PERSEUS
POLICY-ORIENTED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

Common methodological procedures for analysis of VMS data, including web-based GIS applications related to the spatial extent and intensity of fishing effort

Deliverable Nr. 3.4

The research leading to these results has received funding from the European Community's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n° 287600 – project PERSEUS (Policy-oriented marine Environmental Research for the Southern European Seas)

This deliverable is to be referenced as follows:
Kavadas, S., Carmen, B., Andrea, B., Piera, C., Stefano, C., C Camilla, C., Lorenzo, D-A., Dokos, J.,Maina, I., Martinelli, M., Massutí , E., Moranta, J., Parisi , A., Quetglas, A., Russo, T., Santojanni, A., Vasilopoulou V., 2014. *Common methodological procedures for analysis of VMS data, including web-based GIS applications related to the spatial extent and intensity of fishing effort*. **PERSEUS Project.**
ISBN no: 978-960-9798-14-3

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Project Full title		Policy-oriented marine Environmental Research in the Southern EUropean Seas	
Project Acronym		PERSEUS	
Grant Agreement No.		287600	
Coordinator		Dr. E. Papathanassiou	
Project start date and duration		1st January 2012, 48 months	
Project website		www.perseus-net.eu	
Deliverable Nr.	D3.4	**Deliverable Date**	19/12/2014
Work Package No		WP3	
Work Package Title		Upgrade-expand the existing observational systems and fill short term gaps	
Responsible		Dr. Joaquin Tintore	
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Status:		**Final (F)**	●
		Draft (D)	
		Revised draft (RV)	
Dissemination level:		**Public (PU)**	●

	Restricted to other program participants (PP)	
	Restricted to a group specified by the consortium (RE)	
	Confidential, only for members of the consortium (CO)	

CONTENTS

Subtask 3.3.3: Fishing Fleet Vessel Monitoring System (VMS)

Responsible: **HCMR**

Participants: **IEO, CNR**

The main aim of Subtask 3.3.3: According to the DOW of PERSEUS, "common methodological procedures will be applied for the analysis, the construction of thematic maps and finally the visualization via GIS. Specifically, the objectives of this subtask are to homogenize data sets and construct a common database, evaluate the quality of the VMS data, introduce a common methodology for data analysis and setting of visualization standards, construct procedures to processes data, design a user-friendly GIS interface". VMS data for Mediterranean EU fishing fleets operating in Spanish, Italian and Greek waters will be compiled and analysed. Progression of the VMS data integrity and structure will also be discussed by considering existing efforts related to the existing VMS systems.

Deliverable: D3.4. Common methodological procedures for analysis of VMS data, including web-based GIS applications related to the spatial extent and intensity of fishing effort.

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Executive summary / abstract

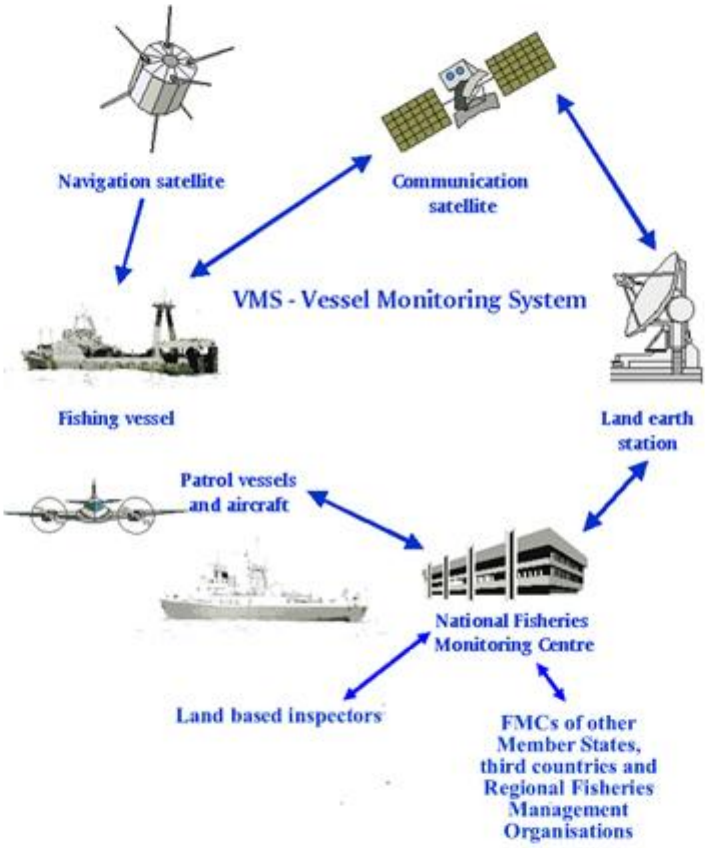
The main aim of the SUBTASK was to apply methods for the analysis of VMS data with the prospect that each method may constitute a common analysis approach among the collaborators for the treatment of such data. The second aim was to develop a web based GIS platform to visualize the results of the analysis. During the implementation period, different approaches were introduced to achieve these goals and several methods were used among partners for the analysis of VMS data. VMS data were combined with other parameters such as bathymetry, environmental parameters, distance from coast, presence/absence of species etc. VMS data from trawlers were analyzed for the western (Spain), central (Italy) and eastern (Greece). Purse seines data were analyzed for Italy and Greece. In addition, the fishing pressure from trawlers and purse seines was used as a criterion in a multi-criteria decision analysis model to estimate a fishing footprint index from coastal fisheries. The results of VMS analysis is important information for the scientists and constitutes a basic cartographic background for studies related to conservation status of a fishing areas, identification of areas with high fishing pressure, migration patterns and movement strategies of the fishing fleet, identification of fishing grounds, etc.. For the analysis purposes, specific routines were developed and where required, specific adjustments were made in order to meet the needs of the analysis. In the framework of the subtask, a part of a PhD thesis was undertaken. The methodologies are available on PERSEUS web site for common use.

Scope

The specific objective of the current deliverable refers to how VMS data can be analyzed and how the results can be combined with other biotic and abiotic parameters. The achieved output meets the requirements of the Common Fishery Policy (CFP) for managing European fishing fleets and for conserving fish stocks (effective monitoring of fishing activities). The proposed methods produce high quality estimates of fishing effort and fishing activity of the fleet, that meet another direction of CFP which refers to "reduce unwanted catches and wasteful practices to the minimum or avoid them altogether". The fishing effort estimates constitute necessary information which must be available for management purposes. From the scientific point of view, "good quality" estimates of fishing effort are required in order to be used in management plans for the operation of different fishing gears and for modelling purposes. Moreover, in the framework of Data Collection Regulation (DCF) there is an obligation for all Member States to analyze VMS data and produce specific indices related to distribution of fishing activities (DCF indicator 5), aggregation of fishing activity (DCF indicator 6) and areas not impacted by mobile bottom gears (DCF indicator 7). The cartographic backgrounds can be used as a "fishery status component" in a generally model according to PERSEUS targets.

Introduction

The vessel monitoring system (VMS) is a satellite-based monitoring system which at regular intervals provides data to the fisheries authorities on the location, course and speed of vessels.



VMS is nowadays a standard tool of fisheries monitoring and control worldwide, but it was the EU which led the way, becoming the first part of the world to introduce compulsory VMS tracking for all the larger boats in its fleet. The EU legislation requires that all coastal EU countries should set up systems that are compatible with each other, so that countries can share data and the Commission can monitor that the rules are respected. Another case is, when VMS data are requested in the context of a specific investigation and provided by the Member State as a file containing VMS positions. At the Commission, the data are processed under the responsibility of the Head of Unit MARE/D4 (Directorate-General for Maritime Affairs and Fisheries, Directorate D: Mediterranean and Black Sea), acting as the Controller"

http://ec.europa.eu/dgs/maritimeaffairs_fisheries/index_en.htm

The essential components of VMS function are tracking vessel locations, identifying possible fishing activity and providing a means of communication. Examples of management rules where VMS could be effective will probably include restrictions related to geographic areas.

These might include but not be limited to:

- an area which is closed for either fishing or navigation or other activity;
- an area which is closed at particular times;
- an area which is restricted for fishing or other activity, to certain vessels on the basis of nationality, type, size, licence status, etc;

- an area for which the amount of access is to be timed or counted and
- an area which is subject to quota or other catch restrictions.

The above, or combinations of the above, are quite common in fisheries management practice. VMS may be applied quite simply and effectively in most of these situations. For example, in monitoring whether a vessel conducts fishing activity in a closed area. In other situations, particularly where quota or catch restrictions apply, it may be necessary to modify the management rules to enable VMS to be fully effective in achieving the management objective. For example, in monitoring a catch restriction on a particular area, it may be necessary to restrict vessel operations to that single area for a given voyage (it is easier for VMS to show no fishing in other areas and port inspections to confirm the size of a catch). This may cause some inconvenience to vessel operations and may not be practical as a result. However, in many situations it will be practical to use VMS with some modification of management rules and this should not be overlooked." (FAO, 2005-2014). The analysis of VMS data can be a significant input for several modelling approaches combining VMS data with bathymetry, environmental and oceanographic data, fisheries data (catches, landings, discards), sea bottom types and habitats.

Legislation

Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006.

Commission implementing regulation (EU) No 404/2011 of 8 April 2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy.

Other monitoring systems

Vessel detection system (VDS)

The EU is also encouraging a wider use of Vessel Detection Systems (VDS), a satellite-based technology (satellite imaging of sea areas) which may help to locate and identify fishing vessels at sea. According to EU legislation (Regulation 1224/2009), fisheries control authorities shall have a technical capacity to use VDS. The basic function of VDS is to allow the identification of vessels and the detection of their positions at sea.

Automatic identification system (AIS)

The Automatic Identification System (AIS) is autonomous and continuous vessel identification and monitoring system used for maritime safety and security which allows vessels to electronically exchange with other nearby ships and authorities ashore the vessel identification data, position, course and speed.

EU fishing vessels will gradually need to be equipped with AIS transmitters:

- As from 31 May 2012: all vessels above 24 m
- As from 31 May 2013: all vessels above 18 m
- 31 May 2014: all vessels above 15 m.

Member States may use AIS data for monitoring and control purposes.

Combined monitoring

The modern technologies for fisheries control do not replace traditional control and surveillance methods, such as inspections onboard vessels or on shore. However, used correctly, the new technologies help to better target actions and therefore cut costs and increase effectiveness. By crosschecking data collected via the different systems, fisheries authorities can apply risk based control strategies and detect illegal activities that could otherwise go unnoticed. Wise, proper and effective use of modern technologies significantly reduces the total costs for fisheries monitoring and surveillance.

Data availability, data use

According to the Commission Regulation (EC) No2244/2003, fishing vessels with total length greater than 15 meters are obligated to be equipped with Vessel Monitoring System, which provides by each vessel the location, heading and speed to the fisheries authorities at a two-hour interval dataset. VMS data are characterized as "confidential" and are provided after relevant application document by the responsible authority. If a university or a research center requests these data, there is a commitment that the data will be used only for research purposes and never the activity of a specific vessel will be reported. This means that the identification number of the vessel is protected and does not become visible anywhere.

