

**General Plan and
Implementation Programme 1977-1982**

Unesco 1977



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FOREWORD

Since the Intergovernmental Oceanographic Commission and the World Meteorological Organization adopted the IGOSS General Plan and Implementation Programme for Phase I in 1969, the routine international exchange of oceanographic data within the framework of IGOSS has become a reality. The Pilot Project for the Collection, Exchange and Evaluation of Bathythermograph Data, which was the initial operational phase of IGOSS has demonstrated that the provision of oceanographic services is feasible and beneficial. It must, however, be pointed out that not all the concepts outlined in the General Plan have proven successful and that some operational deficiencies still exist. Nevertheless, the success of the Pilot Project has led to the conclusion that IGOSS be designated operational while, of course, further programme developments to strengthen and expand the system are being undertaken. This recommendation was approved by the IOC Executive Council and the WMO Executive Committee in 1975 at their fifth and twenty-seventh sessions, respectively.

Recognizing that developments in oceanographic services have necessitated some changes in the scope of IGOSS, the Fourth Joint Session of the Working Committee for IGOSS and the Executive Committee Panel of Experts on Meteorological Aspects of Ocean Affairs recommended preparation of this new General Plan and Implementation Programme. This plan does not suggest major revisions in the scope or objectives of IGOSS but is intended as a guide for further development and as an expression of the manner in which participating nations wish IGOSS to develop. The need for a second General Plan incorporating new techniques and results of experience gained during Phase I was foreseen and called for in the General Plan and Implementation Programme for Phase I.

During its next phase, IGOSS will be improved and expanded by: the incorporation of oceanographic data gathered via satellites and buoys; the automation of shipboard observing techniques; the implementation of a synoptic analysis and prediction system and the monitoring of marine pollutants. Yet a very basic problem, the lack of an adequate bathythermograph data base, still faces IGOSS participants.

Lastly, it is important to re-emphasize the principle contained in the General Plan and Implementation Programme for Phase I that "the ocean and the atmosphere should be observed and studied together because they continuously affect each other in a number of important ways." This principle has been reinforced while IGOSS has been developing and it is correct to expect IGOSS to contribute significantly to the solution of important problems being studied jointly by meteorologists and oceanographers. The First GARP Global Experiment and GARP sub-programmes require oceanographic inputs and have identified IGOSS as a supporting programme. Oceanographic experiments being conducted under the auspices of the Long-Term and Expanded Programme of Oceanic Exploration and Research require meteorological data and services in a similar manner through the World Weather Watch and the Marine Meteorological Services System of WMO. The concept that the Meteorological Services System and IGOSS are complementary and should thus be developed and operated together remains a central theme of IGOSS.

The Integrated Global Ocean Station System (IGOSS)

Plan and Implementation Programme 1977-1982

INTRODUCTION

General

1. The Integrated Global Ocean Station System (IGOSS) is a joint IOC/WMO operational service programme for the provision of information on the state of the oceans. Through IGOSS, states are provided the means by which they may cooperate multi-laterally in pursuit of their efforts to improve oceanographic services to various marine activities and to support the scientific study of the oceans and the atmosphere. When IGOSS is fully operational, participating states throughout the world will be able to obtain: additional oceanographic data; synoptic and near-real-time oceanographic analyses and predictions; data summaries; selected services designed for special, perhaps limited area, applications; and technical support in the operations of oceanographic service programmes. It is understood that for technical and perhaps financial reasons, full implementation of this plan might not be achieved in some parts of the world during the period 1977-1982.

