Earthwatch

Guidelines for implementing this global environmental assessment program are presented.

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In June 1972, at the United Nations Conference on the Human Environment in Stockholm, Sweden, representatives of some 113 nations met to translate their environmental concerns into a plan for action to preserve and enhance the human environment. The highlights of the action proposals, which have since been implemented, include (i) a U.N. Environment Program (UNEP) headed by an executive director; (ii) a voluntary UNEP fund, to reach $100 million over 5 years; (iii) a UNEP governing council of 58 nations; and (iv) a U.N. interagency coordination board for UNEP.

The Stockholm Conference adopted 109 specific recommendations for UNEP. These recommendations were cast into a framework composed of three major parts: environmental assessment, environmental management, and supporting measures. The designation Earthwatch was adopted for the environmental assessment part of the program, which would provide the basis for responsible environmental management. Earthwatch was designed as a four-part program involving monitoring, research, evaluation, and information exchange.

Environmental management consists of setting goals and criteria and the consummation of international agreements and conventions. The UNEP framework for action was completed with a third element consisting of education and training, technical assistance, and public information, which supports both environmental assessment and management activities (see Fig. 1). In addition to planning these functional activities, the conference recognized seven priority program areas that addressed critical global environmental needs: (i) human settlements and habitat, (ii) health of people and of the environment, (iii) terrestrial ecosystems, (iv) environment and development, (v) oceans, (vi) energy, and (vii) natural disasters (*1*).

The Stockholm Conference set the stage for concerted world action to solve environmental problems of concern to both developed and developing nations. In the fall of 1972 the U.N. General Assembly endorsed the establishment of UNEP and its action plan and agreed to the location of the UNEP secretariat in Nairobi, Kenya. Maurice Strong (Canada), secretary-general of the Stockholm Conference, was named executive director of UNEP. Also designated were a deputy director and two assistant executive directors, one for program matters, the other for administration and fund management activities; a governing council was formed; and nations began making pledges to the UNEP fund. These pledges, from some 57 countries, have since exceeded the goal of $100 million over 5 years, with more than 95 percent of the funding coming (in pledges in excess of $1 million) from the following 15 countries: United States, Soviet Union, Japan, West Germany, Canada, France, Sweden, United Kingdom, Australia, Norway, Italy, Denmark, Netherlands, Belgium, and Switzerland (*2*). The United States has pledged an amount not to exceed 40 percent of the total contributed.

Thus, Earthwatch was launched to focus on problems that affect all mankind—including the implications of climate change and the extent of man's influence on the climate, marine pollution and its effect on the resources of the seas, the preservation of genetic resources, the effects of environmental pollution on human health, the impact of natural disasters, the identification and protection of endangered species, the plight of human settlements, and the preservation and enhancement of renewable natural resources. To implement the Earthwatch program will require an exemplary effort on the part of all nations of the world. The focus of Earthwatch is on problems having international significance. Their solutions require international participation. The difficulties to be overcome are political, institutional, socioeconomic, scientific, and technical; yet it is critical that the effort be undertaken.

Progress Since Stockholm

Since the U.N. General Assembly endorsed the UNEP action plan, there have been three meetings of the UNEP governing council (June 1973 in Geneva, and March 1974 and April 1975 in Nairobi), with intervening intergovernmental meetings on various topics, including one on monitoring held in Nairobi in February 1974 (*3*). At the latter meeting great progress was made in designing and implementing the Global Environmental Monitoring System (GEMS)—a major step in the evolution of Earthwatch. Among the accomplishments of the meeting were the specification of principles; the identification of program goals, priority pollutants, and related environmental factors; and the recommendation of a program of future work and institutional arrangements (*4*).

The principles that were adopted as guidelines for intergovernmental cooperation in monitoring include (i) building on existing national and international systems to the maximum possible extent; (ii) providing assistance where necessary, especially in training and equipment, to ensure effective involvement of the developing countries; and (iii) sharing the responsibility for implementing international monitoring systems in areas outside national jurisdiction, such as the oceans and space.

Program goals provide the focus for GEMS so that it can be responsive to priority subject areas of UNEP. These goals are:

- An expanded human health warning system.
- An assessment of global atmospheric pollution and its impact on climate.
- An assessment of the extent and distribution of contaminants in biological systems, particularly food chains.
- An assessment of critical environmental problems related to agriculture and land and water use.
- An assessment of the response of terrestrial ecosystems to pressures exerted on the environment.
- An assessment of the state of ocean pollution and its impact on marine ecosystems.
- An improved international system allowing monitoring of factors necessary for understanding and forecasting disasters and implementation of an efficient warning system.

