An intermediate complexity food web model to explore fisheries management scenarios under climate change

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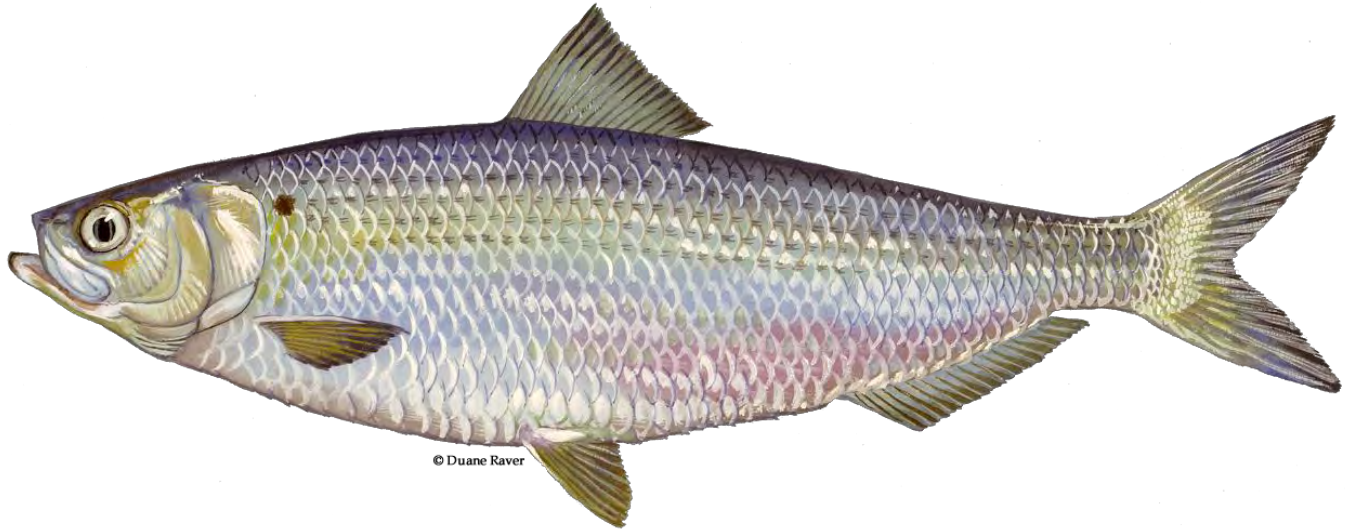
Ifremer

Session 12: Scenarios and models to explore the future of marine coupled human-natural systems under climate change

Scenarios and models to explore the future of marine coupled human-natural systems under climate change

Scenarios and models
to explore the future of
marine coupled
human-natural systems
under climate change

FISH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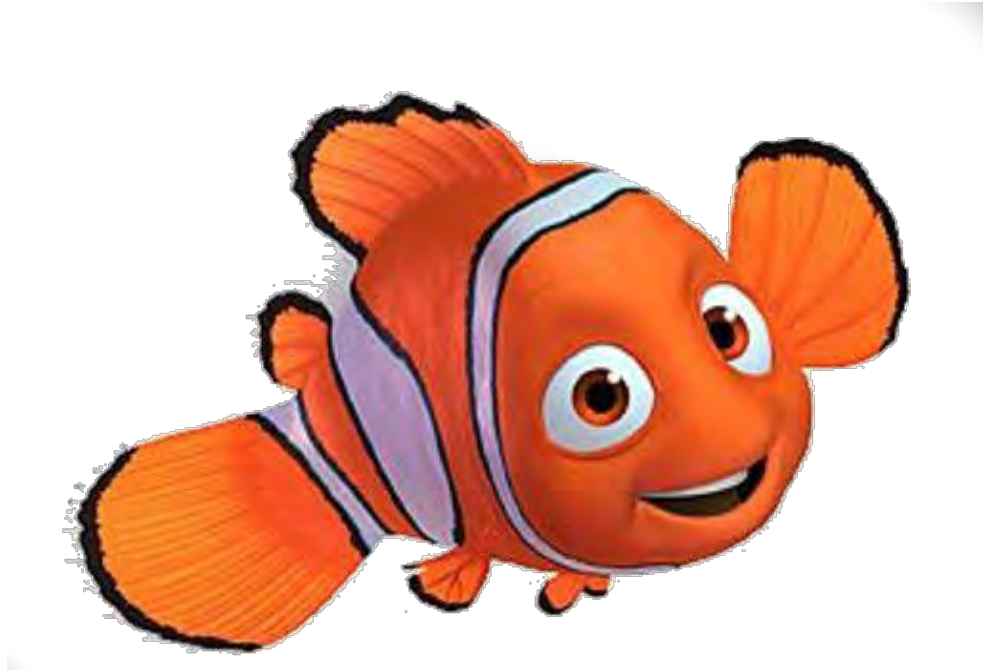
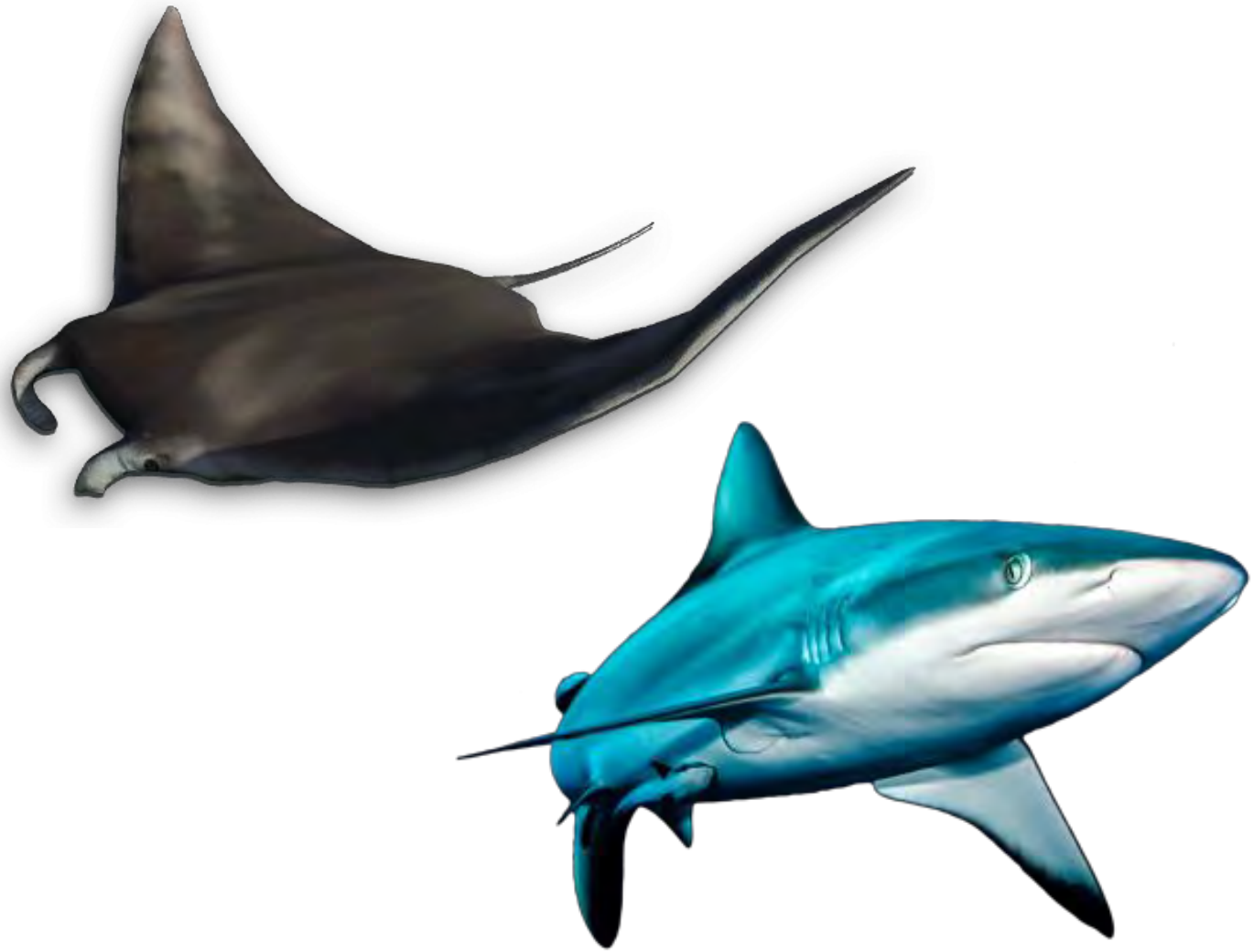
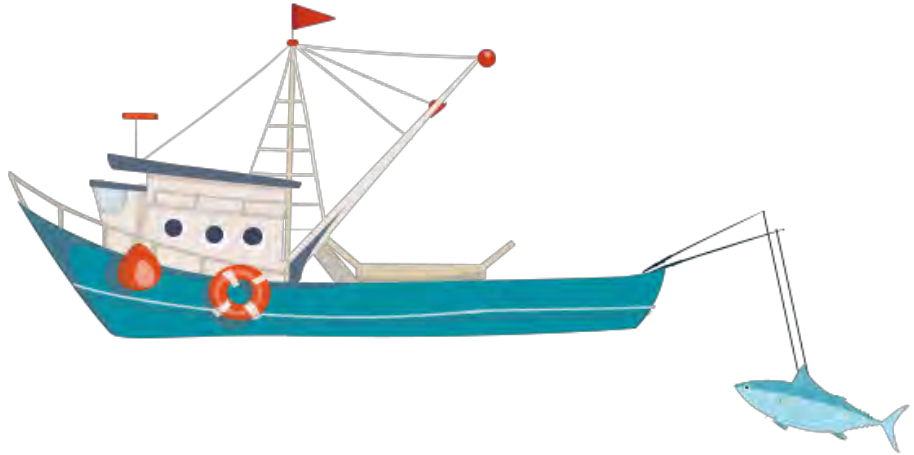
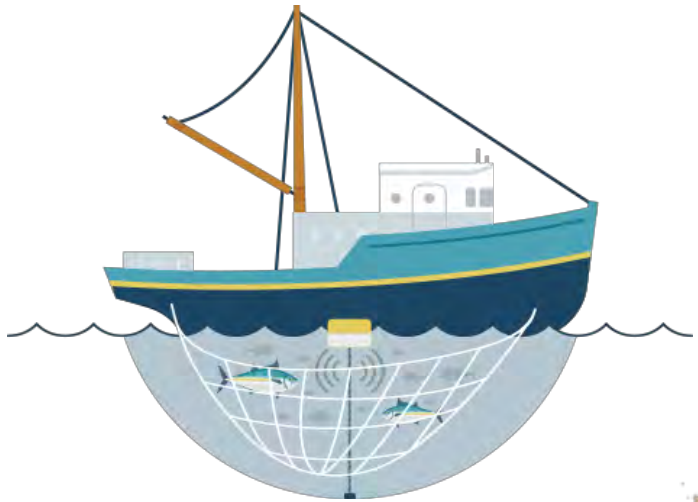