Purpose

2. The need for oceanographic services and scientific study stems from mankind's continuously growing need for more food from the oceans and land alike and other resources that may be in or be under the sea, for improved maritime transport, and for better protection against hazards of the ocean and atmosphere. The availability of food and water, basic essentials of life for man, is controlled to a large degree by the natural and man-induced characteristics of the oceans. Long-term anomalies in the thermal structure may induce climate changes that have adverse effects on crops, even to the extent of causing droughts. Currents may meander, taking vital fish out of the reach of man's fleets and relied upon upwellings and the associated good harvests may not appear. Growing marine pollution affects richness and quality of living resources and may alter exchanges of energy and matter between the ocean and atmosphere and, hence, the stability of the climate. Energy, another essential need of modern man in short supply, must be conserved and new sources discovered or developed. The oceans are highways on which goods must be transported safely and over the most economical route: least fuel consuming in this case. Ocean current and wave observations and forecasts are needed for this purpose. Improved data from ocean areas would contribute to the development of forecasting techniques concerning tropical storms. In addition, more information concerning near-surface ocean conditions is necessary to allow improved weather forecasting models to be developed. The IGOSS programme should be expanded appropriately by nations to meet the data and product services required to satisfy these and other needs.

3. Some of the needs for operational monitoring and prediction services, the primary role of IGOSS, were cited briefly in the previous paragraph. A comment on the potential of nations to provide oceanographic services is necessary at the outset of this plan as, in some respects, capabilities are limited. A full understanding of the physical processes involved and the development of models to describe and predict the oceanographic and atmospheric environment have not yet been achieved. It is

still not clear what avenues must be followed to correct this situation but several scientific activities to which IGOSS may contribute and benefit from should be undertaken. IGOSS, through its observation programme can contribute surface and sub-surface data, particularly from bathythermographs, at fixed locations and along standard tracks as part of the global monitoring programme. Further, processed data and global and specialized analyses could be provided through the IGOSS Data Processing and Services System (IDPSS).

Principles

4. The principles for the development of IGOSS stipulated in the General Plan and Implementation Programme for Phase I are as relevant for the period 1977-1982 as they were for Phase I. They, along with additional principles, are as follows:

- i. IGOSS should be a global oceanic system and consist of national facilities and services provided largely by the participating Member States themselves with co-ordination and support from IOC and WMO and other international and regional organizations.
- ii. IGOSS, to be effective, should be a co-ordinated system responsive to the operational and research requirements agreed upon among the participating nations and should utilize the most modern observing, communication and processing technology available.
- iii. IGOSS should be a dynamic system, flexible enough to be adapted to scientific and technical advances.
- iv. IGOSS should be planned and operated closely with the World Weather Watch (WWW), and Marine Meteorological Services System (MMSS) of WMO.
- v. IGOSS should be capable of providing support to co-operative investigations and scientific experiments through the provision of data and products derived from these data.
- vi. All types of IGOSS observations, their accuracy, frequency, technical characteristics, means of telecommunication, reporting codes, and methods of data exchange and storage should be standardized and uniform.
- vii. IGOSS should be used only for peaceful purposes, due account being taken of the national sovereignty and security of States, in accordance with the provisions of the Charter of the United Nations.

Expected Benefits

5. The need for information about the ocean environment goes beyond the oceanographic community. Scientific and industrial institutions, as well as government, public, and private interests concerned with maritime policy and economic development need information to achieve practical goals. The following list indicates areas of interest which could benefit from information made available through IGOSS programmes which provide data and/or analyses and forecasts of

surface, sub-surface and bottom water temperature, salinity, surface and sub-surface currents, tides and tidal streams, storm surges, tsunamis and other water level anomalies.

- i. Fisheries including mariculture - for improved efficiency, exploitation and management.
- ii. Shipping, safety of navigation, routeing and cargo care.
- iii. Ocean and offshore engineering - improved efficiency, design, planning and management, exploitation of mineral resources, protection and safety.
- iv. Meteorological Services - improved short-and long-term weather forecasts.
- v. Sea ice and iceberg prediction services - formation and breakup, movement and decay.
- vi. Pollution abatement and control - protection of living resources and man, effluent and waste disposal, distribution and transport of pollutants.
- vii. Recreation - planning, navigation, safety and protection.
- viii. Search and rescue operations.
- ix. Harbour control - scheduling, management and design, protection and safety.
- x. Support of oceanographic and meteorological research, undertaken in national and international programmes.

