Alteration of coastal productivity and artisanal fisheries interact to affect a marine food web

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Join work with
Derek Corcoran, Alejandro Pérez-Matus, Evie A. Wieters, **Sergio A. Navarrete**, **Pablo A. Marquet** & Fernanda S. Valdovinos

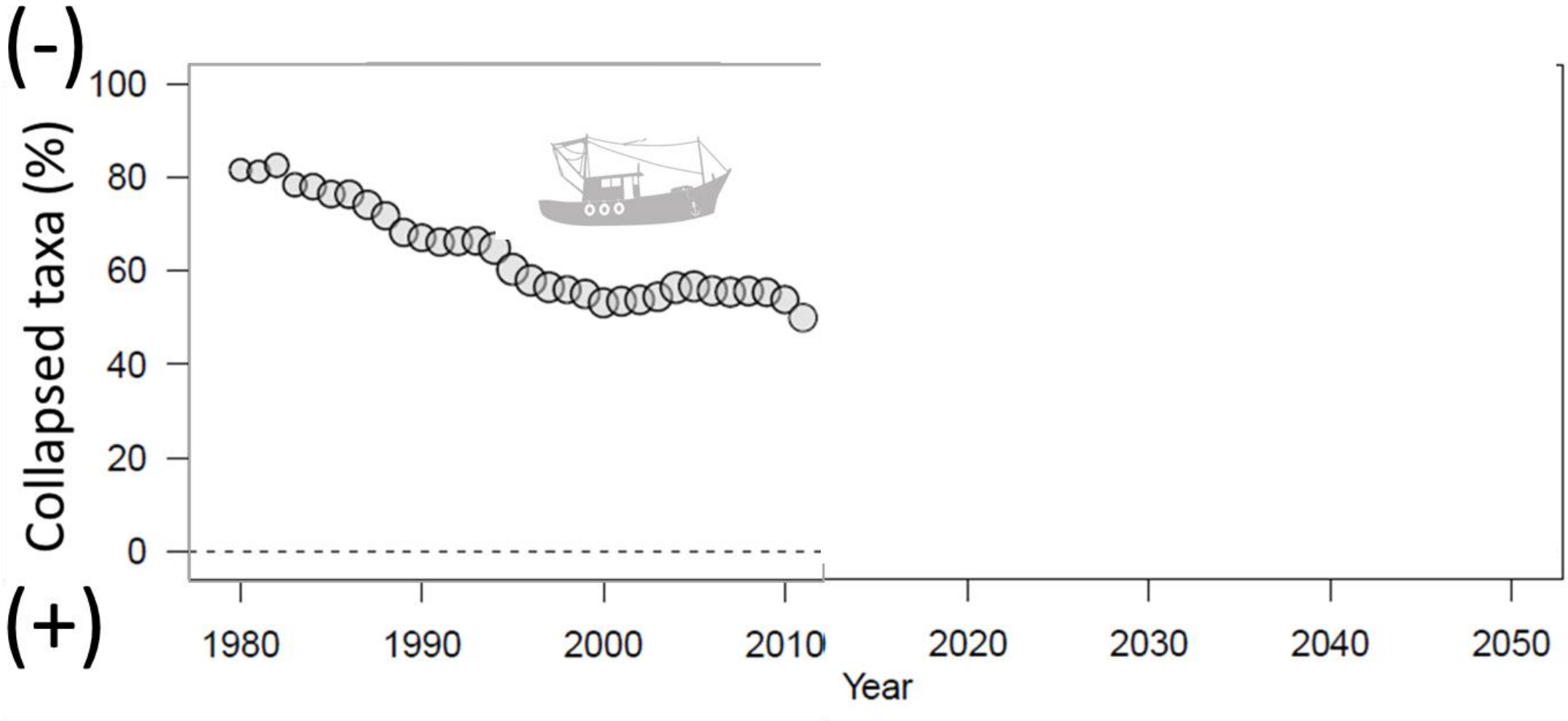
ADVANCED CONSERVATION STRATEGIES

SECOS
INSTITUTO MILENIO EN SOCIO-ECOLOGÍA COSTERA

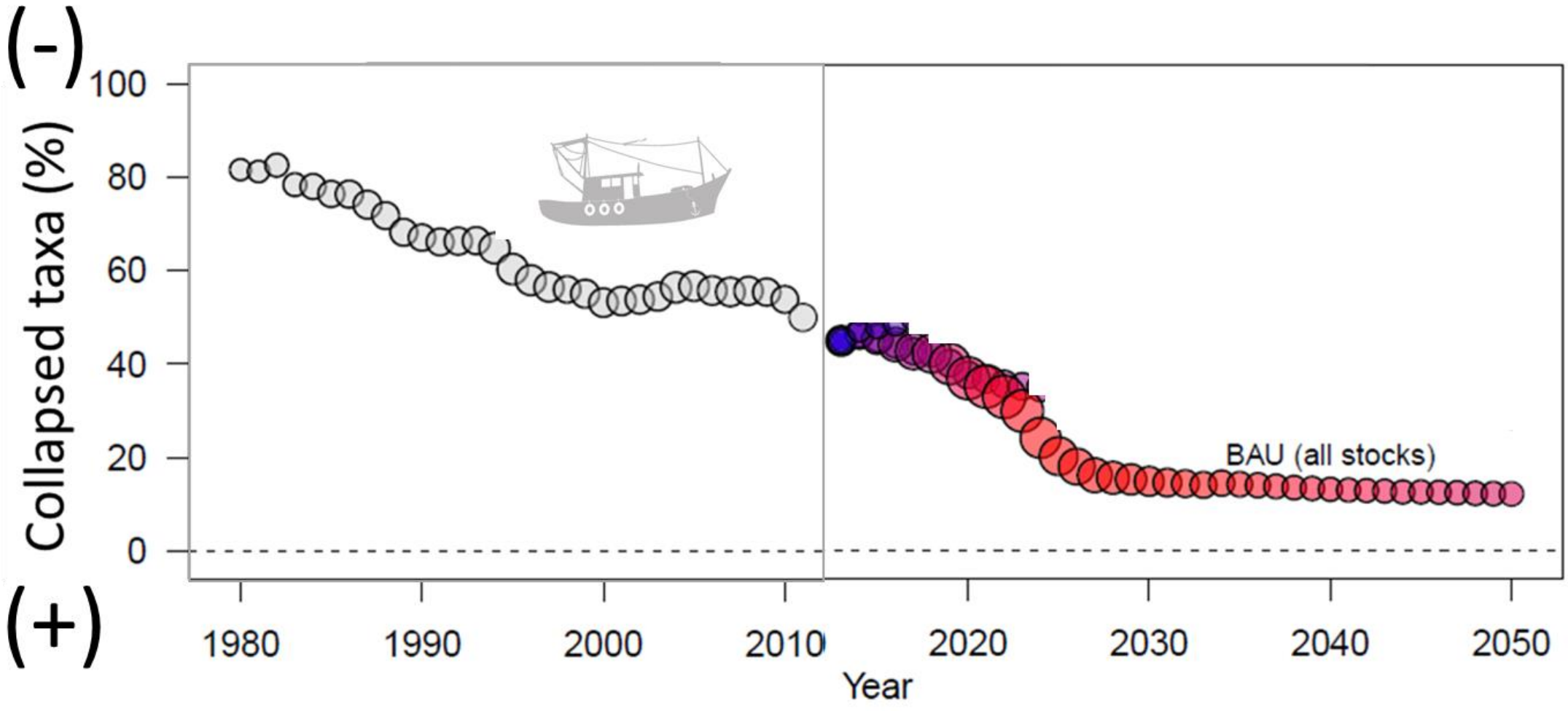
UNIVERSIDAD CATOLICA DE LA SANTISIMA CONCEPCION

EcoDep conference
September 15th 2021

Photo: harvardmagazine.com



Worm et al. 2006, Costello et al. 2016



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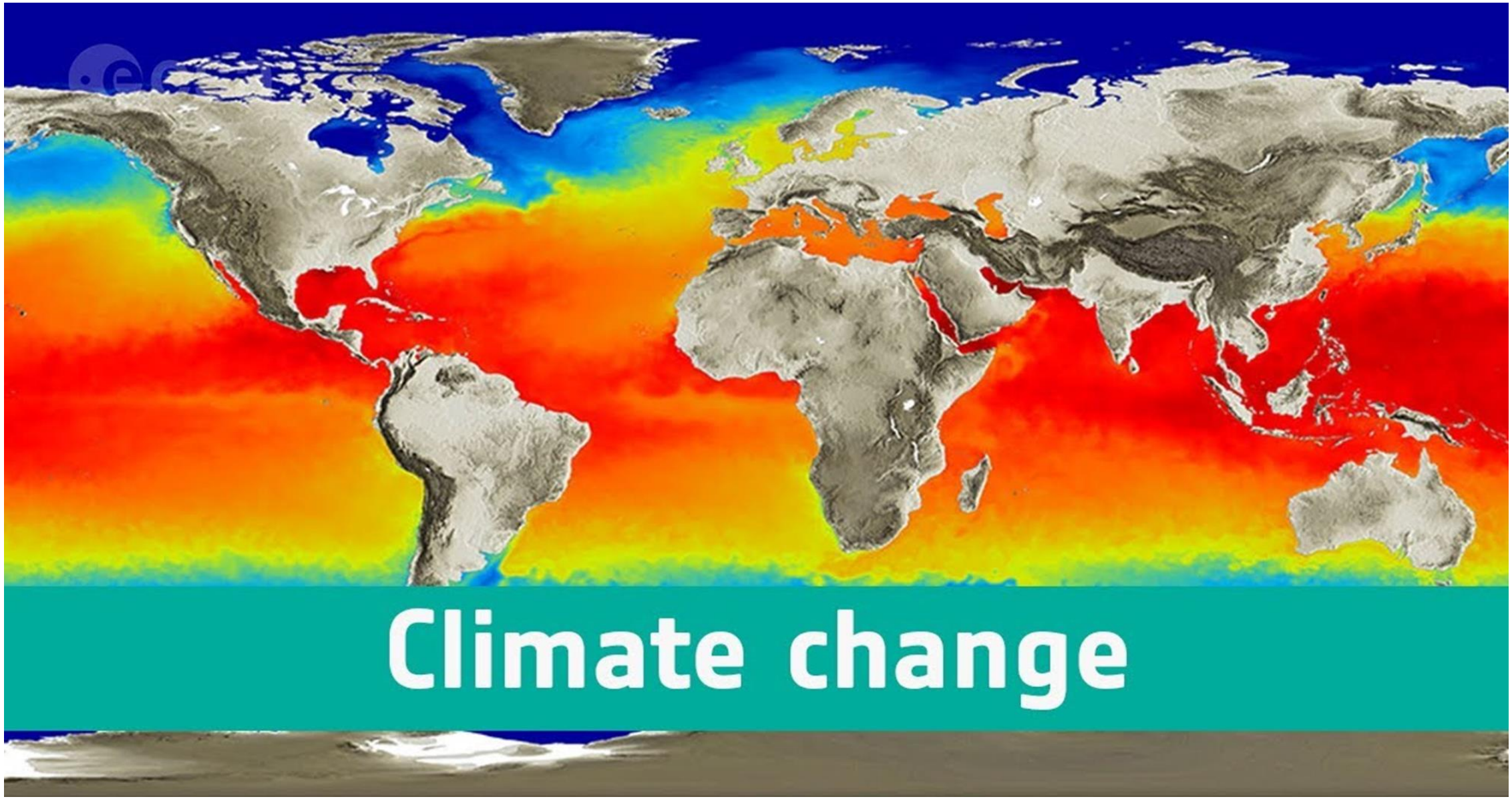
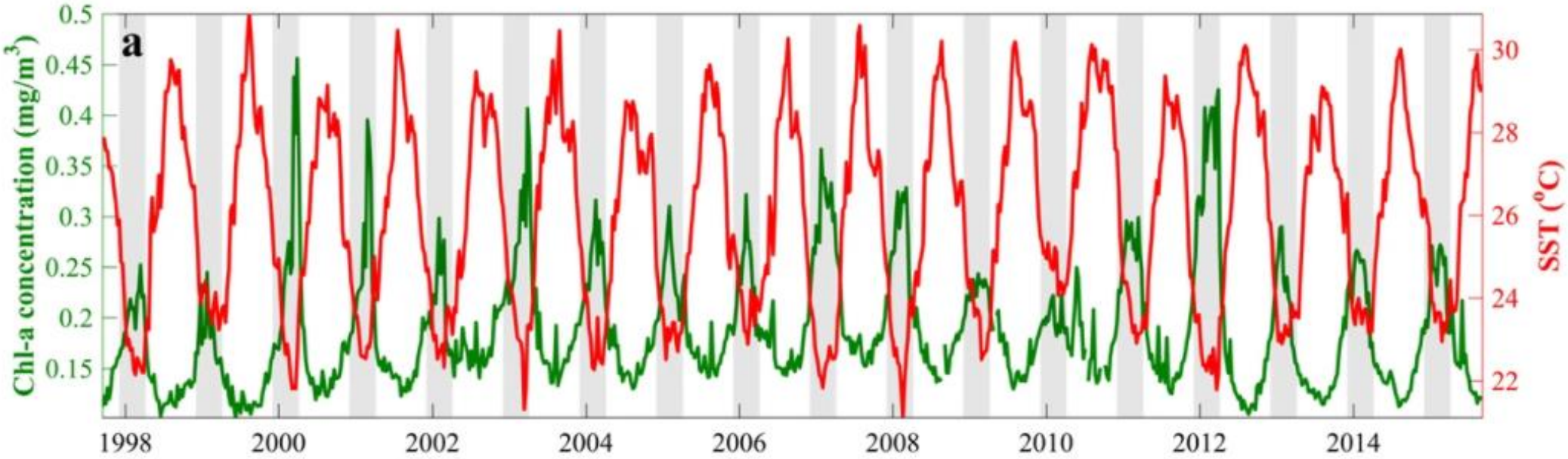
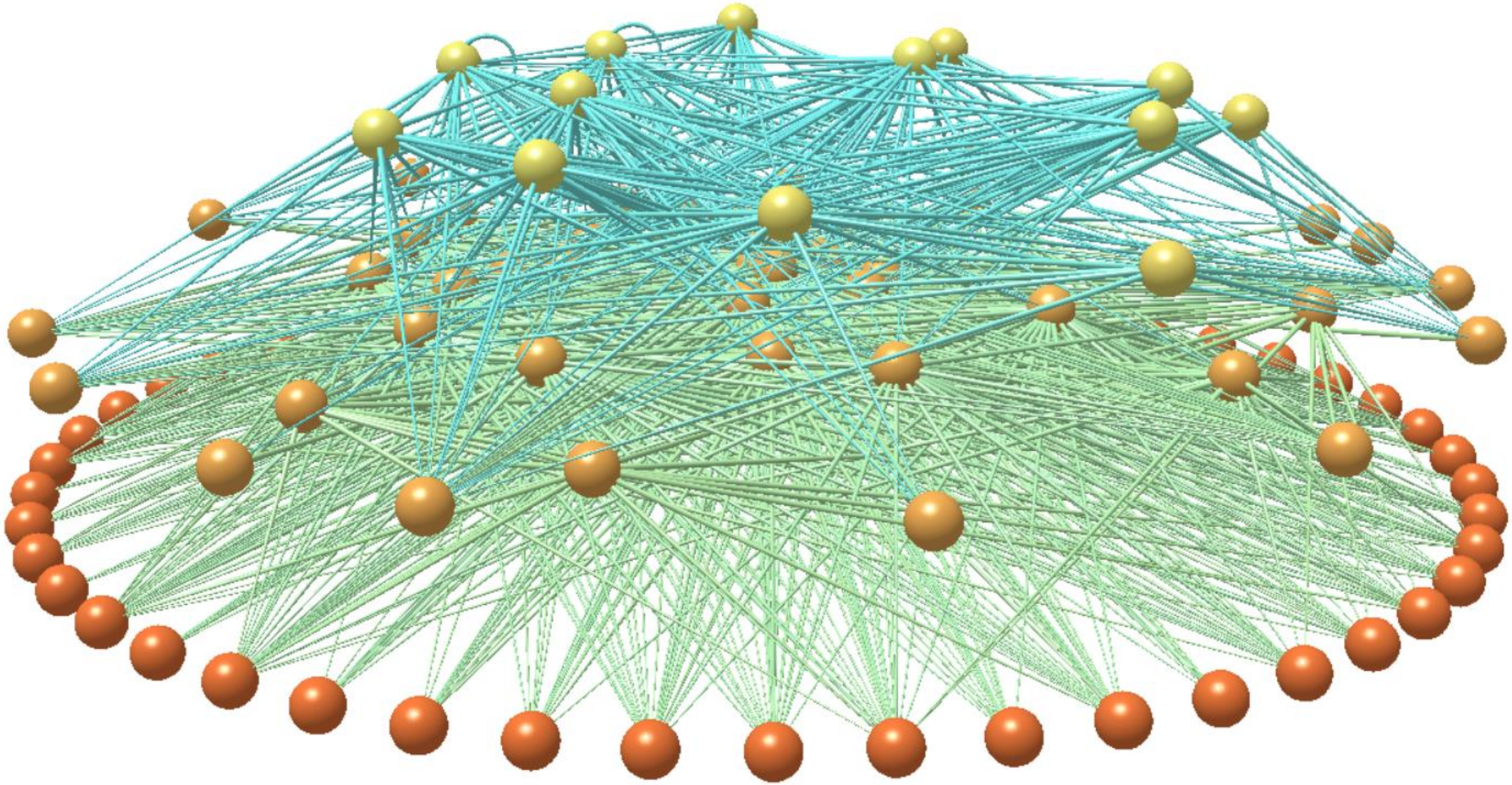

