ECOSYSTEM BASED FISHERIES MANAGEMENT IN THE MEDITERRANEAN

Honourable Minister, Excellencies, Ladies and Gentlemen,

Welcome to the Fourth APS Annual Seminar on the Development of Agriculture and Fisheries in Malta. And thank you for accepting our invitation. Your presence is greatly appreciated. It encourages us to continue developing this annual initiative.

These seminars focus on specific issues with a twofold objective. Firstly, they highlight particular themes that the Bank believes should be given recognition by all those operating in the sectors of Agriculture and Fisheries. Secondly, the selected theme is developed with the contribution of specialists who identify key areas that demand attention and action from all those involved. These seminars do not provide an instant solution. They examine issues; describe local and regional management structures; and they propose measures that will lead to better resource allocation and growth in the area under study. The audience is selected; but the experiences will be shared among a larger group following the publication of the proceedings.

This year's seminar is a follow up to last year's analysis of the Code of Conduct for Responsible Fisheries prepared for the global fisheries sector by the Food and Agriculture Organisation of the United Nations. The Code was examined in the context of the Conservation Zone around the Maltese Islands and in the Mediterranean. A Maltese version of the Code was also made available in hard copy and on the FAO's website. The interest generated in the theme led the Bank to dedicate this year's seminar to a related subject addressing the issue of Ecosystem Based Fisheries Management around the Maltese Islands and in the Mediterranean.

Orderliness in the fishing industry in a region that sees annually more aggressive exploitation of the once bountiful natural resources is a necessary, though not sufficient, condition for the very existence of the various species that inhabit or pass through the Mediterranean. It is equally important to identify and track the changes in the ecosystem that is meant to generate a living habitat for the families of fish that ply these waters. The scientific knowledge thus collated will serve to make us appreciate better the intricate network that supports the food chain for so many creatures and, at the same time, highlight the fine balance that keeps the system in place, alive and flourishing. The survival of the system should be an object in itself, but it is also important for mankind, especially for those who live along the coastal shores of the Inland Sea. Collaboration will reinforce historical links; mismanagement will induce suspicion, distrust and, at times, outright animosity. In this case, not only will the natural habitat be the loser but also humanity at large.

APS Bank is proud to collaborate with the FAO, the Ministry of Agriculture and Fisheries, the Department of Fisheries and Aquaculture, and the International Oceanographic Institute of the University of Malta and address a series of issues related to Ecosystem Based Fisheries Man-

agement in the Mediterranean. The speakers represent a wealth of experience that they are prepared to share with us this morning.

The foreign guest speakers will focus on the MedSudMed project to illustrate the interlinkage between the Code of Conduct for Responsible Fisheries and the Environment.

Mr. Fabio Massa, Director FAO-MedSudMed project, will describe the main objectives and the operations of the project. He examines the role of education and of example – learning by doing - in the survival of ecosystems.

Mr. Dino Levi, Scientific Director of the MedSudMed project, explores the technical issues related to ecosystem-based management of fisheries using the experience in the Southern Mediterranean as a case study.

In turn, Mr. Derek Staples will specifically address the relationship between the Code of Conduct and Ecosystem based management.

The two Maltese speakers, Mr. Aldo Drago, Director of Research at the International Oceanography Unit, University of Malta, and Mr. Matthew Camilleri, from the Department of Fisheries and Aquaculture, will explain the oceanography features around the Maltese Islands and the background to the establishment of the twenty-five mile conservation zone. These are themes that should be of direct interest to many in the audience this morning.

On your behalf, I thank the speakers who made this meeting possible. I wish also to thank the respective organizations that allowed the speakers to participate. In particular, I wish to publicly acknowledge the support we always found from His Excellency Mr. Francis Mifsud Montanaro, the former permanent representative of Malta to FAO, and to thank him for his encouragement and dedication. At the same time, I take the opportunity to greet His Excellency Mr. Abraham Borg, the new permanent representative. Both these gentlemen are with us this morning.

As always we are honoured by the presence of the Minister of Agriculture and Fisheries who accepted our invitation to present the views of the Malta government on this subject. On behalf of APS Bank I thank the Minister for joining us and invite him to present his address.

The Hon. N. Zammit, Minister for Agriculture and Fisheries

OPENING SPEECH

Mr Chairman, distinguished officials and guests, colleagues from the Fisheries Conservation and Control Division, ladies and gentlemen.

Malta has conserved its twenty five-mile fishing zone for more than thirty years whilst enjoying the sustainable exploitation of fisheries resources, which fisheries resources heavily contribute both to the quality of life of our locals and also to the catering and tourism industry.

The fruit of the responsible management of our demersal fisheries, in particular, has not only been reaped by Maltese fisheries, but has spilt over into the adjacent areas of our fisheries conservation zone. These adjacent areas which have been continually replenished by recruitment originating from the said conservation zone. As such, on accession to the European Union, the Maltese twenty five-mile fisheries conservation zone will retain its status by means of a special management regime within the framework of the EU Common Fisheries Policy. As a member of the European Union, Malta will continue to contribute to the scientific activities of the General Fisheries Commission for the Mediterranean whilst enjoying the support of the European Commission and other member states in management decisions as well as in their implementation at both national and regional levels.

Malta has worked hard during recent years to jointly develop a new fishery statistical system and the associated catch assessment scheme. This objective was achieved with the dedicated assistance of Dr Rino Coppola from FAO, coupled with the support of FAO's sub-regional project COPEMED. This system is serving as an important tool to provide reliable and timely statistics, which information is essential in the implementation of a responsible fisheries management, thereby satisfying both national and international requirements.

Malta has also updated its national fisheries legislation. This per se *reflects Malta's obligations that are laid down in international fisheries agreements and instruments and which protocols Malta has ratified over the years.*

The strengthening of its monitoring and surveillance capacity is also underway through the recruitment of trained fishery protection officers, through the introduction of a satellite based Vessel Monitoring System and through the modernisation of the Maritime Squadron fleet of the Armed Forces of Malta.

The international call to adopt the Ecosystem Approach to Fisheries has set new challenges for the GFCM and its members. The distinct nature of the Central Mediterranean lends itself as a natural laboratory to study the interactions between fisheries resources and the biotic and abiotic environment. In this context, FAO's recently launched sub-regional project MedSudMed has taken on the responsibility of pioneering and addressing multidisciplinary scientific research in this Large Marine Ecosystem. Malta hosted the first scientific activity of MedSudMed in December 2002 and I ensure that it will continue to be fully committed to this four-year project. This MedSudMed project will

contribute to the incorporation of the ecosystem approach further into the management regime of Malta's 25-mile Fisheries Conservation Zone.

In conclusion, I would like to thank APS Bank for organising this seminar, which is an important follow-up to last year's seminar, as well as our friends from FAO who have once again honoured us with their presence and contributions. I trust that you will all find this morning's programme interesting and informative.

Dr Fabio Massa - Project Director

THE MEDSUDMED (FAO) PROJECT

Honourable Minister, Mr Chairman, Excellencies, Distinguished Guest, Ladies and Gentlemen.

- First of all I would like to thank the APS Bank their invitation to this important seminar and for the opportunity to give you a general outline of the MedSudMed Project, in which the Republic of Malta is a key partner through the Department of Fisheries and Aquaculture of the Ministry of Agriculture and the other scientific institutions involved in the Project.

- MedSudMed "Assessment and Monitoring of the Fishery Resources and Ecosystems in the Strait of Sicily" is a 4-year FAO Regional project, funded by Italy though the Ministry of Agriculture and Forestry Policies; the participating countries are the Republics of Italy, Libya, Malta and Tunisia.

- The Project started in April 2001, one of its main objectives is to support the scientific community of the participating countries in the development of a monitoring system for the fishery resources and marine ecosystems, particular attention is paid to biotic and abiotic issues related to marine fisheries. The Project takes the guidelines and principles of the Code of Conduct for Responsible Fisheries into consideration, recognising the importance of an appropriate knowledge of the ecosystem for fisheries management.

- The Conference on responsible Fisheries in the Marine Ecosystem (Reykjavik, 2001) included a recommendation on the integration of "ecosystem considerations" into fisheries management. It stressed that this approach should be used as a "scientific basis of existing and future knowledge". The study of the dynamics of marine ecosystems could help in reflecting some of the many dimensions of fisheries in a complex marine ecosystem.

- These concepts are more significant in areas characterised by a high species complexity, supporting shared fisheries and shared resources, such as in the area of the MedSudMed project, the Strait of Sicily. In this case the "study of ecosystem parameters related to fishery systems" must start by the strengthening the scientific cooperation between the countries. Therefore particular attention must be paid to upgrading the scientific knowledge and inter-country collaboration and harmonisation in the collection and processing of scientific data.

- In this framework the main tasks of the Project MedSudMed are:

a) To increase the scientific knowledge on the ecosystem in the Project area, related to the fishery resources.
b) To strengthen the national and regional expertise and support scientific cooperation.

c) To standardise the methodology and approach to the studies of the relationship between fishery resources and biotic and abiotic factors.

- In order to fulfil these objectives the Project concentrates on:

a) Identifying which ecosystem considerations can be included in fisheries management; collecting the scientific information available on fisheries and related ecosystems; creating a critical review of formal and grey literature; implementing research activities.
b) Implementing an Information System to: gather and analyse scientific data; prepare an ad hoc GIS to include and analyse all the information; define operational, computer based "modular package".
c) National capacity building *ad hoc*, on-the-job-training; establishing strong cooperation with the other FAO regional Projects in the Mediterranean (CopeMed, AdriaMed), with he GFCM and its Scientific Advisory Committee and specific Sub Committees, and the other international institutions and organisations.

- Furthermore the Project started on:

- the preparation of an inventory of scientific information available in the four countries, including an overview of the status of research activities on fisheries related to ecosystem studies
- the preparation of a review of the available data or data-banks in the Project area with particular attention to environmental parameters.
- Establishing relations with the national scientific institutes and setting up the Project's scientific network.

- During this year and a half of activities, discussions on the methodological approach permitted the identification of some specific priority topics that are being and will be addressed by the Project. These matters were highlighted by the different research institutes involved, which represent the Project's scientific counterparts.

- During the first meeting the MedSudMed Coordination Committee (held in Rome in 2002) three main areas of research were identified, together with objectives on which the Project should focus its attention:

- The first to describe the spatial distribution of demersal resources according to the environment and of the fishery system.
- The second to manage and analyse the oceanographic processes influencing the abundance and spatial distribution of small pelagic species.
- The third to manage and assess the possibility marine protected areas for fishery management purposes.

- For each of these aspects the Coordination Committee decided that an Expert Consultation should be organised, to gather the available knowledge and expertise on each aspect and to identify the gaps in the methodology applied and the criteria for data collection, thus identifying the need for national and regional training. On the basis of the results that will be obtained from these three Expert Consultations, a fourth Expert Consultation will be held for aspects related to data and information systems.

- On the basis of the results the Expert Consultations, the Project is establishing a multidisciplinary scientific network among researchers and institutions to identify research activities and training on the specific topics which will subsequently be implemented.

- Another expected result of the Project is a computer-based package, with the capacity for storing, analysing and representing the main parameters describing fish stocks, their environment and the fisheries depending upon them.

A further important aspect that must be underlined concerns the methodological approach applied and the results of the MedSudMed Project which underline the pilot role played by the project. MedSudMed, as well as the other FAO Regional Projects, represents an opportunity not only for the area in which the Project activities will be developed, but also a contribution for all the Mediterranean region.

Other important aspects of the Project including the new methodology approach will introduced to you in greater depth by the Scientific Director of the Project, Prof. Levi.

Thanks you very much for your attention.

Prof. Dino Levi Scientific Director

AIMS AND RESEARCH ACTIVITIES OF MEDSUDMED AS A PILOT STUDY FOR EBFM

Let me first express my compliments and my gratitude to the Organizers and the attendants of this seminar for their timely and keen initiative and venue.

Fabio Massa's short contribution has right now clearly outlined the frame wherein MEDSUDMED stands, both from the scientific and the institutional standpoint. This facilitates my task.

Looking this morning at the brochure which was prepared for this meeting, namely at the short C.V.'s therein, I realized that for reasons of pace, I assume, the central piece of mine had been cut off.

I would not like to start speaking of myself, which would not be either wise or polite, but for the fact that what I sent for the brochure was in fact and "ad-hoc" abstract of my C.V. to highlight the links with MEDSUDMED, and the missing part is critical for that aim.

Forgive me now if I dare to read it. It says: "…omissis…*In the last eighteen years, as the Director/founder of the NRC Institute in Mazara del Vallo, he progressively tried to afford another research switch: towards ecosystem management. Having experienced the independence from fishing of fluctuations of small pelagics in the Adriatic (co-working with colleagues in*

Ancona and M.R.A.A.G.) he is now exploring the Po river influence through fuzzy logics. But he also encouraged the set-up of an original programme on small pelagics' ecology in the Sicilian Straits by parallel approaches (egg-larvae, echo-surveys, satellite imagery, meso-scale oceanography coupled with biological sampling… now talking place (also co-financed by DG XIV…).

His stronger involvement, though, has been since 1982 on demersal fisheries, when he introduced the technique of stratified-random trawl-surveys in the regional programmes.

National and EU programmes were then implemented, and dissatisfaction of classical single-species approaches to stock-assessment progressively increased. His effort ever since has been thus along two lines: 1) the maximum possible use of scanty informations, 2) the development of new synecological methods (lastly, great attention to ANN is giving some preliminary but encouraging forecasts…)

Further to development and direction of the above two research guidelines (on small pelagics and on demersal resources) he promoted an entirely new lab and research group in the Gulf of Castellammare, solely devoted to artisanal (coastal) fisheries' ecology, artificial reef studies, monitoring marine refugia.

He lectured as V.P. at the university of Parma, Palermo, Bari, Venice; published some 200 papers and reports, mostly in refereed journals and has since 2002 the scientific direction of the FAO MEDSUDMED program (Assessment and monitoring of the fishering resources and the ecosystems in the Straits of Sicily) GCP/RER/010/ITA, financed by the Italian Ministry of Agriculture and Forestry Policies, hosted at the IRMA-NRC premises in Mazara del Vallo."

It is for the above facts, that at the first meeting of scientific nature of the program which took place at the

premises of FAO on the occasion of a SAC-GFCM meeting (Italy 2002) with representatives of all countries involved, after the Fishery Monitoring Expert had paid visit to the same countries, I was given the task to draw the main scientific guidelines of the Project.

In so doing I obviously had in front of me the first results of the visits to countries, with a first assessment of what was going on, what could be foreseeable, what could be feasible, and the works and experience at IRMA, in Mazara del Vallo and Castellammare del Golfo.

Three main illustrative proposals of issues were hence identified, plus a fourth one, the Information System, which was since the very beginning an integral part of the original project Document (GCP/RER/010/ITA).

Quoting now from the text, I will try to attach with every issue an example of practical research experience carried our or IRMA.

1. Spatial distribution of demersal resources in the Strait of Sicily according to environment and fishery features.

1.1 Rationale

Despite the management framework adopted recently, very little information is available on distribution, integrity and separation of marine resources stocks in the Strait of Sicily. Besides, according to the usual assessment procedures, most of the demersal resources in these MUs resulted "fully exploited" or "overexploited", and a reduction of fishing effort and changing in fishing pattern was generally recommended in order to insure a sustainable exploitation of these resources (Levi *et al.*, 1998). However, most of the above mentioned geographical sub-areas need further description regarding biological processes and/or fish movements. As a consequence of this lack of information several biological stocks of the same species may be exploited within each management unit, and stocks which enter a given management unit may have been exploited by fisheries elsewhere.

Many approaches have been adopted for the identification of stocks. These include studies on distribution and abundance of various life-history stages, marks and tags, both natural and artificial, meristics and morphometrics, calcified structures, genetics and life history parameters. Some of these methods are expensive and time-consuming, while other ones may quickly give information on identity of stocks. Amongst them the spatial distribution of species populations, which are already well sampled by research surveys at various stages of their life cycle, represents a useful tool for the identification of stocks and allows giving advice for short term management problems (Pawson and Jennings, 1996).

1.2 Objectives

The aim of this proposal is the identification of spatial distribution of different phases (recruits, adults and any significant age groups) of commercial fishes in relation to environmental features and fisheries characteristics in the Straits of Sicily. This study will provide the basic information dealing with the recognition and delineation of different stocks in the Strait of Sicily, as preliminary for an effective stock assessment and management in the area.

