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A UN Ocean Decade Event
#MSEAS2024
Marine Socio-Ecological Systems Symposium

Cumulative and interactive effects of human uses and climate change: a point of view based on networks

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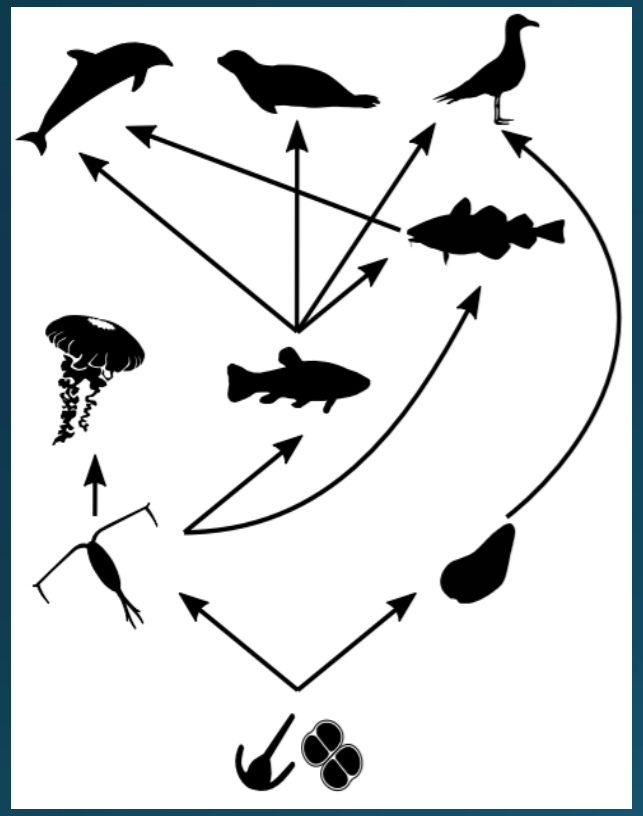
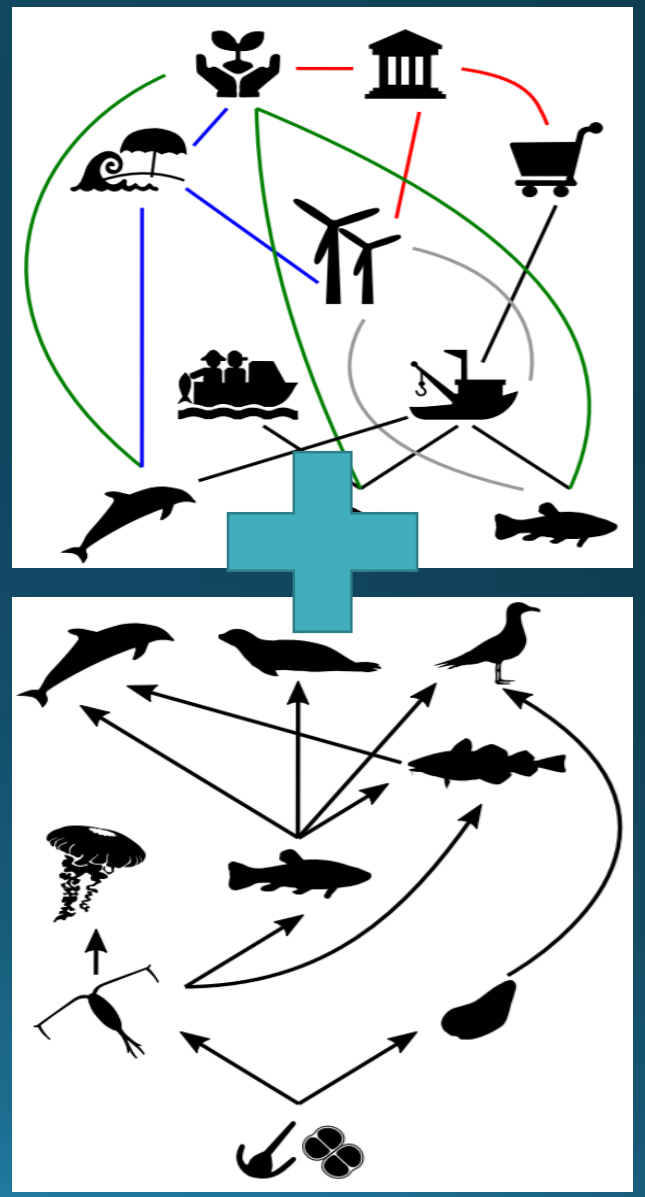
6 Ifremer, France
7 CNR, Sesto Fiorentino, Italy
8 GEOMAR, Kiel, Germany
9 LEMAR, Plouzané, France
10 LOG, Wimereux, France

cnrs

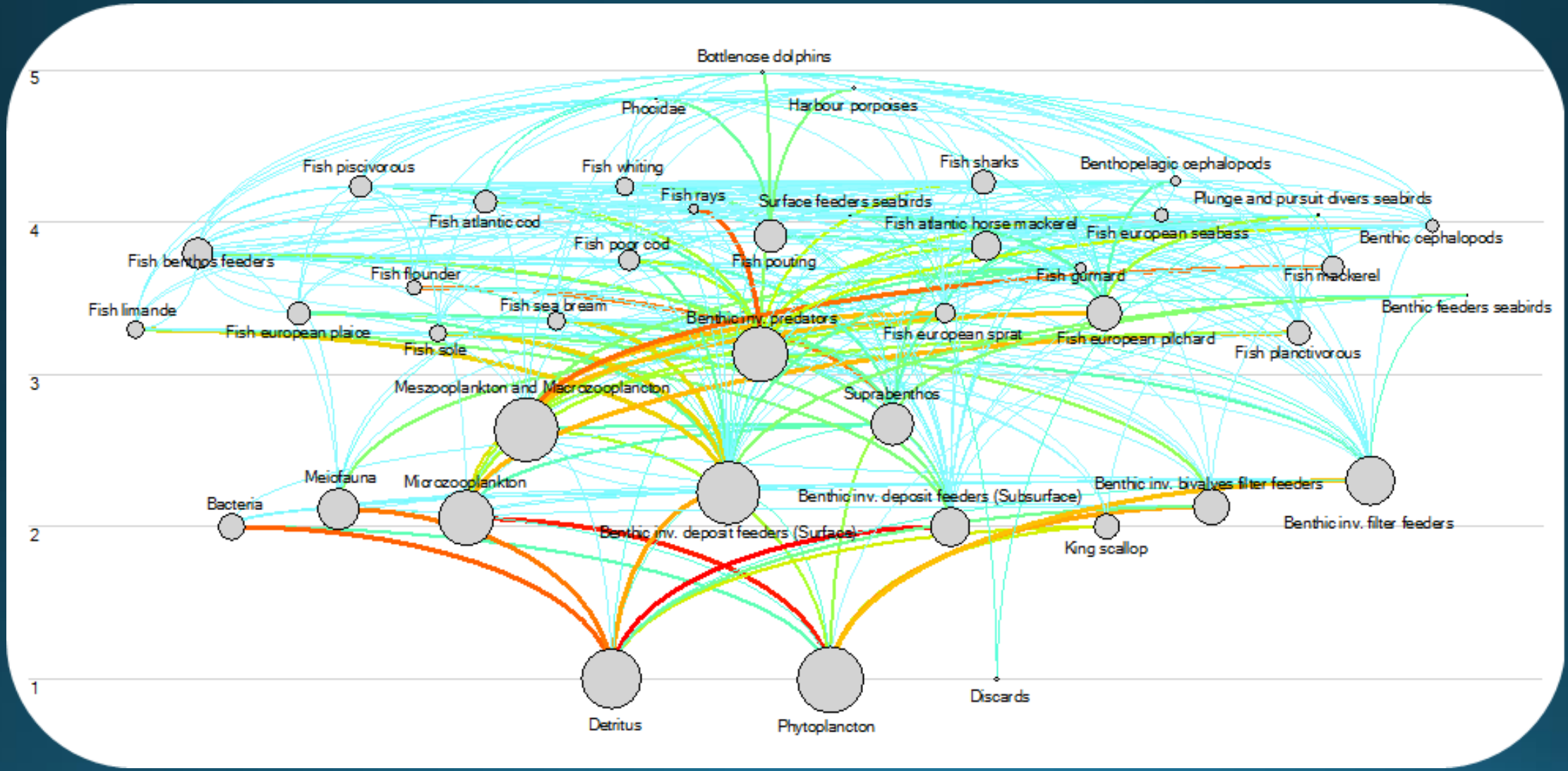
Trophic network



Social-ecological system network



Trophic Network



Trophic Network

A « spaghetti plate » according to Pimm, 1982

⇒ A need for indices that characterize the food web functioning

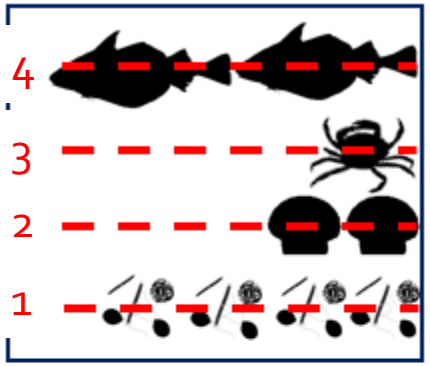
⇒ Ecological Network Analysis development (Patten, Ulanowicz)

Various origins:

- Ecological concepts (Odum)
- Graphs theory and topology
- Information theory (Shannon)
- Input-Output analysis (Leontief)

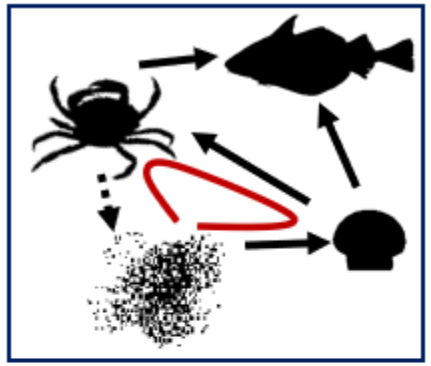
Pimm, S. L. 1982. Food webs. Springer, Dordrecht.