The starting period to collect VMS data differs between countries. For Spain and Italy the staring year was 2006 while in Greece was the year 2009. For the purposes of this subtask, Spain analyzed data covering the area of Balearic Islands for the year 2012. Italy and Greece analyzed data covering the whole country: 2012 for Italy and 2010-2011 for Greece.

Common data base structure

A common data base structure was proposed to hold information of VMS signals (Table 1.), the registered fishing vessels (Table 2) and the fishing ports (Table 3). Data for the registered fishing vessels and fishing ports are provided by the European Commission under the fleet register web platform:

http://ec.europa.eu/fisheries/fleet/index.cfm

Table 1. VMS signals

FIELD NAME	DESCRIPTION	DATA TYPE
CD_COUNTRY	Country	VARCHAR2(3)
VMS_CFR	Vessel Identification number	VARCHAR2(9)
VMS_DATE	Day-month-year-time	DATE
VMS_LATITUDE	Latitude	NUMBER(7,4)
VMS_LONGITUDE	Longitude	NUMBER(7,4)
VMS_SPEED	Speed of vessel	NUMBER
VMS_COURSE	Course of vessel	NUMBER
VMS_VESSEL_GEAR1	Gear 1	VARCHAR2(3)
VMS_VESSEL_GEAR2	Gear 2	VARCHAR2(3)
VMS_VESSEL_TYPE	Vessel type	VARCHAR2(32)
EST_DEPTH	Estimated depth	NUMBER(4)
DIST_COAST	Distance from coast	NUMBER
GSA	GSA	VARCHAR2(10)
FISH_RECT	Fishing rectangle	VARCHAR2(5)
RECT_5MIL	Rectangle 5x5 mil	VARCHAR2(10)
RECT_10MIL	Rectangle 10x10 mil	VARCHAR2(10)
TERRITORY	Territory flag	CHAR(1)

Table 2. Registered fishing vessels

FIELD NAME	DESCRIPTION	DATA TYPE
CD_COUNTRY	Country code	VARCHAR2(3)
CFR	Vessel Identification number	VARCHAR2(12)
EVENT CODE	Event Code	VARCHAR2(3)
EVENT START DATE	Event Start Date	DATE
EVENT END DATE	Event End Date	DATE
LICENSE IND	License indicator	CHAR(1)
REGISTRATION NBR	Registration Number	VARCHAR2(12)
EXT MARKING	External marking	VARCHAR2(12)
VESSEL NAME	Vessel name	VARCHAR2(64)
PORT CODE	Port code	VARCHAR2(3)
GSA	GSA	VARCHAR2(10)
IRCS CODE	IRCS Code	CHAR(1)
IRCS	IRCS	VARCHAR2(16)
VMS CODE	Vms Code	CHAR(1)
GEAR MAIN CODE	Gear Main Code	VARCHAR2(3)
GEAR SEC CODE	Gear Sec Code	VARCHAR2(3)
LOA	Overal length	NUMBER
LBP	Lbp	NUMBER
TON REF	Tonage Reference	NUMBER

FIELD NAME	DESCRIPTION	DATA TYPE
TON GT	Tonage GT	NUMBER
TON OTH	Tonage Other	NUMBER
TON GTS	Tonage GTS	NUMBER
POWER MAIN	Power Main	NUMBER
POWER AUX	Power Aux	NUMBER
HULL MATERIAL	Hull Material	CHAR(1)
COM YEAR	Commercial Year	NUMBER(4)
COM MONTH	Commercial Month	NUMBER(2)
COM DAY	Commercial Day	NUMBER(2)
SEGMENT	Segment	VARCHAR2(3)
EXP COUNTRY	Export Country	VARCHAR2(3)
EXP TYPE	Export Type	VARCHAR2(3)
PUBLIC AID CODE	Public Aid Code	VARCHAR2(3)
DECISION DATE	Decision Date	DATE
DECISION SEG CODE	Decision Seg Code	VARCHAR2(3)
CONSTRUCTION YEAR	Construction Year	NUMBER(4)
CONSTRUCTION PLACE	Construction Place	VARCHAR2(3)

Table 3. Fishing ports

FIELD NAME	DESCRIPTION	DATA TYPE
CD_COUNTRY	Country	VARCHAR2(3)
CD	Fishing port	VARCHAR2(3)
NAME_GR	Fishing port name	VARCHAR2(50)
NAME_EN	Fishing port name (ENGLISH)	VARCHAR2(50)
CD_MATCH	Census Match code	VARCHAR2(12)
LATITUDE	Latitude	NUMBER(7,4)
LONGITUDE	Longtitude	NUMBER(7,4)
FISHING_AREA	Fishing area	VARCHAR2(32)
GSA	GSA	VARCHAR2(10)
FAO_CODE	FAO code	VARCHAR2(6)
CD_REGION	Region code	VARCHAR2(2)
CD_PREFECTURE	Prefecture code	VARCHAR2(3)
NSS_AREA	National Statistical Authority fishing area	VARCHAR2(7)
SEA_CD	Sea code	VARCHAR2(6)
GULF_CD	Gulf code	VARCHAR2(6)
BAY_CD	Bay code	VARCHAR2(6)
COVE_CD	Cove code	VARCHAR2(6)
CHANNEL_CD	Channel code	VARCHAR2(6)
REG_PORT_FLG	Registered port flag	VARCHAR2(1)
ISLAND_LAND	Island/Land flag	VARCHAR2(1)

References

EC, 1224/2009. Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006. Official Journal of the EU L 343, 1–50.

EC, 2244/2003.. Council Regulation (EC) No 2244/2003 of the European Parliament and of the Council of 18 December 2003 laying down detailed provisions regarding satellite-based Vessel Monitoring Systems, Official Journal of the EU L333/17

FAO 2005-2014. Fisheries and Aquaculture topics. Vessel Monitoring Systems. Topics Fact Sheets. Text by Andrew Smith. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 27 May 2005.

http://www.fao.org/fishery/topic/13691/en

Analysis of VMS data

VMS data analysis can be explained through two modules:

1. **Procedures and methodological steps**: This is the basic part concerning the common methodological procedures for VMS data analysis. The aim is to estimate fishing effort indicators and to define common spatial references for visualization. The methodological steps are:
    a. Primary analysis
        i. Quality control of data (duplicated records, vessel positions on land, implausibly high speeds, headings outside compass range);
    b. Data enchancing (integate legislation and bathymetry, interpolation);
    c. Metier identification (combine VMS data and logbooks);
    d. Estimation of fishing effort indicators (Days at sea, Days*GT, Days*KW, fishing hours,);
    e. Visualization (spatial cell size, geographical coordinate system, etc.);

2. **Fishing effort applications**: The aim is to use the output of the fishing effort estimates to various implementations satisfying National and European requirements. In the framework of PhD thesis supported by PERSEUS, the following applications were introduced:
    a. Identification of fishing grounds for the target species of a gear (e.g. bottom trawl);
    b. Identification and mapping migration spatiotemporal patterns of the investigated fishing fleet;
    c. Data Collection Framework indicators (distribution of fishing activities, aggregation of fishing activity and areas not impacted by mobile bottom gears)
    d. Using VMS data from trawlers and purse seiners to Multi Criteria Decision Analysis to estimate fishing pressure index;
    e. Evaluate fisheries statistics data using VMS fishing effort estimates;

The module 1 as well as a, b, c, d from the module 2 are consistent for CFP purposes.

A review of methods by each partner and the adjustment to common methodological procedures are described in the next sections.

Concerning the module 1 it will be useful to emphasize the following:

While different approaches and tools have been applied and tested by each partner (see next sections), a common methodological workflow was defined and applied to the different national VMS datasets. This workflow is represented in Fig. 1.

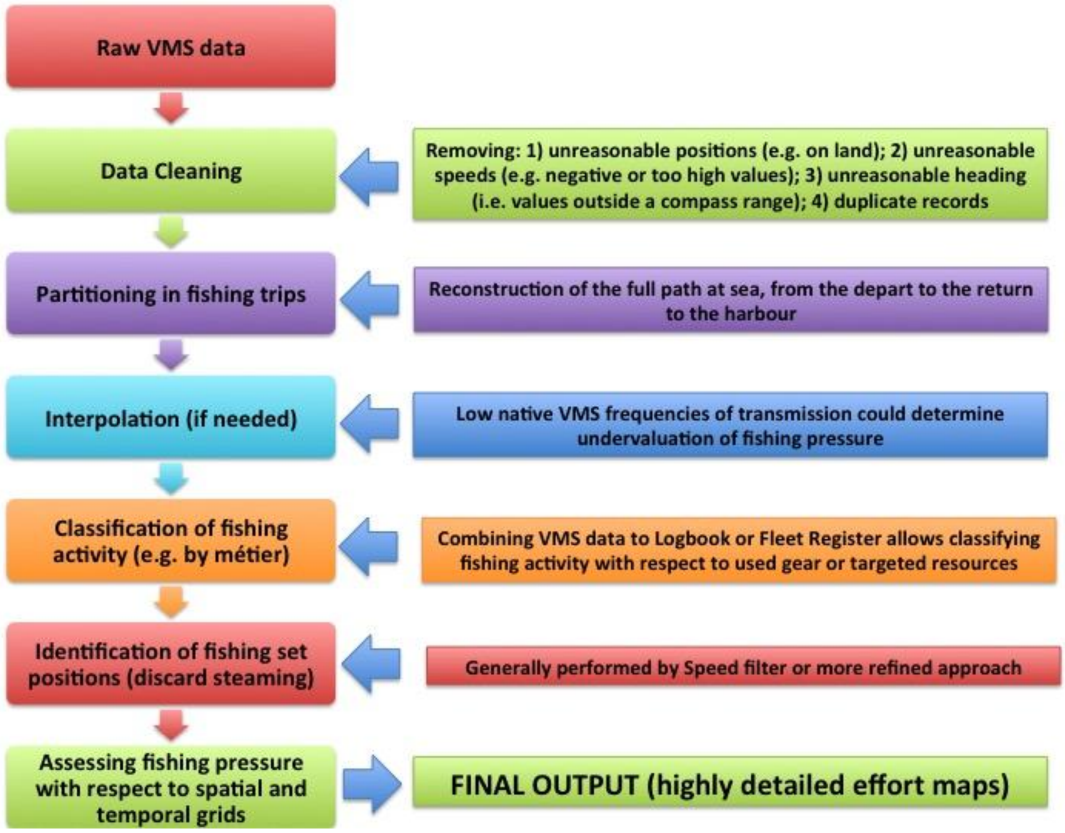


Fig. 1. Workflow for module 1 (Procedures and methodological steps)

Basically, the workflow is aimed at refining the information provided by VMS data, even reducing noise, and enhancing it by crossing VMS data with external sources of information such as bathymetry and Logbook data.