Elements of IGOSS

6. The basic elements of IGOSS are:

- (i) The IGOSS Observing System (IOS) consists of various facilities for obtaining oceanographic and marine meteorological observations at sea from ships, buoys, satellites and other platforms with the support of the Global Observing System of the World Weather Watch.
- (ii) The IGOSS Data Processing and Services System (IDPSS) consists of national, specialized and world oceanographic centres for the processing of the required observational data and preparation of required products (oceanographic analyses and forecasts) and provision of services to various marine user groups.
- (iii) The IGOSS Telecommunication Arrangements - the use of the WWW Global Telecommunication System, satellite relay or interrogation links or other newly developed facilities and techniques for collection and distribution of the required observational data from oceanic observational platforms as well as for exchange and distribution of processed information.

- (iv) The IGOSS Data Archiving and Exchange System - The use of existing mechanisms and channels for international oceanographic data exchange, consisting of *World Data Centres (Oceanography) (WDC), Regional Oceanographic Data Centres (RODCs), National Oceanographic Data Centres (NODCs), Designated National Agencies (DNA), and IGOSS Responsible National Oceanographic Data Centres (IRNODCs) in order to ensure preservation of observational data and IGOSS products and their provision to users on national and international levels. Development of archiving and exchange procedures for oceanographic data including IGOSS data are the responsibility of IOC Working Committee for International Oceanographic Data Exchange.

7. In addition to the basic elements mentioned above, IGOSS has embarked on the following programmes:

- (i) The IGOSS Marine Pollution Monitoring Programme - Established as a function of IGOSS and to be co-ordinated with IOC WC for GIPME. It is to comprise regular observations of selected pollutants as well as relevant oceanographic and meteorological parameters. The development should be carried out through progressive integration of national and regional pollution monitoring programmes and by launching pilot studies and projects dealing with monitoring of selected pollutants in certain oceanic areas.
- (ii) IGOSS Education and Training Programme - To enable developing countries to participate actively in IGOSS, considerable attention of relevant IOC and WMO bodies, in particular the IOC WC on TEMA and WMO EC Panel on Education and Training should be directed to the subject of education and training for IGOSS purposes. The fields of synoptic oceanography, marine pollution monitoring, oceanographic observations, data processing and archiving and application of products and services should be emphasized. In addition, studies are in hand with a view to developing an ocean current programme.

8. As well as the programme elements listed above, research is needed in order to ensure a sound scientific basis for the development of IGOSS. Studies are needed in areas such as: modelling of the general circulation of the ocean; studies of the ocean variability; and air/sea interaction. These studies should be conducted by scientists and research laboratories of the participating countries and within the framework of international scientific programmes when appropriate. Support for research may be provided through IGOSS in the form of data and products.

Review of the Programme Developments (1969-1975)

9. The initial operational programme of IGOSS, the Pilot Project for the Collection and Exchange of Bathythermograph Data (BATHY Pilot Project) has been carried out successfully since January 1972. An average of 1,550 reports were exchanged via the GTS monthly during 1973 with 1,250 per month in 1974. Evaluations

* For definitions of functions refer to IOC Manuals and Guides No.1 - Manual on IGOSS Data Archiving and Exchange.

of the BATHY Pilot Project were made in 1973 and 1974. In 1975 the IOC Executive Council and WMO Executive Committee approved the conversion of the Pilot Project into an operational programme. The following deficiencies were identified during the Pilot Project that must be overcome during the next phase of IGOSS:

- (1) relatively few Member States participated;
- (2) the amount of data made available by participants was limited; and,
- (3) a considerable amount of data were lost at various stages of data relay and transmission.

