

Interactive viewer of information on catch, effort, fleet and fishing grounds

Luciano FORTUNATI⁽¹⁾, Umberto MAMMINI⁽¹⁾, Diana LARI⁽¹⁾, Riccardo CIARDELLI⁽¹⁾,

Fabrizio SERENA⁽²⁾, Alvaro ABELLA⁽²⁾

⁽¹⁾ CNUCE-CNR, Via S. Maria 36, 56126 Pisa (Italy)

(tel.: +39-050-593269, fax: +39-050-904052, e-mail: l.fortunati@cnuce.cnr.it)

⁽²⁾ Ag. Regionale per la Protezione Ambientale della Toscana (ARPAT-GEA), 57100 Livorno, Italy

Abstract

The collection of information through interviews to fishermen at the landings generally produces a set of data related to several aspects: active boats, used gears, fishing areas, fishing timing, landed species and relative weight, fishing effort, etc. If this information is periodically collected, the amount of data rapidly increases. Normally, such data is analysed with tools which do not consider the geographical position of each single datum and hence the produced statistical or synthetic information is not geographically correlated.

The developed system described here is based on a geographical information system (GIS) which can manage and analyse these kind of data (integrated with ancillary data as coastline, bathymetry and toponyms) by referring them to the respective geographical positions, thus producing efficient summaries, both in tabular and graphic form (histograms, charts, thematic maps, tables, ...). The system makes available a set of functions with which users can operate dynamically on the set of data, by selecting from the various parameters that characterise the data (time period, fishing gear, species, ...). The results obtained furnish temporal and spatial information on various aspects of a fishery: a better understanding of fishing strategies, composition and structural characteristics of the active fleet, distribution patterns of the abundance of main exploited stocks constitute a solid starting point for more detailed studies focusing the management and the development of the fishing activities.

The system is based on ArcView GIS 3.1 software by ESRI and Access DBMS by Microsoft. The current version makes use of data related to a specific fishing area for a specific time period but it can be generalised to historical data sets relating to any geographical context.

1. The data

The system operates on two types of datasets: the first is a group of three quite static datasets consisting of ancillary data about boats, gears and species, the second is a growing dataset made of data periodically acquired through interviews to fishermen at the landings. Originally the two datasets were acquired in tabular form and successively inserted as tables in an Access database.

There is also a set of geographical data (acquired from cartography or automatically generated) containing geographic features, used to have a better description of the environment and also as background to represent the results of processing. Specifically, data regarding the bathymetry have been exploited along with data on the coastline and ports; data regarding the fishing areas are automatically generated subdividing the area of study into a set of regular Grid Elementary Areas (GEAs), for which information about fishing activity is acquired. All the geographical data were inserted into Arc/View GIS and organised into layers of homogeneous geographical elements (points, lines and polygons).

1.1 Information samples

The current version of the system makes use of data related to the fishing activities in the Northern Tyrrhenian sea from 1990 to 1998. For this period, information through interviews to fishermen at the landings were collected, once each month. For each fishing boat, a form containing the following information fields was filled :

port and date: fishing trip date, landing port;

boat and gear: boat code, boat name, used gear;

fishing activity: number of hauls, trip time (duration), fishing time (duration), fishing area, min and max depth, effort;

catch: the number of boxes and the weight for each fished species.

These data were then inserted in the database generating thus a set of tables according with the structure reported below.

1.2 Tabular data and their organisation

The several tables containing information on the fishery and on the fishing activities are organised in an Access database (MLFD.mdb) as reported in the Relational Data Model of Fig. 1.1. The more important tables with their description are here reported:

- PORT: contains information about the port and the respective survey area;
- BOAT: contains the structural characteristics of the boats (horse power, gross tonnage, ...);
- GEAR: contains the characteristics of the gears;
- SPECIES: is a list of all the species that includes scientific and common names;
- FISHINGBOAT: contains information about the activity of the boats (trip date, ...);
- FISHINGGEAR: contains information about the use of the gears (trip date, ...);
- FISHINGTRIP: contains information about the fishing activities (trip date, trip time, fish time, hauls, effort, sea depth, fishing areas, ...);
- CATCH: contains information about the catch (species, boxes, weight, ...);
- GEA: is the list of the elementary areas of the grid where the fishing activities were performed (trip date, boat, ...).

