MEDAC WG 1
WEBINAR 16 April 2021

Maximum Sustainable Yield (MSY) in management of Mediterranean fisheries. Some food for thought

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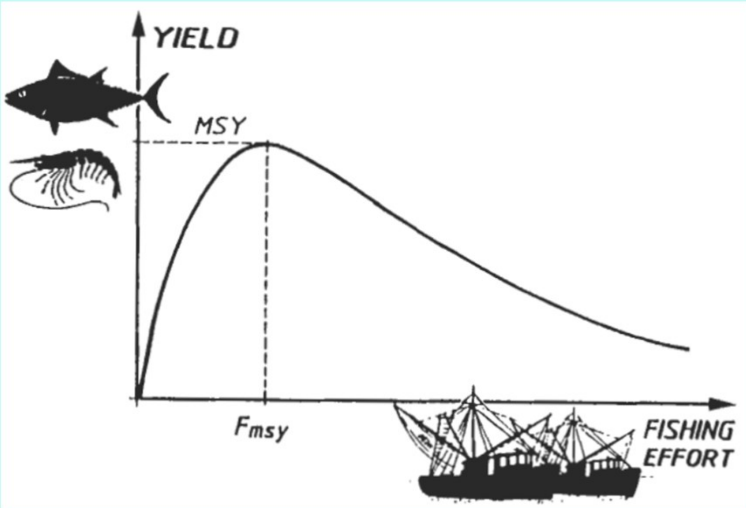
On the origin of MSY and an useful definition

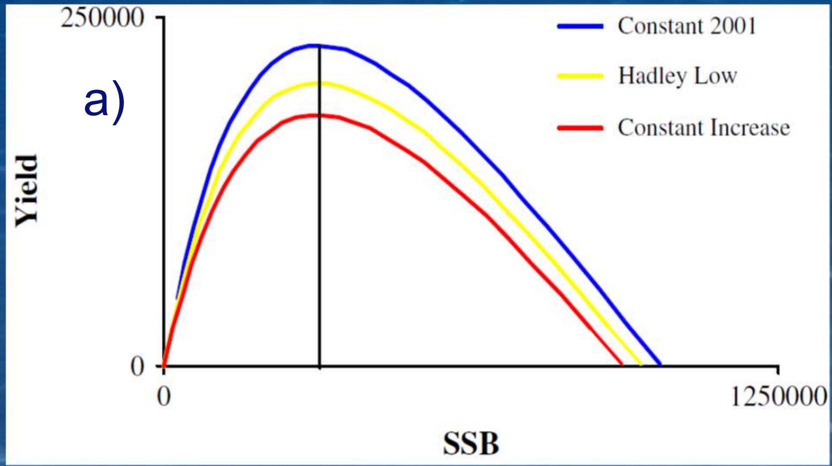
The notion of 'maximum' or 'optimum' steady yield, obtainable at intermediate levels of fishing effort, was introduced in the works of several pioneers of fishery science (Hjort, Russel, Graham) during the 1930s (Mesnil, 2012).

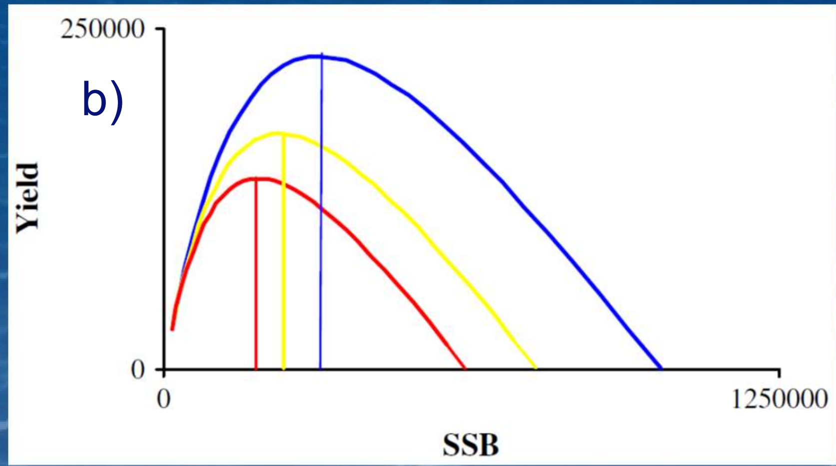


MSY has been defined as the largest average catch or yield that can be taken on a continuing basis from a stock under existing environmental conditions (Ricker, 1975).

