International Scholars Journals

Advances in Aquaculture and Fisheries Management ISSN 2756-3278 Vol. 11 (1), pp. 001-005, January, 2023. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

A semi-automatic system for labelling seafood products and obtaining fishery management data: A case study of the bottom trawl fishery in the central Mediterranean Sea

Gioacchino Bono*, Salvatore Cusumano, Cinzia Badalucco, Vito Pipitone and Sergio Vitale

Istituto per l'Ambiente Marino Costiero, Consiglio Nazionale delle Ricerche, Via L. Vaccara, 61, 91026 Mazara del Vallo, Italy.

Accepted 16 April, 2022

This study is on the implementation of a semi-automatic labelling system (LS) of the Mediterranean Sea seafood harvest to address the increased need for seafood authentication and inherent difficulties of commonly used indirect techniques for estimating fisheries yield and fishing effort. Sensitive data required for anti-counterfeit policies, such as date and catch area, can be acquired and recorded on the label by user-friendly automated software that excludes any possible manipulation by the crew. Based on results obtained from the installation of the LS on bottom commercial trawlers, the system certified the origin of the seafood products and simultaneously provided, indirectly, geospatial fisheries yield and fishing effort data of the main exploited species.

Key words: Seafood, labelling, Mediterranean Sea, data management.

INTRODUCTION

Market integration has become, in recent decades, the most significant step in the evolution of market economies. The wide use of information communication technology (ICT) systems and a significant reduction in merchandise transportation costs are bringing international markets increasingly closer. This phenomenon, which has become well known under the term globalization, has reached every economical sector to varying degrees.

Based on a general tendency towards globalization of markets, the price of various production processes are progressively declined, striving (as can be expected) for the lowest production costs. The lowest costs do not necessarily correlate to higher productivity and efficiency, but are simply associated with lower production costs and different workforce rules of engagement. The response to this general trend, especially in developed economies, has been product differentiation and valuation of local specialty products. Strategies such as these require tools geared toward reducing the asymmetric information between the producer and consumer. Without efficient informative tools that allow identification of the diverse quality of products, as underlined by Akerlof (1970), consumers run the risk of purchasing goods that in reality

*Corresponding author. E-mail: gioacchino.bono@cnr.it. Tel: +39 0923 948966. Fax: +39 0923 906634.

Abbreviations: LS, Labelling system; **ICT,** information communication technology; **GPS,** global positioning system; **GSA,** geographical sub-area; **GFCM,** general fisheries commission for the Mediterranean; **FAO,** food and agriculture organization; **NMEA,** national marine electronics association; **CNR,** Consiglio Nazionale delle Ricerche; **GIS,** geographical information system; **EAN,** European article numbering; **RFID,** radio frequency identification; **VMS**, vessel monitoring systems.

they do not want. This reduces the consumer's willingness to pay, which in turn forces better products to leave the market or to use a single market (at a single price). The market for fish products is not isolated from the globalization process and the Mediterranean sector in particular is the focus of our study.

The Mediterranean fish industry is of special interest since the general effects of globalization are compounding with the inefficiency of traditional strategies to protect the shared fishery resources. The presence of 24 countries around a relatively closed basin (each with a different culture, legal tradition and levels of economic development) have in fact restricted the adoption of any method of resource regulation, thereby contributing to an increasing depletion of resources. In addition, reduced fish stocks have increased the resource extraction costs (that is, increased fishing effort is required), thereby trapping Mediterranean producers in an economical tradeoff; on one side is the need to adapt to decreasing international prices and on the other the need to absorb increasing local production costs. The current economic policy strategy adopted to meet this double pressure on the fishing industry has been to subsidize the various sector enterprises by many governments, thereby transferring the losses from the single operator to the collective whole without directly addressing the problem of competition by Mediterranean producers and the problem of sustainable resource management.