There is also a set of working tables defined both in the Access and in the ArcView environments used to contain dynamic information about the current selections or the result of the processing functions.

1.3 Geographical data

A set of six layers of geographic features were used to define the geographical environment:

- LAND and COASTLINE: containing the land (polygons) and the coastline (lines).
- PORTS: identifies the active ports (points) in the surveyed area;
- BATHYMETRY: bathymetry (polygons and lines) referred to 50, 100, 200, 500, 1000, 2000 m. isobaths;

- GEA: a grid of squares (1" x 1" size), aligned to meridians and parallels, defined in the survey area ($X_{\min}= 9^{\circ} 16'$, $X_{\max}= 10^{\circ} 25'$, $Y_{\min}= 43^{\circ} 24'$, $Y_{\max}= 44^{\circ} 06'$);
- CATCH, EFFORT, CPUE: are layers of points used, after processing, to localise the Catch, Effort and CPUE variables relatives to each Grid Elementary Area (GEA). Each point is located in the centre of the respective GEA.

All these data are identified in a reference system of geographical coordinates (longitude, latitude) expressed in decimal degrees (DD); when they are mapped, they are converted in the UTM reference system, with distances expressed in miles. All these data are organised into shape files (.shp) and handled by the ArcView system.

2. System Functions

The system is designed to display information in a synthetic, selective and interactive way, thus enabling the user to select the different parameters that characterise the analysis to perform. These functionalities are available for operating on the previously described data and can be activated by pushing virtual buttons located in the upper part of the user interface.

2.1 Types of selection

The system allows the following selections:

- *port(s) selection*: allows the selection of one or more ports;
- *boat(s) selection*: allows the selection of one or more boats;
- *gear(s) selection*: allows the selection of one or more gears;
- *species selection*: allows the selection of one or more species;
- *period selection by month(s) or year(s)* : allows the selection of the period on month or year basis.

These operations can be performed by using a set of buttons reported in Fig. 2.1. Each button activates, for a further selection, a window (see Fig. 2.2) containing the list of possible choices: multiple selection is allowed. Each selection sets the respective parameter that will be used by the processing function; the initial default selection of all the parameters is set to "All". The current selection is maintained updated in reserved tables of the Access database.

There is also another allowed selection, active only for one specific function:

- *active/total boat selection*: allows the selection of active or all boats for the analysis of the fleet structure. This selection is stored in a global variable.

2.2 Types of representation

The system allows the two types of representations: one for geographical the other for statistical information.

Are part of the first group all the representations of data that can be mapped on a geographical background as:

- a) land, coastline, bathymetry, ports, toponyms: common reference base to all the maps;
- b) location of the GEAs;
- c) distribution of the gear use;
- d) mapping of catch, effort and CPUE (by using proportional symbol);
- e) mapping of catch, effort and CPUE (by using surface);
- f) mapping of catch, effort and CPUE (by using contour).

All the representations (as showed in Fig. 2.3) are carried out in the UTM reference system, with metric coordinates.

Are part of the second group some statistical representations related to the:

- a) fleet structure;
- b) gear use.

These representations (as showed in Fig. 2.4) are carried out as histograms and cumulative histogram.

2.3 Types of processing functions

The system is designed to perform a set of predefined processing functions giving the user information on fleet structure, gears use, catch, effort and CPUE. This can be done in a selective and interactive way, enabling the user to select the various parameters that are involved in the specific processing function. The available functionalities are accessible by the *Function* menu (see Fig. 2.5) in the menu bar.

