

Spanish Ocean Observation System. IEO Core Project: Studies on time series of oceanographic data

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The Marine Environment Department of the Instituto Español de Oceanografía (IEO) is conducting several research projects based on the systematic and continuous study of the Ocean with observations made regularly over much longer periods than a year-round and covering events in all seasons. The principal goal of the core project "Studies on time series of oceanographic data" is to understand the underlying causes of temporal variability of the physical and biological properties and processes in the pelagic ecosystem in the neritic and oceanic waters surrounding the Spanish coast. The scientific objectives are integrated in the framework of GLOBEC and JGOFS. The research effort involves 1) time series measurements in several transects along the Spanish coast, on both the Atlantic and the Mediterranean sides, and 2) synoptic observations by satellite imagery.

The network of time series stations are being sampled according with JGOFS recommendations at monthly intervals at Santander (started in 1991), Cudillero (1993), La Coruña (1988), Vigo (1987), and Baleares (1993), and seasonally at Fuengirola (1992), and Cabo de Palos (1996). Each transect includes the sampling in, at least, 3 stations of coastal, neritic and oceanic characteristics. Sampling includes measurements on hydrographic parameters and diverse analysis on the community structure and properties of phytoplankton, zooplankton and ichthyoplankton. Sampling design also includes specific works oriented to the study of processes and the study of hydrographic phenomena by means of AVHRR satellite images. A data management system was developed for both: to archive the data and as a tool for data analysis and elaboration of reports. This project also supplies data to ICES data bank, and annual summaries on main results are reported to the ICES Working Groups WGOH, WGSSO, WPE and WGZE.

The project is supported by the IEO. Average annual cost, including depreciation of durable equipment, consumables, travels and overheads, is 175,000 Euro.

1. INTRODUCTION

The marine ecosystem's variability over time shows large fluctuations on a wide variety of scales (e.g. seasonal, interannual, decadal, etc.) which strongly limit the attempts to make predictions of how changes in the environment affect the physical and biological properties of water masses over a given time period. This high variability also limits our present ability to differentiate anthropogenic from naturally occurring effects. Thirdly, the wide range of variation also makes it difficult to compare data differing either in sampling location or year of sampling.

Because of these constraints, many authors have advocated the search for trends in time series as the best procedure to identify and compare common patterns of variation among different oceanographic data sets [1, 2, 3, 4]. It was also with the purpose of overcoming these bottlenecks that the establishment of long-term observation programmes has been encouraged by different panels and science plans developed in the frame of the IGBP and other initiatives (e.g. EuroGOOS, JGOFS, GLOBEC, etc) [5, 6, 7].

Coherent with the need to produce historical series of oceanographic data and within the framework of these international programmes, in 1991 the Instituto Español de Oceanografía (IEO) started the core project "Studies on time series of oceanographic data", a research project based on the systematic and continuous study of the ocean with interdisciplinary observations made regularly over much longer periods than a year and covering events in all seasons. This research project constitutes one of the most complex and complete contributions to ocean observation in Spain.

2. SCOPE AND OBJECTIVES

The Instituto Español de Oceanografía (IEO) is the main oceanographic research institution in Spain, with a national network of research centres comprising 7 laboratories in the Spanish coast (4 in the Atlantic and 3 in the Mediterranean). As the IEO is a public research organism, and the results of its research provide support to the Spanish government and international organisations, a significant proportion of the effort of the marine ecology and fisheries departments has been allocated to the understanding of mechanisms influencing fish recruitment, and to factors which influence biological production and can alter ecosystems.

Thus, since the mid-80's the IEO has conducted several research projects on the temporal variability of physical and biological properties and processes in the pelagic ecosystem. This topic was considered a research priority in the 90's, and in 1991 the core project "Studies on time series of oceanographic data" was started.

The project addresses two major scientific questions.

- 1 The understanding of underlying causes of temporal variability, quantification of trends on oceanographic properties and biological communities, and predict future scenarios and effects of global change in marine resources.
- 2 To identify significant mesoscale processes, and understand the effects of physical forcing on pelagic marine ecosystems.

The research effort involves 1) time series measurements in several transects along the Spanish coast, on both the Atlantic and the Mediterranean sides, 2) synoptic observations by satellite imagery and 3) local process studies.

3. OPERATIONAL PROCEDURES

The research project includes 7 transect sites around the Spanish coast, 4 in the ICES[♦] area (Santander, Cudillero, A Coruña, Vigo) and 3 in the Mediterranean (Fuengirola, Cabo de Palos and Baleares) (Figure 1). All transects run perpendicular to the coast, and include at least three sampling stations of coastal, neritic and oceanic characteristics. Each station is visited monthly (seasonally in Fuengirola and Cabo de Palos), with periods of intensification mainly in spring and summer, to study local processes. At each site, sampling involves extensive physical, chemical and biological measurements, paying special attention to the sampling and analysis of temperature, salinity, nutrients, PAR, fluorescence, chlorophyll a, phytoplankton species, biomass and zooplankton species, and ichthyoplankton abundance. Depending on the transect, measurements on physiological rates are also included. These data are being obtained from 4 research vessels that serve the seven transects. Parameters are sampled in accordance with JGOFS protocols, using standard oceanographic equipment (CTD, plankton nets, Niskin bottles, etc.)