While the main output of this workflow is represented by Fishing Set Positions (FSP) with related information about vessel characteristics (overall length of vessel, engine power KW, etc.) and used gear, accessory outputs can be produced in terms of descriptors/indexes of fishing pressure.

It is important to stress that, while the different methods and tools are characterized by adjustments and are customized on the basis of the available data (with can therefore differ in terms of format, structure and issues), the rationale defined by this workflow is already respected. In this way, the workflow allows obtaining preliminary outputs, which can be used for different and more advanced analyses.

Methodologies and results: a case study for Greece

VMS data are provided by the Hellenic Ministry of Maritime Affairs, Islands and Fisheries (following a requesting procedure). VMS data are characterized as confidential, and only the results obtained from the analysis of data may be published. The available datasets cover the period from January 2009 until December 2013. The Fisheries Data Center of the Institute of Marine Biological Resources and

Inland Waters is responsible to host the data, to evaluate, analyze and distribute the results of the analysis in maps or in statistical tabulated matrices.

VMS data analysis and estimation of fishing effort from trawlers and purse seiners

In Greece, all trawlers (295 vessels) are equipped with VMS, while 225 purse seiners and 84 coastal vessels have total length greater than 15 meters and therefore are equipped with VMS. The majority of coastal fishing vessels are not obligated to have VMS.

PRIMARY ANALYSIS OF VMS DATASET

Data quality control constitutes a basic step in VMS data primary analysis. Some common errors in VMS dataset are:

- vessel positions on land
- implausibly high speeds (over than 20 knots)
- headings outside a compass range (0 to 359)
- duplicated records

In addition, vessel positions lying either in harbours or very close to them were identified. After filtering out the common errors, points in harbour were removed using a 300 meters buffer from coastline. Vessels with the same fisheries strategy (trawlers or purse seiners) identified by the type of vessel's license which provided by the fleet register. For the classification of mobile polyvalent licenses, as trawlers or purse seiners, temporal and spatial restrictions for each fisheries strategy were used. For example fishing vessels with mobile polyvalent licenses which usually operate in the period from June to September that fishing from trawlers is prohibited, are classified as purse seines.

It was assumed that a "fishing day" for trawlers is a 24 hours period and for purse seiners is the period from 20:00pm until next day's 4:00am which differentiated by one hour during winter months (19:00pm to 4:00am). Classification of fishing activity as "fishing", "steaming" or "mooring" consist one of the most important processes in VMS data analysis. Speed thresholds for trawlers and purse seiners, dependent on depth stratum, experimental sampling and onboard observations, were used in order to define the "fishing" activity. It considered that trawlers are classified as "fishing" at speed intervals lower or equal to 4 knots and purse seiners at speed intervals lower or equal to 1 knot. In addition fisheries legislation for both gears was integrated in order to define fishing areas that fishing activity is permitted (Kavadas & Maina, 2013).

ESTIMATION OF FISHING EFFORT

Fishing effort from trawlers and purse seiners was estimated for signals that classified as "fishing". The distribution of fishing effort expressed in days at sea, in days multiplied by *Gross tonnage (GT)* and also in days multiplied by *Kilowatt (KW)* (Kavadas & Maina, 2013). It was assumed that every vessel visits a fishing rectangle (5x5 km) more than once at a "fishing day"; thereby a weighted value is given in each rectangle is dependent on the number of visits it receives within 24 hours. Annual and monthly distribution maps of fishing effort estimated by the following procedures (Table 4).

Table 4: Methodology to estimate the fishing effort by grid cell

(a) Each group of signals spatially joined to the related grid cell (5x5 km)	
(b) Calculate the number of signals (p) per vessel (v) and day (d)	$T_{v,d}$=count($p_{v,d}$)
(c) Calculate the number of signals per grid cell (c), vessel and day	$T_{c,v,d}$=count($p_{c,v,d}$)
(d) Allocate weight in each grid cell per vessel and day. The resulting value is multiplied by tonnage (GT) and power engine (KW)	$E_{c,v,d}= T_{v,d,c} / T_{v,d}$ (≤1) $\Sigma E_{c,v,d}=1$ (one "fishing day") $G_{c,v,d}= E_{c,v,d}*GT_v$ $W_{c,v,d}= E_{c,v,d}*KW_v$
(e) Estimation of fishing effort by 5x5 grid cell	$DS_c= \Sigma_v\Sigma_d E_{c,v,d}$ $GTD_c=\Sigma_v\Sigma_d G_{c,v,d}$ $KWD_c=\Sigma_v\Sigma_d W_{c,v,d}$

The produced maps are presented in ANNEX-I, Figure 1 to 20.

Spatio-temporal distribution of fishing pressure on bathymetric zones

The spatio-temporal distribution of fishing pressure on bathymetric zones based on VMS data of Greek bottom trawlers and purse seiners fishing fleet. Annual and monthly distribution maps of fishing effort in conjunction with bathymetric contours for fixed depth strata (lower than 100m, 100 to 200m and 200 to 500m), were used in order to estimate total fishing effort by depth stratum. To avoid the problem of fishing rectangle's (5x5 km) adjacent overlapping in depth strata edges, fishing effort was included as a proportion of the area that falls inside each stratum. For the comparability of fishing effort values between bathymetric zones, the total fishing effort of each zone was computed by 1000 km^2 (Maina, et al., 2013).
The produced maps are presented in ANNEX-I, Figure 22-23. This methodology was submitted as a poster in the framework of 40th CIESM congress (see ANNEX-II, page 1).

Using VMS fishing effort estimates to evaluate fisheries statistics data

Annual fishing effort from trawlers distributed in five sub-areas of North Aegean Sea according to the Hellenic Statistical Authority (EL.STAT) sampling scheme. For each sub-area, annual fisheries production data provided by EL.STAT was correlated with the corresponding fishing effort, in order to evaluate fisheries statistics data. Two indicators were calculated by sub-area and by year:

- ratio between days at sea (d) and total days at sea (Td) in the study area (d/Td);
- ratio between fisheries production (p) and total fisheries production (Tp) in the study area (p/Tp).

These indicators were correlated in order to evaluate the reliability of EL.STAT fisheries production estimates for each sub-area. Moreover, trawler's fishing fleet by registration port was investigated spatially (Kavadas, et al., 2013a). VMS, fleet register and EL.STAT fisheries statistics data hosted in the integrated fisheries information system IMAS-Fish (Kavadas, et al., 2013b).

This methodology was submitted as a poster in the framework of 40th CIESM congress (see ANNEX-II, page 65).

The use of vms data to identify migration spatial patterns of open sea fishery

Migration spatial patterns investigated for nine sub-areas of Aegean Sea according to the Hellenic Statistical Authority (EL.STAT) sampling scheme. VMS signals for trawlers and purse seiners, to which quality control analysis has been carried out and signals are classified as "fishing", allocated by vessel, fishing area (EL.STAT), year and month. These signals combined with the Fleet Registry census data expressed by fishing port. Pivot tables were used in order to reveal the variation of vessel's fishing activity in sub-areas that vessels are registered, in combination with fishing activity in sub-areas that vessels are distributed, according to VMS data (Maina & Kavadas, 2013).

Identification of patterns

At a preliminary stage, VMS signals which are characterized as "fishing" (Kavadas & Maina, 2012), were combined with the location of registration ports which distributed in nine fishing areas of Aegean Sea, according to the Hellenic Statistical Authority sampling scheme. The total number of VMS signals per fishing area and month led to a primary exploration of spatiotemporal patterns.

The exploration of global measures reveals whether a pattern is "dispersed", "random" or "clustered" in space and over what scale that clustering occurs (Fortheringham et al., 2000, Fortin & Dale, 2005). The global exploration of patterns is based on the estimation of two statistical measures: the Global Moran's I statistic and the Ripley's K function. The Global Moran's I statistic measures spatial autocorrelation is based on a variable's locations and attributes (Moran, 1950). It was used for assessing the overall pattern and trend of fishing effort and finally for the evaluation of the most appropriate scale to be used in Anselin Local Moran's I test. In order to measure the intensity of spatial clustering for each distance, Z scores were estimated by Global Moran's I statistic for a series of increasing distances. Ripley's K function examines how the spatial clustering or dispersion of feature centroids changes when the neighborhood size changes (Ripley, 1977). In this work, the Ripley's K function is used in order to evaluate the overall scale of clustering.

Mapping clusters

The exploration of local measures, examines the location of bottom trawlers hot spots in the Aegean Sea and the "stability" or "non-stability" of these hot spots, on monthly basis. Anselin Local Moran's I statistic was applied to monthly fishing effort values, for identification and mapping of statistically significant hot spots. The Anselin Local Morans'I statistic (Anselin, 1995), detects local spatial autocorrelation and it can be used to identify hot spots, local clusters or spatial outliers as well as to reveal the areas of high fishing pressure. The analysis of global and local measures was made by ESRI's spatial statistics module (ESRI, 2011). Hot spots were combined with the VMS signals and the location of registration fishing ports. The identification and mapping of a hot spots variability index that expresses the alterations in migration of bottom trawlers, estimated by aggregating the hot spots for all months. Hence, a variability index for the entire fishing period was created.

This work was presented in the framework of PERSEUS GA meeting (Athens January 2014). In Fig. 21 on ANNEX-I, the variability index of the bottom trawlers hot spots for 2010-2011 is presented. An extended paper was submitted in the 11th Panhellenic Symposium of Oceanography and Fisheries (will be held in Lesvos at May 2015).

Using VMS data from trawlers and purse seiners to multi criteria decision analysis to estimate fishing pressure index

Due to the increasing development of the fishing fleet that operates in the coastal zone and the limited information about spatial distribution of coastal fisheries, a combination of geographical data and Multi-criteria Decision Analysis methodology was applied in order to estimate fishing pressure from coastal fisheries index (FPc). FPc estimated by fuzzy product process of the coastal fishery suitability index (Sc) and the spatial coastal vessels activity index of registered vessels in the study area's ports (Ac).

Estimation of Sc based on certain evaluation criteria (bathymetry, distance from coastline, environmental conditions, fishing effort from trawlers and purse seiners etc.) and a simulation process of pairwise comparisons of importance of pressures, which is based on the minimization of the consistency ratio, as a measurement method of the Analytic Hierarchy Process (AHP). Also an indicator, by vessels length and vessels GT, developed in order to estimate the Ac. Spatial interpolation techniques and a Fuzzy membership function have been used for the estimation of the Ac. A sensitivity analysis on the weights of the decision criteria and the performance values of the alternatives were estimated according to the AHP. Also the optimal interpolation result defined by a cross validation process. Additionally four scenarios applied to Fuzzy membership functions in order to select the linear as the most suitable type of function. Finally a spatial clustering process was performed as well as to reveal the areas of high FPc in the study area. This work was submitted in the GFCM-1st Regional Symposium on sustainable small scale fisheries in the Mediterranean and Black sea (ANNEX-II, page 66). An extended paper was accepted by journal Mediterranean Marine Science under the title: "Multi-Criteria Decision Analysis as a tool to extract fishing footprints and estimate fishing pressure: application to small scale coastal fisheries and implications for management in the context of the Maritime Spatial Planning Directive. Authors: Stefanos Kavadas, Irida Maina, Dimitrios Damalas, Ioannis Dokos, Maria Pantazi, Vassiliki Vassilopoulou.