Far from attempting to offer the panacea to solve all problems, the system we propose attempted to contribute to the solution, from a methodological point of view, by addressing two specific problems that are considered to be prominent topics in the seafood industry: (1) To enable accurate information transfer between producers and consumers; and (2) to facilitate data collection, which is essential for fish stock assessment. To address these objectives, we developed a labelling system tailored to Mediterranean production systems currently in place. The system represents an important informative tool for identifying the origin of products and is the foundation for an efficient tracking (Borresen and Frederiksen, 2004) system that accompanies the data through the entire market channel down to the end consumer. Furthermore, this identification system allowed for the adoption of concrete product differentiation strategies and evaluation of Mediterranean local specialty products. At the same time, the labelling system offers the opportunity to collect geospatial fisheries yield and fishing effort data for the main exploited species. This information would help better address some of the problems facing traditional fisheries management actions that were inadequate to safeguard the decline of fish stocks (Pauly et al., 2002).

In particular, in the central Mediterranean sea, some indirect acquisition methods of fishery-dependent data based on auto declaration by the producers and/or on landing interviews (Bazigos et al., 1984, Andreoli et al., 2000; Spagnolo and Placenti, 1998) are not reliable since the data are provided several days after fishing operations and therefore, the data are reconstructed accounts and are not tied to real-time observations.

Described below is the structural and functional architecture of a system designed for the trawl fishing industry and a description of its strengths, which may contribute to an increased flow of information between producers and consumers and give authenticity to the essential data needed to evaluate commercial fish stock in the Mediterranean.

MATERIALS AND METHODS

The labelling system is based on years of direct and careful observation of all the phases of the Mediterranean bottom trawl fishery including the packaging and stacking of fish products until the vessel reaches the harbor. The planning of the LS considered both the lack of familiarity of fishermen with ICT instrumentation and the inherent difficulties involved when attempting to modify well-coordinated work patterns. For these reasons, the hardware com-ponents and software development have been carefully designed with solutions geared towards minimizing system-operator interaction and maximizing the simplicity of procedures to be done on board.

System description

The functional and architectural LS schematics (Figure 1) can be described considering: weighing and labelling subsystem (WLS); database and transmission management subsystem (DTMS); database and web server (DWS) which is an optional system for data analysis or for real-time commercialization activities.

WLS

The components of this subsystem include a marine scale, processing-acquisition hardware and a label printer. These components are installed in a damp area of the fishing vessel where fish are normally processed and therefore, must contain water-protection mechanisms to prevent water infiltration and subsequent corrosion induced by salt water.

The processing-acquisition unit utilizes a touch screen interface and the management system was developed to minimize the role of the operator. From a functional point of view, the new system works in the following manner:

(1) The weighing operation is allowed only after the end of a haul for which the captain (through the DTMS software subsystem) has given permission (haul authorized weighing); otherwise, it disables label printing.

(2) In the processing area, the operator can video-select the fish species (that for simplicity are presented with an icon or commercial name), the size-grade (first, second, third, etc.), the type of processing

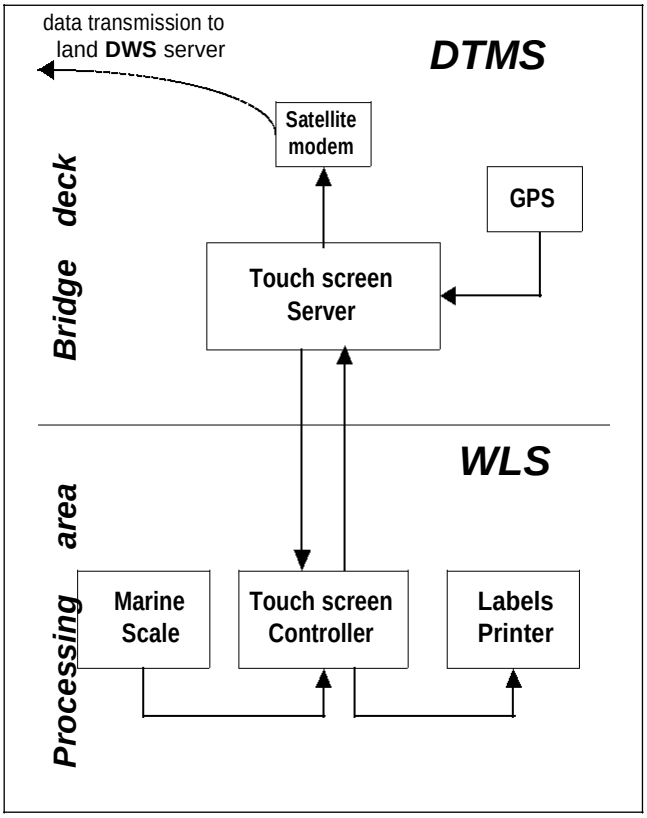

Figure 1. The fishing vessel operations and data flow. Video of the system is available: http://lnx.utp-iamc.org/index.php?option=com_content&task=view&id=22&Itemid=29.

