MareFrame

Scientific Conference
"Advances in Ecosystem-based Fisheries Management"

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This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

MareFrame

A Gadget multispecies model to explore the fisheries management implications of prey-predator interactions in the Strait of Sicily trawl fishery.

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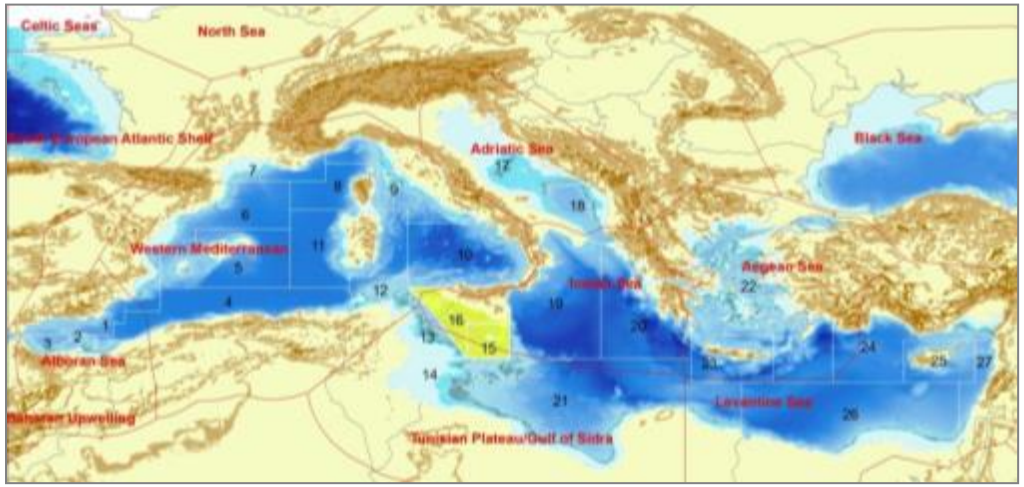
The fishery

The Strait of Sicily is one of the most important fishing areas of the Mediterranean



Multi-national trawl fishery:

Italy: 390 vessels
Tunisia: 74 vessels
Malta: 14 vessels
Egypt: ??

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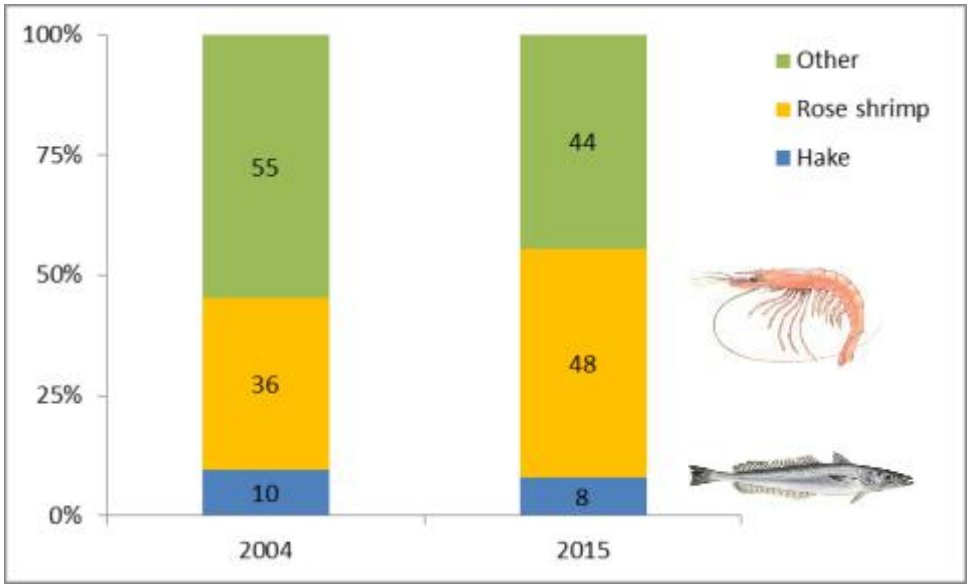
The fishery

Deep water rose shrimp (DPS) is the main stock in terms of gross revenues (48% of the total) and profits (Italian data). Hake is the main commercial by-catch.

% gross revenues by target species



The two stocks are overexploited with hake: F_{cur}/F_{msy} = 3.2; rose shrimp: F_{cur}/F_{msy} =1.3.

Hake predator of rose shrimp

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The management context

International GFCM management plan for trawl fishery

REC.CM-GFCM/40/2016/4

establishing a multiannual management plan for the fisheries exploiting European hake and deep-water rose shrimp in the Strait of Sicily (GSA 12 to 16)

General Fisheries Commission for the Mediterranean
Commission générale des pêches pour la Méditerranée

Goal: achieving F_{MSY} for hake and rose shrimp by 2020

Problem: can we get the goal without impairing the socio-economy of trawl fleets.