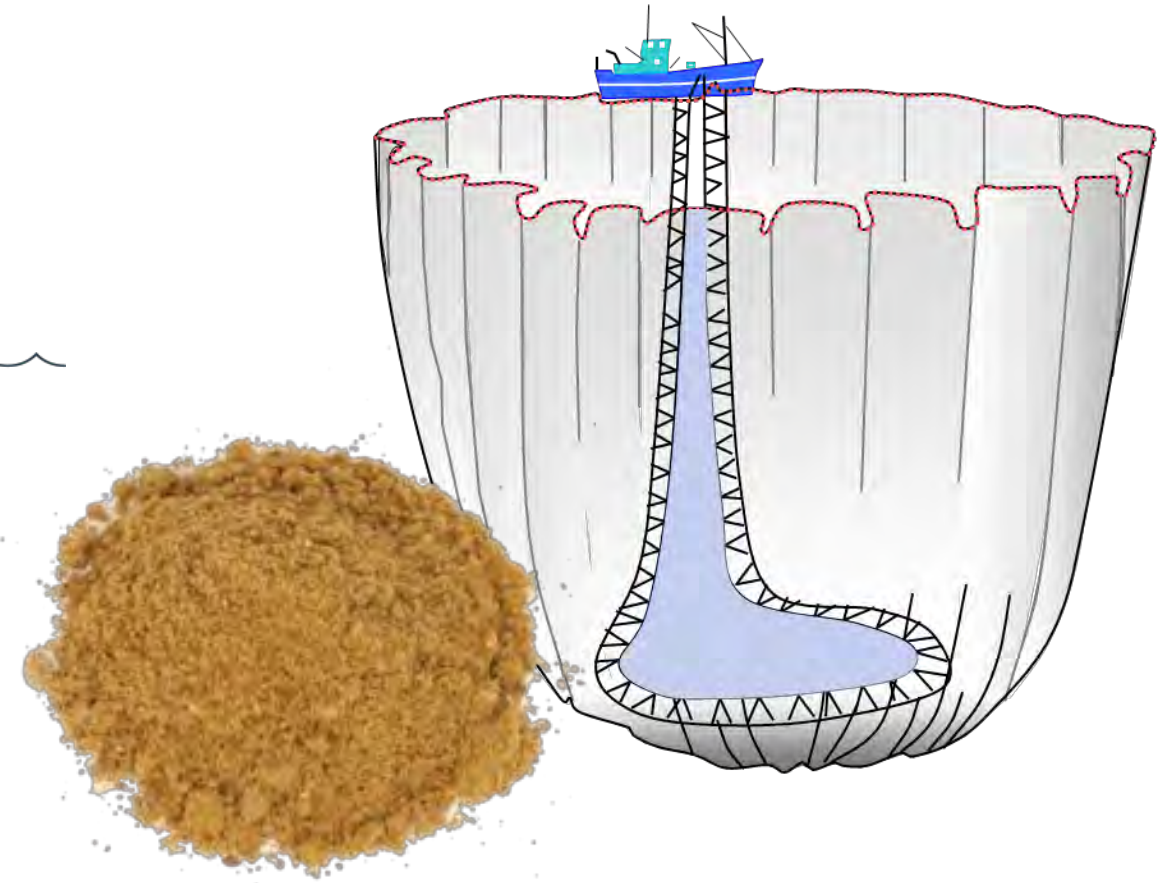

Sabores
PERUANOS




Wild Planet
WILD ALBACORE TUNA FILLETS
ORGANIC ROASTED CHICKEN BREAST
WILD SALMON
ALBACORE WILD TUNA
SKIPJACK WILD TUNA
WILD SARDINES
In Mariner's Sauce
WILD SARDINES
Skinless & Boneless Fillets in Extra Virgin Olive Oil
WILD SARDINES
In Extra Virgin Olive Oil Lightly Smoked
WILD MACKEREL
Skinless & Boneless Fillets in Extra Virgin Olive Oil







Human-natural systems are structured around complex social, economic and ecological interactions

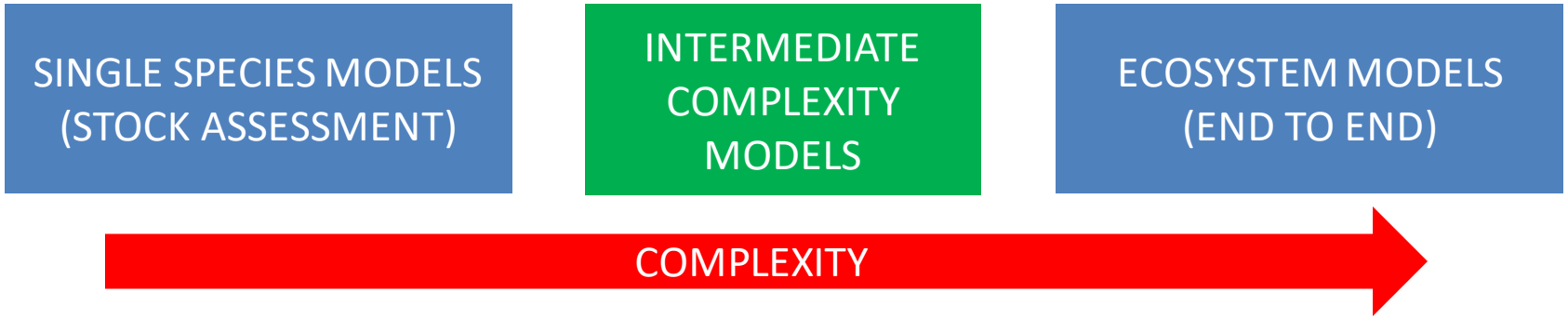
Climate change itself is related to complex socio-economic interactions

Marine ecosystems dynamics is too.

Introduction

Marine ecosystem models can be used for climate change impact studies.

Fishing scenarios are usually very simple (e.g. “business as usual”), mainly due to technical limitations.



