

The Oceans and Enclosed Seas

7.1. INTRODUCTION

Many specialized Agencies, regional organizations and scientific committees have an interest in monitoring the sea. There are world-wide observing networks in physical oceanography, including measurements of salinity; the ICES Data Centre in Copenhagen has in fact been in existence since 1902. Studies of the chemical and biological composition of the oceans on the other hand, have been undertaken regionally for the most part, the growing number of such programs being an indication of international interest. A basic principle, therefore, is that the GEMS oceanic components should be built around: (a), existing regional chemical and biological studies; and (b), the global physical oceanographic programs. The third scale of monitoring, in impact areas, will be most difficult to implement because the space and time variability is usually largest here, and the selection of sampling sites and water-quality indicators will not be an easy task.

Because ocean weather ships are stationed in remote areas, they could be used to commence a modest baseline program. The weather ships were originally established to provide meteorological observations, navigational assistance and rescue services in support of trans-oceanic aviation but this primary justification is now diminishing. The ships could direct their attention to chemical and biological monitoring. In this case, however, consideration should be given to some relocation because the present stations are not necessarily best suited for the purposes of GEMS, particularly in terms of the main features of ocean circulations. It should be noted that if changes are made, however, the ongoing series of atmospheric and oceanic data, which are of value in establishing physical baselines, may be broken. Thus, careful attention must be paid to the possible conflict between the need for unbroken atmospheric and oceanic series versus the desirability of improving monitoring effectiveness through station relocations.

Isolated islands have been suggested as an alternative to ocean weather ships but local effects (convergences, etc.) will often make their shorelines non-representative of conditions over the open oceans. In spite of this, island stations can play a role in monitoring relative levels of pollutant fluctuations and in serving as sites for early detection of pollutant increases. The concentrating effects of islands may in fact sometimes enhance their effectiveness in the latter role. An example of useful island-station monitoring is the program of sampling and analysis of petroleum tar balls on beaches and over the open ocean being carried out by investigators at the Bermuda Biological Station. Another possible use of an island is as a telemetry terminal for signals received from buoys located several kilometres offshore.

Ships of opportunity, fishing vessels and oceanographic research ships have also been suggested for monitoring the seas but there are several related problems.

a) Commercial ships are not prepared to stop to take deep-water samples. (Several research laboratories are presently attempting to develop deep-water sensors that can be used with moving ships.)

b) Commercial shipping has preferred navigation routes while fishing fleets follow the fish stocks. Hence, not only would the spatial distribution of observations be biased but also there would be the possibility that samples would be contaminated by other ships in the vicinity.

c) Observations from moving vessels confound space and time variations. Until pilot studies demonstrate that horizontal gradients in an area are insignificant and that time variations are slow, observations from a stationary platform are preferred. In many instances, the upper mixed layer of the sea, which responds rather rapidly to atmospheric changes (particularly wind), is characterized by significant chemical and biological variability.

d) In the case of oceanographic research vessels, programs are determined by particular interests of the Institutes, and these interests often change from cruise to cruise. To add a commitment for repetitive measurements of specific elements and indicators would degrade the research programs of the Institutes. Nevertheless, these vessels have a fundamental role to play in pilot studies.

Despite the above-noted comments, there are some exceptions, the plankton monitoring program in the North Atlantic (by the Edinburgh Oceanographic Laboratory of the Institute of Marine Environmental Sciences (UK), and formerly of the Scottish Marine Biological Association) being one notable example. The first regular observations were in 1931, and by 1968, thirty-three merchant ships and weather-ships were participating in the program. The Continuous Plankton Recorder, towed at a depth of 10m, provides information on abundances and species of plankton, integrated over 16-km intervals (Oceanographic Laboratory Edinburgh, 1973).

There have also been a number of programs for routine sampling of commercial catches of fish. In this connection, the migratory behaviour of marine life should be noted. Birds and salmon, for example, travel great distances, while seaweed has a rather narrow environmental sphere. Without adequate information about the life cycles in the former case, the interpretation of observations on populations, chemical contents, etc., will be difficult.

Because the oceans are the final sinks for many pollutants, the importance of monitoring cannot be over-emphasized, if for no other reason than to provide continuing reassurance that the very large (but not infinite) assimilative capacity of the seas is not being over-burdened. In impact areas, of course, this state may already have been reached in some cases. A useful ecotoxicological review of harmful substances in the marine environment has recently been published (GESAMP, 1973).

