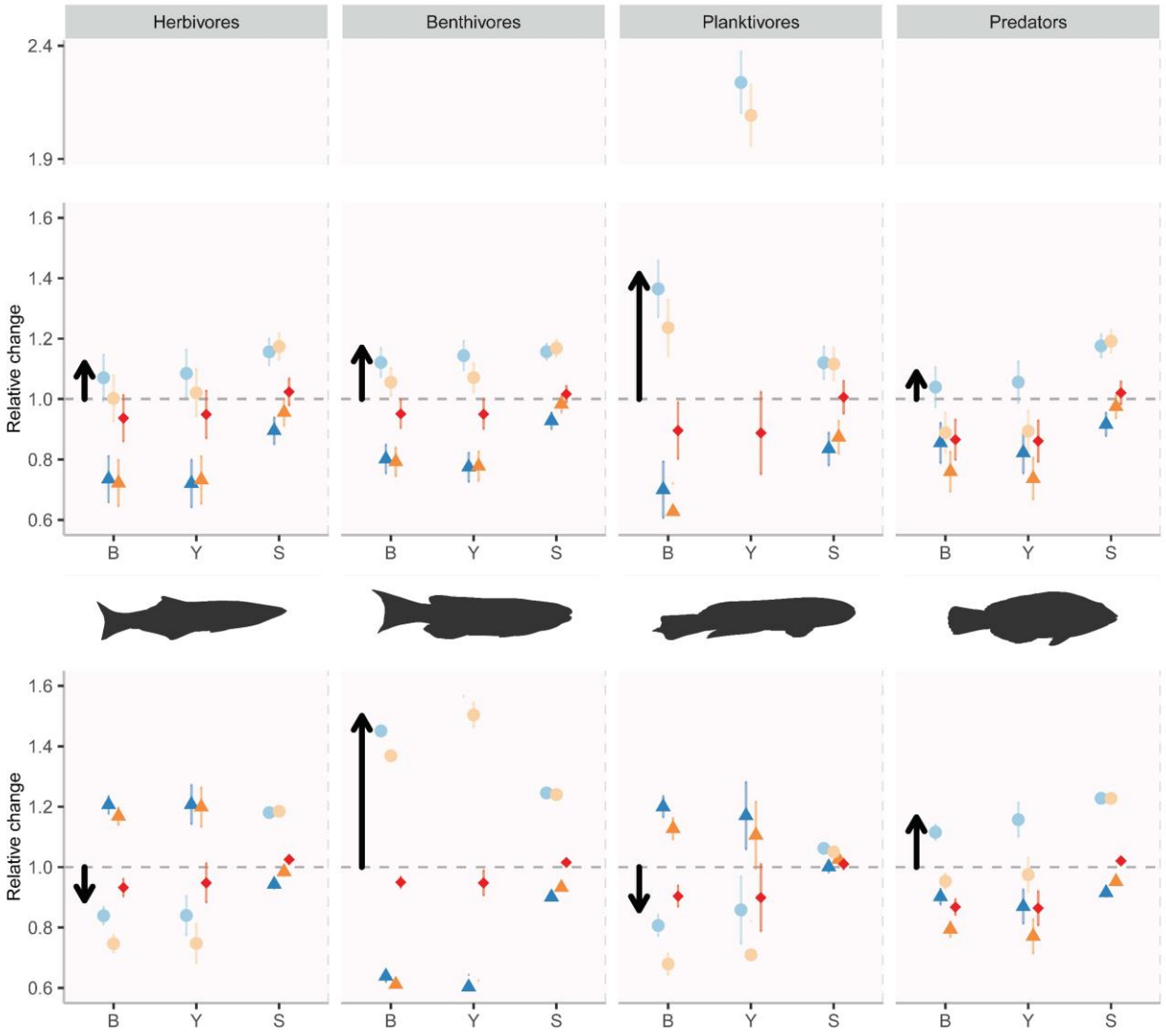
- *Final set of* ***29 parameter combinations*** *that satisfied all criteria used to run all productivity and temperature scenarios*

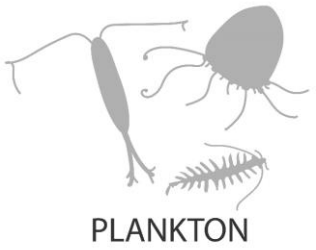




Results:

1. Changes in benthos abundance or size structure had major impacts on coastal fish species biomasses and yields
2. Changes in productivity had larger impacts than physiological responses to temperature alone





Scenario
- Increase
- Decrease
- Increase & warming
- Decrease & warming
- Warming

B Biomass
Y Yield
S Size

Results:

3. Changes in plankton caused similar biomass responses across trophic groups, but changes in benthos led to opposite responses

Benthic size spectrum simulator

Scenario

1 2 3 4

Temperature

8°C 12°C 16°C

8 8.8 9.6 10.4 11.2 12 12.8 13.6 14.4 15.2 16

Plankton

Abundance (κ)

1 2 3

1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3

Slope (λ)

1.8 2.15 2.5

1.8 1.9 2 2.1 2.2 2.3 2.4 2.5

Benthos

Abundance (κ)

3 6 9

3 3.6 4.2 4.8 5.4 6 6.6 7.2 7.8 8.4 9

Slope (λ)

1.5 1.9 2.3

1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3

Run Scenario 1 Reset

About | Methods and assumptions | Biomass | Yield | Mean size

Exploring climate change scenarios using south-east Tasmanian rocky reef ecosystem model

This application allows you to explore some outputs of the size-based Tasmanian rocky reef ecosystem model under different plankton and benthos abundance and temperature change scenarios. The model was built using the size spectrum modelling framework mizer (http://sizespectrum.org/mizer/).

In order to represent coastal communities more accurately, in this study the mizer modelling framework has been modified to allow for multiple size-structured background resources. These modifications are available as a mizer add-on tool (https://github.com/sizespectrum/mizerMR).

How to run the model

To explore how changes in temperature, as well as plankton and benthos abundance (κ) and size spectrum slope (λ) affect model species biomasses, yields and mean sizes, adjust the slider to a new value(s) and click run scenario. You can plot up to four different scenarios at a time. Results are displayed as a difference between the baseline scenario with default values for the five environmental parameters.

https://fishsize.shinyapps.io/BenthicSizeSpectrum/

Benthic size spectrum simulator

Scenario

1 2 3 4

Temperature

8°C 11.1°C 16°C

8 8.8 9.6 10.4 11.2 12 12.8 13.6 14.4 15.2 16

Plankton

Abundance (κ)

1 2.2 3

1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3

Slope (λ)

1.8 2.2 2.5

1.8 1.9 2 2.1 2.2 2.3 2.4 2.5

Benthos

Abundance (κ)

3 6.55 9

3 3.6 4.2 4.8 5.4 6 6.6 7.2 7.8 8.4 9

Slope (λ)