A Sustainable Yield curve depends from biology of the stock (growth, mortality, and reproduction) and fishery features (the gear-selectivity and the spatial/time allocation of effort by gears) (Scott & Sampson, 2011)

THE SENSITIVITY OF MSY TO CLIMATE CHANGE





Stock production curves of Cod under three climate change scenarios when the SSRR is modelled according to Ricker (1954) including temperature effect (Kell et al., 2005):

a) Survival of recruits is directly related to temperature, the yield is scaled by the recruitment strength for a given temperature, and the SSB at MSY remain constant

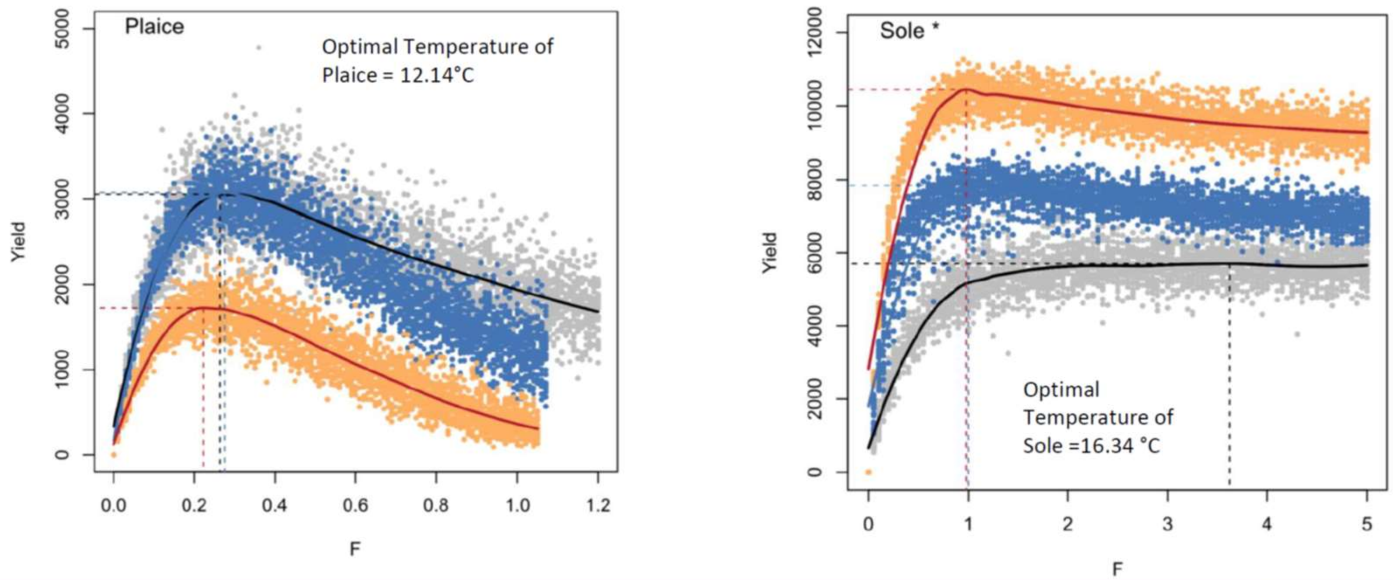
b) Density-dependent processes are acting so that recruitment is limited by available habitat, which in turn is related to temperature.

Constant 2001: Future temperature equal to that in 2001. A “best-case” scenario.
Hadley low: This resulted in around a 0.2°C temperature increase by 2040. This is the most “ecologically friendly” projection.
Constant increase: A 0.026°C increase each year. This results in an approximately 1°C temperature increase by 2040. A “worst-case” scenario.

