A new observing system for the collection of fishery and oceanographic data

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Abstract

The remark about the great potential offered by fishing boats for the continuous and repeated observations led ISMAR-CNR to develop the Fishery Observing System (FOS) within the framework of the EU research program Mediterranean Forecasting System: Toward an Environmental Prediction (MFSTEP).

Eight fishing vessels were equipped with FOS instrumentation to collect fishery and oceanographic data. The vessels belonged to different harbours of the central and northern Adriatic Sea. Anchovy and sardine were chosen as the target species. Geo-referenced catch data, associated with in situ temperature and depth, are the FOS products.

This system (built in 2003) is still working and collects daily very important data in order to evaluate the fishing effort and the influence of the environment on the abundance distribution of the target species.

1 Introduction

Fishing boats can offer a great potential for repeated and continuous observations of environmental parameters in coastal area. Thus, the CNR coordinated a programme for the development of a Fishery Observing System (FOS hereafter) in the framework of the EU research program Mediterranean Forecasting System: Toward an Environmental Prediction (MFSTEP). Data collection started on August 2003 and since then, a lot of fishery and oceanographic data were stored and analysed in order to address some important issues. Data were collected from fishing vessels working in the Adriatic Sea, a semi-enclosed basin of the Mediterranean, where fishing activity is very enhanced. The activity and results relative to the period October 2003- August

2005 were presented in Falco et al. (2007).

Real time estimates regarding the time and spatial distribution of fish abundance are difficult to obtain. Acoustic surveys and landings information are the traditional tools used to achieve stock abundance information (Daskalov, 1999 ; Hedger et al., 2004 ; Denis et al, 2002). They demonstrated to be efficient for scientific purposes and a posteriori evaluations of fish stock abundance. On the other hand, acoustic surveys do not adequately cover the spatial extent of the stock and the temporal coverage of the surveys data is generally gappy, because it is not always possible to carry out surveys regularly. Landings data are provided at later time and so they can not guarantee real time when used for management and operational purposes ; all the above mentioned elements are crucial.

The FOS developed in the framework of the MFSTEP project was thought in order to fix those elements. A time continuous picture of fish abundance distribution was obtained by means of geo and time referenced abundance index (CPUE), which were used together with a detailed sets of environmental descriptor (obtained both from models and in situ measurement), in order to address a more complicated problem, namely the relationships between environmental conditions and the distribution of the target species. For this project, the main target species was the anchovy (Engraulis encrasicolus, L.), that is in general one of the most important commercial species of the Mediterranean Sea, and in particular, the most important target of the Italian pelagic fishery in the northern and central Adriatic Sea ; in this area, during the period 1976-2006, the annual catch was estimated to range between 20000 and 30000 tonnes and it has increased up to 44.000 tonnes in the three-year period 2006-2008 (Santojanni et al., 2003 ; Barange et al., 2009). The Adriatic Sea is indeed one of the most important fishing area for this species.

The results obtained from the analysis of the collected data is still underway (see Falco et al., 2007 for details) and thus not conclusive. In general, understanding how the environment can influence the distribution of fish stocks is complicated. Many studies tried to answer to this question and to understand how environmental variability can affect recruitment and fish distribution (e.g. Yáñez, et al., 2001 ; Attrill and Power, 2002). The problem becomes more complex if one accepts that the state of the relationships between climate/environment and stocks is not stationary (Mann, 1993): there is evidence indeed that the relationships hold for one or two decades, then move to another state as consequence of the changing environmental conditions (e.g. Klyashtorin, 2001).

In order to address this complicate issue, long time series of both environmental and abundance data, which are also comparable on time and spatial scales, are necessary. The FOS developed and currently working in the Adriatic Sea is oriented toward this long term objective.

2 The MFSTEP FOS

The development of the FOS was primarily based on the research of a good compromise between the necessity of collecting data regarding the fishing activity and the impact of the instruments used for this purpose. The FOS underwent to a number of improvements and in the last version it consists mainly of three components: an electronic logbook (EL), a GPS (Fig. 1a) and a temperature and pressure recorder

(Fig. 1c). The software used to collect and store data on the EL was developed ad hoc for this application (the section used to input fishery data is showed in Fig. 1b). Each single component of the FOS generates a file: catch and position data are stored on the EL, temperature and depth data are stored on the memory of the sensor. Temperature data are collected every time the fishing gear is hauled. All the data are then stored in a database and collated in the post processing stage. The EL is basically a computer with a touch screen as user interface. It is very compact in order to occupy a small space and it looks like common equipment installed on the deck of the fishing vessel. The EL features six powered serial communication (two DB9 and four RJ45) ports and up to six 2.0 USB connections. The GPS is powered by the EL, then each time the EL is turned on, the GPS as well and it starts to send position data to the memory of the EL.

