Training Course in the integration of the impact of environment on stocks productivity in Management Strategy Evaluation models

ICES CIEM

SEAWISE

Introduction on BEMTOOL model and how EMSRR were integrated in the model in SEAwise

Fondazione COISPA ETS

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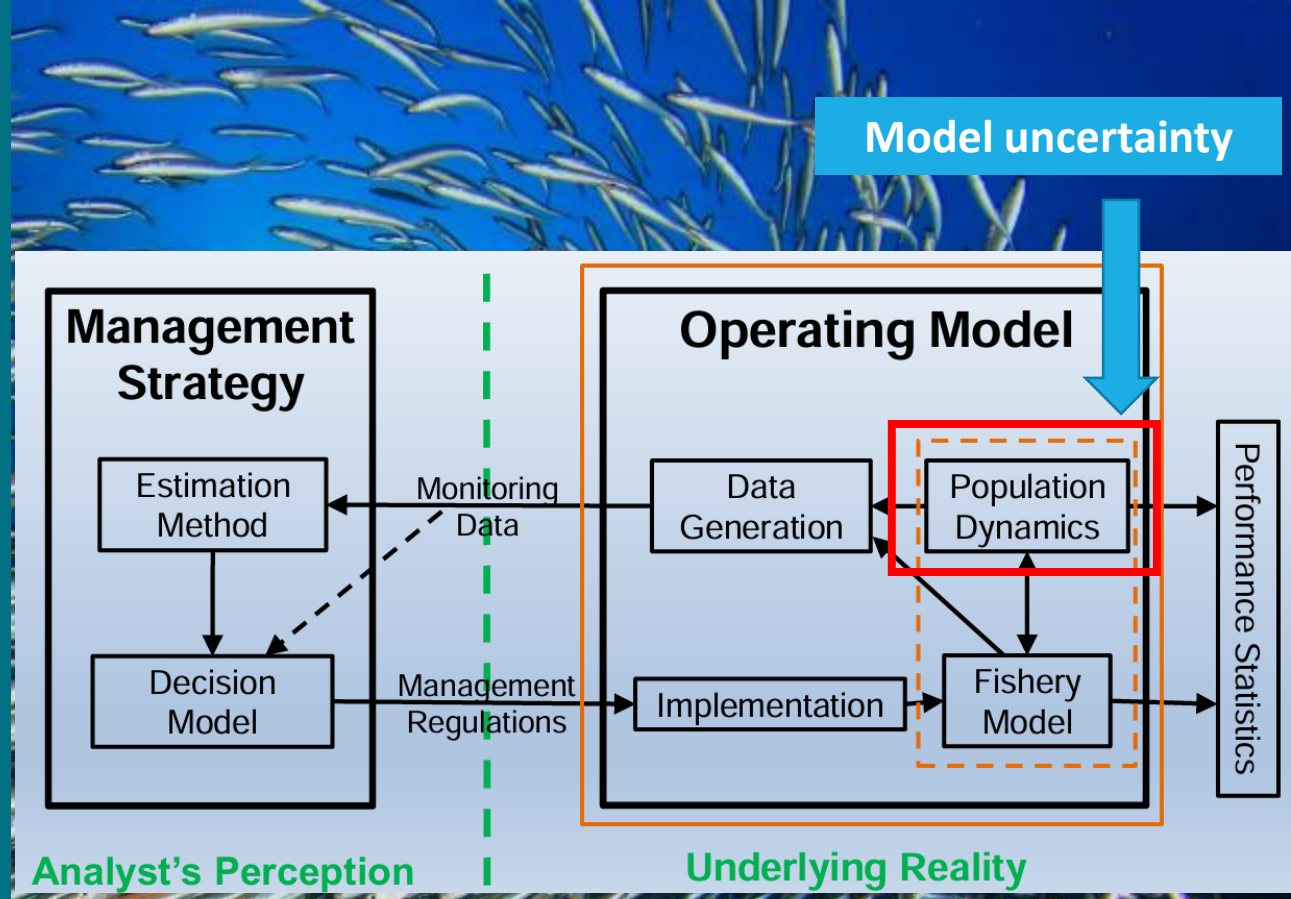
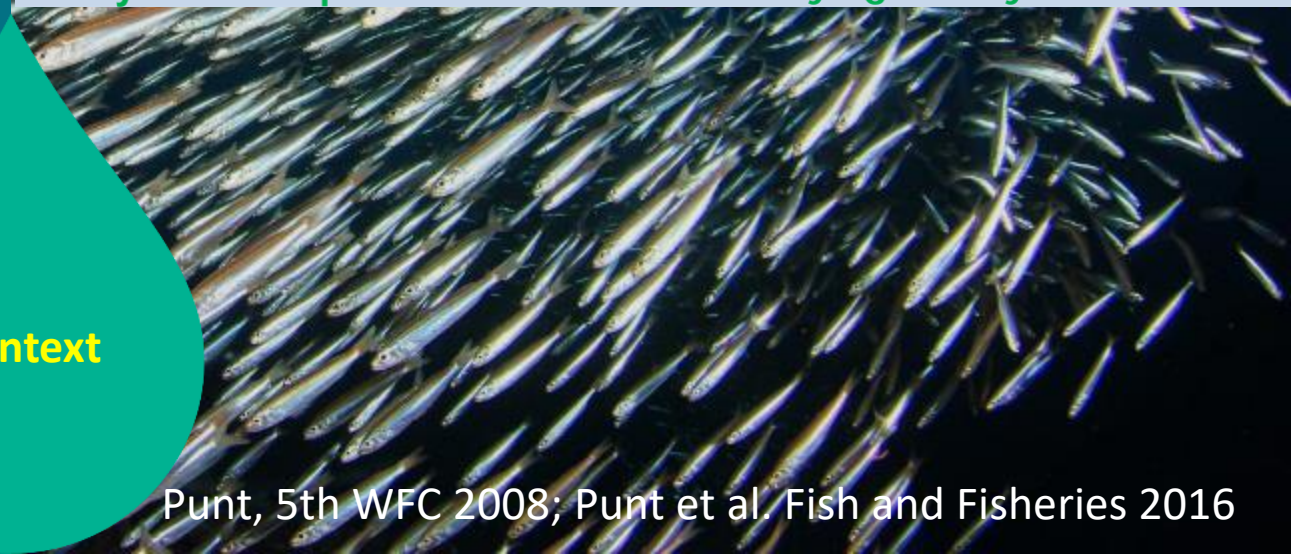
SEAwise has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000318