Prey-predator reationships can affect fishery performance?

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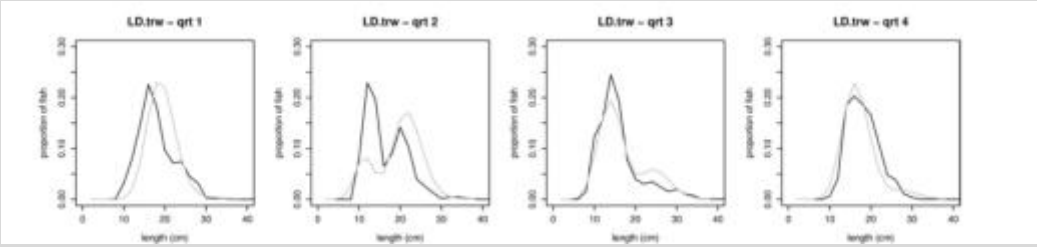
Modelling approach: Gadget

MareFrame

Gadget

Minimum realistic model. It carries out forward simulations based on many parameters describing biological processes (growth, predation, maturation) and fisheries dynamics. Model outputs are compared to observed measurements to get a likelihood score.

The model ecosystem parameters can then be adjusted, and the model re-run, until an optimum is found, which corresponds to the model with the lowest likelihood score. This iterative, computationally intensive process is handled within Gadget, using a robust minimisation algorithm.



Begley and Howell, 2004; Begley, 2005
http://www.hafro.is/gadget/

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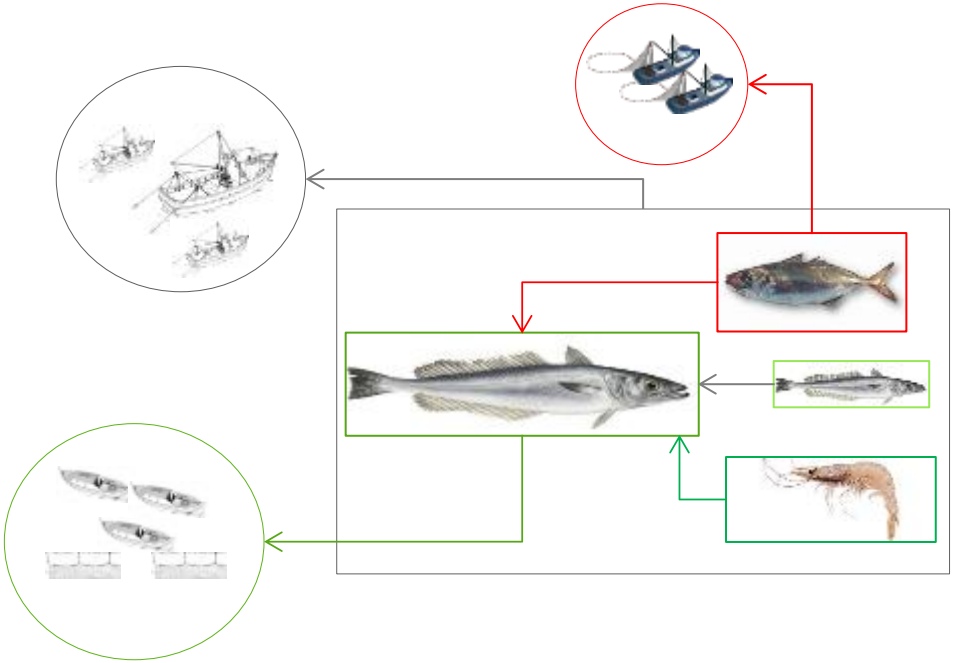
Multispecies – Multifleet GADGET model for hake, deep water rose shrimp and horse mackerel



5 Fleets: trawlers, artisanal vessels, purse seiners (Italy-Malta, Tunisia)

3 stocks (hake: HKE + rose shrimp: DPS + horse mackerel: HOM)

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GADGET single species models

Summary of models (length-based)

- ✓ Time: 2002-2016 (Italian, Tunisian and Maltese catches)
- ✓ Fleets: commercial trawlers and artisanal vessels (ITA-MLT, TUN)
- ✓ Medits bottom trawl survey fleet
- ✓ Recruitment all year (HKE, DPS), seasonal (HOM)
- ✓ Fleet selectivity knife edge (DPS, HOM), dome shaped with a right tail (HKE)