THE SENSITIVITY OF MSY TO CLIMATE CHANGE

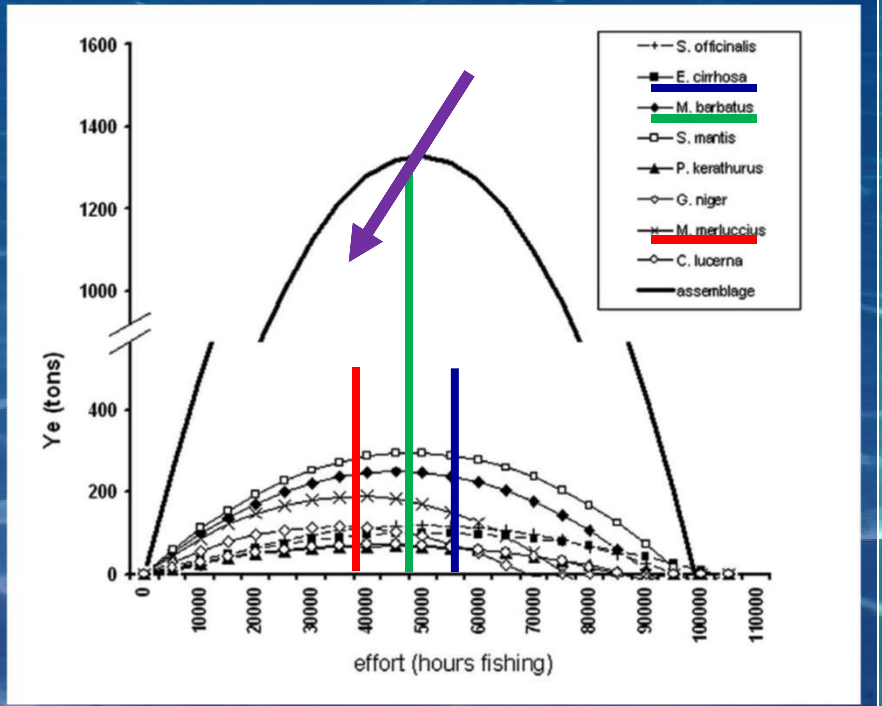
The effects of climate change on reproduction, growth and natural mortality can change stock productivity by changing MSY (by Travers-Trolet et al., 2020)

Some simulations on Sustainable yield vs. fishing mortality of flat fish in the English Channel



What kind of MSY in mixed fisheries?
The case of the coastal bottom trawling in the Ligurian Sea

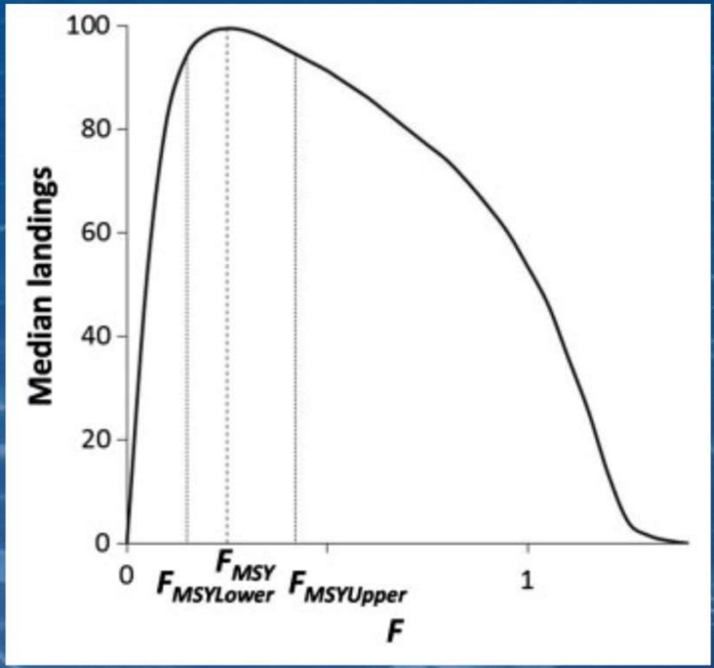
- **The question of what kind of MSY should be pursued in multi-species fisheries remains to be solved...**
- **... when different species with different biological characteristics (first maturity, longevity and maximum size) are caught together, the F_{MSY} of one causes the overfishing or underfishing of the other**



Sustainable yield curves of Viareggio trawling for 8 species and for the entire assemblage by a Schaefer model. The optimal level of fishing effort for the red mullet corresponds to that of the assemblage (from Abella et al., 2010).

