

Identification and mapping of the Essential Fish Habitat of small pelagics: anchovy and sardine in the Mediterranean Sea.

The present proposal aims at the identification of the habitat of small pelagics in the Mediterranean Sea in relation to environmental parameters as well as its temporal variations in order to meet managerial purposes. This will be achieved by compiling and analysing all relevant data concerning anchovy and sardine stocks from several areas of the Mediterranean i.e the Aegean Sea, the Iberian coast ++ **other participated areas**.

- **STATE OF THE ART**

Small pelagics like anchovy, present high fluctuations regarding their abundance as well as their distribution, largely depending on environmental conditions (Freon & Misund, 1999). The study of those environmental parameters that affect the spatial distribution of economically important stocks like anchovy, has gained particular attention lately due to the concern regarding the effect of climate change on fisheries resources (Cury et al., 2003). Furthermore, habitat modelling of a species in relation to environmental parameters has expanded considerably in the last decade (Guisan & Zimmermann, 2000; Riou et al., 2001; Francis et al., 2005; Planque et al., 2007). Defining the potential habitat of a species practically means determining the combination of those environmental factors that constitute suitable conditions for its survival (Guisan & Zimmermann, 2000; Planque et al., 2007). It is increasingly becoming an effective tool for understanding the processes that affect the interannual variability in species distribution and provide essential information for ecological studies and management purposes.

Sustainable management requires the knowledge of species habitat as well as how habitat area changes depending on environmental parameters. Thus, the development of large-scale descriptive and predictive models of fish presence and abundance is fundamental for effective management activities such as placement of Marine Protected Area networks (Conover et al., 2000), spatial zoning of different permitted fishing activities (Rice & Cooper 2003) and regulative use of the coastal environment (Coleman et al., 2004; Francis et al., 2005). The characterization of suitable habitats for different life stages and their seasonal and interannual variability will contribute to a more effective management

The aim of this project is to identify those areas in the Mediterranean Sea that could be considered as potential habitat for anchovy and sardine (i.e. adult, spawning and juvenile grounds) and to predict the temporal (seasonal and interannual) variation of suitable habitats in relation to environmental parameters. Furthermore, the temporal dimension of annual recruitment in relation to the seasonal evolution egg production, extension of spawning habitats and environmental conditions will be addressed in an effort to identify the factors that contribute to population integrity and variability.

For this purpose abundance data concerning anchovy and sardine stocks will be used along with satellite environmental data. Satellite environmental data are readily accessible with low cost allowing predictions for many years, periods within a particular year and different regions and could be used as proxies to infer spatial variability in environmental factors and assess ecological relationships. New powerful

statistical techniques and Geographical Information Systems (GIS) tools have evoked during the last decade and are being widely adapted in the development of predictive habitat distribution models in ecology (Guisan & Zimmermann, 2000; Riou et al., 2001; Francis et al., 2005).

The availability of satellite environmental data that go back in time will allow the study of the temporal changes in spatial indicators and therefore makes them a very good tool for the study of the effect of climate change on small pelagic fish habitat. Moreover, a predictive habitat model based on satellite environmental data allows the prediction of EFH of small pelagics in real time, making it a very useful management tool.

In addition within the project, each species environmental preferences based on field collected measurements of ambient biotic and abiotic environmental conditions will be studied.

- **STEPS OF THE ANALYSIS**

The overall project will be organised into five main workpackages:

WP1. The aim of this WP is to use satellite environmental parameters to identify and map those areas in the Mediterranean Sea that could be considered as Essential Fish Habitat (EFH) for anchovy and sardine in different phases of their life cycle (i.e., adult, spawning and juvenile grounds). For this purpose, the following data will be used:

- ❖ Satellite environmental data
- ❖ Presence absence and/ or abundance data (ichthyoplankton and acoustic data) for anchovy and sardine from different areas of the Mediterranean **i.e. Greece, Spain ++ other participated areas.**

Statistical models e.g. Generalized Additive Models (GAMs) will be used for modeling. The probability of anchovy/sardine presence will be estimated based on available satellite environmental parameters at different periods of the year (*trimester or preferable months?*) depending on the timing of research surveys at sea. Essential Fish Habitat identification will be based on the mapping of those areas related to a specific probability of species presence.