- *Fleet Structure*: gives information about the fleet structure based on horse power (HP) or gross tonnage (GT): 9 fixed range classes with the respective frequency are reported in two charts representing alternatively their distribution as total or percentage values;
- *Fishing Strategies*: gives information on the frequency of gear use by means of a chart containing a cumulative histogram for a set of used gears in a period of max. 12 months or 12 years (for monthly and yearly representations);
- *Gear Use Distribution*: gives the spatial distribution of the GEA where a specific fishing technique has been used during a chosen period;
- *Catch, Effort, CPUE Distribution*: this function may be performed in subsequent steps obtaining spatial information on the single variables represented by:
 - symbol: a set of circles of 4 different dimensions, which surfaces are proportional to the observed data, are positioned in the centres of each GEA; the classification is performed according to a fanschy schmanschy algorithm;
 - surface: a grid of cells is generated from the symbol representation after an interpolation or kriging process and classified in 10 equal interval classes (NoData included);
 - contour: an 8 levels contour is generated from the surface representation.

After the first step (symbol representation), new layers are added to the view: these can be made visible in addition to the previous active themes, each themes can be overlapped by moving their relative position in the legend area of the view.

It is important to underline here that all the above functions (with exception of the Fleet Structure function) are executed taking into account the current selection of all the parameters previously described: it means that the user can have either a global or a selective (depending on the parameter) information.

There are also three other utility functions, available in the button bar:

- *Program Restart*: to put the system in the initial status;
- *Selection Info*: to see the current selection;
- *Selection Print*: to print the current selection.

3. Architecture

The system was developed using a geographic information system (ArcView GIS 3.1 by ESRI) and a database management system (Access 97 by Microsoft) in an integrated environment. The two systems communicate by using the Open Database Connectivity (ODBC) protocol to access the SQL Server by external programs (see Fig. 3.1). The developed application consists of a set of ArcView scripts in Avenue language, which carry out the various specific functions.

In input the system has two types of data: one geographic, consisting on a set of shape files (.shp) of geographic features, and one tabular, consisting on an Access database (.mdb) and a set of working tables (.dbf).

In output the system produces a set of views and charts in accordance with the specific representations of the different functionalities.

The user interface is based on the standard schema of the ArcView system and includes the documents: *Views*, *Tables*, *Charts*, *Layouts* and *Scripts*.

- *Views*: when the system is activated, the View environment (titled “Mapping of Landed Fish Data”) is set up. It contains the base layers land, bathymetry, coast line, ports, grid elementary areas and toponyms, with the relating legends already set. On this View all the various representations are built dynamically and interactively, starting from the three predefined themes Catch, Effort and CPUE. A series of buttons, specific to the application, are added to the button bar associated with the View, each of which corresponds to a specific selection function. The *Function menu* is also added to the standard menu. Depending on the activated processing function, new layers may be generated, with the respective legends properly set.
- *Tables*: the system uses permanent and dynamic tables. The permanent tables (loaded at start-up or after restart) are those involved in the parameter selection, the dynamic tables are generated by the various processing functions.
- *Charts*: three charts are present: two for describing the fleet structure (by Horse Power and Gross Tonnage) and one for the fishing strategies.

- *Layouts*: three layouts are defined for printing the current View and the current Charts. The layouts have a different structure and contain several elements, as reported in Fig. 3.2.
- *Scripts*: when the system is activated all the scripts of the application are defined.

3.1 Organisation and structure of the system

The system is designed to operate essentially in two phases (see Fig. 3.3): the first consists in the selection of the parameters, the second in processing functions operated on the selected data. This second phase can include, for a subset of functionalities, a further processing step working on the data previously generated.

- *Selection phase*: the user can specify the selection of the parameters (Port(s), Boat(s), Gear(s), Month(s)|Year(s), Species) involved in the further processing steps. For each selection the corresponding tables in the Access database are set with the chosen items. At the start up of the system or when the Reset button is pressed all the tables (and consequently all the selections) are set to “All” (i.e. all items selected). The current selection can be inquired by mean the Info button: this activates the display of all the selection tables showing the current contents.
- *Processing phase*: the user can activate the processing functions that will operate on the previous parameters selection. A first group of functions (*FleetStructure* and *FishingStrategies*) furnishes graphic representations that includes statistical information, the second group (*GearUse*, *Effort*, *Catch* and *CPUE Distribution*) gives a spatial information regarding to the specific theme. This last information is located in the sample points (centre of GEAs) or interpolated creating a spatial continuous (surface) or contour.