10. Operational instructions required for participation in IGOSS are contained in the following Manuals and Guides:

- Manual on IGOSS Data Archiving and Exchange (IOC Manuals and Guides No.1)
- Guide to Operational Procedures for Collection and Exchange of Oceanographic Data (BATHY and TESAC) (IOC Manuals and Guides No.3)
- Guide to Oceanographic and Marine Meteorological Instruments and Observing Practices (IOC Manuals and Guides No.4)

11. A second operational programme, the Pilot Project on Marine Pollution Monitoring was launched in 1975. This initial IGOSS marine pollution project is an internationally co-ordinated programme for monitoring petroleum-derived oils. An operational plan, containing a description of procedures for sample collection, preservation and analyses was prepared. This plan was accepted as a basis for the development of the Joint IOC/WMO/UNEP Pilot Project on Baseline Studies and Monitoring of oil and petroleum hydrocarbons in the Mediterranean, which is considered as a substantial input to the IGOSS Pilot Project on Marine Pollution Monitoring. Upon the initiative of UNEP, a study of the feasibility of a programme for monitoring background levels of selected pollutants in open ocean waters was undertaken by consultants appointed by UNEP, WMO and IOC. This study showed that such a programme can be initiated in 1976, as a pilot phase in the Atlantic Ocean.

12. A plan for the IDPSS has been developed the purpose of which is to make available to specialized and national oceanographic centres basic processed observational data and analyses and forecasts for real-time and near-real-time applications. Studies have been made on the design and development of the IGOSS Observing System. As a result of these studies a proposal was made for the establishment of an IGOSS Basic Observational Network (IBON). The IDPSS and IBON concepts are incorporated in this general plan and implementation programme for 1977-1982. Other studies and reviews have been undertaken on the development of new ocean data acquisition systems, user applications of oceanographic products and services, an ocean current observation programme, telecommunication aspects of IGOSS and the provision of support for GARP experiments.

Recent Developments

13. The success of satellites to provide sea surface observations as well as their potential for communicating data from platforms at sea to processing centres must be considered as an important development. Even though the use of satellites

has not been incorporated in IGOSS as yet, expert groups have studied their use in conjunction with the development of automated data acquisition and transmission devices and the development of environmental analysis and prediction routines.

14. Planning bodies are now considering the role IGOSS may play in helping to solve the critical world problems concerning food and energy. One role will be to contribute to the global monitoring systems for specifying the present climate for introduction into realistic models used to compute the future climate and to verify the predictions made in the recent past. Current observations in certain significant areas and predictions are needed for search and rescue operations, navigation and ship routing. The IGOSS ocean current monitoring project which may be initiated on a pilot basis in the 1977-82 period stems from the growing need for operational ocean current information.

15. The Global Atmospheric Research Programme has already contributed to a clearer understanding of the need for coupled air/ocean models and related monitoring. Continued co-operation between IGOSS and GARP will be mutually beneficial.

16. A significant event affecting IGOSS development was the United Nations Conference on the Human Environment held in Stockholm in June 1972. The action plan drawn up in Stockholm and approved by the UN in Resolution 90, called upon the "IOC, jointly with WMO and, as appropriate, in co-operation with other interested intergovernmental bodies, (to) promote the monitoring of marine pollution, preferably within the framework of IGOSS." The IGOSS Marine Pollution Monitoring Pilot Project is the first operational response of the IOC and WMO to this resolution.

Need for Further Systems Development

17. An efficient global oceanographic service programme encompassing observational, telecommunications, data processing, product formulation and dissemination and data storage and retrieval elements is a vast undertaking that could only be considered if multi-national interest exists. The usefulness of an oceanographic service will be only realized when: adequate amounts of data become available; the ocean and air/ocean dynamics are better understood; the system is able to overcome technological restraints in response to user needs and, in addition, adequate resources are made available by participating nations. The state of IGOSS development relative to the optimum service is such that:

- (i) Data collection for synoptic purposes has only reached the 10-20 per cent level of foreseen requirements. For this reason, ships must be used to a far greater extent to measure surface and sub-surface variables and development must be accelerated on data acquisition devices such as buoys, satellites and radars. Sensing and transmitting oceanic parameters from these should be through automatic means whenever possible.
- (ii) A general shortcoming exists in most oceanographic prediction techniques in that a basic understanding of the physical processes involved is usually lacking. Studies and experiments must be directed at the understanding of oceanic mechanisms and their interaction through a range of time and space scales before oceanic prediction is attempted.
- (iii) Many of the innovations that will lead to a sophisticated service system have been identified. Further study and development will be required to take advantage of modern technology and techniques.