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A list of pollutants in order of priority was established, as shown in Table 1. The design of GEMS must take selected elements of this list into account along with appropriate related environmental factors so that the respective program goals may be achieved. For example, in approaching the assessment of the impact of atmospheric pollution on climate, GEMS must not only provide a system for monitoring particular pollutants, such as sulfur dioxide, suspended particulates, ozone, oxides of nitrogen, and carbon dioxide, but also for monitoring climate indicators, such as areal extent of sea-ice, the advance and recession of glaciers, sea level change, drought, desertification, and changes in freshwater bodies. In this way, cause and effect relationships may be critically investigated.

At the second session of the UNEP governing council the executive director was authorized to design and begin to implement GEMS as well as the International Referral System (IRS) (*5*). The third session of the council noted the progress made in staffing the UNEP secretariat, including the recruitment of Francesco Sella as the director of GEMS. The governing council took the decision that further progress in GEMS could best be achieved by convening several small groups of government experts, working with specialized agencies, to design elements of GEMS to meet the identified goals (*6*).

The third session of the governing council also noted the progress being made in regional activities, as in the Mediterranean area, and plans for other regions, such as the Indian Ocean and the Caribbean. Decisions were made calling for ocean baseline stations, accelerated research on the population dynamics of marine mammals, and expanded monitoring of marine pollutants, and bringing investigations of climate change, weather modification, and ozone depletion in the upper atmosphere into focus under Earthwatch.

Throughout this period, progress was made in developing the IRS, primarily through the efforts of task forces of experts drawn from several nations (*7*). The basic purpose of IRS is to encourage worldwide interchange of environmental information through the design, coordination, and operation of a system of referral to sources of environmental information and data. Essentially, IRS provides an internationally standardized method of identifying and describing such sources in a form that can be searched and retrieved in terms of topics of environmental concern.

The IRS can be viewed as the sum of a number of linked referral systems located in different parts of the world. Governments must cooperate in order to derive maximum benefit from IRS. To facilitate the participation of nations in the international system, support from UNEP could be requested to provide training and assistance either to set up a new national environmental information referral system or to strengthen an existing one.

The IRS operates through a network of national, regional, and sectoral focal points, each with its own community of sources and users. All governments have been invited by UNEP to designate their national focal points and many have now done so. The Environmental Protection Agency has accepted the responsibility to provide the operational focal point for the United States.

Each focal point makes up its own directory of environmental sources and sends this information to the IRS central unit, Nairobi, for inclusion in the international directory of sources. For all practical purposes IRS is operational; it has a shared computer capability, many national focal points have been designated, and its information source index system is in an advanced stage of development.

At the second session of the governing council the executive director was asked to develop the other two parts of Earthwatch—evaluation and research—in the same way he is developing GEMS and IRS. This decision was endorsed at the third session, with the view that the goal of Earthwatch—global environmental assessment—cannot be achieved without the full interaction of monitoring, information exchange, evaluation, and research.

In these early phases of program development and allocation of funds, the dual

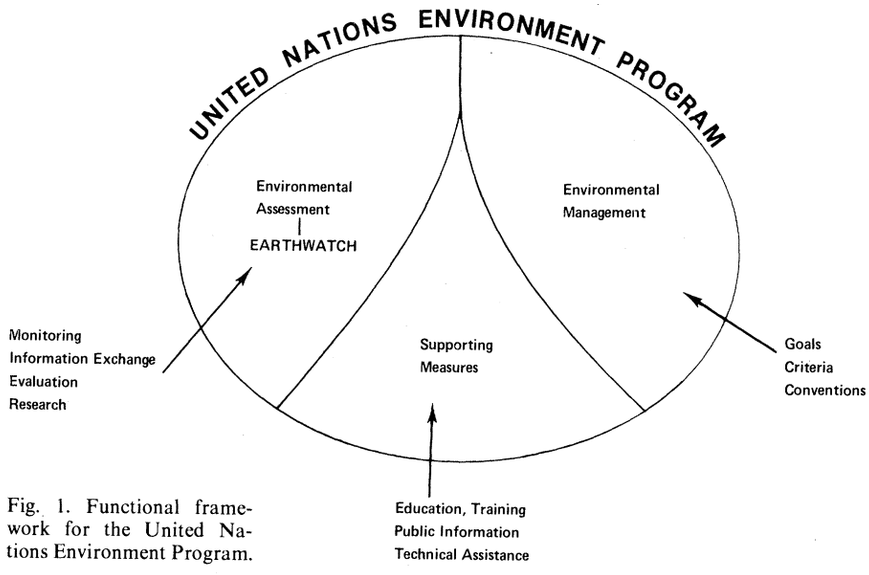

Fig. 1. Functional framework for the United Nations Environment Program.

