



**FP6 - 44294**

**SARDONE**

**Improving assessment and management of small pelagic species in the  
Mediterranean**

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Specific targeted research or innovation project

## **SARDONE – Policy Implementation Plan**

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## **General overview of SARDONE results**

SARDONE project was aimed at developing a series of tools which will enable a better understanding, stock assessment and fishery management of small pelagic fish resources (anchovy and sardine) of the Mediterranean. This note briefly describe the perspectives that SARDONE project has opened and the tools developed. Some of them are of possible immediate implementation, others require further investigation and developments.

The premises for the proposal of SARDONE were the fact that some stocks of small pelagic species in the Mediterranean were over-exploited, but the management measures which may have remedied the situation were not well understood. A need had emerged to better understand the distribution of post-larval stages and how this distribution depends on oceanographic features. Furthermore, post-larval sardines and anchovies are caught in locally important mixed small-scale artisanal fisheries but little is known about the effect this mortality has on the yield of larger sardines and anchovies. A clear need thus emerged for a sound scientific basis upon which the improvement of the management of sardine and anchovy exploitation in the Mediterranean could be based. SARDONE fulfilled these requirements exactly. In fact, one part of the research developed juvenile surveys towards the proper management of the resource, whilst another part focused on the characterization of nursery areas, through retrospective analysis of past acoustic surveys, and field investigations. The problems related to understanding of post-larval and juvenile ecology and the impacts of fry fisheries were tackled and the information gained will aid the development of monitoring tools, has filled gaps in present knowledge, and has allowed the development, lest still preliminary, of a tool to assess the impact of these fisheries on the adult stocks. In particular the specific question of linking occurrence of concentration of late larvae to oceanographic processes in the region was approached through the use of hydrodynamic and Lagrangian modelling and has yielded important results which are crucial for the future development of forecasting tools aimed at improving the fishery management of these resources. Finally, the current stock assessment practice in the Mediterranean has been reviewed, the feasibility of applying models, allowing for an adaptive management, currently used in the Atlantic, was explored, and finally ameliorative methods were applied ensuring the best assessment outputs possible with the data and methods available at present.

## **SARDONE results in a fishery management context, implementation of new tools and methodologies**

SARDONE tried to tackle the problem of fishery management of small pelagic in the Mediterranean from a multiple point of view. Investigations were aimed at detecting nursery areas, at developing echo-surveys for recruitment strength estimation, at filling the gap in knowledge on the ecology of late larvae and juveniles, at improving the selectivity of current fishing gear, at assessing the impact of fry fisheries on the stocks, at exploring the application of novel stock assessment methodologies to Mediterranean small pelagic stocks.

It is evident that some of these activities were centered on specific management problems and therefore tools were developed to directly address these issues (e.g. stock assessment and impact of fry fisheries); on the other side SARDONE addressed some more basic science issue (e.g. juvenile feeding, larval dispersal through oceanographic modelling, etc) which are absolutely essential for the future development of fishery science on small pelagic in Mediterranean but that cannot be the object of an immediate implementation plan.

## SARDONE results without an immediate fishery management implementation

Acoustic data collected from past and on-going surveys were compiled, evaluated, summarized, and gaps in data were identified. These data were also re-processed to extract information on sardine and anchovy juveniles. To identify potential nurseries areas. In a future implementation perspective the persistency of these potential areas with suitable environmental conditions corresponding to high probability of anchovy or sardine juveniles should be evaluated. Moreover the coupling of potential nursery areas, suitable for both anchovy and sardine should be examined. The areas that present a high inter-annual persistency for each species, as well as the potential areas that are suitable for both species could be the most important for the juvenile from a management point of view. They could be the object of seasonal fishing closures, given also the fact that, as clearly pointed out by another SARDONE result, it is very difficult to obtain a technological selectivity in Mediterranean small pelagic fisheries, therefore it would be easier simply to forbid to fish in specific areas in determinate periods.

SARDONE defined a procedure for Mediterranean harmonized juvenile surveys, as a means of estimating year-class strength of pelagic stocks in the Mediterranean. The main constraint to an immediate implementation of this result is the lack of manpower and means of Mediterranean scientific acoustic teams. A juvenile recruitment survey need to be processed rapidly if it has to be used to regulate the fishery. This is not possible at present, but could be feasible in the future if acoustic data processing techniques will be improved. An alternative could be the increase in number of scientists and technicians devote to acoustic prospection, but it is not very likely to happen in any of the Mediterranean countries.

SARDONE performed a study of Mediterranean fry fisheries with the aim of testing various population dynamics tools with respect to their capability of assessing the impact of fry fisheries on the dynamics of the stocks. According to Art. 15, paragraph 3 of Council Regulation (EC) No 1967/2006 of 21 December 2006 "Concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94" the application of a minimum landing size to marine organisms fished commercially does not "...apply to fries of sardine landed for human consumption if caught by boat seines or shore seines and authorised in accordance with national provisions established in a management plan as referred to in Article 19, provided that the stock of sardine concerned is within safe biological limits.". This means that the sole fry fishery legally authorised by the European Union, under a specific authorisation framework, is that for sardine, *Sardina pilchardus*.