3.2 Organisation and structure of the data

There are two types of data that the system manages: geographical and tabular ones. The geographical data are stored in .shp files, the tabular data may consists on tables resident in .dbf files or coming from an SQL query from the Access database (virtual tables).

- Geographical data: consisting on shape files of points, lines and polygons. The following datasets make part of this type of data: bathymetric layers (lines and polygons), emergent land (polygons), location of ports (points), definition of the GEAs (polygons), location of the fishing activity

(points). These files are generated with a GIS, exported as ArcView shape files and inserted in the application's environment.

- Tabular data: consisting of an Access .mdb database and .dbf files containing information indirectly correlated to geographical issues:
 - .mdb database created from a series of Excel tables: a set of Access utilities was used to distribute the information among the different database tables according to the defined data model. A set of working tables (permanent and dynamic) is also created as result of SQL queries generated by the ArcView system. The database updating (not available at present) is planned with a customised user interface that allows the input of data acquired from the interviews directly to the database.
 - .dbf files automatically created by the system at start-up or after restart or created by the user to save specific themes as result of an interesting processing: they contain the complete list of ports, boats, gears, months, years, species.

In general, all the data required by the application are recorded in the ArcView Project structure: if the project is saved previously to the closure of the application, all the data and the selected options will remain and stored with the possibility to be successively used in the next run.

4. Results

The system for the management and analysis of the spatial information associated with the fishing fleet activities described here was utilised for the study of the Viareggio (Italy) fishery (Northern Tyrrhenian Sea) by analysing data proceeding from interviews made in the Viareggio harbour during the landing operations.

The used software allowed to describe the dynamics of the Viareggio fleet. Fisheries in the area are multispecific and several gears and fishing strategies are employed. The frequency of utilisation of each fishing strategy and the structural characteristics of the fleet (Horse Power and Gross Tonnage) and the frequency of use of gears along time were easily graphically displayed. Thematic maps showing the spatial information on fleet and fish resources distribution are very easy to construct by

choosing the gear, samples, species that the user intend to analyse. The graphical representation of maps can be chosen by the user depending on their successive use (circles which areas proportional to the observed values, isolines or areas of homogeneous values obtained by interpolating available information). They were demonstrated very useful for a better knowledge of the quite complex dynamics of the fishing fleet and of its changes with time.

The software allowed to illustrate the changes related to the use of gears and of fishing strategies that show important seasonal changes mainly depending on the availability of certain species in the fishing grounds as well as on changes in the commercial demand. By the analysis of the maps, it was also possible to observe, for each fishing strategy, the seasonal changes on the distribution pattern of fishing effort that may occur. By means of the overlapping of the charts of fishing effort distribution by gear and the charts of distribution of abundance of species a better understanding of which are the target species for each fishing strategy was gained.

5. References

- Kemp, G. Meaden
Visualisation for fisheries management from a spatio-temporal perspective
ICES Annual Science Conference
Cascais, Portugal, 16-19 September 1998
- L. Fortunati, G. Garofalo, R. Demontis
TSDV: a GIS tool for inspecting trawl survey data
ICES Annual Science Conference
Cascais, Portugal, 16-19 September 1998
- Potter, M., Petitgas, P., Petit D. 1997
Interaction between fish and fishing vessels in the Javanese purse seine fishery.
Aquat. Living. Res., 10: 149-156
- Petitgas, P. 1993
Geostatistics for fish stock assessment: a review and an acoustic application.
ICES J. Mar5. Sci. 50: 285-298
- Maynou, F., Conan, G.Y., Sardà F. 1995
*Modelling the spatial distribution and assessment of *Nephrops norvegicus* (L) by geostatistics.*
Rapp. Comm. Int. Mer Médit., 34:35-36