Parameters

- L_∞=fixed, K= (estimated)
- M: vector
- Recruitment (estimated)
- Maturity ogives
- Selectivity parameters (estimated)

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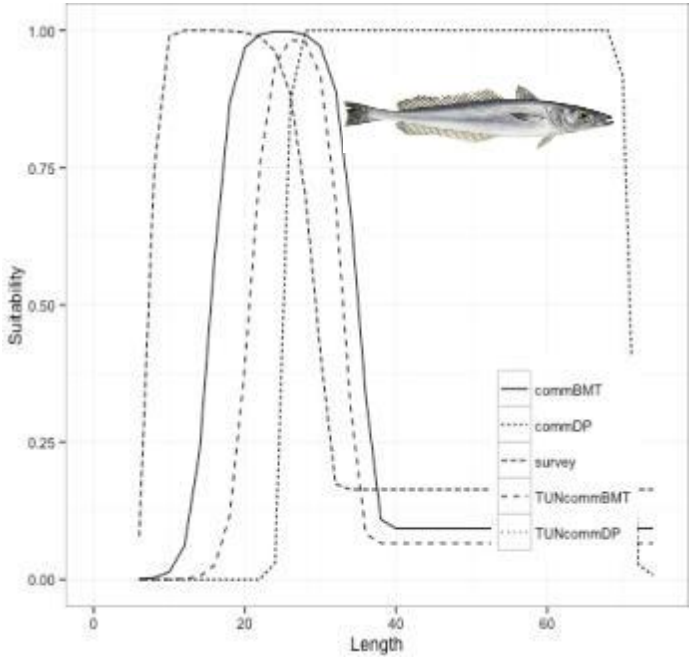
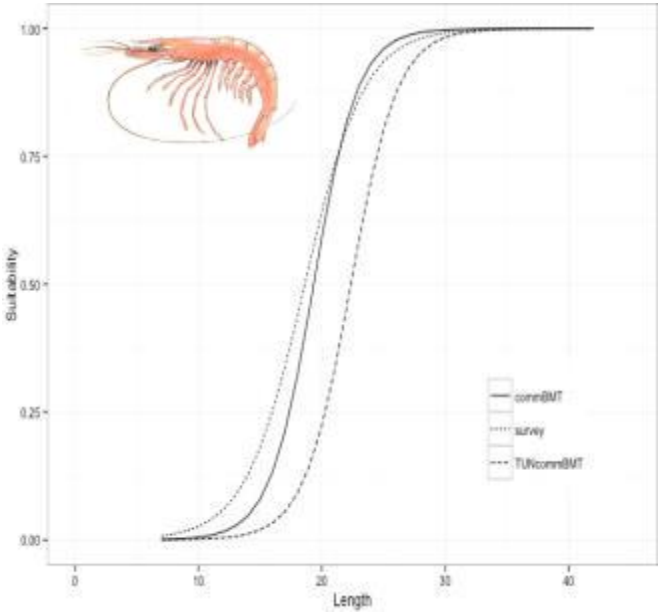
GADGET single species models

Fleet selectivity curves





Ad-hoc fleet selectivity curves:

- Italian trawlers
- Tunisian trawlers
- Italian artisanal
- Tunisian artisanal
- Medits

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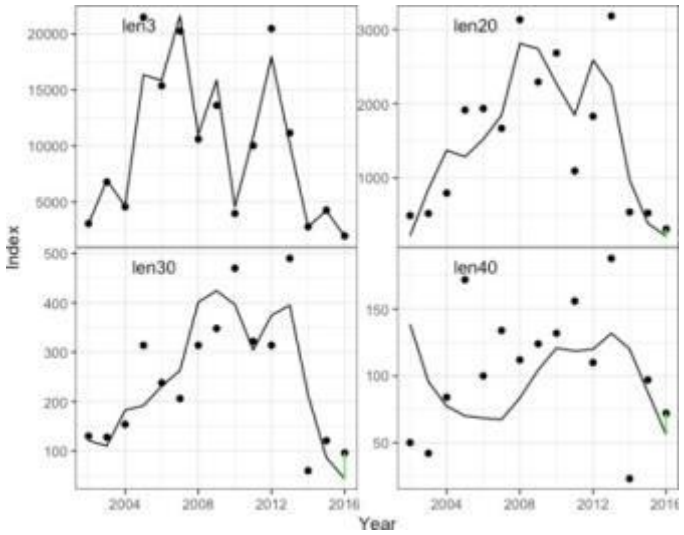
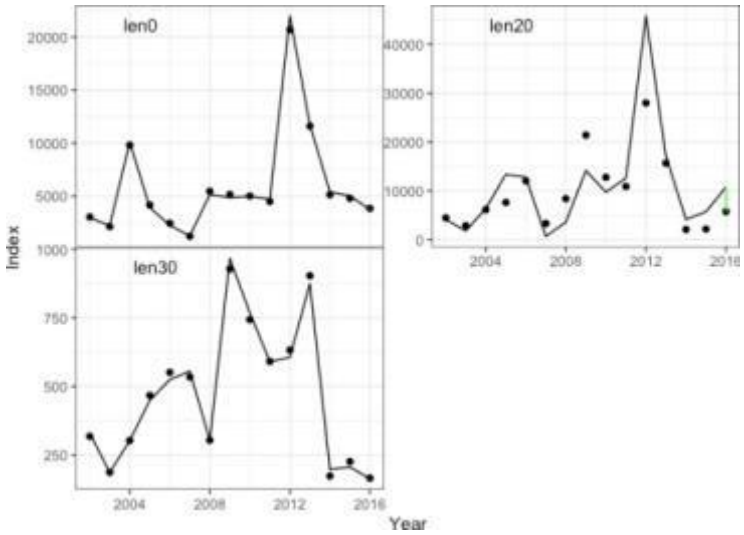
GADGET single species models