Identification of fishing grounds for the target species of a gear (e.g. bottom trawl)

The potential habitats of the most important commercial species and vessel monitoring system data (VMS) from trawlers were modeled in order to identify fishing grounds. The data for the analysis were collected during research activities conducted by HCMR since 1985. In this work, sixteen target species from trawlers were studied. The methodology is based on: (a) the assessment of the probability of species presence using Generalized Additive Model (GAM), (b) the estimation of a threshold of species presence using the Receiver Operating Characteristic analysis (ROC), (c) the combination of presence/absence model and the estimated fishing effort from trawlers using VMS data, (d) the identification of the main fishing grounds using Hot Spot analysis. The results revealed that the most important fishing grounds are identified in the Northern part of the Aegean Sea, in Euvoikos, Saronikos and Patraikos gulf and in the islands of Chios and Dodecanese. This methodology was presented in the 1st International Congress of applied Ichthyology & Aquatic Environment, November 2014, Volos Greece (see ANNEX-II, page 60).

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Methodologies and results: a case study for Italy

CNR contribution for the Italian case study

Analysis of integration of dataset from Fishery Observing System (FOS) and VMS signals

Area: Central and Northern Adriatic Sea

Period: 2006-2010 dataset

Target fishing fleet: Italian Adriatic Mid-water pair trawlers targeting small pelagic fishes

Introduction to Fishery Observing System (FOS) dataset

Since 2003, seven commercial vessels fishing for small pelagic species in the North and Central Adriatic Sea have been equipped with an integrated system for the collection of data regarding catches, position of the fishing operation, depth and water temperature during the haul.

The FOS was initially developed by the staff of CNR-ISMAR Ancona as part of the EU-FP5 "Mediterranean Forecasting System, Towards Environmental Predictions" (MFSTEP) project, and has been kept active thanks to successive funding from the Italian Ministry of Agricultural and Forestry Policies (Research programme on anchovy and sardine stock assessment in the Adriatic Sea using population dynamics models). At the present time staff of CNR-ISMAR Ancona is involved in the upgrading and spatial extension of this kind of systems in the framework of other two projects (CNR project SSD-Pesca and EU-FP7 project JERICO – "Towards a joint European research infrastructure network for coastal observatories").

The idea for FOS comes from consideration of the fact that variations in environmental parameters play a very important role for fish species, considerably influencing both their reproduction and natural mortality (Santojanni et al. 2006); furthermore, thanks to the frequency of fishing operations and the spatial cover they provide, commercial fishing vessels suitably equipped with data collection systems can produce extremely high quantities of data of interest to oceanographers.

Small pelagic fish –anchovies (*Engraulis encrasicolus*) and sardines (*Sardina pilchardus*) – are amongst the most important fishing resources in the Adriatic (Morello and Arneri 2009). Two methods are used by the Italian fishing fleet to catch small pelagic fish: 1) Mid-water pair trawls (*volante*); 2) Purse seine with light (*lampara*). Vessels monitored with FOS include both *volanti* and *lampare* but Mid-water pair trawlers dataset was selected for the analysis proposed by CNR in this subtask, because of the presence of both FOS and VMS systems on this kind of vessels.

FOS components and function

Essentially, the FOS model used to collect data from 2006 to 2010 was made up of an electronic logbook for collecting fishing data, a sensor capable of recording environmental parameters and a GPS system allowing georeferencing of these data.

The touch-screen electronic logbook (Fig. 2, A) is turned on by the captain of the boat when setting out on a fishing trip; using dedicated software, (Fig. 2, B) it is possible to insert information about quantity and size of the commercial species caught each time the net is used, as well as indicating, when necessary, the quantity and size of the by-catch.

These data refer mainly to the target species, anchovies (*Engraulis encrasicolus*) and sardines (*Sardina pilchardus*), but there is also the possibility to insert data about some other commercial species of secondary importance (e.g. mackerel, horse mackerel).

The logbook is connected to a GPS antenna (Fig. 2, A) that allows to record the route of the boat during each fishing day (1 ping/min) and to obtain the location of the haul. The fishing-net has a sensor (Fig. 2, C and D) attached to it; its mounting position varies with the boat. This sensor records water temperature and depth (as pressure data).

Combining GPS tracks and sensor data recorded (the probe starts to record data once in the water), we obtain length, depth and routes of each haul during each fishing trip (Fig. 3). To these data are added those on catch and by-catch input by the captain.

FOS Products

This system is therefore able to supply catch data for georeferenced hauls, with associated temperature and depth data. From these elements it is possible to obtain estimates of fishing effort and catch, calculated for fishing unit by day, as well as indices of target species relative abundance in terms of size, space (area) and time (Dubroca 2007; Falco et al. 2007).

The catch per unit effort (CPUE) can also be estimated; this can be standardized and used with other available oceanographic data in order to have the best possible understanding of the influence of the habitat on the ecology of the species (Falco et al. 2007). Integration of catch data and oceanographic data is in fact fundamental for understanding the processes regulating fish stock distribution during the various life cycle phases. This information is necessary in order to supply the relevant authorities with indications for sustainable fishery development.

From a strictly oceanographic point of view, the system produces an enormous quantity of data in the form of historical series of georeferenced temperature profiles.

Future developments: FOOS (Fishery and Oceanographic Observing System)

In the near future the sensors currently in use will be replaced with new-generation probes offering greater reliability and able to record more oceanographic parameters (JERICO FP7 EU project). The system will also be upgraded in order to allow both oceanographic and catch data to be acquired in near-real time and to be mounted on vessels using other fishing methods, such as bottom trawling (SSD – Pesca CNR project in collaboration with CNR-IAMC). The upgrade will thus allow the study of other important fishery resources, such as demersal fish and will make the spatial enlargement of FOS-FOOS data collection easier.

VMS from Italian fleet: data and procedures

The Italian fleet consists of about 13,000 vessels, 3500 of which were commercial vessels (the rest were recreational vessels). Over 60% of these 3500 vessels is equipped with VMS. Moreover, the majority (over 60%) of the 2076 Italian vessels equipped with VMS are licensed to use more than a single gear type. VMS data generated from the Italian fishing fleet are currently processed by the methods proposed in Russo et al. (2011a;b).

VMS signals were processed following the rationale proposed by Bastardie et al. (2010) and the methodological procedures set up by Russo et al. (2011a,b) and Russo et al., 2013. At first, raw VMS data were cleaned: duplicated and aberrant (on dry land or too far from the previous/successive pings) pings were removed and in harbor pings were flagged (Fig. 4). Then, the pings series for each vessel were partitioned in tracks, that is trips starting from and ending to a given harbor. Tracks were interpolated at a standard frequency of 10 min between successive pings using the approach described in Russo et al. (2011a) (Fig. 5). The high frequency tracks so obtained were inspected in order to identify and separate fishing from steaming points. This has been done using a simple speed filter (fishing points were associated to specific speed range for each métiers), following a largely used approach which has been validated for towed gear such as trawl (Piet et al., 2007; Lambert et al., 2012). Corresponding logbook data were assigned each tracks using a crossing algorithm. When logbooks were not available, the methodology presented in Russo et al., 2011b was applied to characterize the fishing activity (i.e. the métier). Finally, the fishing points identified this way were grouped per month and plotted over a 3 km × 3 km square grid. The output of this procedure was represented by 48 count grids in which a value (number of fishing points) was associated to each cell (Fig. 6). These grids were used as inputs for the following analyses. However, the procedures developed in the Italian experience with VMS data allow to visualize and manage processed VMS data, even allowing to produce other kind of outputs (Fig. 7 and Fig. 8).

All the above steps were performed using the “**VMSbase**” software, an R package with graphical interface. This package is in the final production phase and will be released within year 2013. **“VMSbase”** also provide the possibility to organize data into a database and then allows to efficiently and quickly managing data, i.e. extract subsets from the whole database (Russo et al. 2014).

Extended information about the methodologies is presented in papers on ANNEX-II, pages 3-59. Selected output is presented in ANNEX-I, Figures 38-41.

VMS model for Adriatic Mid-water pair trawlers

The activity of the midwater pair trawlers operating in the Adriatic sea can be largely captured by the VMS data, since almost all the fishing units are equipped by blue-box. A model of the searching phase characterizing this particular kind of fishing activity is at a developmental stage. This model deals with the selection of fishing grounds as a result of the information (both historical and real-time) retained by each fishing unit and of the reciprocal observation of the behaviour of all the operating fishing units. The aim of this model is the analysis of midwater pair fishery dynamics in the framework of game-theory, eventually providing insights for the evaluation of the effects of different management approaches and of external (e.g. fuel cost) or internal (e.g fish abundance) factors. Moreover, this model will be integrated in a latent-variables model to extrapolate the CPUE provided by FOS data to the whole midwater pair fleet operating in the Adriatic Sea.

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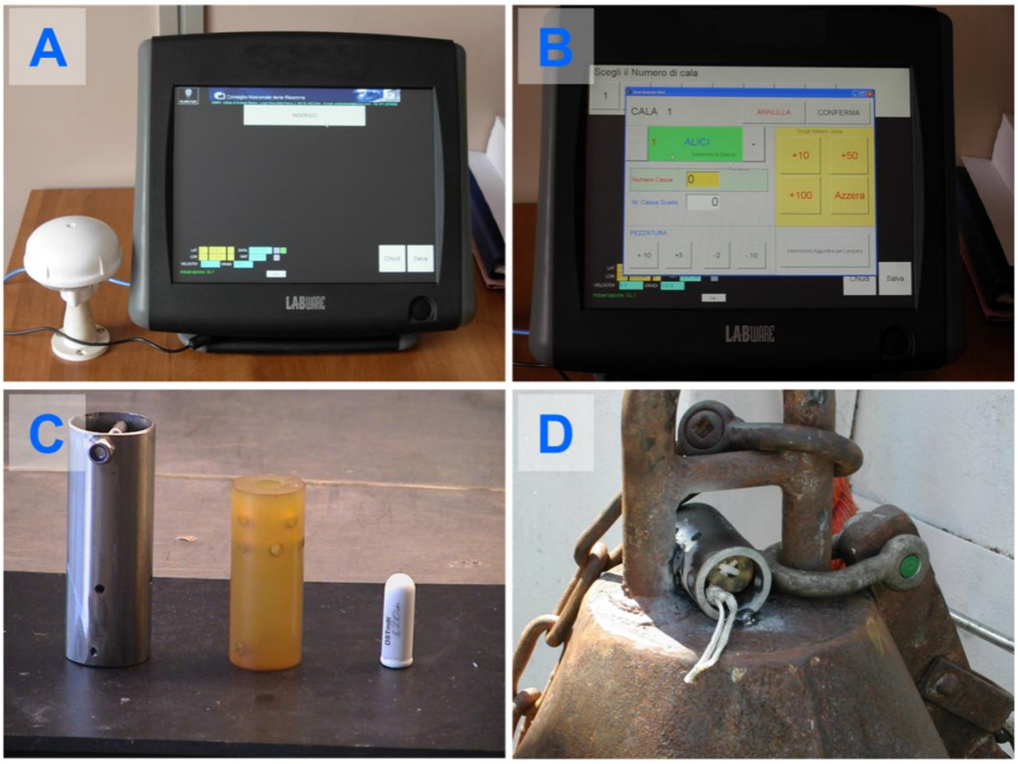

Figure 2: FOS touch-screen electronic logbook and GPS antenna (A), dedicated software for catch data collection (B), temperature and pressure sensors (C, D).

