7. The design of global environmental monitoring

7.1. INTRODUCTION

In the previous chapter the variables relevant to the environmental problems which should have the highest priority were examined, and those considered the most suitable for monitoring were selected. Other relevant variables discussed were those that are regarded either as having lower priority or as being difficult to measure accurately at present.

The variables referred to as "biological" are much more difficult to measure and interpret than the physical and chemical ones. For some of the latter type, monitoring programmes are either well-established or planned. For example, measurements of climatically related variables are co-ordinated by WMO and those variables related to human health by WHO. However, no such coordination exists in certain other areas, especially those involving biological variables. Such deficiences must be eliminated by establishing a monitoring system that covers all aspects of the human environment. At the same time, all the parts of the monitoring system must be co-ordinated, a feature which can be promoted by proper design of the system itself.

From the viewpoint of economy, a variable should not be measured at more sites, transects or areas than are necessary to establish global trends. On the other hand, as many variables as possible should be measured at the same location; such measurements will support each other and favour an integrated evaluation. An integrated monitoring system should be designed to measure both causal and effect variables, such as DDT and species reproductivity, with the different measurements correlated in space and time. This approach most effectively utilizes stations or monitoring areas in which many activities are concentrated. Some variables, such as atmospheric carbon dioxide, require measurements at very remote sites with a minimum of human activity. Measurements of another group of variables cannot be confined to a restricted number of sites. This type arises in such studies as comprehensive surveys e.g. vegetation mapping, land use, distribution and disease frequencies in organisms including man. Thus, the overall monitoring system must be designed with sufficient flexibility to include the demands of these various specific sub-programmes.

The global environmental monitoring system proposed consists of reference areas (or stations), high exposure areas (or stations) and other monitoring systems not tied to a restricted number of such areas or not at all tied to fixed locations.

7.2. REFERENCE AREAS

Two types of reference areas are proposed: Baseline, or low-exposure areas and regional, or medium exposure, areas.

The baseline areas should be located in very remote regions with no nearby sources of pollution. The functions of the measurements should be to provide information on the current background situation and to determine globally significant trends in the abiotic environment as well as in biota. Thus, they should be planned to operate "indefinitely". The stations selected should be representative of fairly large areas of the globe, because of the primary functions for baseline stations and the desirability of maintaining a minimum number of monitoring stations.

The reference areas should if possible represent all the major biome types, namely:

1. Tundra

2. Coniferous forest

3. Deciduous forest

4. Tropical forest

5. Savannah

6. Thorn scrub

7. Grassland

8. Desert

9. Open ocean

10. Upwelling area

11. Coastal shelf

12. Estuary dola add to appear balling and the propagation to a state internet

13. Epicontinental or semi-closed sea

Although there are marginal zones between biome types, the above biomes embrace almost all the earth's surface and are found in both the northern and the southern hemisphere. To obtain representative measurements of bioenvironmental conditions, at least two stations should eventually be located in each of these biome types; in the first phase, a total of not less than ten terrestrial baseline areas should be established.

The baseline monitoring areas within each biome type should be well removed from local areas which have already been significantly altered by man's activities and land usages. Although very little land surface on the globe has not been affected in som degree by man, substantial areas, particularly those deliberately reserved as wilderness areas, show minimal direct impact from man, and these should receive first priority in siting. Since the monitoring programme is to operate indefinitely, these sites and their surroundings should be dedicated to monitoring in perpetuity. As a general rule, land-based reference stations should be located in natural areas which are approximately 100 kilometres removed from any significant human settlements and large-scale agricultural activities. The observing station itself should be designed for minimum impact on the natural biota and environment, or need not necessarily be located within the baseline area.

Although, open ocean monitoring poses less stringent requirements for representativeness, it does pose substantial logistical and operational problems. Current efforts within the International Decade of Oceanographic Exploration to obtain an initial survey of the biotic component of the oceans, as well as environmental surveys of temperature, currents, and nutrients, are badly needed for a more definitive design of a longer-term monitoring programme in the earth's seas.