ENA indices, from theory to ecosystem health indicators



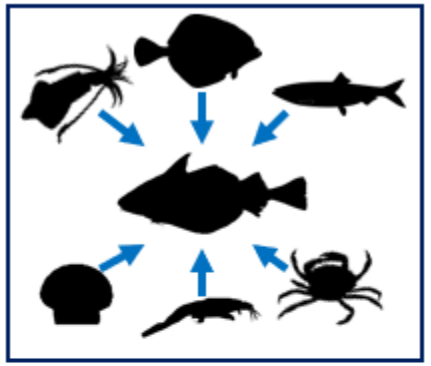
Mean Trophic Level (MTL2):

Mean trophic level of the network's groups.



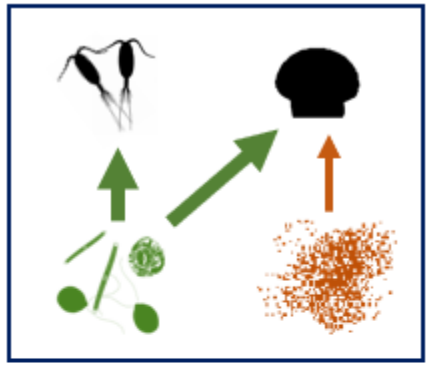
Finn Cycling Index (FCI):

Fraction of recycled energy (Finn, 1980).



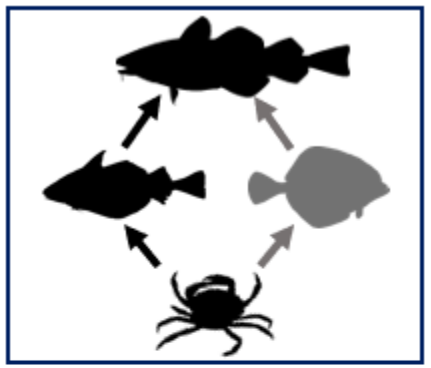
System Omnivory Index (SOI):

Level of omnivory of the system (Libralato, 2013).



Detritivory on Herbivory (D/H):

The ratio of Detritivory over Herbivory.



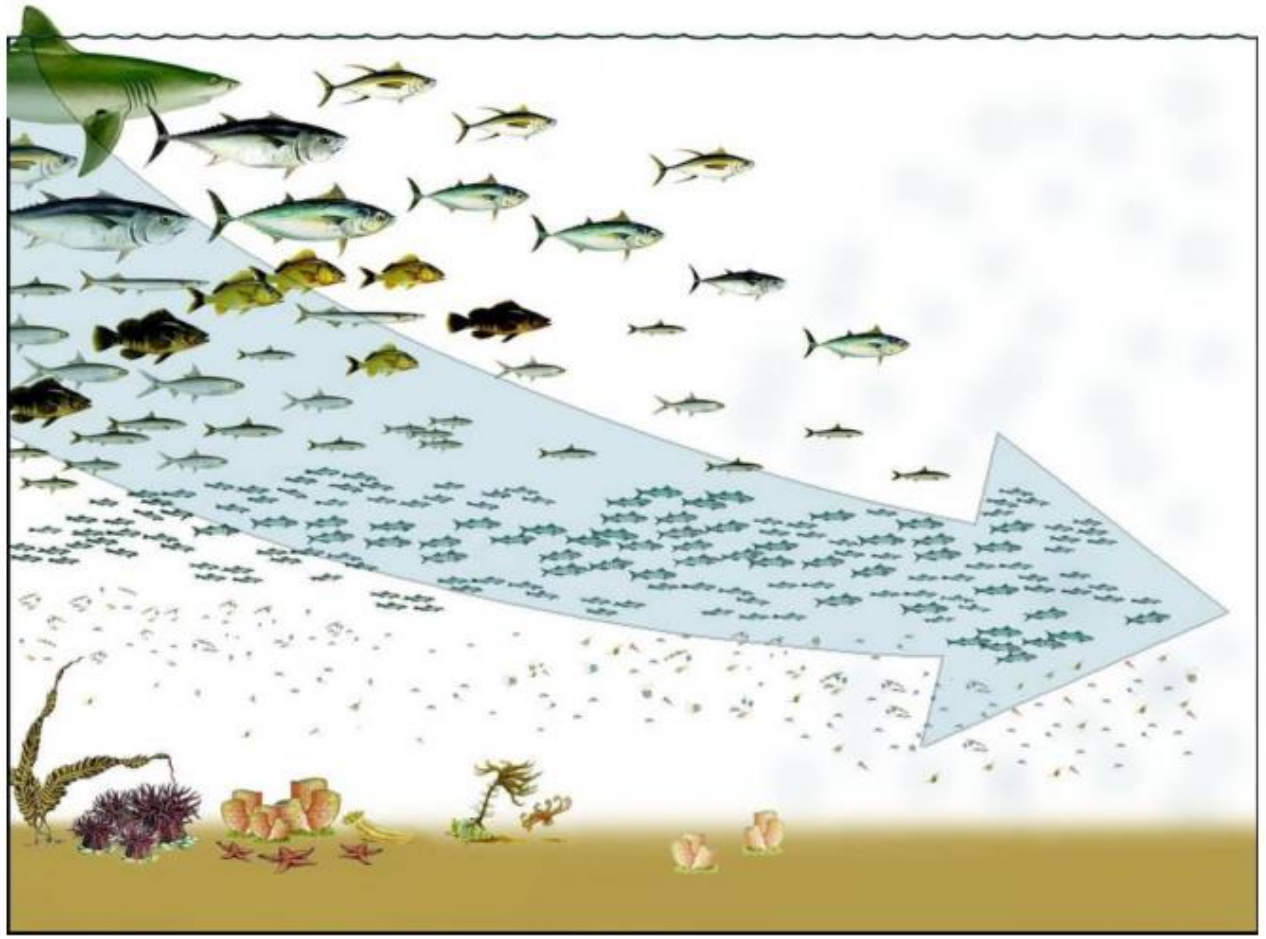
Relative flow redundancy (R/DC):

Redundancy of the flows in the system (Ulanowicz and Norden, 1990).

Functioning and organization → **Ecological resilience Ecological theories** → **Candidate indicators of ecosystem health**

Safi G et al. 2019. Vitamine ENA: a framework for the development of ecosystem-based indicators for decision- makers. Ocean & Coastal Management

ENA indices, from theory to ecosystem health indicators



"Fishing Down the Food Webs" (Pauly et al., 1998)

Ecological paradigm
"fishing down the food web"

The mean trophic level
expected to decrease
in response to fishing.

