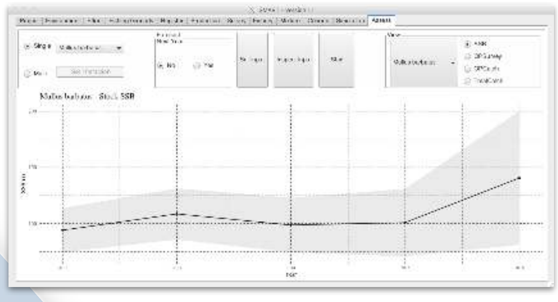
Spatial **M**anagement and **A**ssessment of demersal **R**esources for **T**rawl fisheries in **R**

8. Assess

Evaluate the biological status of the stocks



Input

Population Parameters

Interactions

The starting input for the Assess Module has been prepared in all the previous steps. The user can choose to perform either a Single Species or a Multi-Species stock assessment.

For the single species, the user can inspect the estimated starting parameters and eventually modify as preferred. For the multi-species assessment, in addition to the starting parameter tweaking, the user must supply the interaction network between the studied species as prey/predator interaction, included cannibalism.

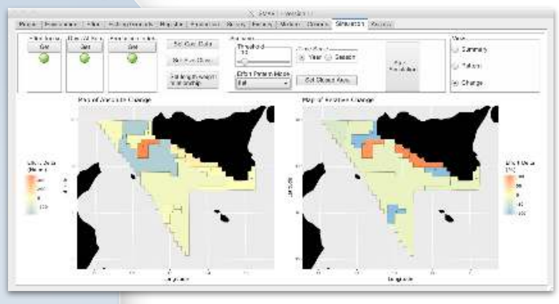
Operations

The Assess Module performs an optimization of the starting parameters to estimate the critical descriptors of the studied species. The optimized parameters include point estimates and variability of the number of recruits, the stock biomass, and fishing mortality.

The assessment follows the framework of a cohort model with Statistical Catch At Age implementation. Specifically, the method is referred to as a model of intermediate complexity or MICE.

7. Simulation

Simulate Management Scenarios



Input

Price

The size/price dataset is a collection of price of species at the market. **Format**: CSV file, with minimum and maximum prices by species and harbor.

Costs

The Costs dataset is built from a sample of vessel with individual based measures of costs. **Format**: CSV file, with vessel IDs, fixed costs, and variable costs.

Strategy

The Management Strategy is made by the different scenario foreseeable by the user. **Format**: the builtin function allows users to select areas subject to fishery restrictions.

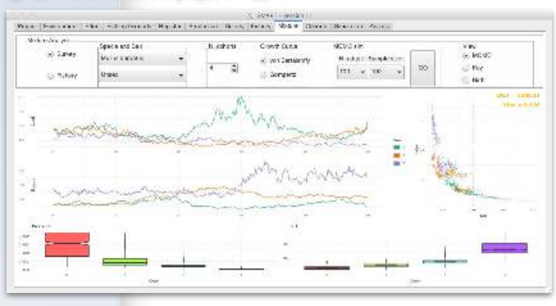
Operations

The Simulation Module performs a stochastic optimization of the individual Fishing Pattern of the studied vessel, seeking the maximization of the fisher profit (revenues minus costs). Other than the explcit input to be provided by the user (species size/price at the market, activity costs, and management strategy), the simulator employs all the intermediate output from the previous steps (observed Fishing Pattern, Fishing Grounds, LPUE matrix, Age/Length Key).

Optimized Effort

6. Mixture

Slice the biological resources into Age Cohorts



Input

Fishery

The Fishery dataset has the same format of the Survey data but it is built from samples provided by the fishers.**Format**: CSV file, with haul position, timestamp, species, weight and length.

Survey

The Survey dataset is built from samples collected during a scientific survey. Each specimen in the sample is classified, weighted and measured. **Format**: CSV file, with haul position, timestamp, species, weight and length.

Operations

The Mixture Module performs a mixture decomposition to identify the age cohorts from the Length Frequency Distribution of the provided species. The Fishery and the Survey dataset are elaborated separately to estimate the growth parameters. The spatial distribution of the species can be merged or it is possible to chose one of the two.

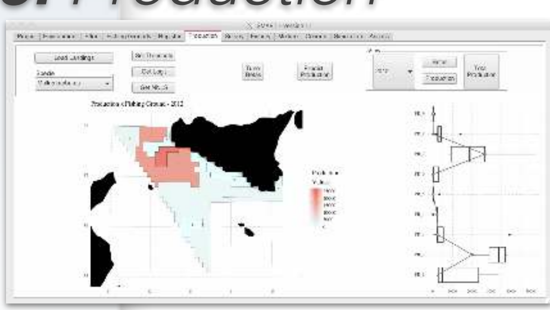
Growth Parameters $L\infty\ K\ t_0$

Age/Length Key

5. Production

Estimate LPUE

Compute Total Production



Input

Landings

The Landings dataset is made of records of the landed quantity by species of a single trip of a sample of vessels. **Format**: CSV file, with vessel IDs, timestamp, species and the landed quantity

Effort Pattern

The other required input is the observed Pattern of Effort (Fishing Hours aggregated by Fishing Ground) as the unit of effort and the landing records (with vessel ID, Timestamp, Species, and Quantity information) both at the individual level.