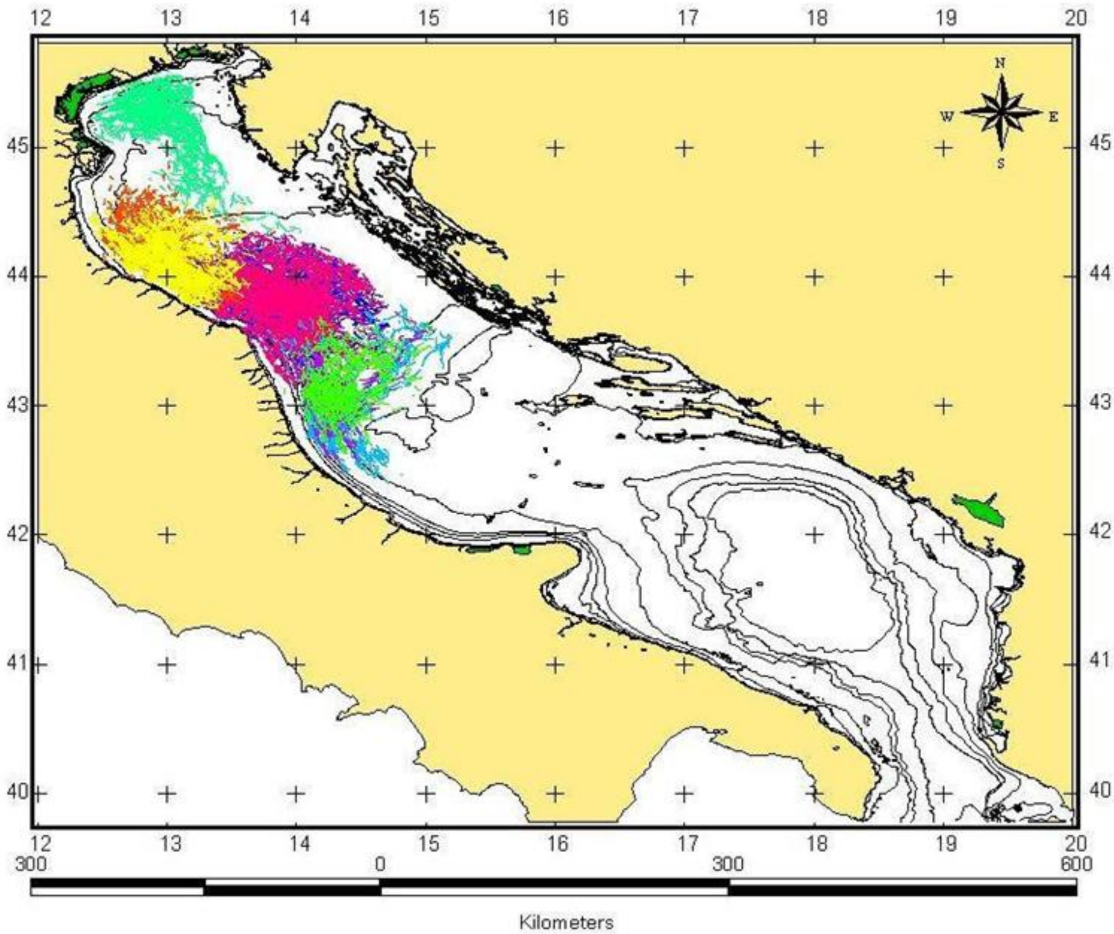

Figure 3: Record of routes of vessels monitored, collected between 2003 and 2008.

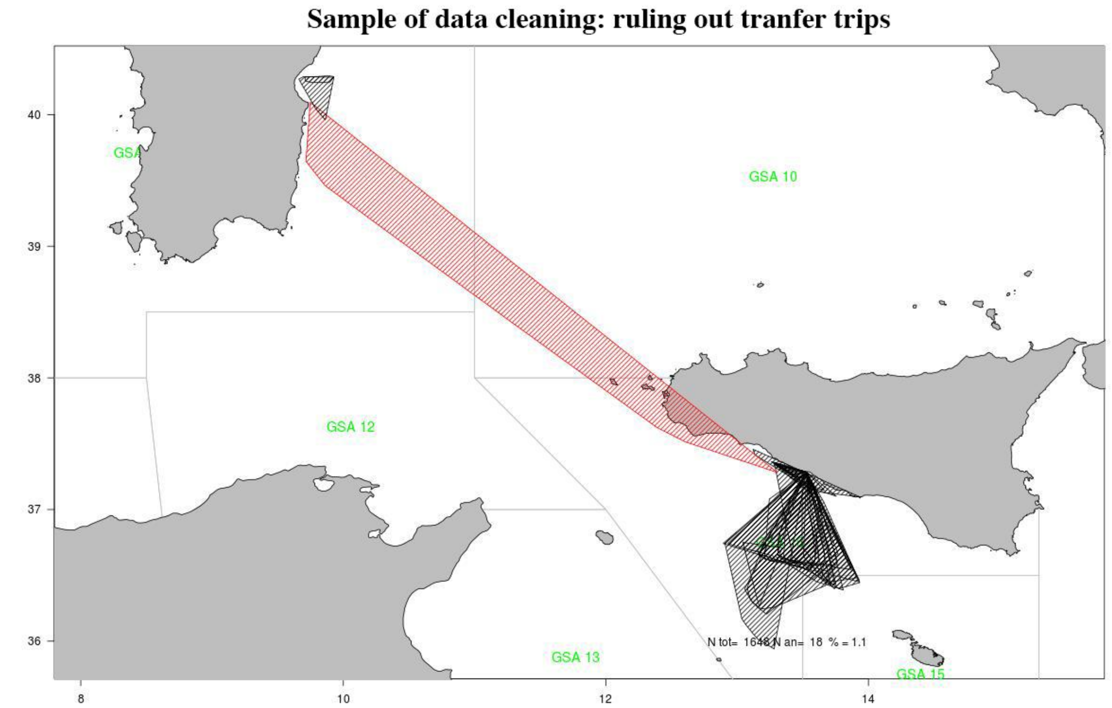

Figure 4 - Sample of data cleaning by ruling out of transfer track, that is trips aimed to change harbour and not characterized by fishing activity

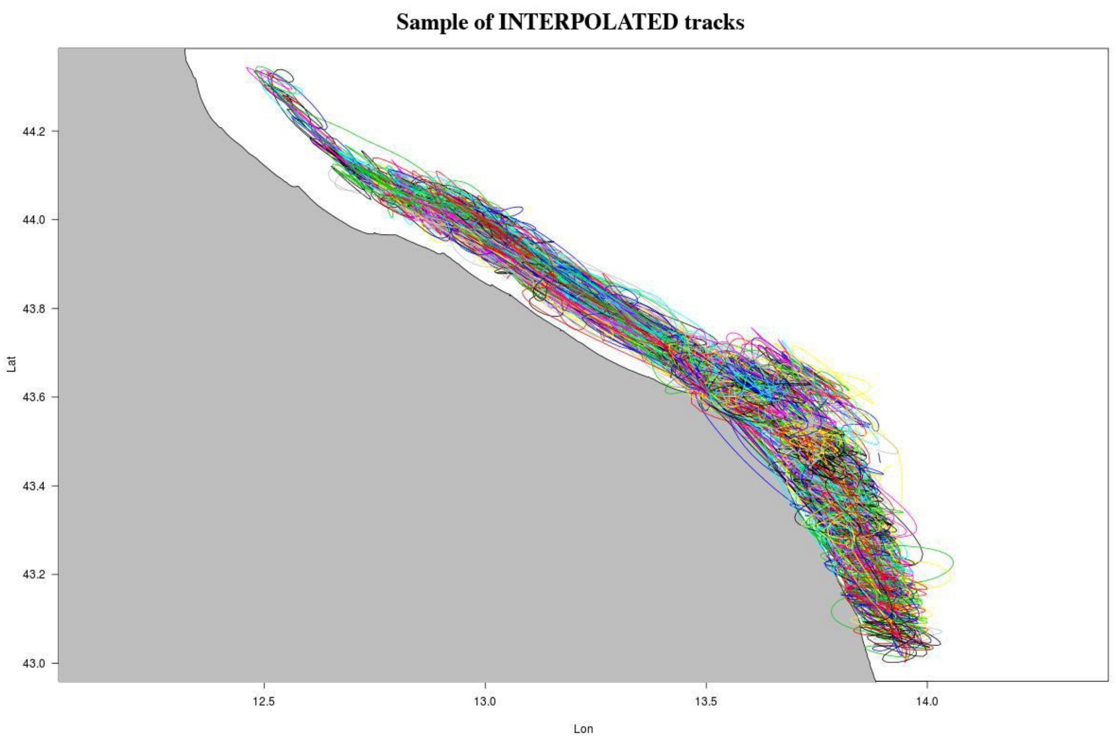

Figure 5 - Sample of interpolated tracks for fishing vessel operating in the Adriatic Sea