The project is divided into the following tasks, designed to study respectively:

1. the main physical features of the area (bathymetrical, sedimentological and hydrological features);
2. the main benthic biocenosis and demersal fish assemblages;
3. the fishing pressure on demersal resources in the area;
4. the spatial distribution of juveniles and adult of target demersal species;
5. the combination of all previous tasks using a Geographical Information System (GIS) in order to give an overall view of the possible interactions between the spatial distribution of the demersal resources and environment and fishery features.

1.3 Methodology

As a general approach, previous studies will be taken as reference. Their analysis should help identify the gaps and the pertinent data to be collected to fill them. Remote sensing data, if the case arises, should be favoured as they are easily obtainable, and have a spatio-temporal resolution well adapted to regional problematics (large zones can be covered, at a relatively fine temporal scale).

Common target species to be studied can be chosen in accordance with the priority species listed by the GFCM sub-committee on stock assessment. However, in order to allow a comparative approach, both species which are considered as forming shared stocks in the area (such as *M. merluccius*, *A. foliacea*, *N. norvegicus*) and those supposed to belong to separate stocks *(M. barbattus*, *M. surmuletus* and *E. cirrhosa*) will be selected as target species.

The main habitat should be described and characterized (type of bottom, typical species,…) mainly by using literature data, at least at first. Then, according to the gaps and according to the sampling possibilities, descriptions can be deepened.

Fishing pressure has started to be described by FAO Copemed Project. With a general agreement, this work could be pursued and developed, in particular for the calculation of fishing pressure indicators to be used as possible external factor influencing the spatial distribution of fish.

Spatial distribution of individuals may be drawn up using either historical data, as well as data provided by on-going national sampling programmes (trawl surveys). According to the data that will be used, an essential requirement would be either to study the possibility of standardization of existing data, or to agree upon a simultaneous and standardized sampling schedule for all parties.

As mentioned previously, all data can then be represented, combined and analyzed using a GIS approach that would help highlighting the most relevant aspects related to the interactions between fishery resource and its surroundings, knowing that this methodology gives the possibility of adding and type of relevant information.

The example from IRMA work (Fig. 1 and 2) are the identified spawning and nursery areas in southern Sicily from many years of trawl surveys (Garofalo *et al.*, 2002) and the improvement introduced into the stock-recruitment relationship by embedding Sea surface Temperature anomaly as a proxy of upwelling index (Levi *et al.*, 2003).

Fig. 1 - Spawning and nursery areas of Mullus barbatus
(From Garofalo at al. 2002)

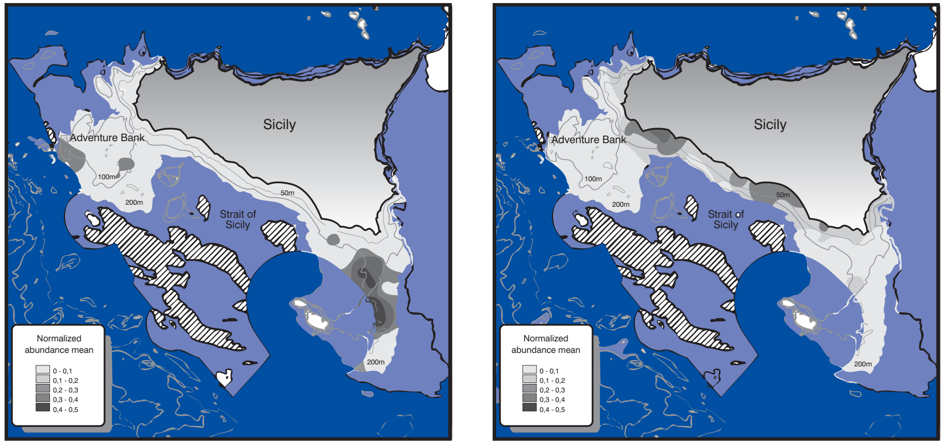
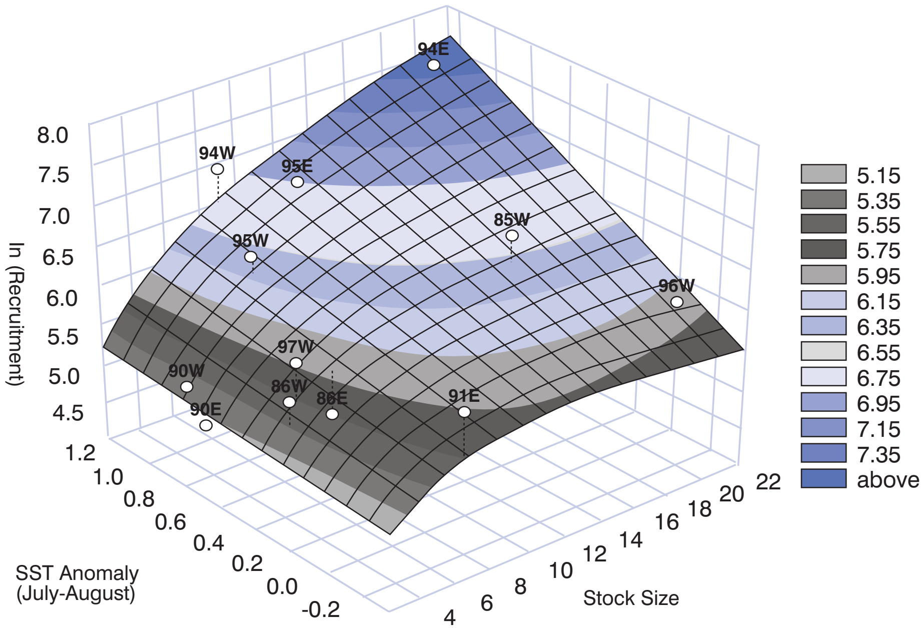


Fig. 2 - Stock-Recruit relationship and environmental factors in Mullus barbatus (From Levi et al. 2003)



2. Small pelagic fish in the Strait of Sicily: stock identification and oceanographic processes influencing their abundance and distribution

2.1 Rationale

Importance of the small pelagic fish is both commercial and scientific (trophic level = importance for ecosystems, ecological importance because of competition that exists between some species like anchovy and sardinella that reproduce at the same period).

Despite annual surveys, little is known on spatial distribution, influence of physical parameters, reproduction and concentration zones, transport of eggs and larvae.

2.2 Objectives

1. Stock identification

2. Oceanographics processes and abundance:
   - analysis of historical data (catches, biomass estimates, Sea surface temperatures, chlorophyll, …) when and where the cases arise;

3. Oceanographic processes and distribution:
   - transport of early life stages (eggs and larvae)
   - influence on recruitment
   - distribution of adults

2.3 Methods

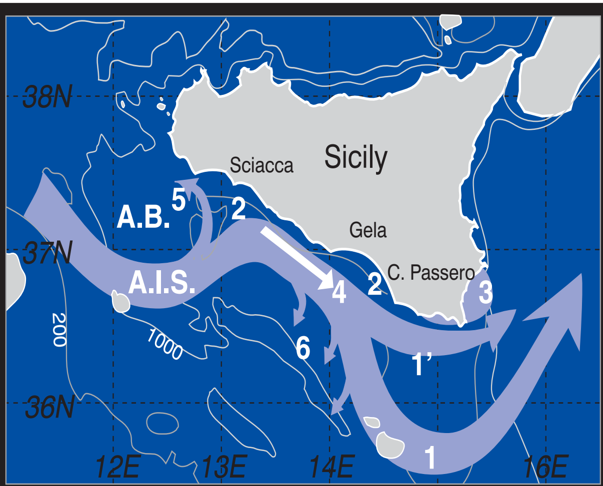
The studies would take place along the coastal zones, on the Italian (Southern Sicilian), Libyan, Maltese and Tunisian continental shelf. For practical reasons, it may not be possible to study the integrality of the coast, more precise study areas should therefore be defined and agreed upon by all four partners.

Methodology / Tasks
1. Bibliographic review
2. Analysis of historical data
3. Stock identification
4. Field work
   - Ichtyoplankton surveys
   - Acoustic surveys
   - Physical oceanography surveys
5. Analysis and integration of collected data

The pertinent example from IRMS work (Fig.3) summarizes some relevant results of the program MAGO (Mazzola *et al.*, 2000)

The Atlantic water coming from the Western Mediterranean Basin forms the so-called Atlantic Ionian Stream (1), which meanders in the Sicilian Channel following closely the bottom topography. The second meander may be absent in which case the AIS runs close to the southern Sicilian shore (1'). In both cases, it leaves a cyclonic circulation cell off Cape Passero when it separates from the shore (3).

Shoreward of the anticyclonic bending of the AIS are found the most favourable anchovy spawning grounds (2). Physical reasons for it could be the upwelling associated to this bending and, particularly, the stagnation point off



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Shoreward of the anticyclonic bending of the AIS are found the most favourable anchovy spawning grounds (2). Physical reasons for it could be the upwelling associated to this bending and, particularly, the stagnation point off Sciacca formed when the AIS impinges the shore. This is, by far, the site of the largest egg concentration. Eggs and larvae (eggs hatch in hardly one day due to the very high surface temperature) would be advected downstream by the AIS (4) and eventually reach Cape Passero, where they may be trapped by the cyclonic circulation (3). Most of anchovy larvae were found here suggesting that this area is the nursery grounds.

Secondary circulation also appears:
When the AIS impinges the shore off Sciacca, a minor branch (5) circulates anticlockwise to close the cyclonic vortex that occupies the Adventure Bank (AB). This secondary circulation can advect eggs in the opposite direction (mortality?). Offshore transportation of eggs (6) would probably occur whenever the AIS flows following the path 1 (mortality?). The most favourable conditions for survival are met when the AIS flows along 1'. Offshore
transport (6) and related mortality processes may be enhanced by windinduced upwelling events, which occur in case of northerly winds.

Fig. 3

Sciacca formed when the AIS impinges the shore. This is, by far, the site of the largest egg concentration.

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3. MPA and Fisheries Management

3.1 Rationale

The Sicilian straits include almost all of the typical Mediterranean coastal and pelagic habitants, with the peculiarity that in some areas they are overexploited and in some others they are almost still intact, and can be considered as marine protected areas (MPAs).

Research on the assessment of fish stocks has been carried out during several years in the area of the Sicilian Straits, in particular within the national borders of each country. Data on underexploited international areas came only recently.

The availability of several habitats under a different stage of protection, and the chance for creating new *ad hoc* MPAs in the region can allow to test a series of hypotheses on the role of the MPAs.

MPAs such as marine reserves, fishery reserves and gear exclusion zones, are considered to be especially useful in socially and biologically complex situations where traditional approaches based on catch and/or effort control would be highly demanding in terms of data and labor. The preference given to protected areas is due to their potential role in *(i)* the recovery of depleted stock, *(ii)* the prevention of recruitment overfishing, and *(iii)* the spillover of fish to adjacent fished areas (Pounin, 1990; Dugan and Davis, 1993; Dayton *et al.,* 1995; Bohnsack, 1996; Holland and Brazee, 1996; Auster and Shackell, 1997; Roberts 1997).

3.2 General Objectives

The general objectives of this research proposal are to use areas subject to different fishing effort to explore aspects of the dynamics of inshore and offshore food webs, and make advances in the scientific-methodological underpinnings of resource and environmental management.

3.3 Methodology

Recent data from the fishery reserve in the Gulf of Castellammare, include an 8 fold increase of fish biomass (Pipitone *et al.,* 2000), a general economic benefit for the

small scale fisheries of the area (Withmarsh *et al.,* 2002) a size structure shift of the whole benthic fish assemblage with some species increasing and others decreasing their average size (Badalamenti *et al.,* 2002).

Since the feeding habits of fishes are commonly size dependent, such that as a fish increases in size within a population (*e.g.,* Frid *et al.,* 1999), or as mean size declines in a population subject to increased fishing mortality (Pope and Knights 1982), so the diet and trophic level will tend to change. Areas closed to fishing provide an exceptional chance to explore trophodynamic and other structural consequences of the recovery in previously-depleted stocks, the dynamics of biological reference points such as trophic level and interaction strengths in whole food webs, and the underlying state-of-the-art methodologies for these. Thus the application of modern methods such as size spectra and stable nitrogen isotope analyses, together with the use of trophodynamic models (Pauly *et al.,* 2000) will contribute to improving the techniques for demersal resource assessment and the assessment of the ecosystem effects of fishing in the Mediterranean so as to improve understanding of marine shelf systems at large scale and ultimately improve the means for management of marine coastal resources.

Figure 4 depicts the field area of experimental work routinely conducted by the team of Castellammare to investigate both the outcomes of trawling ban in the Gulf and the trophodynamic changes introduced by artificial reefs and / or trawling ban. (Badalamenti *et al.,* 2002)

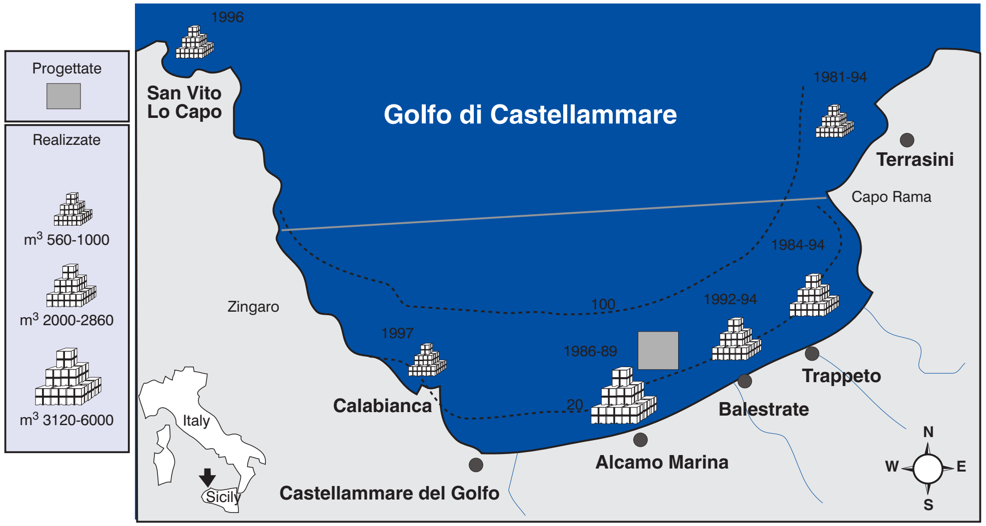

Fig 4.

4. "MEDSUDMED" DataBase and Information System

The fourth and "horizontal" illustrative proposal, whose "father" is Rino Coppola, deals with a "computer-based package with the capacity for storing, analyzing and representing the main factors describing fish stocks, their environment and the fisheries depending upon them" (Coppola *et al.*, 2002)

Figure 5 charts the main components, with a view to **independency, modularity** and **interactions** (ibid.)

Finally, a few words about the challenge facing us. It is typically a work in progress, whose proposals shall become programs through, as a start, "Expert Consultations". The first one, on the first Illustrative Proposal, took place here in Malta last December. Its outcomes will be made available for the next one (possibly in Tunisia) on MPA, and so on.