(whole, head-off, gutted, etc.), and the type of packaging used (tray, box, etc.).
(3) The operator, through a simple push of a button or the touch of a screen area, activates the self-adhesive label printing that can then be attached to the package.

This process reduced the number of steps that must be completed by the operator, especially since the weighing operation is normally done by one commercial category at a time (for example, all shrimp matching one size are processed, then another size or species, etc.). Therefore, the steps required are limited only to positioning the box on the scale and to pressing a single button (to print the label; operation is described below in section 3).

All other data printed on the label (including scientific name, date, fishing vessel, company owning ship, catch area, setting number, fish type, etc.) are obtained automatically by the DTMS positioned in the bridge deck.
The subsystems connections (WLS and DTMS) can be done with a single UTP cable, through a small LAN Local Area Networks), or wirelessly. To avoid improper use by on-board personnel that are not authorized to execute weighing and labelling operations, both subsystems WLS and DTMS require a username and password during the access phase.

DTMS

This subsystem located in the bridge deck, is connected to the global positioning system (GPS) and collects in its database all data relevant to ship vessel activity. The following statics data is inserted only once during the system configuration: ship vessel identification data (name, registration number), identification of the company that owns the ship, the scientific and common name of species captured, whether they be fish, crustaceans or cephalopods, the type of production, etc. In a specific table, all dynamic data are saved for each catch, according to the following fields: (1) Haul number; (2) catch area; (3) species name; (4) size/grade; (5) weight; (6) latitude at start of haul; (7) longitude at start of haul; (8) date and hour at the start of haul; (9) latitude at the end of haul; (10) longitude at the end of haul; (11) date and time at the end of haul; (12) catch area according to allocation in macro-areas and geographical sub-area (GSA) pursuant to general fisheries commission for the Mediterranean (GFCM, 2000). More specifically, the DTMS carries out the following functions:

(1) Obtains in an entirely automated manner the geographical location of the fishing vessel through a GPS positioning device;
(2) Allows the Captain to determine the start and stop of haul and to activate the weighing and labelling operations;
(3) Memorizes all the fishing activity data from both DTMS and WLS;
(4) Automatically sends the capture data to DWS.

Identification of the capture zone in accordance with food and agriculture organization (FAO)-GFCM requisites is done automatically through the execution of a proper algorithm (Area Finder) developed in the DTMS software that acquires the geographical coordinates from the GPS according to National Marine Electronics Association (NMEA) standards.

DTMS also allows transmission to land of the catch data obtained over the course of the day. A software module was programmed to generate a text file every 24 h with the daily catch data. Therefore, a file is created for every fishing day; this file is then added to the previous records in the same folder. DTMS by a scheduler transmits data daily via a satellite modem connected to the internet to access a file transfer protocol (FTP) server. All settings and authentication credentials for server connection (telephone number of the internet provider, username and password for internet and FTP access) are pre-set on the DTMS software settings. The DTMS software transmission module allows for appropriate adjustments to synchronize data and troubleshoot connection problems (connection interruption, satellite unavailability, etc.) The connection method and the use of small daily log files for catch data transfer have been thoroughly designed to minimize transmission costs. In fact, a real-time transfer (technically possible and doable) of catch data to a land server via satellite has been discarded due to costs associated with this solution.

DWS

This is an optional component that is non-essential for fish labelling. In the LS testing phase, this server was installed on-site at the Consiglio Nazionale delle Ricerche (CNR) to carry out essential functions:

(1) To receive and process data from fishing vessel via satellite

communication;
(2) To allow equal access to the vessel owners in the project via a Web server.

As previously stated, it is possible to obtain the catch data via the internet and an FTP client installed in the machine. For the FTP Server, a freeware software has been used (ServU-32), configured in a way to minimize the risk of a hacking attack. The files received are stored in an adjoining directory that is later imported, through a specially designed application, into a database table. This application is also done daily through the system scheduler. The scheduler application execution time is postponed by one hour after transmission to ensure there is no interference with the fishing vessel transmission.