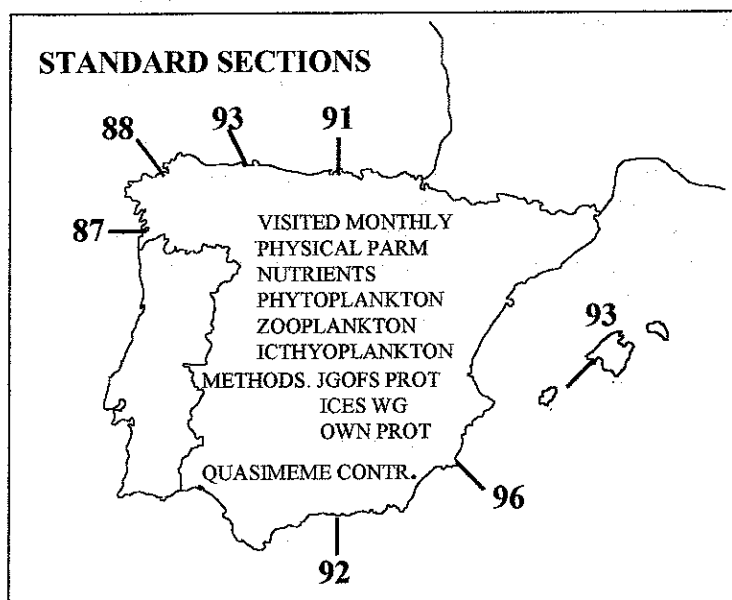


Figure 1 Map showing the location of the 7 transects sampled in the project with indications on sampling details and year of initiation.

♦ International Council for the Exploration of the Sea

Recently the project has implemented SST by satellite remote sensing as a routine tool for exploring large areas. Four daily passes of NOAA satellites 12 and 14 with Advanced Very High Resolution Radiometer (AVHRR) sensors are received in Santander. The infrared signal is processed to obtain SST images of the waters surrounding the Iberian Peninsula with a resolution of 1 x 1 km. By request or for specific research activities, the images are optimised to enhance mesoscale features.

The time series of sampling extends from 1987 (Vigo[♦]), 1988 (La Coruña[♦]), 1991 (Santander), 1992 (Fuengirola), 1993 (Balears), 1993 (Cudillero) and 1996 (Cabo de Palos). The collection of AVHRR SST satellite images has been available since July 1998.

A total of 24 scientists from 7 different IEO laboratories and from the University of Oviedo are directly involved in the project.

4. SUPPORTING ACTIVITIES

The complexity of the project requires supporting activities, which are programmed yearly by the IEO Co-ordination Group in its annual meeting. The first and second years were spent developing the internal organisation of the project, clarifying objectives, and establishing a working methodology

In response to the need to deal effectively with the large and varied volumes of data that have been accumulated as result of sampling and from the compilation of existing data, the IEO has developed a database that acts as an archive of data and as a tool for analysis and elaboration of reports. A Data Reporting Format (logbook) was created, which is of general use and provides the database with the essential metadata of analysis and observations, and also plays a role as a control of data quality

In order to ensure that the data are of high quality, and to make sure that all data are processed in a similar manner, sampling is being carried out in accordance with JGOFS protocols where possible, and/or following our guidelines. In the case of the analysis of nutrients, all the laboratories of the IEO where nutrients are being analysed have participated in the QUASIMEME exercise during recent years. A checklist of phytoplankton and copepods (main zooplankton group) were also produced.

Project support costs for attendance of national and international meetings (Symposia, Working Groups, etc). Courses on statistical analysis of time series analysis, taxonomy (phytoplankton and zooplankton), and one workshop on analysis of zooplankton have been programmed and covered within the project.

Funding for co-ordinated projects based on this core project has been obtained from different national and local agencies (CICYT, CYTMAR, Gobierno de Cantabria, Fundación Marcelino Botín, Fundación Pro-Vigo, and others). The number of proposals is expected to increase in coming years.

