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Pelagic fisheries in Galicia (Spain): A brief study using GIS and remote sensing imagery

Jesus M. Torres-Palenzuela, Patricia Conde-Pardo, Julio Martín Herrero
Dept. Applied Physics, Faculty of Sciences, University of Vigo, Lagoas Marcosende, 36200 Vigo, Spain
jesu@uvigo.es

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ABSTRACT: An European project has been carried out (from January 01 to August 01) under the title "Pelagic fisheries in Scotland (UK) and Galicia (Spain): observer studies to collect fishery data and monitor by-catches of small cetaceans". In Galicia, these studies provide an opportunity to evaluate the success of the multi-task observer protocols for collecting a variety of data on fishing activities on-board common fishing vessels. All collected data are spatially structured and integrated into a GIS, aiming its analysis in relation to oceanographic factors such as sea surface temperature values (from NOAA-AVHRR) and chlorophyll-a concentration indexes (from SeaWiFS). In this work, data and results corresponding to Galician coast are presented.

1 INTRODUCTION

GIS techniques applied to fisheries can be a very helpful tool for fisheries managers. The need for modern technological aids in fisheries management was stressed by the General Fisheries Commission for the Mediterranean (GFCM) during its 21st Session (Spain, 1995).

Hopefully, GIS techniques could provide only benefits to fisheries studies contributing to:

- Definition of parameters for fishing effort.
- Data organization: database design and graphical analysis.
- Identification of spatial/temporal patterns.
- Spatial overlaying of multiple parameters.

Nowadays, it appears clearly that spatial dimension has to be taken into account when it comes to designing a fisheries management tool.

The main purpose of this paper is to illustrate the utility of GIS tools and techniques in oceanographic studies not only dealing with physical and morphological patterns but also with biological data analysis as for example in the fisheries domain.

The GIS is becoming a promising tool for studying marine fisheries, especially to understand the special behaviour of some stocks and to reveal relationships between features in an easier and faster way (Simpson, 1992).

2 AREA AND SPECIES OF STUDY

2.1 *Area of study*

Galicia is situated in the North-west of the Iberian Peninsula, approximately between the northern latitude parallels 42º and 44º, and between the western longitude meridians 7º and 8º (Fig. 1) The morphology of the Galician coastline is highly variable with a total length of 1,198 Km. Galicia's con-tinental shelf is narrow, ranging in width from 20 to 35 Km. This unfavourable factor (being fisheries mainly situated over the continental shelf) is compensated by the good conditions for fish habi-tability. Richness of the area is largely due to the

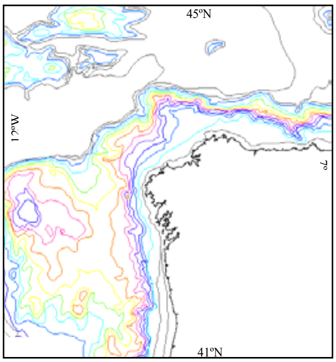

Figure 1. Area of study

periodic upwelling episodes (Fraga, 1981; Blanton *et al.*, 1984). which provide the necessary nutrients to support a high primary production. These favourable conditions make Galicia to play an important role into the world fishery market.

2.2 *Species of study*

Galicia is the leading fishing region in Spain, due to the high stocks unloaded on its many fishing ports situated on a particular and unique coastline consisting of estuaries named "Rias". Among this high productivity we find pelagic fisheries. Species as blue-whiting, mackerel and horse mackerel are caught by bottom and pair trawlers, which operate at depths between 100-200 m.

3 STEPS ON THE PROJECT

We can enumerate the following steps in the project:

- *Task1. On-board collection of catch, discards and effort data for target species*

Observers collect specific data for each trip *("Mareas")* on the biological and environmental domain.

- *Task2. Data base assembly*

All collected data are loaded into a database to be queried by the GIS tools.

- *Task3. GIS integration of on-board collected data and satellite data*

All spatial data are georeferenced (latitude, longitude) and integrated into a GIS to be analysed.

3.1 *On-board collection of data and storage*

Each time an observer goes out to sea, there is new information to be taken. Each observer has a codename (A,B or C) and each day out to sea is reported, so that we are able to classify all data entries by observer and by date.