- Simplified dynamics, focus on fisheries
- Formal parameter estimation (data driven)
- **Detailed management and fishing scenarios for tactical decisions (e.g TAC estimation)**

- Complex dynamics, focus on ecological interactions
- No formal parameter estimation (process driven)
- **Very simple fishing scenarios, improve understanding.**

Models of Intermediate Complexity for Ecosystem assessments (MICE)

DATA DRIVEN

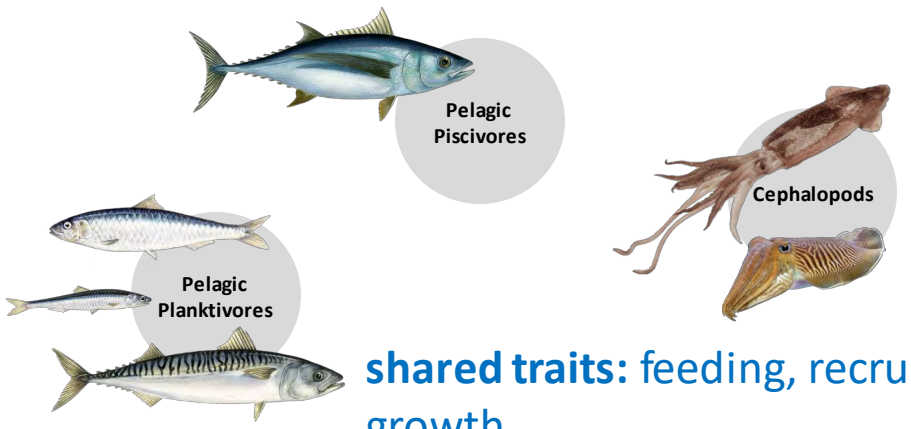
- Parameter estimation
- Fisheries data

FISHING SCENARIOS

- Tactical issues
- Complex fishing strategies

REDUCTION OF COMPLEXITY

- Question driven
- Only main ecological relationships
- Reduction of complexity: **Functional groups**

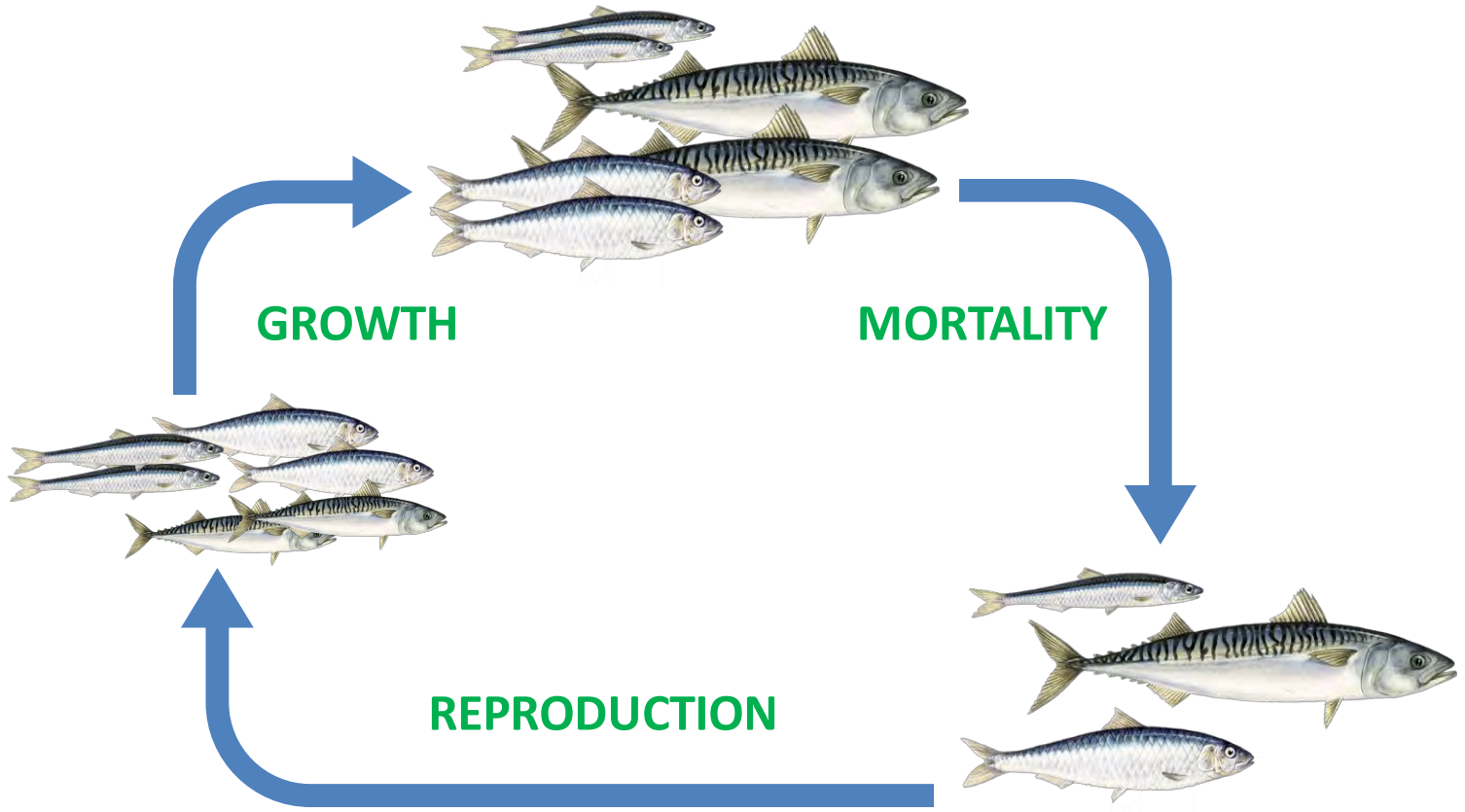


shared traits: feeding, recruitment, growth

OBJECTIVE:

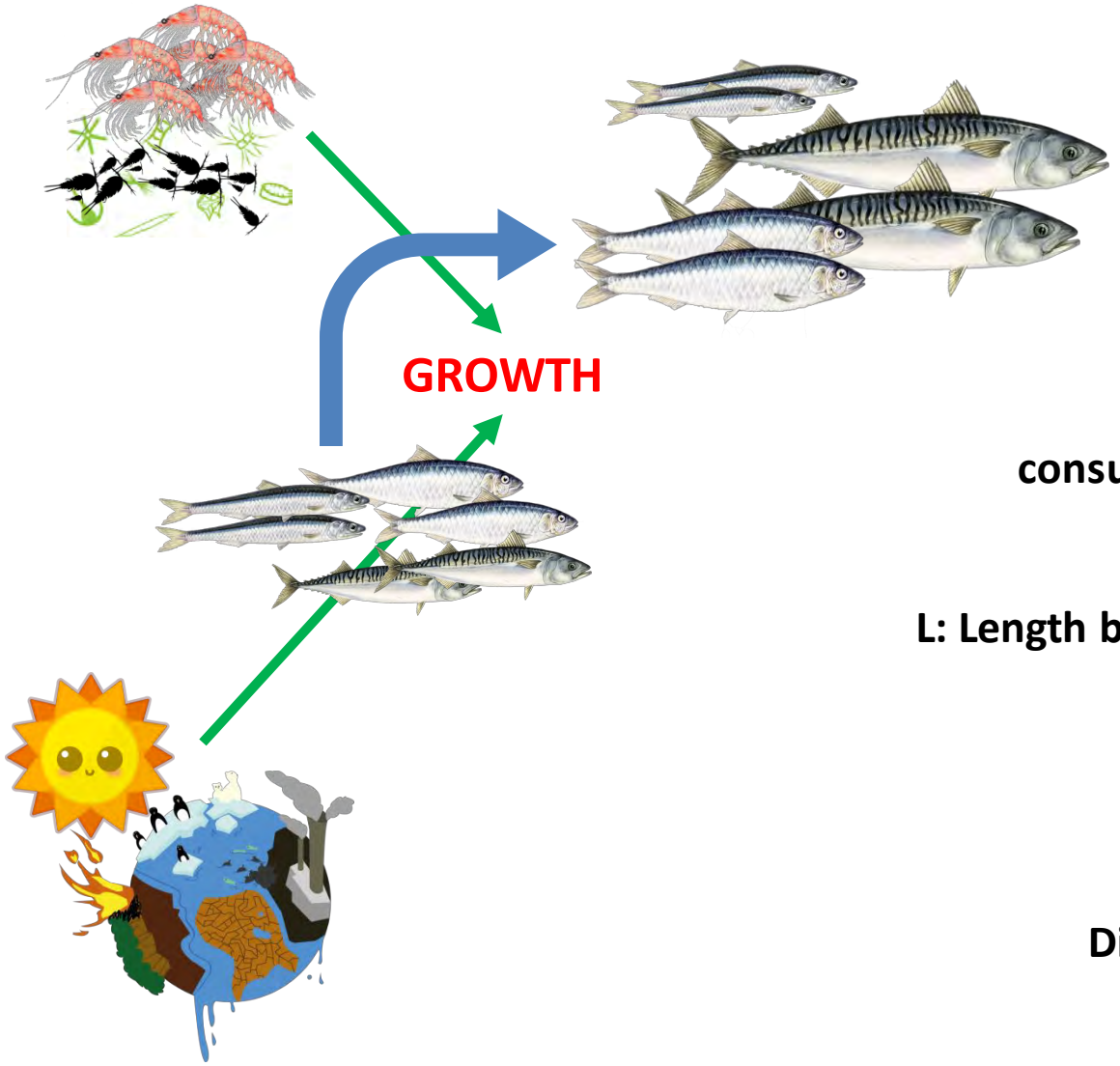
Develop a MICE to explore the links between functional groups, fleets and environmental variables

MICE model



- Age based dynamics (quarter time step)
- N: Abundance by functional group and age (state variable).