Model fitting

Survey indices by length group: Medits (n Km^{-2})





Simulated

Observed

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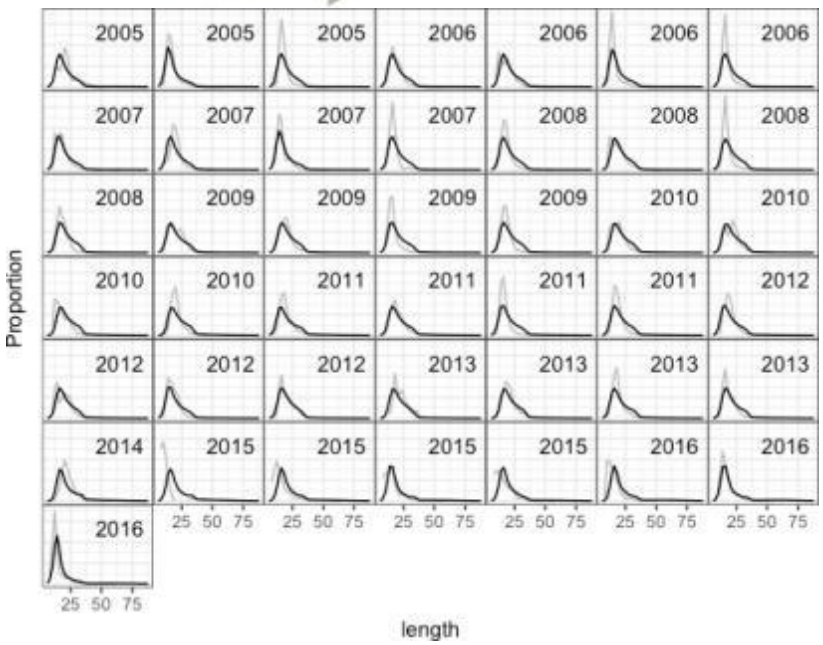
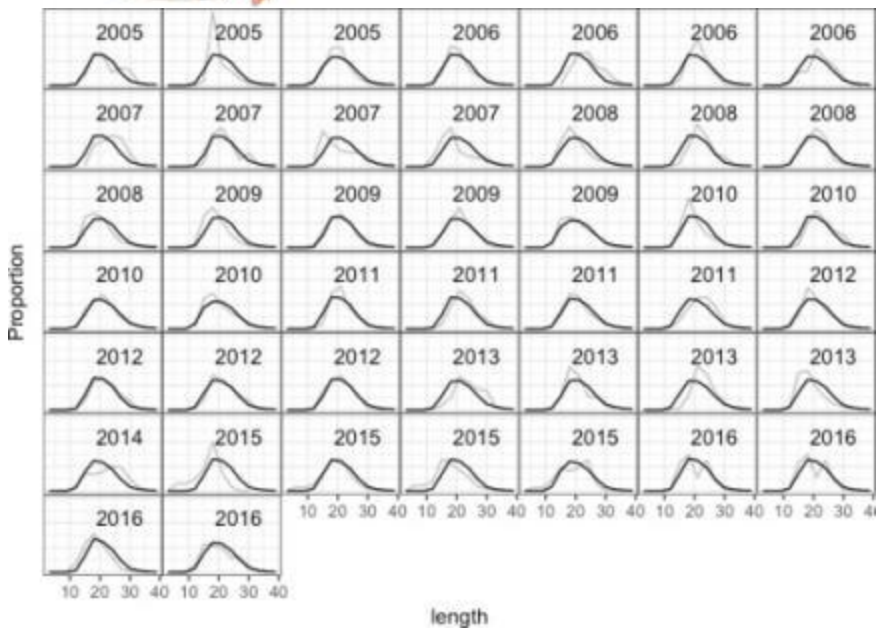
GADGET single species models