Table 1. List of priority pollutants developed at the Intergovernmental Meeting on Monitoring at Nairobi, 1974.

Order of priority	Pollutant	Medium
1	Sulfur dioxide plus suspended particulates	Air
	Radionuclides	Food
2	Ozone	Air
	DDT, organochlorine compounds	Biota, man
3	Cadmium and compounds	Food, man, water
	Nitrates and nitrites	Drinking water, food
	NO and NO_2	Air
4	Mercury and compounds	Food, water
	Lead	Air, food
	Carbon dioxide	Air
5	Carbon monoxide	Air
	Petroleum hydrocarbons	Sea
6	Fluorides	Fresh water
7	Asbestos	Air
	Arsenic	Drinking water
8	Mycotoxins	Food
	Microbial contaminants	Food
	Reactive hydrocarbons	Air

nature of the UNEP framework, which has both functional and problem-oriented activities, has not been clearly distinguished. This problem was discussed at the third session of the governing council, and a decision was taken that the executive director should partition funds by program activity and then show how these funds are distributed in accordance with the functions of environmental assessment, management, and supporting measures that thread their way through all program activities.

A Foundation Exists for Earthwatch

Earthwatch is not yet fully developed as a U.N. program activity. However, it can draw on the ongoing and relevant environmental programs of the U.N. specialized agencies, governments, and nongovernmental organizations (see Fig. 2). In this section we give examples of such programs. The role of UNEP in managing Earthwatch is not to assume or duplicate ongoing activities, but to provide a framework for coordination and synthesis of these activities, to fill unmet needs, and thus to attack multidisciplinary problems more effectively. The end products of Earthwatch will be many and varied, as will be their users. Products will include data and information, predictions, warnings, trends, and surveys. Assessment transcends all of these, and at the same time is an integral part of each one. Here we will attempt to place ongoing activities in perspective in relation to three of the four components of Earthwatch—monitoring, research, and information exchange. The evaluation (assessment) component does not yet have a strong basis in ongoing activities.

The space and time scales of environmental processes to be monitored are both long- and short-term ones, ranging from climate change and ecosystem evolution to the immediate impact of pollutants and natural disasters on human health and welfare. The essential elements of the monitoring portion of Earthwatch are global environmental observations, data processing and analyses, and communications.

Global environmental observations. The facilities required for a comprehensive global monitoring system include air and water pollution observing stations, land-use reporting facilities, health surveillance activities, hydrologic stations, terrestrial observing sites, surface and upper-air meteorological stations, coastal marine stations, ships, seismology stations, ocean buoys, aircraft, and geostationary and polar-orbiting satellites.

A number of programs are under way that provide the basis for international

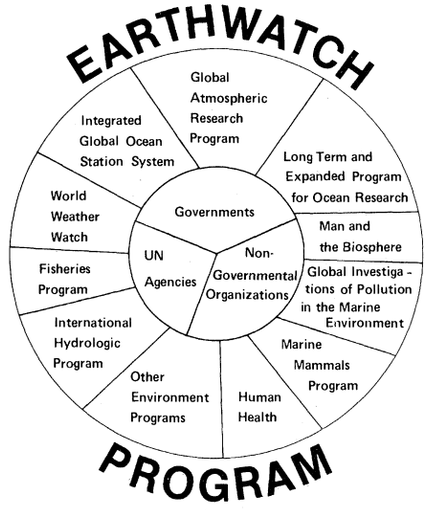

Fig. 2. Representation of Earthwatch as an integration of national and international programs.

warning and for prediction and assessment of health hazards, natural disasters, and other potential environmental concerns. The World Health Organization (WHO), for example, coordinates international programs for the surveillance and issuance of warnings relating to communicable diseases and the adverse effects of drugs (*8*). It also coordinates programs for monitoring air quality, environmental radiation, and community water supplies in cities and industrialized areas. These programs help to identify and forecast the concentrations and trends of specific air pollutants, such as sulfur dioxide, suspended particulates, ozone, and oxides of nitrogen, as well as their effects on the health of the people.

The World Weather Watch (WWW) of the World Meteorological Organization (WMO) provides a comprehensive means for detecting, locating, and tracking weather systems and for issuing timely warnings and predictions of potential natural disasters, such as floods and tropical cyclones (*9*). The WWW includes some several thousand land stations and merchant ships, numerous aircraft, special ocean weather ships, an increasing number of automatic weather stations, ocean buoys, and environmental satellites (*10*). The operation of this system exemplifies the benefits to be derived from an integrated global observing program. This concept is currently being extended to include observation of oceanic conditions through the development of the Integrated Global Ocean Station System (IGOSS) by the Intergovernmental Oceanographic Commission (IOC). An IGOSS pilot project is now under way to test selected components and operational requirements of the planned system (*11*).