The study performed a stock assessment including the juvenile catch and exploring sensitivity of the results obtained to the uncertainty in the data. Analyses were concentrated on the Manfredonia *bianchetto* (sardine larvae) fishery which was the better documented in terms of data. Prior to the assessment, an extensive review of the literature on natural mortality (M) for sardine and anchovy late larvae was carried out to identify models of larval mortality we could use. Results showed that any *bianchetto* (sardine fry) fishery impacts the overall adult stocks to variable extents depending, mainly on the natural mortality function used. The use of the most plausible one (Pepin, 1991) indicated impact levels on the adult stock ranging between 0.3 and 3.7% for the Adriatic and Manfredonia. Results varies also according to the amount of catches of sardine fry compared to the size of the adult stock. The general finding can be summarised that under a well define condition of monitoring and stock assessment the sardine fry fishery can be authorised, but there must be a defined annual quota which could be modified according to the results of stock assessments but that shall be always set in a precautionary way. SARDONE developed a simulation tool that could be used to study different scenarios in different areas.

One of the objectives of SARDONE was to identify and select appropriate stock assessment methodologies to effectively assess the major stocks of small pelagic fish in the Mediterranean. The applicability of the methodology successfully used to assess the stocks of Bay of Biscay anchovy and Iberian sardine in the Atlantic was studied for Mediterranean stocks in the western Mediterranean, the Adriatic and the Aegean. One of the main features of these methods is that, even if they incorporate statistical analysis of the catch at age data (ICA), they are mainly based on relative population estimates from direct research surveys such as the Acoustics and the DEPM.

For each stock, the available data for the assessment were scrutinised and reviewed for quality, putting forward several suggestions for potential improvements, as it was considered that major improvements would arise from the amelioration of the basic data set. Testing different assessment methods according to the suitability of the data available was performed. Models such as integrated Catch at age analysis, or Biomass difference models or Length based analysis, (VIT) were checked in one or other stocks, and compared with the currently applied ones (VPA-type methods). Emphasis was also given to incorporating, when possible, the FLR (Fisheries Science in R) assessment framework ([www.flr-project.org](http://www.flr-project.org)) or suitable programs in R. Selecting the best, most suitable, assessment method so far, and the alternative ones, which give complementary views to the assessment, but requiring yet some further testing or addition of more years of observations. The results of this part of SARDONE are already implemented as they are incorporated in the stock assessment procedures of EU Mediterranean countries.

SARDONE investigated the selectivity of Mediterranean pelagic trawls. The results indicated that in general no escapement was recorded at the codend; both in the pair- and single-boat trawls, the higher escapement ratios were found to be in the netting before the codend; higher escapement ratios were found in the single-pelagic trawling; different escapement ratios were found for different pelagic species. A study on the behaviour of fish by means of an experimental trawl using horizontal separator panels showed that the use of different codends does not affect the trawl behaviour; Sardine and Picarel clearly preferred the upper part of the trawl, while Anchovies and Bogue have been found more abundantly in the lower-codend; a size-behaviour relationship was found for Hake and Horse Mackerel, with juveniles in the lower part and adults in the upper part of the trawl; juvenile Mackerel preferred the upper codend and adults the lower codend. But for anchovy and sardine (main target species) fishing depth always substantially influenced the length frequency distribution of the anchovy and the sardine caught and may therefore play a more important role than any other technical measure in improving the selectivity of Mediterranean pelagic trawls. This call, as already mentioned, for the necessity of protecting specific areas rather than trying to improve the selectivity of the fishing gear.

#### SARDONE results without an immediate fishery management implementation

SARDONE investigated in the development and testing of a suitable monitoring tool, based on available acoustic and fishing gear technologies to sample early life history stages (late larvae) of anchovy and sardine. This was done in the Adriatic where the presence of traditional fry fisheries allowed the straightforward selection of the area of investigation. Even if acoustic characteristics of small pelagic fish larvae are far from being fully understood, specific surveys, such those experimented during SARDONE, showed the potential to be a good tool to start collecting useful information. Further work is needed to bring to the definition of a proper and standardised methodology to perform late-larvae biomass estimation. And further work is needed as well in the complete characterization of late-larval habitats in relation to topographic and oceanographic conditions. SARDONE did a preliminary work through the development of a tool simulating the advection of eggs, larvae and late larvae from spawning areas using hydrodynamic models. Linking occurrence of concentration of late larvae to oceanographic processes (described by 3d oceanographic models) in the region is crucial for the future development of forecasting tools aimed at improving the fishery management of these resources.

SARDONE greatly contributed to the determination of growth and diet compositions of late-larval/juvenile of anchovy and sardine (which were mostly unknown) in different areas of Mediterranean. This with the aim of further contribute to the improvement of current ecosystem models (Ecopath/Ecosim) that have been developed for the NW Mediterranean and the Adriatic Sea during recent years. These models require estimates of daily ration and growth rates of the major functional groups in order to describe energy fluxes throughout the ecosystem. Small pelagic species are fundamental components of any ecological model taking into account high trophic levels (i.e., fish and fishery) in the Mediterranean. These models are based on trophic web interactions and enable to quantitatively describe the structure and functioning of exploited marine ecosystems. Moreover the improvement, through a comparative approach, of the understanding of the biotic and abiotic agents that control growth and feeding rates could help consequently to understand variation in the recruitment strength. To detail ontogenetic fractions of key species included in the models (like sardine and anchovy), from an ecological point of view, is one of the most important elements to be developed. This would enable the further understanding of the dynamics of recruitment in an ecosystem context. This objective does not provide a direct link to the issue of immediate fishery management but is aimed at building up the knowledge necessary for more scientifically sound ecological modelling which are being developed