The process will also help to better define what an ecosystem approach to fisheries is. We stick, for the moment, to the definition of ecosystem attributed to Eugene Odum by De Angelis (1993) "An ecosystem includes all of the Organisms in a given area, the flows of matter and energy between each other and between the organisms and the physical environment, and the relevant storages of

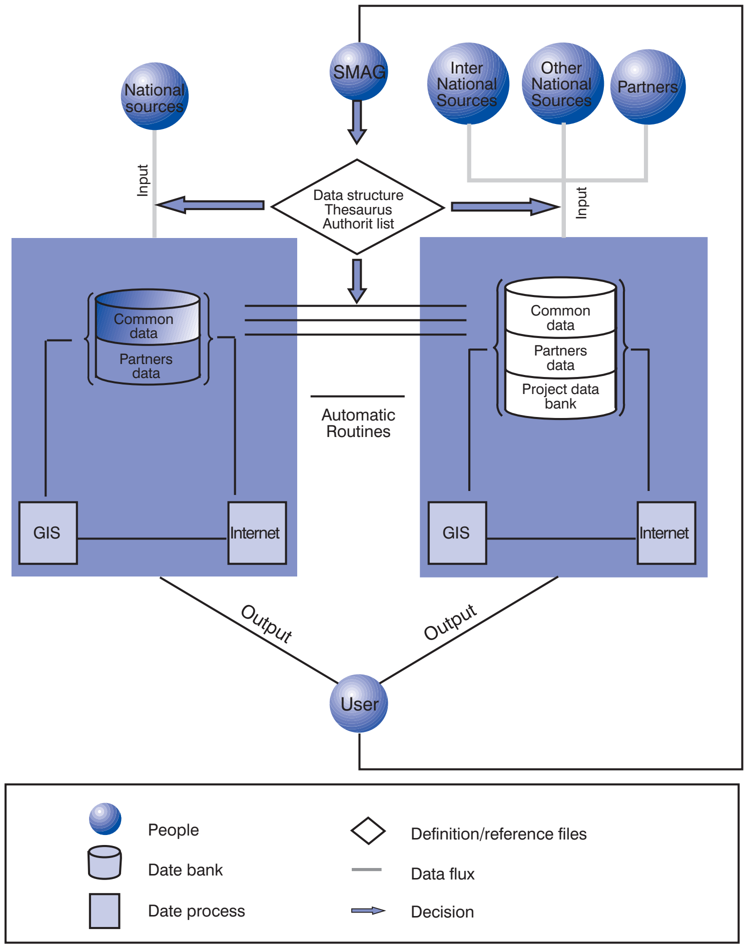

Fig. 5

biotic and abiotic matter and energy. The biotic community interacts with the physical environment in a coherent way so the flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles" (in: *D.M. Ware 'Aquatic Ecosystems: Properties and Models', pp. 161-194 of 'Fisheries Oceanography An Integrative Approach to Fisheries Ecology and Management' Edited by Paul J. Harrison and Timothy R. Parsons, 2000. Blackwell Science Fish and Aquatic Resources Series 4).*

As will also come out from this seminar (D. Staples, this meeting) there is a well known phenomenon in science: the observer's view modifies the observed system. EAF will be different from Economists, social scientists, biologists… I would be glad to have MEDSUDMED giving a small but significant contribution to the Fisheries Biologist's view in this part of the LME called Central Mediterranean.

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ADDRESSING THE NEED OF MARINE OBSERVATIONS FOR FISHERIES

1. Introduction

The quest to gain knowledge and understand the workings of the oceans has been a constant undertaking by mankind since the dawn of history. Information on the sea has served navigators to exploit ocean winds and currents, ancient explorers to reach new continents and merchants to reach distant harbours, fishermen and whalers to ascertain their catches, and navies to master ocean space. The need and practical use of ocean knowledge has become even more important today with our increasing dependence on the sea, and an evolving conscience confessing its commitment to the sustained management of ocean resources and obligation towards ocean governance.

The practical study of the sea has in the last two decades leaped forward along with the advancement in science and technology, improved sensors to observe the sea by direct measurements as well as remotely from space, and in particular with the progress in information technology. It goes today under the name of 'Operational Oceanography' which can be defined as the activity of systematic and long-term routine measurements of the seas, oceans and atmosphere, and their rapid interpretation and dissemination [1,2]. Important products derived from operational oceanography are:

- *nowcasts*: providing the most usefully accurate description of the present state of the sea including living resources;
- *forecasts*: providing continuous forecasts of the future condition of the sea for as far ahead as possible; and
- *hindcasts*: assembling long term data sets which provide data for description of past states, and time series showing trends and changes.

Operational Oceanography proceeds usually, but not always, by the rapid transmission of observational data to data assimilation centres. There, powerful computers use processing software and numerical forecasting models to extract added-value information from the data. The outputs are used to generate data products, applications and services often through intermediary value-adding organisations. Examples of final products include warnings (of coastal floods, storm impacts, harmful algal blooms and contaminants, etc.), electronic charts, optimum routes for ships, prediction of seasonal or annual primary productivity, ocean currents, ocean climate variability, etc. The final products and forecasts are targeted for rapid distribution to industrial users, government agencies and regulatory authorities. Operational oceanography thus fulfils the demands of the many marine activities, providing support to recurrent and emerging needs such as for safer and more efficient navigation, improved and new marine services, effective assessments on the state of health of the ocean, mitigation of marine hazards, forecasting climate variability, and further mastering of the oceans as a resource of food, materials, energy and space.

2. Implications for fisheries

The physical environment is a key influencing factor on the behaviour and distribution of fish. Marine organisms live in a very dynamic and changing medium with water movements carrying with them fish larvae from one place to another, sea current streams and favourable water temperatures being exploited by migrating pelagic species, upwelling water providing nutrients at the surface from the deeper parts of the ocean, and the general conditions of the marine environment dictating the overall behaviour of fish and creatures in the sea.

Ocean weather - Indeed we are all accustomed to the rapidly changing patterns of atmospheric phenomena that we follow from daily forecasts, with high and low pressure systems evolving and interacting, producing severe winds, and fronts with associated rain. It is however hardly realised by the general public that even the ocean is populated by similar ever-changing systems. The continuously evolving oceanic systems are the equivalent of atmospheric highs and lows, and are often termed the ocean 'weather'. They occur in the form of gyres and eddies, revolving and moving, transferring heat and momentum, and causing water masses to mix. The oceanic physical patterns constitute what is better known as the ocean mesoscale variability. As in the atmosphere, they can trigger intense activity producing strong currents, shaping the temperature and salinity fields, and giving rise to frontal areas separating warm and cold water masses.

The wind field plays a major role in the evolution of the upper ocean phenomenology and thus drives what is known as the barotropic (depth-averaged) component of the ocean currents. The gyres that characterise the surface circulation of the basin are mainly forced by the wind.

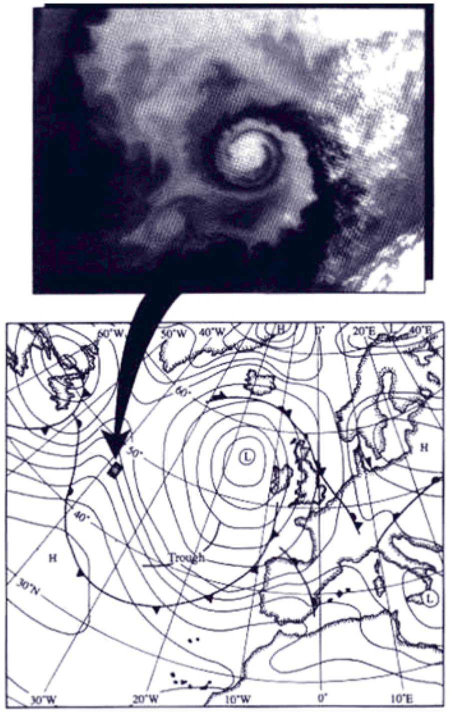

Fig. 1 Comparison of spatial scales between oceanic and atmospheric synoptic variability - from Chapter 4 in Oceanography, An Illustrated Guide by Summerhayes & Thorpe [3].

The action of the wind does not however only cause horizontal motion, but also triggers vertical movements that feed the deeper water masses. The effect of a cyclonic (anticlockwise) wind in the northern hemisphere causes a divergence of surface water away from the centre of action, and there results a lowering of sea level and a vertical rise of the thermocline (see Fig. 2). The associated upward movement (upwelling) of water is termed Ekman Pumping. The opposite effect occurs in the case of an anticyclonic (clockwise) wind which creates a convergence of surface

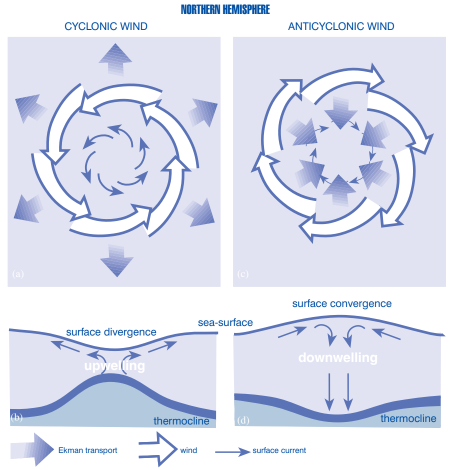

Fig. 2 Examples of divergence and convergence zones forced by the wind in the Northern Hemisphere (Adapted from Ocean Circulation, Open University Course Team, [4])

water, with a consequent rise in water at the centre, a lowering of the thermocline and a downward movement (downwelling) of water.

The heat and water budgets of the Mediterranean basin are also key forcing agents dictating the general circulation. They mainly alter the vertical density structures of the ocean water masses. These density anomalies can produce gravitational adjustments leading to what are called baroclinic flows, that is currents triggered by the 3D density structure of the seawater column, and which usually vary with depth. The slow Mediterranean thermohaline basin scale circulation maintains the two-layer flow consisting of a fresh Modified Atlantic Water (MAW) eastward surface flow and a deeper saltier westward Levantine water flow.

Recent observational data and numerical studies have furnished a new picture of the Mediterranean surface circulation that departs somewhat from that advocated in the early 80s [5]. It is mainly characterised by the westward flow of the Atlantic Water vein which divides the basin in two regimes, with anticyclonic gyre systems to the south, and predominantly cyclonic flows to the north. In the western basin the Atlantic Water enters through the Strait of Gibraltar and feeds what is known as the Algerian Current that is characterised by large meanders along the African coast. Beyond Sardinia this current bifurcates into two branches, with one flow moving north into the Tyrrhenian Sea and the other proceeding towards east across the Sicilian Channel where it drives the Atlantic Ionian Stream. This swift current moves into the Ionian Basin and further leads to the Mediterranean Mid-

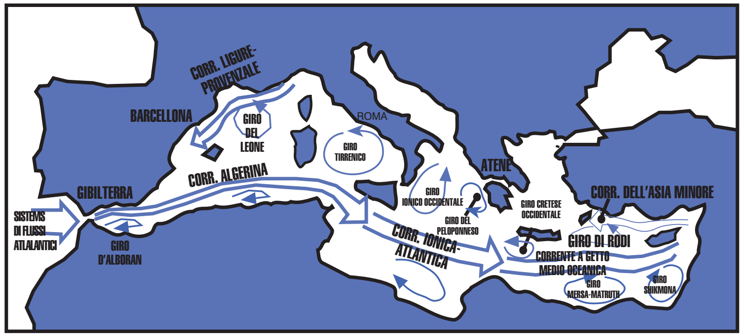

Fig. 3 General pattern of the surface circulation in the Mediterranean Sea

Oceanic Current that starting from South of Crete leads to a system of gyres in the Eastern basin.

The eddy field (mesoscale) patterns triggered by the synoptic scale atmospheric forcing (wind field vorticity) are in addition superimposed upon the general background larger scale circulation [6]. The mesoscale field structures give rise to eddies, coastal upwelling, jets and frontal zones, such as are depicted in the satellite image in Fig. 4. They evolve on time scales of the order of 1-10 days, which is much slower than that of atmospheric movements, but the spatial scale (10-100 Km) is much shorter with respect to atmospheric systems. This means that a much greater resolution of observations is necessary to map oceanic

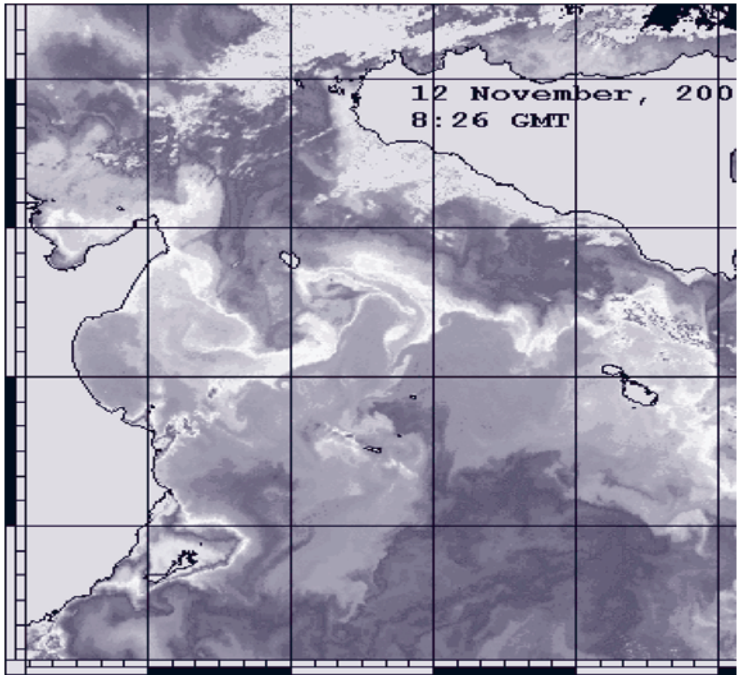

Fig. 4 Satellite picture showing the complex surface circulation structures in the Central Mediterranean on 12/11/2002. (Picture by courtesy of Sergey Stanichny, Hydrophysical Institute, Ukraine)

movements, rendering the effort even more demanding both on technology and resources with respect to atmospheric mapping and forecasting. In this context satellite imagery in the infra-red, visible and very high frequency ranges of the spectrum become very useful tools to acquire synoptic maps of the ocean surface circulation [7,8]. Remote sensing has opened the way to sample the richness in structure of the oceanic eddy field, and we have only just started to assess the importance of these oceanic eddies in shaping the large-scale ocean circulations and their impact on climate and the biology of the oceans [3].

Impact of the physical conditions on fisheries - Mesoscale phenomena play a significant role in the exchange, mixing, distribution and redistribution of the main physical, chemical and biological parameters of the marine ecosystem. They carry biogenic material and shape the phythoplankton biomass distributions that constitute the most rudimentary levels of the marine food web, and thus bear important links to biological processes. Particular fish stocks are known to favour certain types of eddy and their associated fronts. It is also well known that important commercial fishing grounds are found in zones of temperature fronts, borders of flows, in zones of divergence and convergence. The convergence of flows produces a "mechanical" congestion of fodder organisms and small-sized fishes. In divergence zones and upwelling areas the high concentration of biogenic elements and supply of nutrients in the upper layer favours the provision of food for fish through the proliferation of phythoplankton and zooplankton organisms [9]. The Maltese Islands are situated in one of the most important upwelling areas of the Mediterranean (refer section 3 for details). The current boundaries associated with these

zones keep changing positions with the seasons and with varying meteorological conditions. Predictions of their movements and future positions is an important subject of synoptic oceanography. Under certain conditions there is an accumulation of species near the current or water type boundaries. A water type boundary might be considered as a limit of the normal distribution of a given species. Greater insight on the relationships and dependencies of bio-productivity and physico-chemical conditions thus offers a possibility to use spatial ocean patterns as fish indicators such as for (i) quantifying stress on fish stocks, (ii) identifying threats on stocks and biodiversity, and (iii) controlling factors affecting the occurrence of fish. The relationships between environmental conditions and fish occurrence thus offers new means for the conservation and sustainable use of marine resources, as well as to improve confidence on fish stock assessments and fisheries management methodology.

Water temperature, oxygen content, pH (alkalinity), nutrients, water stratification, proximity to land and seabed morphology and type, constitute a strong bearing on where fish reside in the sea. Understanding how these factors affect fish is essential in defining habitats of marine creatures and in forecasting the abundance, transit pathways and locations of migrating pelagic fish.

Temperature is perhaps the most important parameter influencing fish distribution and abundance. Although short-term changes such as weather conditions may impact a fish for a day or two, temperature has more predictable and seasonal effects. The vertical temperature gradients in the sea are also several orders of magnitudes sharper than horizontal temperature gradients such as those at the surface. Temperature tells a fish when to spawn, when to feed, as well as where to be located.

Homoiothermic species maintain a constant body temperature. But most fish are ectothermic tending to take on the temperature of the surrounding water. Like cold-blooded animals their metabolic rate thus varies greatly with temperature, meaning that fish in colder water operate at a slower rate than fish in warm water. It also means that a cold fish is less active, digests food items at a slower rate, feeds less frequently and requires less energy than a warmer fish. Growth and lifespan are also largely attributed to water temperature. Fish in warmer environments have a longer growing season and a faster growth rate than do fish in cooler waters. This fast growth comes at the price that fish in warmer waters tend to have a shorter lifespan than do fish in cooler waters. Every fish species is different and each species has a preferred temperature range at which it is most active. Each species also has a temperature range related to spawning. Water temperature also affects the immune system and wound healing capacity of fish. The immune response can be severly inhibited when water temperatures go below a certain threshold. On resumption of normal temperatures there is furthermore a time lag that can be as long as a week before the immune system starts to function normally again. Unfortunately fish parasites and bacteria tend to become active a lot quicker as temperature starts to rise again, and often take advantage of sluggish fish.