Climate change

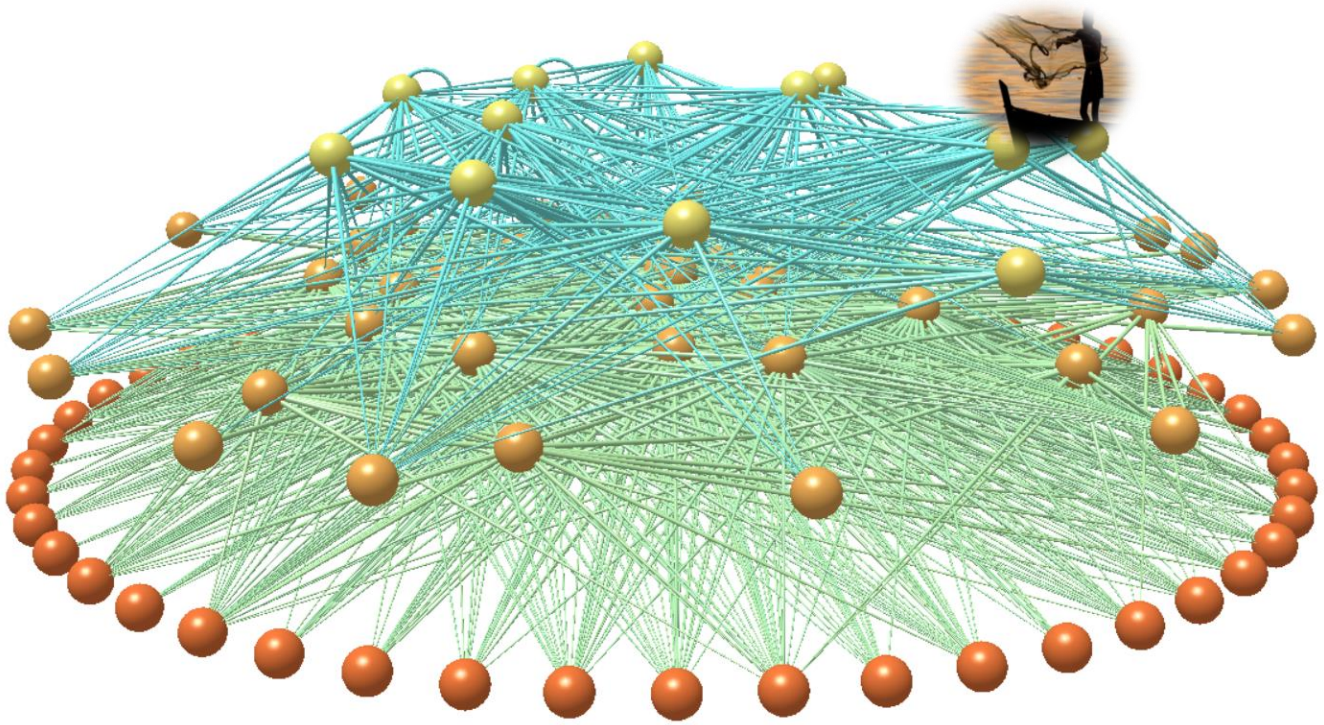
- Sea surface temperature
- Ocean stratification
- Mixed layer depth
- Coastal water nutrients