In arriving at these recommendations, we have been keenly aware of the need both for representative monitoring locations in all parts of the world and strict comparability and reliability of the data gathered by the network. Since areas chosen for the global environmental monitoring system may serve both national and international purposes, international agreements on the station's mode of operation will be required. Also, so that all interested nations may be included, and have the benefit of comparative analyses, the basic parameters must be minimal in number and measurable at reasonable costs.

The second classification of reference sites are the "regional", or medium exposure areas. These areas will also be located in regions fairly remote from strong contamination sources, but this criterion is not as stringent as that for the baseline stations. Consequently they will often be areas with "normal" agricultural or silvicultural conditions. The purpose of these stations is to document changes in regional environmental quality and to provide data useful in determining the budget of various contaminants. Since these sites will occasionally experience high concentrations of pollutants, they will typically not provide measurements representative of global background conditions; instead, they will give an indication of the general state of contamination over the settled areas of the globe.

To accomplish this global survey, a minimum of 100 areas should be established. Every country, regardless of size, will be invited to participate. The largest countries might each offer ten or more such areas. The siting criterion is simply that it be representative of an integrated region, which may be defined on the basis of geography, biota, climate, land use, etc. The initial list of variables to be monitored at each area will be similar to that for the baseline areas, but not as comprehensive and requiring less sophisticated instrumentation so that countries with modest resources can participate.

At least two of the initial set of reference areas should be designated as international research areas. The stations serving these areas should be internationally staffed and funded. One should be located in the tropics. Their functions will be to develop standard measurement methods, to conduct pilot studies and to determine which additional variables should be included in the monitoring system. The nations should be invited to nominate sites for these stations.

7.3. HIGH EXPOSURE AREAS

In choosing the numbers and locations of high exposure areas it is necessary to consider the wide variety of exposures which may be of importance. These range from acute air and water pollution episodes on an urban or regional scale through extensive ecological, meteorological, and hydrological alterations induced by large-scale land use practices (urbanization and agricultural practices) to long-term degradation of the soils by increased salinity induced by irrigation practices. In general, these impacts produced or augmented by human activities are local or regional in extent and therefore currently pose a variety of problems around the globe. Some of them are becoming so widespread that even though they do not constitute a global problem by virtue of transport mechanisms, they are of common concern to many people.

The main purposes of these stations are to study the effects of contamination on man and biota and to follow trends in densely populated areas. Since they will be located in the vininity of areas with strong pollution sources they will not provide information on global conditions. They should, however, provide an opportunity to detect significant cause and effect relationships in the bioenvironmental system long before they become widespread.

Criteria for choices of impact stations should again be based primarily on biome type with subtypes defined by human activities, and they should emphasize the most common types of bioenvironmental problems. These include urbanization and industrialization of land areas, agricultural and forest management of land areas, and mineral exploitation and associated distributional activities. Thus, the high exposure sites should be located in or near cities, areas of intense farming, and areas of mining, petroleum production or transport. These activities are now represented in essentially all of the biome types. Therefore, the minimum number of high exposure stations should be approximately three times the number of baseline stations. A special type of high exposure stations is that needed to record the output from the large rivers to the oceans.

No attempt has been made to provide a unique list of substances to be measured at these sites since the important, high-concentration contaminants will vary from station to station. A general list would, however, include many of the high priority substances recommended for the baseline areas, such as the heavy metals and common pesticides. Other toxic, but relatively short-lived pollutants like sulphur dioxide will also be included that are not recommended for baseline monitoring. In addition, a strong emphasis will be placed on measuring the effects of the contaminants, such as the symptoms of human health disease.

7.4. OTHER MONITORING SYSTEMS (REGIONAL AND GLOBAL SURVEYS)

7.4.1. Variables in Relation to Climatic Changes

In the SCEP and SMIC studies it was pointed out that global censuses repeated at regular intervals are needed for assessing climate trends. Several of these censuses could be carried out by means of remote sensing from satellites with techniques in existence or in the process of development. These variables are related to conditions at the earth's surface such as:—The temporal and geographical distribution of the earth-atmosphere albedo and outgoing radiation flux over the entire globe (with an accuracy of at least 1 %); high resolution registration of the global distribution (horizontal and vertical) of cloudiness; the extent of polar ice and snow cover (recorded with lower resolution), and the surface temperature of the oceans. There are also variables related to human activities, which can be measured from satellites at longer time intervals, e.g., areas under irrigation, artificial lakes or dams, the extent of urbanization and changes in vegetation. Because of the special technique involved, measurements by satellites must be treated as a separate system. A special satellite system for these variables only will be expensive, but there are possibilities of using satellites with other functions (weather surveillance) to reduce operating costs.