MICE model



Somatic growth depends on food consumption and environmental conditions.

L: Length by functional group and age (state variable).

Every cohort grows independently.

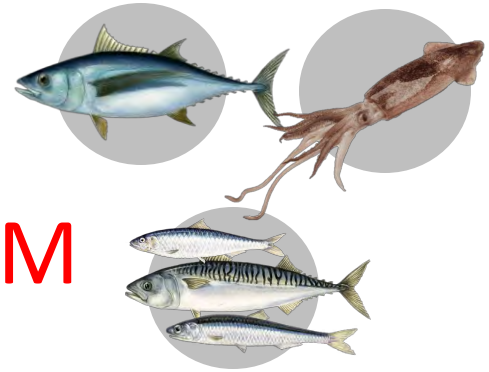
Different growth models are available (e.g. von Bertalanffy, exponential).

MICE model

Exponential survival model

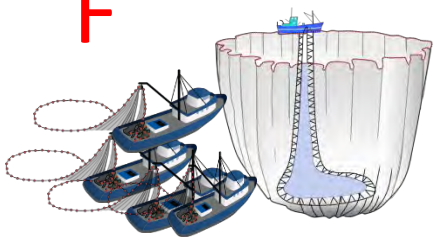
$$N_{s,a+1}(t+\Delta t) = N_{s,a}(t)\exp(-Z_{s,a}(t)\Delta t)$$

Z = M + F



M

F



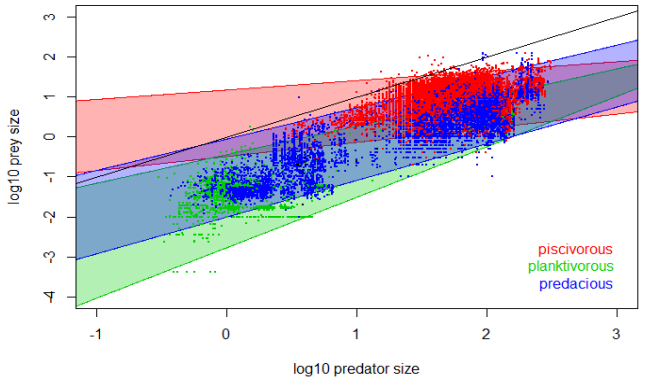
MORTALITY

Natural mortality is identified by taking into account predation from all accesible predators.

prey accesibility ~ f(size ratios, group traits)

empirical relationships using stomach content data (DAPSTOM, ICES, Barnes et al. 2008)

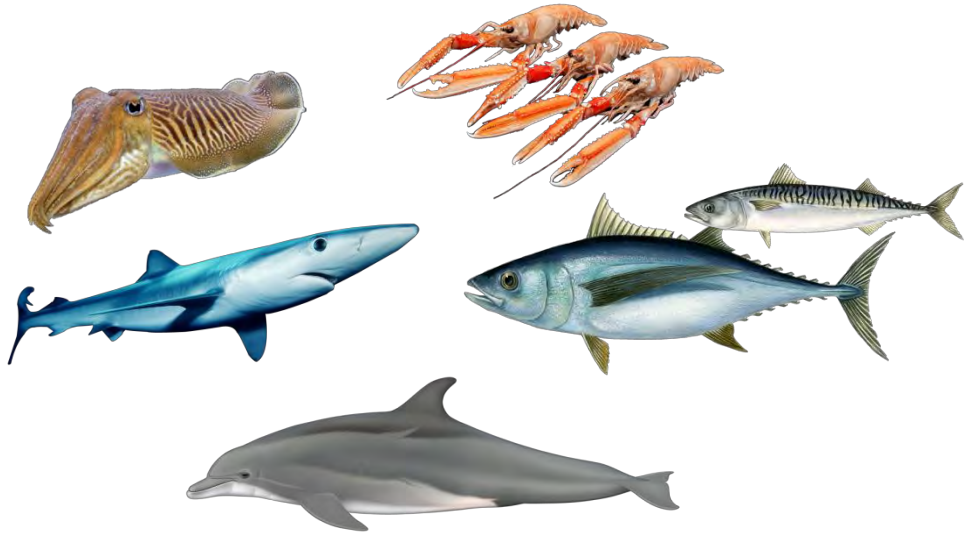
Multiple fleets targeting several function groups