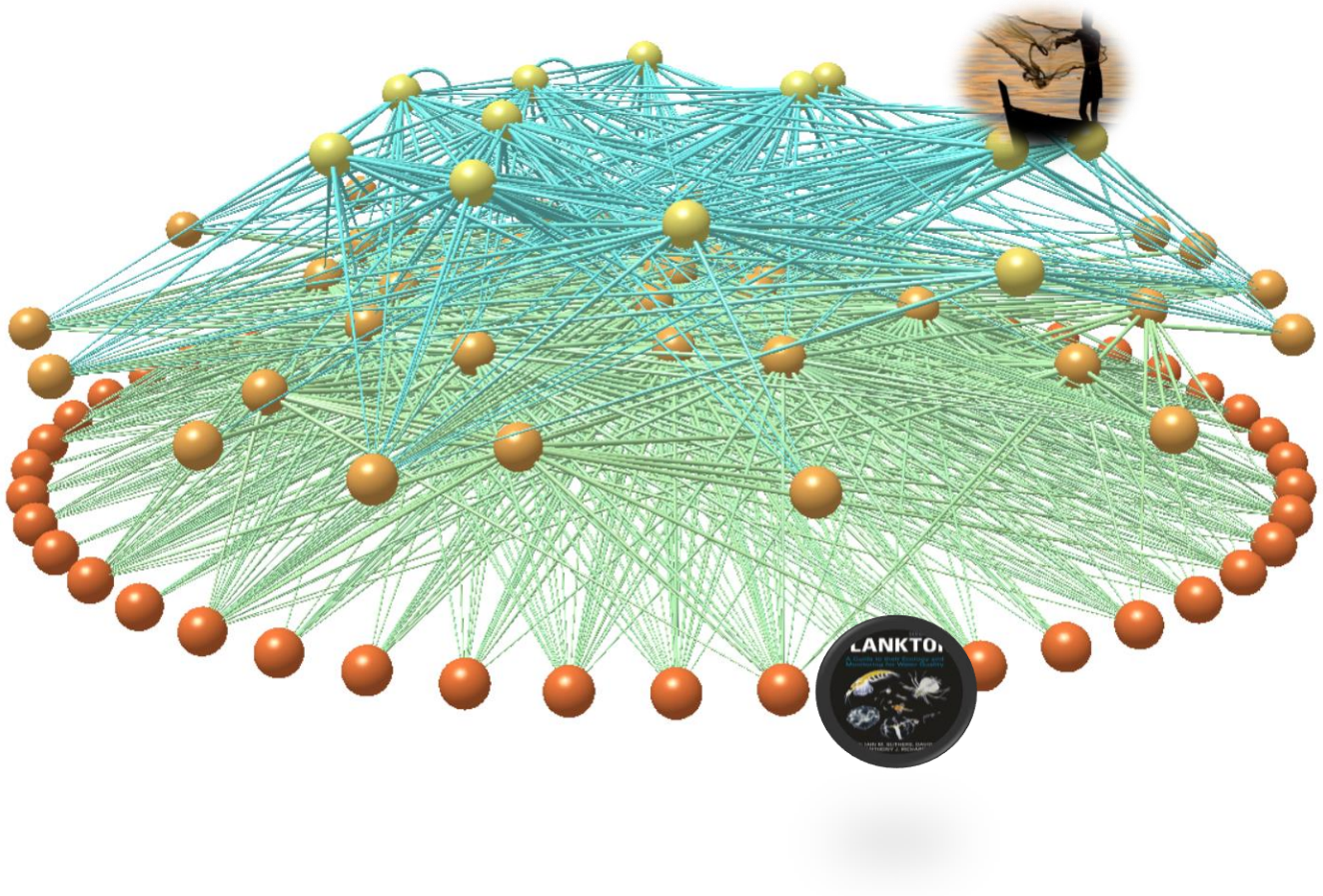
Gittings et al. 2018

Photo: Catalina Velasco





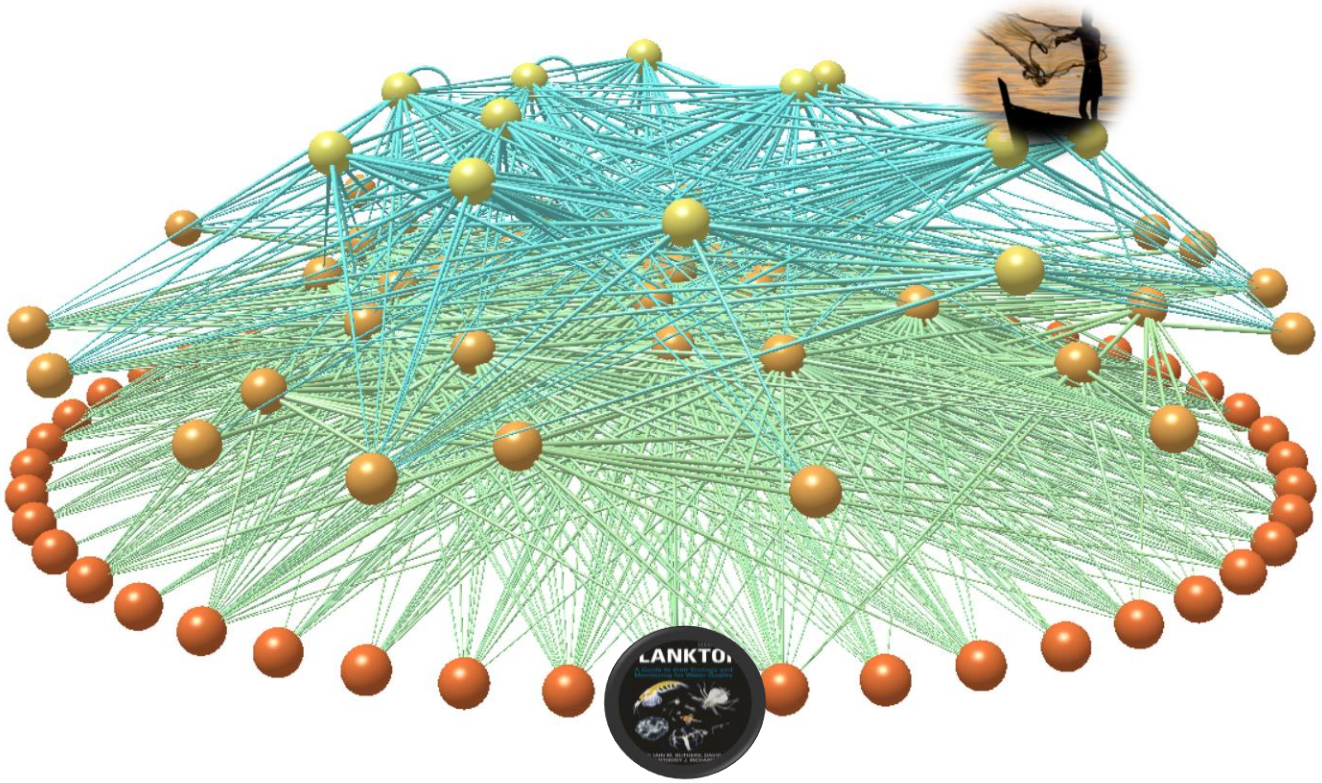
Antropogenic pressures



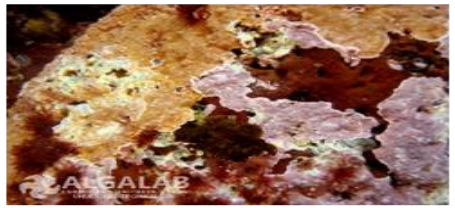
Antropogenic pressures

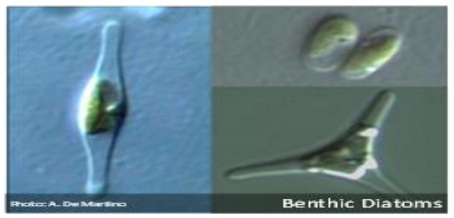
Climate-driven effects

WE ASSESSED THE INDEPENDENT AND COMBINED EFFECT OF FISHERIES AND PLANKTON BIOMASS CHANGES ON FOOD WEBS

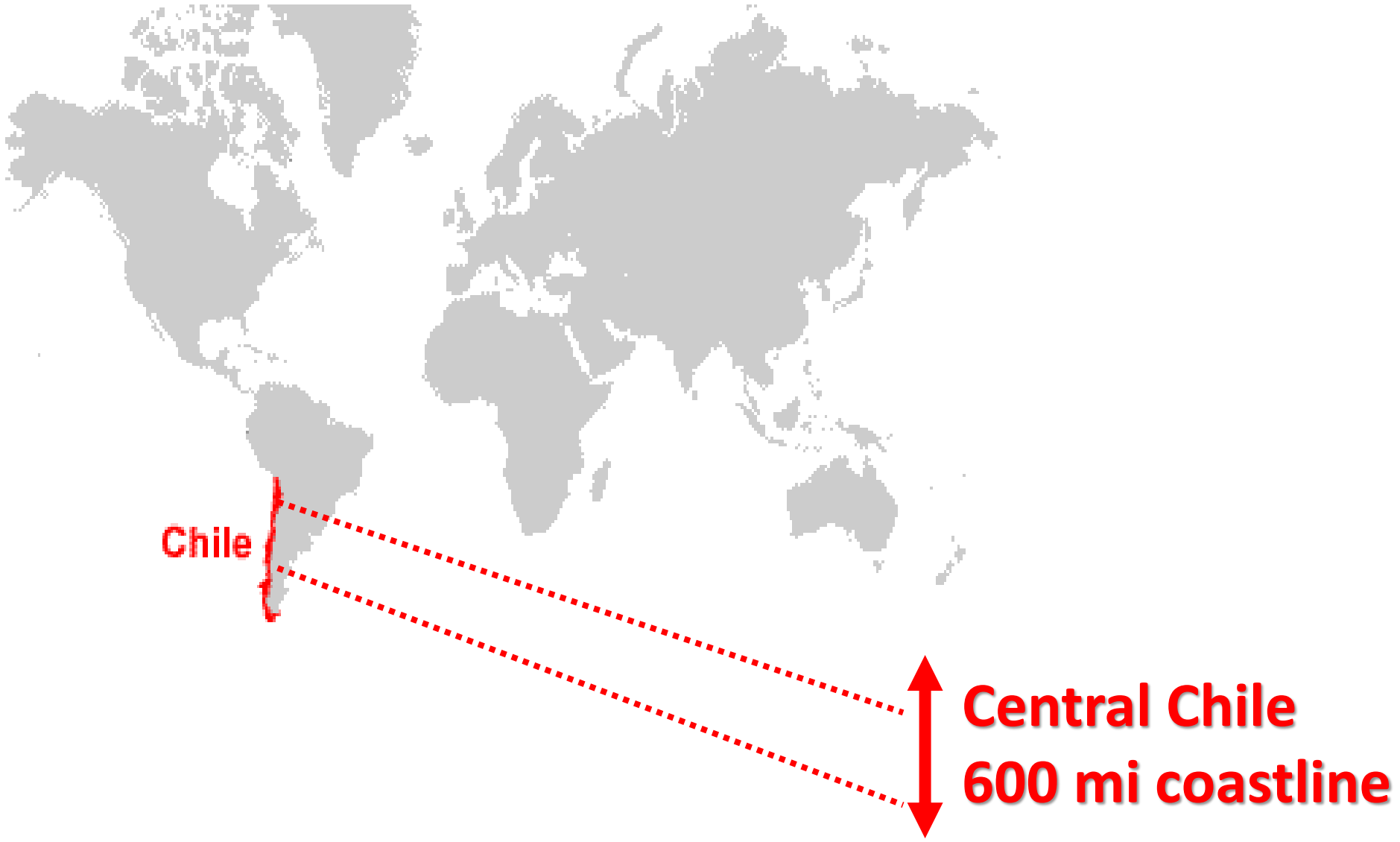


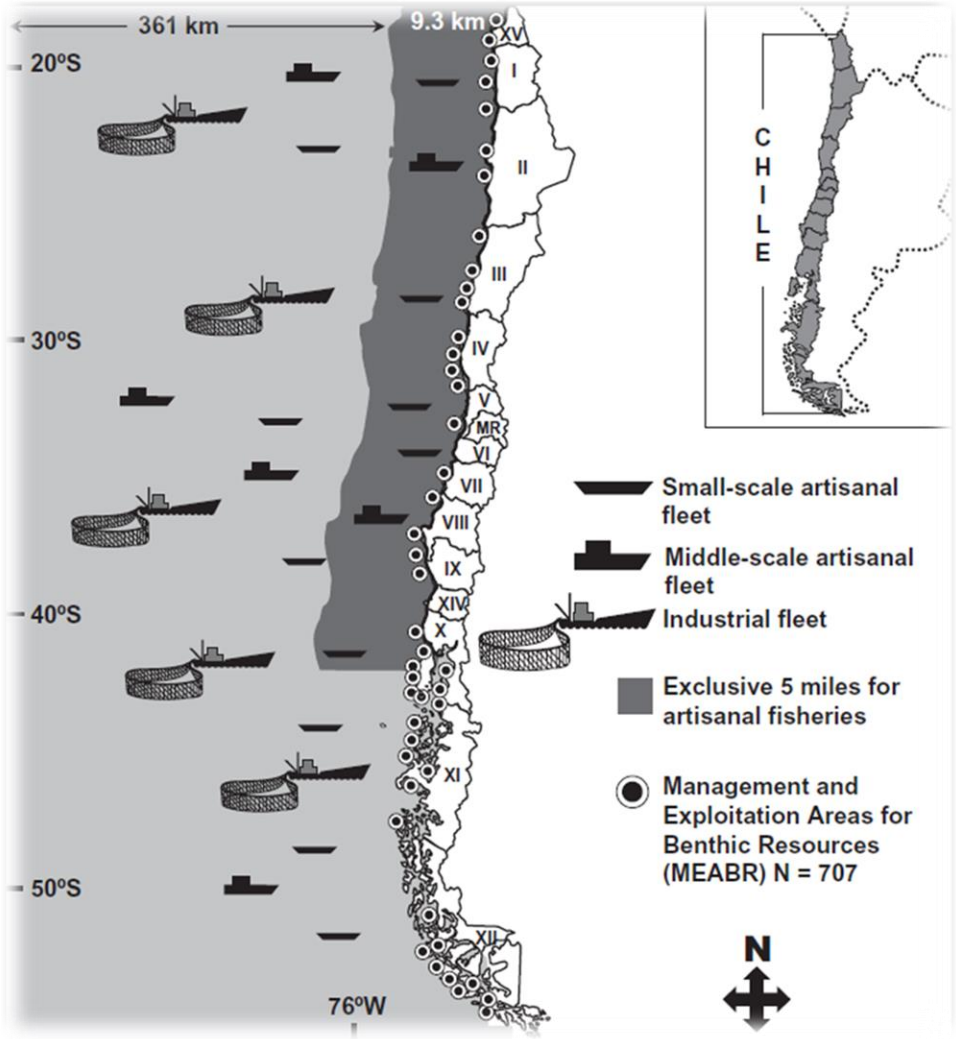

Intertidal rocky shore
Kéfi et al. 2015



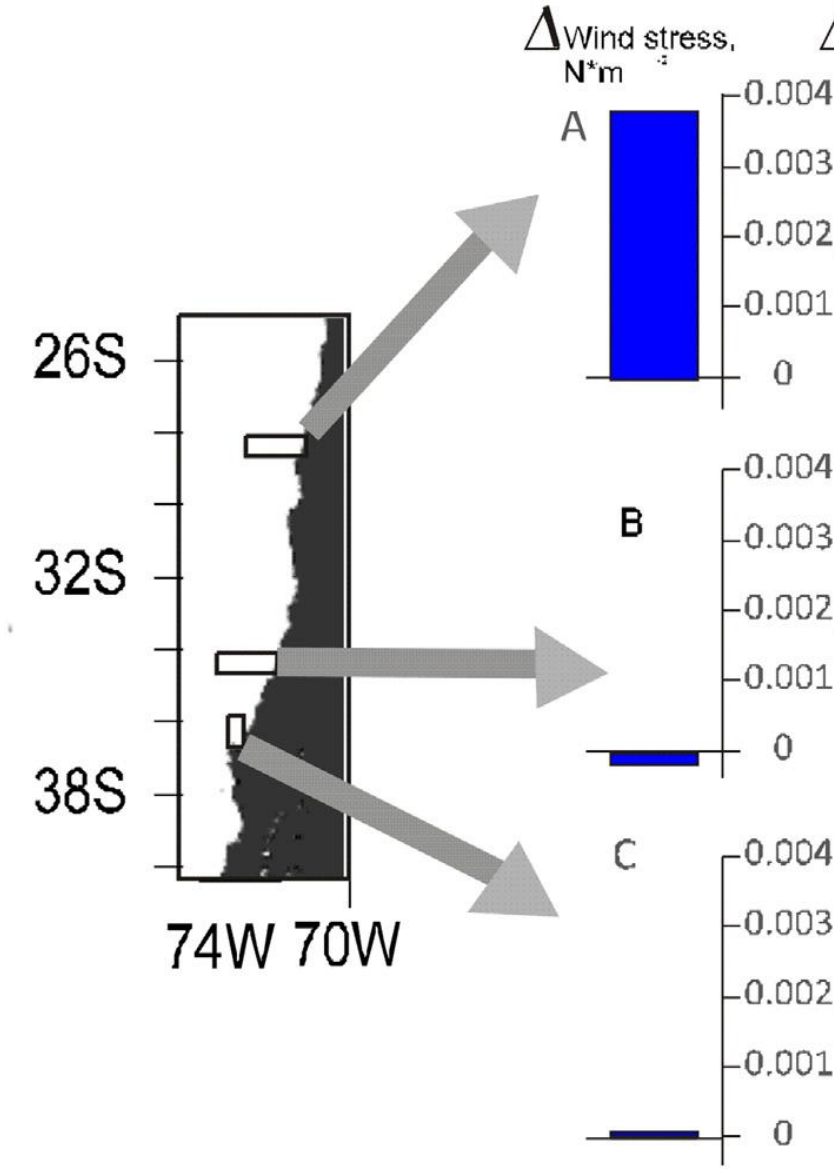


Harvested species

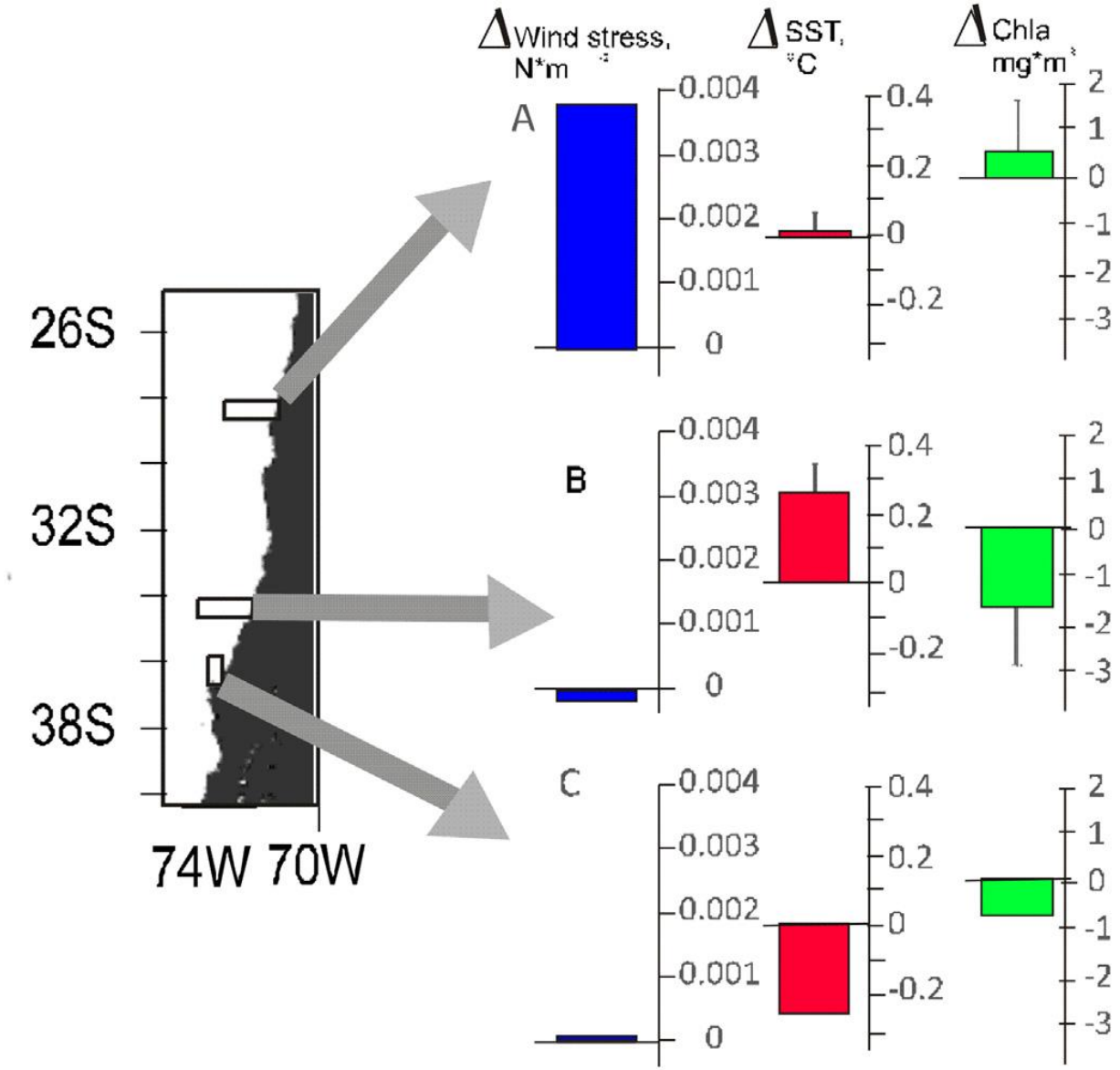

Chile
Central Chile
600 mi coastline



Gelcich et al. 2010

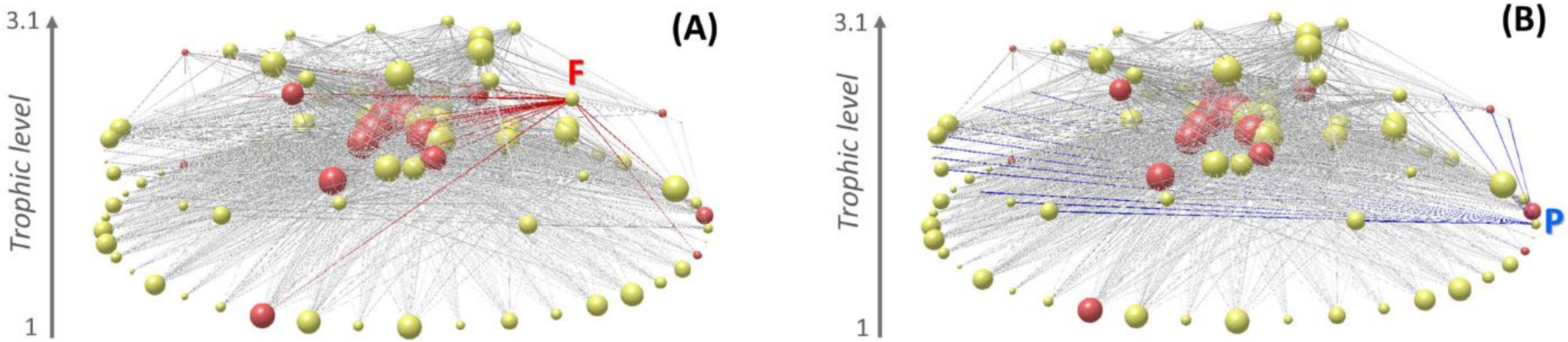


Weidberg et al. 2020



Weidberg et al. 2020

Chilean intertidal rocky-shore food web

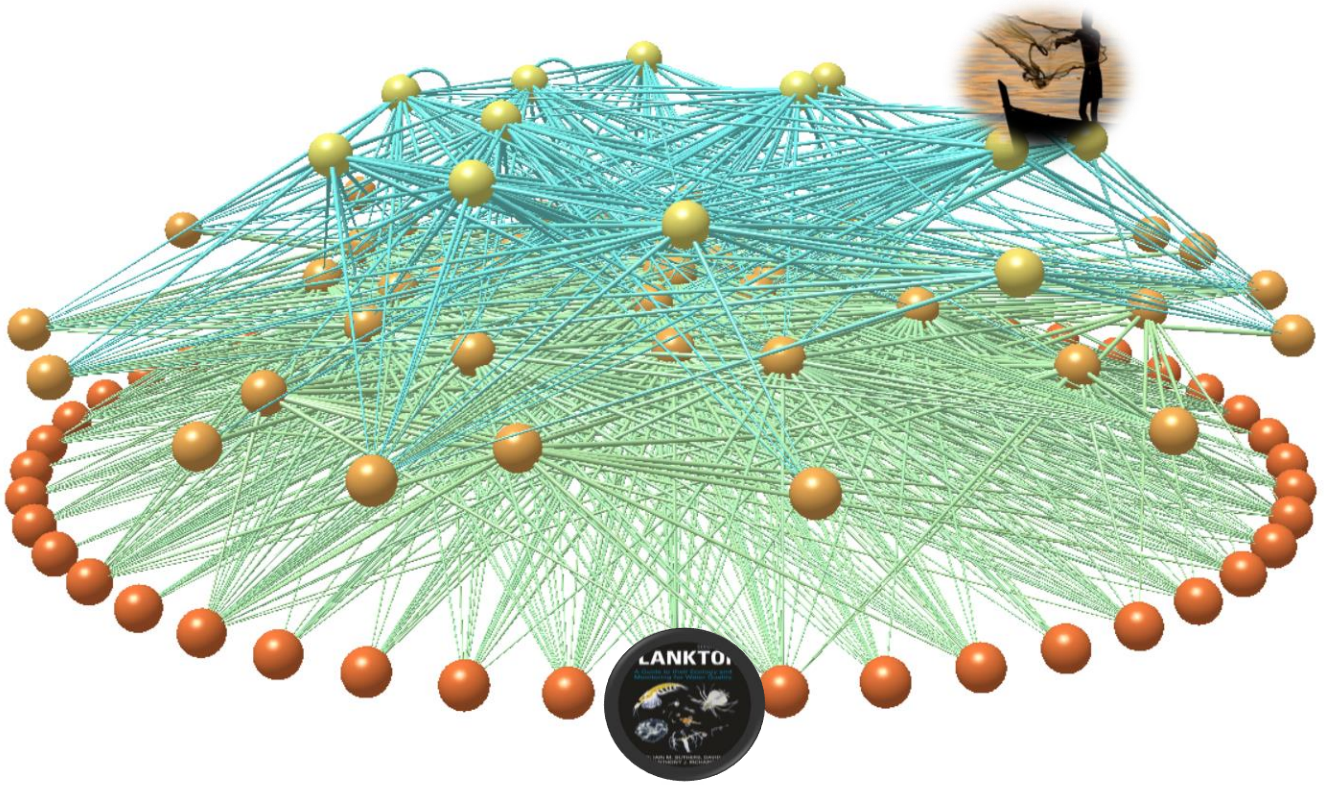


Harvested species

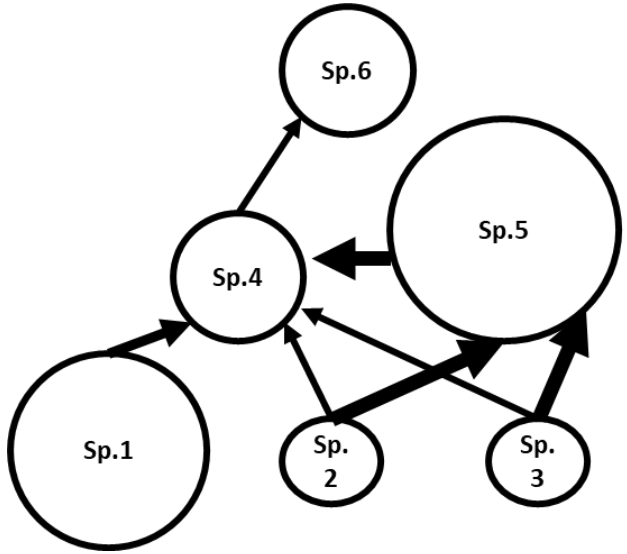
Non-Harvested species

Ávila-Thieme et al. 2021

WE ASSESSED THE INDEPENDENT AND COMBINED EFFECT OF FISHERIES AND PLANKTON BIOMASS CHANGES ON FOOD WEBS



Allometric Trophic Network model (ATN)