Background

- Most early operating models considered a single stock, ignored climate drivers of recruitment, growth and natural mortality (Punt et al., 2014).
- Climate and environmental variation is increasingly recognized as factor which often needs to be included when evaluating management strategies.
- In literature, one of the approaches developed to address this issue is to link the environmental variables to the parameters that determine the dynamics of the population represented in the operating model (A'mar et al. 2009a; Ianelli et al. 2011; Punt, 2011), or regime shift changes in parameters can be modelled (A'mar et al. 2009b; Wayte 2011; Szuwalski and Punt 2013).
- Recruitment is often identified as one of the key processes regulating fish population productivity that needs to be included as **model uncertainty** in the operating model to identify robust alternative Management Strategies.
- When evaluating different climate change scenarios, alternative OMs should represent an alternative yet plausible reality, reflecting the range of uncertainties.

Context

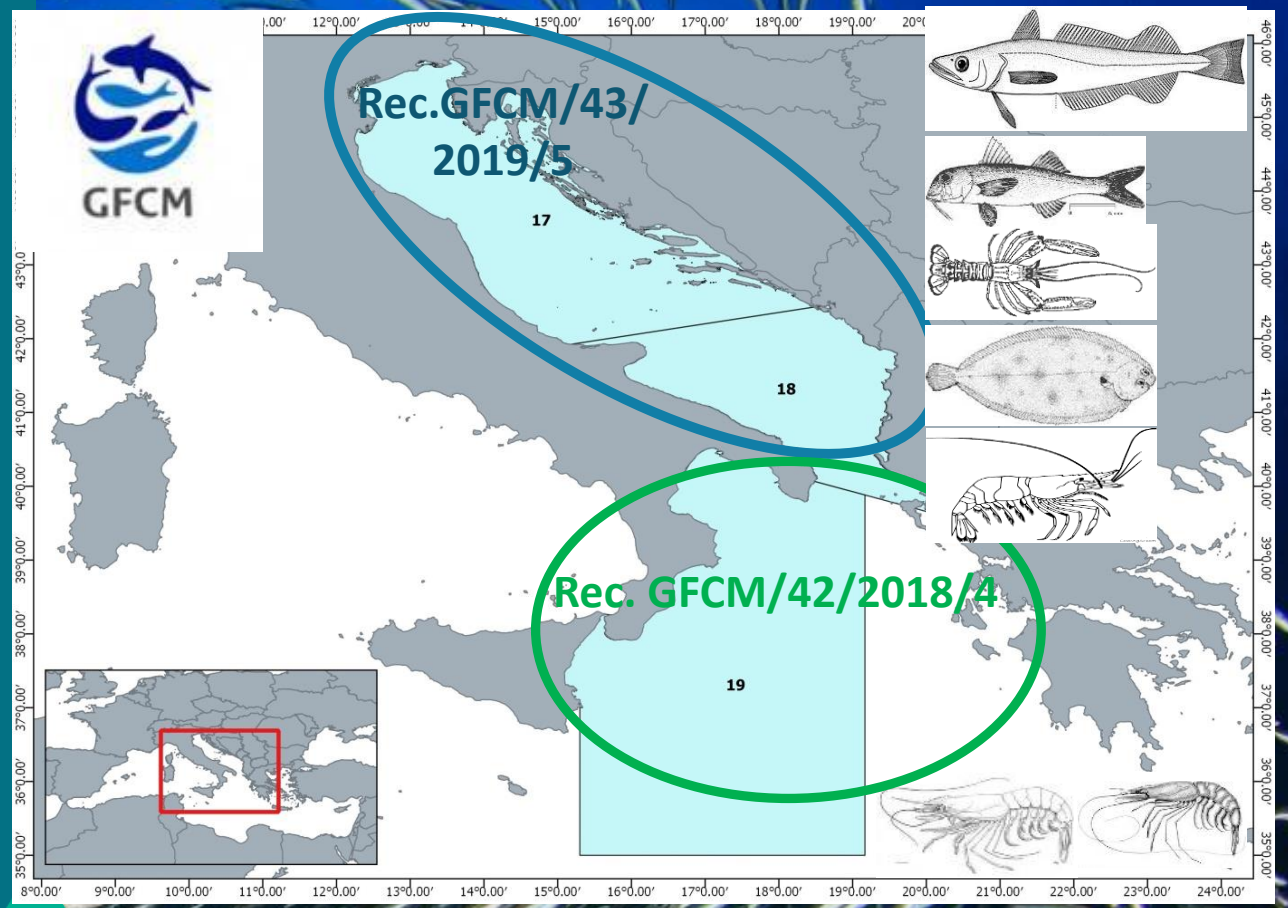




Punt, 5th WFC 2008; Punt et al. Fish and Fisheries 2016

The Adriatic and Western Ionian Seas case study in SEAwise

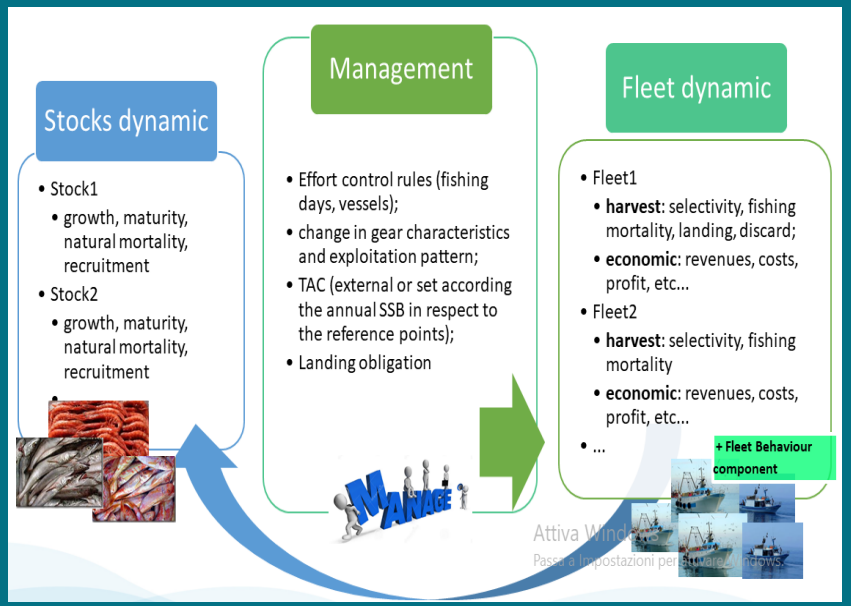