When fully implemented, WWW and IGOSS will provide comprehensive observation of the oceans and the atmosphere through an integrated system which will include the common use of facilities, sensors, and platforms such as ocean buoys, ships, and satellites (*12*). For example, polar-orbiting environmental satellites operated by the United States and the Soviet Union carry optical and infrared imaging sensors with resolutions of 1 to 6 kilometers, providing twice-daily global cloud photographs, both day and night, and sea surface temperatures once a day in cloud-free areas. In addition, these satellites take vertical temperature soundings of the global atmosphere above the clouds, or to the surface in cloud-free areas. They provide worldwide information on the location and movement of major weather systems, identify and track storms, permit surveillance of polar and coastal sea ice, and provide worldwide data on sea surface temperatures (*13*). This information is made available to the world community as part of the WWW. Approximately 94 countries and trust territories have a capability for direct receipt of this satellite information.

Further, the first Geostationary Operational Environmental Satellite (GOES) was launched by the United States on 17 May 1974, the second on 5 February 1975. Additional satellites of this type are planned by Japan, the Soviet Union, and the European Space Research Organization to provide a coordinated coverage around the equator (see Fig. 3). GOES will significantly improve the monitoring capability to provide for timely warnings of certain impending natural disasters by providing nearly continuous high-resolution viewing.

Currently, several baseline stations are being operated by the United States to monitor background atmospheric constituents including carbon dioxide, ozone, and particulate matter. Additional stations are planned by many countries as part of a proposed WMO global network (see Fig. 4). A systematic program to record baseline conditions for other aspects of the environment has not yet been initiated. The Man and the Biosphere (MAB) program of the U.N. Educational, Scientific, and Cultural Organization (UNESCO), however, provides an appropriate framework for global monitoring of terrestrial ecosystems (*14*).

Several observing programs of regional and national scope now under way can provide further support to a global network. The Food and Agriculture Organization (FAO) observes conditions and trends in the production and utilization of agricultural and fisheries resources to assess future yields and evaluate alternative management practices. More than 45

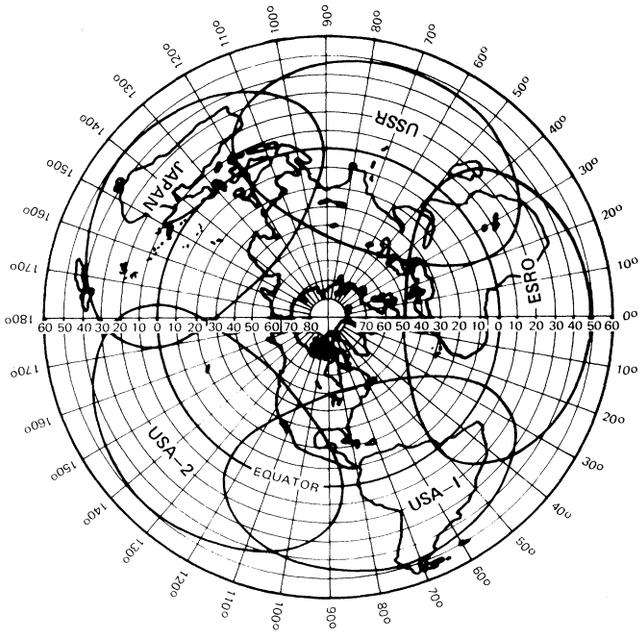

Fig. 3 (left). Fields of view of geostationary satellites, assuming 50° maximum angular distance from subsatellite point and based on plans of Japan, the Soviet Union, and the European Space Research Organization (*ESRO*). Fig. 4 (right). Atmospheric baseline monitoring station at the South Pole for measuring background levels for various gases and aerosols, ozone, solar radiation, and radionuclides.

countries participate in the WMO's regional network, which currently includes more than 60 operational stations; approximately 30 more are being planned. The observing program at these stations includes precipitation chemistry and turbidity. At least 45 additional stations may be required in developing countries to fill critical gaps in the WMO design.

Further, WMO through its operational hydrology program develops guidance and standards and otherwise assists member countries in carrying out national programs pertaining to hydrological forecasting and the operation of hydrologic networks (data collection, transmission, processing, storage, retrieval, and publication). Through the International Hydrological Program (IHP) and in collaboration with WMO, WHO, FAO, the International Atomic Energy Agency (IAEA), and the International Council of Scientific Unions (ICSU), UNESCO has fostered improved national monitoring of water quality. The International Tsunami Warning System of IOC monitors seismic activity and tidal conditions and provides alerts to 16 countries and territories of the Pacific basin of potentially destructive seismic sea waves. These regional and national monitoring networks and others of global scope that are coordinated or planned by other specialized agencies of the United Nations must be taken into account in the design of the global environmental observing system. One of the major international agencies of the scientific community, the Scientific Committee on Problems of the Environment of ICSU, has assisted substantially in this design effort.