The thermal structure of the water column with depth is also an important factor. Water temperature profiles are usually measured with CTD (conductivity, temperature and depth) sondes and/or XBTs bathy chermographs, but may also be measured with a temperature sensor in a netsonde attached to a trawl. There are pelagic fish which are found above the thermocline or close to the thermocline, while others are found mainly in deeper water. The information on the depth of the thermocline can thus be useful for setting the depth of the long lines and of drift nets (e.g. in herring and salmon fisheries), to determine the optimal depth of midwater trawling, as well as to decide whether a purse seine cast is advisable (e.g. in case of a deep mixed layer depth (MLD) shoals might dive below the pursing depth). Many species have diurnal vertical migrations, which are limited either upwards or downwards by the existence of the sharp thermocline that acts as an environmental barrier. Other species tend to aggregate in the thermocline regions and especially in areas where the thermocline would intersect the bottom off a coast. A knowledge of the thermocline depth thus provides a means for the tracking and study of these fish. Furthermore most species prefer certain optimum temperatures and their normal distribution is limited between a minimum and a maximum temperature.

Dissolved oxygen in the sea is another key requirement by all submerged plants and animals, including algae and fish. These organisms are constantly removing dissolved oxygen from the water and excreting carbon dioxide during their normal respiration process. In fish the extraction of oxygen from the water and transfer to the bloodstream is done by gills, lungs, specialized chambers, or skin, any of which must be richly supplied with blood vessels in order to act as a respiratory organ. Extracting oxygen from water is more difficult and requires a greater expenditure of energy than does extracting oxygen from air. Water is a thousand times more dense than air, and at 20 ^{o}C it contains only about 3% as much oxygen as an equal volume of air. Fish, therefore, have necessarily evolved very efficient systems for extracting oxygen from water; some fish are able to extract as much as 80% of the oxygen contained in the water passing over the gills, whereas humans can extract only about 25% of the oxygen from the air taken into the lungs.

Oxygen intake in the sea occurs at the air-sea interface, and is subsequently carried by vertical currents to aerate the deeper parts of the oceans. The solubility of oxygen in water reduces as temperatures increase. Conversely, due to the increased metabolic rate, the oxygen requirement by fish increases as water temperatures increase. With warmer water the gap between the level of dissolved oxygen and the minimum oxygen demand of the fish becomes even more close. Clearly, if the total oxygen demand of the system, which includes fish, bacteria and submerged plants, exceeds the dissolved oxygen levels, the fish, especially the larger species, are likely to suffer.

The release of carbon dioxide during respiration has an acidifying effect (reduced pH) on the sea water. In addition to respiration, all plants, including all algal forms, photosynthesise actively during daylight hours. In this process carbon dioxide is absorbed from the water and the sun's energy used to convert it to simple organic carbon compounds. Contrary to respiration, this process has an alkalising affect (increased pH). These two processes, respiration and photosynthesis, carry on alongside each other, with photosynthesis being the dominant during the day while removal of oxygen from the water and excretion of carbon dioxide by respiration takes on again during the night when plants stop to photosynthesise. This leads to variations in pH even in reasonably well circulated waters. In poorly buffered water this can cause significant diurnal fluctuations in pH - being more alkaline in the evening and less so during daytime.

Each species of fish has its own very narrow range of pH preference, and levels outside of this range will cause health problems. Changes in pH, even though they may still be

within the preferred range, are likely to be stressful and damaging to the fish health. High acidity or alkalinity can cause direct physical damage to skin, gills and eyes. Prolonged exposure to sub-lethal pH levels can cause stress, increase mucus production and encourage the thickening of the skin or gill epithelia with sometimes-fatal consequences.

Fish also have to maintain their own constant internal pH. Even small fluctuations of blood pH can prove fatal. Extreme external or water pH can influence and affect blood pH, resulting in either acidosis or alkalosis of the blood. Furthermore changes in pH will affect the toxicity of many dissolved compounds, such as for example ammonia which becomes more toxic as pH increases.

Effect of bathymetry - Bathymetry is a term used to describe the topography, or bottom contours of the seabed. There are deep valleys and rifts, trenches, steep mountains and hills, and flat plains and shelves - all beneath the ocean's surface. The bathymetry of an ocean, sea, or bay influences the flow of water in that area as the moving water interacts with the ocean floor. This has then direct implications on the bottom substrate characterisation (including bottom sediments, geological features underlying the waters, and associated biological communities and submerged aquatic vegetation) and hence on aquatic habitats and fish type. Changes in sea depth lead to variations in temperature, salinity and nutrient concentrations, and finally dictate which animals live there. In areas where bottom sea currents hit a shallow shelf on the ocean floor, colder deep water is forced upwards as it makes its way over the shelf. This action brings high concentrations of nutrients from the ocean floor to the surface waters, which power marine food webs and create an abundance of food for fish, seabirds, and marine mammals.

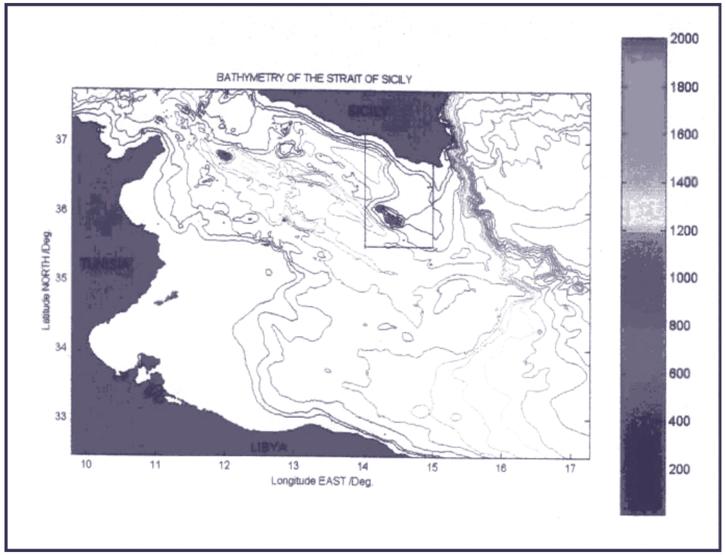

Fig. 5 The Maltese Islands lie on a ridge separating the two main Mediterranean basins, with its southern perimeter close to the shelf break, and in an area exposed to complex hydrodynamical phenomena.

The Maltese Islands lie at the edge of the southeastern continental shelf of Sicily. As shown in Fig. 5, the region presents a rather complex bathymetry in the form of a large roughly square bank with the Maltese Islands residing on its southernmost extremity. The shelf is interrupted from its extension towards west by the relatively deep Gela Sicilian basin separating it from Adventure Bank. On its eastern extremity it deepens abruptly into the deep Ionian Sea with a very sharp escarpment (known as the Malta Escarpment). The Malta Graben to the southwest of Malta forms part of a cluster of flat bottomed depressions reaching a depth of around 1650m. In its shallower parts the shelf is characterised by a plateau in the middle part, with an

average depth of 150m. The shelf is flanked by a submarine ridge protruding in the form of a submerged extension of Cape Passero and embracing the shelf area along the eastern and southern perimeter. The Maltese Islands represent the emerged part of this ridge while the Hurds Bank to the northeast of Malta shallows to a depth of just over 50m. The islands are very close to the shelf break and flanked by a very steep bathymetry in the south.

Except for rather narrow pathways, the continental shelf of Malta is thus disconnected from the adjacent shallow sea areas and groundfish species are believed to be somewhat isolated. From the fisheries point of view, this means that fish populations over the Malta platform area should be considered as an independent management unit stock especially for shelf demersal resources [10]. The limited extent of this area accentuates the vulnerability of the ecosystem and calls for precautionary measures against unsustainable fishing efforts and bad fishing practices.

Improving fisheries management - Fish stock assessments usually adopt population dynamics methods involving the regular collection of catch, fishing effort and biological data pertaining to given stocks at a number of ports in the region of interest. The dynamics of fish is however complicated in its interaction with the natural system, and mortalities by predation and/or by fishing for different life stages, are not easy to measure. Fish stock assessments, especially for highly mobile pelagic species such as tunas, can be greatly misleading if changes in abundance are not evaluated with a consideration that capture potential is strongly dependent on the natural variability of oceanographic conditions. Yet there is today still a great lack of knowledge on the relationships between species density and environmental conditions. Additionally, missing data, limitations inherent in catch per unit effort (CPUE) indices, and the enormous difficulty of producing integrative models, render pelagic fish population assessment issues and resource allotment questions devoid of sufficient confidence. The truth is that the overall management of fish stocks today, and limits on fish catch established by regulations and guidelines set by the Fisheries Commission, are not based on a sufficiently robust scientific background. The scientific community is thus asked to furnish some answers and intervene to put fisheries management on a more solid foundation.

This is by no means an easy endeavour and requires a leap forward in our understanding of the complex biogeochemical oceanic processes and of the interactions and functioning of ecosystem components. The challenge is to develop the basis for an eco-system based approach to the management of fish resources, in which forecasts of the ocean's physical behaviour can lead to forecasts of the distributions of productivity, and, eventually to forecasts of the ecosystem and the associated fish development. Knowledge of how different species interact with environmental variables, especially temperature, salinity, density, stratification, and other biological variables such as zooplankton distributions, is necessary. This is not yet achieved because, while progressively more accurate 3D fields of environmental variables are beginning to be available daily as model forecast output, there are still very limited (spatially and/or temporally) information about geographical distributions of fish and their daily variations.

Operational oceanography and marine observations conducted over various temporal and spatial time scales through a collaborative undertaking between countries is the unique key towards an improved capacity in providing essential indicators for the conservation and sustainable

use of marine living resources. Modern satellite sensors view the spatial distributions and resolve the temporal variability of the physical and biological parameters of the waters in near real time with a delay ranging from a few hours to a few days. Near-real-time multi-spectral data (thermal and optical satellite images) can be used for the routine mapping of relevant processes in the oceanic ecosystem, and offer a unique possibility for the complex investigation of the biological and physical processes by establishing correlations of 3D environmental fields to pelagic fish abundance. The integration of fisheries data for a joint analysis using remote sensed, meteo and model data to develop algorithms for the tracking of fish stocks through the elaboration of fields of sea surface temperature and chlorophyll, position and displacement of frontal zones and mesoscale structures (eddies, jets, upwellings, etc.), offers the solution towards the adoption of an operational fisheries management tool.

The overall objective is to develop a short term forecast system for fish abundance, applicable to different pelagic species and adaptable to different marine regions. Fisheries nowcasting/forecasting is one of the current MFSTEP (Mediterranean Forecasting System - Towards Environmental Predictions) research tasks with a pilot application to anchovies in the Adriatic Sea. The concept relies on the creation of a Fishery Observing System targeting to obtain detailed data in near real time on spatial and temporal deployment of fishing effort and commercial catches, including depth and in situ temperature during hauls, obtaining series of geographic referenced data, relating statistically the fishery data to environmental variables from observations and models, and subsequently leading to the release of operational nowcasts/forecasts of anchovy abundance, distributions and movements.

3. Studies of the marine physical environment in Malta

The PO-Unit - The main contributions to the study of the physical characteristics of our coastal seas are those conducted by the Physical Oceanography Unit. The PO-Unit was established under the Malta Council for S&T in the early nineties. It now constitutes the research arm of the IOI-Malta Operational Centre at the University of Malta. The Unit undertakes fundamental research in coastal meteorology, hydrography and physical oceanography with a main emphasis on the experimental study of the hydrodynamics of the sea in the vicinity of the Maltese Islands. It offers facilities for the gathering, processing, analysis and management of high quality physical oceanographic observations both for long term and baseline studies as well as for general applications in marine environmental research and assessments. The Unit endeavours to enhance its activity on an operational scale by the installation and maintenance of permanent monitoring systems to provide data for ocean forecasting, and by applying numerical modelling techniques in the study of physical marine systems. It operates in collaboration with international organisations with which it has expanded its activities through a number of funded research projects. The Unit also provides services and technical support to local entities including government departments and private agencies. It organises conferences, seminars, workshops and specialised training programs in order to promote oceanography in Malta and in the Mediterranean.

Ocean Data Management - Furthermore the PO-Unit provides support to local entities involved in marine research and monitoring to collect and maintain oceanographic data according to international standards. The PO-Unit plays the role of keeping track of ocean observations made in the vicinity of the Maltese Islands. Data collected by individual scientists, local agencies and governmental departments is primarily kept under the respective sources, and under different, often incompatible formats. The PO-Unit aims to identify these data holdings and bring the data under one database with standardized formats.

The PO-Unit has followed and promoted the IOC/IODE (International Committee for Oceanographic Data & Information Exchange) activities in the past years through the organisation of regional meetings and training courses. Contact is kept with local entities involved in marine research and monitoring in order to disseminate IODE products and updates on IODE activities. The involvement in several projects has further enhanced the expertise of the PO-Unit in ocean data quality control, transcoding and management to international standards. It has also consolidated the role of the Unit to locally promote the IOC/IODE products and activities in Malta. The most important contributions in ocean data management concern the Global Oceanographic Data Archaeology Rescue Project (GODAR) [11] with a regional workshop held in Malta, and the participation in MEDAR/MEDATLAS [12,13]. These two initiatives have enabled the location and collation of a large number of marine data in the Mediterranean. During the period 2001/2 the PO-Unit has supported the establishment of the MeDir directory which consists of an online searchable database of marine scientists and professionals working in the Mediterranean region (http://ioc.unesco.org/medir). The PO-Unit is currently involved in another project related directly to oceanographic data and information management - SEA-SEARCH (http://www.sea-search.net). This project targets the extension and enhancement of the current online European database on ocean metadata by including other European states and some Mediterranean Partner countries. On a national scale this project will provide a framework to enhance and update the national database of oceanographic data sets, holdings and research projects.

The Unit also provides technical support to several activities of the 'Mediterranean network to Assess and upgrade Monitoring and forecasting Activity in the region' (MAMA) project (refer to Section 4), including the conduction of surveys and assessments on current routine ocean monitoring activities in the Mediterranean.

Research activities in physical oceanography - In the past the PO-Unit conducted several physical oceanographic surveys especially in the NW coastal area of the Maltese Islands. Subsurface sea currents were also studied at several stations. These measurements were aimed to study the phenomenology of the sea currents on the shelf, particularly in connection with the expression of coastally trapped waves in the form of strong diurnal signals. The Unit is also responsible for the collection of meteo and sea level data at two coastal stations in Ramla tal-Bir and Mellieha Bay respectively.

In February 2001 the installation of a sea level gauge in the Portomaso marina at the Malta Hilton in St. Julians was completed. It constitutes the first real-time monitoring station for oceanographic data in Malta and forms part of the MedGLOSS sea level network [14]. The instrument, donated by the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM), collects sea

level data (every half-a-minute), seawater temperature, atmospheric pressure and waves in the marina. Data can be viewed online on the website of the PO-Unit (www.capemalta.net). Besides the importance of these measurements in relation to studies on global climate change and sea level rise, the use of this data is essential for studies on salt intrusion in the natural ground water acquifer, effect on the dispersion and flushing of pollution in the coastal areas, calculation of extreme sea levels in connection with the building of coastal structures, and other applications. Rises in sea level by only a few tens of centimeters can have serious consequences for many coastal areas; the most evident are coastal inundation and erosion.

The coastal seiching phenomenon - The long term sea level measurements have also permitted the scientific study of non-tidal short period sea level fluctuations which are the expression of a coastal seiche, known by local fishermen as the 'milghuba' [15,16,17,18]. The seiche is a rapid sea level oscillation with typical periods of about 20 minutes, which can be easily followed by the naked eye. This phenomenon has now been observed to occur all along the northern coast of the Maltese archipelago and manifests itself with very short resonating periods in the adjacent coastal embayments. Weak seiching is present uninterrupted and appears like a background 'noise' on the tidal records. During random sporadic events the seiche oscillations can become greatly enhanced, reaching a vertical range of a few tens of centimetres, and thus completely masking the astronomical signal (Fig. 6). The maximum peak-to-peak amplitude measured in Mellieha Bay reached 1.1m. The seiche is accompanied by currents that are comparable in size to those generated in coastal areas characterised by tidal forcing. The detailed study of the 'milghuba' has involved the use of open sea bottom pressure gauges in conjunction with measurements from a land-based array of micro-barographs. Reference to similar sea level variations (known as the 'Marrubbio') on the southern coast of Sicily is found in the Italian 'Portolano' for ship navigation. Their occurrence is reported to be most frequent in May or June in association to south easterly winds, and their crest-to-trough amplitudes can reach as high as 1.5m. The phenomenon is attributed to the response of the coastal sea level to signals generated in the open sea, which are believed to be mainly triggered by the presence of atmospheric pressure disturbances travelling in the lower troposphere as trapped gravity waves. The periods of these seiche oscillations are similar to those of tsunami waves. Their transformation as they approach the coastal areas, and their amplification in bays and harbours can be equally disastrous. The associated strong currents can furthermore be a hazard to navigation.

