

MAMA—Towards a new paradigm for ocean monitoring in the Mediterranean

The MAMA Consortium:

S. Vallerga (main coordinator and MedGOOS Chair)¹, A. Drago (Assistant Coordinator and MedGOOS Executive Secretary)², T. Aarup, A. Abdelbaki, A. Abuissa, H. Awad, M. B. Awad, C. Beken, S. Besiktepe, A. F. Boargob, G. Brundrit, M. Capari, A. Carlier, B. Cermelj, G. Casazza, F. S. Civili, Y. Cohen, C. Tziavos, H. Dahlin, M. Dalla Costa, P. Drakopoulos, N. C. Flemming, J. Font, G. Fusco, I. Gertman, G. Georgiou, A. Harzallah, G. Herrouin, A. Ibrahim, N. Kabbara, Z. Kljajic, H. Kouyoumjian, J. Legrand, J. L. Lopez-Jurado, P. Magni, A. Mahmoud Al-Sheikh, C. Maillard, V. Malacic, G. M. R. Manzella, P. Marchand, M. Morovic, P. Pissierssens, N. Pinardi, K. Nittis, D. S. Rosen, C. Summerhayes, A. Ribotti, G. Reed, A. Selenica, I. Salihoglu, C. Sammari, D. Sauzade, C. Silvestri, M. Snoussi, R. Sorgente, C. Tziavos, G. Umgiesser, M. Vargas, B. Vucijak, J. Woods, M. Zavatarelli, G. Zodiatis

¹*Consiglio Nazionale delle Ricerche & International Marine Centre, Italy*

²*IOI-Malta Operational Centre, University of Malta*

Abstract

Sustainable development requires the intelligent management of the marine environment, to protect the marine ecosystem, minimise the impacts of climate change and anthropogenic influences, and provide benefits for a wide range of users. Routine ocean monitoring and forecasting based on sound science, long term and adaptive monitoring, and co-operation between nations, is the main tool for such a management. The assets and needs of all countries have to be identified, as well as the constraints impeding data exchange and marine observations in the EEZs. The challenge is to build a monitoring system based on up-to-date science and technology, and adapted to the specificity of the basin for the benefit of different users in all Mediterranean countries. It is necessary to involve all riparian countries in the process of building the Mediterranean monitoring system. A strengthened and dedicated link between the scientific community and the public authorities is moreover necessary to provide a sound scientific background for policy decisions based on environmental monitoring.

Building on these concepts the Mediterranean network to Assess and upgrade the Monitoring and forecasting Activity in the region (MAMA), funded under the EESD Programme of the 5th FP, and involving partners from all the Mediterranean countries, aims to establish the multi-national network that will prepare the institutional linkages and regional platform for such an integrated and sustained monitoring system in the region. The project builds on the trans-national pooling of scientific and technological resources and provides a concerted basin-scale effort towards the planning and design of the initial ocean observing system in the Mediterranean. The system-wide approach of MAMA is expected to trigger an enhanced motivation on the relevance of systematic

* Corresponding author, email: aldo.drago@um.edu.mt

marine observations for the sustainable and shared use of the marine resources of the Mediterranean Sea. These catalytic ingredients constitute the thrust of MAMA and an enabling asset to the future projection into long-term commitments at governmental level.

Keywords: Operational oceanography, Mediterranean, networking, capacity building, awareness, inventories

1. Preamble

The improved understanding and trend prediction of the marine ecosystem, for the benefit of the economy of coastal States and the protection of public health, are longstanding issues in the Mediterranean. Indeed the combined effects of global climate change and human alterations of the environment are already pronounced in many coastal waters of the global ocean, including to no lesser extent the Mediterranean Sea. Yet the maritime sector contributes up to 5% of the GNP of the riparian countries, and this is expected to increase in the future. The increasing range of maritime transport, off-shore industries, tourism and human activities in the coastal area are exacerbating pressures on the marine environment, raising even more the need to adequately manage its resources. Routine and long term monitoring of the ocean and coastal seas, the forecasting of the state of the sea based on sound science, reliable assessments, and the efficient co-operation between nations, constitute the main management tools.

In addition, the role of the oceans on the functioning of the global climate system is now well recognised. The mutual influence and interaction between the ocean and the atmosphere is even more intense in a land-locked sea like the Mediterranean. Meteorologists use atmospheric observations from a network of land and ocean surface measurements to produce three- to five-day weather forecasts to anticipate the impact of storms, warm periods and other day-to-day events. Reliable longer term climate predictions covering the broader patterns of the weather over seasons and years, require additional and improved observations within the upper layer of the oceans.