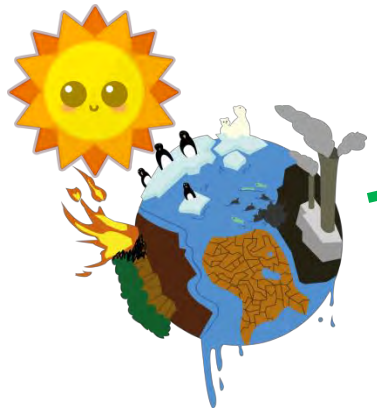
MICE model

Recruitment model

$N_{s,0}(t+\Delta t) = R(SSB_s(t), \textbf{ENVIRONMENT})$

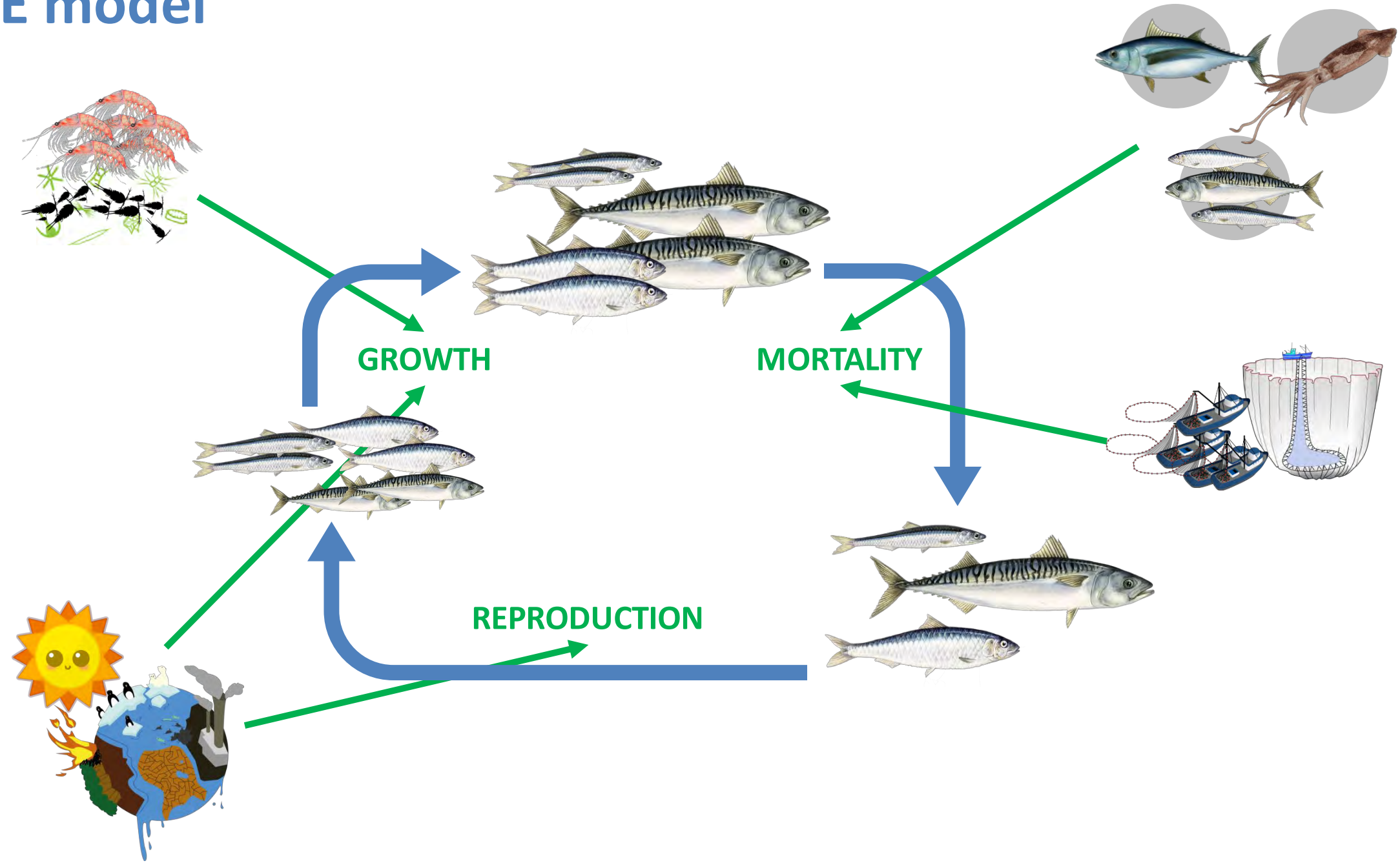


Different recruitment models to deal with several life histories

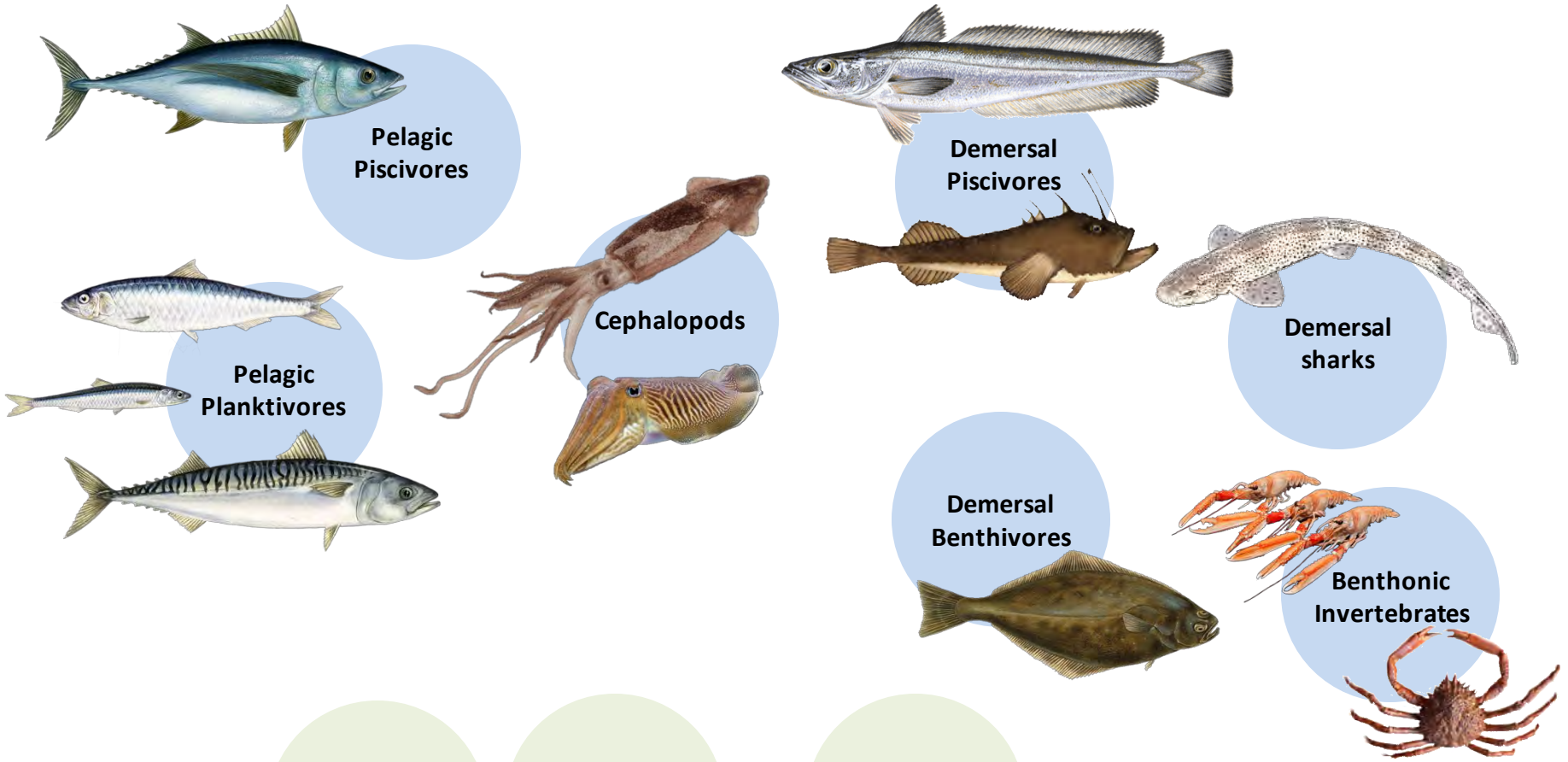


REPRODUCTION

MICE model



Case study: Bay of Biscay



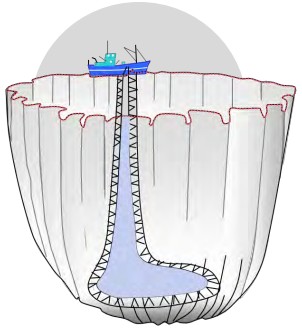
10 functional groups

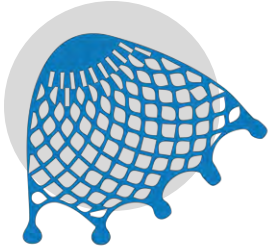
Case study: Bay of Biscay

Pelagic trawlers

Mixed trawlers

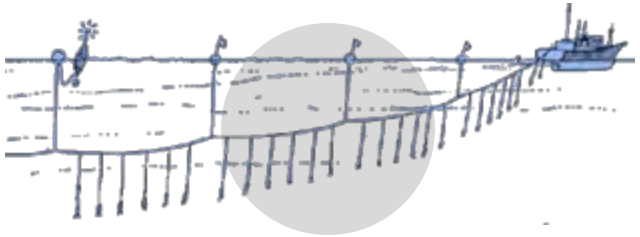
Purse seines

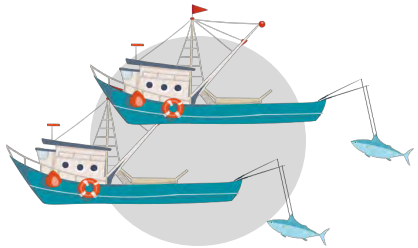




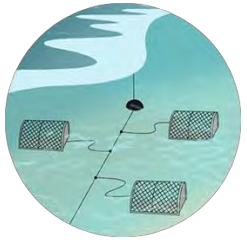
Nets

Hooks





Other gears

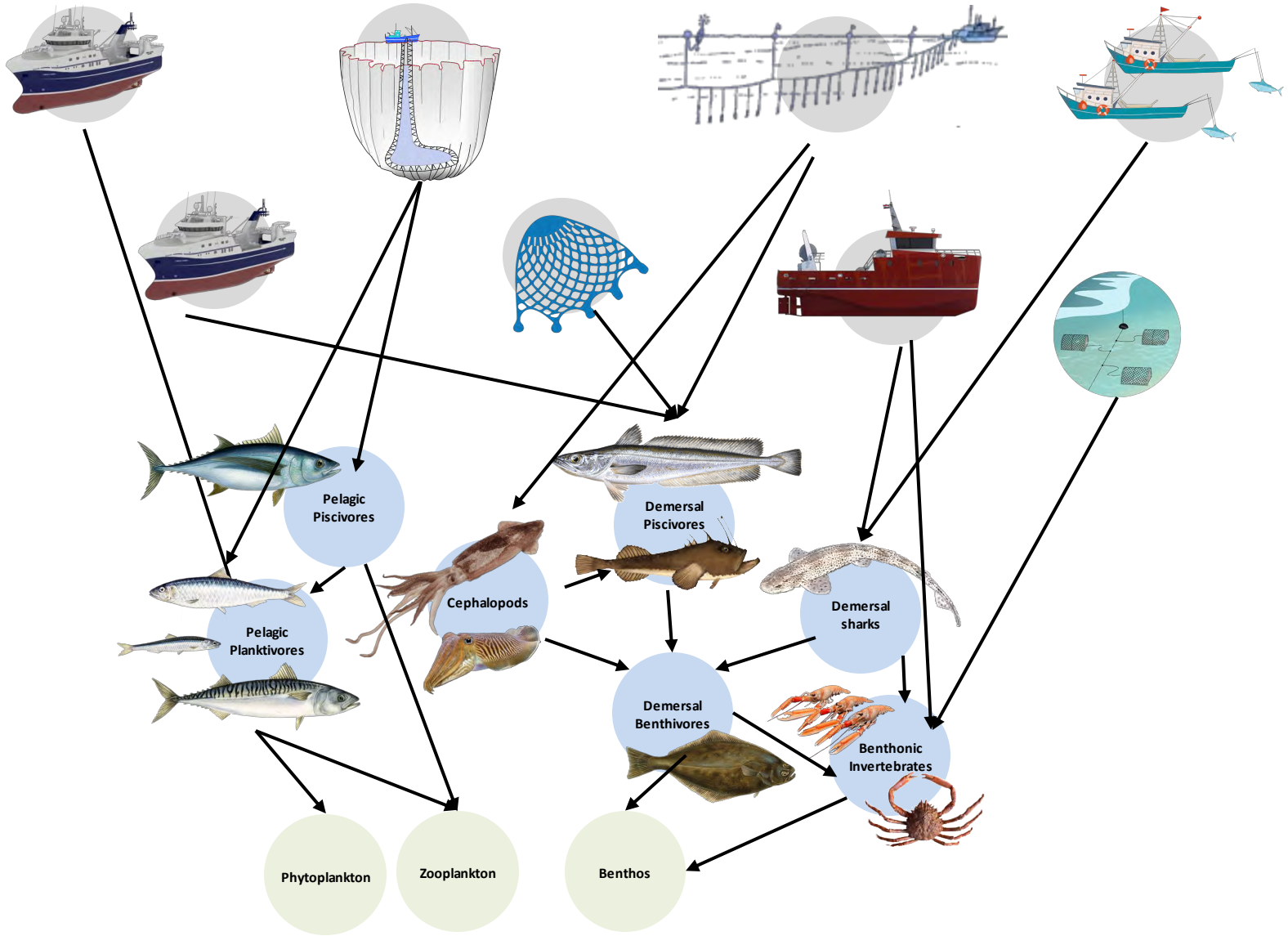


Pots

Dredges

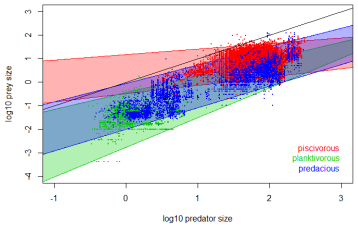
8 fleets

