The Use of MapObjects to map, edit and analyse GPS data from the Portuguese crustacean trawl fleet, for fisheries research purposes

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ABSTRACT

The ActiveX control MapObjects 2.0 Pro was used, within a specific application, to map, edit and analyse GPS data transmitted via satellite by the Portuguese crustacean trawl fleet, every 10 minutes. The MapObjects 2.0 Pro was used, instead of ArcView, because it allows data editing, while spatially displayed, with an immediate database update (implemented with Access 2000). The developed application comprises three modules: the first one maps and edits data for a single vessel or group of vessels, for chosen periods of time; the second one defines the boundaries of all fishing trips performed by vessel along the year; the third one identifies and defines the trawl hauls, within each fishing trip. The fishing trips and trawl hauls were identified by plotting the vessel speed against time, together with the visual inspection of the correspondent vessel track on the map. Semi-automatic procedures were introduced to estimate the limits of each fishing trip and trawl hauls.

1. Background

The Portuguese Crustacean Trawl Fishery

The Portuguese crustacean trawl fishing fleet operates with a 55 mm mesh size gear, in the Southwest (Alentejo) and South (Algarve) coasts of Portugal, between 100 and 700 metres depth (Figure 1). The target species of this commercially important Portuguese fishery (around 5500 tonnes in 1999) are the Norway lobster (Nephrops norvegicus), the pink shrimp (Parapenaeus longirostris) and the blue and red shrimp (Aristeus antennatus). Although Nephrops is the most valuable of
the three species, it is the third most important species landed (in weight). In 1998 and 1999, *Nephrops* represented, respectively, 10 and 5.5% of the total landings of the three species of crustaceans, while *Parapenaeus* was by far, the most important species landed (72% in 1998 and 87% in 1999).

![Map of the Southwest (Alentejo) and South (Algarve) coasts of Portugal showing the area where the Portuguese Crustacean Trawl Fishing fleet operates.](image)

**Figure 1.** Map of the Southwest (Alentejo) and South (Algarve) coasts of Portugal showing the area where the Portuguese Crustacean Trawl Fishing fleet operates.

The crustacean trawlers land in several fishing ports along the Southern Portuguese coast. Almost all the landings are taken in a refrigerated vehicle from the landing port to the fish market in Vila Real de Santo António (VRSA). The importance of this fish market is due to its geographic location, near the boarder with Spain.

DOCAPESCA, the company that runs the fish markets in Portugal, routinely collects the landings statistics of each trawler by fishing trip (of one or more days of duration). This information is assembled and sent, periodically, to the Directorate-General of Fisheries and Aquaculture (DGPA) database. However, there are four
trawlers with freezing facilities that do not sell their catches in the fish market. The catches of these vessels are recorded in logbooks and sent directly to DGPA.

Stock Assessment and Fisheries Management

In this fishery, only *Nephrops* is under Total Allowable Catch (TAC) regulation (ICES, 1999). The assessment of the current state of the South-Southwest *Nephrops* stocks (Functional Units 28 and 29 - Alentejo and Algarve, respectively) is made for the ensemble of the two stocks, by the *Nephrops* Working Group (NWG), which meets under the auspices of the International Council for the Exploration of the Sea (ICES). Within the NWG, the Portuguese Fisheries Institute (IPIMAR) is responsible for the data collection and stock assessment of the Portuguese *Nephrops* stocks. At the present, all three crustacean species have a minimum landing size.

The fishery data used in the *Nephrops* stock assessment are annual landing figures, provided by DGPA and landing size compositions (the landings size structure) raised from samples taken by IPIMAR, in the VRSA fish market. The fishing effort data (number of trips, numbers of hauls per trip and number of hours per haul) is recorded in fishing logbooks by the trawler skipper and may not be accurate. The geographical location is reported at ICES statistical square level (0.5° latitude and 1° longitude or 30 x 30 miles squares), covering very large areas. Therefore, these statistical squares are not suitable to obtain the exact location of the fishing activities. In general, the information contained in the Portuguese logbooks is considered to be unreliable. Therefore, the information on the geographical location or even the area (Algarve and Alentejo) where the catches take place is not included in the current *Nephrops* stock assessment studies.

Data on the location and speed of the vessels
At the same time, information on the location of the crustacean trawlers is being recorded by MONICAP, the National Vessel Monitoring System. Global Positioning System (GPS) data are recorded, every 10 minutes. The location data and related information on the vessel speed are transmitted via satellite in packages every 8 hours. This programme was the first to be implemented in Europe and is now fully working for all trawlers with more than 15 metres long. However, MONICAP data has only been used to control trawling operations, by the Portuguese General Fisheries Inspectorate (IGP). In Portugal, trawling is only allowed six miles off the coast.