7.4.2. Source Monitoring

Information on substances emitted to the environment is important to any global monitoring system and is especially needed for global budgeting. Data are readily available for some of these substances, e.g., the amount of oil transported over the oceans, but in general we need to develop new methods for data gathering for critical substances. Substances which have been selected for global monitoring (mercury, lead, cadmium, DDT, PCB and combustion products of fossil fuels) should have first priority. These data must be based on national production statistics in industry, mining, etc. but there should be international agreement to transmit certain types of data to one central coordination body.

To assess present and future environmental risks it is important to have a continous record of critical chemical substances emitted to the environment. At the same time these substances should be evaluated in regard to possible health risks to human beings and to ecosystems. To assess these environmental emissions it is necessary to have a detailed knowledge of the techniques of industrial processes. Special attention has to be given to impurities in crude chemicals and to organic chemicals which have high biological activity even in extremely small amounts, e.g., hormones and antibiotics. An ultimate aim of such an international registry will be to record the amounts of all old and new potentially dangerous substances added to the environment every year. It has to be stressed that a very large number of new substances are added to the environment each year but only a few of these may be of potential risk in the future. A registry may thus not only give information on the dangerous substances but also information on substances which are harmless to the environment.

7.4.3. Variables in Relation to Biological Changes

Repeated biocensuses and surveys have been suggested as suitable variables for global environmental monitoring. These may have different priorities. Some can be started at once, others need research and development before inclusion in a global system. Registers of vanishing or endangered species and certain types of bird censuses should have high priority. Registration of endangered species is already carried out on a global basis by IUCN. Internationally co-ordinated census programmes for waterfowl and sea birds also exist in several regions and in many nations extensive census schemes for passerines are in an advanced state. These programmes only need consolidation and extension. The distribution of species highly sensitive to certain specific substances or variables in relation to phenology and aerobiology may be included at a later date.

All these variables need a very special kind of organization to be monitored effectively, and it seems proper that each of these variables should be treated as a special subsystem.

The registration of gross vegetation changes by satellites is a high priority variable. The newly emerging system using Earth Resource Technology Satellites seems to be the appropriate way to register these changes. It is essential that an international framework be created to handle this type of information. In the future it is likely that satellite registration of biological variables in the oceans may be of great importance to global monitoring.

7.4.4. Short-lived Phenomena

The present system used by the Smithsonian Institution for registering short-lived phenomena may, if extended, be a very valuable tool to record events which are indicators of environmental change. The biological aspects have been previously stressed, but other records such as oil spills and volcanic activities are also important for the global environmental situation. We recommend that this system should be enlarged and internationally supported.

7.5. DATA HANDLING

Data handling involves several separate fuctions including collection, processing, transfer, publication and storage. Within each of these functions the specific activities may depend on the media being monitored, whether the data must be used on a real-time basis, on the specific parameters monitored, etc. Thus, the data handling system must be designed with flexibility to include a variety of measurements, to allow for inclusion of additional variables at future dates, and to include the cataloguing of past data.

The primary office for data handling within each country should be an international data centre, or centres designated by that country. This centre would have the responsibility of collecting the relevant data obtained by the nation and disseminating it to users and a central repository. Most observations obtained by the global environmental monitoring system will not be used on a real time basis and could be made available to the scientific community on a monthly, quarterly, or longer basis depending on measurement frequency. In some cases these centres might also carry out certain analyses to indicate trends for key environmental factors. The international publication of these data should be organized by the

co-ordinating unite of the global environmental monitoring system. This unite will also be responsible for a central data library, in which records of all published data are available.

