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CERES storyline - dolphinfish in the Mediterranean

What do we expect under climate change?

The dolphinfish *Coryphaena hippurus* ("llampuga", "dorado" or "mahi-mahi") is a world-wide distributed tropical and subtropical large migratory species of commercial intrest. In Europe, the Mediterranean is part of its northern distribution limit. There, dolphinfish lives fast and dies young (max age of 3 years), dwelling surface waters that uses only for reproducing and growing until juvenile stage. After that, adults move (supposedly) to the Atlantic. Only juveniles (age 0) are targeted by a seasonal and intense fishery based on FADS.

Due to its thermal requirements for spawning and growing (above 19°C), it is expected that climate change will affect the

- change in spawning season and area of spawning
- presence of the species in the Mediterranean
- accumulated growth until the fishery is open (always at a fixed time)

The consequences for the fishery can include

- changes size/abundance at the onset of the fishery
- change in presence of the species through the year
- change in market behavior depending on the latter two points

This can lead to the adoption of adaptive management measures, including changing the timing of seasonal closure, plans to incentive/discourage the consumption etc..

How vulnerable is the dolphinfish?

This species meets several requirement of sensitivity to climate change.

1. The studied fishery is located at its northern distribution limit, hence the probability that environmental changes affects distribution/phenology is higher.
2. In tropical areas, the species is present all year round and spawn throughout the year. In the Mediterranean, the thermal window enabling the lively fishery constraints the species to spawn (may-june) and grow until juvenile stage (around 60 cm).
3. The growth of this species is extremely high, attaining up to 70 cm in 6 months, the fishery targets only age-0 individuals and its vertical distribution is mostly confined to the first tens of meters . Therefore, even heat waves will affect the whole fishery in a particular year.

We anticipate that increasing warming can affect the length of the spawning season and the growth of the fish. Therefore, it is not unlikely that this species increases its presence through the year, and that the landed sizes and total catches vary in the coming decades.

What is the economic value of this species??

This species is exploited in the NW Mediterranean by the small-scale fleet in the Balearic Islands, Malta, Italy and Tunisia and supports a major fishery for three months at the end of summer/autumn. In the case of the Balearic islands, for example, It is the most important fish in terms of weight for the small-scale fleet (345 boats in 2010). With less than 10% of effort (boat-days) devoted to this fishery, it generates 26% in weight of all landed fish and 13% of the gains (data for 2004-2016, Palmer et al., in press). Fishing boats are small, around 7m, and catches tend not to exceed 80 kg per trip, although the fishery has established a self-regulated maximum of 200 kg per boat in order to control the prices. Maximum gains are around 45 000 euros/month during the fishing season. The fishery

CERES Office
Universität Hamburg Germany
contact@ceresproject.eu
ceresproject.eu

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employs most fishermen of the small-scale fleet for three months. The fishery is based on purse-seine around fixed FADs whose number and location are strictly regulated, and assigned to individual boats. As an appreciated fish of the season since ancient time, it has profound cultural value in these places.

What are the challenges?

The main knowledge gaps that will try to be solved within CERES are:

- Environmental constraints for spawning and growth (physiological limits, ranges of preference)
- Historical series of abundance, or proxies for it
- Species ontogenetic and seasonal movement
- Robustness of the fishing fleet in front of climate change (adaptability, shift in species)
- Relationship between fishery regulations, biological data and the formation of market price

What is the working program in CERES?

1. New data are being extracted from existing otolith collections in order to relate the individual growth variability to changes in environmental conditions. For that, a cooperation with other countries (Tunisia, Italy, Malta) has been established within the frame of CERES and FAO, and otoliths have been provided to CSIC in order to conduct such analyses.
2. In cooperation with the Spanish Institute of Oceanography, all spatially-explicit data from longline catches of adult dolphinfish are being analyzed to delineate the environmental constraints for spawning.
3. In cooperation with the strong industry of sports fishing in the Balearic Islands, a citizen science-based field study has been launched, by which catches of dolphinfish spawners are positioned through GPS and sent to CSIC.
4. Growth: a dynamic energy budget (DEB) model is being explored as a tool to relate temperature-related growth to observations.
5. Spawning constraints. A spatial statistical model based on multiple data sources is being built. Further, we will explore the outcomes of the climate envelope modelling approach for this species, implemented by PML.
6. Abundance index. As no abundance index exists for the species (but it is known that its fishery is based on recruits and it is environmentally-driven), we will apply a Depletion model based on catches that has been recently and effectively used for this species in the Pacific Ocean.
7. Environmental data (productivity, temperature, stratification and eddy kinetic energy) are being explored by comparing the outcome of several existing coupled physical/biogeochemical models (e.g. Copernicus). This process will enable the selection of relevant environmental data that can be projected, and relevant data to be used in shorter-term exercises.
8. We will modify the MEFISTO bioeconomical model (V.4.0) for the species. In particular, we will analyze the effects on:
   - within-season availability to fishermen
   - mean initial size at the onset of fishery (price?)
   - size-progression within the season (will that affect the market?)
9. With all that data, we will work on adaptation strategies of the fishing sector, including the effects of possible adaptation strategies by the artisanal fleets. We will also include an analysis of robustness of the artisanal fleet based on FADs with respect to climate change, and the potential effects of management measures on the flexibility of the fisheries sector to adapt to climate driven changes.

For further information please contact:

Ignacio Catalán

Spanish National Research Council , Spain

E-mail: ignacio@imedea.uib-csic.es

CSIC
Consejo Superior de Investigaciones Científicas

CERES

CERES Office
Universität Hamburg Germany
contact@ceresproject.eu
ceresproject.eu

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