6. Figures

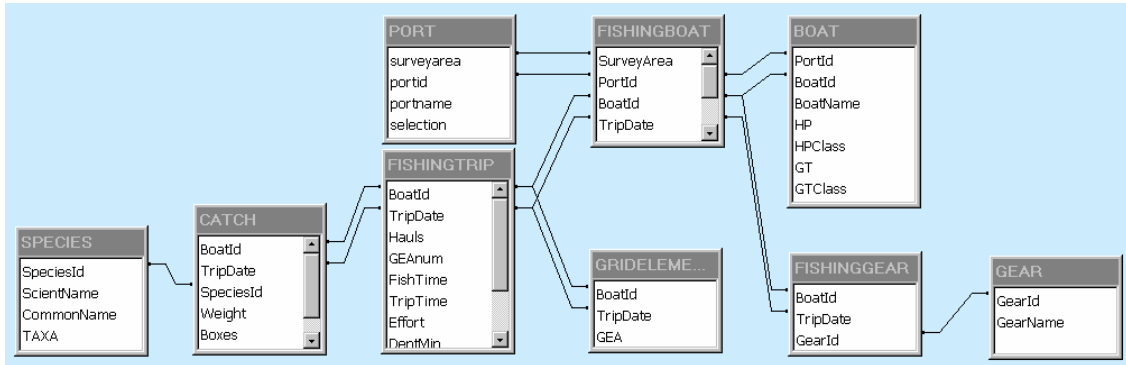


Fig. 1.1 - Data Model

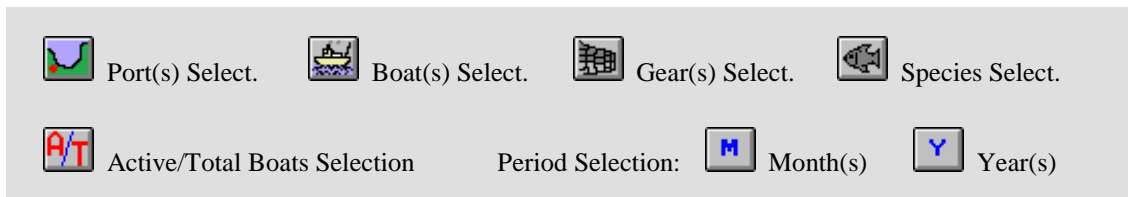


Fig. 2.1 - Selection buttons

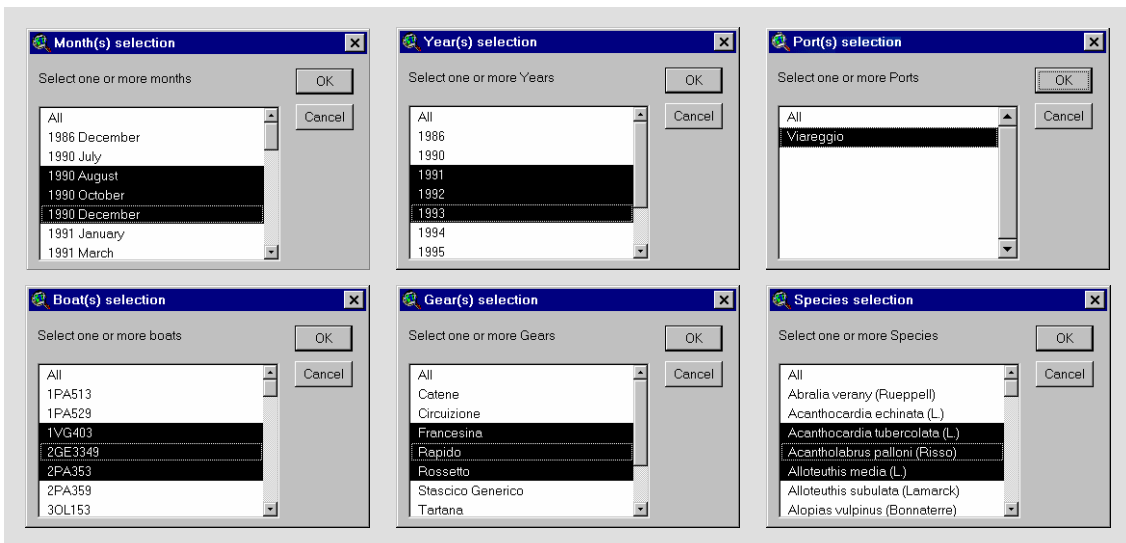