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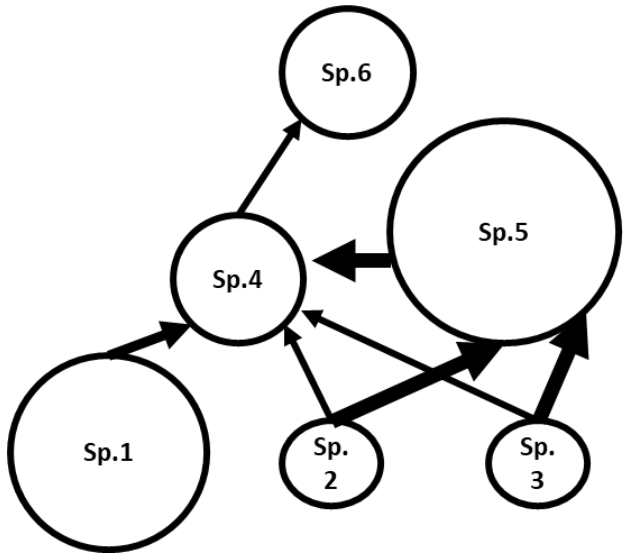


Consumers

Resources consumption gain | Maintenance loss | Predation loss | Fisheries loss

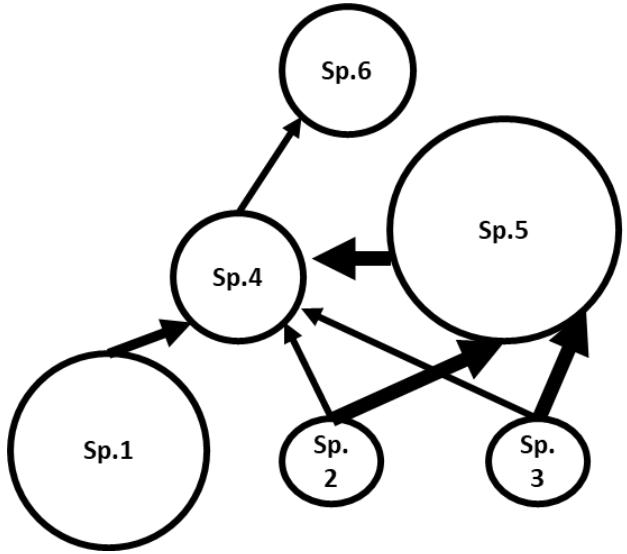
$$\frac{dB_j}{dt'} = f_a x_j B_j \sum_i y_{ji} F_{ji}(B) - f_m x_j B_j - \sum_z \frac{x_z y_{zj} B_z F_{zj}(\boldsymbol{B})}{e_{zj}} - F_{max\,j} B_j$$

Basal species

Growth gain | Predation loss | Fisheries loss

$$\frac{dB_i}{dt'} = r_i B_i \left[1 - \frac{\sum_{b=basal\ species} c_{ib} B_b}{K}\right] - \sum_j \frac{x_j y_{ji} B_j F_{ji}(\boldsymbol{B})}{e_{ji}} - F_{\max\,i} B_i$$

Allometric Trophic Network model (ATN)



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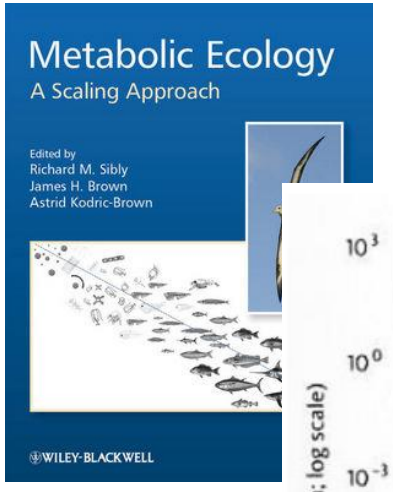
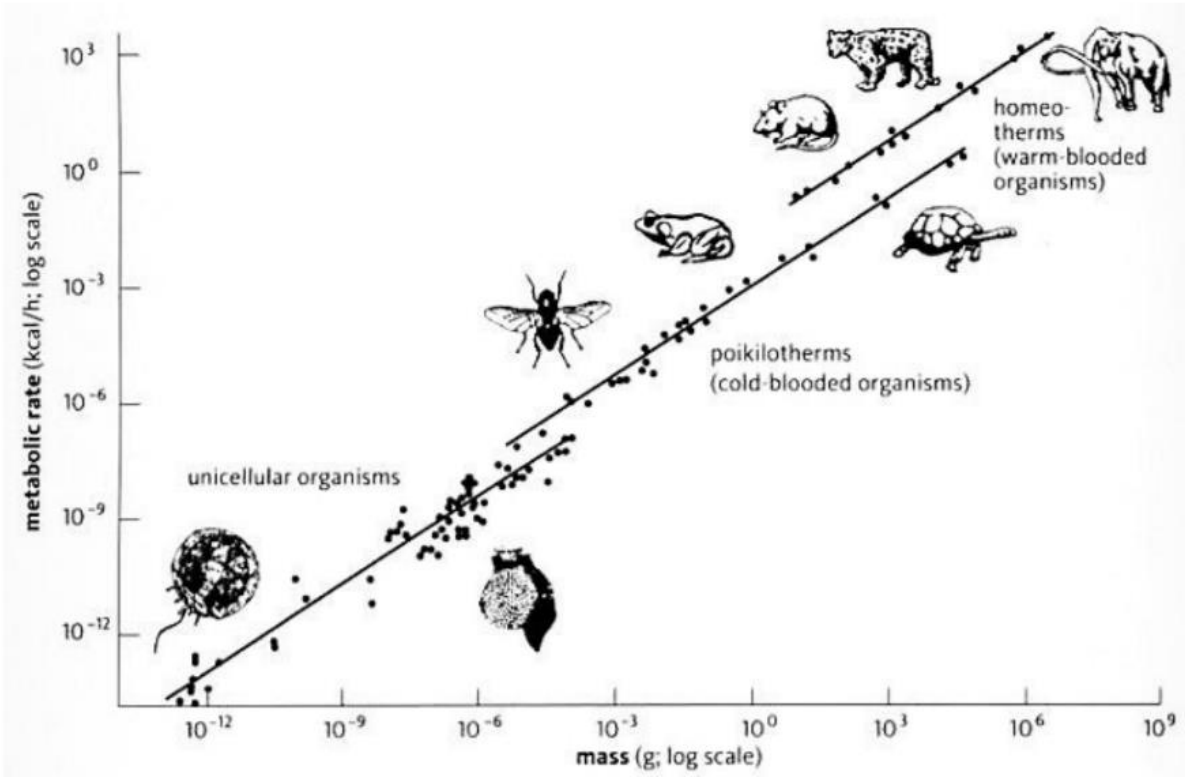
$$\frac{dB}{dt} = d_{local} + S$$





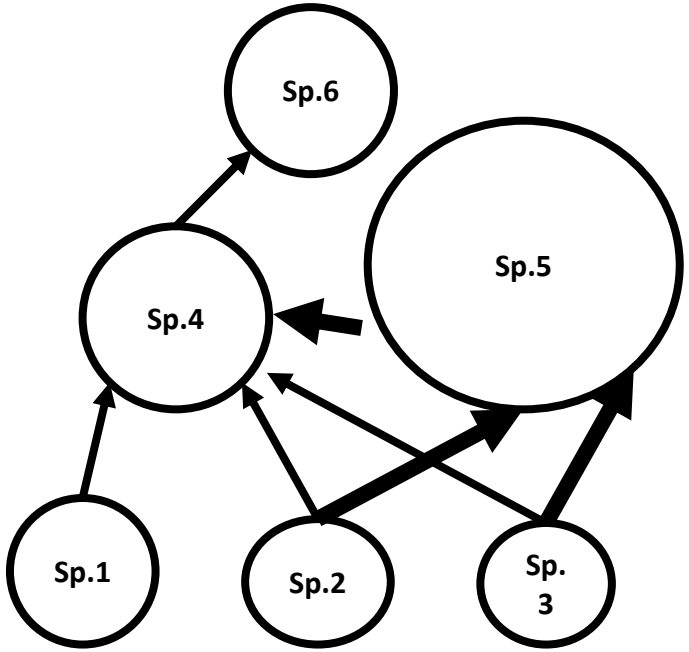
$$B \alpha M^{3/4}$$

B = Biological rates

- Production
- Reproduction
- Ingestion

M = Body mass

Brown et al. 2004. *Ecology*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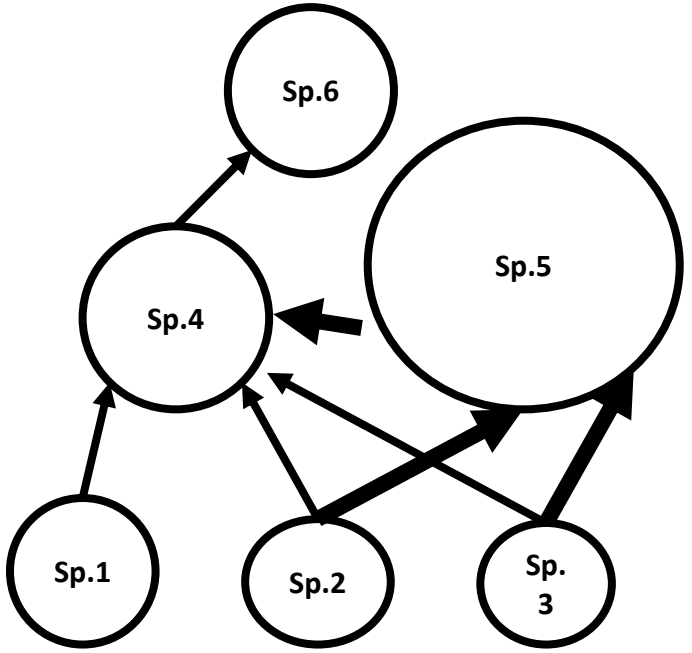
Sp.5
Sp.4
Sp.1
Sp.2
Sp.
3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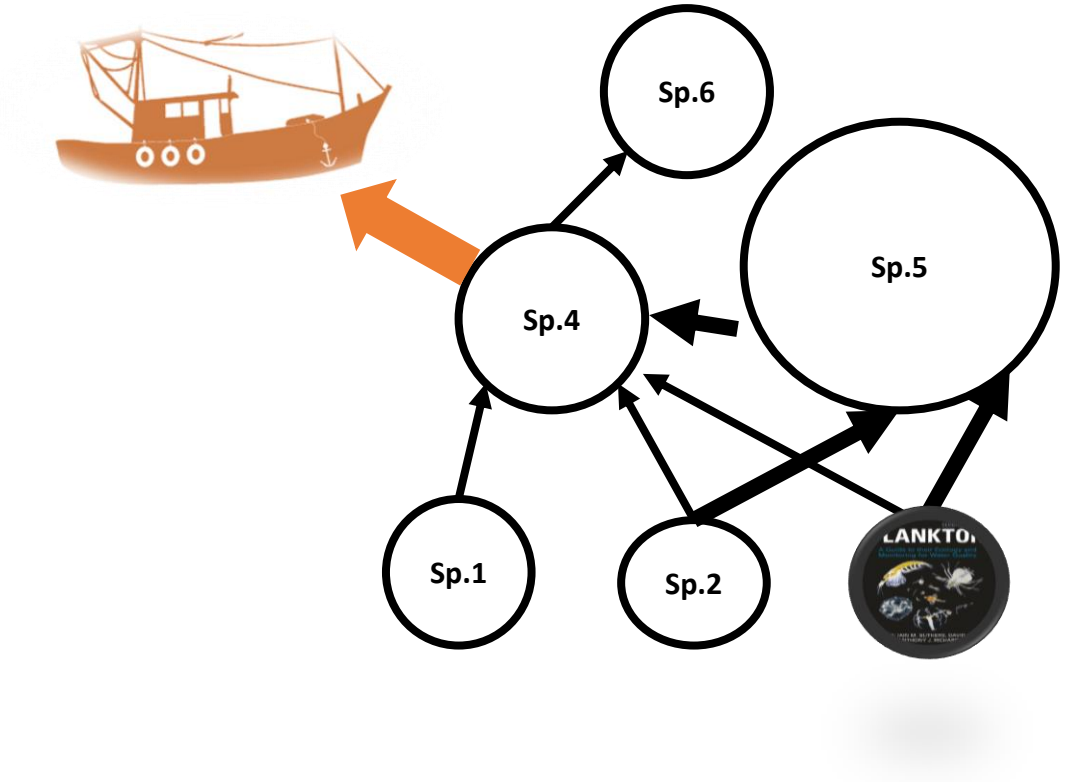
Sp.6
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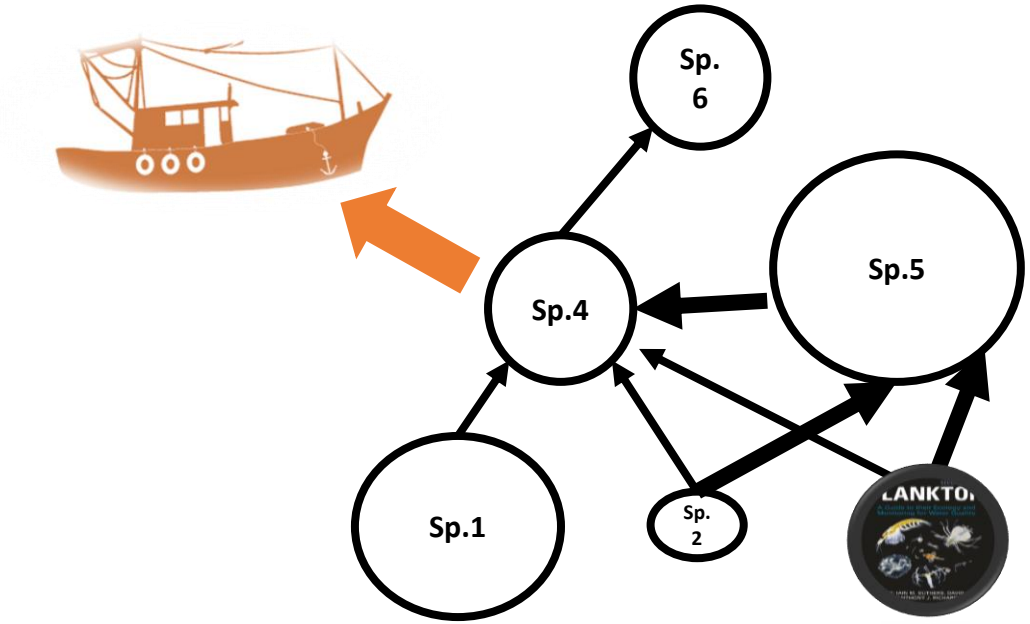
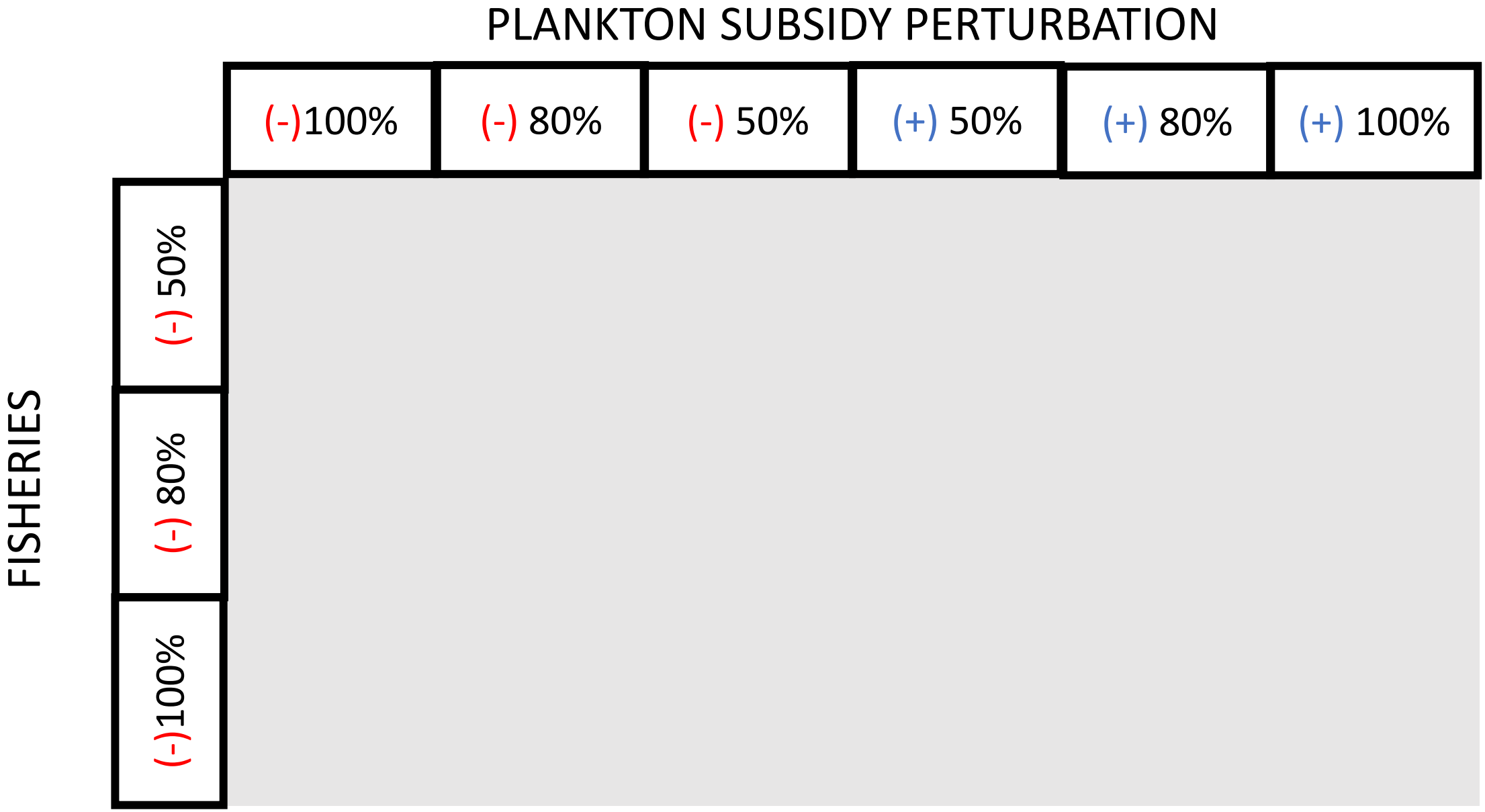