Model fitting

Trawl catch size structure (Italian trawlers)





Simulated

Observed

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Linking species through consumption

$$C_p(l,L) = \frac{N_L M_L \psi_L F_p(l,L)}{\sum_p F_p(l,L)}$$

$$F_p(l,L) = (S_p(l,L) E_p N_l W_l)^d$$

$$\psi_L = \frac{\sum_{preys} F_p(l,L)}{H\Delta t + \sum_p F_p(l,L)}$$

From MULTISPEC (Bogstad et al., 1997, Begley, 2005)

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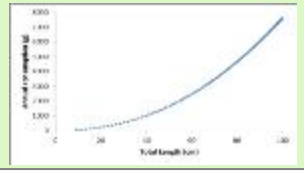
Linking species through consumption

DATA USED:
1. Diet composition (hake): proportion of rose shrimp, horse mackerel, hake, other food in hake stomachs (2013-2014);

2. Hake length-prey length relationship (2013-2014)

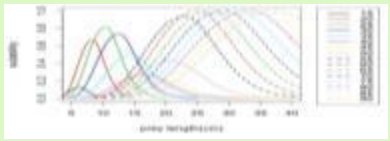
A bio-energetic model (Temmings and Herrmann, 2009) to calculate the annual consumption (kg year^{-1}) of each hake length group

$$F = \frac{1}{K_3} \times 3 \times K \times W_{\infty}^{\frac{D}{b}} \times W^{\frac{a}{b}}$$



Prey suitability functions related to the predator length/prey length relationship

$$S(l,L) = \begin{cases} p_0 + p_2 \hat{y}(L) \exp\left[-\frac{\left(\log\frac{L}{l} - p_1\right)^2}{p_3}\right] & \text{if } \log\frac{L}{l} \le p_1 \\ p_0 + p_2 \hat{y}(L) \exp\left[-\frac{\left(\log\frac{L}{l} - p_1\right)^2}{p_4}\right] & \text{if } \log\frac{L}{l} > p_1 \end{cases}$$



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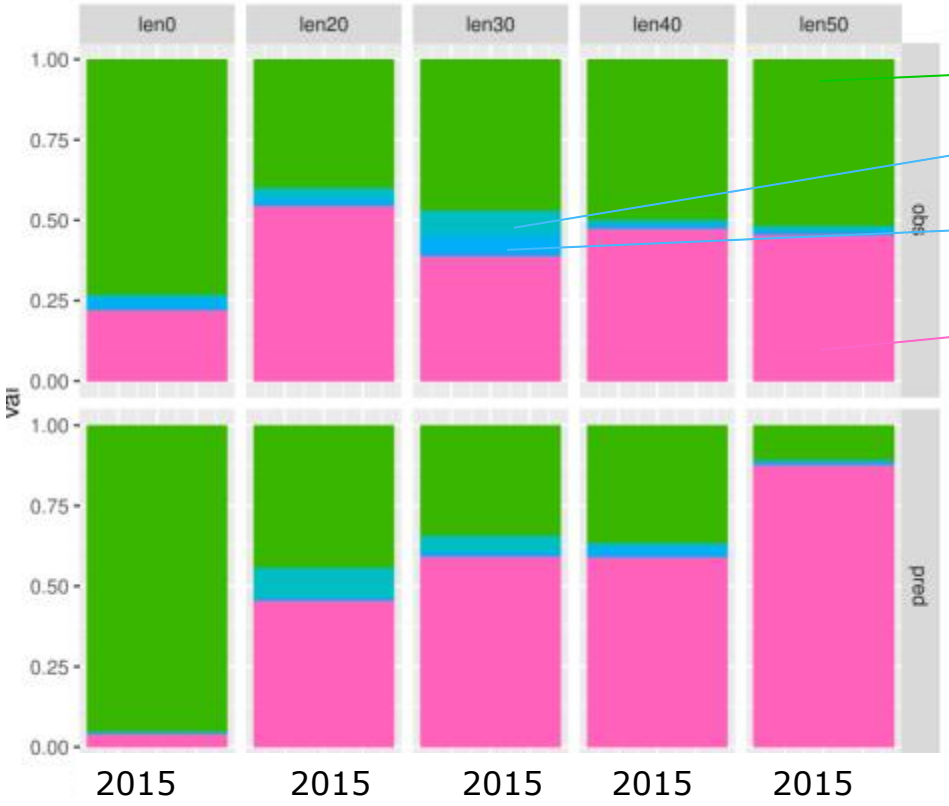
Hake diet: observed/predicted