Case study: Bay of Biscay



Parameterization

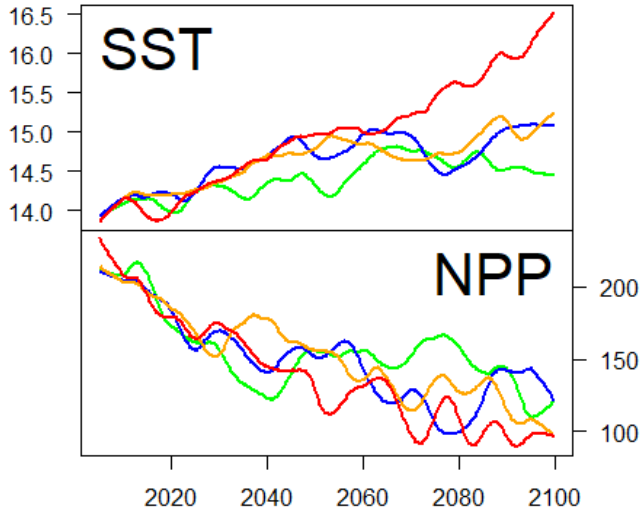
FishBase



R

Simulation experiments (1)

- Environmental scenarios (4): 4 RCPs CMIP5
- Fishing scenarios (2):
  - Statu quo
  - Zero fishing



IPSL-CM5A

Sciences de l'environnement

Institut Pierre Simon Laplace

RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

FISHERIES & MARINE ECOSYSTEM
FISH-MIP
MODEL INTERCOMPARISON PROJECT

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-209
Manuscript under review for journal Geosci. Model Dev.
Discussion started: 6 October 2017

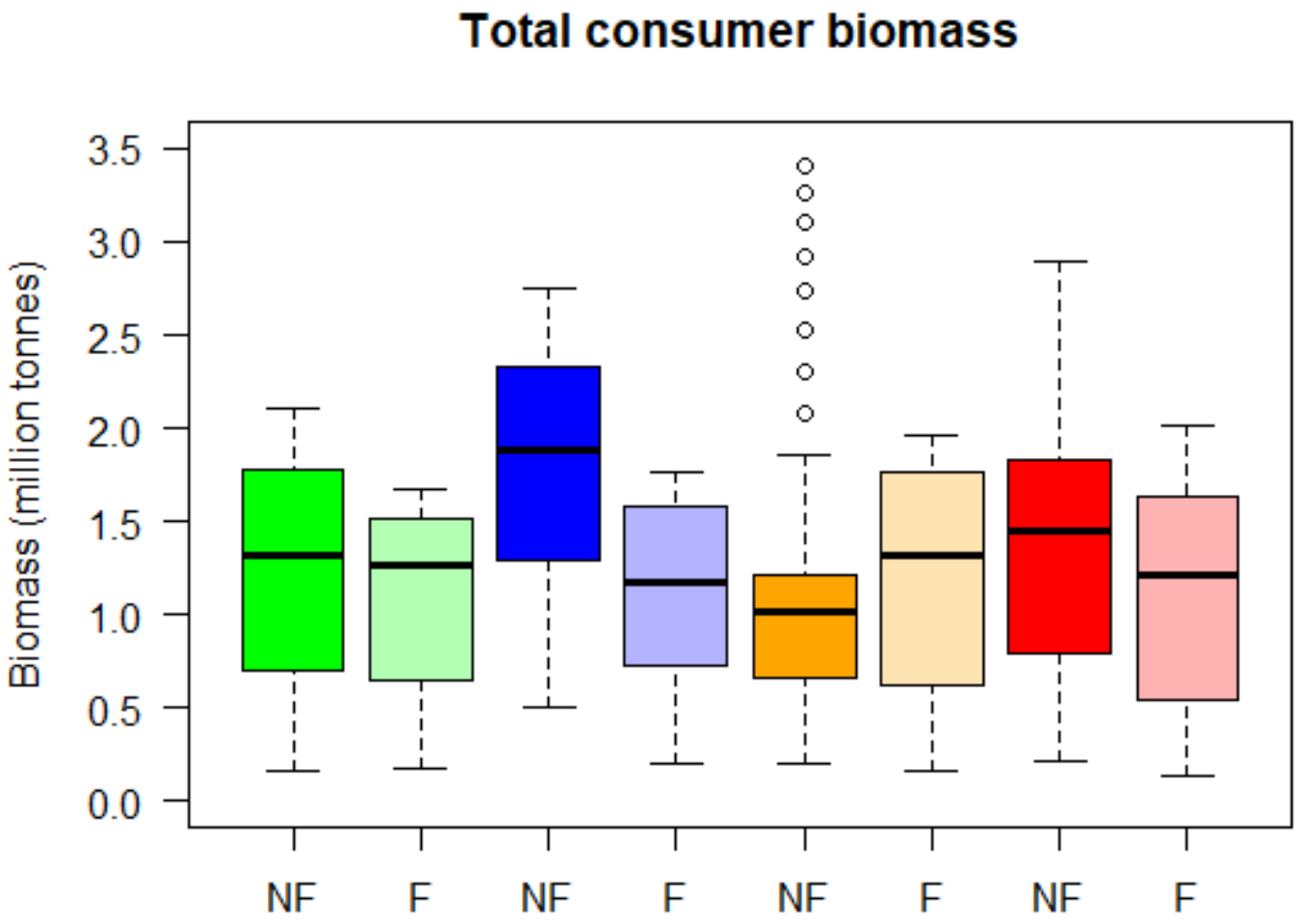
Geoscientific Model Development Discussions
EGU

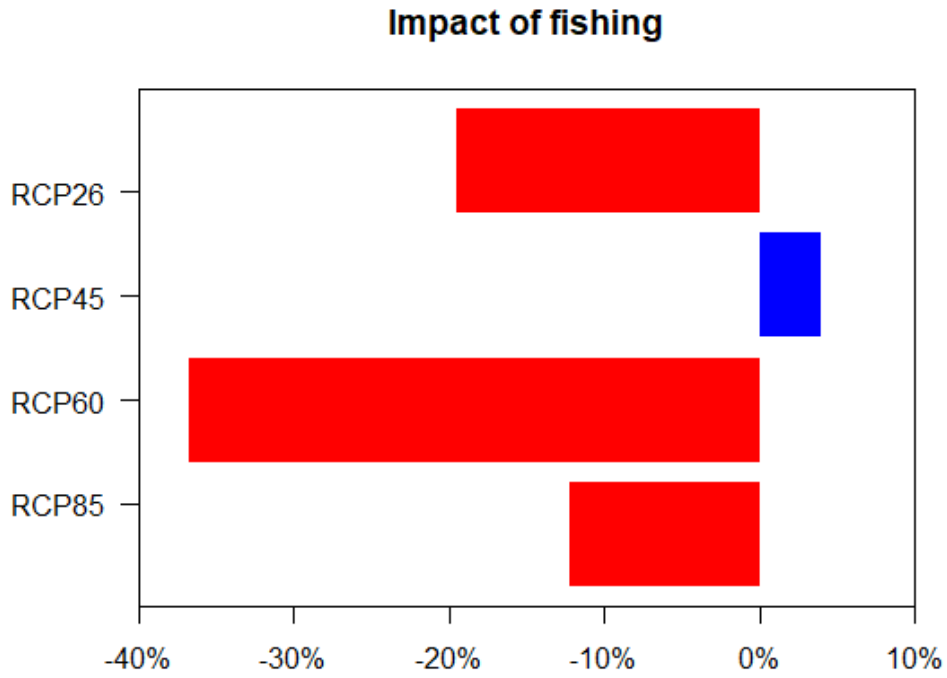
A protocol for the intercomparison of marine fishery and ecosystem models: Fish-MIP v1.0