The application functions in a batch mode and conceptually performs the following operations: (1) Checks the work file contents; (2) verifies that files found have already been imported; (3) adds the new file records received to the database table. The database application contains, in addition to the "service tables" ("species" and "imported files"), the records of users who could have had access to the data via a Web server.

Once the data is received by the fishing vessel and have been imported to the database, they are immediately available via a Web server. Data obtained through the DWS may be viewed in a summarized form and are only accessible by authorized users (typically the vessel-owners and their staff). The catch data may be itemized based on the following criteria: (1) Period or date; (2) Single commercial species; (3) All species.

RESULTS AND DISCUSSION

This labelling system has been tested by three fishing vessels equipped with different hardware systems and scales marketed by three industry leaders in the European region. All configurations installed gave positive results and met project expectations. Below are a few of the LS system strengths:

(1) It was a good replacement of the current fish labelling system, which is based on manual and non-transparent data entry of pre-print labels.
(2) It was flexible and complementary to the established consolidated operative actions normally done by fishermen. The system, in fact, was designed to be as user-friendly as possible, by minimizing the number of steps and making them simple and intuitive.
(3) In compliance with European law (article 4, regulation 104/2000 and article B of regulation 2065/2001), the fish labels contained the required minimum information components, and were enhanced with additional elements that provided precise and qualifying information to consumers, such as the catch area, for example. In fact, to comply with existing standards, only one of the three FAO macro areas (ex. 37.1, 37.2 and 37.3) where the product was caught is required, but this system also added the GSA where the vessel was located at the time the product was caught and labeled. An improvement was therefore made towards greater geographical characterization of fishery products.
(4) Data reliability was improved; the information printed on the label did not require subjective entries entered by the shift worker, but were instead obtained by automatic detection equipment.
(5) Relative affordability and quality of the entire system, including both hardware and software. In regards to the software, the development of the "Area Finder" module allowed the replacement of an expensive license to use the GIS (geographical information system).
(6) The system is the starting point for the development of an application capable of tracking fish products from "sea to dish" (Frederiksen et al., 2002; Thompson et al., 2005). Rapid advances have been made in IT standard methods used to code any consumer good, such as European article numbering (EAN) or, even better, Radio Frequency Identification (RFID) tags. These systems may use the information obtained to build the basic elements of a successful seafood tracking program.
(7) The LS did not only address the needs tied to fish labelling but, as previously stated, was designed to facilitate assessment of the dynamics of exploited fish populations over time (Hilborn and Walters, 1992). In fact, the collective action of the captain who works on the DTMS (registers the haul and fishing time) and the operator working on the WLS (registers the catch composition), produced a string of time-space fishing effort and yield fisheries data. These data are the fundamental tools to the most common fish stock assessment methodologies. Furthermore, the commercial fishing vessels became useful Vessel Monitoring Systems (VMS) that could extend to a significant group of vessels, over a specified fishing ground, which would increase the chances of success in the management and control of Mediterranean fishing.
(8) This system is implementable in all bottom trawl fishing vessels larger than 12 m. Thus, in alternative (or in complementary) to traditional paper logbook, it stands as an accurate catch reporting tool to the improvement of the national statistical and information system, targeting the Mediterranean fishery (Coppola, 2007; GFCM, 2009).
(9) Lastly, such information would integrate with other direct methods of data collection carried out by the various trans-national research programs based on experimental trawl surveys (Abellò et al., 2002) carried out by the European countries.

After testing this system, it was clear that transparent labelling in the Mediterranean fishing industry is possible and convenient. The effectiveness of this system was closely connected to a user-friendly architecture integrated (in an automated format) with all the information normally found on board. It was also the only instrument available

to enable Mediterranean product diversification on global markets and for social responsibility towards the shared resources.

The increased transparency between the producer and consumer provided a method to identify the Mediterranean fish product in an accurate and unmistakable manner, giving specific responsibilities and subsequent economic benefits, to the fishing vessel. These benefits included incentive not to ignore the entire product distribution chain, acquire and maintain credibility, reduce the substitution rate of products in the market and obtain a greater rate of return. These responsibilities fostered consumer choice and the consumer in turn regained the tools needed to reward high quality and increased product transparency.