- (iv) The long-term trend in the levels of pollutants in the world's oceans can be assessed only by measurements carried out over a period of many years of sites that are not directly influenced by inputs from the mainland or by ocean dumping activities. At present, information about the nature of open ocean water pollution is limited. Furthermore, because of different analytical methods that have been applied so far without thorough intercalibration, it is difficult to compare all the published data.

RELATION OF IGOSS TO OTHER INTERNATIONAL PROGRAMMES AND ORGANIZATIONS

World Weather Watch

18. The IGOSS will continue to use extensively facilities of the World Weather Watch and should therefore be developed in close relation with the implementation of the World Weather Watch. The essential elements of the World Weather Watch are:

- i. The observation networks and other observational facilities, called the Global Observing System (GOS),
- ii. The meteorological centres and the arrangements for the processing of the observational data for the storage and retrieval of data, called the Global Data-Processing System (GDPS), and
- iii. The telecommunication facilities and arrangements necessary for the rapid exchange of the observations and of the processed data, called the Global Telecommunication System (GTS).

19. GOS consists of the surface-based sub-system and space-based sub-system. The surface-based sub-system includes such platforms as fixed sea stations, mobile ship stations and automatic marine stations. Fixed sea stations (stationary ship stations and fixed and anchored platforms) provide essential and detailed meteorological and oceanographic data from critical locations in ocean areas, where more economical means are not available. Mobile ship stations, known commonly as WMO voluntary observing ships, have been used for taking bathythermograph observations for IGOSS. Progress has been made in the development and deployment of buoys which take and transmit marine meteorological and some oceanographic observations. Mobile and fixed observation platforms mentioned above constitute part of the six WMO regional basic synoptic networks which in their aggregate form the global basic network. Meteorological satellites under the space-based sub-system of GOS are divided into two groups, those in near-polar orbits and those in geostationary orbits. They provide observations of, amongst other things, temperatures of the sea, snow and ice cover. One of the important features of meteorological satellites is their capability to collect and relay environmental data sensed by a variety of ocean platforms both stationary and non-stationary.

20. GTS provides the telecommunications facilities and arrangements for the rapid and reliable collection, exchange and distribution of observational data and processed information. IGOSS will depend on GTS for the international exchange of oceanographic data and processed information. Where the processing of data

exchanged under IGOSS is closely linked with the processing of data exchanged under WWW, international co-ordination is needed between the data processing component of IGOSS (i.e. IDPSS) and the corresponding component of WWW (i.e. GDPS).

Marine Meteorological Services System

21. The Marine Meteorological Services System (MMSS) provides, to the extent possible, marine meteorological and other related geophysical information for all shipping routes, fishing areas and areas of other marine activities. Activities undertaken under the MMSS are closely linked with the oceanographic analysis and prediction services developed under IGOSS, namely the IDPSS. The further development of the IDPSS should be undertaken in close co-ordination with the MMSS to ensure the rational use of resources available and to avoid duplication of efforts.

Long-term and Expanded Programme of Oceanic Exploration and Research/International Decade Ocean Exploration 1971-1980 (LEPOR/IDOE)

22. The purpose of LEPOR/IDOE is "to increase knowledge of the ocean, its contents and the contents of its subsoil and its interfaces with the land, the atmosphere and the ocean floor and to improve understanding of processes operating in or affecting the marine environment, with the goal of enhanced utilizations of the ocean and its resources for the benefit of mankind". The results of some of the research programmes under the auspices of LEPOR/IDOE will have immediate use within IGOSS and other oceanographic service programmes. As understanding of the ocean is advanced, so can monitoring and prediction systems be advanced: important scales and processes can be monitored and accounted for in prediction models. It is the responsibility of those developing services, including IGOSS, to identify for the LEPOR/IDOE participants the research that is required to improve that service.

23. The data obtained during LEPOR/IDOE experiments, if relayed to IGOSS oceanographic centres in real-time, may be used in generating products already on-line. Data and products can be provided through IGOSS to researchers as well as to supplement their data collection programmes.