⇒ MTL proposed as indicator of ecosystem's health

Pauly, et al. 1998, Science
Arroyo et al. 2019, ICES J Mar Science

ENA indices, from theory to ecosystem health indicators

Marine Strategy Framework Directive / OSPAR - COBAM : expert groups created in December 2011

COBAM = Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring

Expert groups

Birds	Fish and cephalopods	Mammals and reptiles	Benthic habitats	Pelagic habitats	Non-indig. species	Food Webs

Lead 2011-2016
Nathalie Niquil / Isabelle Rombouts / Georges Safi
Present lead Ulrike Schückel

Functional indicators
(based on fluxes)
Holistic indicators
(everybody in)

ENA opens a window on research

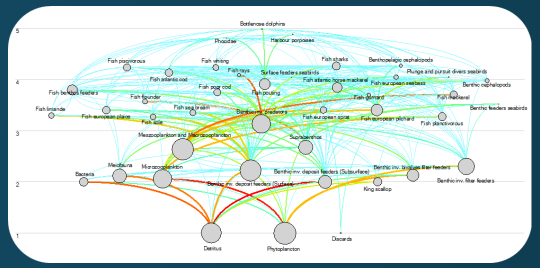
Rombouts et al. 2013, Ecological Indicators
Safi G et al. 2019, Ocean & Coastal Management

ENA indices, from ecological theories to ecosystem health indicators

Ecological Network Analysis

Numerical indices
of emergent properties

The static way:
Ecopath => one ENA value



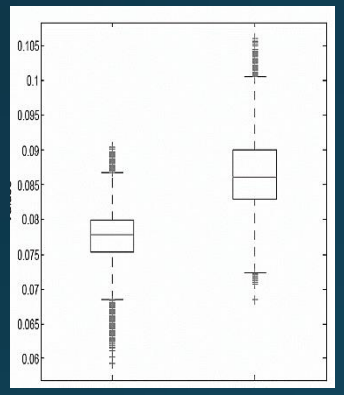
The statistical way:

LIM-MCMC => ENA

Mathematical optimization

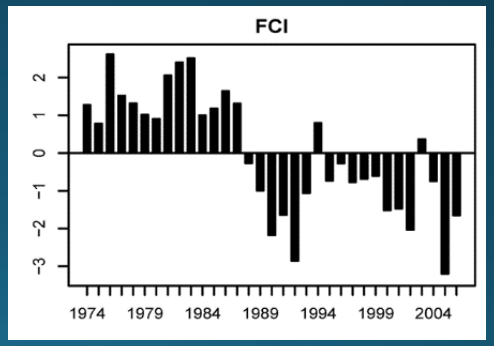
Statistical comparisons

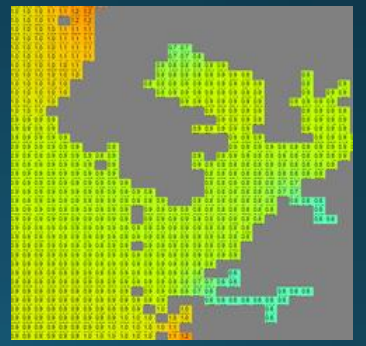
(Cliff's delta)



FCI (recycling)

The dynamic and spatial way:
Ecosim / Ecospace => ENA time series and maps





Applications to study **impacts**

A new rapid R library samplelim

Article Girardin et al. 2024, at https://hal.science/hal-04455831

Code: https://github.com/pregnault/samplelim

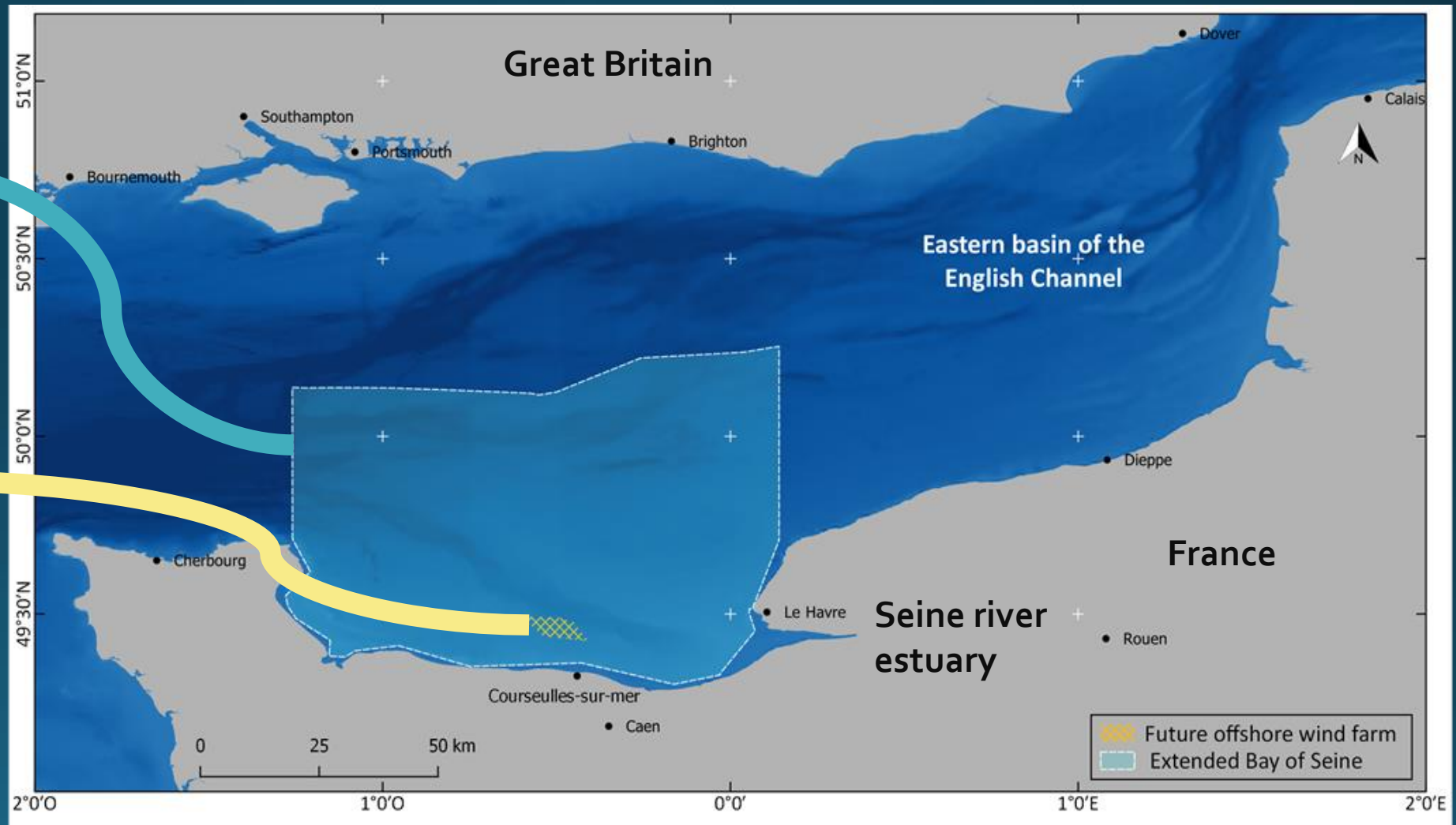
The offshore wind farm project of the Baie de Seine

Extended Baie de Seine:

Ecopath
Ecosim 2000 – 2015
Ecospace
Present vs
OWF after 30 years

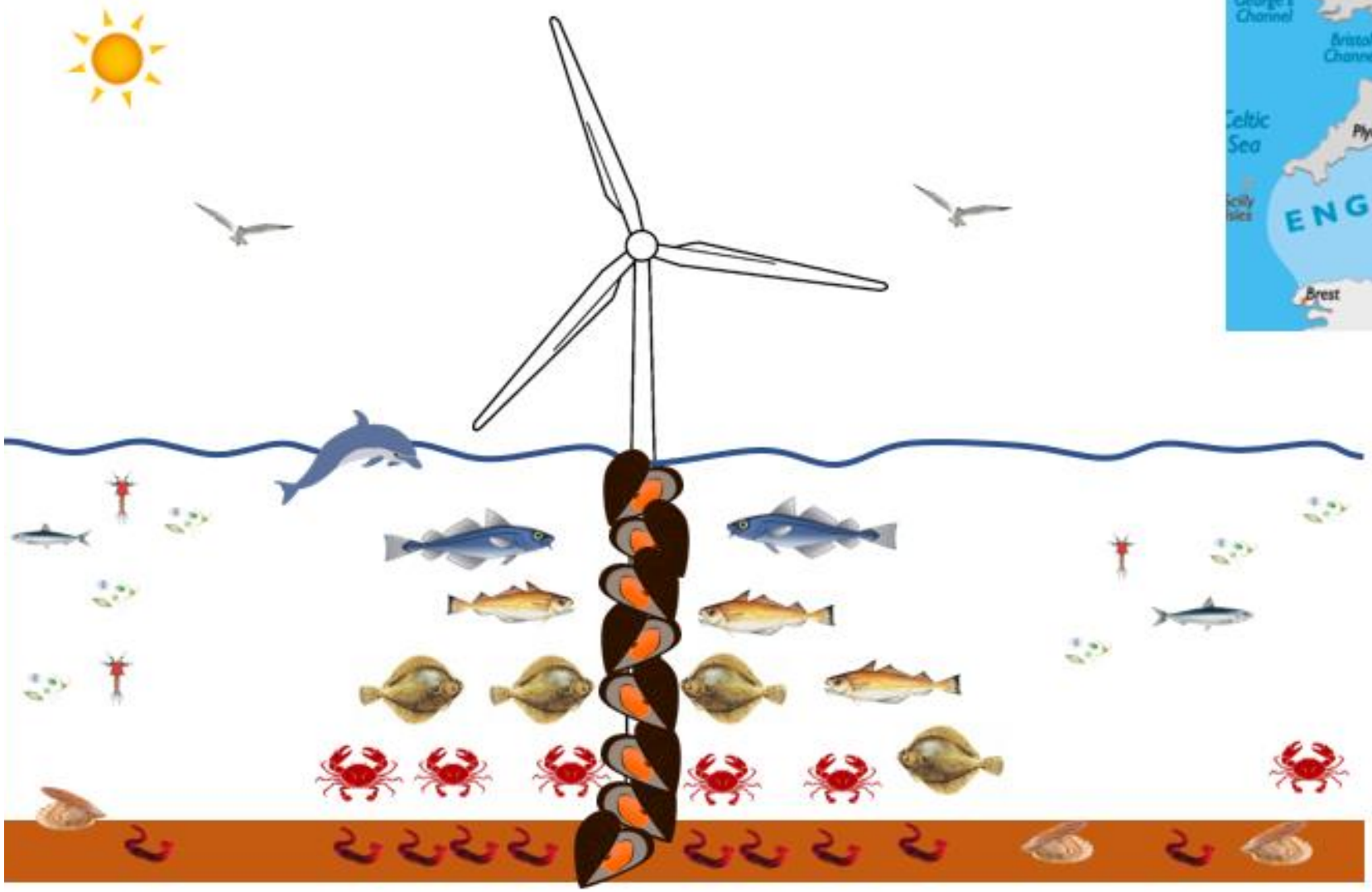
Offshore wind farm:

LIM-MCMC
Present vs
OWF after 30 years



Halouani et al. 2021, J Marine Systems
Nogues et al. 2021, Ecol Indicators
Nogues et al. 2022, 2023 ICES JMS

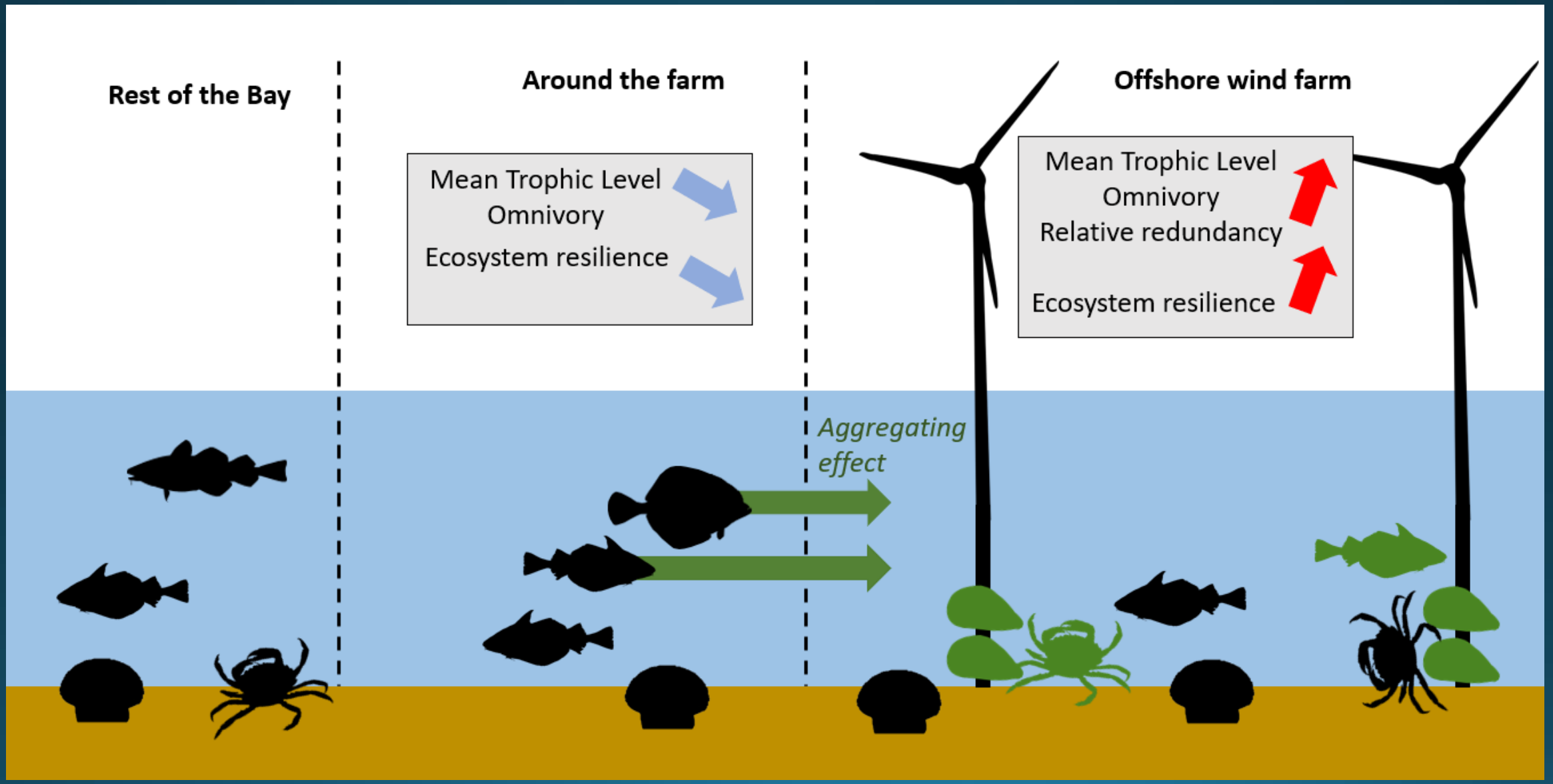
The offshore wind farm project of the Baie de Seine



Artificial reef effect

Baie of Seine

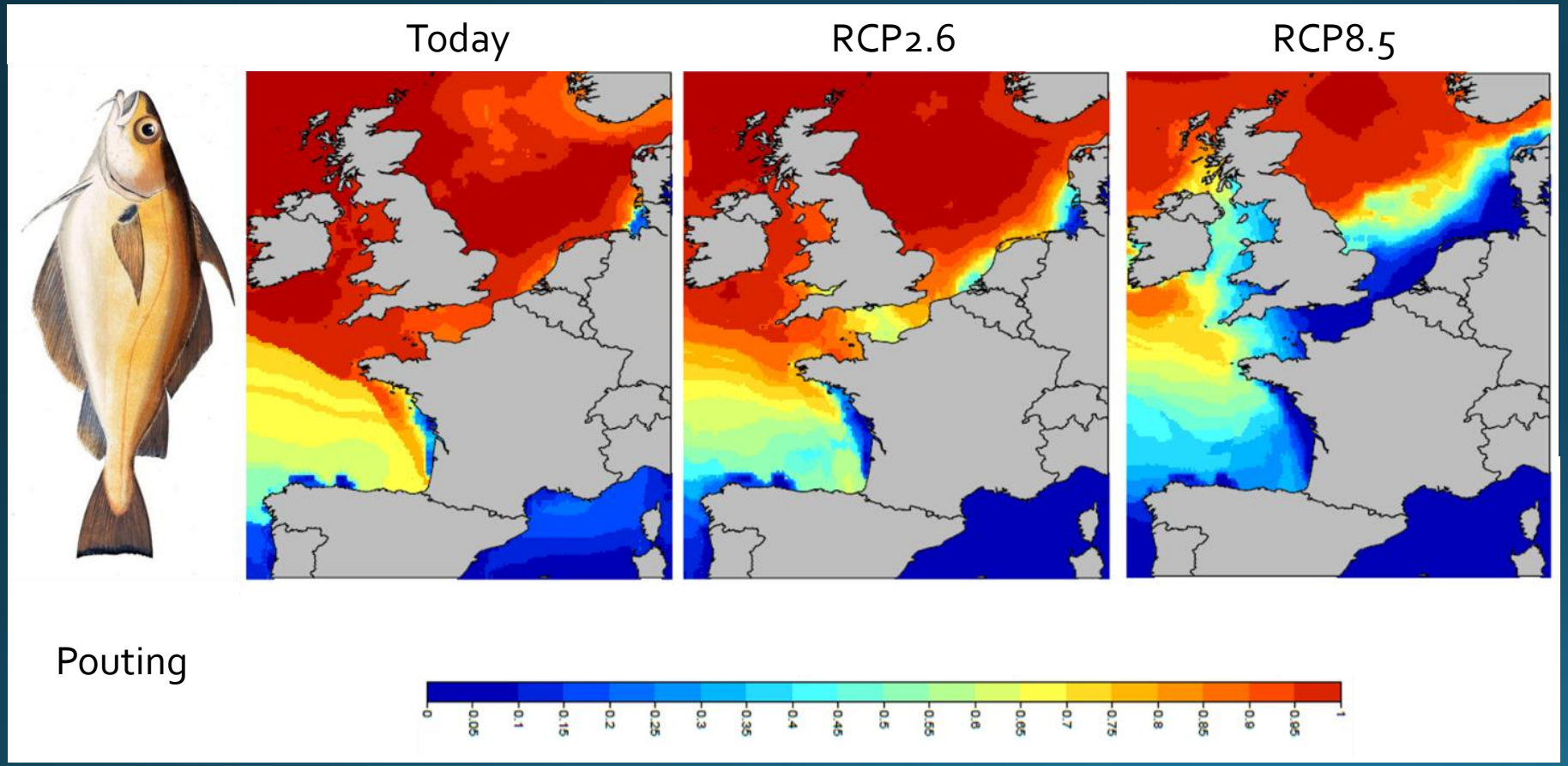
The offshore wind farm project of the Baie de Seine