An important aspect of environmental assessment is the development of natural disaster risk maps to assist in local, regional, and global planning activities. For example, the Worldwide Standardized Seismic Network provides observations from 120 stations in 60 nations that contribute to the development of seismic risk maps, an essential step in hazards reduction and preparedness planning (*15*). In addition, the WMO Tropical Cyclone Project will provide similar information on cyclone risks for development planning purposes (*16*).

Global surveys provide the most comprehensive assessment of the condition and availability of natural resources and the impact of management practices. The high-resolution, multispectral sensors of research satellites provide global information on such environmental processes as land-use patterns, the status of terrestrial ecosystems, hydrological conditions, and oceanic phenomena. The use of such satellites to survey resources is being evaluated and demonstration projects are being conducted, particularly in developing countries, to illustrate the environmental applications of remote sensing.

In some countries, the amount of land available for cultivation in any one year could well determine the difference between survival and famine. Conditions in such countries are characterized by loss of productive soil through erosion, shifting and creeping desert sands, variability in the productivity of classes of the savannah, changes in rain forests due to shifting cultivation and forest management, and development of conditions favorable for migrating locusts.

The problem of maintaining an adequate supply of water is serious in many parts of the world. In many cases there is simply inadequate rainfall in the area, but in others the problem involves identification of water sources and the proper management of the water that is available to the area. To assist countries in the latter case in developing and managing their water resources to meet their present and future requirements for water of high quality, information from environmental satellites can help identify and delineate the extent of watersheds and additional groundwater resources. This information will support appropriate engineering projects for the conservation and distribution of water resources. UNEP is primarily concerned with problems of water quality and with the environmental aspects of water quantity management.

Global environmental data processing. Processing and analysis of environmental data and samples are required before conditions and trends can be meaningfully assessed. Processing may be done by computer or manually. The sooner an assessment is required, as in the case of warnings and short-term predictions, the greater is the need for computer facilities.

The WMO coordinates, under the World Weather Program, a global network of world, regional, and national meteorological processing centers. These centers can provide the basis for an interdisciplinary data processing service. A beginning has been made in this direction with the processing of oceanographic information collected by the IGOSS pilot project. The role of the centers can be expanded further to process a broader range of environmental data.

Examples of other international centers for the processing and analysis of data and information include the International Tsu-

nami Warning Center, Honolulu, and the system of national and regional oceanographic sorting centers that provide service to the international community. The establishment of a unified processing system would not only provide for efficiency and economy but also facilitate the development of comparable analytical approaches and the collation of results to assess multidisciplinary problems.

Global environmental communications. Communications for the exchange of data must also be shared by multidisciplinary activities for efficiency and economy. A likely candidate for this is the Global Telecommunications System (GTS) of the WWW. This system currently consists of facilities and arrangements necessary for the rapid collection, exchange, and distribution of observed and processed environmental data among designated world, regional, and national meteorological centers. The GTS links 25 regional telecommunications network hubs that serve three World Meteorological Centers in Washington, D.C., Moscow (Soviet Union), and Melbourne (Australia); 25 regional meteorological centers; and approximately 150 national meteorological centers. This system could be considered as a prototype for the global environmental communications network required for Earthwatch (see Fig. 5). To illustrate the concept of communications sharing, the GTS is now providing communications support to an IGOSS pilot project by collecting and disseminating data and information on sea surface and subsurface temperatures.

The GOES system will provide a new capability to the international communications system. In addition to providing nearly continuous high-resolution viewing for environmental warnings and predictions, the U.S. geostationary satellites will have a data collection and relay capability. Signals from remote monitoring equipment such as automated hydrological, atmospheric, oceanographic, and terrestrial facilities can be received by the satellite and relayed to processing centers via the GTS. The United States has offered the use of the GOES data collection and relay capability to countries that provide their own transmitting and receiving equipment and where there is mutual interest.

The International Telecommunication Union's World Administrative Radio Conference of 1967 allocated six high-frequency bands specifically for the purpose of rapid collection, exchange, and dissemination of marine environmental information (*17*). The IOC and the WMO have joint responsibility for coordinating internationally the use of these frequencies to meet requirements for collection of data related to oceanography in a worldwide system.

Research activities. A number of major research programs have been initiated or are being planned by the U.N. agencies. The Global Atmospheric Research Program (GARP), jointly developed by WMO and ICSU, is aimed at providing scientific knowledge needed to improve the time range, scope, and accuracy of weather forecasts, and to gain a better understanding of the physical basis of climate (*18*).