What kind of MSY in mixed fisheries?
The “Pretty Good Yield”

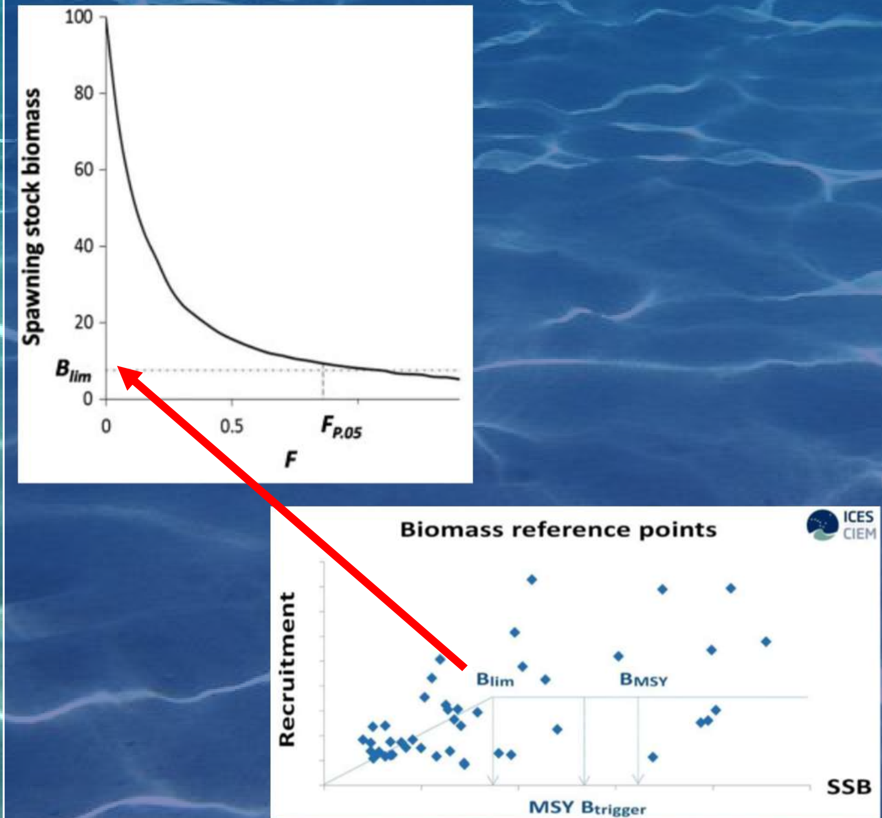
Due to the frequent occurrence of “**flat top curves**” in the relationship between fishing mortality and yield, Hilborn (2010) suggested using the F range delivering 80% of the maximum sustainable yield to provide “**pretty good yield**”.



In mixed fisheries, an approach for maximizing long-term yield could be to attempt to use target fishing mortalities within a “pretty good yield” range providing, for example, 95% of MSY on average. Advice on such ranges was incorporated in analyses supporting the development of multiannual management plans of the EU (Rindorf et al., 2017).

Fishing for "Pretty Good Yield" ranges without impairing recruitment

To assess the **precautionary features of the Pretty Good Yield strategy**, a reference point can be added ($F_{P.05}$).
$F_{P.05}$ is defined as the **fishing mortality resulting in a 5% probability of the spawning-stock biomass falling below a level for which impaired recruitment is expected (B_{lim})**.