Sp.
6
Sp.5
Sp.4
Sp.1
Sp.
2

FISHERIES

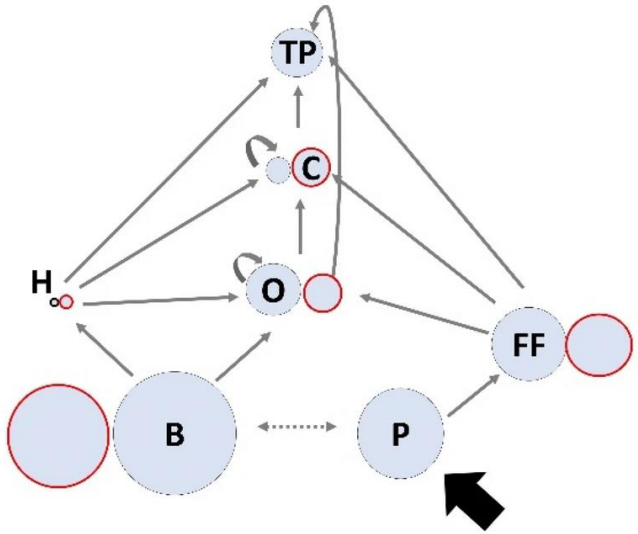
(-)100%	(-) 80%	(-) 50%

PLANKTON SUBSIDY PERTURBATION

(-)100%	(-) 80%	(-) 50%	(+) 50%	(+) 80%	(+) 100%


PLANKTON SUBSIDY PERTURBATION
(-)100%
(-) 80%
(-) 50%
(+) 50%
(+) 80%
(+) 100%
FISHERIES
(-) 50%
(-) 80%
(-)100%

(A) Before perturbation



(B) After fisheries

110 g/m²

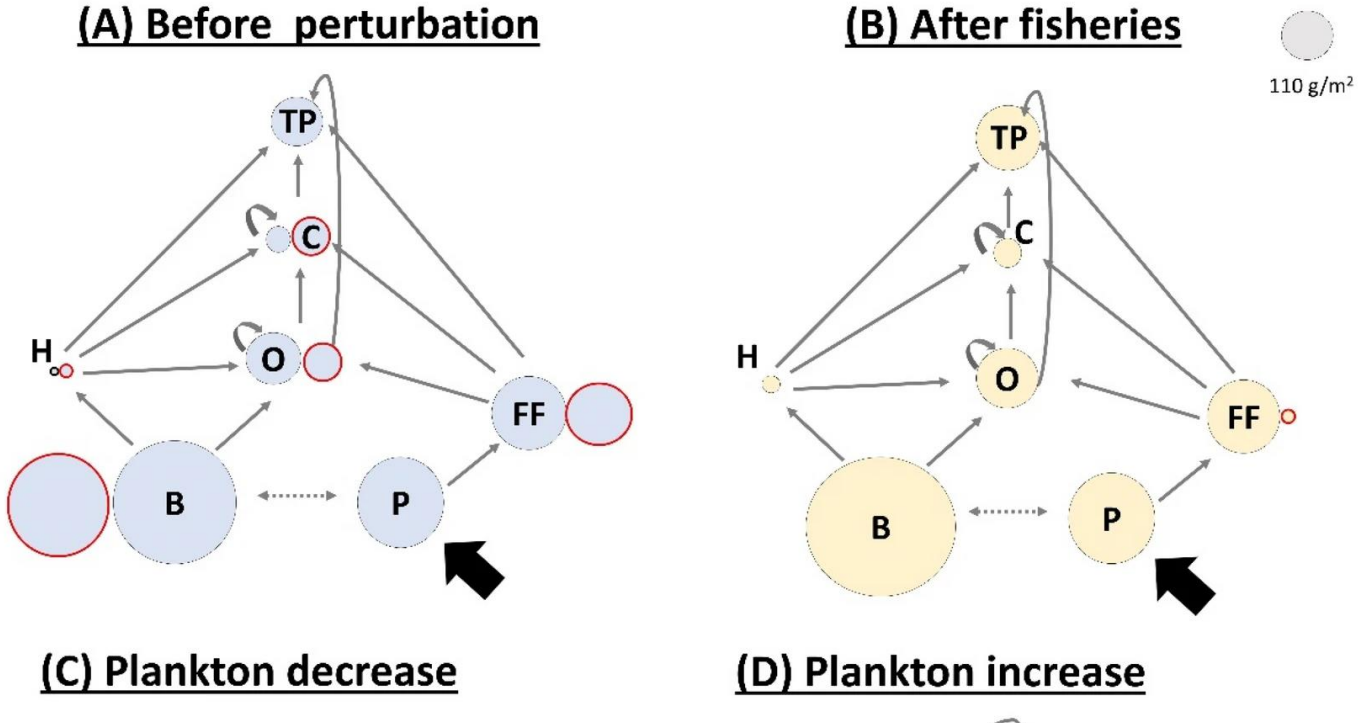
(C) Plankton decrease

(D) Plankton increase

- Non-harvested
- Harvested

P: plankton node
B: basal
FF: filter-feeders
H: herbivores
O: omnovores
C: carnivores
TP: Top predator

Ávila-Thieme et al. 2021



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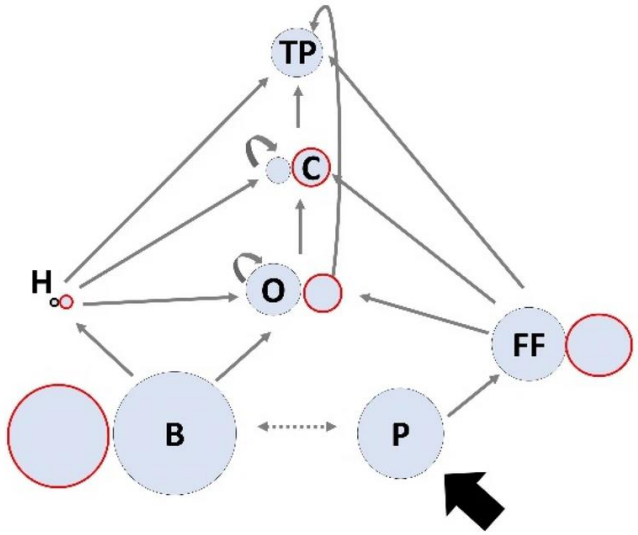
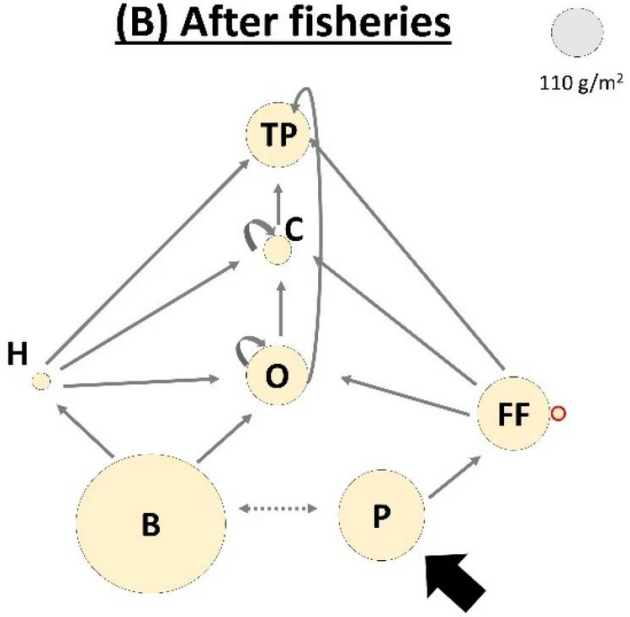
Ávila-Thieme et al. 2021

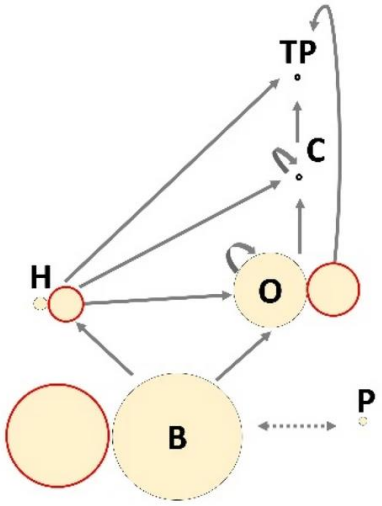
(A) Before perturbation



(B) After fisheries



(C) Plankton decrease



(D) Plankton increase

Non-harvested

Harvested

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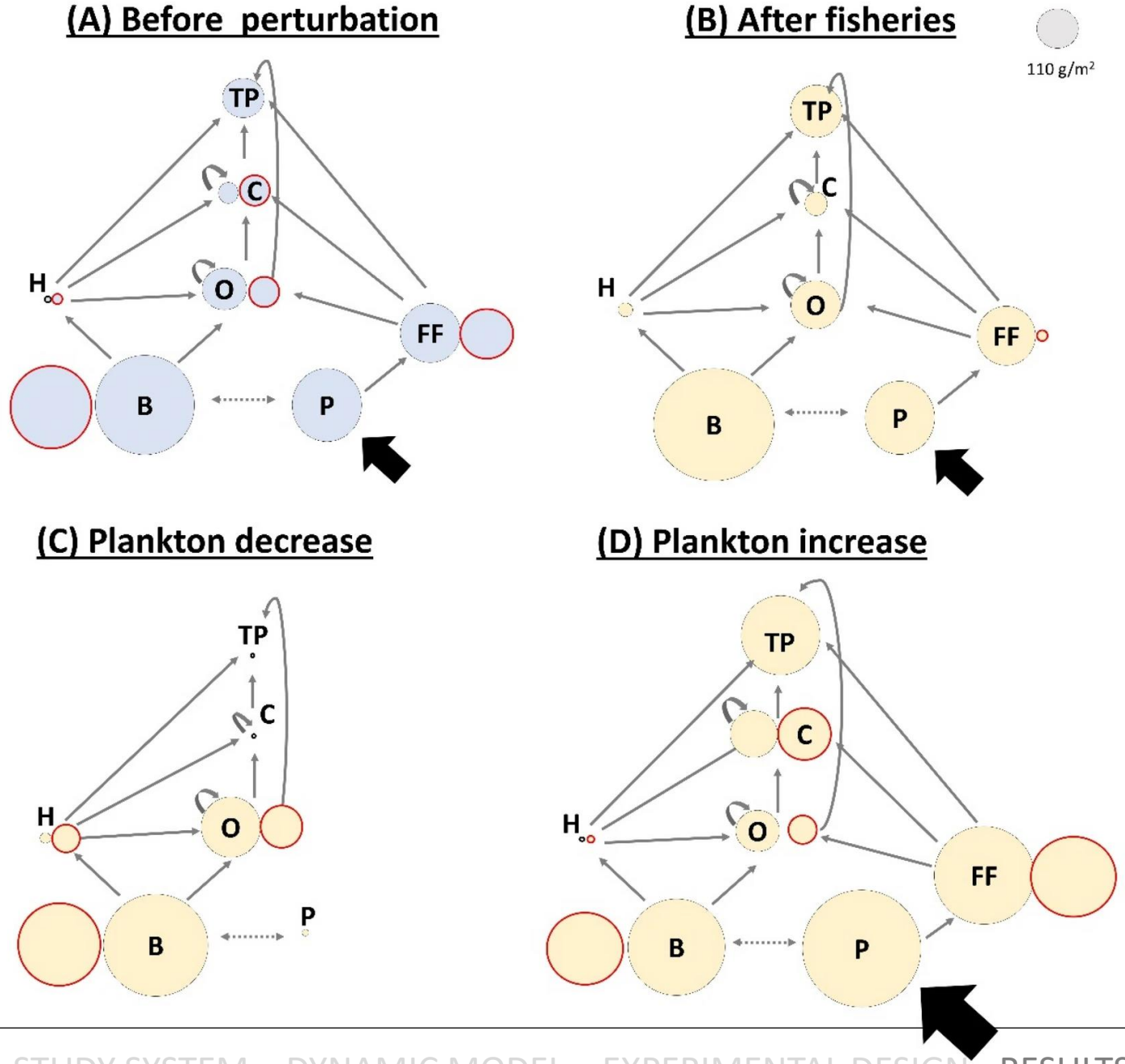
Ávila-Thieme et al. 2021