The central data library could have either of two forms. First, it could be one large central facility in which the data from all countries and all disciplines or media are filed. A new body would have to be established for this function. Second, the data could be stored in several dispersed centres, each representative of a certain monitoring area. Several such world data centres were established for the International Geophysical Year for meteorology, oceanography, and a number of geophysical disciplines. The WHO has established centres for storing key health data. If the multi-centre system is adopted, a strong effort must be made for co-ordination between centres and for a referral system, organized by the global environmental monitoring central unite, to provide users with information on availability and location of environmental data. We believe that the second system is the more practical method for the present. Regardless of whether the first or second approach is adopted, these centres will be a primary source of data for research on environmental processes and for determining long-term environmental deterioration.

Real time distribution of data will be necessary in some circumstances, such as petroleum spills, natural disaster observations or hazardous concentrations of air and water pollutants. The mechanism for this distribution currently exists within the framework of the World Weather Watch and its system of world and regional centres. This system, which is funded and operated by individual nations, could readily be slightly expanded to accommodate these environmental data.

7.6. PILOT STUDIES TO DEVELOP GLOBAL MONITORING

7.6.1. General Remarks

Additional research and development is needed both to start and to improve a global environmental monitoring system. This can be done through a series of pilot activities. The international science community has a great responsibility and must in our opinion play an important role in the initiation and design of monitoring. We believe that SCOPE could provide a valuable service in this context since it has been set up to examine global environmental problems. In SCOPE, all the different scientific unions with interests in the global environment are represented. SCOPE has an initiating and co-ordinating role but at present no operational function. For the operation of international scientific programmes. ICSU has special bodies such as SCIBP, GARP, SCOR, SCAR, COSPAR, etc. These bodies could be used for operating international pilot monitoring projects. We recommend however, that for the time being, SCOPE should offer to take the responsibility for these pilot studies after consultations with the proper organizations and nations concerned. The tasks of the ICSU organizations will be briefly examined below. The very special conditions in the marine area will be treated in a separate more extensive section.

7.6.2. Pilot Studies in the Non-Marine Aeras

Within the International Biological Programme, several activities are of importance as potential pilot projects. The role of the biome studies has been discussed in relation to the reference stations. Biome studies will have a special status in relation to the global environmental monitoring system as permanent research projects. Ongoing work on the tundra biome is a typical example of such activities.

Intensive studies have been carried out by scientists from nine nations operating within the IBP which will indicate those aspects of the tundra ecosystem that are particularly sensitive indicators of environmental change. The tundra biome workers should be specifically requested to focus their attention on to this point, both in their current research and in their final synthesis in 1974. A continuing terrestrial ecology monitoring programme should be initiated in 1975, based on the recommendation of the tundra biome working group.

Other parts of the present International Biological Programme may also be used for the selection of proper variables for global monitoring. The IBP Aerobiology Programme is now preparing plans for aerobiology monitoring based on a global network of stations. A co-ordination between these pilot projects with other similar activities aiming to have similar parts included in the permanent global environmental monitoring is essential. As mentioned earlier, world-wide studies of phenology have also been proposed within the International Biological Programme.

When the International Biological Programme is replaced by a new international programme, these activities may be taken up in a more extensive way in order to find useful variables for global monitoring.

It is important to all monitoring studies to separate and recognize the natural phenomena, which are superimposed on each other and which interact and give very complicated patterns and variations. These natural mechanisms have to be studied if it should be possible to identify and discriminate the human impact. It is thus of great importance to study natural rhythms in relation to physical variables such as different kinds of radiation and their biological effects (e.g., heliobiological rhythms) both on species and on ecosystems. Such research projects should be supported on a national, regional and international basis.

A study of the environment of Antarctica and the Sub-Antarctic Islands provides another opportunity to initiate pilot projects and to find suitable variables – both biological and physico-chemical. The Antarctic Treaty facilitates open research on the Antarctic continent by all nations. There is also an ICSU organization – SCAR – to give advice and operate pilot projects.

In developing programmes in relation to climatic changes the natural organization is GARP, which is backed by ICSU and WMO. This organization may serve as a good model for co-operation between a non-governmental scientific organization and an intergovernmental agency.