Fig. 2.2 - Windows for single and multiple selection

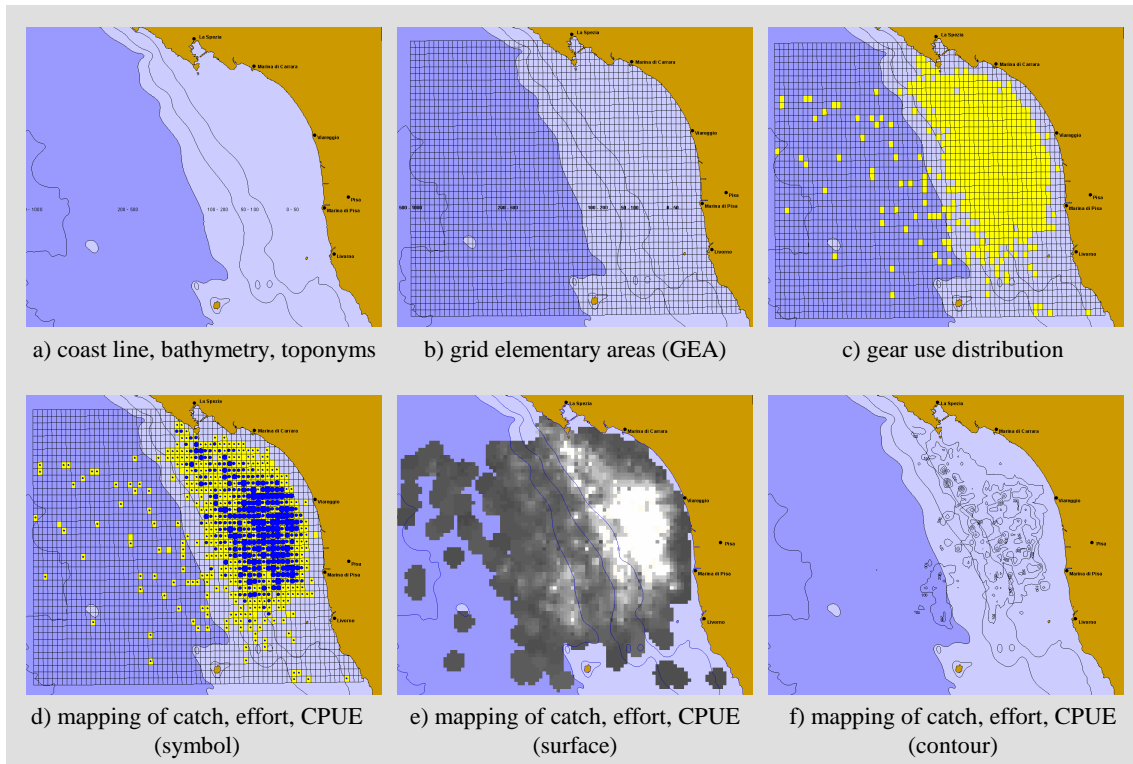


Fig. 2.3 - Geographical representation types

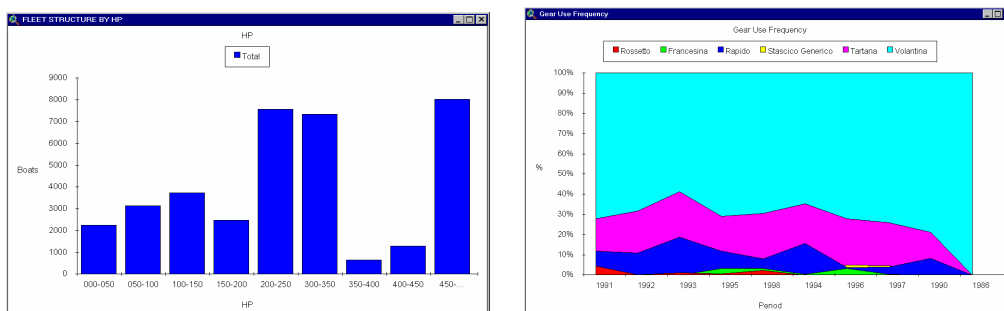