Nogues et al. 2022, 2023, ICES JMS

Scenarios of climate change effects on species distribution

Species habitat suitability: niche modeling



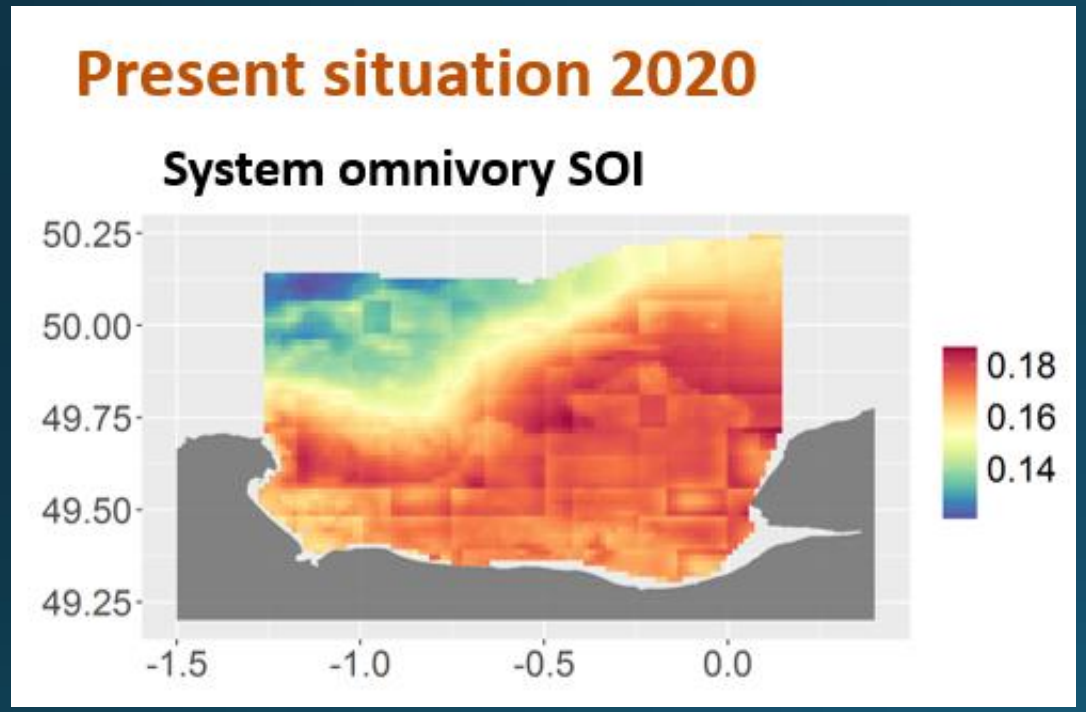
Correlative model:

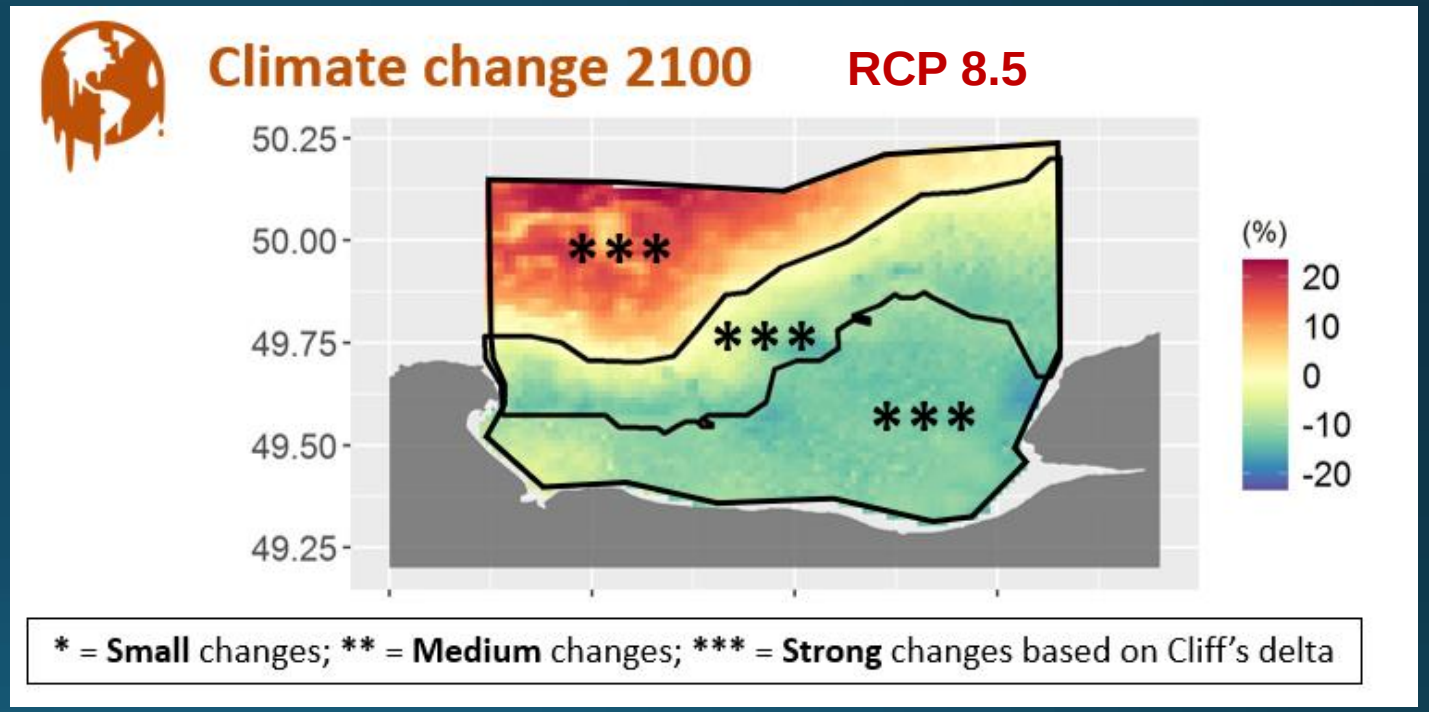
Species occurrence data
*
T° and Salinity projections according to IPCC scenarios

Changes in the habitat suitability estimated for 72 species

Ben Rais Lasram et al. 2020, Ecol Informatics
Nogues et al. 2021, Ecol Indicators; 2022, 2023, ICES JMS