The advantages of the labelling system studied extend, based on our opinion, beyond the important flow of information from producers and consumers. Assuming that the system can be extended to a greater number of vessels, the information obtained (catch zone, time, species and quantity) could be statistically processed and returned in aggregate form to the operator, allowing the best measurement of the quantity withdrawn, the fishing effort and estimates of the profit. Since a system such as this could be progressively extended across the Mediterranean region, it could become a regional database. This has a double benefit for fishing operators: prevention of foreign products to enter in the market passing as Mediterranean products and easy management of the production levels that reach the market. Verification means being able to address both demand segmentation and price differentiation and also to obtain increased knowledge of exploitation levels and the catch-effort relationship.

The knowledge of self-action is a central element in the efficient use of collective resources, since it tends to internalize the negative externality impact of resources exploitation. With that aim in mind, an awareness is not only theoretical on the negative impact of each persons actions on the collective resource, but also concrete knowledge (measured with the database provided by the operators themselves) of the effects that fishing has on species conservation could form the base for a new model of resource management. A model not necessarily imposed by traditional regulatory systems but that monitors resources with a new sensitivity and social responsibility such an approach well regarded by the recent Nobel Prize recipient in Economics, Elinor Ostrom (1990).

REFERENCES

Abellò P, Bertrand JA, Gil de Sola L, Papaconstantinou C, Relini G, Souplet A (2002). Mediterranean Marine Demersal Resources. The Medits International trawl survey (1994-1999). Scientia Marina. 66(2): p. 280.

Akerlof G (1970). The Market for Lemons: Quality Uncertainty and the Market Mechanism, Quarterly J. Econ. 84: 485-500.

Andreoli MG, Levi D, Cannizzaro L, Garofalo G, Sinacori G (2000). Sampling statistics of southern Sicily coastal trawl fisheries: Minipestat programm. SAC-GFCM-Sub-Committee of Stat. Info. Madrid. Spagna. p. 18.

Bazigos GP, Cingolani N, Coppola SR, Levi D, Mortera J, Bombace G (1984). Studio di fattibilità per un sistema di rilevazione campionaria delle statistiche della pesca (PESTAT). ParteI: Statistiche sulla flottiglia da pesca. Quaderni dell'Istituto Ricerche Pesca Marittima. 4(1): p. 16, 358.

Borresen T, Frederiksen M (2004). Technical possibilites for introducing traceability in the seafood industry. In: Shahidi F, Simpson BK editors. Publishing Company, St John's, NL, Canada. Seafood quality and safety. Sci. Technol. pp. 31-38.

Coppola SR (2007). An adaptive approach for the improvement of fishery statistical systems in Mediterranean countries under FAO projects. No. 79. Rome, FAO. Studies and Reviews. General Fisheries Commission for the Mediterranean. p. 54.

Frederiksen M, Osterberg C, Silberg S, Larsen E, Bremner A (2002). Info-Fisk. Development and validation of an internet based traceability system in a Danish domestic fish chain. J. Aquat. Food Prod. Technol. 11(2): 13-34.

GFCM (2000). Report of the 2nd Session of the Sub Committee on Stock Assessment. Madrid (Spain), 26-28 April 2000. General Fishery Commission for the Mediterranean. Scientific Advisory Committee. Sub-Commun. on Stock Asses.

GFCM (2009). Report of the Workshop on the GFCM Regional Logbook for the Mediterranean and Black Sea. Rome, Italy, 29 June -1 July 2009. General Fishery Commission for the Mediterranean. Scientific Advisory Committee, Sub-Committee on Stat. Info.

Hilborn R, Walters CJ (1992). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York. p. 570.

Ostrom E (1990). Governing the commons. The Evolution of Institutions for Collective Action. Cambridge University Press. p. 280.

Pauly D, Christensen V, Guenette S, Pitcher TJ, Sumaila UR, Walters CJ, Watson R, Zeller D (2002). Towards sustainability in world fisheries. Nature,. 418: 689-695.

Spagnolo M, Placenti V (1998). I sistemi di informazione statistica della pesca in Italia. Quaderni I, Angeli F Ed. p. 157.

Thompson M, Sylvia G, Morrissey MT (2005). Seafood traceability in the United States: Current trends, System design and potential application. Compr. Rev. Food Sci. Food Saf. 1: 1-7.