7.2. MONITORING AS A BASIS FOR REGULATORY SURVEILLANCE

One of the stated objectives of GEMS is to make it possible to check the effectiveness of established regulatory mechanisms. Article IX of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters provides: "The Contracting Parties shall promote, through collaboration within the Organization and other international bodies, support for those Parties which request it for *inter alia* the supply of necessary equipment and facilities for research and monitoring"—"Preferably within the countries concerned, so furthering the aims and purposes of this Convention". In this connection, the view has been expressed that GEMS should be designed to operate on a real-time basis to detect oil spills and other marine dumping. There are a number of reasons why a negative reply must be given, at least for the next ten years.

a) The required density of ship or buoy stations would be so large as to make the cost exorbitant.

b) The supporting telecommunication facilities and regional analysis centres could be linked to the World Weather Watch, but the system would require expansion.

c) Remote sensing by satellites or aircraft might be feasible for detecting oil slicks (See Section 12.6) but not deep-water dumping.

Parties to the Convention and regional authorities may of course proceed to develop early-warning systems but they should not be considered to be a part of GEMS, nor should UNEP funds be used for this purpose.

In a more positive vein, GEMS can play an important role in determining average regional values, particularly in impact areas, to determine whether there are long-term upward or downward trends in water quality and marine life, thus checking the effectiveness (over periods of years) of established regulatory mechanisms. A note of caution should be added, however. Because the geophysical environment is characterized by long-term secular fluctuations, the interpretation of trends in water quality or fish populations within a region may be difficult.

There is one other way in which GEMS can assist in checking the effectiveness of established regulatory mechanisms, as follows:

Recommendation 15: It is recommended that the appropriate Specialized Agencies include in their oceanic monitoring programs, a provision for increasing the frequency of observations made at regular stations, and for temporary activation of supplementary stations, as quickly as possible after a marine episode of international significance is reported.

The London Convention of 1972 on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter designated IAEA as the competent body to define high-level radioactive matter which should

not be dumped at sea, and also called upon the Parties to take full account of the Agency's recommendations in issuing permits for dumping other radioactive matter.

The IAEA has been taking the necessary steps to meet such responsibilities.

Recommendation 16: It is recommended that the IAEA keep under periodic review the recommendations called for under the London Convention of 1972 with respect to ocean dumping of radioactive wastes in order to ensure that the principles involved remain valid with the development of techniques and the provision of new data.

7.3. MONITORING PROGRAMS

7.3.1. Monitoring in Remote Areas

The use of weather ships is recommended for an initial program. Because the present monitoring activities vary from ship to ship, there is need for agreement, amongst the participating countries, on a minimum comparable program. At weather ship P in the Pacific, for example, measurements are made daily for salinity, silicate, phosphate and nitrate, and weekly for alkalinity, total CO₂ and atmospheric CO₂. In the eastern Atlantic, on the other hand, the chemical constituents are monitored only intermittently, usually to meet the needs of specific research investigators, and the results may or may not be published in the scientific literature.

Recommendation 17: It is recommended that UNEP use its good offices to promote the development of a minimum program of monitoring for selected priority pollutants at ocean weather ships, both in the atmosphere and the sea. When inter-governmental agreement is reached, the program may contribute data to GEMS Phase I.

7.3.2. Regional Monitoring

IOC has proposed a pilot project for monitoring marine pollution. The first phase will begin with the analysis of surface oil residues and dissolved petroleum hydrocarbons in samples of sea-water. This should be supported.

Recommendation 18: It is recommended that the pilot project for monitoring of petroleum residues and dissolved hydrocarbons in samples of sea-water be supported, including the costs of technical conferences, preparation of manuals, training, regional workshops and equipment for laboratories and commercial ships registered with developing countries. Based on the results of this pilot study, a proposal should be prepared in 1976 for an operational program and/or for additional pilot studies, noting the substances contained in Annexes I and II of the Convention on Ocean Dumping (See Appendix C of this report.).

The hydrocarbon content of marine waters is only one of many indicators of the health of the oceans. However, the pilot project is a useful first step, and it has the support of IOC, including the research and technical groups of experts within IGOSS. Extension of the project to other pollutants should be considered at a later date, and in the light of the scientific advice of GIPME.

Additionally, there is a need to examine the sources and sinks of marine pollution. The question of monitoring river outflows is considered in the next subsection. Another important term in the mass budget of oceans is the transfer across the air-sea interface. Part of the marine input comes directly from precipitation. (See Recommendation 9.) Part of the oceanic loss occurs with evaporating sea spray. However, a significant transfer takes place across the interface during fine weather, due to evaporation (gain to the air) and absorption (gain to the sea). Measurements of a substance in the sea and at shipboard level in the air indicate the direction of transfer but not the magnitude. There is a boundary-layer resistance at the interface, and the mass-transfer rates are complicated functions of the turbulent structures of both the atmosphere and the sea. This problem has been recognized for a number of years by various groups of experts, and a joint SCOR-IAMAP-ACMRR W/G has recently been organized. The following recommendation is therefore made.