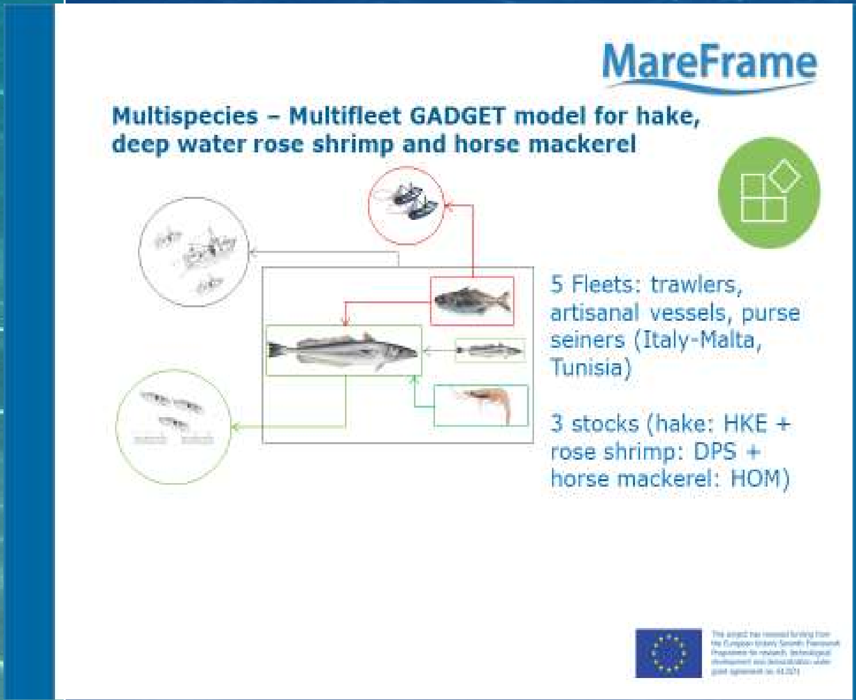


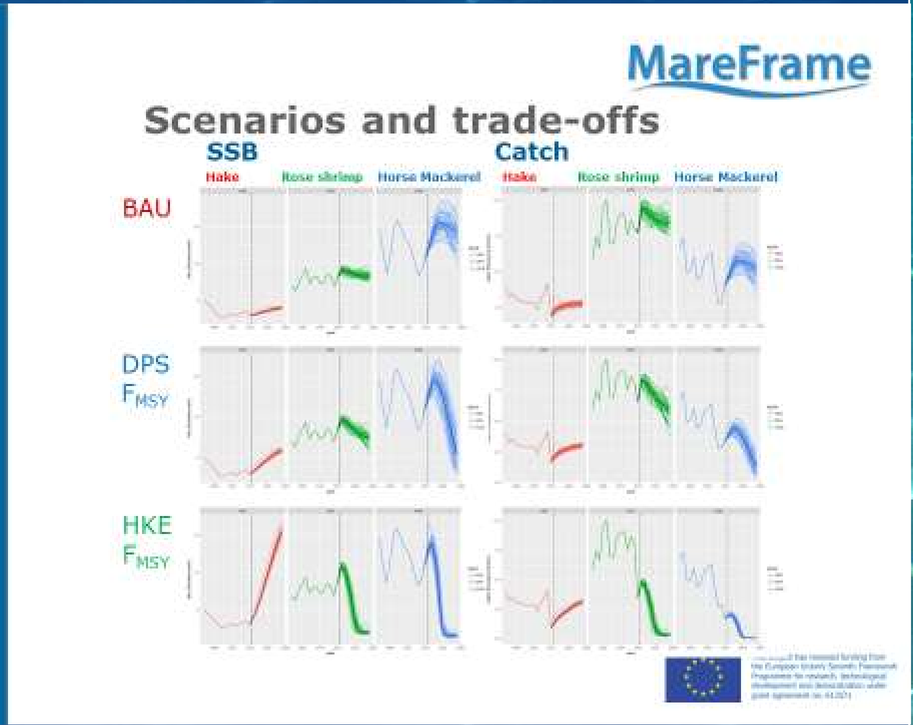
Main results for 19 stocks of bony fish in the North Sea:

- If the species has a small asymptotic size (<20 cm), it is unlikely that F_{MSY} is precautionary.
- If the species has a medium asymptotic size (<50 cm), it is unlikely that the range of values between F_{MSY} and F_{MSY}upper is precautionary.
- If the species has a large asymptotic size (>50 cm), it is likely that the range of values between F_{MSY} and F_{MSY}upper is precautionary, and a further investigation can be performed to confirm this.
- 95% of MSY can, on average, be attained between 0.7- and 1.4-times the F_{MSY}, but the upper part of the range should not be used without a detailed investigation of precautionary considerations.

by Rindorf et al., 2017

Exploring different MSY strategies in mixed fisheries when species are related by trophic web





The functional relationships between main species and fleets exploiting deep water rose shrimp in the Strait of Sicily

The F_{MSY} of Hake strategy involves a sharp reduction in the catch and biomass at sea of Deep water rose shrimp and Horse mackerel. The shrimp F_{MSY} strategy allows recovery of SSB of the 3 species without dramatic variations in yield

What kind of Maximum Sustainable Yield?
The case of the deep water bottom trawling in the Strait of Sicily

- In the Strait of Sicily, deep water rose shrimp (DPS) and giant red shrimp (ARA) are the main target of Italian trawling, with over 50% by weight and 61% in value of the total landing.
- Hake (HKE) is the main associated commercial by-catch, with catches accounting for about 10% of landings and 9% in value.
- To achieve HKE MSY in 2020, F would need to be reduced by about 80% of the 2017 value.
- A reduction of F of about 30% would have been sufficient to reach the MSY of DPS.