All the information registered by the observers during the fishing trip is recorded and integrated on the database. All latitude and longitude data can be represented on the GIS to obtain a fishing location map for all fishing trips and observers (see Fig. 2)

Each observer records on a haul by haul basis the following information:

- Species composition of catches and discards as well as catches weight by species.
- Main characteristics of every haul and environmental data, such as fishing location, depth, sea surface temperature, etc.
- General information about vessels such as length, tonnage, hold capacity, etc.

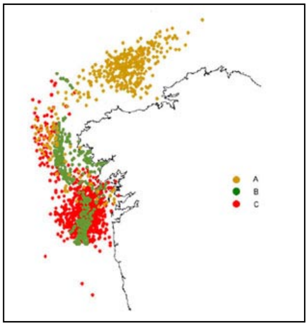

Figure 2. Graphical representation of fishing catches by observers.

3.2 *Data base assembly*

All data, collected on-board by the observers, are structured on a geographical reference to allow a quantitative multi-parameter modelling through the GIS tools.

Over this database scheme, any desired query can be easily done.

3.3 *GIS integration of on-board collected data and satellite data*

The geographical position (latitude, longitude) makes possible to extract fine information of fishing trips.

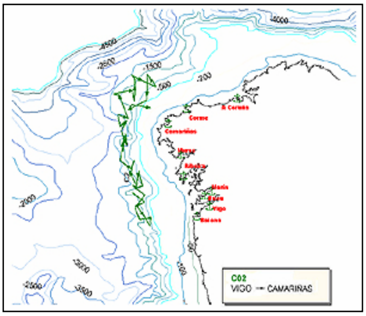

Figure 3. Example of graphical representation of a fishing trip.

All data and images are integrated as different vectorial layouts on GIS software. The main layouts combine coastal line and bathymetry of the geographical area between latitude 41º- 45ºN, and longitude 7º-12ºW.

All satellite images were pre-processed. SST (Sea Surface Temperature) maps were obtained from thermal data from AVHRR (Advanced Very High Resolution Radiometer onboard NOAA satellite) using *AVHRR Oceans Pathfinder SST* algorithm (Walton, 1988; Walton *et al*, 1990), and SeaWiFS (Sea-viewing Wide Field-of-view Sensor onboard SeaStar spacecraft) data turn into chlorophyll-a concentration images using the *SeaWiFS Bio-optical Algorithm Mini-workshop* (O'Reilly *et al.,* 1998).

All satellite images are georeferenced in latitude and longitude and integrated as layouts into the GIS software, so that we can overdraw data taken from the database to obtain any statistical feature of interest.

4 DATA INTEGRATION AND ANALYSIS

The basic idea of the project is the integration of satellite imagery into a GIS, together with the data base information (see Figure 4).

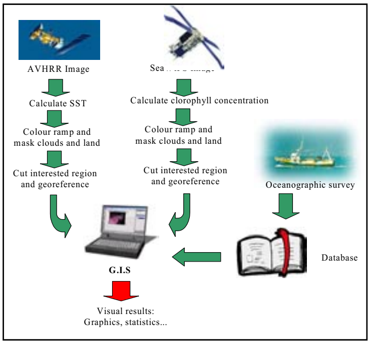

Figure 4. Data integration into GIS.

All overlays into the GIS (coastline, bathymetry, fishing ports) must be referred to a same geographical projection which give directly latitude and longitude coordinates in decimal degrees on the screen.

Probabilistic interpolation techniques were used to elaborate temporal graphics (see Fig. 5) on the basis of data collected on-board the fishing vessels (such as sea surface temperature); or spatial graphics (see Fig. 6), on the basis of data reported by satellite sensors.

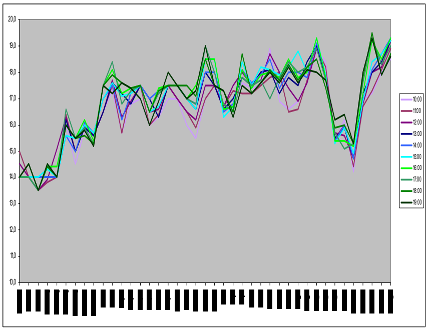

Figure 5. SST obtained by observers on board vessels from 15th May to 19th June.