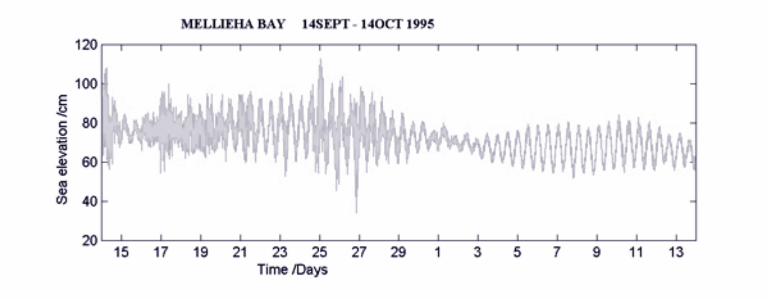

Fig.6 Time series of sea level measurements in Mellieha Bay showing seiching events

Hydrographic measurements - Several physical oceanographic surveys conducted mainly in the period 1992/4 have served to give a first understanding of the phenomenology of

the coastal oceanography in the NW area of Malta. Analysis of these water column (CTD profiles) and subsurface current measurements indicate the presence some intriguing unprecedented hydrodynamical aspects that are influenced by processes covering a wide spectrum of time scales.

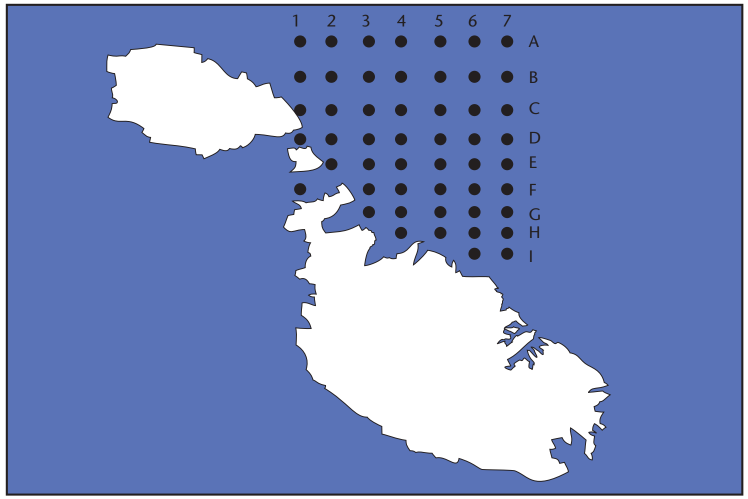

Fig. 7 Station positions visited during the Oceanographic survey during 1993

The most important phenomenon is the occurrence of intense diurnal and semi-diurnal baroclinic flows, that typify the current field with a rotary oscillating character similar to that of tidally dominated regimes [19,20,21]. This gives rise to unexpectedly strong subsurface currents, often with opposed directions of flow in the upper mixed layer close to the surface as compared to those in the deeper layer below the sharp thermocline. Very often the current sets downshore in an SSE direction for most of the day, and subsequently reverses with weaker magnitude for the rest of the day (Fig. 8). These currents are not related to the wind and cannot either be a signature of the barotropic tidal wave since tidal amplitudes in the vicinity of the Maltese Islands are all too small. These signals are thus believed to ba an expression of the trapping of energy at the shelf break in the form of shelf wave modes. Grancini & Michelato [22] actually reported such a tidal component of the eddy kinetic energy in their sea current measurements over the

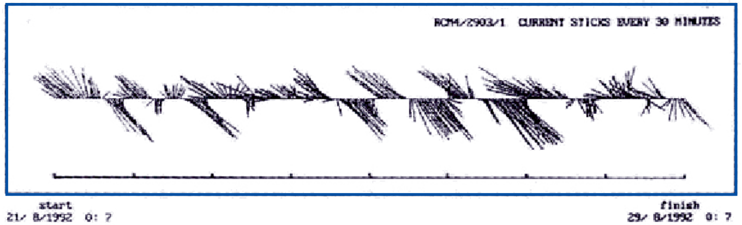

Fig. 8 Strong diurnal signature in the deep subsurface currents outside Mellieha Bay

Sicilian shelf, with an intensification close to our Islands. These currents are thus related to the close proximity of the Islands to the shelf break in the south, and are most probably an expression of a topographically trapped wave that takes the form of an internal Kelvin-like waveform in the deeper sea away from the shelf break, and is accompanied by shelf wave modes propagating over the continental platform and in the region of the Maltese Islands. A vertical oscillation of the thermocline in the form of an internal tide accompanies these flows. This results in vertical movements of the water column isotherms that have been quantified to reach crest-to-trough amplitudes of the order of 8m [23].

The implications of these phenomena on fisheries is still largely unexplored and will require multi-disciplinary studies with an opportunity to touch upon highly relevant current research themes.

Numerical modelling - The most significant numerical modelling effort of the PO-Unit is that conducted within the framework of the EU-funded Mediterranean Forecasting System Pilot Project (MFSPP) [24,25]. A high resolution (1.6Km horizontal grid on average, 15 vertical sigma layers) eddy resolving primitive equation numerical model is run over a domain covering the Malta shelf area, with climatological forcing, and including thermohaline dynamics with a turbulence scheme for the vertical mixing coefficients on the basis of the Princeton Ocean Model (POM). It is used to simulate the seasonal variability of the water masses and transport in the Malta Channel and proximity of the Maltese Islands. It is coupled by one-way nesting along three lateral boundaries (East, South and West) to an intermediate coarser resolution model (5Km) implemented over the Sicilian Channel area. The fields at the open boundaries and the atmospheric forcing at the air-sea interface are applied on a repeating 'perpetual' year climatological cycle [26].

The model is able to reproduce, with the right order of magnitude, the salient dynamical features in the area, providing in addition a detailed insight into their 3D phenomenology and their seasonal variability [27]. The model also reveals the water mass composition in the region, and the impact of the heat and momentum fluxes at the air-sea interface in mixing and altering the hydrophysical structure through the seasons. This modelling effort has now prepared the way for the future implementation of shelf-scale real-time ocean forecasting of physical parameters in the vicinity of the Maltese Islands. This is the endeavour of the PO-Unit under the framework of the current second phase of MFS, the Mediterranean Forecasting System – Towards Environmental Prediction (MFSTEP) [28], and will be done through the sequential coupling of a hierarchy of successively embedded model domains that will downscale the hydrodynamics from the coarse grid Ocean General Circulation Model of the whole Mediterranean Sea to the finer grid in the Malta shelf area.

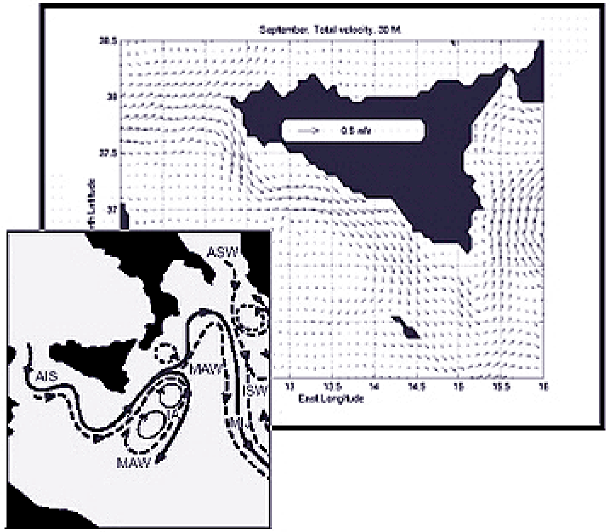

Fig. 9 Results from the Malta shelf model showing the simulated Atlantic Ionian Stream (AIS). The AIS characterises the surface circulation throughout the year. It is a swift topographically controlled current carrying fresh Modified Atlantic Water across the Malta Channel which starts its path as a meander to the South of Adventure Bank.

The main numerical model results include upwelling in summer and early autumn along the southern coasts of Sicily and Malta; a strong eastward shelf surface flow alongshore to Sicily forming part of the Atlantic Ionian Stream which is present throughout the year with significant seasonal modulation; and a westward winter intensified flow of LIW centered at a depth of around 280m under the shelf break to the south of Malta. The seasonal variability in the thermohaline structure of the domain and the associated large scale flow structures are shown to be significantly linked to changes in the surface momentum and heat fluxes.

The energetic and meandering Atlantic Ionian Stream (AIS) [29] is a swift topographically controlled current that normally starts its path as a meander to the south of Adventure Bank. It then proceeds southeastwards and loops back northward around Malta, forming the Maltese Channel Crest. As it reaches the sharp shelf break to the east of Malta, it abruptly gains positive vorticity and tends to deflect with an intense looping northward meander forming the characteristic Ionian Shelf Break Vortex. The progression of the AIS towards east carries with it the fresh modified Atlantic Water (MAW) across the Malta Channel. The contrast in temperature of the exiting MAW with the warmer Ionian Sea produces the Maltese Front which constitutes a conspicuous thermal filament on sea surface temperature AVHRR maps.

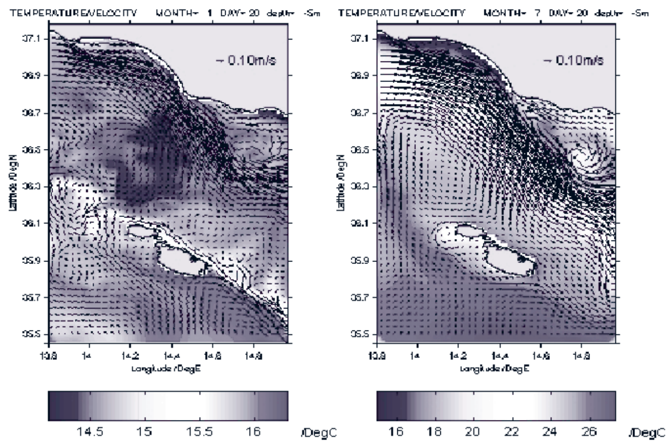

Fig. 10 Model velocity and temperature at 5m during (a) winter and (b) summer

Frequent coastal upwelling events bring to the surface cool water that is then swept along by the mesoscale eddy formations. The upwelling zone runs along the whole southern coast of Sicily and generally extends for a considerable distance (~100Km) offshore especially over Adventure Bank and on the Malta platform. The southeastward advection of these cold patches in the form of long plumes and filaments are a very characteristic feature in the thermal IR images of the region. The Sicilian upwelling thus produces a large influence on the upper layer dynamics in the region and has important implications on the biological productivity and fisheries activity. Although the upwelling events peak in summer and early autumn, they tend to be toward year round with a period of attenuation in spring. Thus the oceanic ecosystem in this zone is not limited to a single productivity event per year, and primary production is significantly greater on period and rate.

The model is also capable to resolve the mesoscale dynamics and produces a detailed spatial and temporal evolution of the rapidly changing flow patterns associated to fronts, eddies and jet meanders. The predominant characteristic of the mesoscale variability in the vicinity of the Maltese Islands consists in the evolution of eddies which form mainly as a result of the impact of the shallowing bathymetry and the proximity of land on the AIS flow. Besides trapping water and particulates, these eddies have associated vertical motions that influence phytoplankton biomass distributions and thus bear important links to biological processes, in particular to the location of fisheries. Moreover the proximity of the islands to the shelf break exposes the southern coast to upwelled water especially during summer.

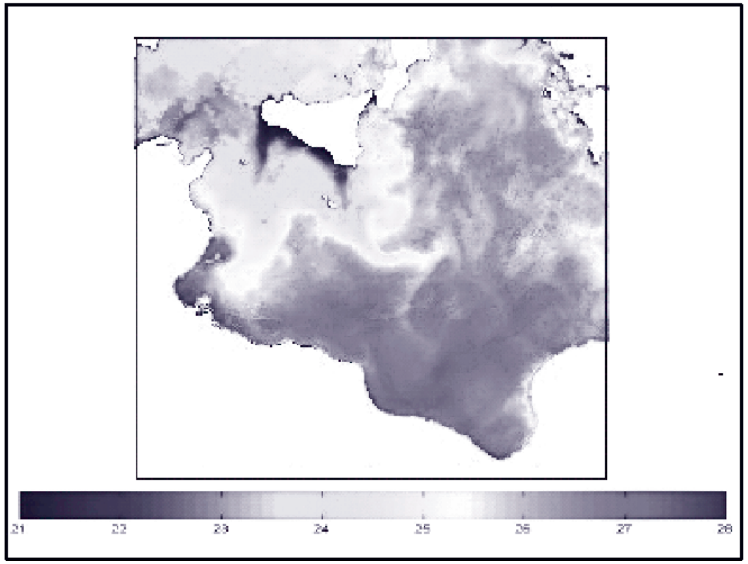

Fig. 11 A view from space showing upwelling along the southern coast of Sicily, very prominent mesoscale structures and sharp fronts in the proximity of the Maltese Islands.

The eastern approaches of Malta are controlled by the influence of the strong southward vein of MAW carried by the AIS that shifts and approaches close to the island especially during the period July to November. This flow triggers anticyclonic eddy formations as it brushes against the southeastern tip of Malta. The AIS vein is displaced away from the coast during winter when a prominent southeasterly meandering flow is established in the northern proximity of the Maltese Islands with a strong baroclinic nearshore current along the northern coast that continues as a prominent southeastward trail beyond Malta. The surface flow in the coastal areas of the islands is highly variable and is in some areas characterised by seasonal reversals of the currents such as to the south of Malta and along the northern coast of Gozo. During summer the AIS is displaced southwards and cuts across the islands with a swerving deflecting path against the northern coast of Gozo. The flow circles around the western tip of Gozo and proceeds with a southeastward current that follows closely the coastal southern perimeter of the area separating the two islands. The flow in this favourite area to local fishermen induces coastal upwelling during summer and early fall.

4. MedGOOS - A regional initiative for operational oceanography

What is MedGOOS? - The Mediterranean Global Ocean Observing System - MedGOOS - is an informal association founded under the auspices of the UNESCO Intergovernmental Oceanographic Commission (IOC) to provide a concerted approach to the development of an operational ocean observing and forecasting system at a regional and coastal scale to the benefit of a wide group of users in the region.

The key priorities targeted by the MedGOOS include the identification of the regional priorities for operational ocean forecasting and marine meteorology, an assessment of the related economic and social implications, and the guidance and assistance to the riparian states towards the harmonious implementation of the Mediterranean ocean observing and forecasting system built on existing elements and based on principles of co-development, co-ownership and sharing of benefits. The MedGOOS aims to build a system to the benefit of a vast spectrum of customers and marine industries, addressing the requirements of governments to enable sustainable development and lead to socio-eco-

nomic goals. The MedGOOS will ensure the upgrading of national systems to the same level of expertise and infrastructure and will stimulate the necessary pre-operational R&D to ensure that GOOS is fully effective when it is eventually established, hopefully in ten to twenty years time.

Brief history of MedGOOS - Since the signing of the MedGOOS Memorandum of Understanding by the founding members in 1999, other marine institutes have joined. Membership already covers most of the riparian countries with a total of 19 members from 16 countries. The regional dimension of the Association is an enabling asset to the future projection of MedGOOS towards long term commitments at governmental level. The MedGOOS members play a leading role as a competent entity for the promotion of GOOS in their country and as a coherent team in the basin. Each member acts as a national focal point, establishing links with the scientific community and the public authorities, developing awareness activities to enable the implementation of MedGOOS and the future projection into long term commitments at governmental level.

The involvement of Malta in the development of MedGOOS has been instrumental. The founding meeting was held in November 1997 in Malta during the Workshop on GOOS Capacity Building for the Mediterranean Region [30] organised by the Malta Council for Science and Technology (MCST) and sponsored by the Government of Malta, IOC, a number of European agencies and the Bank of Valletta International Ltd. In 1998, the MedGOOS Executive Board decided to recognise this contribution by assigning to Malta the prestigious hosting of the MedGOOS Secretariat. The Secretariat currently operates under the IOI-Malta Operational Centre of the University of Malta. The presence of the MedGOOS Secretariat in Malta is certainly of great prestige. It is a benefit for MedGOOS itself, while it enhances the role of Malta in the quest to promote regional cooperation in the peaceful uses of the Mediterranean Sea.