An improved understanding and functioning of climate variability relies on systematic observations of both the ocean and atmosphere, with concomitant improved predictions of both. Sustained, integrated and routine data sets of the ocean and coastal seas will also target multiple users. 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 provide benefits to many sectors in industry and services such as marine transportation, safety and public health.

National ocean monitoring and forecasting programmes already exist in some countries on the northern perimeter of the Mediterranean, but efforts are not co-ordinated. In other cases, national capabilities, including human skills and available technology, are not sufficient, and/or not well integrated to provide a comprehensive approach. Data on a regional scale are not brought together over large expanses of the basin, especially along the southern and eastern perimeter. Data are often taken from 'platforms of convenience' and at locations that may not be the best ones from an oceanographic point of view.

On the other hand, coastal seas are affected by ocean and atmospheric processes occurring on a regional or global scale, and dictate the need for a regional approach to observations and to the absolute necessity of data sharing. This is most evident in the Mediterranean Sea, characterised by generally narrow shelf areas, where large-scale oceanic structures predominantly force the coastal ecosystem (Pinardi and Flemming, 1998a). Moreover ocean nowcast/forecasts require observations of sufficient duration, spatial extent and resolution as well as real-time data telemetry, assimilation into models and analysis. This is the way in which the monitoring of the open ocean areas and coastal seas will provide a comprehensive means for assessing the health of the marine environment, understanding ocean variability and its reaction to external changes, for improving their sustained exploitation and mitigating their threat through a suite of new marine services and applications.

2. The answer is MedGOOS

The sustainable management of the seas and oceans was called for by Agenda 21 (Agenda 21, 1992) and resulted in the launching of the Global Ocean Observing System (GOOS), to be planned and implemented regionally. The European component of GOOS was established in 1994 by 14 European agencies, reaching 30 in 2001. The EuroGOOS Association developed its strategy, science plan, technological surveys, and implementation plans in the European seas (Pinardi and Flemming, 1998a; Woods *et al.*, 1996a; Woods *et al.*, 1997b; Bosman *et al.*, 1998; Prandle and Flemming, 1997; Buch and Dahlin, 2000). The EuroGOOS Mediterranean Task Team developed the science base for an ocean forecasting system in the region, through EC funded projects. The institutional framework for the Mediterranean Global Ocean Observing System (MedGOOS) was established under the auspices of the UNESCO/Intergovernmental Oceanographic Commission (IOC) in November 1997 (IOC, 1998), during the Workshop on GOOS Capacity Building for the Mediterranean Region in Malta.

The mission of MedGOOS is to respond to the priority demands outlined above by facilitating 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 MedGOOS strategy was endorsed by over thirty national institutions, interagency and intergovernmental organisations, from almost all the Mediterranean countries, at a dedicated meeting held in Rabat, Morocco in 1999. To date the MedGOOS association binds together 18 marine institutions from 15 European and Mediterranean Partner countries, namely Morocco, Egypt, Israel, Cyprus, Turkey, Greece, Albania, Serbia and Montenegro, Slovenia, Croatia, Bosnia and Herzegovina, Malta, Italy, France and Spain. MedGOOS focuses on the regional priorities for operational ocean forecasting and marine meteorology, addresses the related economic and social implications, and guides and assists the riparian states to 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.

Furthermore MedGOOS promotes the upgrading of national systems to a uniform level of expertise and infrastructure, and stimulates the necessary pre-operational R&D to ensure that GOOS is fully effective when it is fully established in the region.

In terms of what concerns the scientific and technological development in the field of operational oceanography, there have also been outstanding achievements in the Mediterranean. GODAR (UNESCO/IOC, 1995a) and MEDAR/MEDATLAS (UNESCO, 1997b; Maillard *et al.*, 1999) have located and collated the major data holdings. The establishment of NODCs and the development of an adequate data management structure in the region (including handling of NRT data) are identified as a basic next step forward. The Mediterranean Forecasting System Pilot Project (MFSPP) has implemented the first phase of the EuroGOOS Mediterranean Forecasting System Science Plan and is the only experience in the region of NRT data exchange, between participating institutes, at time scales of hours (buoy data), days (XBT data) or weeks (remote sensing SST and SSH data).