Global Atmospheric Research Programme

24. GARP is a joint WMO/ICSU (International Council of Scientific Unions) programme for studying those physical processes of the atmosphere that are essential for an understanding of the large-scale fluctuations which control changes of weather, and a better understanding of the physical basis of climate. In order to develop the necessary understanding, certain programmes and sub-programmes, essentially international in character, and of a theoretical and experimental nature, have been formulated. They deal with specific physical and dynamical processes, either of a global or regional character. Within the several sub-programmes experiments have been designed to determine the behaviour of the whole atmosphere or some part of it, relevant to the particular sub-programme.

25. Synoptic oceanographic data and analyses are required for determining boundary conditions for operational medium-range weather prediction models and in research as one of the factors in assessing the feasibility of longer-range weather and climate predictions. Scientific experiments dealing with ocean-atmosphere interaction require data on sea surface and sub-surface temperature, water density and where possible,

ocean currents. The scale in which these data are required is determined by the experiment and arrangements, therefore, include the establishment of a suitable network of observations in the area of the experiment. Members should endeavour to arrange for such a permanent and global network of sea surface and sub-surface temperatures, water density and ocean current observations by 1978, when major scientific experiments under GARP will be conducted.

26. The First GARP Global Experiment (FGGE) is the main observational part of the GARP Global Sub-programme and is concerned with the large-scale dynamics of the atmosphere, the central theme of GARP. It is an effort to provide a world-wide test of how well existing models of the earth's atmosphere can simulate the present climate. The Observational Phase of FGGE consists of a Build-up Year from September 1977 to August 1978 and an Operational Year from September 1978 to August 1979, including two Special Observing Periods of intensive data collection, each of two months duration. The data management plan for the First GARP Global Experiment (FGGE) includes BATHY and TESAC as special observing systems. IGOSS participants have been called upon to increase their observation frequency during FGGE and to support specific GARP sub-programmes such as MONEX.

The Global Environmental Monitoring System (GEMS)

27. Several programmes and studies on marine pollution monitoring undertaken within the framework of IGOSS have been recognized by UNEP as an essential contribution to GEMS and are being developed in co-ordination and with the support of UNEP. This includes: Pilot Project on Marine Pollution (petroleum) Monitoring, Joint IOC/WMO/UNEP Co-ordinated Pilot Project on Baseline Studies and Monitoring of Oil and Petroleum Hydrocarbons in the Mediterranean and the preparation of the programme for monitoring background levels of selected pollutants in open ocean waters.

28. GEMS is a major step in the evolution of Earthwatch - a major functional task of the United Nations Environment Programme (UNEP). The goals to be achieved through the functioning of GEMS include, inter alia:

- (i) An assessment of global atmospheric pollution and its impact on climate;
- (ii) An assessment of the extent and distribution of contaminants in biological systems, particularly food chains;
- (iii) An assessment of the state of ocean pollution and its impact on marine ecosystems;
- (iv) An improved international system allowing the monitoring of the factors necessary for the understanding and forecasting of disasters and the implementation of efficient warning systems.

29. The Governing Council of UNEP has decided to:

- (a) Include ocean baseline stations, analogous to the atmospheric baseline stations, which could take the form of island stations, data buoys or ships of opportunity;
- (b) Assist in the expansion of the Integrated Global Ocean Station System to include other pollutants in addition to petroleum hydrocarbons;

- (c) - Support education and training efforts that should enhance the participation of developing nations and thus improve the overall effectiveness of the ocean programme.

Food and Agriculture Organization of the United Nations

30. Events in the upper zone of the ocean in any area of the world may have some influence on living resources in that area. In this sense, any information that can be collected under IGOSS as to the physical, chemical and biological characteristics of the upper zone may have some relevance to research on marine living resources. But oceanographic factors affecting the abundance and distribution of living resources are different from area to area, from situation to situation and from resource to resource. For example, temperature is one of the factors determining the distribution of fish; a sharp temperature boundary often constitutes a barrier to fish distribution and movement. Similarly, the extent and intensity of coastal upwelling appear very important, although it is not known exactly how this affects the abundance of fish. Surface currents often affect the distribution and survival of eggs and larvae. The survival rate in the early stages of development of fish is, to a greater or lesser extent, determined by the availability of the right kind of food at the right time.