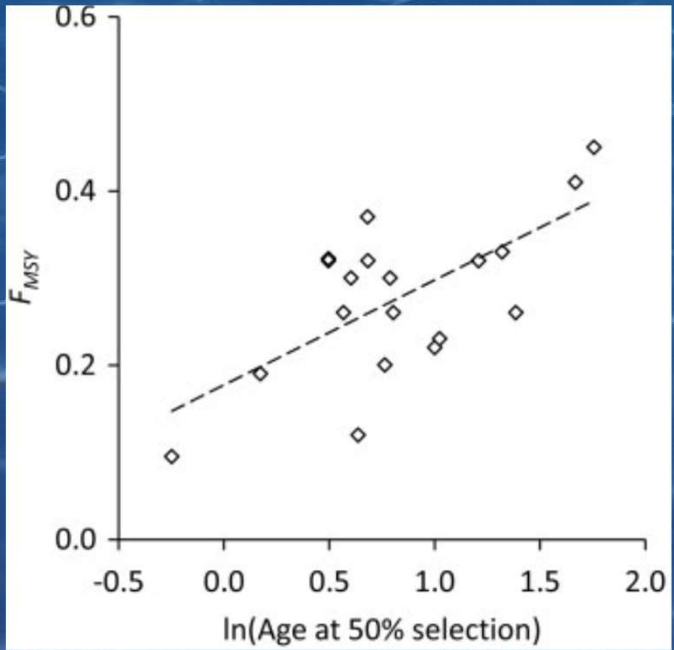
- At the DPS MSY, the HKE SSB would increase by 25% while shrimp catches would remain stable;
- At the HKE MSY, the catch of DPS would be halved.
- Pursuing DPS MSY would provide better profitability, economic sustainability, labor costs and employment in the medium term than the HKE MSY strategy.

…further **improvement in stock status of hake** could be obtained **by adopting technical measures** aimed at improving the **exploitation pattern**

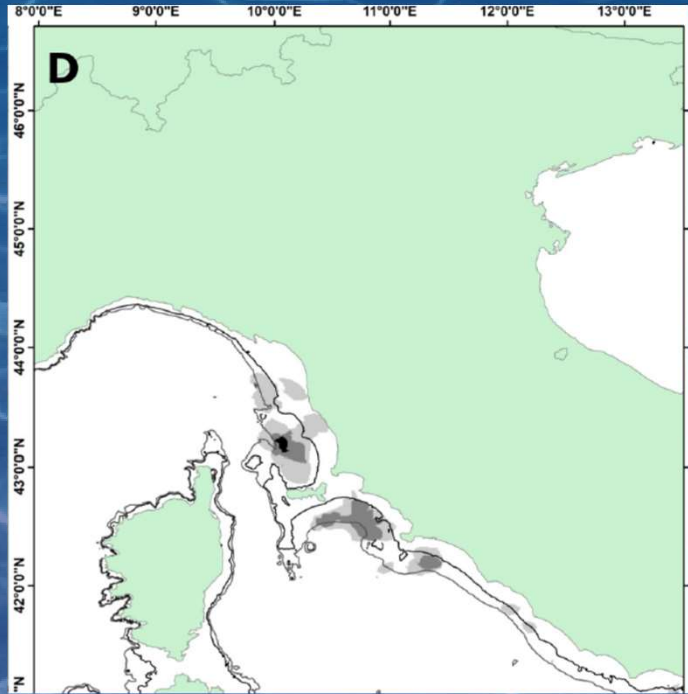
Improving the exploitation pattern in the Mediterranean fisheries

Why do we need to improve the exploitation pattern?