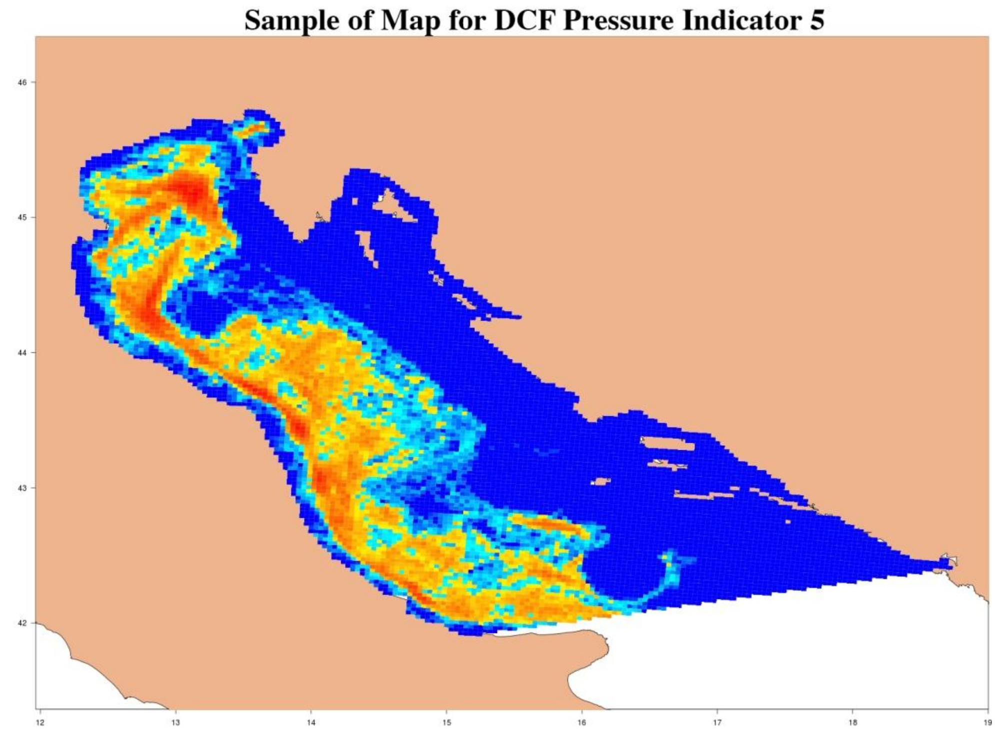

Figure 6 - Sample of map in which 3x3 km cells are plotted in a color scale according to the level of fishing effort (DCF indicator 5)

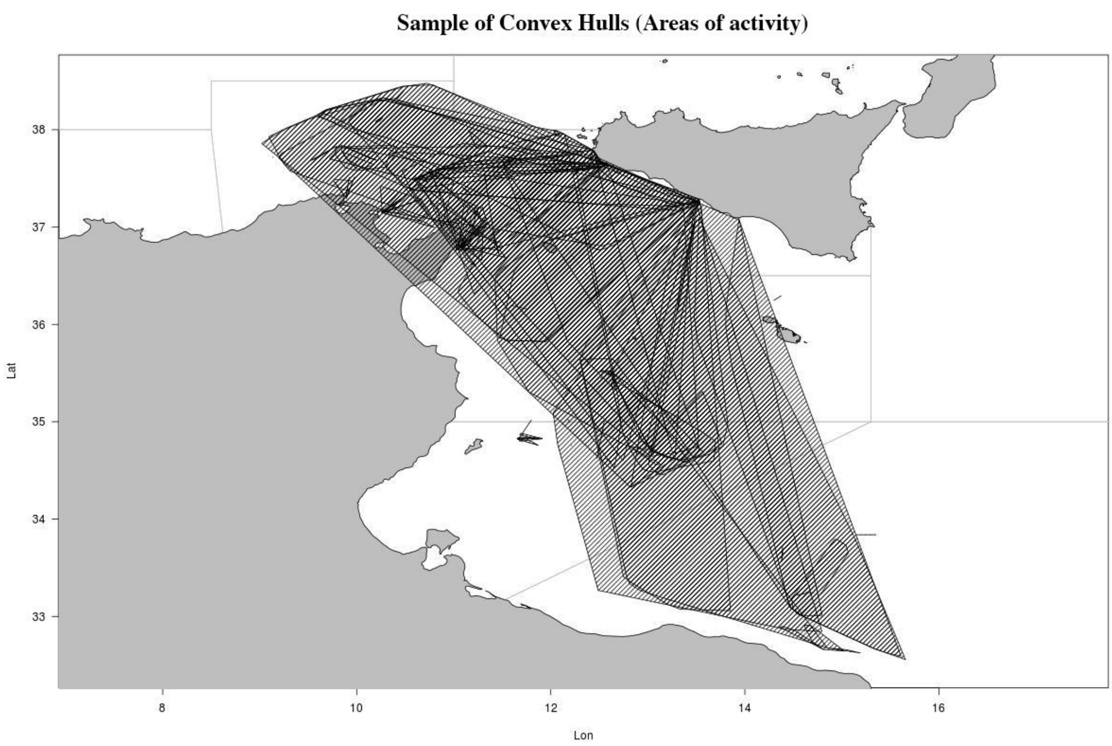

Figure 7 - Sample of analysis of area of activity

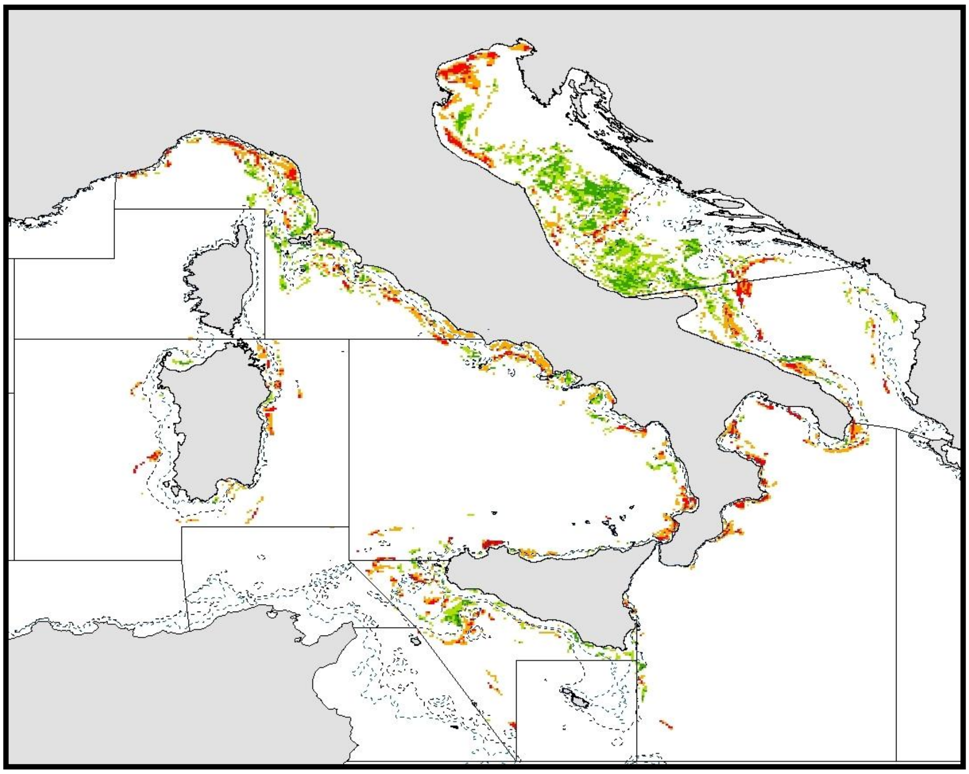

Figure 8 - Analysis of fishing ground in a given year (red areas: increasing effort; green areas: lowering effort)

Methodologies and results: a case study for Spain

Spatial distribution of fishing pressure using vessel’s track lines

DATASET AND STUDY AREA

The present methodology was developed in the framework of the Spanish national project INDEMARES (LIFE+ "Inventory and designation of marine Natura 2000 areas in the Spanish sea”; http://www.indemares.es) in the case study of the Menorca Channel (Balearic Islands, western Mediterranean; Fig. 9). The VMS dataset available for that project covered the area situated between the islands of Mallorca and Menorca during the time series 2005-2010. The data was provided by the national Fisheries Monitoring Centre (*Secretaría General del Mar*). The dataset includes information on all fishing vessels longer than 15 m, which in our case only includes bottom trawlers since all small-scale units do not reach that length. The vessels equipped with the VMS are committed to automatically transmit their positions at least every two hours.

Fig. 9. The 10 study areas covered by the Spanish national project INDEMARES highlighting in red the Menorca Channel area (western Mediterranean).

PREVIOUS DATA TREATMENT

In order to reduce the noise in the dataset, the following steps were followed prior to the data analysis:

1. Remove records corresponding to vessels from ports without fishing activity in the area.
2. Remove records situated very close to fishing ports (<3 nautical miles).
3. Remove the vessels with sporadic activity in the area (<10 records per year).
4. Check the fishing modality assigned to the vessels.

5. Select ranges of vessel speed and working time corresponding to the actual fishing activity performed in the study area.

   Working time: In the Balearic Islands, commercial trawlers are only allowed to work 12 hours per day (from 05:00 a.m. to 05:00 p.m.) five days per week (from Monday to Friday).

   Fishing speed: In accordance with Eastwood et al. (2007), the fishing speed was assumed to correspond with the interval including the 95% upper limit from the frequency distribution of transmitted speed records. This analysis showed that bottom trawlers fish at a speed range between 1.5 and 5.0 kn (Fig. 10).

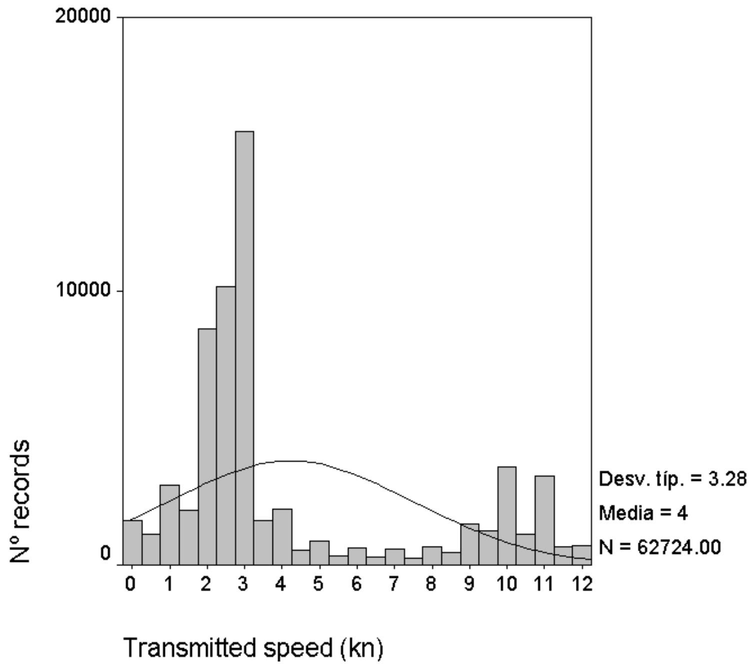

Fig. 10. Frequency distribution of transmitted speed records obtained from a sample of 20 bottom trawlers working off the Balearic Sea during 2005-2010.

It is important to note that we did not transform the transmitted speed (instantaneous speed) into calculated speed in our preliminary analysis. However, according to Gerritsen and Lordan (2011) this step is necessary prior to the selection of the fishing speed range. Calculated vessel speed is based on the assumption that the vessel travels in a straight line between VMS positions at a constant speed.