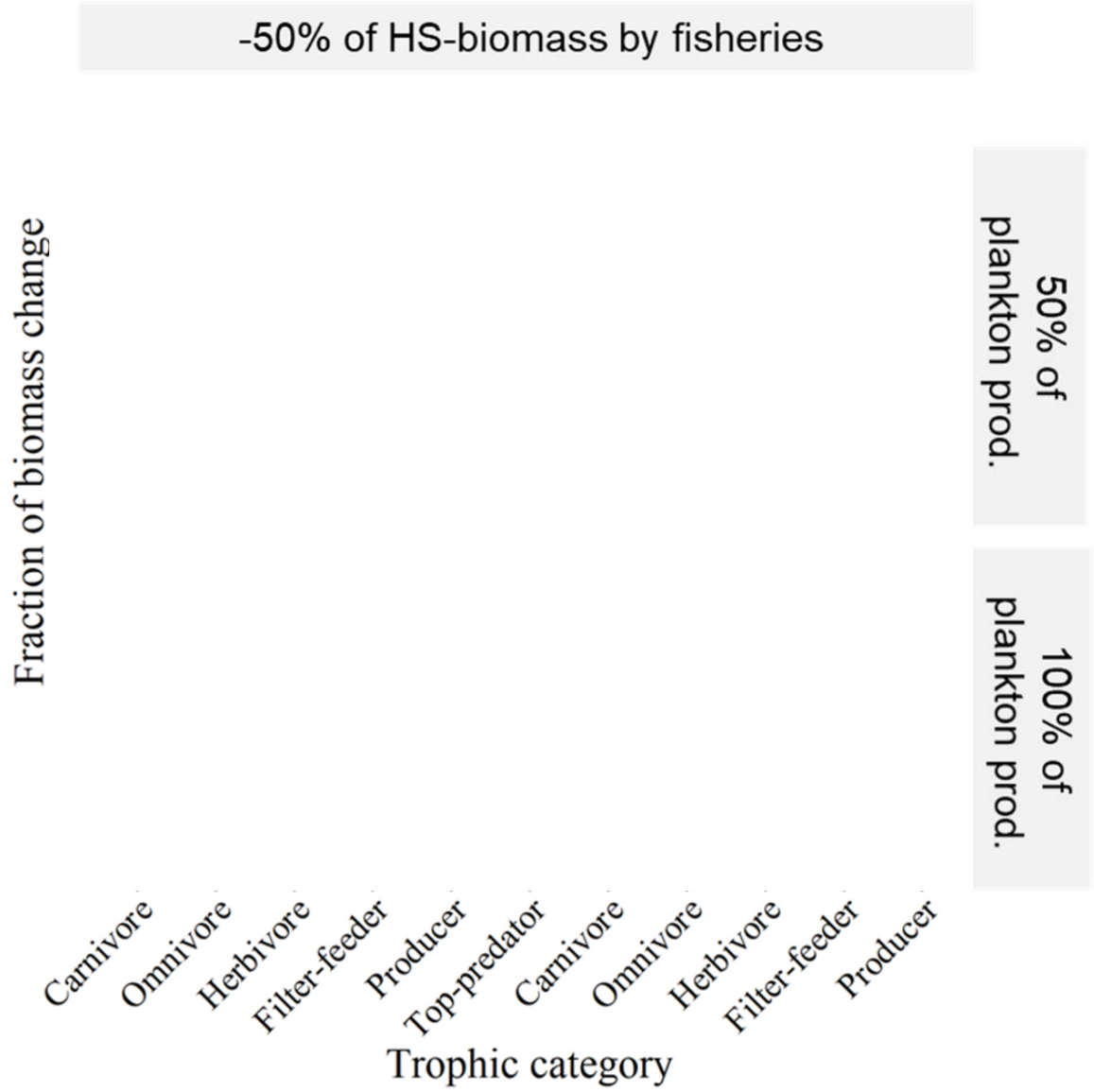
Ávila-Thieme et al. 2021

-50% of HS-biomass by fisheries

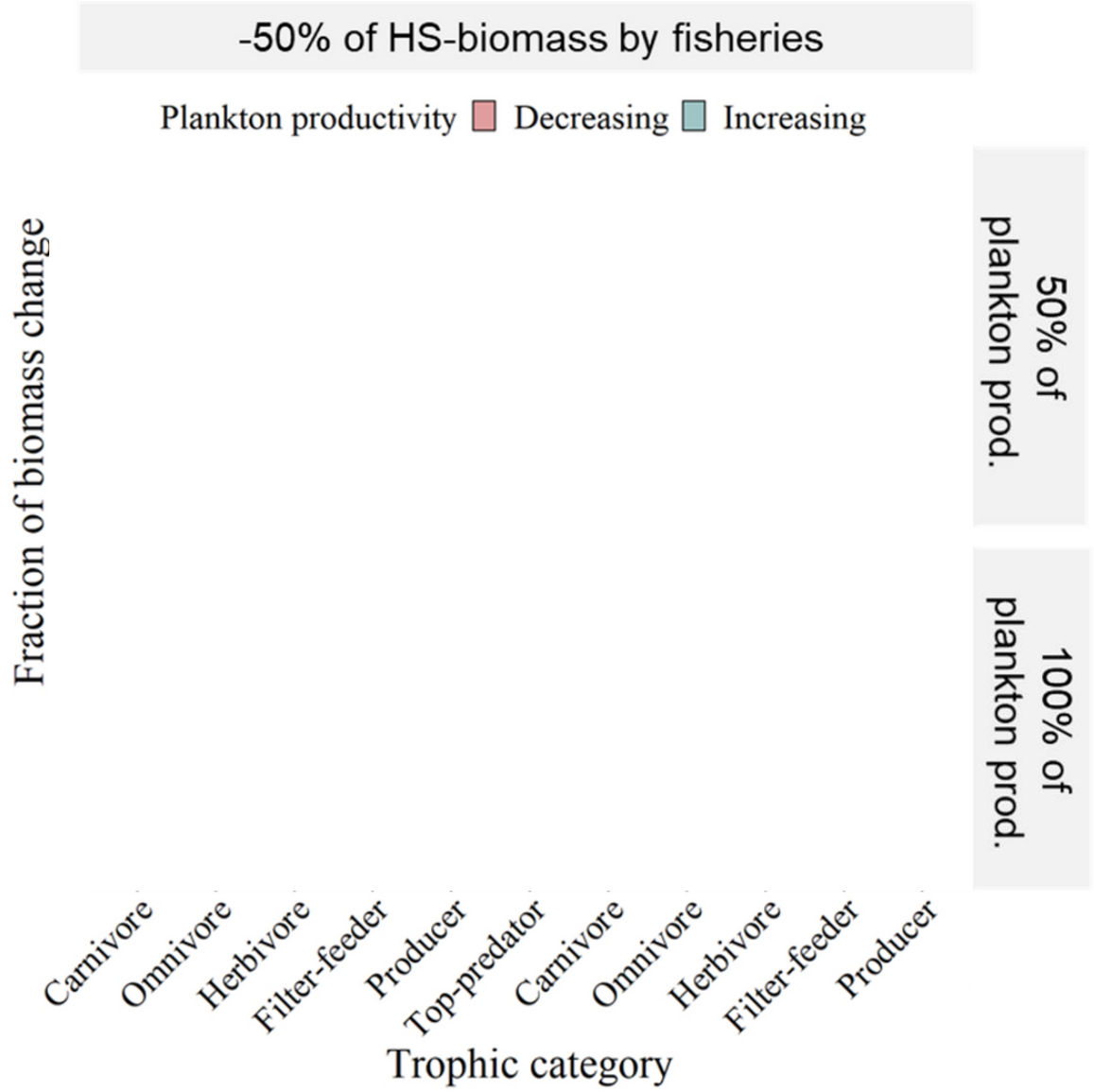
50% of plankton prod.

100% of plankton prod.

Ávila-Thieme et al. 2021



Ávila-Thieme et al. 2021



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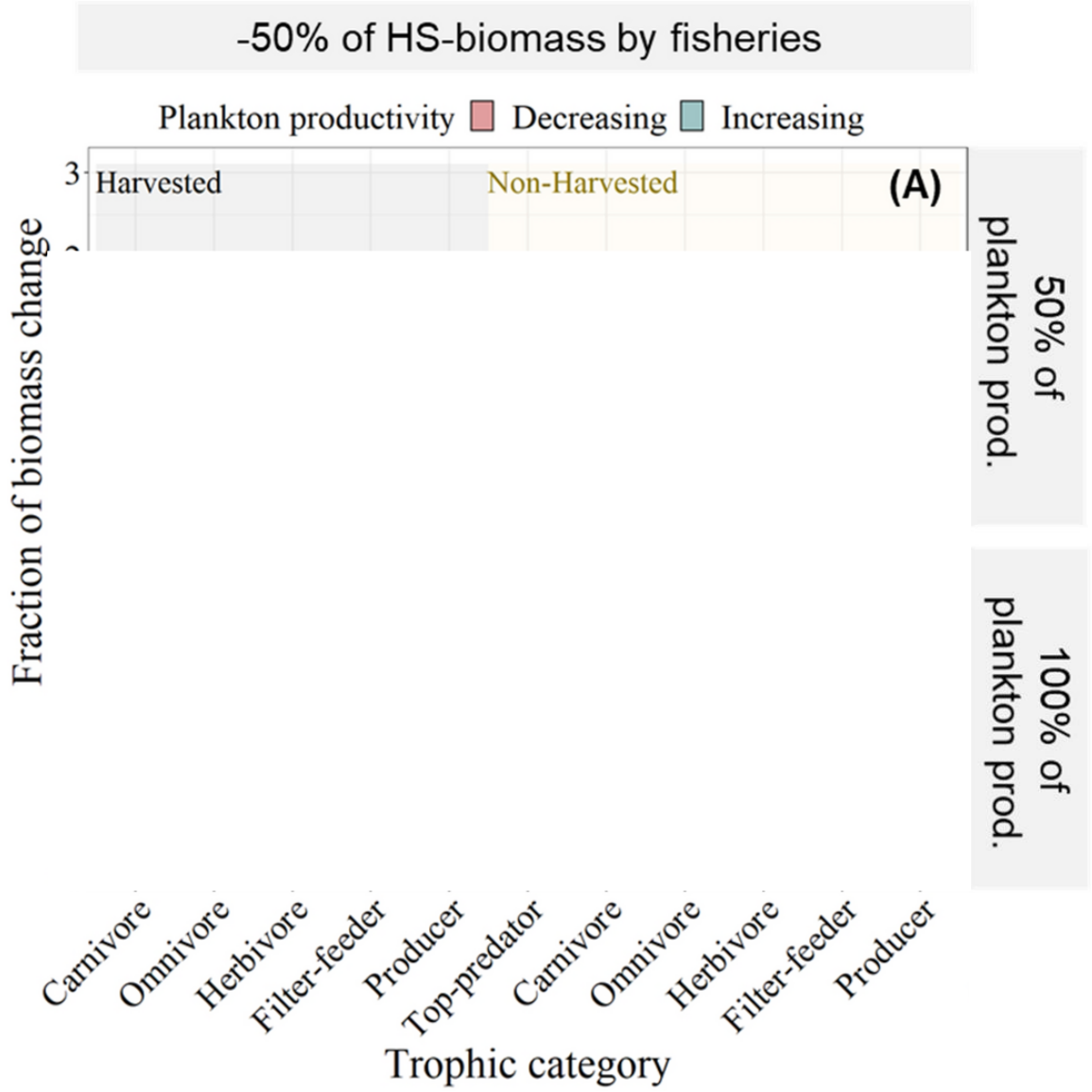

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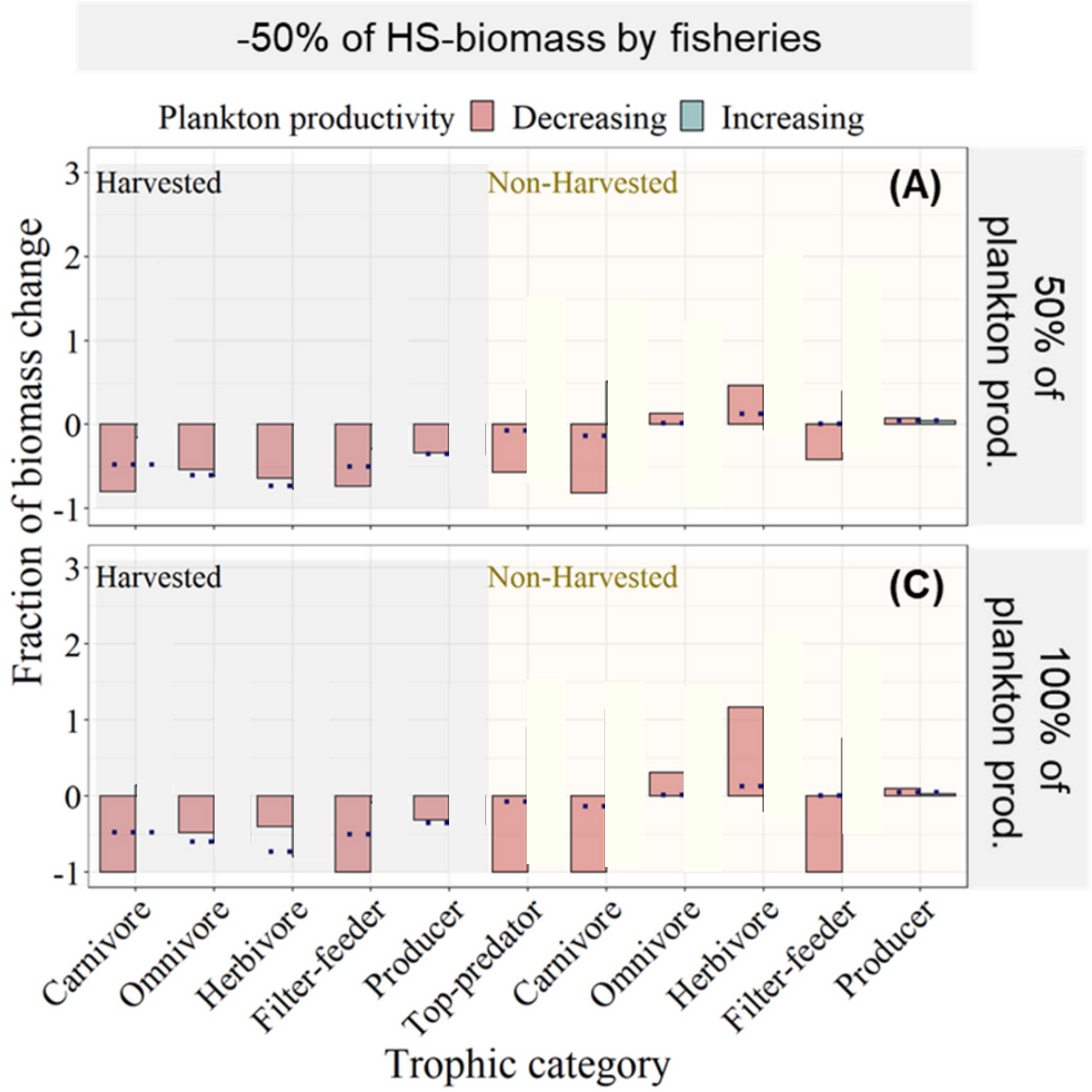
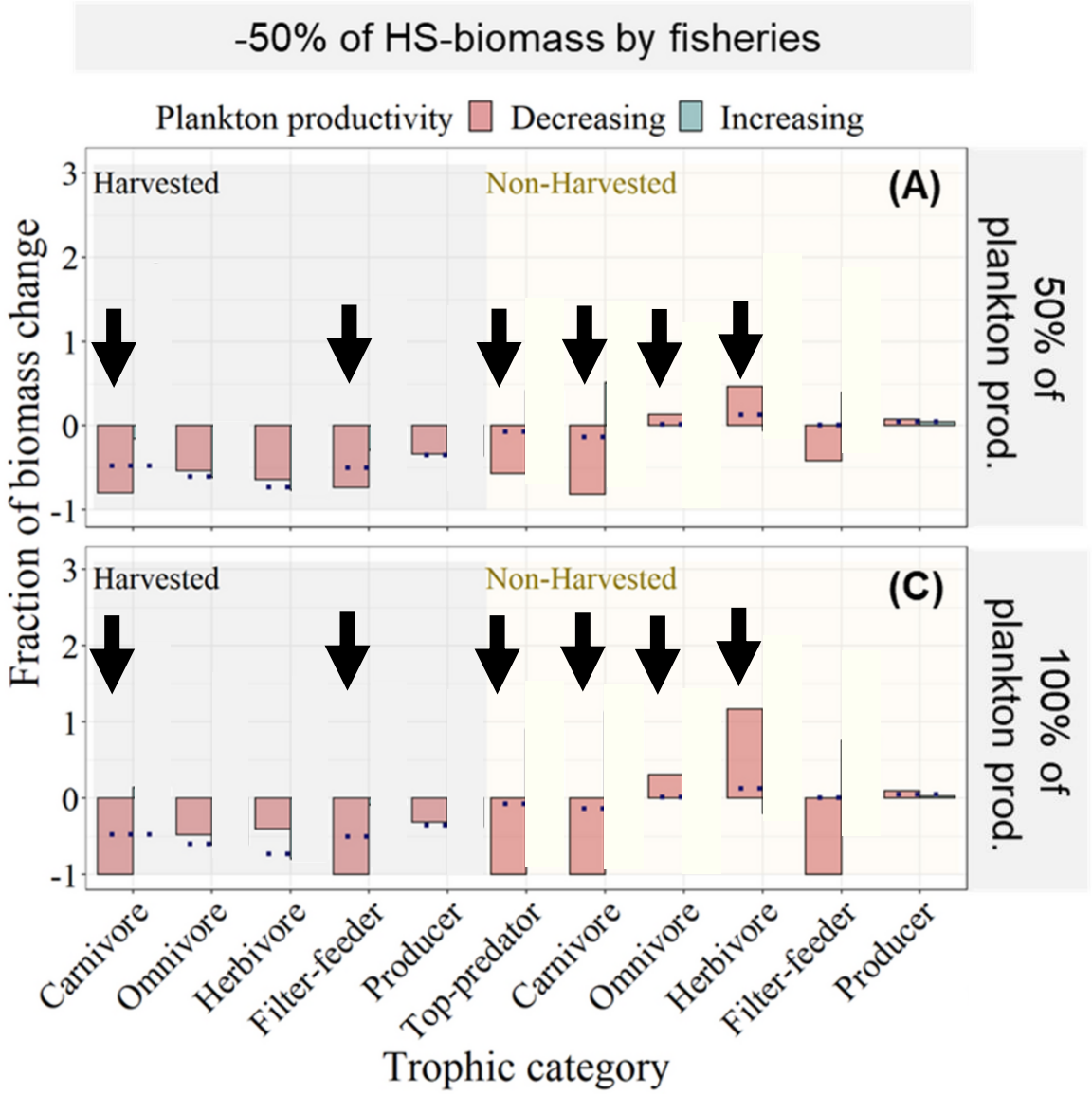
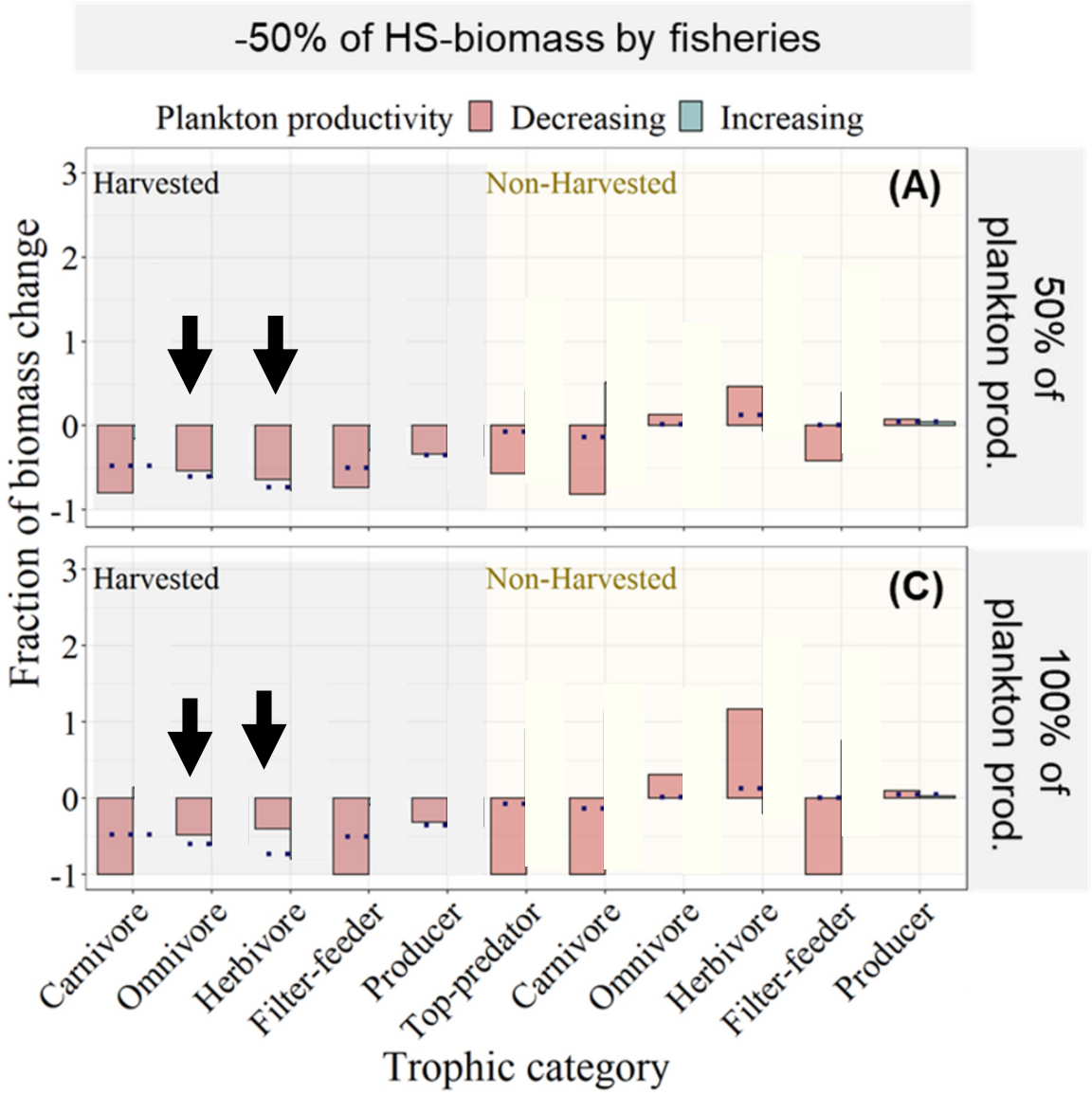