- **the larger the size of the individuals caught, the higher the optimal level of fishing effort**
- **a better pattern of exploitation will mitigate discarding and the related problems (landing obligation)**



F_{MSY} as a function of size at first capture (by Rindorf et al., 2017)

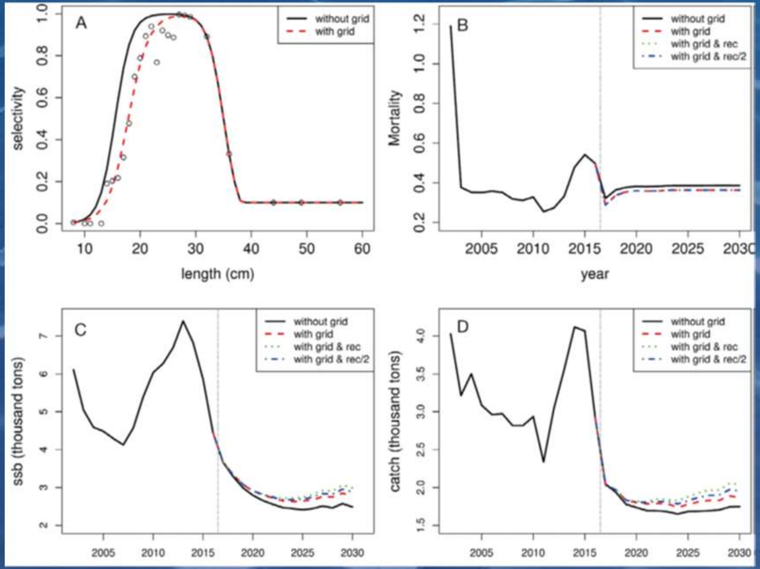


Areas with the highest co-occurrence of undersized Hake, Deep water rose shrimp, and Horse mackerel in GSA 9. Depth contours shown are 100 and 200 m (by Milisenda et al., 2021).

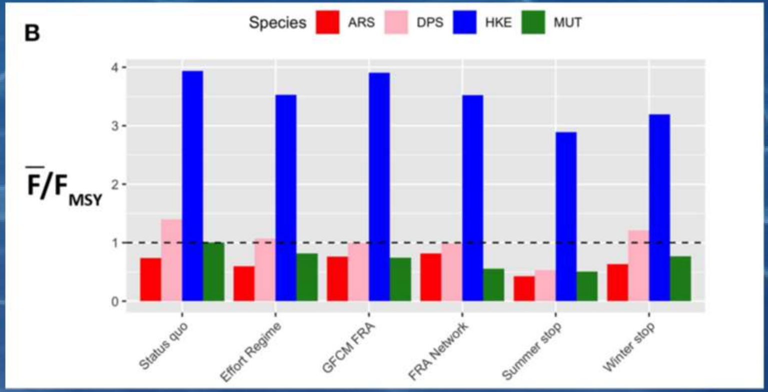
Improving the exploitation pattern in the Mediterranean fisheries

How can we improve the exploitation pattern?

- increasing the gear selectivity by adopting grids and separators allowing undersized individuals to escape in trawling,
- delaying the catch size of juveniles through space and/or temporal closures to fishing when and where juveniles aggregate or a combination of the two approaches.



Gadget simulations plots of HKE stock exploited by trawling without grid (black solid line) and with different kind of grid (colored lines) (by Vitale et al., 2018)



Exploitation rate (F/F_{MSY}) of main target species exploited by trawling in the Strait of Sicily under different management scenarios (by Russo et al., 2019).

Some food for thought

- The global change is expected to modify the sustainable yields of the Mediterranean fishery resources;
- Due to the “flat top curves” in the relationship between fishing mortality and yield, the so called “pretty good yield” (PGY) could be adopted as target for fisheries;
- In identifying the F_{MSY} ranges related to the PGY for management decisions, all values of F within the defined range should avoid to impairing recruitment;
- Realistic objectives in mixed fisheries should be defined and pursued by a gradual and agreed approach, taking into account the whole dimension of fisheries, and adjusting the management measures according to the progress of results;
- In mixed fisheries without food interaction among resources, catch or effort target related to MSY of the main species driving fisheries could be adopted, while the impact on accessory species could be mitigated by space/time closures and more selective nets;
- In the case of mixed fisheries with food interaction among resources, assessment and management could also consider interactions in the trophic network;
- Issues on MSY need to be inserted within the more wide framework of the Ecosystem Approach to Fishery Management, including the ecological, economic, social and institutional dimension.

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