The fishermen input directly the daily catch information by means of a dedicated software, thought to be as user friendly as possible. Information regarding some species are required. They are indicated by the software and for each species the skipper enters only the total catch for haul, an estimate of the mean size of the individuals in the catch (this information is required only for anchovy and sardine) and the discards (in terms of catch and size). The unit of measurement were set in accordance with the common ways used by fishermen of the Adriatic fleet to indicate catch and mean size for the two considered species, then catches are estimated per boxes of fish and the mean size is expressed in number of fishes per kilogram in regard to anchovy and in two categories (large or small) for sardine. In the post-processing phase, catches are converted in kg using a known conversion factor between boxes and kg. This factor generally differs from harbour to harbour.

The third component of the FOS is a temperature and pressure sensor (TPs hereafter Fig. 1c). The probe used is produced by Star Oddi company (Iceland) and its main characteristic is the reduced dimension. This characteristic is important because the sensor is attached to the fishing gear (an example of TPs installed on the a weight, used to sink a pelagic trawler net, is showed in Fig. 1d) and a small equipment may have a low impact on the gear and can be easier positioned in a safe way. Two types of TPs are used: DST Milli and Logic. While the first is a standard product made by Star Oddi, the second, was produced following some indications suggested to the company by CNR-ISMAR. In fact the Milli type, once switched on, collects data continuously, even when the boat is not working. This aspect limits the duration of memory and batteries. Furthermore the response rate to temperature variations, after some comparisons with standard oceanographic probe, resulted to low especially where temperature gradient are strong (e.g. in correspondence to thermocline). The DST Logic was made in order to fix the fore mentioned points and so, in the final version, the new TPs collects data only when the pressure overcomes a threshold value (factory defined) and the rate of response to temperature variation is now significantly increased with respect to the Milli TPs as well as the memory space.

3 FOS data set

Starting from August 2003, eight fishing vessels have been supplied with a FOS. The vessels belong to different Italian harbours of the central and northern Adriatic Sea working on different fishing area. Fig. 2 shows that contiguous fishing areas overlap on the southern and/or northern boundary allowing then to obtain a whole imagine of the fishing ground of the selected boats. Since the area exploited by the fishing fleet of one harbour is approximately the same for each single vessel of the fleet, it can be assumed that the single area exploited by one vessel is representative of the fishing ground of the entire fleet belonging to the harbour. These two aspects have relevant implications on the calculation of the fishing effort.

FOS was installed on eight boats belonging to the fleets of Chioggia, Rimini, Ancona, S. Benedetto del Tronto and Giulianova degli Abruzzi, from north to south respectively (see Fig. 2 for harbour positions). At present two vessels per harbour are monitored, with the exception of Chioggia and Giulianova (where only one vessel is monitored). This choice ensured a good spatial coverage at least for the middle Adriatic.

Four vessels were equipped with the instrumentation within the first 3 months from the beginning of the data collection (August 2003). The remaining four were provided with a FOS a year and half later, thanks to the Italian national funding of the Directorate General for Fishery of the Ministry of Agriculture.

The vessels monitored are all pelagic trawlers (volante in Italian) and work all year round with the exception of the boats of Giulianova and San Benedetto, which at the end of May and until approximately the half of October, change fishing gear and are then set up as light attraction purse seines (lampara in Italian).

Since August 2003, about 18000 hauls data were collected. Fig. 2 represents a map of the data collected from October 2003 to December 2007.

Catch data (number of boxes of fish and size mainly), position data (relative to the track of the vessels during the trawling phase or mean position if the vessel is working as lampara) are available for each haul. All these information are included in separate files which have to be merged in order to provide geo and time referenced catch data to which associate also temperature and pressure data measured during the haul. These three different files are uploaded on an ad hoc database developed in MS Access®. The uploading procedure ends with the data collation: catch data are geo-referenced and associated with temperature at depth data. This operation is done for each volante and lampara haul. The selection of haul positions is based on depth data obtained by TPs. The start time of the haul is set to coincide with the lowering of the gear and the end time coincides with the lifting of the gear. All positions included in this time interval are then selected. Catch data are input sequentially and for every fishing day there is a correspondence between the temporal sequence of catches and TPs measurement. Thus the order of the hauls (as they were stored in the catch file) and their date allow merging of daily TPs data with catch and position data. While catch data cover all the period of measurement, temperature and pressure data are sometimes missing. There are various reasons for these failures: first of all in some cases the sensors were lost or damaged, furthermore, when the GPS does not receive the signal, TPs data cannot be associated with geographic position.