31. FAO will attempt to identify the fishery requirements for IGOSS products based on which, and within the IGOSS programme, a "pilot project" will be developed for a specific region and fishery. The experience gained during the pilot project phase will contribute to our understanding of the ways in which environmental factors may affect fisheries' operations. Based on the results, IGOSS services can then be developed progressively to meet the requirements of fisheries on a regional and global basis.

Scientific Committee on Oceanic Research

32. The Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU) co-ordinates research and conducts studies which are directly related to IGOSS. For example, SCOR working groups have been formed to work on: Internal Dynamics of the Ocean; Oceanographic programmes during FGGE; the influence of the ocean on climate (with IAPSO); mathematical modelling of oceanic processes (with IAPSO); and coastal upwelling processes. As needs arise within IGOSS for oceanographic studies, SCOR should be called upon to assist in IGOSS development.

International Council for the Exploration of the Sea

33. The International Council for the Exploration of the Sea (ICES) is both a supporting and user organization of IGOSS. Members of ICES have provided data and participated in a pilot project for thermal structure analysis (OVERFLOW 73) for the north-east Atlantic. The Service Hydrographique of ICES is a permanent Regional Oceanographic Data Centre co-operating in the IGOSS Data Archival and Exchange Programme. The research projects conducted under the auspices of ICES have similar relationships to IGOSS as that of the LEPOR/IDOE programme.

OBSERVING SYSTEM

Purpose and Principles

34. The purpose of the IGOSS observing system is to provide participating nations with marine environmental data required for operational and research purposes. Its facilities may be used in support of other IOC/WMO or international programmes, providing that such utilisation would not be detrimental to achieving the primary purpose of the IGOSS observing system.

35. The IGOSS observing system can be considered as an important contribution to the United Nations Global Environmental Monitoring System (GEMS), as it will provide information on a regular basis for assessment of the state of the ocean and its effect on weather and climate, as well as for interpretation of pollution monitoring data.

Observational Data Requirements

36. As for Phase I of IGOSS, the primary data requirements will be for ocean thermal structure and salinity data. During 1973, approximately 17,000 BT reports were exchanged within the framework of the IGOSS BATHY pilot project, while during the same period, in addition, the World Data Centre A (Oceanography) received 58,083 observations from oceanographic stations (temperature and salinity). This indicates great potential for increasing the amount of ocean temperature data to be exchanged on a synoptic basis.

37. While the BATHY pilot project demonstrated that the IGOSS observing system is a viable one, it also revealed that meaningful oceanographic analyses and predictions could not be prepared unless the present level of the availability of ocean temperature data is significantly up-graded. Estimates of the BATHY data which would enable nations to produce meaningful sub-surface analyses have been made and are given in the table on page 12.

38. One of the main uses of IGOSS data will be as input to ocean/atmosphere numerical models. For this purpose, the thermal structure in the upper 500 m will be required. Real-time surface current information is also of great importance and a significant improvement in sea surface current observations should be made.

Network Design and Observational Strategies

39. Observational strategy in IGOSS aims to employ the most suitable techniques and ensure that the frequency of sampling (time and space) is optimum, taking cognizance of the way in which the observations are to be used. Information needed to formulate an observational strategy for a particular parameter is as follows:

- (i) A knowledge of the variability (time and space) of the parameter;
- (ii) Present, and likely future methods of measurements of the parameter;

ESTIMATED BATHY REQUIREMENTS FOR PREPARATION
OF MEANINGFUL SUBSURFACE ANALYSES

<u>AREA</u>	<u>Approximate No. of Water Masses</u>	<u>Approximate No. of Observing Points</u>	<u>Daily Observations Required</u>	<u>Minimum Monthly Observations Required (Best Distribution)</u>
North Atlantic Ocean	14	56	112	3,360
South Atlantic Ocean	10	30	60	1,800
Mediterranean Sea	2	8	16	480
North Pacific Ocean	18	70	140	4,200
South Pacific Ocean	12	36	72	2,160
North Indian Ocean	7	21	42	1,260
South Indian Ocean	8	24	48	1,440
TOTAL	71	215	490	14,700

- (iii) The uses or purposes of the observations;
- (iv) Instrumental accuracies.