This experience has demonstrated the feasibility of such a system but, at the same time, revealed that major technological and scientific developments are still required to apply operational forecasting in the coastal areas, even if the major tools are ready to be assembled (Pinaridi *et al.*, 2001c; Pinaridi *et al.*, 2003d). The Mediterranean ocean Forecasting System: Towards Environmental Predictions (MFSTEP) is an RTD project currently running under the 5th Framework Programme of the EU as a follow-up to MFSPP. It seeks to consolidate and further develop the Mediterranean ocean forecasting system by enhancing the hydrodynamics predictive component, through the application of advanced technologies for improved multi-parametric monitoring in operational mode, and by implementing marine ecosystem predictions. All these projects involve the participation of Institutions of some of the South and Eastern Mediterranean countries, thus offering a first important North-South enhanced research cooperation in marine science.

3. MAMA, a MedGOOS project

The MFSPP experience has started to build the S&T base required to develop and implement an operational ocean observing and forecasting system in the Mediterranean. While the methodological approach to extend environmental predictions into the coastal areas is unfolding, the needs dictated by the variability of the marine ecosystem and the demands of the potential end-users are shaping the very challenging requisites that an effective and useful ocean/coastal monitoring and predictive system must have.

It is becoming more apparent that the transit to the implementation phase necessitates a parallel effort to broaden the participation to all the riparian countries, to build a case for operational oceanography in the region, and to set up an organisational framework that supports the establishment of an ocean observing and forecasting system on the basis of trans-national cooperation and with an assurance to its sustained functioning in the future.

An ongoing 3-year project entitled “The Mediterranean network to Assess and upgrade the Monitoring and forecasting Activity in the region (MAMA)”, funded by the 5th EU Framework Programme and involving for the first time all the Mediterranean countries, is intended to resolve these deficiencies. MAMA brings together a consortium of major marine institutions aiming to put in place the institutional networking and enhance the necessary infrastructure for a future integrated and sustained observing and forecasting system in the Mediterranean.



Figure 1 MAMA consortium with a representation from all the Mediterranean countries

MAMA is a direct outcome of the MedGOOS strategy which advocates an implementation process that centres upon long-term partnerships, capacity building to favour direct participation, the creation of awareness on the far-reaching benefits, an open approach to all stakeholders with demonstration applications, and the design of a system that addresses the specific needs of the region. This project will enable MedGOOS to make the first concrete steps and be in a position to provide guidance to the Mediterranean states, stimulating the necessary awareness, invoking capacity building and pre-operational R&D to ensure that MedGOOS is fully effective when it eventually attains maturity, hopefully in ten to twenty years time.

MAMA focuses on the trans-national pooling of scientific and technological resources in the basin, through the sharing of experiences and the transfer of expertise, to bring capacities in operational oceanography at comparable levels, and provide an integrated effort towards the planning and design of the initial ocean observing and forecasting system in the Mediterranean. Furthermore, MAMA will interact with end-users, stakeholders and relevant international organisations, work in the whole basin to trigger local awareness on the benefits of operational oceanography and ocean forecasting with dissemination of results and demonstration products, and build momentum towards long term commitments by governments.

MAMA is 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 9 workpackages, with a strong emphasis on assessing current capacities, cooperation, networking and awareness. A high level advisory board is providing on-line monitoring on the quality of the work and with suggestions for future development.

4. Update on the main MAMA activities

After the first year of activities, several key activities have already been initiated. The network is working in harmony and following anticipated schedules, already a good result given the geo-political complexity of the partnership.

4.1 Assessing the present situation

A key activity in MAMA is the assessment of the present Mediterranean capability in terms of infrastructures, programmes, human resources, and funding for pre-operational oceanography. This exercise is being undertaken by a process of national consultation with public authorities responsible in marine affairs, marine research institutions and marine service providers in general.

The information is being collected by means of a survey conducted by an online Questionnaire on Marine Monitoring Activities in the Mediterranean covering a comprehensive overview on the availability of technological infrastructures and equipment; human resources and funding capability; and existing national/international initiatives related to operational oceanography in the region. Country profiles are also being prepared to give an overview on:

- the operations of institutes/agencies/organisations dealing with the monitoring, assessment and forecasting of the state of the ocean and coastal areas
- the national structure for the support and running of marine monitoring and research activities
- the key public administration/authorities responsible for marine affairs, and for environmental policy formulation and implementation
- the relevance of the maritime sector in the economic activities of each country;
- implications for MedGOOS in the optimal design and implementation of operational forecasting for maximal benefits to the coastal states.