Fig. 2.4 - Statistical representation types

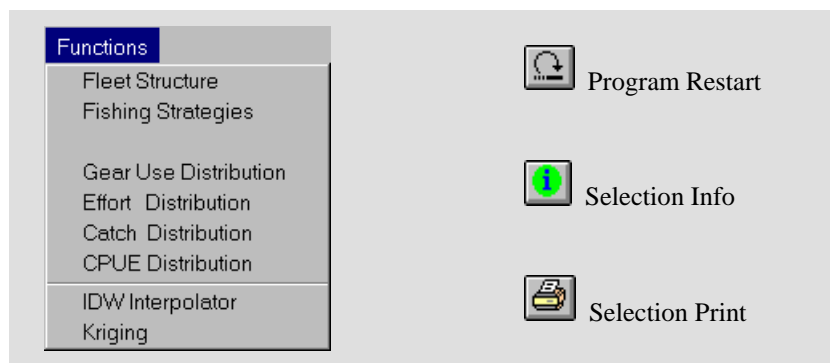


Fig. 2.5 - Function Menu and Utility Buttons

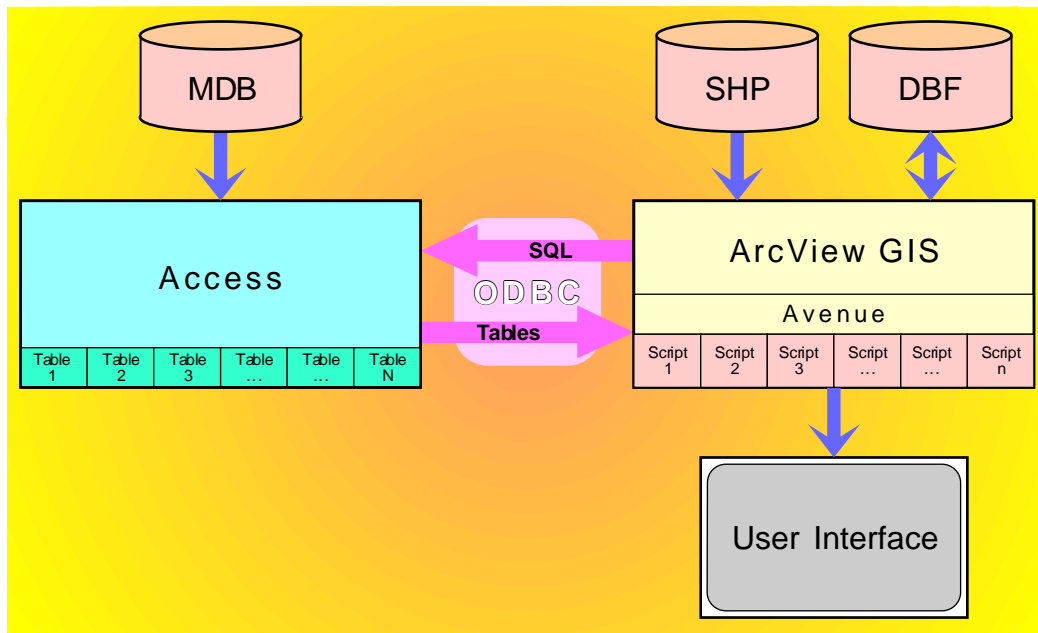


Fig. 3.1 - System Architecture