- In the Adriatic Sea a Multi-Annual Management Plan (MAP) regulating the demersal fleets was established in 2019 by the General Fisheries Commission for Mediterranean Sea (GFCM, Rec. GFCM/43/2019/5 and following ones). The MAP is based on effort quotas and technical measures. The objective is to achieve Fmsy for all the key stocks (European hake, red mullet, deep-water rose shrimp, Norway lobster, common sole) by 2026 (Recommendation GFCM/43/2019/5 and following ones). After 2026 this objective needs to be maintained.
- In the Ionian Sea a multiannual management plan for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp was established in 2018 (**Rec. GFCM/42/2018/4 and following ones)** . The stocks are mainly managed through catch limits and technical measures.



Fisheries management in the area

BEMTOOL bio-economic model

BEMTOOL is a MULTI-FLEET and MULTIPLE STOCK bio-economic simulation model for MIXED FISHERIES to provide advice within Management Strategy Evaluation dimensions.



Data requirement

- Stock assessment results, including process error (e.g. on stock-recruitment relationship) and uncertainty on sub-models (e.g. selectivity, maturity ogive);
- Transversal data (e.g. effort)
- Socio-economic data (e.g. fixed, variable costs, employment).
- Other relevant information (e.g. historical management measures applied).

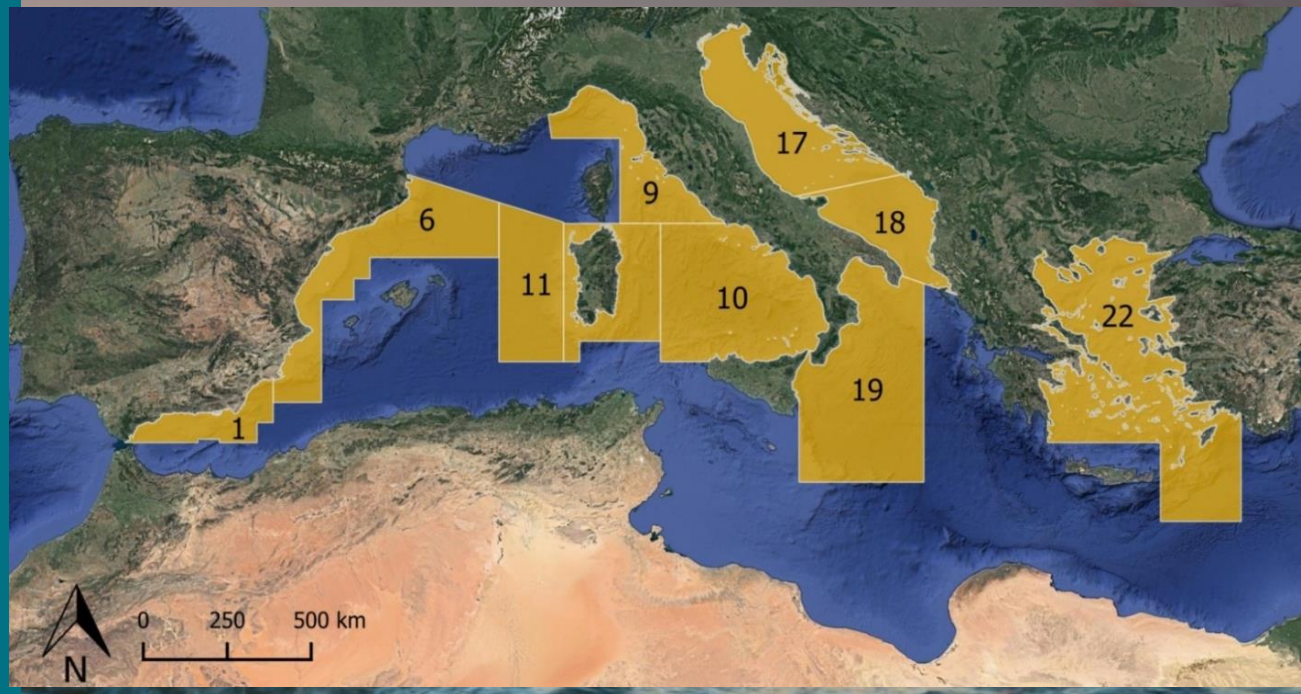
The new version is freely available on the training GitHub:

https://github.com/ices-tools-dev/SEAwise_ecoMSE

BEMTOOL model

BEMTOOL bio-economic model selected applications

- STECF EWGs (since 2019) fishing effort regime from Western Med MAP;
- Sbrana et al. (2022) – device-based gear selectivity changes;
- Spedicato et al. (2022) – stock units configurations;
- FAIRSEA project (Fisheries in the Adriatic region - a shared ecosystem approach);
- Spedicato et al. (2018) – impact of Landing Obligation;
- Russo, Bitetto et al. (2017) – rotating fishing ban;
- Rossetto et al. (2015) – MCDA.



Applications

BEMTOOL MSE framework (short-cut type 1)

Recruitment, growth, maturity and M

OPERATING MODEL

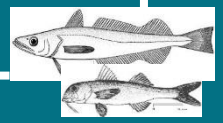
MANAGEMENT STRATEGY

Biological, pressure (by fleet) indicators

Socio-economic (by fleet) indicators

Population dynamics (Aladym)

multiple stocks



Fleet selectivity

Fishery model

multi- fleet

Implementation

Management regulation

Inclusion of error (estimation emulator)

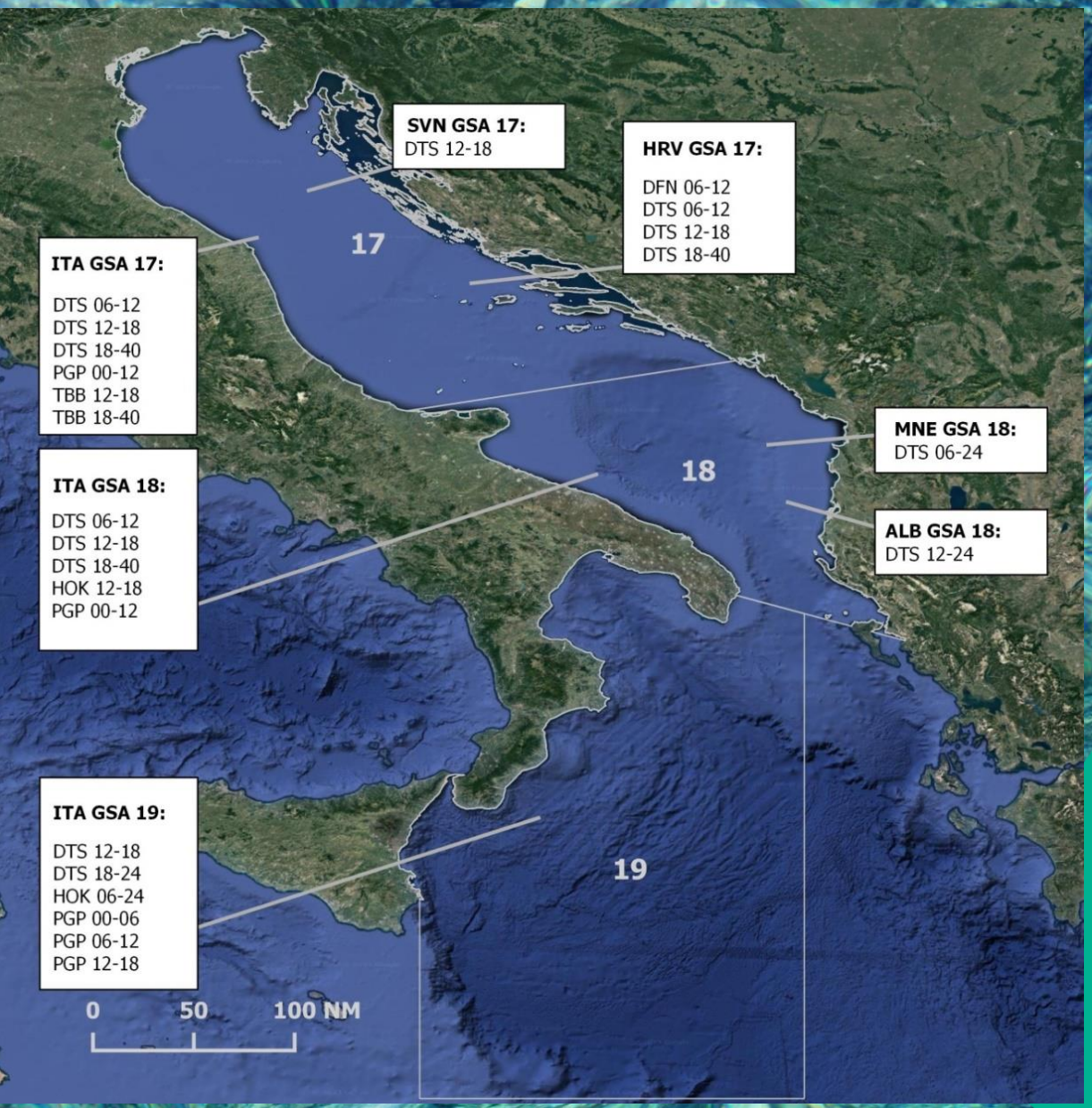
Management decision

Effort quotas, LO, gear selectivity change, spatio-temporal closures, TAC/ catch limits and combination of measures