The usefulness of MONICAP data for fisheries research purposes is obvious. The full analyses of data provided by this system will allow the possibility to measure and map the fishing effort performed by trawler and for the whole fleet, along the year. The cross analysis of landings with fishing effort will allow to map landings by species. As a consequence, landings per unit effort (LPUE), for each species, can be calculated more accurately and mapped. LPUE can be an important indicator of the biomass of each of the three exploited crustacean populations.

2. The GeoCrust project

The University of Algarve (Faculdade de Ciências do Mar e do Ambiente), with the financial support of the European Community (Study Project DG XIV 99/059), is carrying out a research project (April 2000 - March 2002), aiming to make the most of MONICAP data to improve the stock assessment of the three most important crustacean species, *Nephrops* in particular (Afonso-Dias, 2000). For the first time these data is being used for fisheries research purposes in Portugal. As a consequence, there is a great expectation in turn of this project, since this experience may show the potential of using MONICAP data to study other Portuguese fisheries.
This paper presents the Geographical Information System (GIS), developed within the GeoCrust project, to map, edit and analyse GPS data. The GIS produced was designed to provide data on fishing trips and trawl hauls tracks (within a fishing trip) of the crustacean fleet to be analysed during this project.

2.1. Development of the Geographical Information System

The data and database

A single relational database was created and implemented with Access 2000 to assemble three types of data: daily landings and fishing fleet technical characteristics (source: DGPA) and MONICAP data (only for 1998 and 1999) for the crustacean trawl fishing fleet (source: IGP).

The geo-referenced digital charts

For this study it was necessary to prepare a digital chart for the Southwest and South coasts of Portugal (below 39° North). For that purpose, the fishing charts AP6, AP7 and AP8, published by the Hydrographical Institute in Lisbon, were raster converted (chart AP5 is being prepared at the moment). These charts were geo-referenced and vector converted in order to create the shapefiles correspondent to the following themes:

1. Coastline - Polygon theme;
2. Depth Contours (50,100,150 and 200-1000 meters, step by 100 metres) - Polygon theme;
3. Toponymy - (names of the main cities, including all fishing ports visited by the crustacean trawl fleet) - Point theme;
4. Six miles line off the coast (trawling is only allowed off this line) - Line theme
5. Sea bed sediments - Polygon theme.
2.2. Methodological Options

The initial idea was to use Arcview 3.2 to develop the GIS. This methodological approach was abandoned due to the limitations of Arcview 3.2 to communicate with the external database (DB), in ACCESS 2000. In this project, it is essential to keep the interaction amongst the User, the GIS and the DB as fast and efficient as possible. The GIS must be able to read and change the data written in the DB tables (bi-directional capability). The Arcview does not allow this interaction to be performed in a fast and versatile way. Therefore, we choose to write our own program. The applications were written in Visual Basic and bundled with two ActiveX controls, the ADODB and Map Objects 2.0 Pro, to communicate with the DB and the GIS, respectively.

Apart from the bi-directional communication between the database and the GIS, such methodological option gave us total freedom to create Computer Applications
from scratch, focus on the specific objectives of the project. Once finished, these Applications will have the advantage of being able to be used on their own without any need for external software installed in the computer.

2.3. Description of the software produced during GIS development

The developed software package comprises three parts: the first part is included in application “Viagens.exe“, which allows mapping and editing data for a single vessel or group of vessels, for different periods of time; the second part is included in application “PrgGeocrust.exe” and allows the definition of the boundaries of all fishing trips performed by vessel along the year; the third part, also included in the former application, allows the identification and definition of the trawl hauls, within each fishing trip.

In this study, a “Fishing Trip” was defined as a trip performed by a trawler that produces a particular landing. The fishing trips and trawl hauls were identified by plotting the vessel speed against time, together with the visual inspection of the correspondent vessel track on the map.

The information is organized (and selected) through a system of Menus and can be displayed on a digital chart.

“Viagens.exe” application

“Viagens.exe” was the first application to be created to display MONICAP data by vessel, for different time units and to correct errors. As recognized during the preparation of the database, MONICAP data had a large number of inconsistencies (e.g., different locations for the same vessel in a particular date and time, inconsistent location within a set of locations (track), locations in the mainland, etc) that needed correction. GIS facilities allowed the detection and correction of MONICAP errors.
“Viagens.exe” allows the visual inspection of the spatial distribution of each vessel activity. This analysis can be made by quarter, groups of quarters, groups of trips or just for a single trip (Figure 3).

![Figure 3](image_url)

**Figure 3.** Screen display of “Viagens.exe” showing the spatial distribution of a particular vessel fishing trips performed during the first three months of 1999.

The implemented templates display, automatically, the distribution pattern of each vessel activity by quarter, making it easy to obtain visual information about each group of trips (Figure 4).
This application allowed the detection of outliers and duplicates (Figure 5) and also allowed the correction and proper modification of these data points.

