
ANNEX III

MONITORING AND ECOSYSTEM ANALYSIS

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This workshop is concerned with the relationship between environmental and fishery variability, especially in the case of small pelagics. This is a question that has intrigued me since I first went to work in the CalCOFI Program more than fifty years ago. Then the collapse of the California sardine fishery was generally blamed on overfishing, but the research program that arose was directed to exploration of environmental change and its possible impacts on sardines and other pelagic fishes of the California Current. The question then - as now - was " which caused the collapse, environmental change or overfishing?" The answer then -as now - was " probably both."

Of course the Mediterranean is very different from the coastal waters of California, but in both regions changes in their ecosystems, including changes in the abundance and distribution of fish species of commercial importance, largely stem from the same processes - variations in climate, in fishing

pressure, in pollution, and in river discharge. Although the principal concern of this workshop is the relationship between environmental variability and that of small pelagic fisheries, full understanding of fishery variability will require information on all of these forcing variables. In other words, they must be monitored.

Monitoring of relevant variables is necessary, but not sufficient. For the resulting data to be most useful to those concerned with the fisheries and their management, they must be shared and pooled, and the aggregate of physical, biological, and operational (i.e., fishing) data subjected to a holistic analysis. These matters have recently been under review by an international panel on living marine resources (LMR) under the GOOS program.

The GOOS (Global Ocean Observing System) is being developed by IOC (Unesco), with the cooperation of ICSU, WMO, and UNEP. FAO has joined in supporting consideration of

living marine resources. The system intends to monitor changes in the condition of the ocean and its ecosystems, to process and analyze the resulting data, and to make them available to users. It is in effect an extension of the weather monitoring network to the ocean and arose from realization that the ocean and atmosphere were closely linked in the development of climate change. However, unlike weather monitoring which consists largely of physical variables, the ocean monitoring envisaged cannot avoid the complications introduced by living organisms.

From the beginning, the LMR Panel took an ecosystem approach and considered monitoring changes in the state of marine ecosystems along with the forcing functions of such changes. If assessments of such observations could be routinely produced, they would be of great utility at a range of time scales, from interdecadal and decadal to the seasonal assessments and predictions needed for fishery management. The LMR Panel produced a catalog of desirable observations, physical, chemical, and biological. These fall into two categories, ecosystem components and ecosystem conditions.

Essential ecosystem components to be monitored include the gamut of trophic levels, from plankton up to fish and top predators like marine mammals and seabirds. Although not exploited, plankton are important not just because of their trophic role, but as potential indicators of ecosystem changes. In the case of these components, information sought includes abundance and distribution; reproduction, recruitment, and growth; ecosystem role; and causes of mortality. For ecosystem conditions, which include nutrient chemistry; temperature, salinity, and dissolved oxygen; ocean velocity field; and atmospheric forcing, desired information includes that on magnitude and distribution, and on causes of variations.

The generalized catalog of potential observations, physical and biological, prepared by the panel is highly schematic. Examples in its reports spelled out in greater detail the desired observations for selected ecosystems - e.g., coastal upwelling systems, shelf ecosystems off Atlantic Canada and in the Yellow Sea and East China Sea, and fisheries observing system in the Gulf of Guinea - unfortunately we had no participant from the Mediterranean, so that task is left for you.

For developing a monitoring program in any region, a first step is to identify existing such programs and the disposition of the data they produce. It seems likely that large scale changes in the atmosphere and perhaps in sea surface conditions will be well monitored, but ocean circulation and mixing are presumably much less well recorded. Higher trophic levels of the ecosystems are usually monitored through fish catch statistics, but these may not be sufficiently comprehensive nor in adequate detail to be used in ecosystem analysis. Only occasional observations are made of top predators (birds and mammals) and of lower trophic levels. Cooperative action by all parties in the region will be needed to design and activate comprehensive monitoring such as that envisioned in the GOOS program.

As monitoring develops, it is essential that the data are quality controlled, freely exchanged, and their location and availability be made known to participants, through, for example, a meta-data base accessible on the Web. There may be few restrictions on the exchange of physical data, but timely exchange of fishery data will require special attention. Also, there are largely unsolved problems of compiling, storing, and making available for retrieval biological data and information which are far more heterogeneous than the more standard physical data.

Another necessary function is the objective (apolitical) assembly and analysis of data on ecosystem forcing and response. In addition to informing governments and other interested parties about changes that might affect resource use and environmental protection, preparation of ecosystem assessments would highlight deficiencies in the monitoring system.

This work could be accomplished in regional analysis centers (RACs). Analysis teams should include scientists from different disciplines, and participation in such activities should attract the interest of graduate students as well as that of established scientists. RACs might be based at national centers but would include participation from other countries contributing data and ideas. In many parts of the world, they are expected to serve as centers for capacity building as well as for analysis.

The analyses will require a blending of the biotic and abiotic data from all sources, national and international, within a region (Fig.). They should yield descriptive products on the current state of the ecosystem and its recent and longer term changes, and analytic products in the form of forecasts of probable future conditions of the ecosystem and its components. Levels of information detail should extend from raw data to indices, alerts, and forecasts. The products would be regularly provided, perhaps on a quarterly basis, to participating countries and organizations and would be made widely available on the web.

Bringing biological data together with relevant physical and other data in a holistic analysis will undoubtedly involve the use of appropriate models such as those being developed in GLOBEC projects. Even with adequate arrangements for data collection, exchange, and analysis, the mechanisms linking changes in populations of small pelagics with changes in ecosystem forcing require in most cases to be elucidated. A cooperative research agenda could result from discussions at this and

subsequent workshops.

Achievement of these actions requires the commitment and financial support of interested governments and appropriate institutional arrangements to make them possible. There would seem to be a need for a continuing organization, perhaps like ICES or PICES, which would organize dealing with both the operational questions of monitoring, data exchange and analysis as well as promoting development and execution of the research agenda required for rational utilization of the sea and its resources. This organization should be multidisciplinary, with oceanographers and atmospheric scientists, as well as fishery and other biologists. The program might be feasible in an existing organization or it might be necessary to create a new organization more suited for the purpose.

QUESTIONS ARISING

- What variables should be monitored in the region of choice? What accuracy is required and what should sampling frequency be in time and space?
- What variables have been monitored in the region and which are now being monitored? Where are the data stored, and how are they made available to users?
- What would constitute an adequate monitoring network for the region? How should existing monitoring programs be augmented to create the desired network?
- How should physical, biological, and operational data resulting from the network be quality controlled and stored for convenient retrieval?
- What descriptive and analytic products are desired by users of the ocean and its

- What should a periodic comprehensive ecosystem status report contain? Where and how can the necessary analysis be performed?
- What research is necessary to explain changes in ecosystems of the region and their production of living resources?
- What institutional arrangements are required to coordinate the monitoring program, including its data management and consequent ecosystem analysis and research?

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