Uncertainty

Analyst's Perception

Underlying Reality



Fleet modelled:

- 24 demersal fleets: 17 ITA, 1 SLO, 4 HRV, 1 ALB, 1 MNE.
- 14 trawlers (DTS), 5 polyvalent (PGP), 2 rapido trawlers (TBB), 1 drift and fixed nets (DFN), 2 longlines (HOK)
- Both Large and Small scale fleets (<12 m LOA) are included explicitly in each GSA (8 out of 24 fleets).

Model conditioning: 2004-2022

In the model management measures in place have been integrated and applied to the different fleet segments:

- Fishing bans;
- Increase in mesh size in 2010;
- Effort opportunities from 2020 (Rec. GFCM/43/2019/5);
- Fisheries restricted areas (Jabuka/Pomo pit).

Integrating stock assessment results

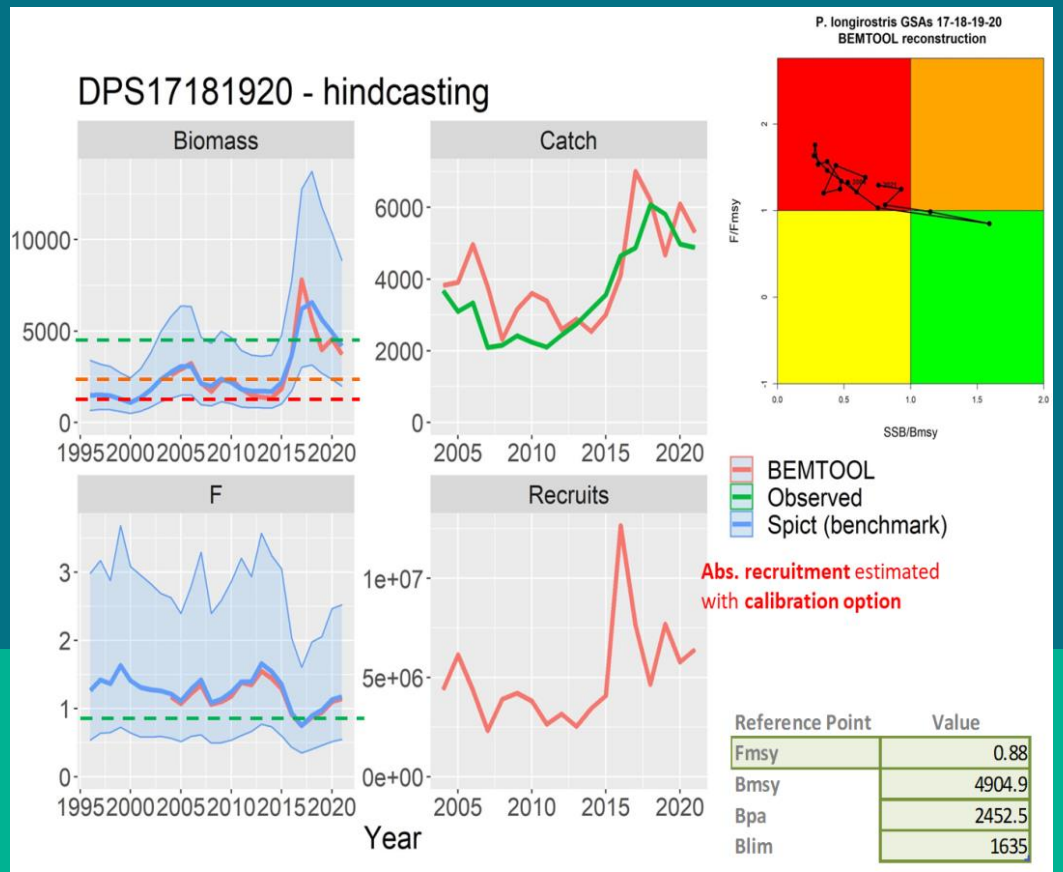
Stock assessments have been replicated in BEMTOOL, integrating the last validated stock assessment results.