Mapping of EFH will include:

- Task1: Eggs and larvae habitat (data from ichthyoplankton surveys, **participants??**)
- Task2: Juvenile habitat (acoustic and/or fisheries data, **participants??**)
- Task3: Adult habitat (acoustic and/or fisheries data, **participants??**)

WP2: Temporal variation in EFH - Identification of the spatial variability of potential habitats during the last decade.

The aim of this WP is to predict the EFH of each target species during the last decade in an effort to identify whether variability of potential habitats is related to population abundance or fisheries catches. Satellite environmental parameters allow flexibility and predictions for various years. Therefore, the models estimated within WP1 will be used to predict the EFH of each species and the spatial location of preferential sites

across the last 10 years. Mapping of eggs and larvae habitat, juvenile habitat and adult habitat will be the deliverables of the specific WP.

WP3: Species environmental preferences

The aim of the specific WP is to identify anchovy and sardine environmental preferences in the Mediterranean Sea based on field measurements of ambient environmental conditions during research surveys at sea.

For this purpose the following data will be used:

- ❖ available CTD and plankton environmental data (or data from other in situ measurements)
- ❖ Presence absence and/ or abundance data (ichthyoplankton and acoustic data) for anchovy and sardine from different areas of the Mediterranean i.e. **Greece, Spain, other participants?**

Statistical models e.g. Generalized Additive Models (GAMs) will be used for modeling. CTD environmental data (or other field data) at different periods of the year (depending on the timing of surveys) will be used within this WP for the determination of the environmental parameters that are related to the habitat of anchovy and sardine as well as each species preferences for those environmental parameters. This will be done separately for:

- Task1: Eggs and larvae (data from ichthyoplankton surveys, **participants??**)
- Task2: Juveniles (acoustic or fisheries data, **participants??**)
- Task3: Adults (acoustic or fisheries data, **participants??**)

WP 4: Investigation on spatial indicators useful for management purposes:

This WP is particularly focused to link population indices with anthropogenic impact, i.e. behaviour, response to shifts, stress versus fishing pressure, exploitation rates, etc...

The aim of the specific WP is to estimate, based on the results of WP2, a time series of spatial indicators of the population, such as:

- The extent of potential habitat or distributional area
- The ratio of distribution area to spawning habitat
- The ratio of distribution area to juvenile habitat
- The centre of gravity within the distribution area
- The number of species patches within the distribution area

These indicators will be examined in relation to fishing and assessments and fishing effort pattern and the fishing mortality trend.

The final outcome of this WP will be:

- Study the relation of these indicators of spatial occupation with indices of stock size (i.e., stock biomass, recruitment, landings).

- Explore the possibility of setting reference points for these indicators that could be used for management.

WP 5. The temporal dimension of small pelagic fish recruitment

The aim of the specific WP is to demonstrate how the seasonal changes in environmental conditions and spawning habitat affect egg production and subsequent recruitment within an annual reproductive period. A case study will be conducted on anchovy, in selected geographical areas.

First, the seasonal pattern in egg production will be estimated during an entire spawning season (May to September) in selected discrete spawning areas of the Mediterranean, onboard ad hoc plankton and adult research surveys at sea. The number and timing of these surveys will be suitable to cover the entire spawning period.

The resulting survival of eggs and larvae spawned at different phases of reproductive period will be assessed based on otolith microstructure and birth-date distribution analysis of a representative, random sample of juveniles collected in the subsequent late autumn-early winter period.

The seasonal patterns in egg production and inferred offspring survival will be related to the seasonal evolution of the oceanographic environment.

This WP will require additional surveys and further data collection.