The bottom trawl fleet from the Balearic Islands generally performs several hauls at four different depth strata every day (Palmer et al. 2009). In bathymetric order, those four depth strata and their corresponding target species (in parentheses) are: 1) shallow shelf (striped red mullet); 2) deep shelf (hake); 3) upper slope (Norway lobster); and 4) middle slope (red shrimp). Owing to the particular spatial distribution of the trawling activity associated to these different fishing grounds, the VMS data analysis was carried out by depth strata (Fig. 11).

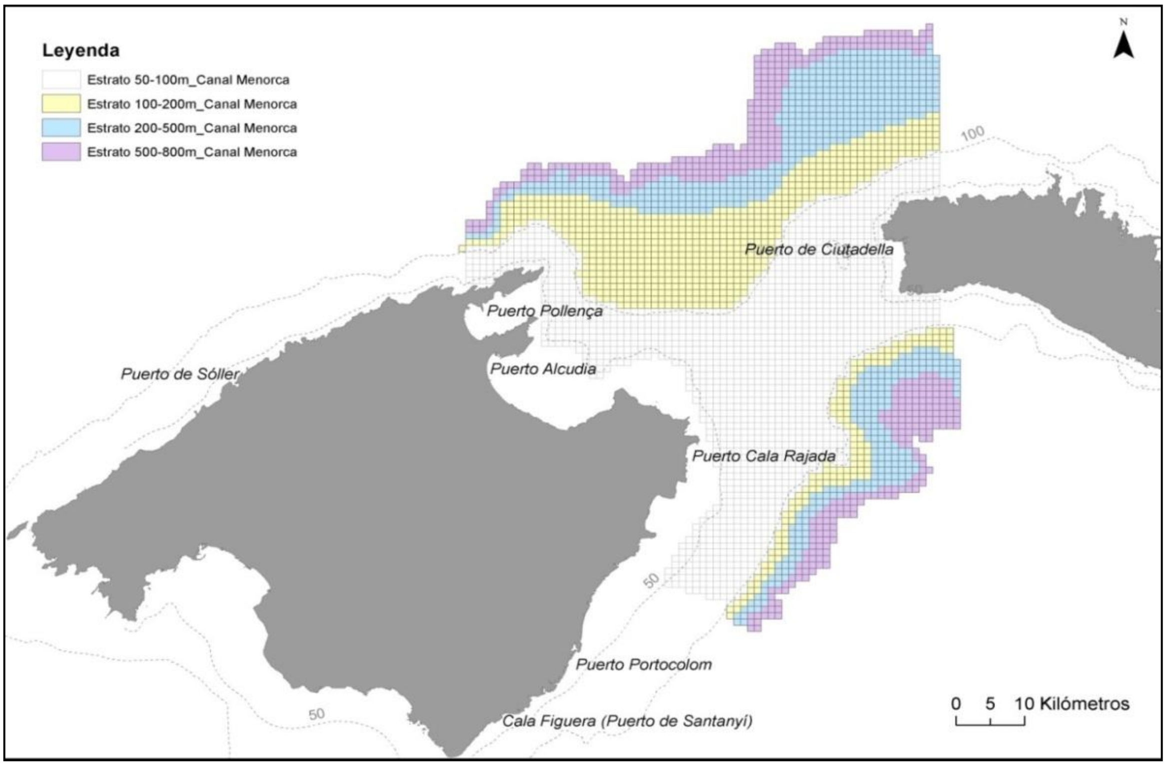

Fig. 11. Fishing grounds exploited by the bottom trawl fleet working on the Menorca Channel area. According to the target species, four different depth strata are exploited: shallow shelf (white), deep shelf (yellow), upper slope (blue) and middle slope (purple).

VMS DATA ANALYSIS PROCEDURE

All spatial analyses were performed using the software ArcGis v9.2. The study area was divided into a grid with unit cells of 1x1 km. The straight-line approach (e.g. Stelzenmüller et al. 2008, 2010; Eastwood et al. 2007), which is based on the proportion of the fished surface by unit area, was used to define the fishing pressure.

The individual fishing points corresponding to the VMS records were converted into straight-line paths per vessel, day and depth stratum using the Spatial Tools available in ArcGis v9.2. As the bottom trawl gear is 20-24 m width, those paths were buffered considering 22 m width (Fig. 12). To calculate the exact fishing tracks, track boundaries were not dissolved. The resulting trawl tracks were assumed as the final fishing footprints by unit area.

The fishing pressure was calculated as the proportion, in percentage, of the total surface of footprint intersects by unit area (1x1 km). Underestimation of fishing pressure was assumed because about 10% of the days only one point per vessel was available, which prevented obtaining tracks.

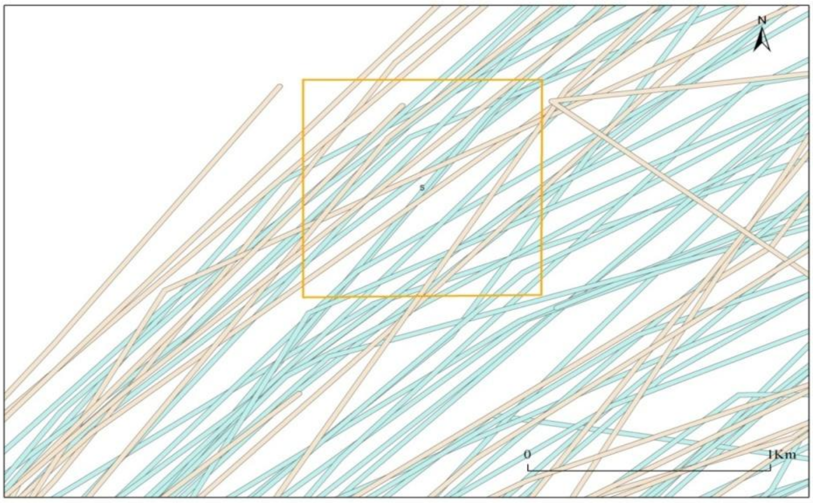

Fig. 12. Different fishing tracks obtained using a trawl gear width of 22 m. The resulting trawl tracks are assumed as the final fishing footprints by unit area.

Finally, as vessels paths can deviate from straight-lines (Eastwood et al. 2007), data from VMS were compared with data from onboard observers taking the vessel position at intervals of 15 minutes (Fig. 13). Owing to the higher frequency of onboard data (15 min vs 2 h), the fishing pressure obtained using onboard observers was found to be higher than that obtained from VMS information (Fig. 14).

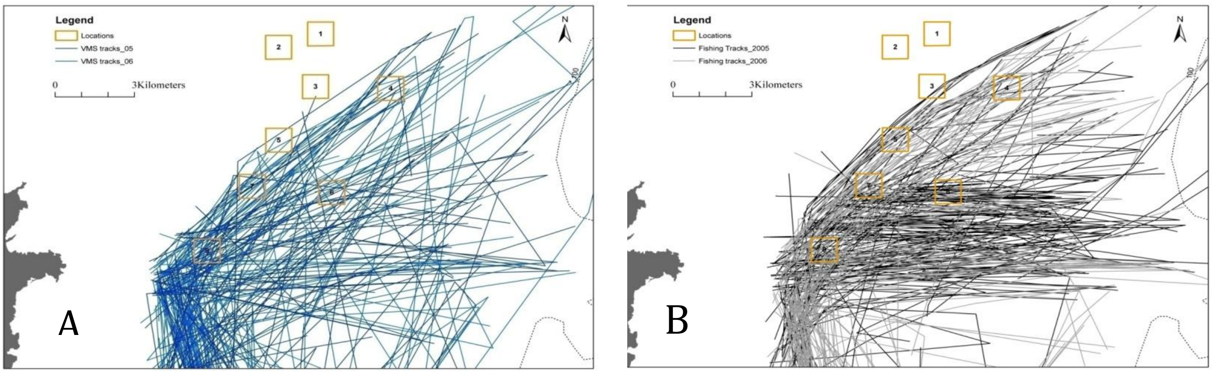

Fig. 13. Comparison of fishing tracks obtained using VMS data (A) and information from onboard observers (B) taken at intervals of 2 h and 15 min, respectively.

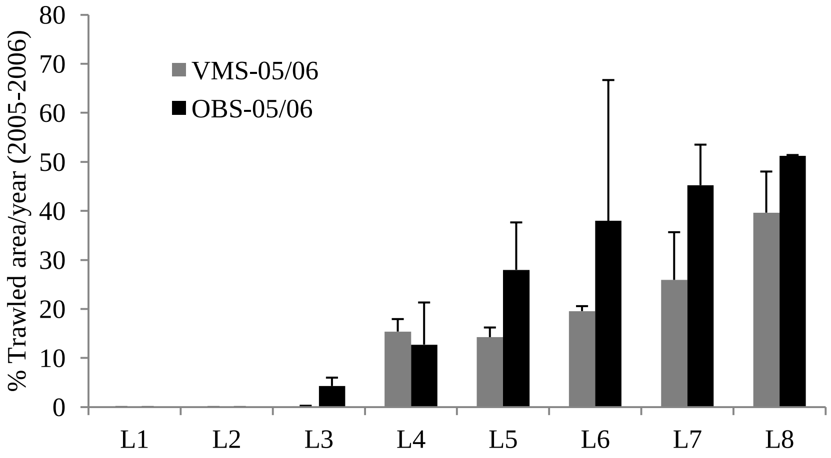

Fig. 14. Comparison of fishing pressure (percentage of trawled area per year) at different locations (L3-L8) obtained using VMS data (grey) and information from onboard observers (OBS; black) taken at intervals of 2 h and 15 min, respectively.

To finish, it should be highlighted that the present methodology is mainly applicable to relatively small areas with reduced fishing fleets, such as the Balearic Islands, where it is comparatively easy to control and manage the individual fishing tracks. Figure 15 shows the spatial distribution of track lines per day and vessel around the Archipelago obtained using VMS data from 2005.

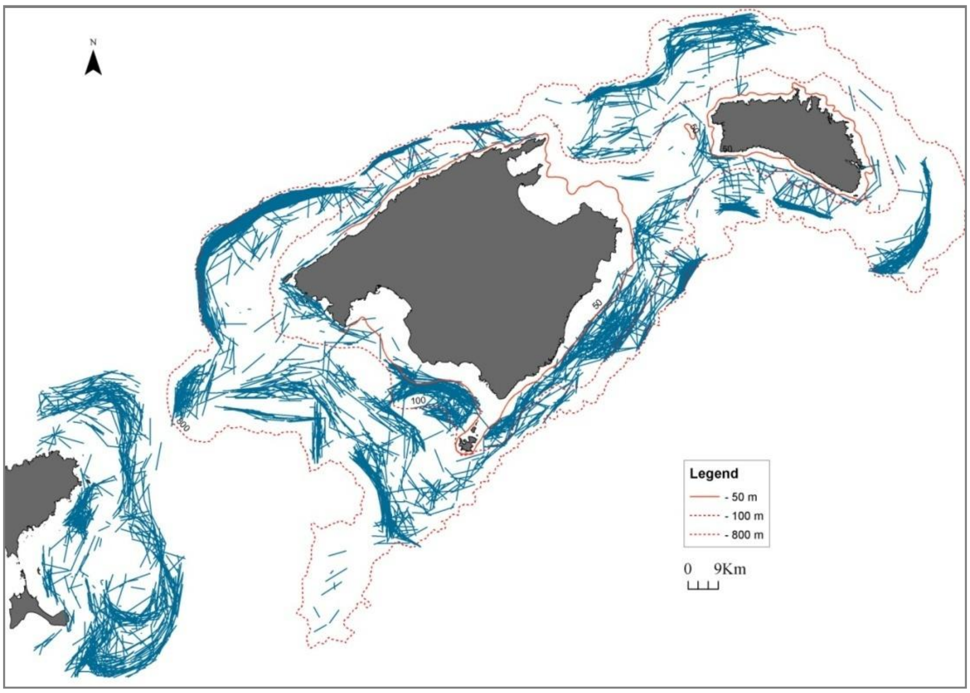

Fig. 15. Spatial distribution of track lines per day and vessel (blue lines) around the Balearic Islands in 2005 obtained using VMS records.