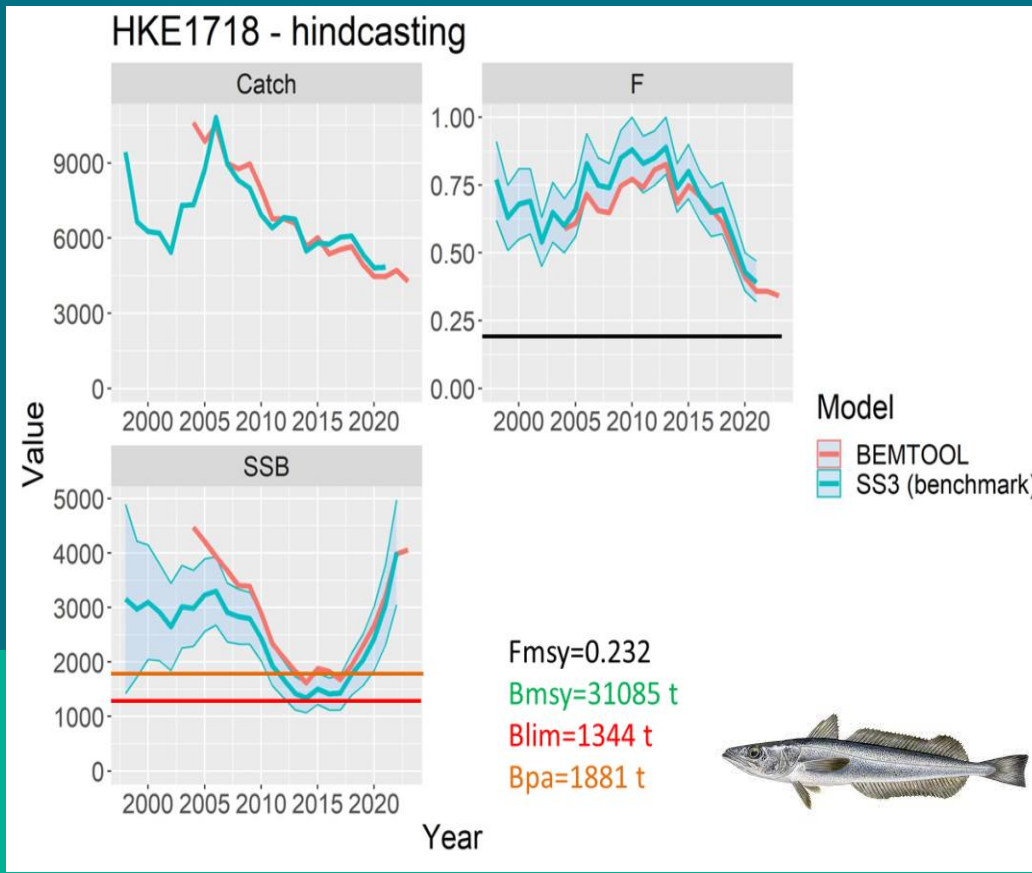
Stocks:

- *European hake;*
- *Red mullet;*
- *Norway lobster;*
- *Common sole;*
- Deep-water rose shrimp.

Age/length structured

Global production





Research objective

Identification of the main source of uncertainty

- Recent massive recruitment events observed for red mullet in Adriatic;
- Expansion of deep-water rose shrimp in Central Adriatic Sea (possibly linked to recruitment increase…)
- Fishing effort re-allocation due to management measures and decreased pressure on the coastal strip
- Some evidence of changes in growth, maturity and condition factor of European hake and red mullet

Stock	SRR model	Environmental variables included	Formulation
European hake 17-18 (HKE1718)	Beverton-Holt	botT, SST	R ~ a * S/(1 + b * S) * exp(-c * sst)
European hake 19 (HKE19)	Beverton-Holt	SST	R ~ a * S/(1 + b * S) * exp(-c * sst)
Red mullet 17-18 (MUT1718)	Ricker	SST,nppv	R ~ a * S * exp(-b * S - c * sst - d * nppv)
Red mullet 19 (MUt19)	Ricker	SST	R ~ a * S * exp(-b * S - c * sst)
Deep-water rose shrimp 17-18-19-20 (DPS17181920)	Beverton-Holt	botT	R ~ a * S/(1 + b * S) * exp(-c * botT)

Our priority

To develop and parameterize alternative Operating Models on recruitment linked to different climate change scenarios, using the Environmental Mediated Stock Recruitment Relationships (EMSRR) to identify Management Strategies robust to this source of uncertainty.

Operating models (climate scenarios)

- No climate change
- RCP4.5;
- RCP8.5.

MSE specifications

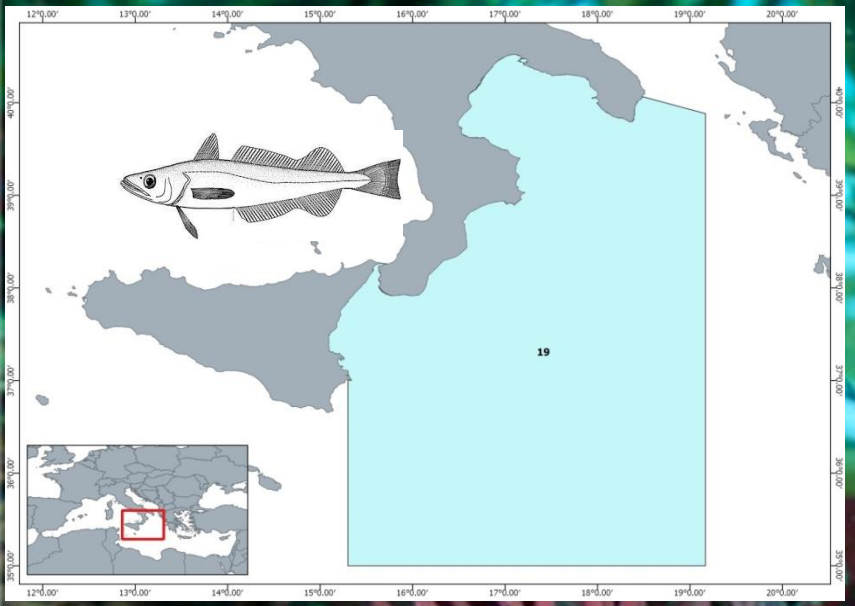
- Projections of environmental variables obtained from 3D monthly POLCOMS-ERSEM until 2060, delta bias corrected **(Kuehn B., 2023)**
- Estimation of the uncertainty from the process error incorporated through a Monte-Carlo approach, using the EMSRR and assuming a multiplicative lognormal error with mean 0 and standard deviation based on historical recruitment times series.
- The reduction to **FMSY** coupled with HCR should be implemented in the Mediterranean management scheme in the short term for these stocks.