The GARP Atlantic Tropical Experiment was the first major observational experiment of GARP in which many nations participated. The field phase was conducted from 5 June to 30 September 1974. Multidisciplinary aspects of this experiment included studies of atmospheric systems in conjunction with physical and biological oceanographic processes.

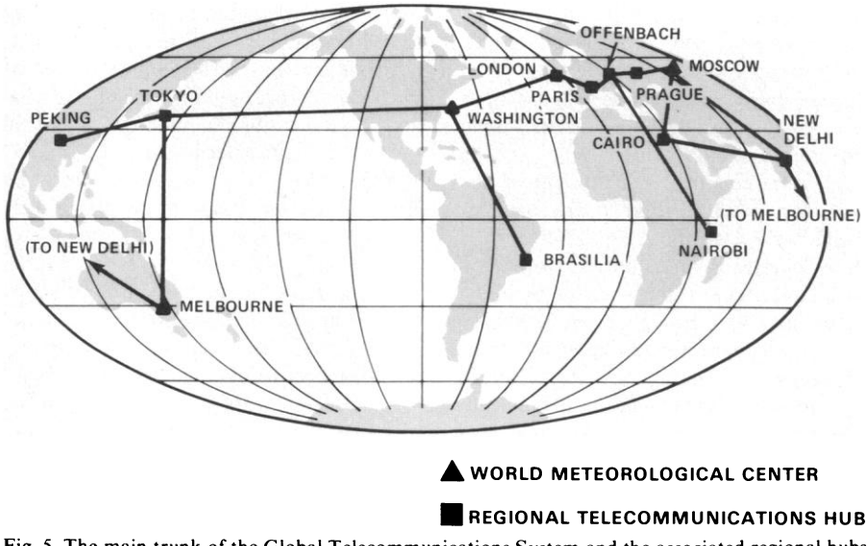

Fig. 5. The main trunk of the Global Telecommunications System and the associated regional hubs connecting the three World Meteorological Centers (as of April 1975).

The First GARP Global Experiment is scheduled for 1978 and 1979. The objectives of this experiment are to obtain a better understanding of global atmospheric motion; to assess the ultimate limit of predictability of weather systems, taking into account the role of the oceans; to develop more powerful methods for assimilating environmental data; and to design an optimum observing system for the prediction of the large-scale features of the general circulation (*19*).

The Long-Term and Expanded Program of Oceanic Exploration and Research is a comprehensive program coordinated by the IOC to examine the physical, chemical, geological, and biological processes of the world's oceans. The acceleration phase of this research has been designated the International Decade of Ocean Exploration. Another major part of the program—the Global Investigation of Pollution in the Marine Environment—is expected to provide needed information on pollution sources, pathways, and sinks within the marine environment and the impact of pollutants on biological systems (*20*). Other subprogram activities include Cooperative Investigations of the Northeast Central Atlantic, the Geochemical Ocean Sections Study, Cooperative Investigations of the Caribbean and Adjacent Regions, and Cooperative Investigations of the Mediterranean.

The MAB program of UNESCO is designed to identify and evaluate the impact of man's activities on the biosphere; to study and compare the structure, function, and dynamics of natural, modified, and managed ecosystems; and to develop methods to monitor significant trends in order to assess management alternatives. To achieve the MAB objectives within each of its 13 international projects, close coordination with other international research programs such as those of WMO, IOC, FAO, the U.N. Industrial Development Organization, and WHO will be required (*21*).

Periodic global experiments must be supported by a continuing program of research to acquire basic knowledge on processes and interactions within the environment. The International Hydrological Program under the coordination of UNESCO is designed to develop a better understanding of processes that influence global water resources. Other research activities include the environmental aspects of disease prevention and cure programs of WHO; research on demographic projections and population policy of the U.N. Department of Economic and Social Affairs; studies on regional planning activities of the U.N. Center for Housing, Building, and Planning; and investigations of agricultural,

forestry, and fisheries processes coordinated by FAO. An important thrust in 1976 will be the convening of a U.N. Conference on Human Settlement (Habitat) to deal with the problems arising from urbanization and its environmental and sociocultural effects.

Information exchange. There is a need to provide an international system for the storage, exchange, and dissemination of environmental information as well as new technologies of pollution prevention and abatement. A major existing activity is the World Data Center system of ICSU, which provides the international community with data storage and dissemination services for meteorology, geophysics, geochemistry, aurora and airglow studies, ionospheric physics, solar activity, cosmic rays, longitude and latitude, glaciology, oceanography, seismology including tsunamis, and gravimetry. In addition, the FAO stores and disseminates data and information related to the production and utilization of agricultural, forestry, and fisheries resources. The concept of data and information management concerning marine pollution, soils, and fisheries is being implemented through the efforts of a Joint Task Team on Interdisciplinary and Interorganizational Data and Information Management and Referral including representatives of IOC, IAEA, WMO, FAO, and UNEP.