Operations

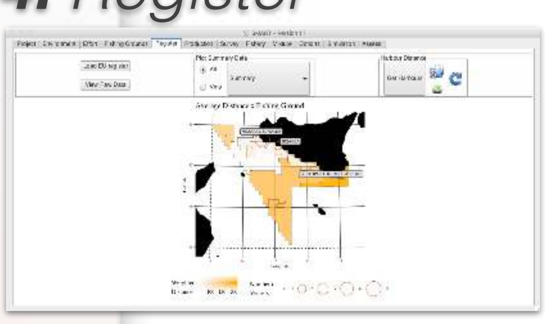
The Production Module loads the raw landings data and connects, for the available vessels, the Effort Pattern to the landed species and quantities. The Logit sub-model discriminates between targeting and by-catch activity. The LANDER model estimates landings rates (LPUE - Landings Per Unit of Effort) for each Fishing Ground.

Logit

LPUE matrix

4. Register

Load Vessel Characteristics



Input

Fleet Register

The Fleet Register stores the vessel specific information as Length Over All (LOA), engine power, and the port of registration. **Format**: CSV file, with vessel IDs, LOA, Power and Port of Registration.

Fishing Grounds

The set of ports names is geocoded to obtain the coordinates of each harbour. The other input is the Fishing Ground configuration from the previous module. The GUI allows users to graphically explore the summary characteristics of the fleet.

Operations

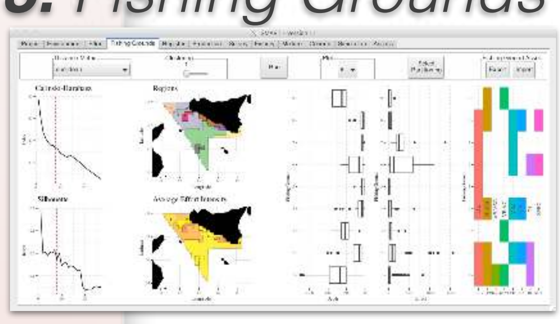
The ***Register Module*** connects the individual characteristics of each vessel to the performed fishing activity. The collected information is employed twice.

First, the port of registration is georeferenced and the average distance between each fishing ground and harbour is computed.

Successively, the LOA and power of the vessel are used to calibrate the individual fishing power in the Production Module.

3. Fishing Grounds

Identify Homogeneous Regions



Input

Environment Data

Effort Pattern

The input for the ***Fishing Ground Module*** is the grid topology, a vector of depth values, the presence/absence matrix of the *seabed* habitats, and the cell-aggregated *Effort Pattern.*

It is possible to supply other custom input. Directly if the provided data conforms to the format, otherwise it is required to adapt the procedure.

Operations

'Regionalization is a classification procedure applied to spatial objects with an areal representation, which groups them into homogeneous contiguous regions'

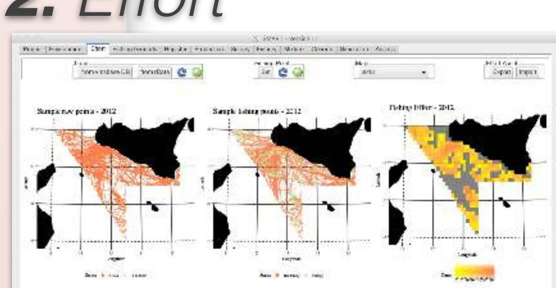
The grid topology is then aggregated into group of adjacent cells with homogeneous conditions. The output of the routine is the regionalised fishing ground configuration.

Fishing Ground Configuration

2. Effort

Identify Fishing Positions

Compute Fishing Effort



Input

vmsbase DB

or custom

The ***Effort Module*** is designed to download already processed data stored in the standard database format of the *vmsbase* package. The data is made by the positions of individual vessels recorded by the VMS or AIS system.

Format: List of dataframes, one for each year, with vessel IDs, coordinates, timestamp, speed and heading.

Operations

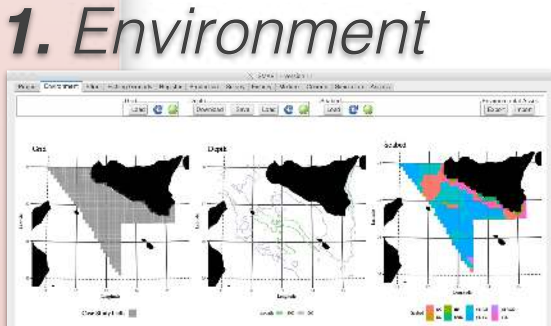
The GUI extracts the effort data from one or more vmsbase SQLite databases.

It identifies the fishing position, based on the gear characteristics, and it computes the individual Effort Pattern aggregated to the grid cells (as individual vessel measures of daily fishing hours by cell).

Effort Pattern

1. Environment

Setup Case Study Area and Environmental Data



Input

Grid

The *Grid* defines the physical boundaries of the case study. The cell size determines the smallest geographical unit. **Format:** Regular square grid as a shape-file.

Bathymetry

Bathymetric information of the area of interest as numerical matrix with the seafloor depth at the center of each cell.

Seabed

Binary data of the bedfloor characteristics as a Presence/Absence matrix of the predominant *substrate* type in each cell.

Operations

The ***Environment Module*** loads the *Grid* to define the case study' extent and the minimal spatial unit of the fishery.

With the *marmap* package, the *bathymetry* data is automatically downloaded and stored as a continuous variable (vector) measured at the grid centers.

The user provided presence/absence matrix for the type of *seabed* is then employed, along with the other variables, to define the *Fishing Grounds.*