♦ Some gaps from 1988 to 1993

□ Some gaps from 1989 to 1991

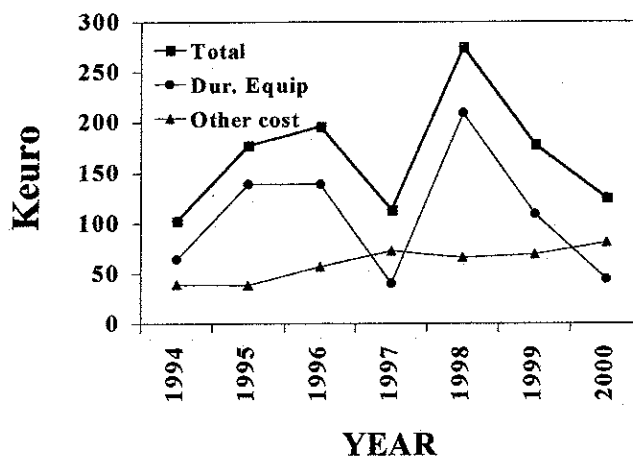


Figure 2. Annual investment in the project

Investment in the acquisition of new durable equipment makes up a major part of the annual budget. The total cost of the project since 1994 (except salaries) is shown in Figure 2

5. RELEVANCE AND BENEFITS

The project addresses major scientific questions and the information obtained are important to science and society. The long time series measurements will provide better bases for rational management of marine resources and uses of coastal areas, which is a commitment of IEO as a consultative agency of the Spanish government and international organisations. As an example, the project supplies data to ICES data bank and annual summaries on main results are reported to ICES Working Groups OHWG, SSOWG, WPE and WGZE. Main results are published periodically in scientific journals and in monographs (e.g. 8, 9, 10, 11, 12, 13, and 14).

The benefits are evident at various levels. Within the IEO, collaboration among scientists from different laboratories and the shared use of durable equipment benefits the rational use of material and human resources (e.g., nutrients analysis is centralised in the laboratory of A Coruña for the Atlantic transects, and in the laboratory of Baleares for the Mediterranean transects).

The time series obtained are also relevant to many other IEO projects, e.g. pollution monitoring, harmful algal blooms, ichthyoplankton ecology, etc. The project has also established close liaisons with universities (Cantabria, Oviedo, A Coruña, Vigo) and research organisations (Instituto de Investigaciones Marinas, Instituto de Ecología Litoral, and Instituto Nacional de Meteorología).

Access to the project database has been requested from hospitals (e.g. Residencia Juan Canalejo, A Coruña), electric power companies (e.g. Electra del Viesgo, Cantabria), universities (including one from Denmark), etc. Data are also used for environmental

assessment studies and the database was particularly useful in evaluating the ecological impact produced by the supertanker Aegean Sea, which wrecked in 1992 and produced an oil spill of 80 000 t in the coastal area off A Coruña.

6. CONSIDERATIONS AND RECOMMENDATIONS

Operational procedures and support activities are required to advance and reinforce the sampling network and to obtain a better yield in the exploitation of results. Satisfaction of both demands would result in a reinforcing of the structure of the project and would be the best guarantee of continuity in long-term programmes of the IEO

Time series can resolve long-term scales of variability in a way that is impossible for standard process-oriented studies. However, practical limitations impose constraints on sampling strategy. The monthly sampling scale limits the observation of hydrographic features whose periodicity is of days or weeks (e.g. upwelling events). Because of this, the project has planned the implementation of two new sampling technologies. Firstly, one, which is already operative, consists of the satellite reception station. Satellite remote sensing offers the greatest potential for providing the truly synoptic data sets that are needed for global synthesis and integration. Secondly, to be achieved in the mid-term, a network of moorings will be deployed at each transect to integrate records of the vertical structure of the water column. Satellite remote sensing of oceanic biology and physical structures and conventional *in situ* methodologies can be made to operate synergistically. Together, they give an integrated and virtually complete range of sampling strategies covering the full spectrum of time and space scales with quasi-synoptic global coverage.

On the other hand, because continuation of long-term monitoring programmes is often heavily dependent on the personal effort and dedication of individual scientists, and because, by the nature of long-term monitoring programmes, they are not competitive when evaluated by their short-term scientific yield, the challenge in the near future is to maintain operative the structure of collaborations among institutions, co-funding of co-ordinated projects, integration of network of sampling into a pan-European one, etc. An additional attraction for scientists to work in long term programmes appears if data sets are pooled together among institutions, as opposed to the isolation of present practices, thereby comparing observations from distant locations. On the other hand, detection of broad-scale changes, and distinguishing them from local imbalances, is possible only when data from distant locations are compared. Finally, this comparative approach will enhance the potential to detect risks and forecast them. Reluctance to share data is a serious threat to the continuity of long-term programmes [15]

The question of whether the marine environment should be monitored is no longer at stake, and there is an explicit demand from an increasingly concerned society for answers as to how and how much the marine environment is changing [15]. Human intervention and global warming are two sources of variability whose long-term impact on the ecosystem is not known, and add a high degree of uncertainty to the proper management of marine resources and uses of coastal areas. The development of a more coherent and comprehensive understanding of how these processes interact with physics and biology of marine ecosystems is a major challenge for coming years which can only be satisfactorily dealt with if collections of data with a suitable temporal perspective are obtained now

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