Other food

hake

rose shrimp

horse mackerel

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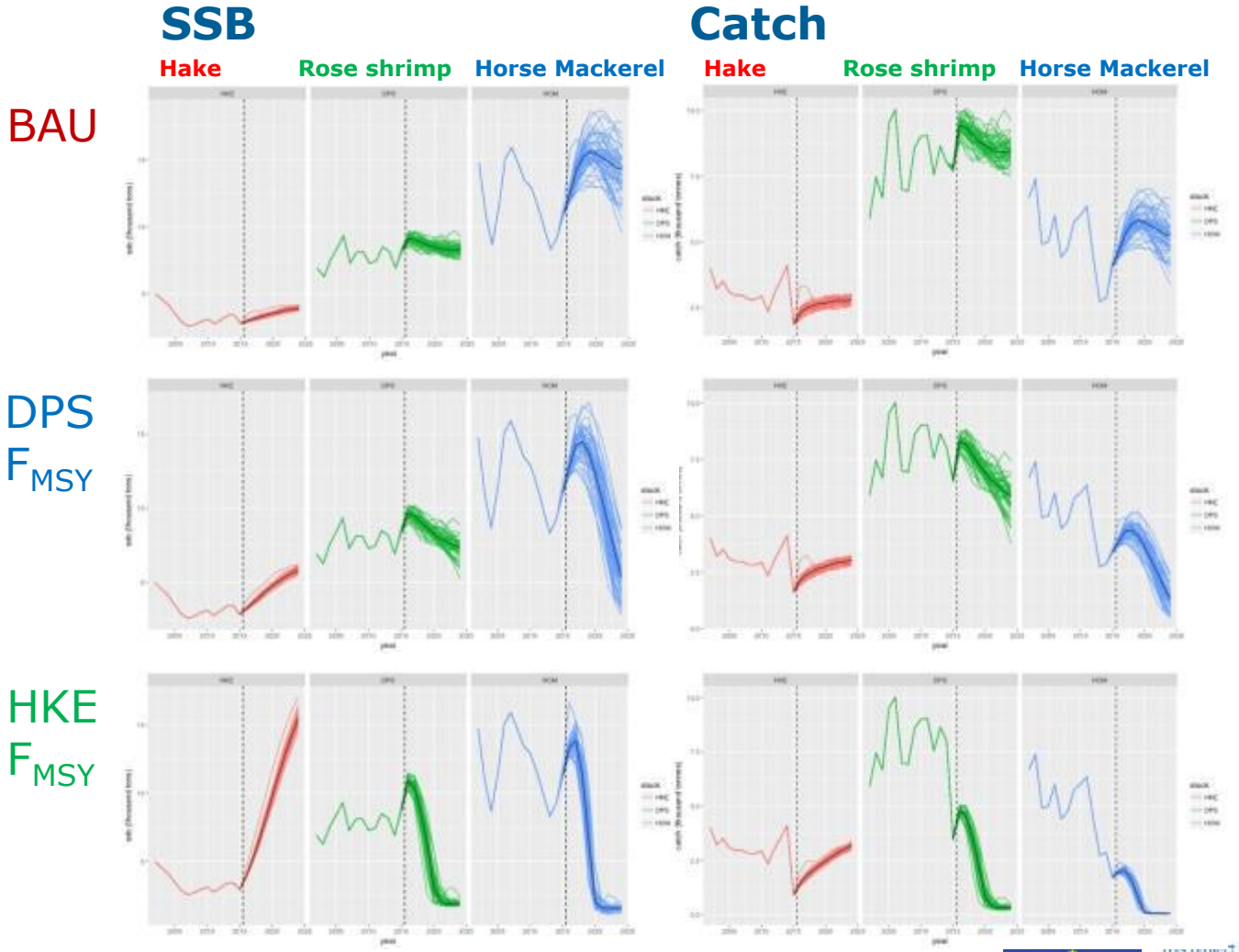
Scenarios and trade-offs