Estimation of fishing effort

Spanish VMS data were analysed using the common method for estimating fishing effort as proposed by this subtask. Monthly and annual maps for 2012 were constructed. The fishing effort was expressed in Days * GT (ANNEX-I Fig. 24-36).

Distribution of fishing effort by bathymetric zone

The common method was adopted to estimate the spatial distribution of fishing effort by bathymetric zone. The constructed map is presented on ANNEX-I Fig. 37.

In the framework of PERSEUS project, a publication is going to be submitted from the Spanish group. The title of the work is "Spatio-temporal dynamics of trawl fisheries in the Balearic Islands (western Mediterranean) integrating vessel monitoring system (VMS) with daily catch data of main target species: Carmen Barberá, Antoni Quetglas, Joan Moranta) (ANNEX-II, page 67).

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VMS perseus geoportal

The PERSEUS geoportal delivers geographic information that depicts the fishing effort of purse seiners and trawlers. We used VMS data to construct the layers that are shown on the geoportal. The areas shown are Aegean and Ionian Sea for Greece and Baleares for Spain. Maps from Italy are not visualized in the portal due to National restrictions. Geoportal application is free accessible at:

http://artemis2.ath.hcmr.gr/

The user can select the layers to be shown by clicking the appropriate checkboxes in the left side tree panel. For the background layer one of the three given layers can be chosen and for the rest he can check or uncheck each layer he wants to show or hide appropriately. For every layer that is shown on the map he can click the ***Legend*** button to see their associated legends. Above the map area are some buttons for panning, zooming in and out and going to the default zoom level in the map. The user can select the layers to be shown by selecting the desired search criteria in the bottom area of the site. Some choices are given for Year, Region, Month, Season, Gear. For every one of these criteria the user can select multiple checkboxes and all the layers adhering to these choices will be shown. If he chooses checkboxes from more than one criterion, then these will be combined so the layers adhering to all the combined criteria will be shown only. By selecting nothing all layers are shown (Figures 16, 17).

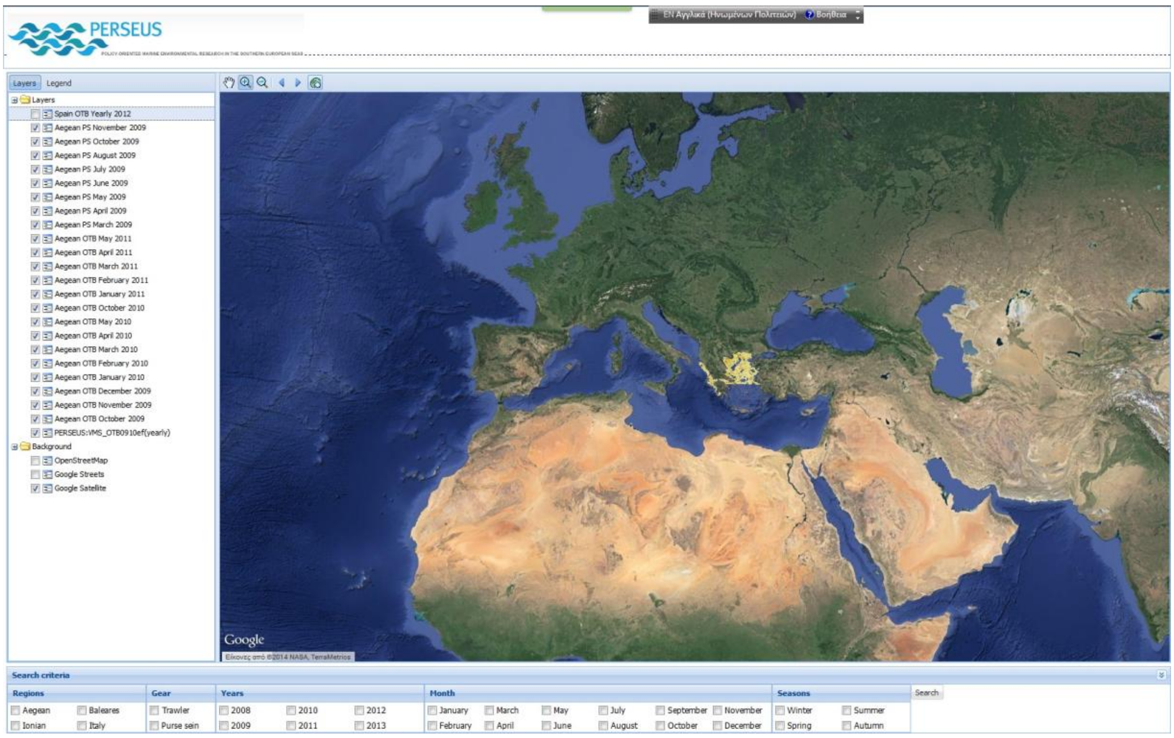

Fig. 16. Geoportal main page

Fig. 17. Categorization of fishing effort layers

<u>Architecture of geoportal</u>

The layers are served by Geoserver 2.5. The color scaling for each layer is given by an appropriately constructed sld file on the server. Apache 2.2 is used as web server. The geoportal was built on the ExtJs 4.2.1 javascript framework and the Geoext 2.0 framework. Openlayers 2.12 javascript library was used for manipulating the layers. Since the ExtJs 4.2.1 version supports MVC architecture, this layout was used for the construction of the site. With MVC architecture the separation of the viewing components from the control code is easy and the site's maintenance becomes more efficient. In the site's root directory there is the ***app*** directory which contains the MVC directory structure. In this structure the ***view*** directory contains the viewing components of the site that comprises by 3 files, the main ***Viewport.js*** file and ***MapPanel.js*** and ***QueryPanel.js***. The ***MapPanel.js*** file contains the main map area and the layers selection area in the tree format. In the right side is the map area with the area map and the layers. At the left side are the layers in a tree layout and the legend of each layer. The user can see the layers or the the legends by clicking the appropriate button located above the tree layout. The ***QueryPanel.js*** file contains the checkbox groups for selecting layers criteria. This way the user can select layers based on gear, year, season, month or region. The selection can be made using multiple criteria. If no checkbox is selected all the layers are selected. In the ***controller*** directory there are 2 files, ***SearchBtn.js*** and ***LegendTabs.js***. The ***SearchBtn.js*** file controls the selection of the layers based on the criteria selected in the checkboxes. The ***LegendTabs.js*** file controls the transition between the layers and the their legends by clicking the appropriate button.

For the loading of the layers and their selection the ***LayersOTB.js*** file is used. In the ***model*** directory the data format is given in the ***Layer.js*** file. The format of the file contains the criteria for searching through the layers in addition to the name of the layer, its name on the server and the server that it is located. The layers are stored as static data in the ***LayersOTB.js*** file in the ***store*** directory. Static data is used because there are not many layers. They are loaded by reading this file in the ***MapPanel.js*** file. In the ***SearchBtn.js*** control file the ***LayersOTB.js*** file is used for the selection of the layers based on the data given for each layer. So if more layers are to be added they are put in the ***LayersOTB.js*** file and they are automatically added to the map.

Conclusion and discussion

During the implementation period of this subtask, two modules were proposed to analyze VMS data that satisfying scientific and management purposes by giving the basic information needed for further analysis and modeling. In addition, the output of these methods satisfies some basic requirements of CFP not only in the manner to collect data but also to analyze them and give concrete and reliable results about the behavior of the fishing fleet controlled by the Vessel Monitoring Systems. On the other hand, improvements and new approaches are ongoing and can be applied in the framework of a PERSEUS follow up project or other similar projects. The collaboration between partners, the exchange of ideas and the review of several methods that were used by each partner, was fully satisfied and the people that were involved in this task were enhance the ways of analyzing the significant information that derived by VMS. All the information that derived from this task referred to a common methodological framework that takes into consideration the particularities of each case study and is available to PERSEUS scientists in order to fulfill the specific needs of the project. The modules that were developed are also compatible with the Descriptor 3 "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock" of Marine Strategy Framework Directive (MSFD: 2008/56/EC) especially under the aspect of the level of pressure and fishing activity.

The analysis of the VMS dataset was explained by two modules. The first module referred to common procedures and methodological steps in order to estimate fishing effort and the second uses the output of the fishing effort estimates to various implementations satisfying National and European requirements. More specifically, the common methodological steps for the analysis of VMS dataset includes the quality control (elimination of errors in the raw VMS data), the data enhancing by integration of legislation bathymetry etc., the crossing of the VMS data with Logbooks, the characterization of fishing activity by a speed rule for the estimation of fishing effort indicators (Days at sea, Days*GT, Days*KW, fishing hours) and finally the visualization by producing high detailed maps of fishing effort with respect to spatial and temporal grids. It is important to highlight that adjustment and customization on the basis of the available data were achieved by the review of methods and the exchange of several ideas by each partner.

The first module allows obtaining the fishing effort output, which can be used for different and advanced implementations as described in the second module. Moreover, in the framework of a PhD thesis supported by PERSEUS, the basic applications that were introduced in the second module are the identification of fishing grounds for the target species of a gear (e.g. bottom trawl), the identification and mapping migration spatiotemporal patterns of the investigated fishing fleet, the Data Collection Framework indicators (distribution of fishing activities, aggregation of fishing activity and areas not impacted by mobile bottom gears), the use of VMS data from trawlers and purse seiners to Multi Criteria Decision Analysis in order to estimate a fishing pressure index and also the evaluation of fisheries statistics data using VMS fishing effort estimates.

In addition, in the framework of this subtask a Geoportal was developed. The VMS PERSEUS Geoportal delivers geographic information that depicts the fishing effort of certain fishing gears (trawlers, purse seiners). The layers that are visualized in the geoportal were derived by the common methodological procedures that were described in the first module. That Geoportal consist a user-friendly web application which meets the open source application standards.

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ISBN no: 978-960-9798-14-3