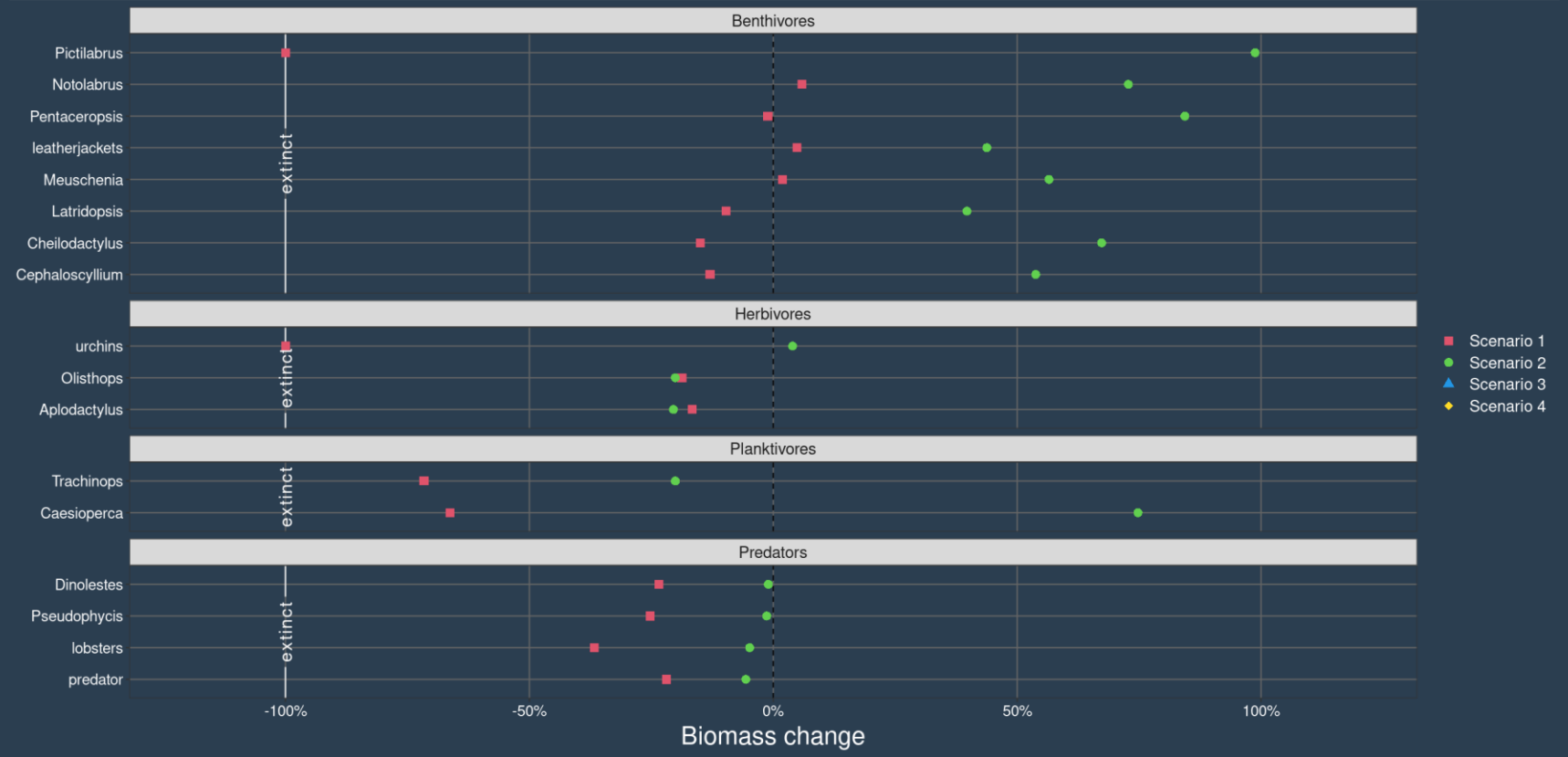
1.5 2 2.3

1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3

Run Scenario 2 | Reset

Copy Scenario 1

About | Methods and assumptions | Biomass | Yield | Mean size



Selected Parameters:

Plankton		Benthos	
Abundance	Slope	Abundance	Slope

Thanks

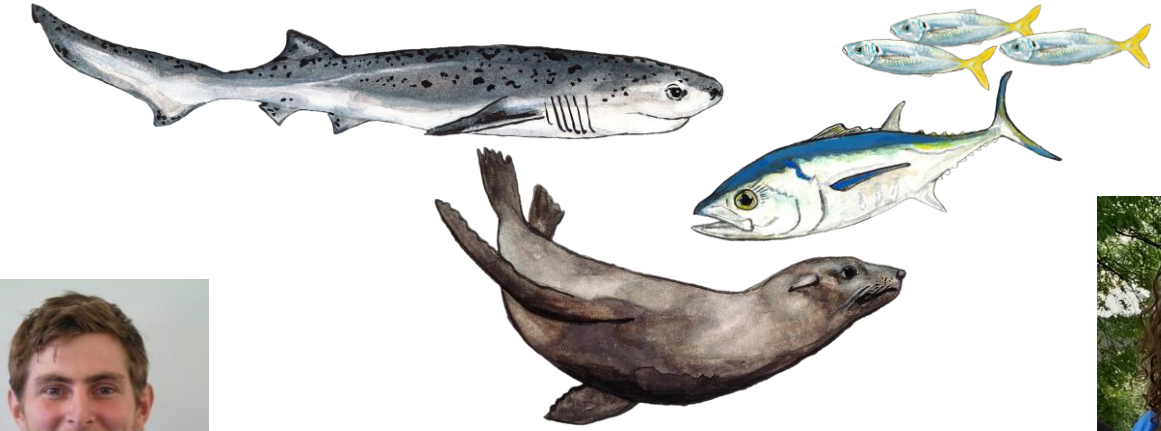
Julia Blanchard, Rick Stuart-Smith

Australian Research Council

Pew Fellows Program in Marine Conservation at The Pew Charitable Trusts

Gustav Delius, Camilla Novaglio

Graham Edgar, Neville Barrett



Dr Freddie Heather: R Shiny application

Dr Amy Coghlan: amazing drawings

REEF LIFE SURVEY