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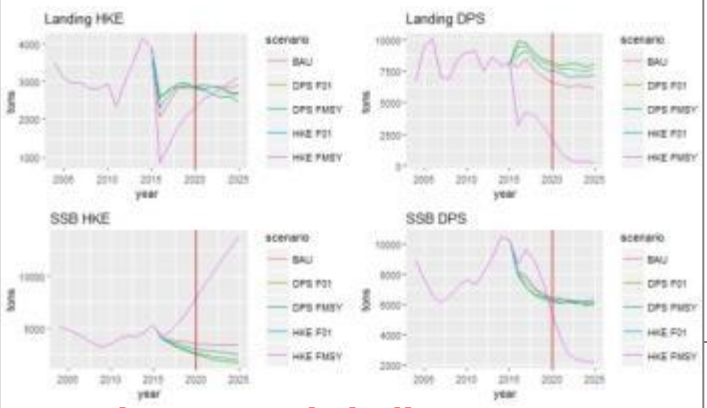
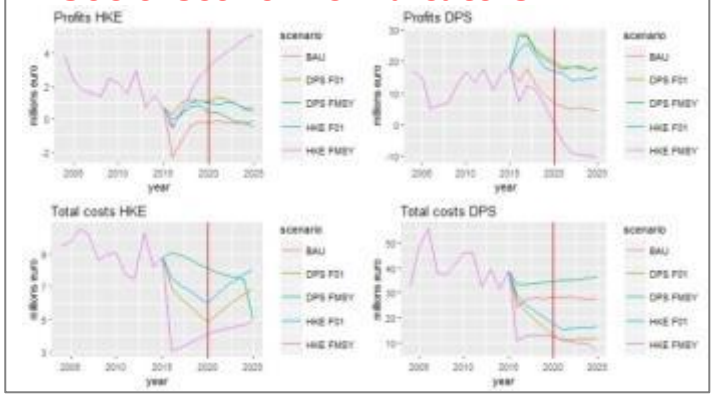
Decision support tool

Simulations on biological and socio-economic indicators under different levels of fisheries exploitation integrated into a MCDA & DST reflecting stakeholders preferences.