Derek P. Tittensor[1,2], Tyler D. Eddy[2,3], Heike K. Lotze[2], Eric D. Galbraith[4,5], William Cheung[3], Manuel Barange[6,7], Julia L. Blanchard[8], Laurent Bopp[9], Andrea Bryndum-Buchholz[2], Matthias Büchner[10], Catherine Bulman[11], David A. Carozza[12], Villy Christensen[13], Marta Coll[14,15], John P. Dunne[16], Jose A. Fernandes[7,17], Elizabeth A. Fulton[11,18], Alistair J. Hobday[11,18], Veronika Huber[10], Simon Jennings[19,20,21], Miranda Jones[3], Patrick Lehodey[22], Jason S. Link[23], Steve Mackinson[19], Olivier Maury[24,25], Susa Niiranen[26], Ricardo Oliveros-Ramos[27], Tilla Roy[9,28], Jacob Schewe[10], Yunne-Jai Shin[25,29], Charles A. Stock[16], Philip J. Underwood[1], Jan Volkholz[10], James R. Watson[26], Nicola D. Walker[19]

Simulation experiments (1)

RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5



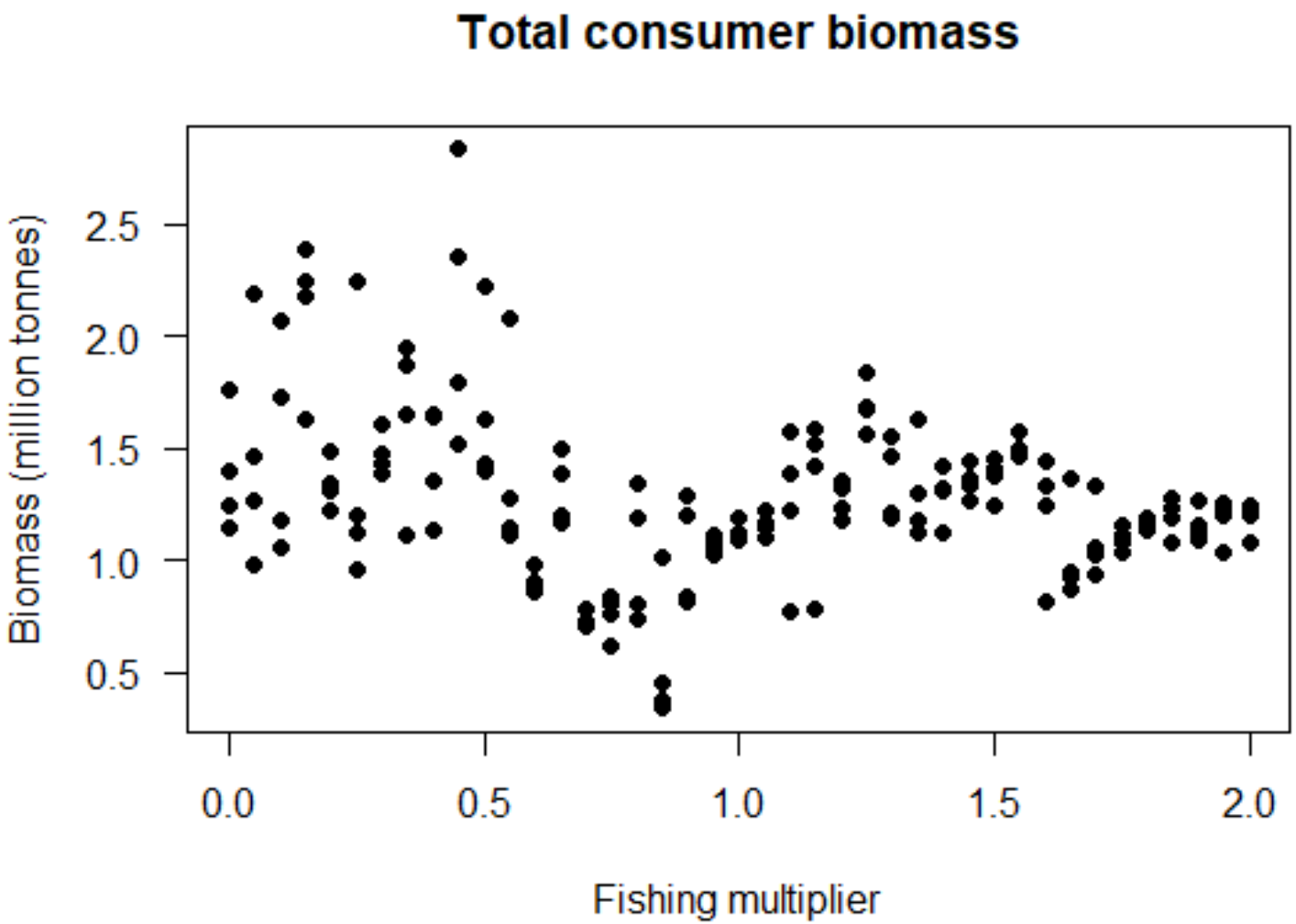


2080-2100

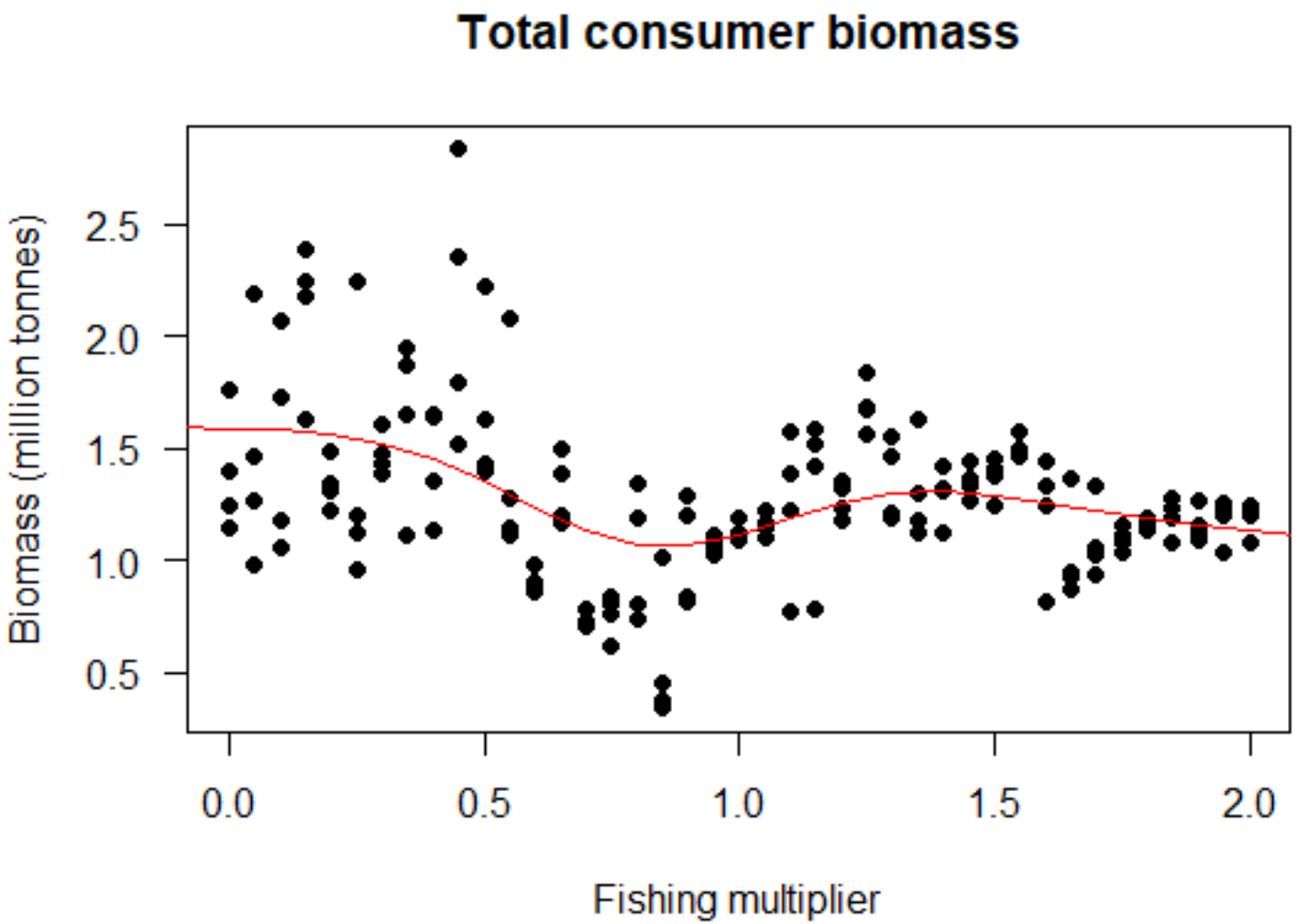
Simulation experiments (2)

- Environmental scenarios (4): 4 RCPs CMIP5
- Fishing scenarios (41):
  - Several multipliers of current effort distribution between fleets: from 0 to 2 in steps of 0.05.