A new area where a similar development should take place in relation to pilot projects for monitoring is remote sensing from satellites. The ICSU-body representing the space technique is COSPAR and the ecological aspects should be represented by IUBS or IBP.

7.6.3. Pilot Studies in the Marine Area

The following suggestions have emerged from discussions with marine organizations, from existing published documents and from contacts with marine scientists. Here, only the essentials of a possible framework are outlined, leaving the elaboration of detailed operational plans to intergovernmental working parties with their respective international scientific advisory bodies. There seems to be a consensus in the marine scientific community that a future global system for marine pollution monitoring should progressively evolve from national and regional networks.

International plans already exist for a programme to collect physical information for the marine area under the auspices of IGOSS. This programme will form the necessary basis for understanding the spread, transport and accumulation of marine contaminants and the effects on biota. Several inter-governmental and non-governmental organizations have stressed the need for the immediate development of a marine pollution monitoring system co-ordinated with other marine activities by a suitable inter-governmental body with proper resources.

International plans already exist for a comprehensive monitoring system of the physical conditions in the oceans and their short, medium and long term variations with a strong emphasis also on meteorological and chemical aspects. This internationally agreed cooperative plan for an Integrated Global Ocean Station System (IGOSS) stands under the aegis of the Intergovernmental Oceanographic Commission (IOC) with strong cooperation with WMO, and is supported by many countries. Joint working groups for preparatory and organizational tasks, such as network design, reporting and communication of data, data collection and processing, coordination of requirements, investigation of use needs, etc., have been established and are supported by a number of scientific advisory groups of experts.

It is of extreme importance for the functioning of a marine pollution observation network and especially for the interpretation of the data on critical substances obtained, that IGOSS is in operation and that a strong coordination is built in between IGOSS and a marine pollution monitoring system, and that IGOSS network is made operational especially in the areas suggested for pilot operations in pollution monitoring.

The initial work will be of greatest practical benefit if it is confined to the monitoring of water, top-sediments and biota for the levels of a few critical substances. This can be done from a small number of carefully selected areas. Although modest in scope and of a pilot nature, we feel that a great deal will be learned if in the beginning, the early programmes contain a large mission oriented research component. The organization suited to handle the development and co-ordination of such international pilot programmes are IOC, representing the inter-governmental executive functions and SCOR with an advisory function, representing international science. After an initial phase of planning and creation of pilot projects with a strong research oriented component the final monitoring and surveying programme will progressively evolve and should be executed by governmental institutions. IOC should be given sufficient resources to mount the task of international coordination. Such a task is demanding a special permanent secretariate for pollution monitoring within IOC.

The necessary steps to develop a final monitoring programme from pilot programmes are indicated in the following three phases.

The preparatory phase. This should be started as soon as possible and should consist of a number of future regional programmes co-ordinated by an appropriate and generally acceptable inter-governmental marine organization with the assistance and advice of SCOR. Pilot programme should be planned on a regional basis and it would be sensible to use for this purpose existing regional international marine organizations which have already given thought to these and have access to the most knowledgeable experts of the region in question. Where no appropriate regional organization exist, one could probably be constituted with assistance from the nations concerned and the non-governmental marine science community. The basis of each region's pilot programme should be dedicated to studying the problems special to the particular region. In order to ensure intercalibration and standardization of methodology, and data collection between regions, the inter-governmental body should co-ordinate these aspects centrally. During this preparatory phase, regional working groups should be set up and at the same time an international marine research and reference station should be established.

There are a number of functions which are essential for the execution of the pilot programmes. These functions can be carried out by working groups which might have a regional character in the beginning. The functions are specified as:

a) Interdisciplinary workshop for the marine sciences of the special region under study. This workshop should make an inventory of relevant knowledge and available information, identify the gaps in knowledge and information, and initiate complementary research.

b) Working group on modelling. This would design appropriate methods of sampling in space and time for the pilot study. This involves developing a preliminary model of water exchange and balance and of the sources, distribution and sinks of the critical substances.

c) Working group on data processing. This would examine appropriate means for data transfer, collection and processing. All regional and national data should be handled in such a way that future integration into a global system is made possible.

d) Working group on methods and standards. This would survey existing methods relevant to the problems of the region. This working group would also have the responsibility for intercalibration of the recommended methods.

e) Regional training workshops. The sophisticated methods which have to be applied to the analysis of most substances and the problems imposed on the analytical work by the need of specialized sampling, preservation and preparation previous to analysis, require special training courses or workshops within the region. It would be a valuable service if universities and similar institutes would serve as hosts for such courses. The finance needed should be provided by international or multinational funding. The participants in such training courses would be the later executors of the programme and they must have a sufficient background education as well as experience in field and laboratory work.