The information will serve to build a regional database on the current arrangements and facilities for pre-operational ocean monitoring and forecasting, and will provide the basis for an assessment on the needs and potentials for operational oceanography in the region. The MedDir directory consisting of an online searchable database of marine scientists and professionals working in the Mediterranean region has already been established by the MedGOOS Secretariat in collaboration with the IODE Secretariat, and can be found at <http://ioc2.unesco.org/medir>.

4.2 National Awareness Meetings

The consultation process will run in parallel and make use of the national awareness meetings programmed in each country, mainly during the second year of the project. These meetings will address a full hierarchy of stakeholders aiming to gain societal support by increasing public recognition and appreciation of the need for operational oceanography. They will also provide an opportunity for direct consultation, to identify national needs for capacity building, infrastructure and local organisational frameworks. Moreover, the meetings will aim to fuel the creation of strong linkages between the scientific community involved in preparing the basis of operational oceanography, and the policy community committed to securing a sustainable society. This should serve as a

catalyst to establish national commitments in favour of MedGOOS, possibly through the creation of National GOOS Planning Committees, involving data and potential service providers, end-users and potential beneficiaries, including entities involved in policy-making, environmental management and the marine industry.

4.3 The MAMA WWW

The first version of the MAMA website (<http://www.ifremer.fr/mama>) has been developed using state-of-the-art technology and on the basis of a dynamic content management system with a multiple author environment, providing a community portal to partners. The MAMA website supports special facilities including a calendar, built-in search engine, forum discussions and a dedicated area reserved for exchanges between the MAMA partners. The website will evolve throughout the project, and use facilities to make it auto-sustaining, requiring little maintenance effort after full development, and compatible to future enhancements and extensions. Besides providing a tool for easy and fast communication amongst the partners, the MAMA WWW is being developed to serve as a showcase for operational oceanography in the region and to promote awareness by means of dedicated Partner Pages focusing on each country, and giving the MAMA WWW a regional dimension and scope.

4.4 Capacity building activities

The capacity building element of MAMA is mainly conducted by means of a visiting scientist exchange scheme. While contributing to strengthen the network, the training-on-the-job experiences offered within the scheme enable the development of skills required to participate in the GOOS. In the first year of activity a number of host centres have provided several training opportunities. Some training visits were also performed outside the MAMA network, at selected centres for technology transfer.

Four high-resolution circulation models are being implemented in key shelf/coastal areas on the southern and eastern Mediterranean shores not yet covered by previous numerical modelling efforts. These models are being developed by the four MAMA partner institutes in Morocco, Algeria, Tunisia and Lebanon with the assistance of the reference modelling institutions UNIBO–CIRSA (University of Bologna) and IMC (International Marine Centre—Sardinia). The models are nested to the basin-wide Mediterranean General Circulation Model developed at the Mediterranean Forecasting Centre (UNIBO–CIRSA). These model implementations serve as a very effective transfer of modelling experiences to new partners in key countries.

4.5 Designing the initial observing system

MAMA is also targeting to contribute to the design of the initial observing system in the region. A report on “Monitoring Strategies for Operational Oceanography” has prepared the background for methodologies to define strategies for routine ocean observing systems that optimally describe the state of marine ecosystems in the three biogeographical areas: the open ocean, the coastal ocean and inshore areas. The attention is purely devoted to GOOS objectives: to provide data on an operational basis for nowcasting/forecasting. The report develops tools and concepts for the design of an operational observing system to repeatedly assess and anticipate changes in the status of

marine ecosystems on national to global scales, by extracting the most important temporal and spatial scales from data and with well-defined optimal sampling strategies.

A number of currently available NRT remote sensing products are being assembled to provide to MAMA partners a general compendium of applications using a range of satellite observations, at different levels of processing, accuracy, spatial resolution, spatial and temporal coverage, NRT delay and platforms. Products developed by some partners such as the Cyprus Coastal Ocean Forecasting and Observing System (Zodiatis *et al.*, 2002) (CYCOFOS—www.ucy.ac.cy/cyocean/) and the new satellite receiving station installed at the Institut de Ciències del Mar (CSIC, Barcelona, Spain) will be included.