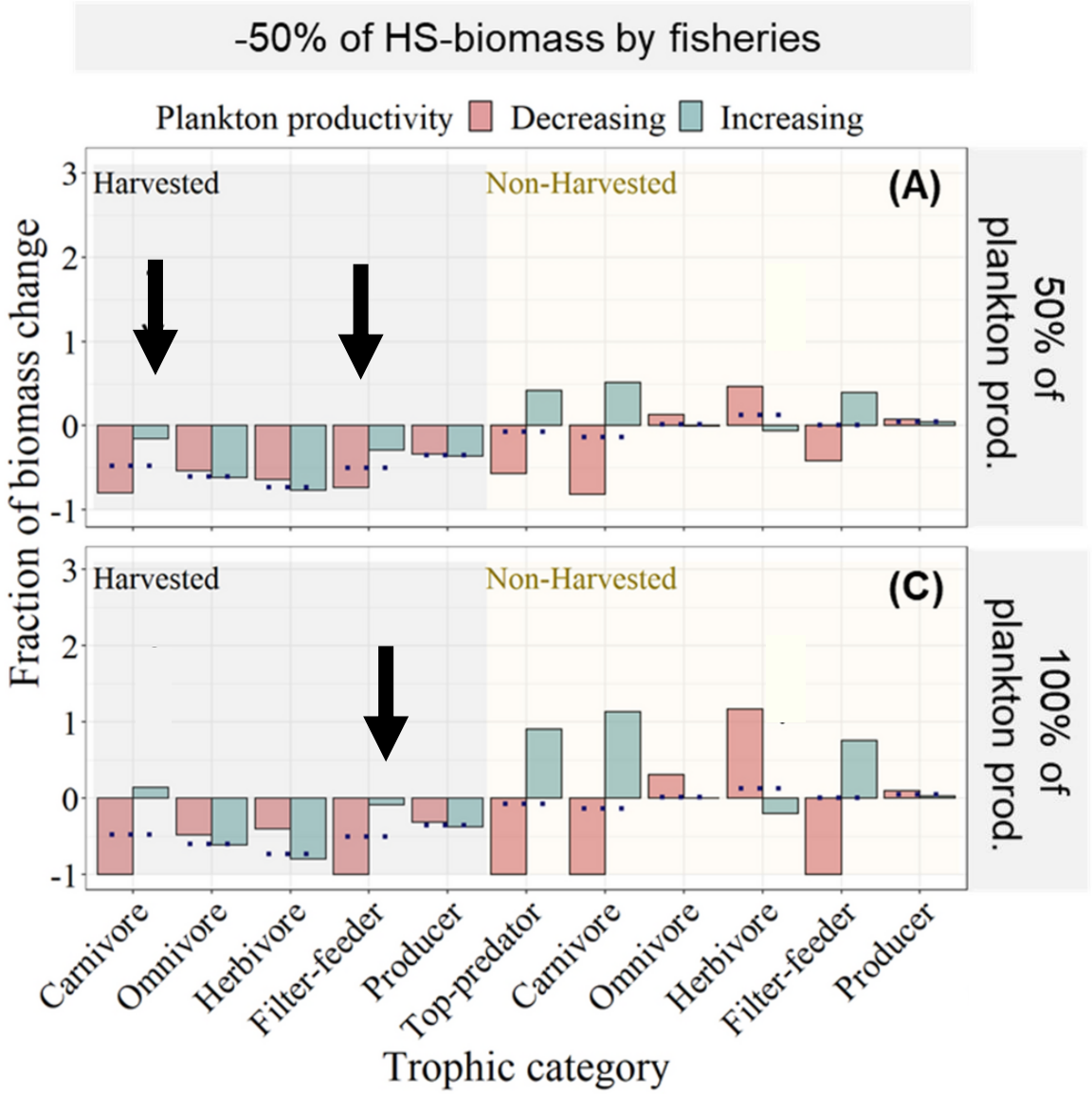
Ávila-Thieme et al. 2021



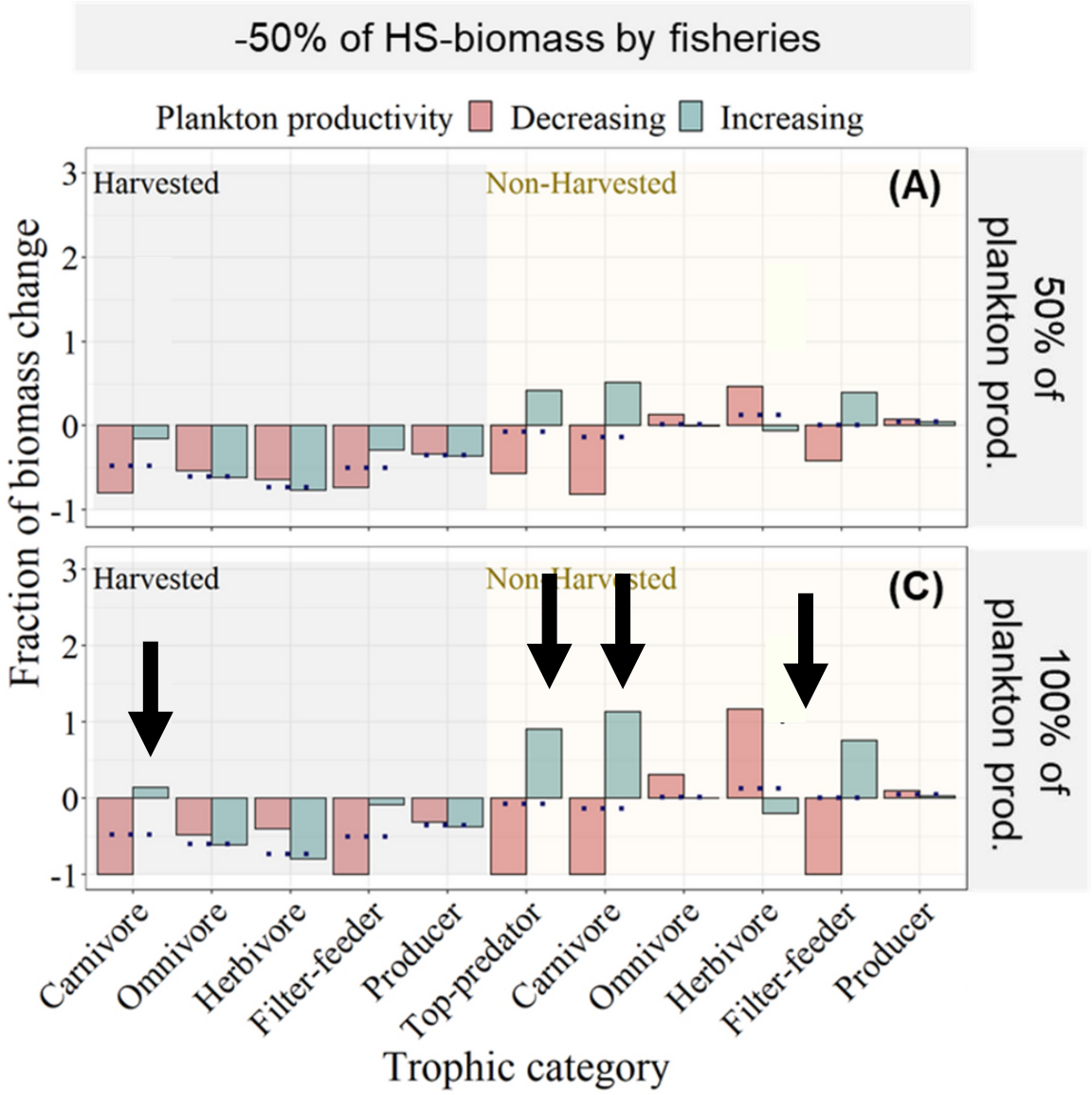
Ávila-Thieme et al. 2021



Ávila-Thieme et al. 2021



Ávila-Thieme et al. 2021



Ávila-Thieme et al. 2021

Intertidal food-web

- Is highly sensitive to climatic variations
- Artisanal fisheries might contribute to dampening the negative consequences of climate change by increasing the biomass of non-harvested species
- Climate change-driven effects may cause that harvested species become more vulnerable to very low exploitation rates

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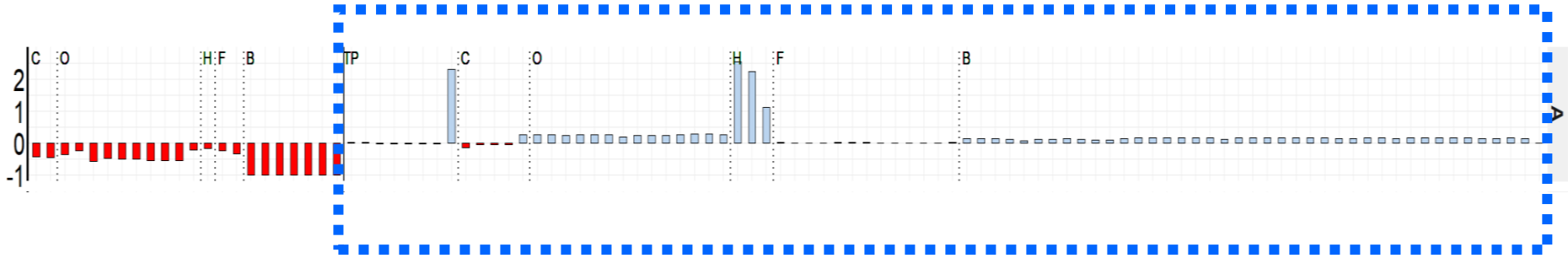
C
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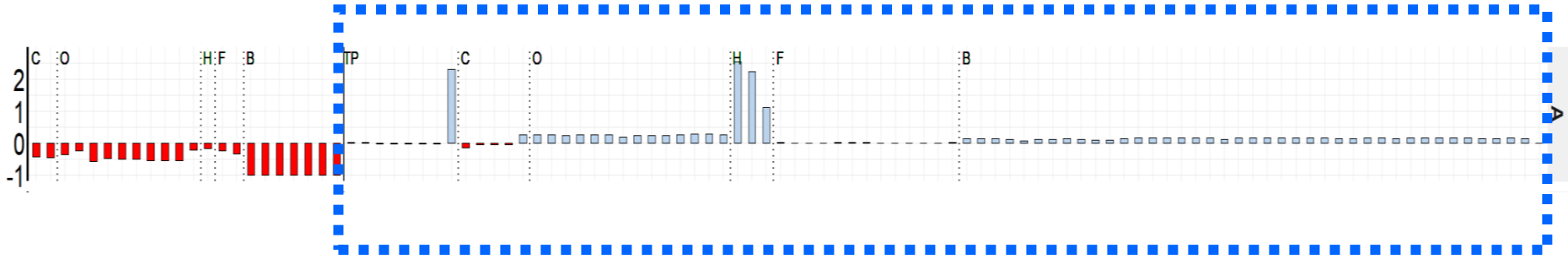
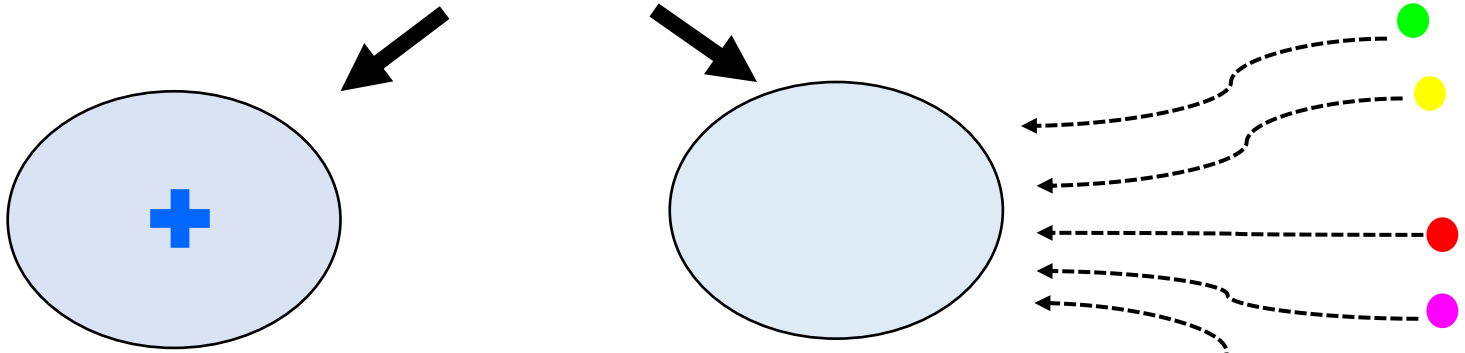


ecological release Crowel 1962



Bradley et al. 2019
Thomsen et al. 2014

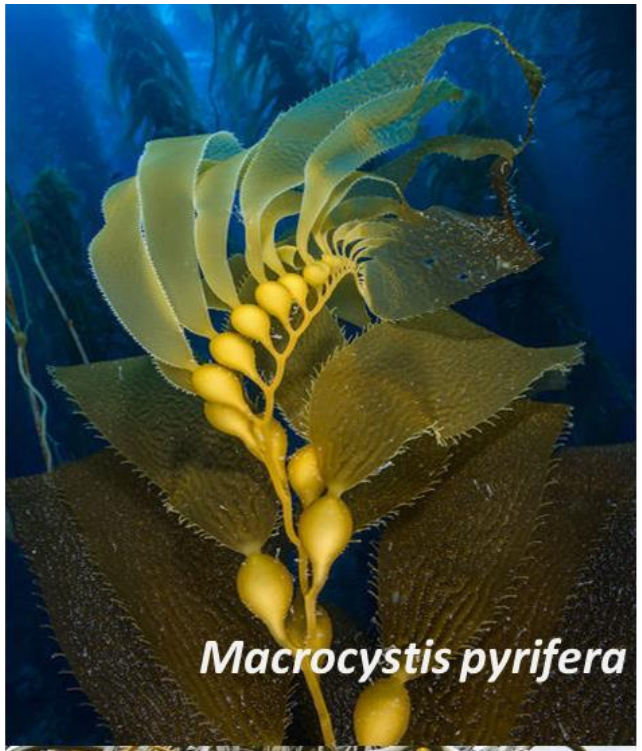
Type of harvested species	Biomass decrease of interest in harvested species	F_{max} value that produce the biomass decrease of interest
Basal species		
	50%	
	80%	
	100%	
Consumers		
	50%	
	80%	
	100%	