Recommendation 19: It is recommended that the work of the SCOR-IAMAP-ACMRR W/G on tropospheric transports of pollutants to and from the sea (Stockholm Recommendation 89) be encouraged, and that IUTAM be invited to join the W/G. It is further recommended that Member States be encouraged to undertake supporting pilot studies.

Finally, there is need for additional pilot studies on marine biota in regions away from main sources of pollution. The principal objective should be the search for meaningful measurable indicators of the health of the marine environment. The following recommendation is therefore made.

Recommendation 20: It is recommended that the appropriate scientific committees and associations jointly be given support to organize amongst marine biological laboratories, pilot studies on monitoring of marine biota in regions away from main sources of pollution, the objective being to search for meaningful measurable indicators of ecosystem behaviour. Priority should be given to such variables as sunlight, timing of seasonal turnover of the surface layer, chlorophyll content, species diversity and nutrients.

In this connection, mention should be made of the important survey paper prepared by SCOR-ACMRR-UNESCO-IBP/PM, "Monitoring Life in the Ocean" (1973), which provides an excellent basis for the development of pilot studies.

7.3.3. Impact Monitoring

Impact monitoring, although most important in terms of effects, and presenting the fewest chemical-analysis problems, is nevertheless the most difficult to realize because of space and time variability. In some cases, a plume of pollution may not mix quickly with the surrounding sea water but may meander offshore in almost laminar layers. Sampling at 10-m depths may miss the peak concentrations within the plume.

Sampling of the mass transport of pollutants at river mouths presents similar difficulties, and an internationally-agreed methodology has not yet been developed. In addition, much of the pollution draining into the sea comes from small streams and rivulets which are not normally monitored, even within national programs. Mention should be made here of the UNESCO RIOS program, within which the monitoring activities at existing IHD river stations will be expanded to include chemical sampling. The following recommendation is therefore made.

Recommendation 21: It is recommended that the appropriate Specialized Agencies in collaboration with SCOR, IAHS and IUTAM be encouraged to develop internationally-agreed methodologies for monitoring the mass flow of pollutants from the continents to the seas, noting the contribution already being made within the UNESCO RIOS program. It is further recommended that Member States be encouraged to host pilot studies. Finally it is recommended that a proposal be prepared in 1976, for an operational program and/or for additional pilot studies.

As mentioned previously, a number of pilot studies of polluted bodies of water are in progress. It seems important that the investigators should maintain contact with one another, exchanging information on methodologies and results, and attempting to reach agreement on monitoring techniques. The following recommendation is therefore made.

Recommendation 22: It is recommended that SCOR be invited to organize a workshop on existing pilot studies of the marine environment in impact areas, with a view to seeking a consensus on monitoring procedures, particularly the space and time optimizations of sampling networks.

Finally, because fish is part of the human diet, a monitoring program is desirable. In this connection, it should be noted that the relation between pollution concentrations in seawater and in marine life varies from species to species and depends (even in the case of an individual species) upon a whole chain of environmental circumstances. The uptake rates cannot therefore be predicted universally from a knowledge of the concentrations (or anticipated changes in concentrations) in sea-water.

There have been a number of recent studies of pollution concentrations in marine life. Preston (1973) has determined the heavy metal concentrations in seawater, seaweed and the muscles of fish collected in the coastal waters surrounding the British Isles. For pesticides, Butler (1966) has recommended the oyster as an indicator species, because it is particularly effective in storing residues and in subsequent flushing from its tissues if sea-water concentrations of pesticides diminish. Butler has described a network of 170 stations that is operating in the coastal waters of the United States. A number of other studies have been reported in other countries. Holden and Marsden (1967), for example, have examined the pesticide residues in seals and porpoises in Scotland and Canada. The following recommendation is therefore made.

Recommendation 23: It is recommended that inter-governmental agreement be sought on methodologies for monitoring fish, seaweed and other foods derived from the sea, for the relevant priority pollutants contained in list 2 in Section 5. The resulting programs should be coordinated with other food-monitoring activities described in Section 11.

When inter-governmental agreement is reached, such monitoring may contribute data to GEMS Phase I.

7.3.4. Complementary Monitoring Programs

The World Weather Watch and the various physical oceanographic monitoring programs will provide essential support to the GEMS marine components. In addition, data on radionuclides (See Section 12.1) will continue to be of value to marine modellers. Finally, solar radiation, which is not included within WWW, is an important quantity in the interpretation of phytoplankton blooming, and should be monitored in GEMS Phase II.