The first MedGOOS project - In 2002, the 3-year thematic network project entitled Mediterranean network to Assess and upgrade Monitoring and forecasting Activity in the region (MAMA) [31] was launched. The project is funded by the Vth Framework Programme, Energy, Environment and Sustainable Development of the European Union. It brings together a consortium made up of major marine institutions from all the Mediterranean countries, and is staging a concerted effort between countries in the region to put in place the institutional and scientific linkages to establish the regional platform for the implementation of MedGOOS. MAMA focuses on the trans-national pooling of scientific and technological resources in the basin. The aim is to share experiences and transfer of expertise, to bring capacities in ocean monitoring and forecasting at comparable levels. The joint effort will contribute to the planning and design of the initial ocean observing and forecasting system in the Mediterranean. MAMA is interacting with stakeholders and relevant international organisations to trigger awareness on the benefits of ocean forecasting. Demonstration products and results are disseminated, national awareness campaigns are organised to build momentum towards long term commitments by governments. Within this effort MAMA is pioneering the implementation of GOOS by an unprecedented endeavour and novel approach that will put the region at the forefront of ocean monitoring and forecasting.

RTD Projects Related to MedGOOS

Recent EU RTD projects are providing the science base for the implementation of the Mediterranean component of GOOS. The Mediterranean Data Archaeology and Rescue of Temperature, Salinity & Bio-chemical Parameters (MEDAR/MEDATLAS) [13,14] and the Mediterranean Forecasting System Pilot Project – MFSPP – [24,25] have already involved the participation of some non-EU Mediterranean countries contributing to co-operation in the region. The MFSPP has tested the feasibility of a Mediterranean pre-operational system to predict physical and biochemical parameters in the basin and coastal/shelf areas for time scales of weeks to months, by generating forecasts based on a nowcasting/ forecasting modelling system and data from a moored station and satellites. MFSPP has also developed interfaces to users to disseminate forecast results. The ongoing project MFSTEP (Mediterranean ocean Forecasting System: Towards Environmental Predictions) is a follow-up to MFSPP and will integrate and extend the observing system with biochemical components, trial forecasts in coastal areas and implementation of nested models.

These projects have started the initial design of an integrated and sustained monitoring/ forecasting system that addresses the needs of the region. They are proving that a long-term coastal/open sea monitoring/forecasting system must build on a strong collaboration among the neighbouring countries to share efforts, resources and provide a monitoring system with optimised temporal/spatial coverage.

Fig. 12 Mama consortium compsed of leading marine institutes from all the Mediterranean countries, three international organisations and an Advisory Board with four members of international repute.

The strength of a regional partnership

An integrated and sustained ocean and coastal observing system needs an enduring collaboration among the neighbouring countries and a strong will to share efforts, resources and knowledge. The early dialogue and the involvement of all the Mediterranean countries in MedGOOS are crucial and vital for its long-term success. The regional dimension of the MedGOOS Association will ensure that this collaborative venture will bring benefits and opportunities equally to all the riparian coastal peoples.

The MedGOOS members play a leading role as a competent entity for the promotion of GOOS in their country and as a coherent team in the basin. The coordination role of each member as a national focal point, the establishment of links with the local scientific community and the public authorities, and the awareness activities are a main thrust for the implementation of MedGOOS and an enabling asset to the future projection into long term commitments at governmental level.

The scientific objectives of MAMA are to:

- Build the basin-wide network for ocean monitoring and forecasting, linking all the Mediterranean countries;
- Identify the gaps in the monitoring systems in the region and in the capability to measure, model and forecast the ecosystem;
- Integrate the knowledge base derived by relevant national and international RTD projects and programmes;
- Build capacities in ocean monitoring and forecasting;
- Design the initial observing and forecasting system, on the basis of a co-ordinated upgrading of capabilities in all Mediterranean countries;
- Raise awareness on the benefits of MedGOOS at local, regional and global scales;
- Bring together all stakeholders to harmonise strategies for operational oceanography at the service of sustainable development.

The expected long-term results are:

- the strengthening of the co-operation of all the Mediterranean countries towards the development of the Mediterranean operational forecasting system running at basin and local (regional to coastal) scales
- the upgrading of the technical and scientific skills of human resources and the research infrastructure needed for the basin wide management of the coastal and shelf area; and
- the establishment of the platform for a Mediterranean virtual data and information centre as a basis for operational interagency exchange, merging data and information, to produce added value oceanographic information, and the delivery of user-oriented products in an operational and interactive mode.

Furthermore MAMA will be contributing to the initial phase of the EC-ESA Global Monitoring for Environment and Security (GMES) initiative, with:

- an inventory on existing monitoring activities
- the design of an initial observing system for the coastal area
- reports on the present monitoring capabilities and on the limitation of data flow

MAMA will be implemented through the planned activities, divided into 8 workpackages, with a strong emphasis on assessing current capacities, cooperation, networking and awareness.

WP1 MAMA NOW – Inventorying and assessment of current national operational oceanographic activities, infrastructures and resources in the Mediterranean.

WP2 MAMA OBSERVING SYSTEM – Design of the real-time coastal data acquisition systems, fully integrated to the basin scale observing system.

WP3 MAMA CAPACITY BUILDING - Enhance in each country the basic technical and scientific expertise required to participate in MedGOOS.

WP4 MAMA MODEL – Transfer of know-how and modelling experiences to partners by dedicated model implementations in new shelf areas.

WP5 MAMA-NET – Design and test elements for inter-agency networking and for the exchange of data and information. Provide guidelines for a regional marine information system.

WP6 MAMA WWW - Establish the MAMA WWW as a reference point and showcase for operational oceanography in the Mediterranean.

WP7 MAMA AWARENESS – Undertake an awareness campaign on MedGOOS addressing governmental agencies and authorities, policy-makers, the marine scientific community, marine industries, the services sector, and the public at large.

WP8 MAMA DISSEMINATION & PRODUCTS – Promote the use and potential of added-value applications of routine data for the management of marine resources.

Benefits of MedGOOS - At its roots MedGOOS is conceived as an end-to-end user-driven system providing locally relevant, regional scale ocean data that is sustained, integrated, operational, and targeting multiple users and applications. The advent of multi-disciplinary, spatially widespread, long term data sets is expected to trigger an unprecedented leap in the economic value of ocean data. This will bring about a radical transformation in our perception of managing marine resources, and secure benefits to many sectors in industry and services such as public health and marine safety. The main perceivable profits will be in the:

- capability to make informed decisions based on the knowledge of the causes and consequences of change;
- effective and sustainable management of the marine environment in favour of fisheries, safe and efficient transportation, coastal recreation and other marine-related industries that contribute a large part of the total GNP for the bordering countries;
- support of economies and for improving standards of living on the basis of enhanced marine services;
- mitigation of marine hazards, with improved search and rescue operations, and in ensuring public health;
- detection and forecasting of the oceanic components of climate variability due to human activity;
- quest to preserve and restore healthy marine ecosystems.

More specific benefits apply to the Mediterranean fisheries. A regional scale ocean observing and forecasting system provides those supportive routine and synchronous observations with full basin scale coverage that constitute the backbone information for a better understanding of the ecosystem functioning, variability and response to perturbations. The capability to acquire, analyse and predict ocean phenomena on such an operational mode is a basic requisite to enable useful forecasts of biomass distributions, and will lead the way to develop fisheries modelling on a firm basis and as a reliable tool for assessment. This would imply a herculean stride towards achieving an effective ecosystem-based fisheries management.

Acknowledgements

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BACKGROUND ON EBFM AND ITS LINK WITH THE CODE OF CONDUCT FOR RESPONSIBLE FISHERIES

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What is an Ecosystem Approach to Fisheries (EAF)?

Recent publicity has highlighted the need to improve the approach used to manage fisheries so that their potential social and economic benefits can be achieved. The depleted state of many of the world's fisheries and the degraded nature of many marine ecosystems have been well documented and of the loss of potential social and economic benefits of fishing highlighted (fisheries currently employ 12.5 million people with about US$40 billion per annum in international trade). Past poor management has contributed to increased poverty, increased inequities and lack of opportunities for many of the world's fishers to make a decent livelihood.

Until recently, at least two different but related paradigms for managing natural marine resources existed, especially in developed countries. The first was that of ecosystem management, which aimed at conserving the structure, diversity and functioning of ecosystems by managing the biophysical components of ecosystems (e.g. introduction of protected areas), focusing on ecosystem well-being. The second was that of conventional fisheries management, which aimed at satisfying societal and human needs for food and economic benefits by managing the fishing activity and the target resources (referred to as Target resources-orientated management (TROM) by FAO), focusing on human well-being.

The concept of sustainable development[1] that evolved throughout the 1980s and 1990s, however, requires a more holistic approach than either of the two paradigms to managing marine resources and requires balancing both human well-being and ecological well-being. Ecosystem approach to fisheries (EAF) is the term adopted to reflect this more holistic approach and the congruence of the

paradigms from a fisheries perspective. The term EAF is preferred to that of ecosystem-based fisheries management (EBFM), which has been interpreted, by some, as being simply an extension of ecosystem management and too narrow in its application.

In the context of sustainable development, responsible fisheries management must consider the broader impact of fisheries on the ecosystem as a whole, as well as the impact of the environment on fish resources and fishing. Fishing activities are known to affect many other components of the ecosystem in both large- and small-scale fisheries. For example, there is often by-catch of non-targeted species, physical damage to habitats, changes to food-chains, or changes to biodiversity. EAF is an extension of current fisheries management practices that recognizes more explicitly these impacts and the interdependence of human well-being and ecosystem well-being. It does not replace the conventional TROM approach. In fact, rigorously applying TROM approaches (with appropriate emphasis on the precautionary approach and rights-based allocation) would begin to help solve some of the current fisheries problems. Such action in the past could have prevented a large number of present ecosystem problems. Thus, EAF in the foreseeable future is likely to be developed as an incremental extension of current fisheries management practices.

The principles and aspirations for EAF are contained in a number of international instruments, agreements and conferences including:

- The 1972 World Conference on Human Environment;
- The 1982 United Nations Law of the Sea Convention;
- The 1992 United Nations Conference on Environment and Development and its Agenda 21;
- The 1992 Convention on Biological Diversity;

- The 1995 United Nations Fish Stocks Agreement; and
- The 1995 FAO Code of Conduct for Responsible Fisheries.

Even more recently, the World Summit on Sustainable Development (WSSD, Johannesburg, South Africa, 2002) adopted a Political Declaration and a Plan of Implementation in relation to capture fisheries. In the Declaration, the Heads of States agreed to:

develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive practices, the establishment of marine protected areas ... and the integration of marine and coastal areas into key sectors (31c).

The purpose of EAF is clear from these many international instruments, reports and scientific publications. Generally speaking,

the purpose of an ecosystem approach to fisheries is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems.

To fulfil this purpose, an EAF should address components of ecosystems within a geographic area in a more holistic manner than is used in the current TROM approach. Doing so will require identifying exploited ecosystems (in their geographic context); recognizing and understanding their complexity as well as the many (sometimes competing) societal interests in fisheries and marine ecosystems. Accordingly ,a definition of EAF is:

an ecosystem approach to fisheries (EAF) strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.

EAF and the FAO Code of Conduct for Responsible Fisheries

Many of the principles of an EAF are contained in the FAO Code of Conduct for Responsible Fisheries. As a general principle the code states that *"Fisheries management should promote the maintenance of the quality, diversity and availability of fishery resources in sufficient quantities for present and future generations in the context of food security, poverty alleviation and sustainable development. Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated or dependent upon the target species".*

As well as this general overarching principle, the Code of Conduct contains a number of provisions which, when considered together, give a good coverage of the requirements of EAF. These include, (i) ecosystem and habitat protection, (ii) role of environmental factors, (iii) environmental impacts of fisheries, (iv) environmental impacts of other users and pollution, (v) biodiversity and endangered species conservation, (vi) multispecies management, (vii) coastal areas, (viii) selectivity, ghost fishing, by-catch, discards and waste, and (ix) risk, uncertainty and precaution. Details of these are included as appendix 1.

Implementing EAF

The FAO Fishery Department will soon be publishing another in the series of FAO Technical Guidelines for Responsible Fisheries[2] - The ecosystem approach to fisheries, based on a draft developed during the Expert Consultation on Ecosystem-based Fisheries Management, Reykjavik, Iceland, 16–19 September 2002.

The guidelines attempt to translate the higher-level principles as described in the FAO Code of Conduct and other international instruments, agreements and conferences into operational objectives and measures capable of delivering on EAF in a broad range of social and economic settings, particularly in developing countries. The approach builds on the contents of the FAO Technical Guidelines for Responsible Fisheries No. 4 – Fisheries Management, but highlights extra requirements for implementing EAF.

Management process

The EAF management process will require the same cycle of planning, implementation and evaluation that is currently recommended for conventional fisheries management, but there will be a greater need for improved consultation with a broader range of stakeholders, and for a more rigorous setting of operational objectives, decision rules and evaluation of management performance. The approach is based on the participation of all relevant stakeholders, to ensure that they have ownership of the outcomes and their implementation. The steps needed in translating higher level policy goals into day-to-day management as shown in Figure 1. include:

1. identify the fishery, area and all relevant stakeholders, broad social, economic and ecological (including the fisheries resource) issues for the fishery, based on the broad international and national policy goals and aspirations and set broad objectives for these issues;
2. break down broad issues into issues specific enough to be addressed by an identified management measure(s), rank the issues based on the risk they pose to the fishery, set agreed operational objectives for the high-priority social, economic and ecological issues identified and develop linked indicators and performance measures;
3. formulate management decision rules;
4. monitor the fishery using the selected indicators, and regularly evaluate the performance of management in meeting operational objectives – by inference, because of the linkages developed between policy goals and operational objectives, this will provide an assessment on how well management is achieving the broader policy goals;

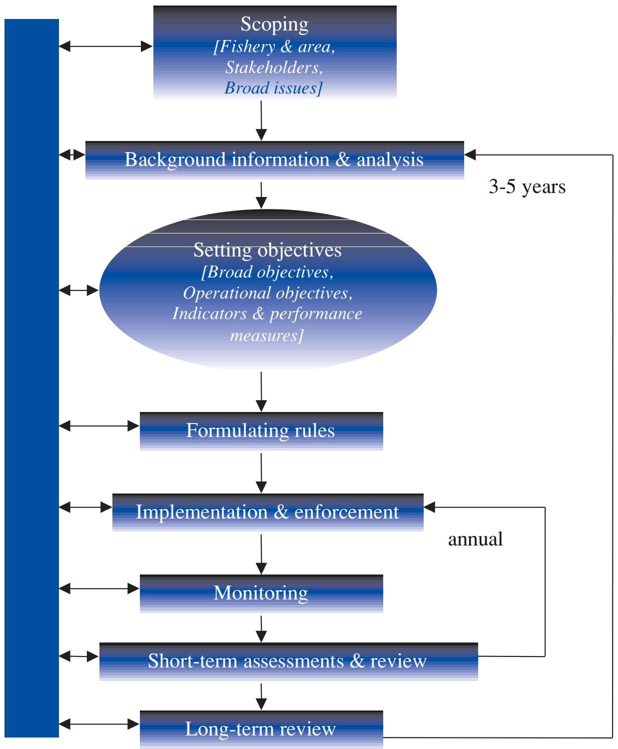


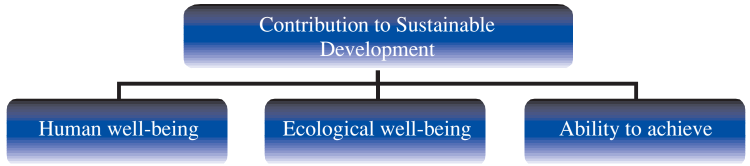
Figure 1: Steps needed to develop and modify an EAF management plan

5. undertake regular short-term reviews; and
6. undertake regular long-term reviews to provide feedback on performance.

A major challenge in moving from high-level policy goals to operational objectives exists in areas where the goals deal with concepts such as ecosystem integrity, ecosystem health and biodiversity. These concepts are difficult to define, and refer in the main, to fairly abstract ideas. It must be stressed, however, that operational objectives to achieve these goals, such as protection of critical habitats must be developed, or EAF will fail.