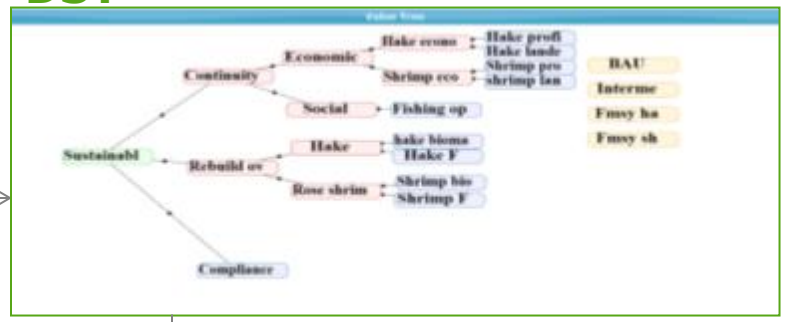
Catch and biomass

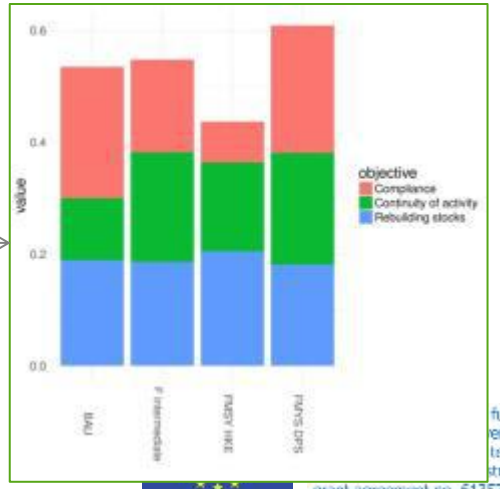


Socio-economic indicators



DST





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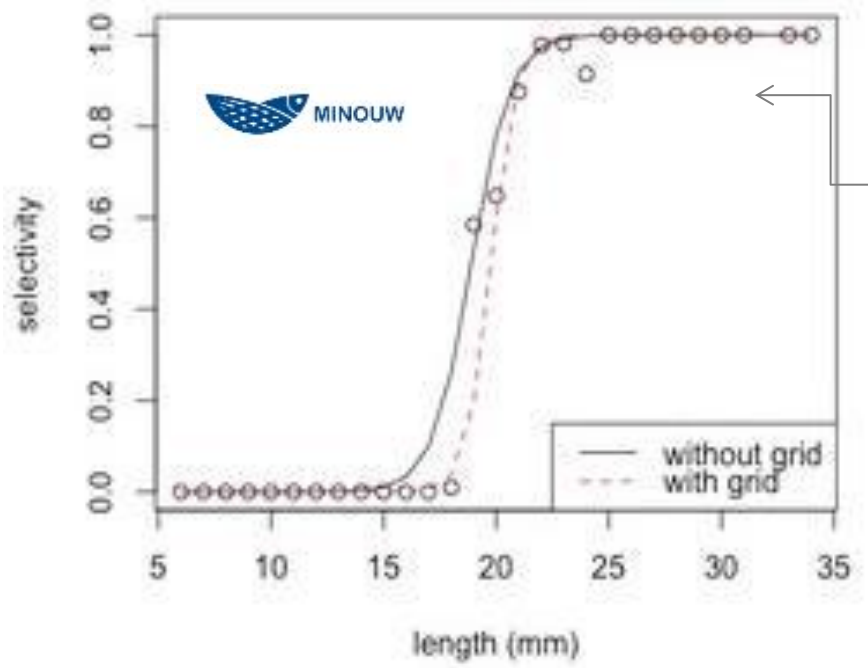
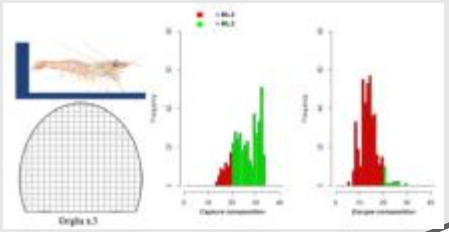
Next steps: Gadget scenarios selectivity (from MINOUW project)

Rose shrimp



MINOUW bottom trawl survey



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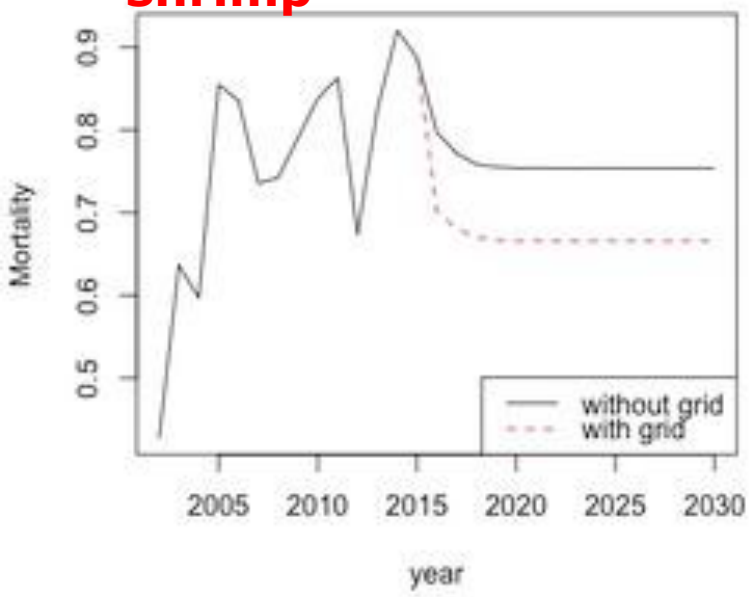
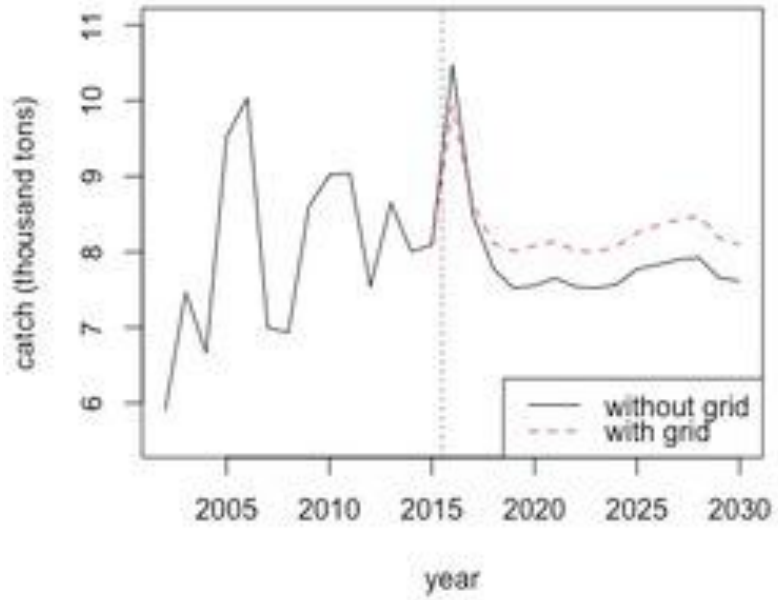
Next steps: Gadget scenarios selectivity

Fishing mortality rose shrimp



Catch rose shrimp



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Conclusions

Single species GADGET: short term advice

Multispecies GADGET: short term advice? More knowledge and improvements required

DST based on single /multispecies models

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