Scenarios of climate change effects on species distribution

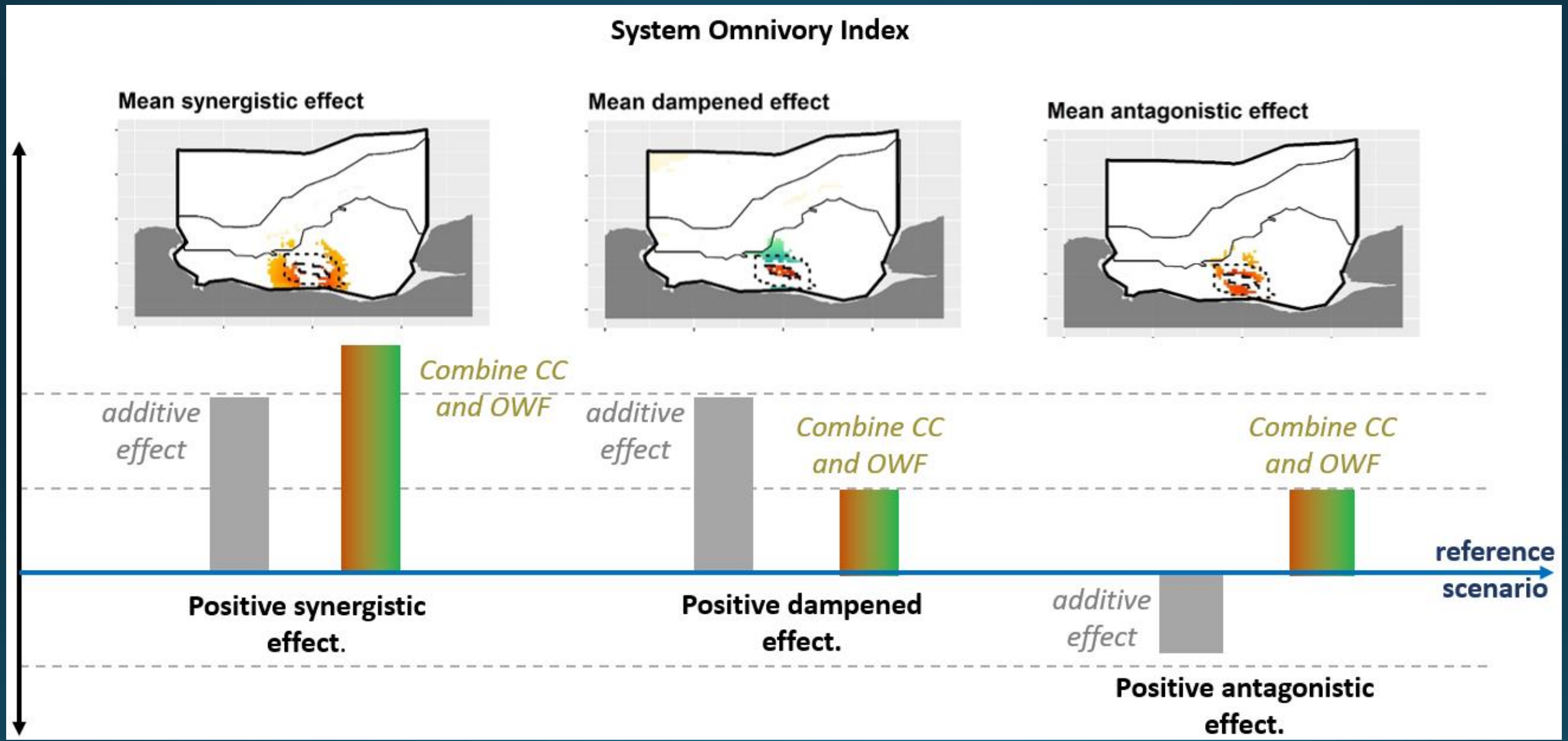




Significant change of all ENA indices

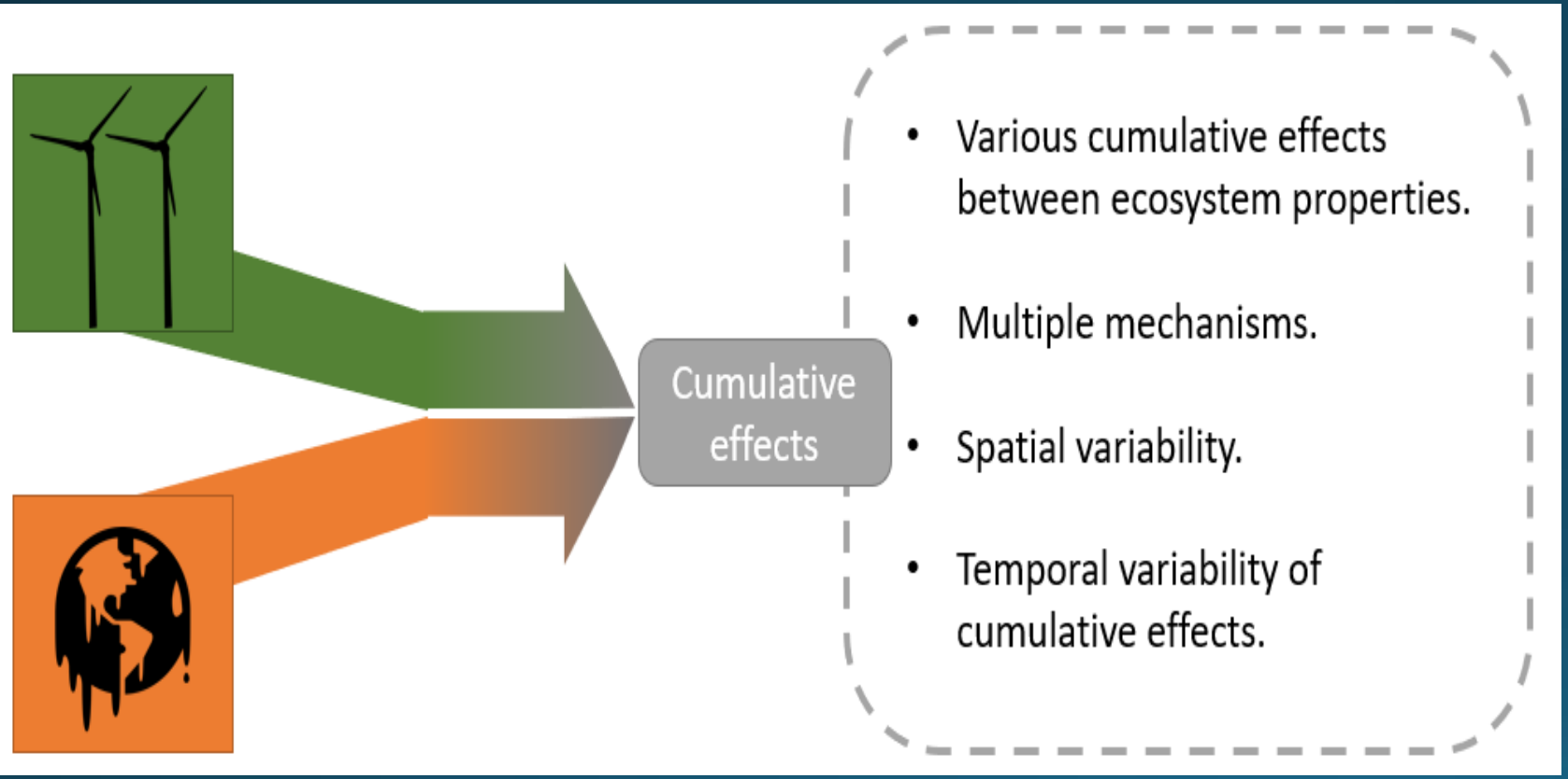
Nogués et al. 2022, ICES JMS

Cumulative effects of climate change and offshore wind farms



Nogues et al. 2023, ICES JMS

Cumulative effects of climate change and offshore wind farms: trophic networks



Application to ecosystem services
⇒ Regulation (redundancy)
⇒ Provisioning
⇒ Cultural

Attachment to the ecosystem under study ?

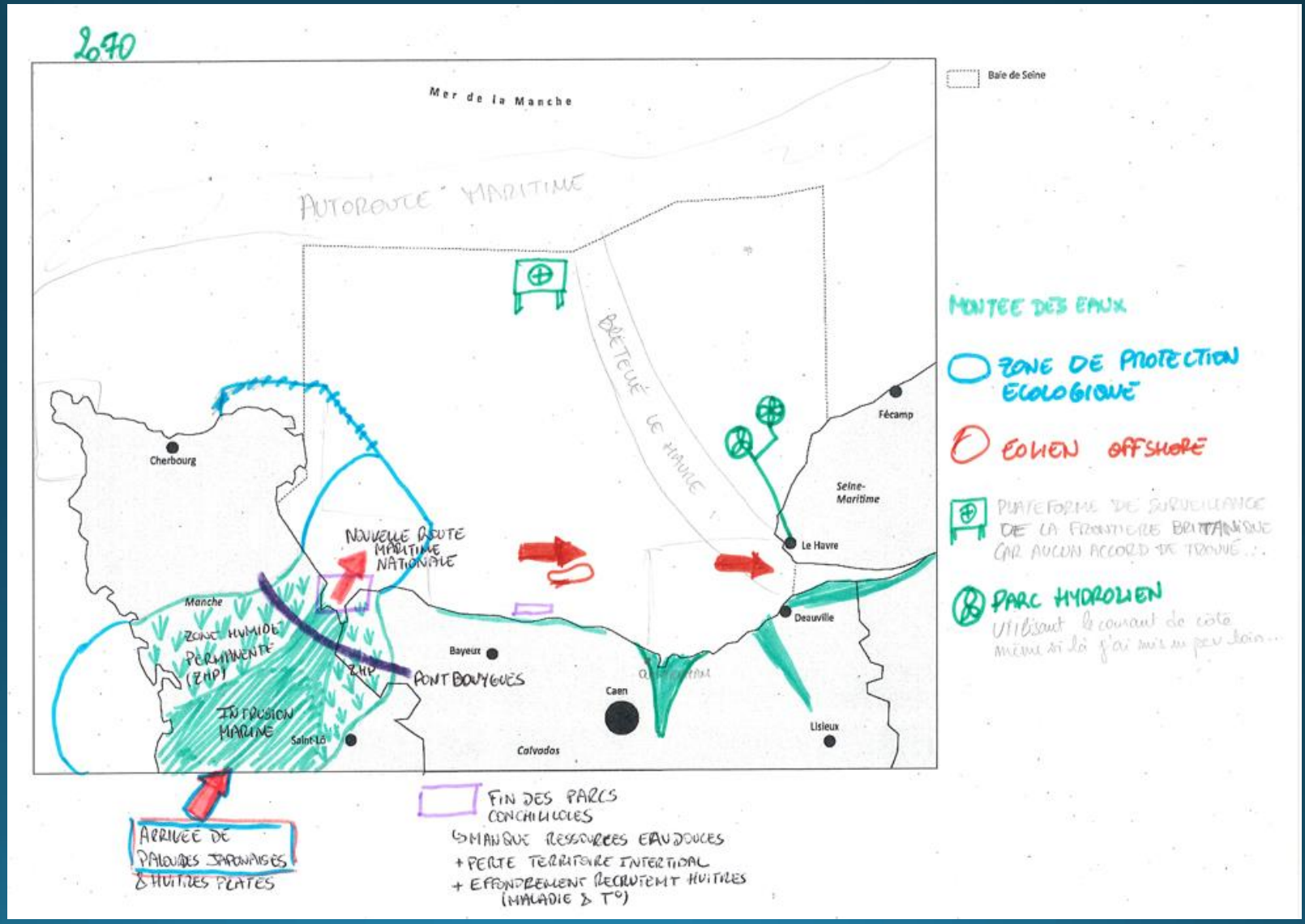
Participatory scenarios of the future

Nogues et al. 2022, 2023, ICES JMS; 2023, Ecosystem Services

Project Sensitroph (coordination Nathalie Niquil & Joanne Clavel)

From the shore to the sea: what sensitive detours for ecosystem models?