Management scenarios

Baseline (status quo);

Fmsy: linear effort reduction corresponding to Fmsy of all demersal stocks in 2026, corresponding to 50% of the effort in GSAs 17-18 and 37% in GSA 19;

PGY: linear effort reduction to achieve a Fmsy combined (here considered as a proxy of PGY) on all the target stocks (HKE 17-18, MUT 17-18, DPS 17-18-19, MUT19, HKE19, ARS 18-19-20, ARA 18-19-20), corresponding to an effort reduction of 25% of the effort.

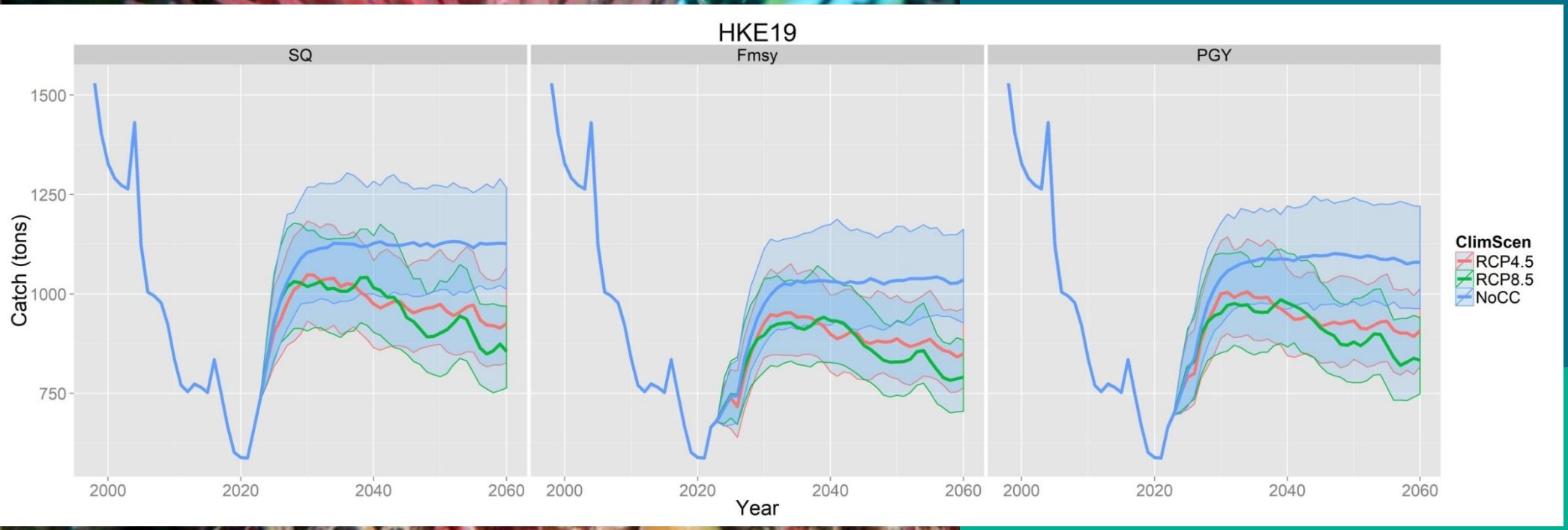


European hake GSA 19 western Ionian Sea

Results

The increase in temperature is expected to affect negatively the recruitment and the SSB in both climate scenarios

From about 2050 the RCP8.5 the less favourable conditions affect more negatively the stock under RCP8.5 scenario across the three management scenarios.