An international referral system is being established for the efficient exchange of information on environmental problems. Such a service will make it possible for the developing nations, as well as the developed ones, to determine what data and information are already available, where they are located, and how to gain access to them. It should prevent unnecessary duplication of existing data files.

The Road Ahead for Earthwatch

The basic building blocks for Earthwatch exist in the national and international environmental programs described in the previous section. Many new blocks are needed, however, before Earthwatch can emerge as a center of activity for global environmental assessment. What follows is one view of the way in which Earthwatch may develop in the years ahead.

This view adopts the programmatic approach comprising the seven areas previously identified at the Intergovernmental Meeting on Monitoring and discussed earlier in this article. A framework for this programmatic approach is proposed that calls for the designation or establishment of three levels of assessment activities—world, regional, and national—to which governments, U.N. agencies, and nongovernmental organizations are expected to contribute. An implementation strategy is proposed that consists of two parallel action streams.

The first stream should utilize proved technology and accepted scientific procedures and techniques for the immediate improvement and integration of the capability of existing international systems to observe, communicate, process, and analyze information on worldwide environmental conditions. The second stream should develop new technology, procedures, techniques, and facilities to observe, communicate, process, and analyze environmental information so that the unmet needs for global environmental assessment may be adequately met.

The proposed framework for Earthwatch calls for the designation of world environmental assessment centers for the seven program areas that have been identified. Regional environmental assessment centers are required to support the world centers; the regional centers, in turn, are supported by national facilities. An example of this proposed organizational structure for the program area of marine pollution and its impact on marine ecosystems is shown in Fig. 6. Analogous structures can be designed for the other program areas.

Assignments would need to be coordinated and acceptance of respective responsibilities would have to be gained from nations to operate the world and regional environmental assessment centers and the supporting national facilities. To facilitate participation by developing nations in this effort, assistance could be sought from UNEP or from other sources for funding and technical support.

The function of each world environmental assessment center would be to provide the focus and capability for intensive assessment of the worldwide environmental conditions relevant to its assigned program area of responsibility. Along with the associated regional environmental assessment