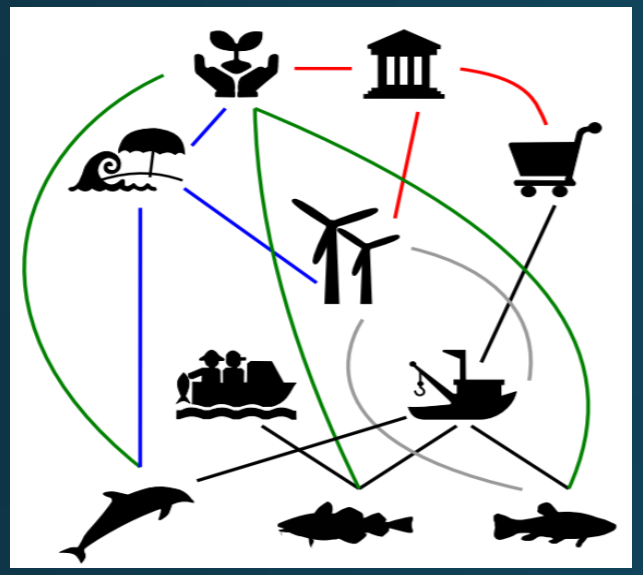
- Semi-structured interviews
- Observations
- Questionnaire (1500 responses)
  - Attachment
  - Perception of complexity
  - Dreams of sea…
- School: dancing the food-web
- Participative workshops
  - Writing workshop based on seashore promenades
  - Stories of the past and the future
  - Map drawing

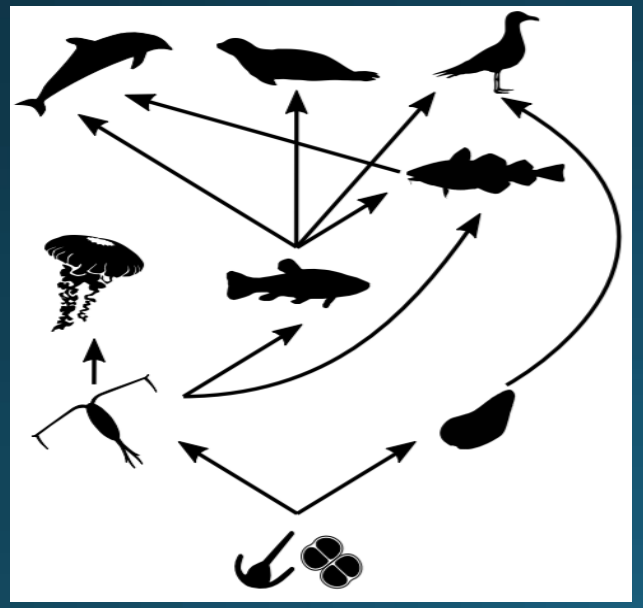


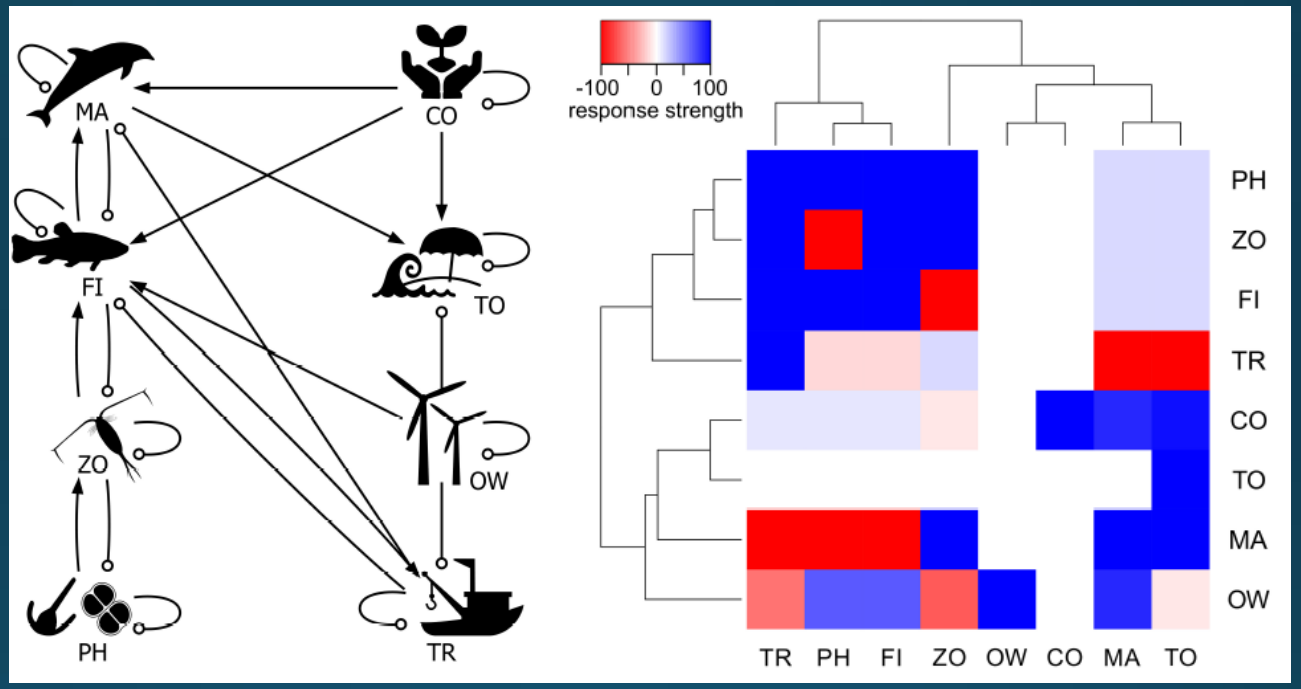
Cumulative effects of climate change and offshore wind farms: trophic networks

- Caution: purely trophic point of view
  => to be weighed against other impacts, e.g. noise, impacts, habitat changes
- Caution: a special site with a long history of human pressures
- Importance of spatial planning. Depending on the zone, do we want to preserve the original biodiversity or adopt a "gardener's attitude"? (Sato-Umi like)

Cumulative effects of climate change and offshore wind farms: SES networks







Loop analysis

Table of predictions, similarities, trade-offs…

⇒ Qualitative modelling (0 / +1 / -1)
⇒ Emergence of a new SES with offshore floating turbines in South Britany
⇒ More details at a coffee break

Positive influence →
Negative influence —●

Niquil et al. 2021, Frontiers EE; Thermes et al. in press, ICES JMS

Cumulative effects of climate change and offshore wind farms: SES networks

- To gather partners around a table / participatory modelling
- Press perturbations => generation of weighted predictions
- Quick testing of various management strategies
- Identification of compartments that behave in synchronous way
- and of antagonistic goals (trade-offs)
- Classification of press perturbations / similarities and potentially synergistic effects.

So what ?

Networks

Theories and paradigms

Local

Global

Cumulative scenarios

Other studies:
Benthic mesocosms
Physiological processes

Normandy

A huge local demand for participatory research

Scenarios of the future

Complexity well considered

How to adapt to change ?

How to use these scenarios
and knowledge ?

Japan

An ancient tradition of practices increasing coastal habitat diversity

"Sato-Umi" = management of coastal seas by local communities for high productivity while maintaining high biodiversity

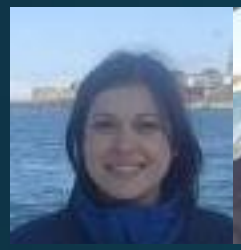
A research direction

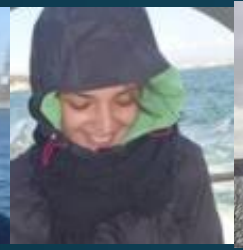
What is the transposability of Sato-Umi experiences to European ecosystems and local communities ?

How to combine modelled scenarios and action ?