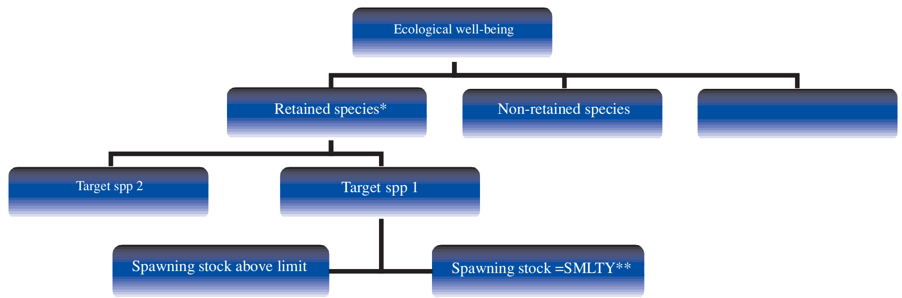
Although there will always be a lack of knowledge concerning ecosystem functioning and structure, uncertainty must not prevent the development of operational goals based on the best available knowledge. This applies equally to data-poor fisheries with low scientific and management capacity, as well as fisheries rich in data and capacity. By conducting a participatory process based on the steps outlined above, all stakeholders will gain a common understanding of the issues, appreciation of the different (often conflicting) objectives that exist and the management measures that can be applied. This will facilitate adoption of the measures, and a longer-term view to future security and sustainability.

To assist in the participatory process with stakeholders, the following framework is suggested. Firstly, the contribution to sustainable development of a particular fishery needs to be considered in terms of two dimensions - human well-being and ecological well-being. The ability to achieve it (institutional and governance issues as well as the impact of the environment on fisheries) also needs to be considered.



Under each of the two main dimensions, major issues are subsequently broken down to smaller and smaller sub-issues that can be formulated into an operational objective that can be addressed by implementing one or a number of management measures.

In the following example the broad issue of "providing a high and sustainable yield from the target stocks" is reduced to two sub-issues that have operational objectives of (i) maintaining the spawning stock of species a above a level that will ensure continued recruitment and (ii) maintaining the stock at a level that will provide the maximum long-term yield.



Similar operational objectives need to be set for all major issues identified in the fisheries, including conserving biodiversity by protecting an agreed area (marine protected area), minimizing bycatch with changes in gear etc., as well as for objectives relating to improving human-well-being such as improving profits, increasing life-style benefits etc.

For each operational objective, it will then be possible to choose an **indicator**, that can be used to monitor how well an objective is being achieved as compared with an agreed **reference point** (limit or target reflecting the desired state). A comparison of the indicator against its agreed reference point informs managers on how well their management interventions are performing (Figure 2).

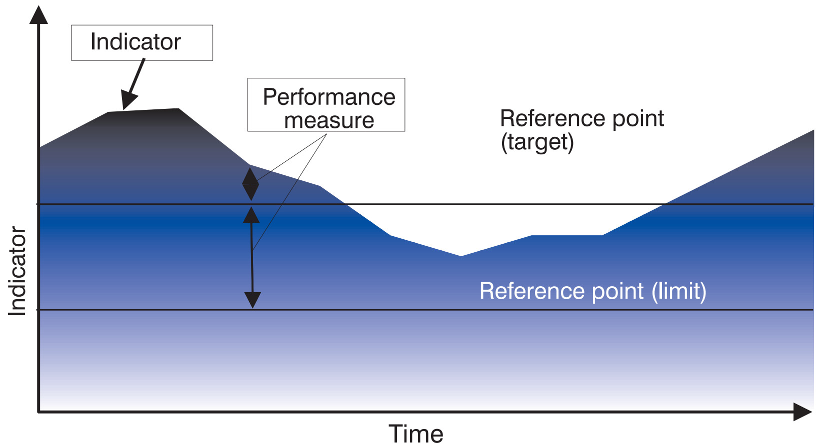


Figure 2: Indicators (values that track the state of a fishery in relation to a particular operational objective) and reference points (a benchmark considered to be desirable, either limit or target) for EAF. The difference between the indicator and the reference value provides an assessment of management performance (performance measure)

Regular reviews (both short-term (eg annual) and longer-term (eg 3-5 years) should then be carried out to compare how well the indicator is tracking against the agreed reference point and provide feedback on the performance of management and the need for continual improvement.

Data and information

EAF will require broader sets of data and information than is currently applied to conventional fisheries management. The availability of relevant information will vary widely among countries, but in almost all cases considerable relevant information will be available if a new approach to what constitutes relevant information is adopted. Collecting and analyzing new information will continue to be important but much of the necessary data has already been collected and will come from outside the conventional fisheries area or from fishers and local people, especially in developing countries. *Management measures*

The measures currently used for TROM fisheries management such as controlling effort, catch, gear and areas and times of fishing will still be main tools for EAF management but many must be broadened to address a wider range of issues than simply management of the target species of the fishery. They must also be broadened to include a greater use of economic incentives and ecosystem manipulations. This may include habitat restoration, establishment of protected areas, restocking or culling of certain species, provided that adequate risk assessments and cost/benefit analyses have been carried out.

Legal and institutional considerations

The detailed requirement for operational EAF are not well covered in binding international fisheries law at present. As a result, few regional fisheries bodies and arrangements make explicit recognition of EAF in their conventions. Similarly, EAF is not frequently an integral part of national fisheries policy and legislation. For EAF to be implemented, legislation will need to be reviewed and improved as appropriate. EAF may require more complex sets of rules or regulations that recognize and cater for the impacts of fisheries on other sectors and the impact of those sectors on fisheries.

EAF requires adherence to the same principles of transparent and participatory management that already guide many current management practices. It also advocates for a greater involvement of a broader stakeholder base, and there will frequently be a need for institutions to coordinate better consultation, cooperation and joint decision-making within a fishery, between fisheries operating in the same geographical area, and between the fisheries and other sectors that interact with them. For example, where one fishery causes a decline in one or more prey species of a predator targeted by another fishery, there must be an institution or arrangement to coordinate the management actions of both fisheries, including the reconciliation of the different objectives of the two. This recognizes the true nature and extent of access and allocation of resources within an ecosystem, often neglected or ignored in fisheries management practices.

A transition to EAF will be greatly facilitated if adequate attention is given to the education and training of all those involved, including fishers, the management agency officials and staff and other stakeholders. The administrative structures and functions, including monitoring, control and surveillance, will have to be adapted as necessary.

Research needs

A start should be made now to implement EAF, where it has not already begun, based on existing knowledge.

However, implementation and effectiveness will undoubtedly benefit from reducing important uncertainties, and further research is needed for this purpose. A number of essential areas for further research exist, including (i) better understanding of ecosystem structure and function and how fisheries affect them; (ii) integrating social, economic and ecological considerations into decision-making; (iii) improving the management measures available to implement EAF; (iv) understanding the management process better; and (v) improving monitoring and assessments.

Threats to an EAF

While the important benefits of EAF are generally recognised, there are a number of major threats to smooth implementation of EAF. A lack of investment in the process will certainly hinder progress and could mean failure in the end. It will also take considerable resources (especially in terms of time) to reconcile the often competing objectives of the different stakeholders, possibly aggravated by the difficulties of ensuring effective participation of all stakeholders in the development and implementation of EAF. Insufficient biological and ecological knowledge will continue to be a constraint, as will insufficient education and awareness, because these affect the ability of all stakeholders, including the fishery management agencies, to exercise their responsibilities. Equity issues will always be difficult to resolve in relation to responsibility for ecosystem degradation between fisheries and other economic activities such as agriculture (including forestry), chemical industries, urban and coastal development, energy and tourism.

These issues will need to be addressed, and as more practical experience becomes available, solutions can be incorporated into future editions of the EAF Guidelines.

EAF and the Mediterranean LME

It is important to recognise that ecosystems occur on many scales, ranging from a drop of water to a whole ocean. One intermediate scale is known as a Large Marine Ecosystem (LME) that are relatively large regions of ocean characterised by distinct bathymetry, hydrography, productivity and trophically dependent populations. The landward limit of LMEs is always the coast and the seaward limit is a fuzzy "eco-geographical limit". The Mediterranean LME is one of 64 LMEs designated around the world.

The LME approach is based on this large geographical area and aimed at providing sustainability of the productive potential of ecosystem goods and services and has evolved from the ecosystem management paradigm. As it stands now, the LME approach can be considered as a science-driven, multi-sectoral approach originating with many of its characteristics, issues, processes, etc. similar to those of coastal area management (CAM) (although the latter is more strongly delimitated by institutional criteria). To date, LME consideration has focussed more on natural resource components (modules) of LMEs with less attention given to socio-economic issues and governance. In this respect , LMEs have not addressed many of the issues identified as contributing to the failure of a TROM approach where many consider that there has been too much effort expended on the assessment of resources (especially stock assessments) and too little on governance and bio-socio-economic aspects.

EAF, on the other hand, is a sector-based approach, based on strong institutional and governance that has evolved from the paradigm of fisheries management. Both approaches have the same overall goals and aspirations that are based on the same principles agreed at, for example, the 1992 United Nations Conference on the Environment and Development and the 1995 FAO Code of Conduct. The main difference lies in the size of the geographical area being considered and the focus of management. The LME approach argues that a management unit should always be at a large scale and it is the sustainability of the ecosystem goods and services that should be achieved (i.e. sustaining productivity and conserving the integrity of ecosystems) whereas EAF argues for a more flexible management unit based on existing fisheries and attempts to balance both human and ecological well-being from a fisheries perspective. Both advocate adaptive management, participation of stakeholders and the precautionary approach

For assessment purposes, LME are considered as 5 modules (i) fish &fisheries (ii) productivity, (iii) pollution and ecosystem health (iv) socio-economics and (v) governance. EAF can be thought of as addressing the "Fish & fisheries" module of LME as well as covering those aspects of all of the other modules relevant to fisheries (Figure 3). However, it also deals with a range of temporal and spatial scales that are more appropriate for fisheries management. It will often involve a smaller number of stakeholders and objectives that can be achieved through management interventions that are more accountable, less complex and costly.

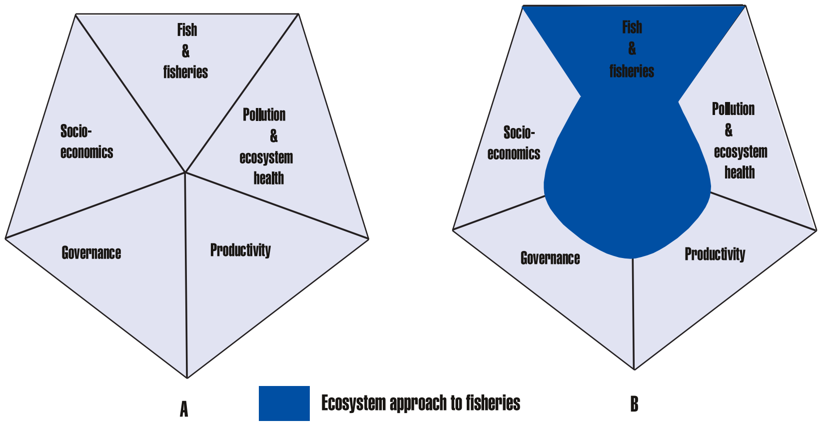


Figure 3: A. The five modules of LME (as shown in the original concept documents).

B. The five modules of LME with EAF superimposed to demonstrate how EAF interacts within LME by addressing the fish and fisheries module as well as the other modules as they relate to fisheries. Note that the spatial scales of LME and EAF may differ.

It could be argued that unless LME develops legally binding instruments (including inter-governmental treaties) the LME concept is most useful as a conceptual framework while EAF is the way to manage fisheries within an LME. In this context, LMEs would seem to be at a scale most suitable for regional marine planning. They are large enough to accommodate blurry boundaries between systems and they provide sufficient homogeneity (in terms of their fauna and flora compared with adjacent LMEs) to assess impacts of different human activities and rationally plan for their contribution to sustainable development. They can also be useful in linking the management of drainage basins and coastal areas with continental shelves and dominant coastal currents. In many cases this may be more appropriate than national planning, especially where a number of small countries share the same resources of a LME, or in a large country containing several LMEs. Depending on the broad objectives of the regional plan at this level, they may also provide an opportunity for large-scale monitoring, and cooperative research.

In the Mediterranean, as the LME is a semi-enclosed sea bounded by many countries with strong interactions between them, it would appear to be a natural unit for large-scale planning. This is facilitated by having identical boundaries for its fisheries (General Fisheries Commission for the Mediterranean) and environmental (Barcelona Convention) institutions. Issues such as pollution and over-exploitation of fisheries can be conveniently dealt with at this level, especially for transboundary stocks. The Mediterranean also has the advantage of being almost entirely bound by land and can be easily delimited from adjacent LMEs (The Baltic Sea, the Baltic Sea Fisheries Commission and the Helsinki Commission is similar in many respects).

Under EAF, however, different scales for the management unit may be required, independent of whether the planning is done at LME or national levels. In many cases smaller ecosystems will be nested within larger ones and the choice of a geographic area for management will need to recognize existing fisheries, management entities and jurisdictions as well as the geographical distribution of key stocks and ecological boundaries. In some cases, this may require defining new management units, while in others it will require coordination of additional measures across fisheries and across other sectors, using existing units. It will also, as described above, entail better coordination across existing jurisdictions and institutions but not necessarily the formation of new ones (especially if they simply add another layer of complexity).

A recent meeting of the FAO Advisory Committee on

Fisheries Research recommended that a series of case studies be set up around the world to trial the EAF methodology. The Mediterranean LME program might be a good catalyst for selecting some examples from this region of the world and contributing to testing and improving EAF implementation around the globe.

Appendix 1

Garcia, S.M., Zerbi, A., Aliaume, C., Do Chi, T., and Lasserre, G (in press) in their "*The ecosystem approach to fisheries: issues, terminology, principles, institutional foundations, implementation and outlook*. FAO Technical Paper" have extracted many of the references to an ecosystem approach to fisheries from the FAO code of conduct for responsible fisheries. A summary of their results follows:

1 Ecosystem and habitat protection: The Code refers to "with due respect" for the ecosystem (Introduction). Recognizing transboundary nature of ecosystems (6.4), it specifies that states should "conserve", "protect" and "safeguard" them (6.1, 6.6, 7.2.2d and 12.10), to keep their "integrity" (9.12), including from the impacts of aquaculture (9.2). It promotes their research (2.1), calling for an assessment of the impact of fishing, pollution, other habitat alterations and climate change (12.5). The Code deals with habitat protection (6.8; 7.2.2d) and the need to "safeguard" (12.10) critical habitats, requesting the rehabilitation of degraded ones (6.5;

7.6.10) and promoting research on the impact of their alteration on the ecosystem (12.5) as well as a prior assessment of the potential impact of new fisheries or introduction of new technologies (8.4.7 and 12.11).

2 Role of environmental factors: The Code states, in its Introduction, that it "takes account of" the environment. Its provisions promote its protection (2g, 6.5 and 8.7). It promotes research on environmental factors (2j) and requires that such factors be taken into account in the "best scientific information available" (6.4) even when the scientific information available is inadequate (6.5). It requires that fishing be conducted "with due regard" for the environment (8.4.1), which should be monitored for impacts (10.2.4). It recognizes, in line with the 1982 Convention, the qualifying role of environmental factors on the Maximum Sustainable Yield (7.2.1).

3 Environmental impacts of fisheries: The Code requires that the impact of fisheries activities (including aquaculture and artificial reefs) should be minimized (6.7, 6.19, 8.9d and 9.1.5) and recommends the development of research on such impacts (8.11) for their assessment (9.15) and monitoring (9.15). It aims at "ecologically sustainable" activities (9.1.3). It promotes a reduction of pollution and use of chemicals (9.4), environmentally sound processing, transport or storage (11.1.7), and calls for regulation of environmental impacts of post-harvest practices (11.1.2). The Code refers to the need for prior impact assessment and monitoring of gear impact (12.11), the prohibition of destructive practices (8.4.2) and the development of environmentally safe gear. The

Code also considers, albeit very briefly, the problem of sound or optimal use of energy (8.6 and 11.8c).

4 Environmental impacts of other users and pollution: The Code also addresses other (non-fishery) users (1.2; 10.1.5) and acknowledges the impact of other human activities on fisheries. It recommends avoiding or settling conflicts (10.1.4 and 10.1.5). It also recognizes that other user's impacts should be assessed (7.2.3) and promotes the development of environmental research (8.4.8 and 12.10). It requires that the negative effects of natural environmental factors should not be exacerbated by fisheries (7.5.5) and calls for restoration of resources affected by other uses (7.6.10). It calls specifically for consultation with fisheries authorities before making decisions regarding the abandonment, in the aquatic ecosystem, of artificial structures (e.g. oil platforms). The Code contains also one article entirely dedicated to the integration of fisheries into coastal areas management (1.1, 1.3, 6.9, 8.11.3 and 10.2.4). The Code calls for a reduction of pollution (7.2.2) through the development of waste disposal systems (e.g. for oil, garbage, decommissioned gear) in harbours and landing places (8.7.4 and 8.9c). Dumping at sea from fishing vessels should follow the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) (8.7.4) for onboard incineration (8.7.2). Emissions into the atmosphere should be reduced (8.8) including emissions of exhaust gas (8.8.1), ozone emissions, phasing out of conventional cooling agents (chlorofluorocarbon and CFCs) (8.8.3) and use of alternative refrigerants (8.8.4).