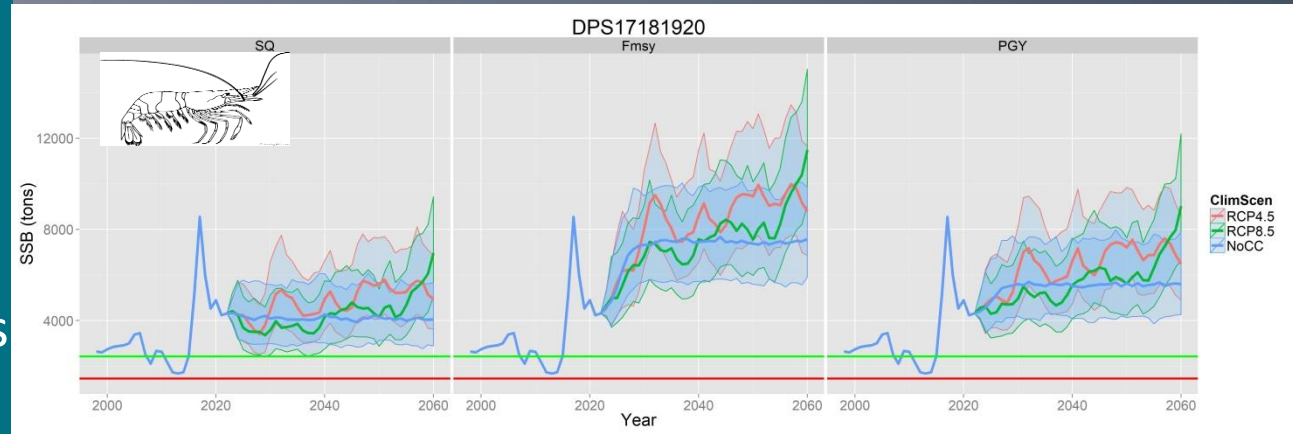


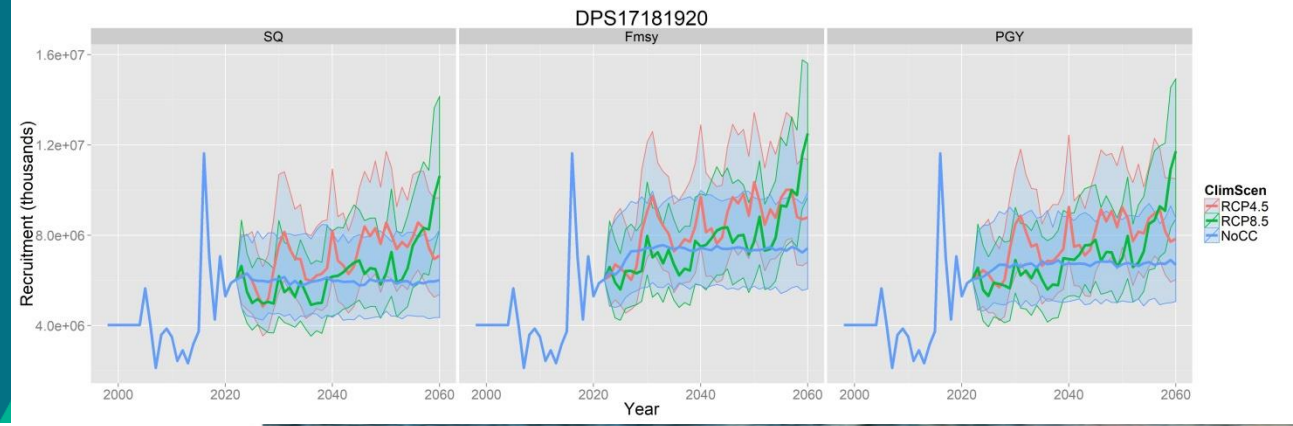
Losses in the catches are comparable between RCP4.5 and RCP8.5 until 2050, while after are more marked for RCP8.5

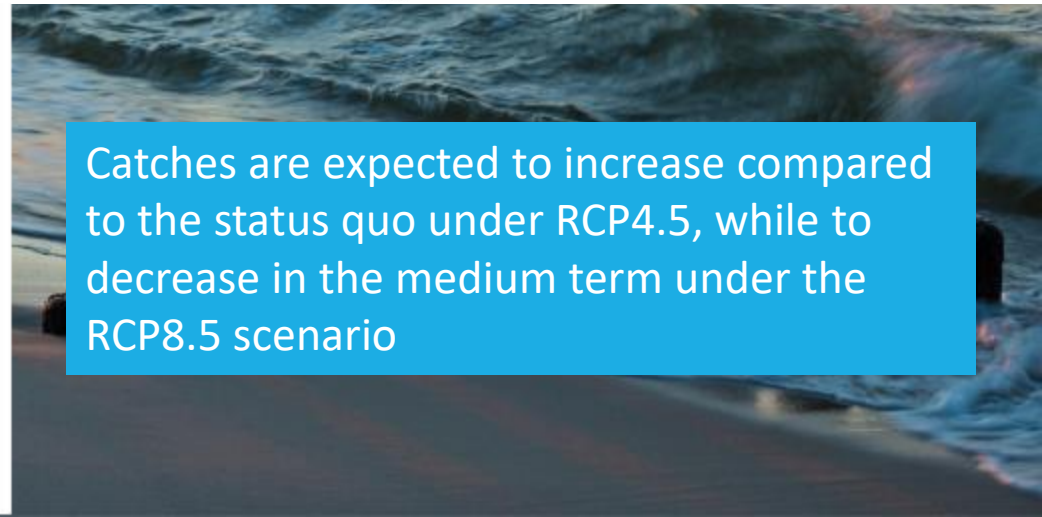
Deep-water rose shrimp GSAs17-18-19-20 Adriatic and Ionian Seas

Using the population dynamic model (not a constant level of SSB), the increased bottom temperature estimated under RCP4.5 and RCP8.5 is expected to foster an increase of the stock productivity respect to the NoCC scenario, being the RCP4.5 the climate scenarios more favourable.

The **FMSY** scenario is the one that improves more the SSB, although providing a catch level similar to the other management scenario.







Catches are expected to increase compared to the status quo under RCP4.5, while to decrease in the medium term under the RCP8.5 scenario

Conclusions and lesson learned

- This work in SEAwise is the first attempt in the Adriatic and western Ionian Sea to integrate the climate change in the recruitment process for the demersal key stocks in a MSE framework.
- The integration of climate change in BEMTOOL highlighted for all considered stocks a decrease in productivity, less or more pronounced according to the stock.
- **FMSY** scenario represents a valid option to mitigate the impact of climate change on stock productivity, allowing to reduce, for the overexploited stock (e.g European hake), the risk to fall below the reference points.

Conclusions and lesson learned

- Considering that there are stocks in Adriatic and Western Ionian Seas that are exploited below or close to **FMSY**, PGY scenario can represent an option to reduce the underutilization of these resources.
- Combining the climate change with management measures can modify the SBB and catch projections respect to assuming constant SSB levels!!
- The discussion on how properly define a HCR for the demersal mixed-fisheries in Adriatic Sea is in progress. One step forwards in the model specification is the re-
- estimation of the reference points for defining the HCR under different climate change scenarios towards a **strategic advice**.
- Next step will be to socio-economically evaluate, using relevant indicators by fleet, the viability of each management scenarios under different climate change conditions; this will be used to provide to managers outcomes by management scenario for **tactical advice** (including uncertainty) also in terms of fleet performances deterioration.

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Questions?