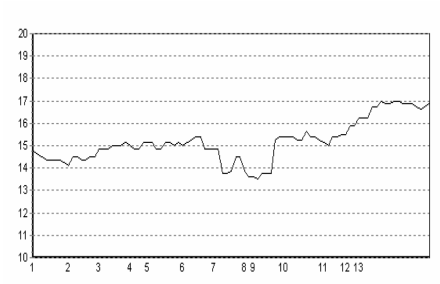

Figure 6. SST graph representation from AVHRR sensor corresponding with the same pixels that the course vessel. X axis represents the hauls positions.

Generating GIS coverages of resources and fishing effort allows incorporation of a high-resolution spatial dimension into population dynamics models. However, that turns into a series of problems: multiplication of the number of parameters, and phenomena such as migration between space units must be taken into account.

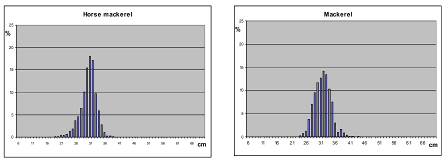

Figure 7. Dynamic Population models. Graphics for target species (estimated from sampling data).

Locating fishing effort is quite a delicate question into a GIS applied to fisheries management. All data must be strictly considered under common criteria. Data collected on board, are the best source of information and database management through GIS or any database engine results into the most efficient and flexible tool for validation and queries (see Figures 7 and 8).

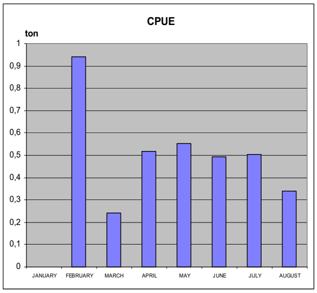

Figure 8. Catch per unit effort

In a study of marine ecosystems we must take into account the oceanographic environment. Oceanic fronts, whether thermal or colour, are the primary sites for aggregations of fish species (Simpson, 1994). With that in mind, the colour scanning instruments (as SeaWiFS) are invaluable instruments when paired with the AVHRR data.

GIS interface combine both biological data and environmental data, offering the scientist a powerful tool on the processing of great amounts of data.

5 RESULTS

With this work was possible to distinguish two periods characterised by their climatic conditions and their corresponding oceanographic phenomenon.

5.1 *Winter period*

The first of these periods corresponds to winter where the cooling phenomenon of coastal waters is mainly due to vertical mixing processes through the water column.

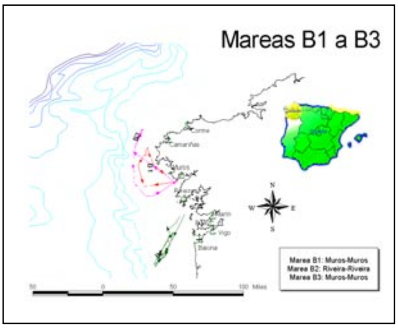

Figure 9. Graphical representation of vessels trips B1,B2 and B3.

Within this period the highest catches are made in the "Mareas" where SST is about 14ºC (Figures 10 and 11).

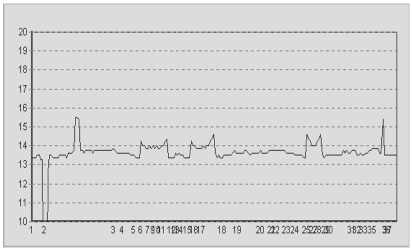

Figure 10. SST for the B1 trip.

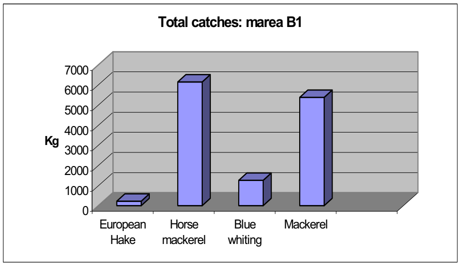

Figure 11. Catches per species in the B1 trip.

Within this period, SST is the parameter that shows more correlation with the maximum catches, being the Horse Mackerel the specie that shows the closest correlation.

5.2 *Summer period*

Upwelling characterises this time of the year. North component winds generate that deep, cool and rich in nutrient waters reach the surface causing an increase in the primary production.

Within this period, maximum catches correspond to the Horse Mackerel. These catches are made in areas characterised by high chlorophyll indexes(Fig. 12 and 13). SST is not the determinant parameter in the catches.