5 Biodiversity and endangered species conservation: The Code reflects "due respect" for biodiversity (Introduction). It promotes its maintenance (6.1), protection (7.2.2d), safeguard (12.10) and conservation (9.2.1), mentioning genetic diversity (9.2.1 and 9.1.2), the need to minimize fisheries impact on biodiversity (9.2.1) and to develop research about fishing gear impact. The Code also recognizes the existence of endangered species that need to be protected (7.2.2), minimizing fisheries impacts on them (7.6.9).

6 Multispecies management: The Code distinguishes between exploited and non-exploited species belonging to the same ecosystem, the "target" species on the one hand and "non-target" species and "dependent or associated" species (in accordance with the 1982 Convention) on the other. Regarding the "dependent and associated" species, the Code promotes the study of their behaviour (12.10), their conservation (6.2 and 6.5), the absence of adequate scientific information (6.5, precautionary approach), accidental fishing mortality (7.2.5), the assessment (7.2.3) and the reduction/minimization of catches (7.2.2, 769 and 6.6) or fisheries impacts (6.6 and 7.2.2). The Code deals with conservation of populations structure (6.1), their rehabilitation in case of damage (6.3) and the analysis of the impacts on them of environmental factors (12). It also includes the need for the scientific study of the inter-relations between populations (7.3.3).

7 Coastal areas: The Code recognizes that these key geographical areas for an ecosystem approach to fisheries management. The Code requires that they

should be protected (2g) and has one article entirely dedicated to the integration of fisheries into coastal areas management (1.1, 1.3, 6.9, 8.11.3 and 10.2.4).

8 Selectivity, ghost fishing, by-catch, discards and waste: Inadequate selectivity of fishing gear is a central ecological issue that impacts on target as well as non-target species, by-catch, discards and waste. The Code dedicates a whole section to the issue (8.5) and promotes the use of more selective gear (7.6.9 and 8.4.5) and calls for more international collaboration in better gear development (8.5.1 and 8.5.4), as well as for the agreement on gear research standards. The Code calls for minimizing discards (12.10) and waste (6.6, 7.2.2 and 7.6.9) including through reduction of dumping and loss of gear (7.2.2).

9 Risk, uncertainty and precaution: The Code, in line with the UNCED Rio Principle 15 and the 1995 FSA, deals with uncertainty, risk and precaution (7.5) and recommends the wide application of the precautionary approach to "preserve the aquatic environment" (6.5 and 7.5.1), taking into account various uncertainties (7.5.2 and 10.2.3), using reference points (7.5.3), adopting cautious measures for new fisheries (7.5.4) and avoiding to add pressure on a stock naturally affected by a negative environmental impact (7.5.5). The Code also recommends a scientific Prior Impact Assessment (PIA) before a new fishery is developed or a new technology is deployed (8.4.7 and 12.11).

References

1 "Meeting the needs of the present without compromising the ability of future generations to meet their own needs", Brundtland Report, *Our common future*, World Commission on Environment and Development, 1987.

2 FAO Fisheries Department. The ecosystem approach to fisheries *FAO Technical Guidelines for Responsible Fisheries* No 4, Suppl. 2.

Mr Matthew Camilleri, Department of Fisheries and Aquaculture

BACKGROUND TO THE ESTABLISHMENT OF THE 25 MILE FISHERIES CONSERVATION ZONE AROUND THE MALTESE ISLANDS

Background and scientific criteria

Malta's negotiations with the European Union prior to its accession as a member state included two years of highly technical discussions related to the establishment of a 25 nautical mile Fisheries Conservation Zone around the Maltese Islands – the first of its kind in the Mediterranean. In fact, five technical documents[1] were produced to back these negotiations and a non-discriminatory management regime was finally agreed upon on the basis of scientific information presented.

Malta has managed an extended fisheries management zone, beyond its territorial waters, since 1971 and has maintained a strict licensing scheme, keeping large scale industrial fishing such as trawling at a minimum. From the start of negotiations, Malta stated that as a member of the EU, Maltese fisheries should be safeguarded and resources within the current 25 mile Exclusive Fishing Zone should continue to be kept at sustainable levels. Concern was expressed on the inevitably large increase in fishing intensity that would occur in the Zone if it were to deregulate the band between 12 and 25 nautical miles which would become Community Waters. Malta had proposed that in line with the "Code of Conduct for Responsible Fisheries" of the Food and Agriculture Organisation of the United Nations, a Precautionary Approach had to be adopted and a tight control on the increase in fishing effort should continue to be kept especially with regards to demersal trawl fisheries. It was demonstrated that there were criteria for defining the area as a distinct Conservation Zone – there was evidence that adult populations of shallow (less than 200m depth) shelf resources within the zone were isolated from adjacent areas and that the Maltese shelf constitutes the main offshore area where spawning could take place for a significant proportion of the zone's demersal resources and other deep water species. Moreover it was argued that as a consequence of the oceanographic features in the region, larval contribution from outside the Zone was an unlikely source of major recruitment of juvenile fish to demersal fisheries. In addition, satellite imagery also showed clear evidence that Malta was surrounded by water masses which are limited in productivity (oligotrophic), making the ecosystem within the Zone more prone to negative effects caused by high exploitation rates.

The opinion of the General Fisheries Commission for the Mediterranean is that effort control should be the main management tool in the Mediterranean through a limitation on the number of boats, their horsepower and fishing capacity. The EU was informed that Malta had taken such effort control measures on a routine basis and from the best available scientific information, the demersal fisheries resources within the 25 mile zone appeared to be close to Maximum Sustainable Yield (MSY) conditions and that they would be placed in a seriously overfished condition, if the fishing effort would be increased even by just adding a few large trawlers.

Amongst the sources of evidence to establish the Conservation Zone, recent scientific trawl survey data were used. Trawl surveys estimate abundance (as biomass and density per km^2) of important commercial species in different depth strata. Comparing abundance data obtained for Maltese waters with those of Sicilian waters revealed that, in general, the abundance or catch rate at depths between 50 and 500 meters was double in the former. With this information in hand and considering that in a published document the Sicilian fleet was shown to be operating at bioeconomic equilibrium point (a situation of no net profit), Malta was able to fairly state that its demersal fisheries were operating at Maximum Economic Yield (using the Gordon-Schaefer model - figure 1) which is close to MSY conditions.

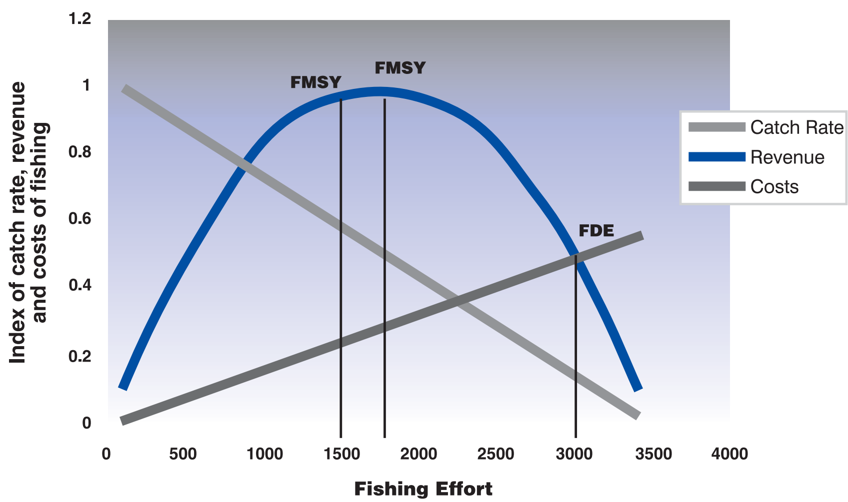


Figure 1. Gordon-Schaefer model of a fishery with MSY normalised to unity (FMEY= fishing effort at Maximum Economic Yield; FMSY = fishing effort at Maximum Sustainable Yield; FBE= fishing effort at Bioeconomic Equilibrium point).

Malta's backing documents also demonstrated that the current fisheries management regime allows escapement of demersal species into non-exploited or slightly exploited areas creating important refugia for spawners and juvenile fish from which the latter eventually recruit themselves into fishing areas both within and outside the Zone. In this respect, it was therefore stressed that areas where trawling is currently absent should continue to remain free from this type of fishing operation, both to maintain these vital sources of recruitment and also to protect fragile benthic ecosystems which are likely to be present in these particular areas.

Besides, focussing on demersal resources, negotiations dealt with highly migratory fish species such as *lampuki*, tuna and swordfish, which make up more than 70 percent of the value of Maltese total annual landings. In this context, it was stressed that the sustainability of fisheries for these species in ecological, biological, economical and social terms should be safeguarded. Backing documents highlighted the fact that the Maltese population involved in the fishing industry is economically, geographically and culturally dependent on artisanal fisheries, and that the introduction of large scale industrial practices would completely disrupt artisanal fishing operations. With particular reference to the vulnerable blue-fin tuna Mediterranean stock, Malta proposed that the Principal of Relative Stability should be applied whereby the fishing effort on this stock in recent years would not change both in intensity and spatial distribution. It was also explained that increasing the fishing effort, especially by using large scale industrial fishing gears, would not only contribute to a reduction in the abundance of tuna stocks but could also affect other species such as mammals and birds.

Drawing up the Management Regime

The measures adopted for the management of resources within the Fisheries Conservation Zone essentially limit fishing effort and capacity by restricting size and engine power (figure 2). In order to maintain current sustainable conditions of demersal resources, trawling fishing effort will not be increased within the Zone and will be shared by non-industrial vessels (under 24 meters in length) which do not use heavy gear and have short fishing trips. In addition, for the purpose of conserving the distinct fish populations of the Maltese shelf, a restriction on engine power has also been included as a measure for trawlers operating in waters shallower than 200m. Moreover, trawling will be limited to specified areas within the Zone so as to conserve existing "refugia" and fragile benthic ecosystems.

With the exception of particular categories of fishing vessels such as those involved in *lampara* (targets pelagic species using light sources) and *lampuki* fisheries, it was agreed that only small scale fishing vessels (under 12 meters in length) will be authorised to fish within the Zone and that the current fishing effort of this category of vessels will not increase. This size restriction would have a direct effect on the limitation of fishing capacity and fishing effort, since, generally, the size of a fishing vessel is directly proportional to the size and number of elementary units of the fishing gear and the effective fishing time. On the basis of the best scientific information available, all the measures described so far will ensure that the state of demersal resources with the Zone would be kept between MEY and MSY conditions.

The management regime also addresses the *lampuki* fishery since fishing operations start within 25 miles from the coastline (usually starting at 7 miles). It ensures that the traditional management scheme will continue to be applied, with the number of courses along which fishermen would lay Fish Aggregating Devices (*kannizzati*) being limited to a maximum of 130, and that this fishery would be protected from interference by other types of fishing operations. The management regime also commits itself to ensuring the sustainability of fisheries for other highly migratory species such as tuna and swordfish which also take place both within and outside the Zone.

Efficient monitoring and control of the activities of vessels within the Zone will be supported by an electronic Vessel Monitoring System. Vessels over 24 meters in length along with those vessels over 12 meters in length which are authorised to carry out fishing operations within the Zone would be obliged to carry the required tracking electronic equipment on board at all time.

Is the Management Regime in conformity with Ecosystem Based Fisheries Management?

The Management Regime for this unique Mediterranean Fisheries Conservation Zone has answered in some ways to the international call to adopt an ecosystem approach to fisheries. In fact, the foundation criteria for defining the Zone includes aspects of productivity, oceanography and physical characteristics in the region. It also covers the conservation of various levels of the fisheries resources in the food chain together with fragile benthic ecosystems, and protects species such as mammals and birds by restricting the type of gear used in the Zone. Ultimately,

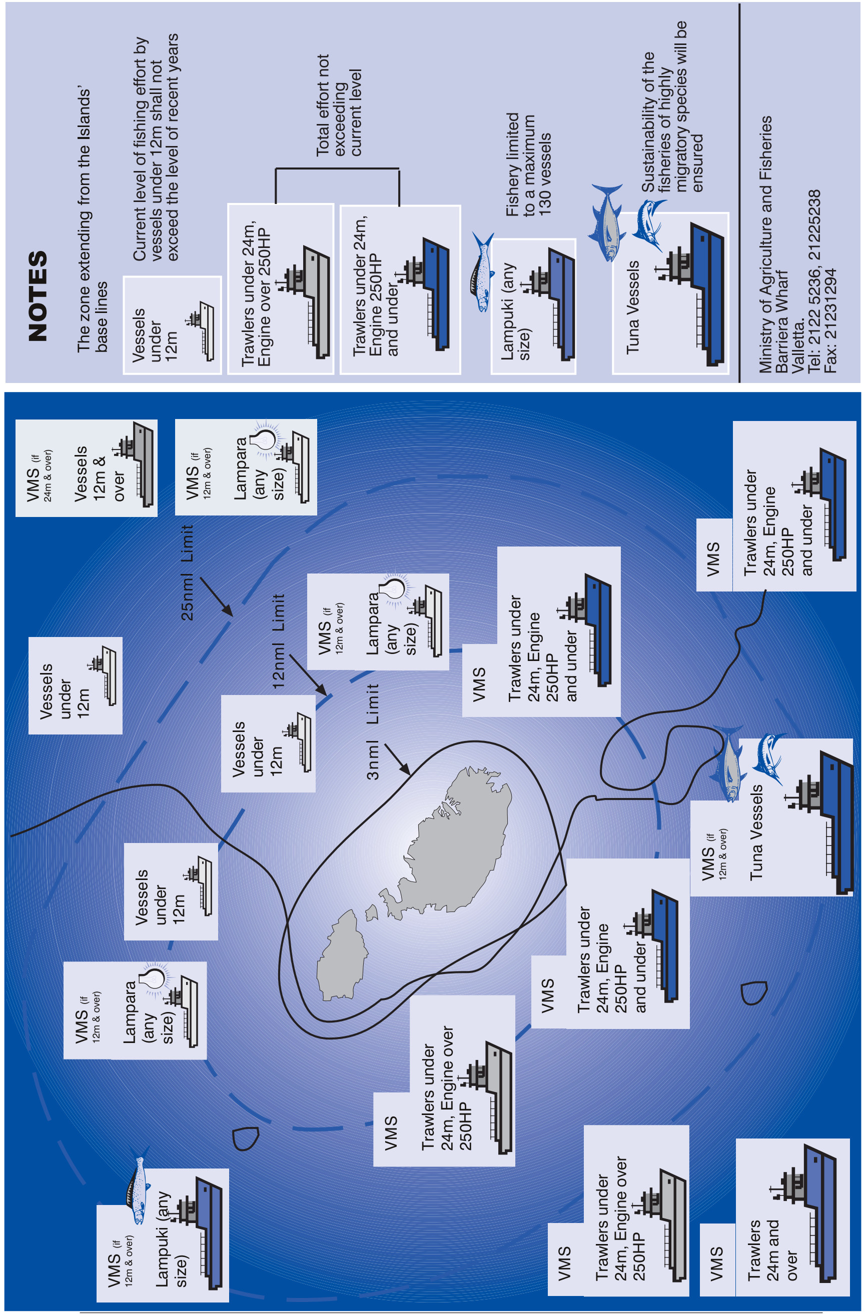


Figure 2. A summary of the Management Regime

the ecological, biological, economical and social environments which, to a certain extent, make up the fisheries ecosystem have been safeguarded and the sustainability of fisheries within the 25 mile Fisheries Conservation Zone has been guaranteed.

Notes

1 - MAF (2000) Maintaining the Maltese Fisheries Management Zone
- MAF (2001) Malta's fishery management system for demersal resources
- Camilleri M. (2001) The Medits 2000 trawl survey reviewed
- Fiorentino F., Norrito G., Ragonese S., Camilleri M. and Bianchini M.L. (2002) An attempt to compare the status of the groundfish resources within the Maltese Exclusive Fishing Zone and the surrounding bottoms of the Strait of Sicily
- Camilleri M., Cordina G. and Franquesa R. (2002) An analysis of the impact of purse seining and industrial longlining in Malta's 25 mile Conservation Zone