MAMA is also raising awareness of the development and use of biological indicators of ocean health as an aid to existing observing systems in the Mediterranean for a sustainable use of the coastal zone. The aim is to combine data sets of environmental and biological variables to identify consistent patterns of association and select primary response parameters that could serve as indicators, or “warning signals”, of related adverse environmental conditions leading to stress in the benthos.

4.6 MAMA–Net

MAMA–Net is preparing to establish a one-stop showcase of operational ocean data and information. The objective of this activity is to initiate a prototype data and information exchange system to support exchange of operational data/metadata between agencies, and provide access to operational prototype products for MAMA partners. The current networking capabilities of the partners have been assessed and the identification of the networking requirements for MAMA–Net are being defined. This will lead to the definition of parameters and products to be exchanged through MAMA–Net, together with common indexes and standard protocols for exchange. The publication of operational products on MAMA–Net will include the development of software tools for pre-processing of data and transformation to GTS format. The selection of appropriate encoding / compressing methods for forecasting model outputs is also being considered. The list of products (data or metadata) to be distributed by project partners has already been partially prepared and includes real time data from the M3A buoy and Poseidon networks and related meteorological—wave—circulation products; temperature (XBT) data from Ships of Opportunity; Sea Level Data in NRT, R/S data and hydrological data.

4.7 MDIM Workshop

Preparations are also underway for a “Marine Data and Information Management” (MDIM) workshop, scheduled within the programme of the 4th MAMA general meeting in Rome next June. The workshop aims to address the steps needed for an improved data and management system with enhanced efficiency, adapted to handle data and information in operational mode, with full geographical coverage of the basin, and aiming towards adding value to ocean data in response to the needs of users.

4.8 MAMA demonstrators

MAMA is also establishing open and constructive links with the end-user community to identify their needs and priorities. The aim is to prove the usefulness of operational

oceanography through pilot demonstration applications and tools. The two main streams of work are to develop:

- a web-based system providing guidance and information on protection from coastal erosion and on Integrated Coastal Zone Management (ICZM) in general. The Coastal Erosion Protection and ICZM Guidance Demonstrator (CEROSPIG), aims to provide information on coastal erosion problems, and to develop a capacity for an integrated Coastal Zone Management based on forecasts of the coastal environment
- a user-friendly interface and provision of tools (software) for viewing and using forecast and ecosystem results. The transformation of data into usable products is still an area to be fully explored and enhanced. Current products are heavily based on physical measurements in the coastal seas and the upper ocean. This task addresses the need to improve and ease the capacity of analysing, merging and using observed and modelled data for the management of the marine resources at short term. The capacity to analyse merged data sets (*in situ*, satellite and modelled) and extract the major information for practical applications is being investigated by a dedicated pilot exercise for the coastal zone. *In situ* and satellite data will be merged to provide information on the status and trends of the coastal marine environment. These products are intended to provide information in the form of a water quality index based on temperature, salinity, oxygen, nutrients concentration. It also aims to provide an example of 'near real time' information to ocean managers and the public in general.

5. Conclusion

An integrated and sustained ocean monitoring system needs an enduring collaboration among the neighbouring countries and a strong will to share efforts, resources and knowledge. An early dialogue is crucial, and the involvement of all the Mediterranean countries is vital, for the long-term success of MedGOOS. 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.

MAMA, a MedGOOS project involving a partnership from all the Mediterranean countries, is building on this thrust and applies the concept of shared development and co-ownership. This will lead to the establishment of the multi-national network to prepare the institutional linkages and regional platform for the implementation of GOOS in the Mediterranean. MAMA takes advantage of the scientific and technological base achieved in Europe, the enlargement process in the European Union, and the Mediterranean policy of the Union, all favourable conditions for a concerted basin-wide effort to form a strong, common research infrastructure for operational oceanography in the region.

The system-wide approach of MAMA, involving all stakeholders and using national ramifications, is expected to trigger consensus and action for systematic long marine observations for the sustainable and shared use of the resources of the Mediterranean Sea. The constraints impeding data exchange and marine observations in the EEZ will be addressed, within the principles of UNCLOS.

These catalytic ingredients constitute the thrust of MAMA and an enabling asset to the future projection into long term commitments at governmental level. This unprecedented effort will put the region at the forefront of operational oceanography and prepare the ground for the region to take full advantage of the emerging opportunities in environmental monitoring and large marine integrated projects in Europe, with the Mediterranean being conceived as a unique test base for implementation.

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