Simulation experiments (2)

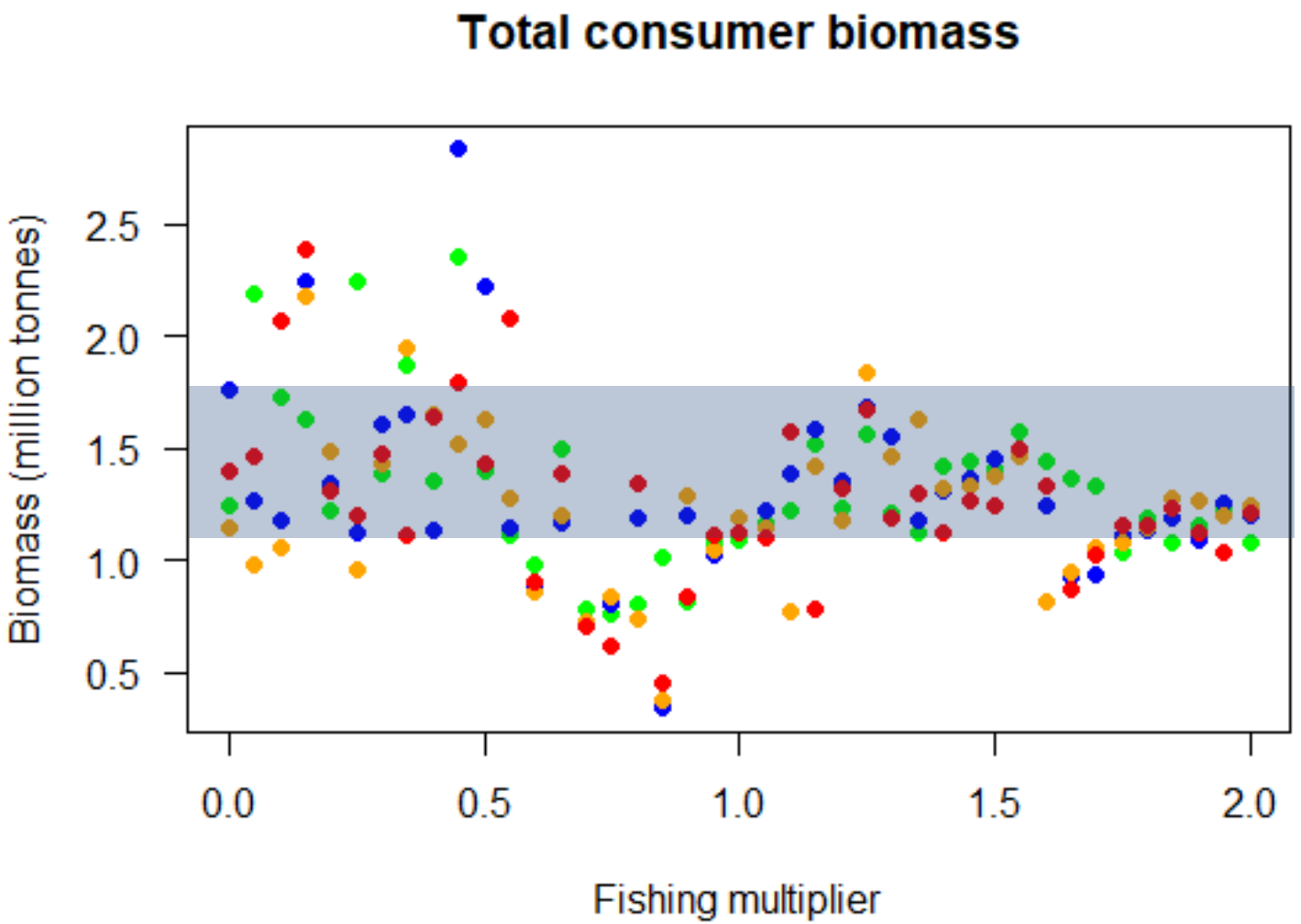


Simulation experiments (2)



Simulation experiments (2)

RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

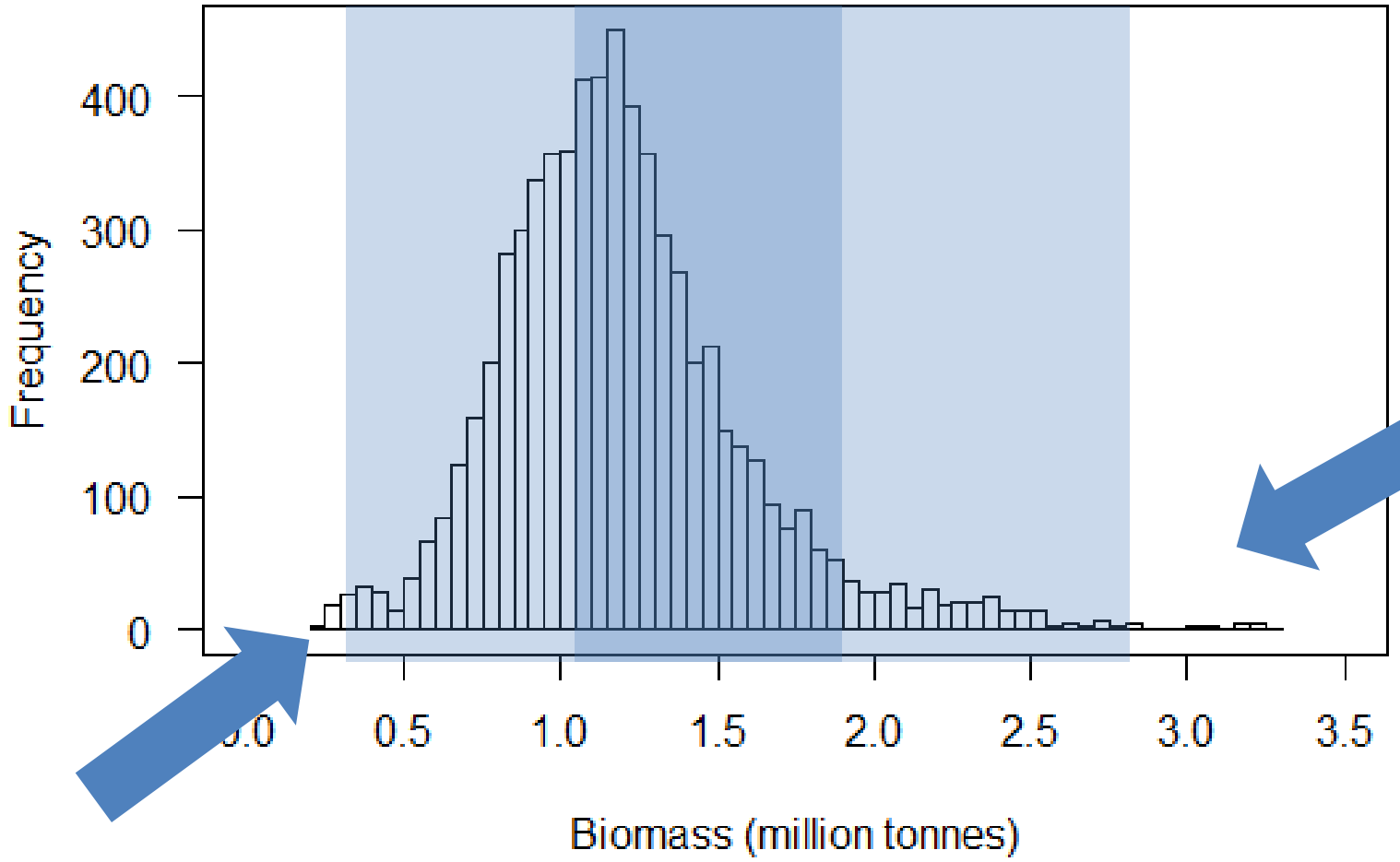


Previous range of variability (Experiment 1)

Simulation experiments (3)

- Environmental scenarios (4): 4 RCPs CMIP5
- Fishing scenarios (6561):
  - Each fleet is affected by three multipliers: 0 (closure), 0.75 or 1.25
  - All combinations are considered (3^8=6561)

Simulation experiments (3)



“GOOD” MANAGEMENT

“BAD” MANAGEMENT

IT’S NOT ONLY ABOUT FISHING LESS BUT FISHING DIFFERENT

Simulation experiments (4)

- Environmental scenarios (4): 4 RCPs CMIP5
- Fishing scenarios:
  - Dynamic allocation of effort
  - The probability of a vessel to remain in the same fleet is a function of the net rent of the fleet.
    - If net rent decreases, probability to change fleet increases. Transition matrix is updated every year.
    - Possible scenarios:
    - (i) total number of vessels remains fixed (no vessels leaves the system),
    - (ii) fleet dynamics, vessels enter and left the system.

Simulation experiments (4)

PERSPECTIVES

Conclusions

- No-fishing and business as usual may not cover the full range of variability related to fishing.
- Fishing less but fishing different: the importance to explore MANAGEMENT SCENARIOS (e.g. effort reallocation) as adaptation to climate change.

- Long term vs. Short term strategies
- Importance of developing fishing management scenarios for impact applications
- Strategies robust to climate change

Acknowledments

PRIME TRADEOFFS

CLIMATE CHANGE IS REAL AND CAUSED BY HUMANS

Thanks!

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