Non-governmental and intergovernmental marine organizations have suggested the establishment of an international institution. Several functions need to be fulfilled by such an institution, or as alternative, by several national institutions with international specialized working groups as coordinators and clearing houses under the auspices of SCOR.

a) Research and development of hardware for sampling critical substances.

b) Research on methods of measurement and analysis, especially analytical methods for new compounds which are expected to cause environmental problems in the near future.

c) Research on reliable standards.

d) Preparation, control and exchange of standards.

e) Training of scientists and technicians.

f) Advice, guidance and personal help during the installation of new laboratories and study areas, especially in less developed countries.

g) The curatorship of a sample bank for reference and standard samples and selected check samples from baseline stations.

It must be stressed, that especially the functions described under c, d and g are essential for the execution of internationally organized pilot programmes.

The phase of establishment of regional pilot programmes. Every region has its special conditions and problems. However, for each region there should be a planning group which, based on the material and activities during the preparatory phase, should plan and probably operate the pilot programme.

The selection of suitable regions for such pilot programmes has already been considered by different bodies representing both intergovernmental and non-governmental organizations. The following regions have been recommended as having the highest priority:

a) North Sea

b) Baltic Sea

c) Mediterranean

d) Puget Sound

Additional regions can also be recommended:

e) Carribbean Sea and Gulf of Mexico

f) Norwegian Sea

g) Northern North Atlantic

h) Black Sea

i) Japanese Sea

j) Chinese Sea

For several reasons, most of the regions indicated above demand an intensified and dense sampling programme over a period sufficient to cover all possible seasonal alterations and other fluctuations. It is suggested that for each of the regions mentioned under a) – d) about 20 stations in coastal areas and 20 stations in the open sea should be operated monthly or at least once every season. Another 20 stations will be needed for each region to cover the main points of injection, *i.e.*, river mouth stations or estuary stations. It is supposed that ongoing and planned national activities within the field of marine pollution monitoring will provide intensified information about the pollution situation and possible fluctuations during the period of the pilot programme for the near-shore areas. The sampling programme for the impact stations at the major points of injection must be rather dense and should apply *in situ* sensing techniques and automated analysis for as many of the critical parameters as possible.

For other regions, especially for the open oceans, seasonal and incidental fluctuations might not play an important role so that a sampling programme with a relatively large grid will provide the necessary baseline information. Such information can certainly be obtained by individual research cruises and through sampling programmes during ongoing and planned research and survey cruises for other purposes and also from weather ships.

There seems to be a consensus in the relevant bodies among the marine scientific community that the data obtained from the regional pilot programmes should be handled by the existing national and regional oceanographic data centres. It may be supposed that the amount of data from the pollution monitoring programme will be much less than the data from physical observations obtained from ongoing research and survey activities. The pollution data, however, will be much more heterogeneous. A careful investigation of possible formats of collaboration between the existing data centres should be carried out to provide for a rapid exchange and processing of data. The adopted system should be flexible enough to allow adjustment to new hazardous compounds and should furthermore allow an integration into a world-wide system.

Before entering the final monitoring programme it is desirable to reduce the number of observation points in the pilot programmes to the minimum possible. This is necessary for three reasons:

- 1. To warrant the execution of a long term programme for the remainder of the stations.
- 2. To keep the cost of the monitoring programme as low as possible, and
- 3. To transfer the programme from being the joint efforts of both research and governmental institutions to governmental institutions only, it being obvious that the execution of routine monitoring programmes is not the task for research institutes.