Ávila-Thieme et al. 2021

Type of harvested species	Biomass decrease of interest in harvested species	F_{max} value that produce the biomass decrease of interest
Basal species		
	50%	0.00125
	80%	0.0022
	100%	0.01
Consumers		
	50%	0.23
	80%	0.8
	100%	1

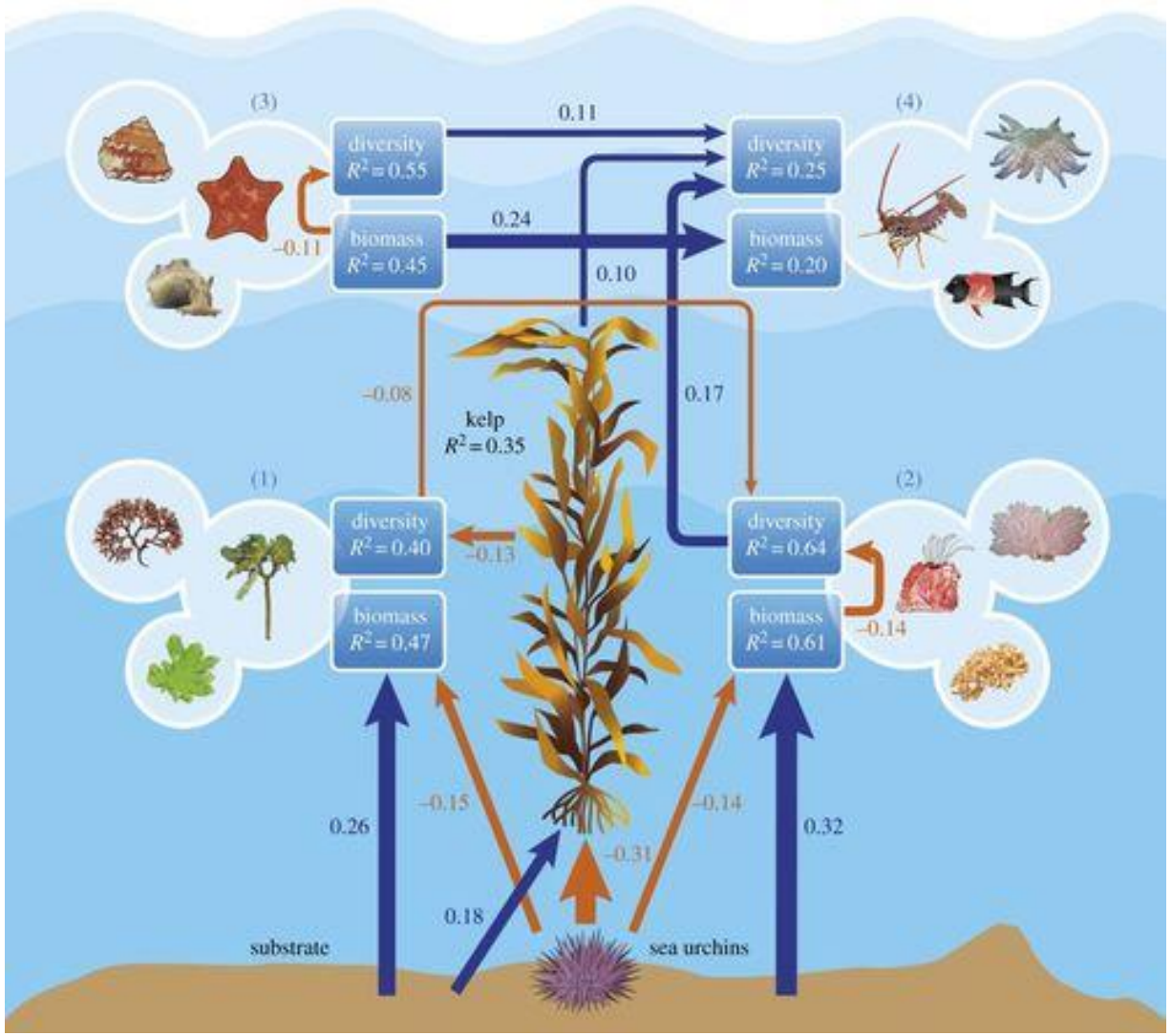
Ávila-Thieme et al. 2021


ALGALAB
Durvillaea Antarctica (bull kelp 1)

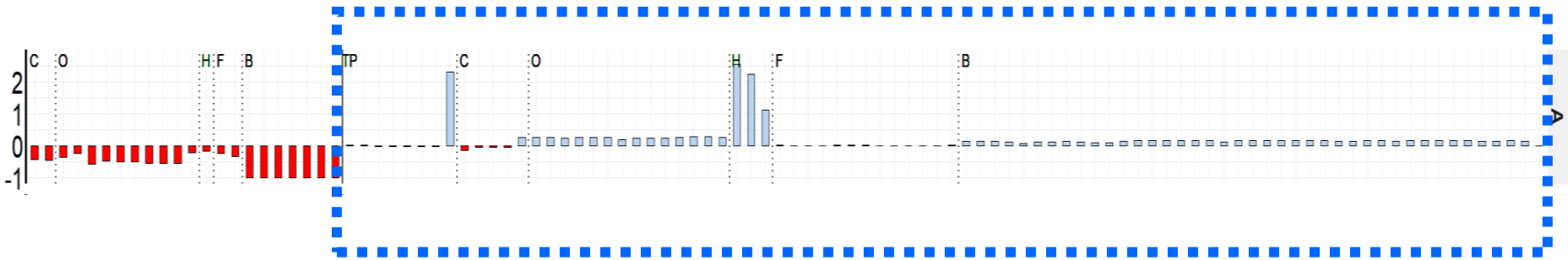

Macrocystis pyrifera


Lessonia spicata (giant grey weed)


algaeBASE
Lessonia trabeculata



Miller et al. 2018


C
O
H
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TP
C
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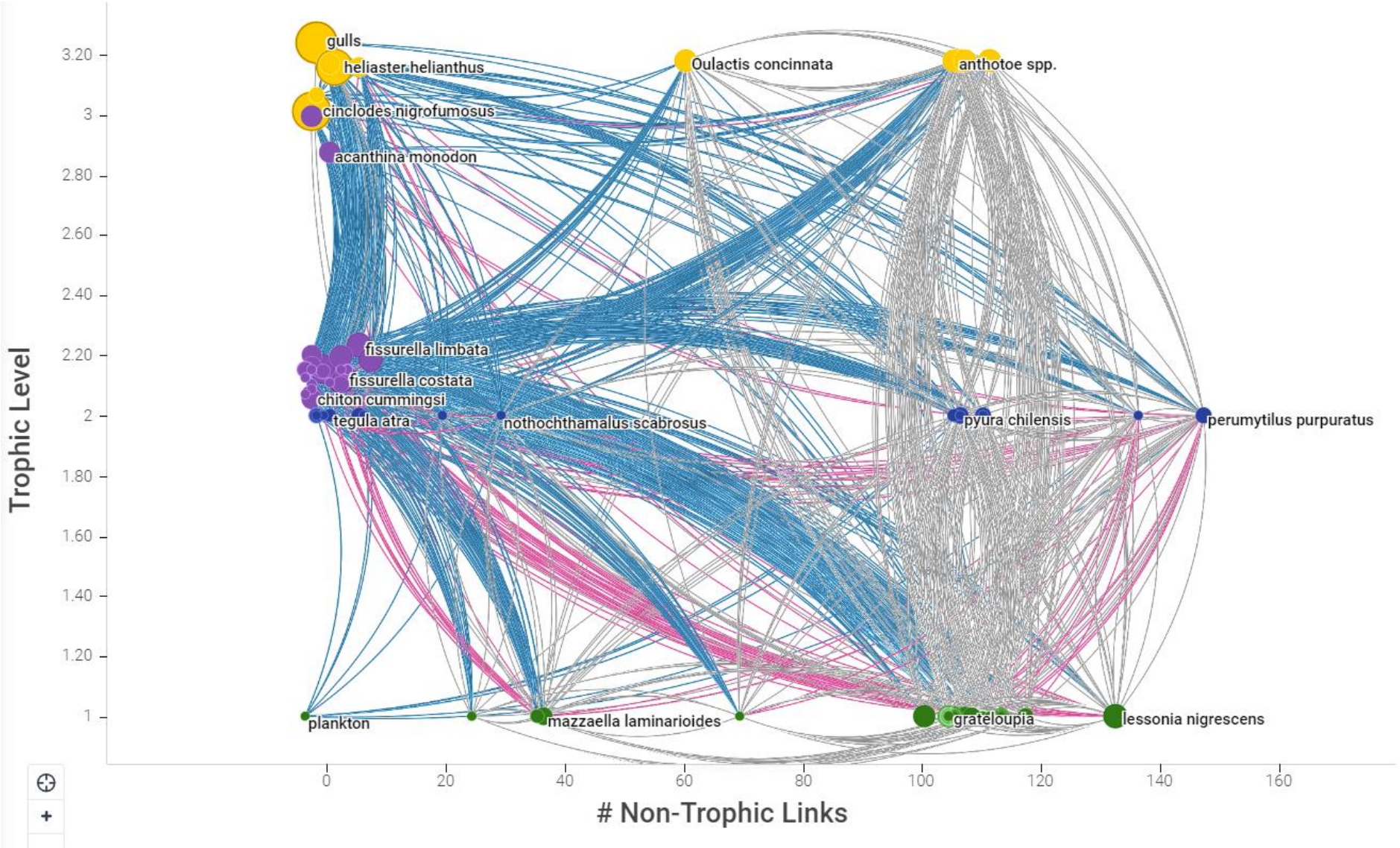
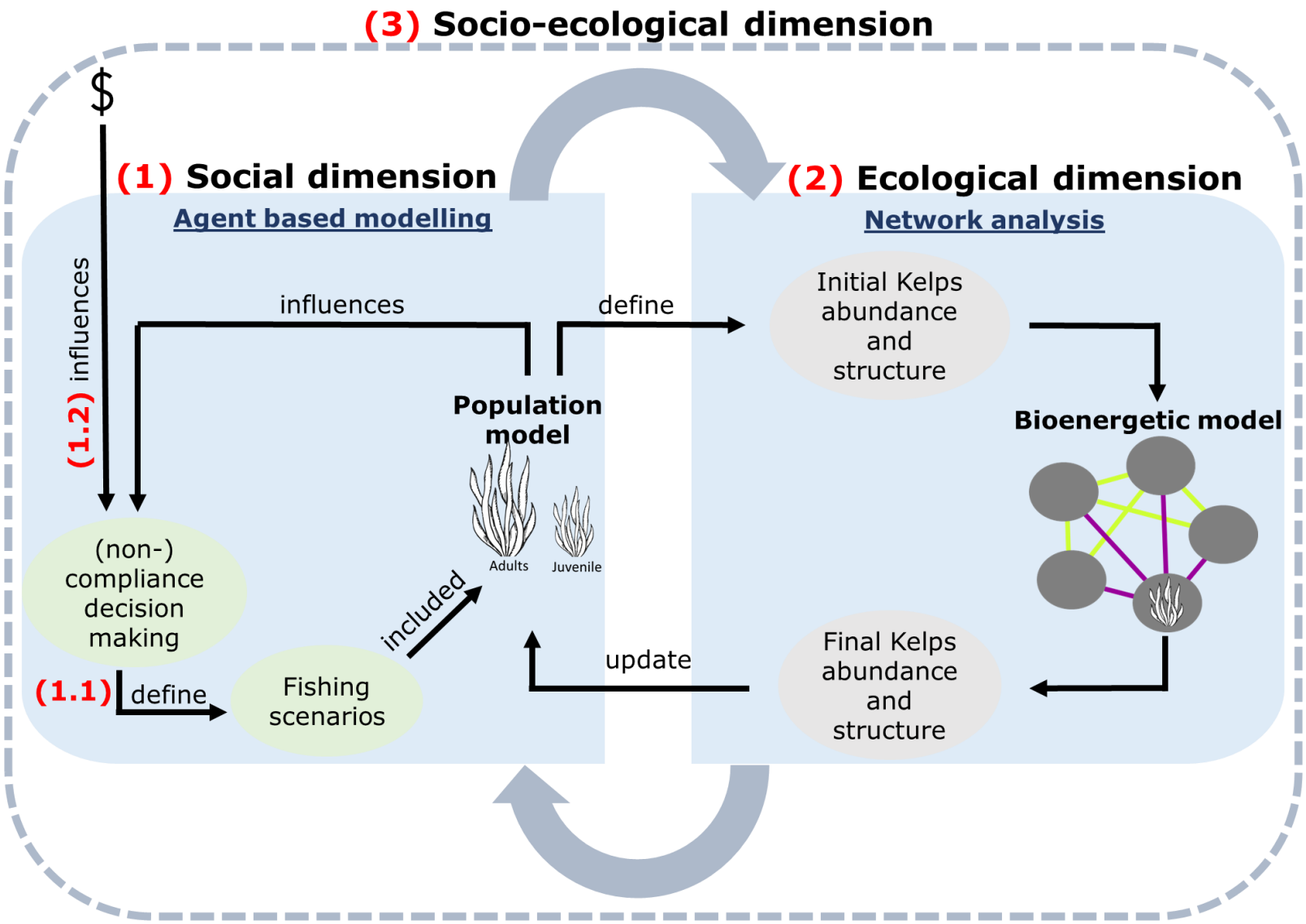
A


gulls
heliaster helianthus
cinclodes nigrofumosus
acanthina monodon
Oulactis concinnata
anthotoe spp.
fissurella limbata
fissurella costata
chiton cummingsi
tegula atra
nothochthamalus scabrosus
pyura chilensis
perumytilus purpuratus
plankton
mazzaella laminarioides
grateloupia
lessonia nigrescens
Trophic Level
3.20
3
2.80
2.60
2.40
2.20
2
1.80
1.60
1.40
1.20
1
0
20
40
60
80
100
120
140
160
Non-Trophic Links

Frangoudes 2011, Westermeier et al. 2019, Donlan 2020

Understanding non-compliance in kelps fisheries from a social-ecological perspective

M. Isidora Ávila-Thieme, Josh Donlan & Stefan Gelcich


(3) Socio-ecological dimension
$
(1) Social dimension
Agent based modelling
(2) Ecological dimension
Network analysis
(1.2) influences
influences
define
Population model
Adults
Juvenile
Initial Kelps abundance and structure
Bioenergetic model
(non-) compliance decision making
included
update
(1.1)
define
Fishing scenarios
Final Kelps abundance and structure

Thanks you for your attention

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