4 FOS results obtained during the MFSTEP project

Together with the development of the FOS, the activity of the MFSTEP sub-task, leaded by the Ancona U.O.S. of the CNR-ISMAR, dealt with the study of the environmental factors driving fishing aggregation. Considering that the period of observation was too short to find conclusive relationships and that the data set was too sparse in order to statistically describe such relationships, at the end of the project preliminary results were obtained from the analysis of the collected data. The analysis was conducted using Generalized Additive Model (GAM) which are suitable tools for exploring a data set and pointing out relationships between dependent and independent variables (Hastie and Tibshirani, 1991). GAM were used in many studies where the relationships between abundance and environmental parameters are of concern (Swartzman et., al 1992 ; Daskalov, 1999 ; Denis et al., 2002 ; Hedger et al., 2004).

The results obtained suggest that oceanographic features can determine abundance distribution specially in the area of Giulianova. This fact is due probably to a dynamic that in this area can be more favourable to fish aggregation. In fact, areas of convergence could be found here (Cushman-Roisin et al., 2001 ; Poulain, 2001), both where the southward long shore current encounters the descending branch of the Middle Adriatic gyre and in correspondence of the frontal zone which separates the coastal fresh water from offshore saltier waters. Bottom topography can be also an important factor in determining areas of strong gradient such as shelf break fronts. Such conditions could contribute to fish aggregation in the Giulianova area (central Adriatic) but it is not yet clear which could be the actual role of the skipper, in using his own knowledge to choose the best fishing area as function of environmental conditions. GAM analysis of the data collected by the fishing vessel of S. Benedetto, which works approximately on the same fishing ground as the Giulianova vessel, shows very similar results. Results obtained from data of Ancona and Rimini are instead more confused. The Adriatic Sea is a semi-enclosed basin where the contribution of the Po River outflow strongly influences both the physics and the biology of the environment. The importance of the correlation between anchovy abundance and recruitment with river freshwater output was already proved in previous studies (e.g. LLoretet al., 2004 ; Santojanni et al., 2006) and river effects can be also noticeable in semi-enclosed basin (Daskalov, 1999). The characterisation of river discharge, the spreading of fresh water and haline fronts location should be analysed in relation to CPUE index at spatial and time resolution which would be probably different with respect to the present study.

5 Conclusion

The marine ecosystem undergoes changes which can be related to some extent to the physics of the environment and that in turn can influence fish distribution. Thus the necessity to have observational tools which are able to provide information regarding all the elements which come into play. The FOS discussed in the previous section represents a first and successful attempt towards the realization of a new tool which can help to deepen the knowledge of the links between resources and environment and also to support the fishery management. It could be applied to other areas of the Mediterranean Sea where fishing activity is important in order to create a wider monitoring system.

At present the limits of the system are essentially two: firstly, FOS data are available approximately every months and secondly, the application of the FOS is subject to the willingness of the fishermen.

The present time interval could be fine for fishery management purposes but is too high for operational applications. For this reason, in a very next future, the TPs will be upgraded with new sensors able to produce more reliable pressure and temperature data, and able to collect salinity and possibly other oceanographic (e.g., fluorescence and/or turbidity) data. Every sensor will be also able to transmit the collected data to EL in order to make available the oceanographic data as soon as the haul is concluded.

Rather the second cited limit puts in evidence the necessity to deepen the relationships with the fishery sector trying to create stronger synergy. Interactions and a stronger link between the research community and the fishing industry (Simpson, 1994) as well as regulatory authorities, would be a first and consistent step towards the institution of an operational fishery oceanography framework aiming to a better management of the resources.

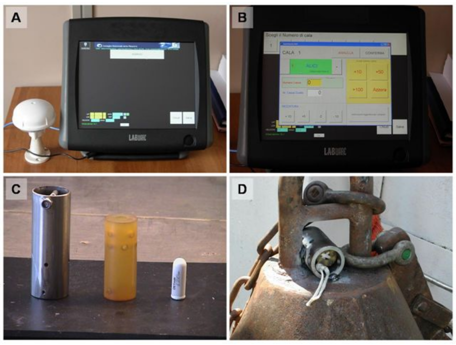

Figure 1: Fishery Observing System (FOS) elements.