The phase of the final marine environmental monitoring programme. The final world wide network for marine pollution monitoring is expected to grow from regional nets and their stepwise integration into a global system. The global system must be flexible to allow for the measurement of new hazardous substances. The probable appearance of such "new" substances can be deduced from the records in the planned World Registry of Chemicals. The necessary methodology and hardware should be developed in due time by the International Research Reference Station described earlier. It is, however, of utmost importance that this system for marine environmental monitoring is fully integrated with the global environmental monitoring system. The essential co-ordination is a free flow of information from the marine system to the global system. In order to reduce the information as much as possible, it seems most appropriate that only processed data are exchanged.

In relation to the evaluation of the results from the monitoring activities it would seem appropriate that we should not only make an evaluation of the global system but also a special evaluation concentrated on the marine environmental problems. Since, however, this final phase is rather far in the future, it is not much use to elaborate on possible details and organisational alternatives which have to depend on experiences and results from the earlier phases.

7.7. ACTIVITIES TO SUPPORT AND PROMOTE ENVIRONMENTAL MONITORING

7.7.1. "Historical Monitoring"

One of the main objectives of the reference stations is to establish trends. In addition to this it is important to extend the "baseline" backwards in time by a process of "historical monitoring". The chemical stratigraphy of marine and lake sediments, peat bogs, glacier and ice cores and similar time-layered materials should be analysed. Coral reefs, tree rings, herbarium and museum specimens of biota collected in former times have all been shown to be highly informative in this respect. As an extension of this activity, it would be essential to develop an efficient storage of collected samples as an environmental archive. Soils, water, biota and air filter samples preserved by deep freezing could be of great value in future.

7.7.2. Environmental Archives

The main purpose for the establishment of environmental archives is to keep samples for future analytical work, i.e. checking earlier results with new methods or to supply material for testing and samples for newly appearing substances in the environment. From a biological point of view it is also important that samples are available for taxonomic checking in the future. We are well aware that such checking is only possible for certain types of substances and certain types of samples such as air filters, water samples and biological specimens. This storage is only partly possible in the traditionally existing museums, as new methods for preservation may be needed and will have to be developed as soon as possible.

It would seem desirable that these environmental archives should be housed in close contact with the reference stations. It is, however, important to get international agreement regarding the use of these archives to guarantee both that material is available for international purposes and also that material is preserved for the future. An international register of existing material should also be kept.

7.7.3. Training (Scientific and Technical) for Monitoring

The success of a global monitoring programme may to a large extent be determined by the personnel available. There are many scientific fields supporting the monitoring programmes and thus there is a need for a specific, broad-based training of all specialists to understand the interacting biosphere. The main groups of sciences are physico-chemical sciences, biomedical sciences, geographical sciences, mathematical sciences and sciences relating to data handling and analysis. Accordingly, the personnel involved in global monitoring will include representatives from many specialities from senior scientists to technical assistants.

This training could be concentrated in special centres in order to promote an unified technical approach to the problems. To promote co-operation and standardization of methods international and multilateral training courses should be supported.

It is of special importance that internationally funded training facilities be made available to the developing countries. Here the International Research Reference Stations, which have been recommended in this Report, will be of great use. It must also be emphasized that reference stations set up in the developing countries by international or national aid organizations from the very beginning act as training centres for scientists and technicians.

The importance of a sound environmental training for the general public, industrial personnel, as well as for administrators, decision- and policy-makers is also stressed. They must all be well informed and made fully aware of the implications of environmental problems emanating from national, regional and international practices and legislation. It is particularly important to inform these people about the benefits from environmental monitoring.

8.2.1. Introduction

In designing a coherent global environmental monitoring system, the basic problem is how to set up the simplest and least costly structure, in torms at money and technical manpower, which is nevertheless effective as regards global coverage, accuracy, reliability, speed and flexibility of response.

1. To use the data emerging from existing or planned programmers

2. To re-design a completely new global system

 To develop co-ordination machinery to obtain from existing programmes data on an internationally agreed set of priority variables which may as a priority variables which may as

We can benefit from a study of the organization and methods of the large number of ongoing monitoring activities already being carried out by grouernments, inter-governmental and non-governmental bodies. These context and clanned programmes are extremely valuable in covering natural envi-