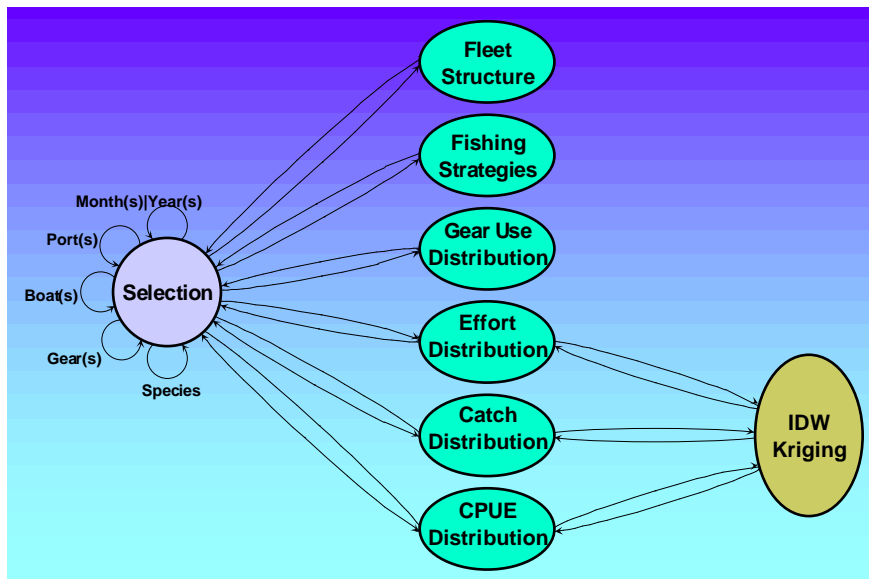


Fig. 3.2 - Operation Diagram

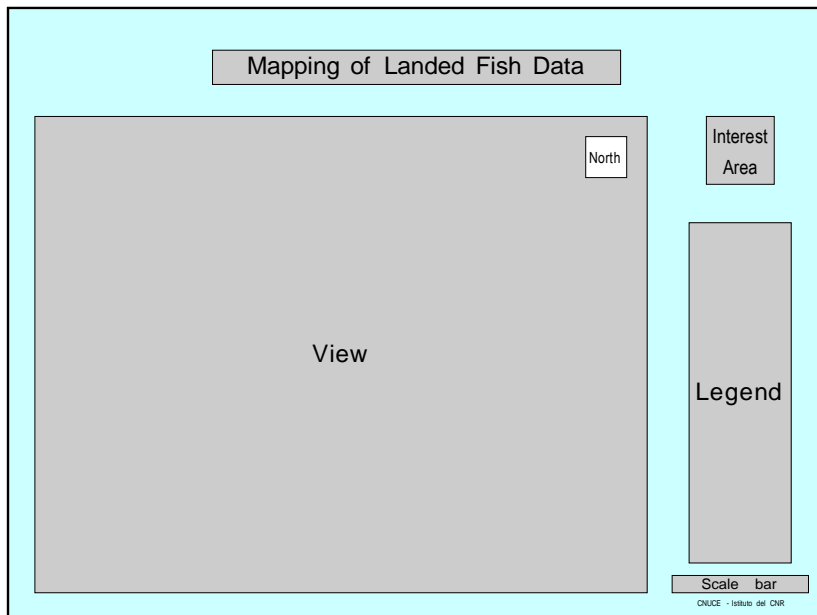
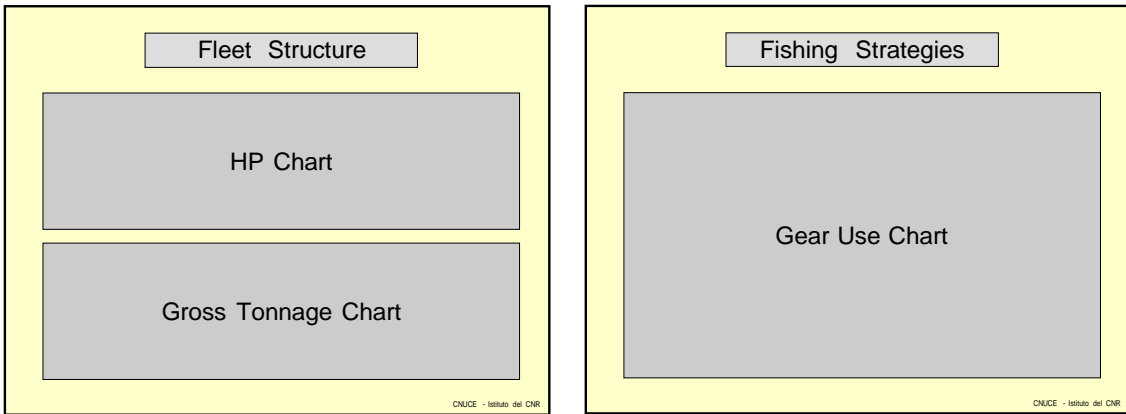


Fig. 3.3 - Print layouts