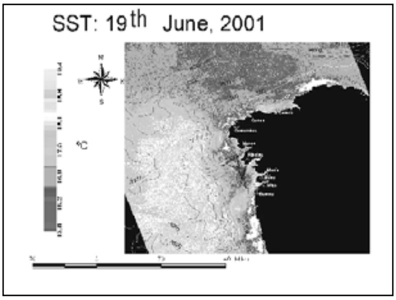

Figure 12. SST image from AVHRR sensor.

In this period there is a high chlorophyll development in the northern area of the Galician coast.

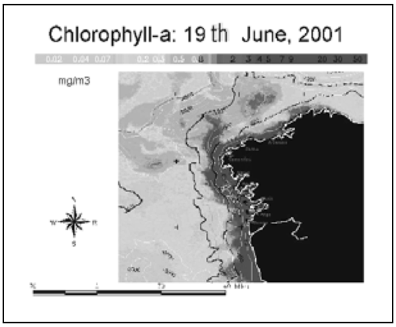

Figure 13. Chlorophyll image from SeaWifs sensor.

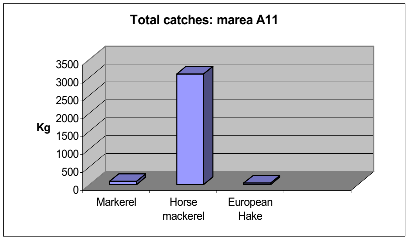

Figure 14. Catches in the "marea" A11 (19th June) in the north area.

6 CONCLUSIONS

A Remote Sensing/GIS system is an invaluable tool for marine fisheries. Both technologies have been proven to be of advantage in fisheries science. A GIS has demonstrated to be an useful tool for displaying of geographical data and permitting the integration of satellite data behind physical and biological parameters.

Thanks to the experience gained in the field of fishery research combined with the technological developments simplifying the management of increasing amounts of information, scientists are capable of processing once again historical datasets in order to better understand the space and time variations affecting stocks. As the accuracy and availability of datasets increases, so do the potential number of GIS applications to fisheries.

The target species with the highest number of catches was the horse mackerel showing also the best relation with the obtained satellite parameters.There are two clearly different periods:

- *Winter,* without upwelling phenomenon, low temperatures are due to a mixing process, highest catches for the horse mackerel at 14º C in SST maps.
- *Summer*, with upwelling where chlorophyll index (and not the SST) determines the high catches of this target specie.These results lead to the fact that the behaviour of some species could be analysed using predictive catch models from satellite data and *in situ* measurements.

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REFERENCES

Barton, I.J., 1995. Satellite-derived sea surface temperatures: Current status. *Journal of Geophysical Research*, 100, 8777-8790.

Blanton, J.O. et al. 1984. Coastal Upwelling of the Rias Bajas, Galicia, NW Spain. In *Hidrography Studies. Rapp. Reun. Cons. Int. Explor. Mer*, 183, pp. 79-90.

Fraga, F. & R. Margalef. 1991. Las Rias Gallegas. In: Estudio y Explotación del mar en Galicia, Universidad de Santiago de Compostela, 1979. 487 p. 101-121.

Fraga, F. 1981. Upwelling of the Galician coast, northwest Spain. In: Coastal upwelling. Ed. F.A. Richards. American Geophysical Union. Washington, 529 p. 176-182

Feldman,G.C. 2000. SeaWiFS Project Home Page. Last updated January 28, 2000.

Fiúza, A.F.G, 1992. The measurement of sea surface temperature from satellites in Space Oceanography, edited by A.P. Cracknell (Singapore: World Scientific), pp 197-279.

Simpson, J.J. 1992. Remote sensing and geographic information systems: implications for global marine fisheries. *A publication of the California Sea Grant College*, Report No. T-CSGCP-025.

Simpson, J.J. 1994. Remote sensing in fisheries: a tool for better management in the utilization of a renewable resource. *Canadian Journal of Fisheries and Aquatic Sciences*, 51 p. 743-771.

Walton, C. C., 1988. Nonlinear multichannel algorithm for estimating sea surface temperature with AVHRR satellite data. *Journal of Applied Meteorology* 27, 115-124.

Walton, C.C., Mcclain E.,P., y Sapper, J., F., 1990. Recent changes in satellite based multichannel sea surface temperature algorithms. *Marine Technology Society Meeting, MTS' 90*, Washington D.C, September 1990.