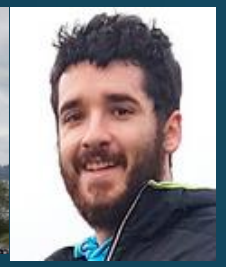
Komatsu, Yanagi (2015) Springer

Special "merci" to the young researchers who contributed to this work


Aurore Raoux


Emma Araignous


Rhoda Fofack-Garcia


Pierre Bourdaud


Quentin Noguès


Ghassen Halouani


Maud Thermes


Théo Grente

Tanka

de Kumagai Ryûko

菫野をどこまでもゆくこのさきは海でありしとうことは忘れて

Sumireno wo / doko made mo yuku / kono saki wa /

umi de ari shitô / koto wa wasurete

Le champ de violettes s'étend toujours,

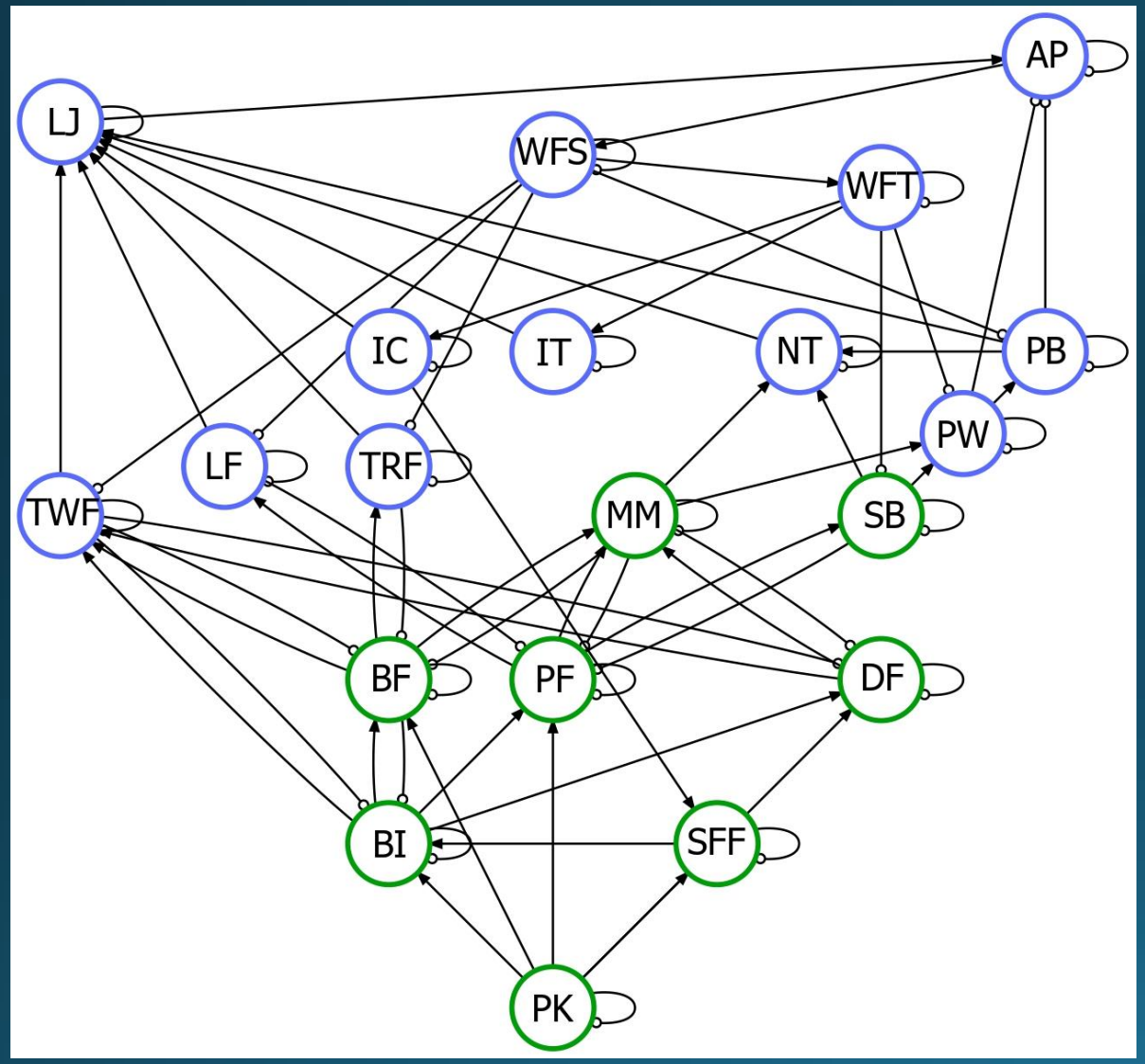
on en oublie que là devant c'est la mer, bien sûr

« As I walk through Tono,
I forget that the first step is the sea. »

Thank you !

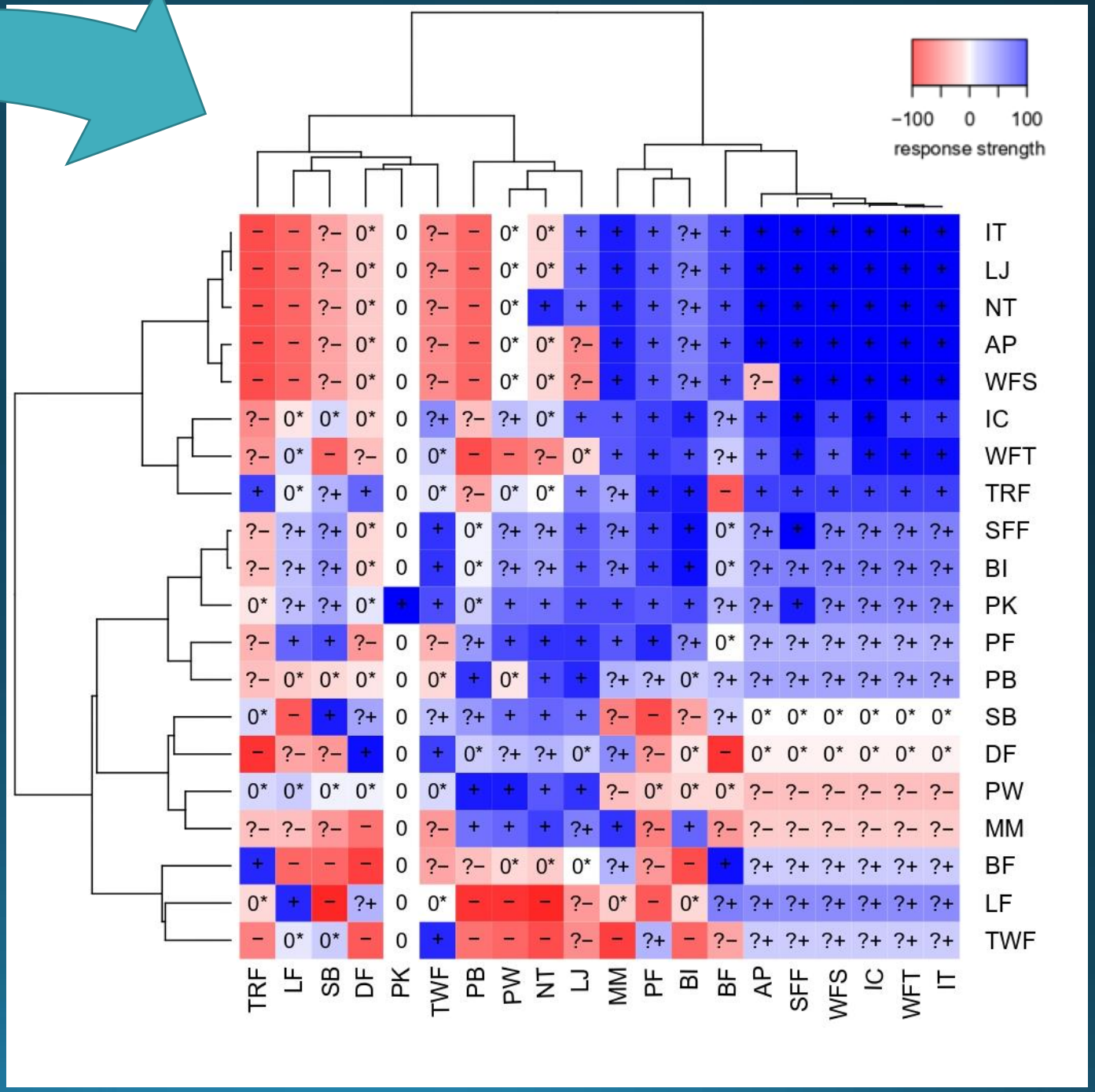
nathalie.niquil@unicaen.fr

Projects
ECAPRHA
TROPHIK
APPEAL
WINDSERV
NESTORE
SENSITROPH



WFS	WF surface
WFT	WF turbines
LJ	Local jobs
AP	Approval processes
IC	Infrastructures & cables
IT	Industrial tourism
NT	Nature tourism
PB	Pleasure boating
PW	Perceived wildness
TWF	Trawl fisheries
TRF	Trap fisheries
LF	Line fisheries
MM	Marine mammals
SB	Seabirds
BF	Benthic fishes
PF	Pelagic fishes
DF	Demersal fishes
BI	Benthic invertebrates
SFF	Sessile filter feeders
PK	Plankton

Thermes et al. in press, ICES JMS



Thermes et al. in press, ICES JMS