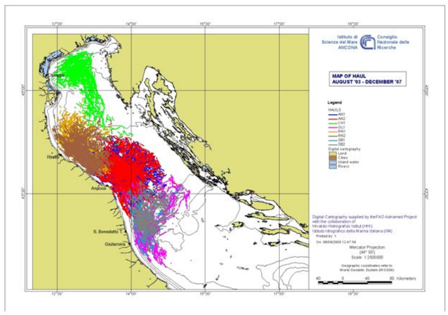

Figure 2: Map of the hauls monitored from October 2003 to December 2007.

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References

[1] R. Hedger; E. Mckenzie; M. Heath; P. Wright; B. Scott; A. Gallego; J. Andrews;. Analysis of the spatial distribution of mature code (gadus morhua) and haddock

(melanogrammus aeglefinus) abundance in the north sea (1980-1999) using generalized additive models,. *Fishery Research*, 70:17–25, 2004.

[2] P. Falco; A. Belardinelli; A. Santojanni; N.Cingolani; A. Russo; E. Arneri;. An observing system for the collection of fishery and oceanographic data. mfstep (mediterranean forecasting system: Toward and environmental prediction) special issue, edited by nadia pinardi. www.ocean-sci.net/3/189/2007/. *Ocean Science*, 3:189[U+FFFD] 2007.

[3] B. Cushman-Roisin; M. Gacic; P.M. Poulain; A. Artegiani;. Physical oceanography of the adriatic sea. past, present and future. 2001.

[4] G. Daskalov;. Relating fish recruitment to stock biomass and physical environment in the black sea using generalized additive models. *Fishery Research*, 41:1–23, 1999.

[5] M. Barange; M. Bernal; M.C. Cercole; L.A. Cubillos; G.M. Daskalov; C.L. de Moor; J.A.A. De Oliveira; M. Dickey Collas; D. Gaughan; K. Hill; L.D. Jacobson; F.W. Köster; J. Massè; M. Ñiquen; H. Nishida; Y. Oozeki; I. Palomera; S.A. Saccardo; A. Santojan;. Current trends in the assessment and management of stocks. in: Climate change and small pelagic fish. pages 191–255, 2009.

[6] E. Yáñez; M.A. Barbieri; C. Silva; K. Nieto; F. Espi;ola;. Climate variability and pelagic fisheries in northern chile. *Progress in Oceanography*, 49:581–596, 2001.

[7] G. Swartzman; G. Huang; S. Kaluzny;. Spatial analysis of bering sea ground fish survey data using generalized additive models. *Canadian Journal of Fisheries and Aquatic Sciences*, 49:1366–1378, 1992.

[8] A. Santojanni; E. Arneri; C. Barry; A. Belardinelli; N. Cingolani; G. Giannetti; G. Kirkwood;;. Trends of anchovy (engraulis encrasicolus,l.) biomass in the northern and central adriatic. *Scientia Marina*, 67(3):327–340, 2003.

[9] L.B. Klyashtorin;. Climate change and long term fluctuations of commercial catches. the possibility of forecasting. *FAO Fisheries Technical Paper*, 2001.

[10] K.H. Mann;. Physical oceanography, food chains, and fish stocks: a review. *Journal of Marine Science*, 50:105–119, 1993.

[11] G.J. Piet;. Using external information and gams to improve catch-at-age indices for north sea plaice and sole. *ICES Journal of Marine Science*, 59:624–632, 2002.

[12] P.M. Poulain;. Adriatic sea surface circulations derived from drifter data between 1990 and 1999. *Journal of Marine Systems*, 29(1-4):3–32, 2001.

[13] M.J. Attril; M. Power;. Climatic influence on a marine fish assemblage. *Nature*, 417:275–278, 2002.

[14] V. Denis; J. Lejeune; J.P. Robin;. Spatio-temporal analysis of the commercial trawler data using general additive models: patterns of loliginid squid abundance in the north-east atlantic. *ICES Journal of Marine Science*, 59:633–648, 2002.

[15] A. Santojanni; E. Arneri; V. Bernardini; N. Cingolani; M. Di Marco; A. Russo;. Effects of environmental variables on recruitment of anchovy in the adriatic sea. *Climate Research*, 31:181–193, 2006.

[16] J.J. Simpson;. Remote sensing in fisheries: A tool better management in the utilization of a renewable resource. *Canadian Journal of Fisheries and Aquatic Sciences*, 51:743–771, 1994.

[17] J. LLoret; I. Palomera; J. Salat; I. Sole;. Impact of freshwater input and wind on landings of anchovy (engraulis encrasicolus) and sardine (sardina pilcardus) in shelf waters surrounding the ebre (ebro) river delta (north-western mediterranean). *Fisheries Oceanography*, 13(1):1–9, 2004.

[18] T. Hastie; R. Tibshirani;. Generalized additive models. 1990.