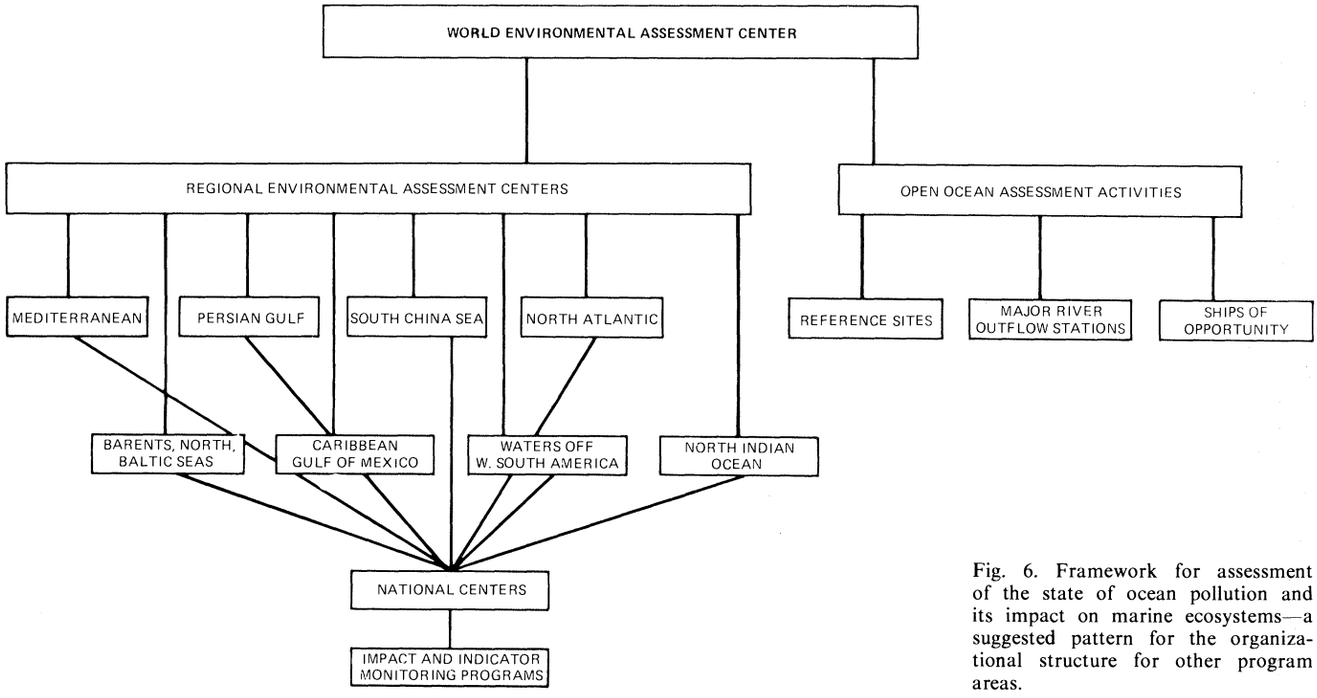

Fig. 6. Framework for assessment of the state of ocean pollution and its impact on marine ecosystems—a suggested pattern for the organizational structure for other program areas.

centers, which would be concerned with environmental problems having regional impact, the world center would share the responsibility for maintaining quality control, developing standard reference materials, ensuring full intercalibration of analytic procedures and instrumentation, and serving as focal points for training and education programs.

The world centers would be expected to issue periodic assessment reports and special alerts, as appropriate, on the basis of which UNEP might wish to organize international actions, or individual nations might wish to respond in some manner.

National facilities would be expected to concentrate on analysis of environmental samples and data collected as a part of the monitoring programs at reference sites (long-term baseline and trend information), impact stations (immediate and near-term information and trends), and indicator programs.

Earthwatch reference sites would be expected to provide a coherent, integrated base of benchmark data and information on physical, chemical, and biological conditions and trends in environmental processes. These sites should include selections from ongoing and planned activities, such as (i) WMO baseline and upper atmospheric programs; (ii) IHP hydrology stations; (iii) lake biome programs; (iv) MAB biome programs; (v) open ocean baseline sites; and (vi) river outflow stations.

Earthwatch impact sites would be expected to provide the basis for a continuing, systematic appraisal of immediate and near-term impacts of natural and anthropogenic activities on the environment and to allow timely warnings of environmental conditions that threaten man and the biosphere. These sites should include selections from ongoing and planned programs, such as (i) regional marine monitoring activities; (ii) climatic index stations; (iii) health effects and exposure programs; (iv) land-use monitoring activities; (v) natural disaster warning and preparedness programs; and (vi) regional atmospheric monitoring stations.

Earthwatch indicator programs would be expected to begin with the designation of a series of target substances or organisms to be included, where feasible, in all reference and impact monitoring activities. Three pilot projects are proposed that would focus on fish, lichens, and human hair.

Effective environmental management to mitigate the impact of pollution on the environment and man will require a detailed understanding of sources, pathways, and sinks. Earthwatch can provide the data and information that will allow tracing a pollutant from its sources through the atmosphere, oceans, soils, fresh water, and biological systems to its ultimate fate. A pilot program is proposed that would focus on a single pollutant, such as lead, and track it through the environment. Particular emphasis should be placed on data acquired at the Earthwatch reference sites and within the impact monitoring and indicator programs. This pilot project would be useful for developing the techniques that could be applied in future programs involving other critical substances.

Effective environmental assessment frequently requires that the data and information that result from the observational system be rapidly communicated and processed before they become outdated. This is particularly the case when warnings and short-term predictions are being generated that are applicable only within a short time span. On the other hand, data and information for longer-range predictions and assessments can usually be transmitted less rapidly. Every effort should be made to use existing or planned communications circuits or methods, such as the WWW global telecommunications system and the international Geostationary Operational Environmental Satellite system.

A fundamental concern when implementing comprehensive monitoring, research, and evaluation programs is the proper management of data and information to ensure its availability both currently and in the future for analyses and the preparation of environmental assessments. There is a basic need to establish more effective coordination among existing national and international data and information centers and to establish new management capabilities that are responsive to the interdisciplinary problems addressed under Earthwatch. Immediate steps are necessary to designate a network of national, regional, and world centers for data and information management based on existing facilities and to identify gaps where they occur.

To ensure the long-term growth of global environmental assessment activities embodied by Earthwatch, it is essential that relevant research programs be supported and that proper arrangements be made for scientific advice from nongovernmental bodies. UNEP has taken some steps in the latter direction—for example, with the support of the proposed international scientific center at Chelsea College (University of London) in the United Kingdom, which will be devoted to promoting global environmental monitoring studies. An expanded source of scientific advice would need to be identified as the full Earthwatch program evolves. Certainly it is not too early to plan for both regional and global environmental assessment research involving the cooperative participation of all concerned nations.

Earthwatch will require the participation of all nations so that all can benefit from it. Earthwatch will be shaped in the coming months—scientifically and politically—and should emerge as a program of active and continuing vigilance over "Only One Earth" (*22*).

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