Figure 4. Template displayed automatically by “Viagens.exe” showing the distribution pattern of one particular vessel’s activity, by quarter, during 1999.

Figure 5. Screen display showing the editing of duplicate points in the database.
In any of the above-mentioned cases it was necessary to read, insert and/or delete values in the database. New tables were created in the database to store the changed data.

"PrgGeocrust.exe" application

The “PrgGeocrust.exe” application was created as a tool to identify and define the limits (beginning and end) of the fishing trips and trawl hauls from a selected vessel. This application was divided in three modules. Module A was used to define the fishing trips for each vessel. Module B can only be used after using Module A. Module B allows the definition of the trawl hauls within each defined fishing trip. An auxiliary module was created to analyse the vessel speed frequency distribution. This module was created to find differences in the trawling speed, which is though to be around 3 knots, but that is not always the case (Figure 6).

![Figure 6](image)

Figure 6. Speed frequency distribution of a selected vessel for a particular period of time.

One fishing trip for an average trawler can last from one to four days (time spent fishing that results in one landing) but, for a freezer trawler, it can be longer. For the freezer trawlers, the concept of ‘fishing trip’ is different. These vessels have freezing facilities onboard and do not need to land their catches so often. They can fish for longer periods and do not sell their catches in fish markets. Instead, they
sell their catches directly to fishmongers. The catch statistics of these trawlers are registered on a daily basis in the fishing logbooks. This information is then reported to the DGPA. Therefore, for the freezer trawlers, the records in the logbooks are the only information available regarding catch statistics.

Module A, in “PrgGeocrust.exe”, allows the identification of the exact limits (the beginning and the end) of each fishing trip, either for the average or freezer trawlers, and allows the qualification of the information available (quality of MONICAP data). A map with the vessel track is plotted along with a graph of the trawl speed, for a selected number of days (Figure 7). This way, the user can easily recognize the hauls (performed at lower and constant speed) and visualize the two most important variables used to define the limits of one fishing trip: the speed near zero and the distance from the landing port (excluding the freezer trawlers).

![Figure 7. Screen display of “PrgGeocrust.exe” module A (identification and definition of fishing trips) showing a four days track for a selected vessel and the correspondent speed graph. The red triangles represent landings (sales in the fish market); the green and yellow triangles represent the beginning and the end of one fishing trip, respectively. The beginning (red cross) of a new fishing trip (one day fishing trip) is being defined (green form).](image-url)
A group of different tools was developed to analyse in detail these data. The limits of one fishing trip are defined either using an automatic procedure or a semi-automatic one, depending on the quality of the data analysed. Both procedures were based in algorithms where the first visit to the port immediately before a sales date (sales in the fishing market were supposed to occur always at 6 am) is considered the end of the fishing trip and the following departure the beginning of the next trip. Departures and arrivals from the port are detected controlling the distance of the vessels from the ports.

Module B was created to define individual hauls within each fishing trip. A semi-automatic method was implemented to define the limits of each trawl haul (Figure 8). After this procedure, it is possible to display on the screen many types of information for each haul, namely the length and swept area, duration, location (geographical areas) and depth. This information is generated and recorded in the DB.

Figure 8. Screen display of “PrgGeocrust.exe” module B (trawl hauls definition) showing four trawl hauls within a selected fishing trip for a particular vessel. Three hauls were already defined. The beginning of the last one (red cross in the speed graph and white cross in the map) is being defined.
For each trip, it is possible to display many types of information on the specific composition of the landings (in a table or pie chart format) and fishing effort used to generate this landing (number of hauls, number of trawling hours or the amount of swept area). Landings per Unit Effort (LPUE), calculated as landings divided by effort (number of hauls, number of trawling hours or amount of swept area), can also be displayed.

3. Further Developments

A final application is now being developed to analyse the spatial and temporal distribution of the results (trawl hauls) using the software already described. This application - “Cálculos.exe” - allows the display of trawl hauls for a single vessel or groups of vessels, for a selected period of time and for a selected geographical area.

For this application a set of tools is being developed to visualize and analyse these data. Two different ways of representing the spatial distribution of the trawl hauls were considered: in lines (Figure 9) and using a grid of densities (Figure 10). These procedures allow the estimation of the crustacean trawl fleet fishing effort. The results are displayed and recorded in an Excel spreadsheet (Figure 9).
Figure 9. Screen display of “Cálculos.exe” showing the spatial distribution of the trawl hauls (lines) conducted by a group of vessels, for a certain period. The Excel spreadsheet displayed on the screen contains the correspondent fishing effort statistics.

Figure 10. Screen display of “Cálculos.exe” showing the spatial distribution (grid of densities) of the trawl hauls conducted by a group of vessels, for a certain period. The legend keys for densities and depth are displayed on the screen.
4. References


5. Acknowledgements

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