At present there is not sufficient information available under any of the above headings. The most important lack is under item (i). In addition, it is emphasized that the relative costs of different methods of measurement will become an important factor in observational strategy as the IGOS system develops in scope and complexity. Overall efficiency and economy will become of increasing importance as total cost increases.

40. Network design can be considered as part of the overall problem of formulating an observational strategy. Network design can be interpreted broadly as determining the real density of observing stations and the frequency of observations at each station that are in some sense adequate. Stations need not be geographically fixed. A question may arise as to whether drifting buoys or moored buoys will be more effective for measuring the temperature structure of the upper ocean. If a statistical model for the temperature structure of the mixed layer can be formulated for different regions from available data, a network design approach provides a method for determining the optimum choice.

41. The problem of network design has been approached in a number of different ways. An approach developed mainly by meteorologists starts from the statistics of the parameter and seeks to estimate the accuracy with which the value of that parameter can be interpolated at a fixed grid point in relation to (i) accuracy of observation and (ii) spacing of observations. This approach has been used in the planning of the Mid-Ocean Dynamics Experiment (POLYMODE) and the North Pacific Experiment (NORPAX). A knowledge of time and space scales, as given for example by the appropriate correlation functions or structure functions, is essential in the application of this approach to network analysis.

42. A second and more direct approach is to divide the region of interest into sub-regions, based on accumulated knowledge of the water masses in the area. At least three sampling stations should then be located in each sub-region. Samples from these stations, if their positions are not co-linear, allow some estimate of zonal and meridional gradients in each area. With this approach, the question of how often samples should be taken must be answered separately, usually on the basis of experience or feasibility.

43. The primary source of vertical thermal structure data during the implementation period 1977-1982 will be from BT's or XBT's used aboard research vessels and voluntary observing ships. To improve the synoptic BT and XBT data coverage, it will be necessary to develop instrument packages that digitize the data and transmit them automatically by satellite.

44. The present methods for determining sea surface currents from ships' set rely on the comparison of observed position fixes with deduced positions made by integration of the ship's motion through the water from a single component log. This method has severe limitations and further efforts are required to develop suitable refined techniques for the measurement of surface currents.

45. The priorities for the next phase of work on observational strategy in

IGOSS are:

- (i) the determination of statistical parameters for the more important properties of the ocean for many different areas, for example, structure functions or the closely related spectra for SST and heat content of the upper layers from existing data as well as from planned research projects;
- (ii) the design of automatic data gathering packages capable of transmitting data via satellite and their installation on ships. The most important data to be gathered and transmitted in this way relates to the structure in the upper 500 m.

Parameters to be Observed

46. (a) The parameters to be observed in the IGOSs observing system with priority for implementation during the period 1977-1982 are listed below:

- (i) Primary parameters: surface and sub-surface sea temperature
surface and sub-surface salinity
wind waves and swell
surface and sub-surface currents
water level anomalies
- (ii) Necessary complementary parameters: wind speed and direction
atmospheric pressure
air temperature
dew point
ice cover and icebergs
solar radiation (if instrumented)

(b) For special projects, such as those relating to chemicals, pollutants, nutrients and the primary productivity cycle, the parameters to be measured will be determined as part of the programme.

IGOSS Basic Observational Network

Purpose and Concept

47. The IGOSs Basic Observational Network (IBON) is established within the framework of the IGOSs Observing System and is intended to act as the major component of this system during the implementation period 1977-1982. It should be considered to be the minimum useful network in terms of the density and accuracy of observations (see paragraph 53).

48. IBON will provide surface and sub-surface data for analysis and prediction of ocean conditions on a world-wide basis. It will also satisfy some of the WMO/WWW requirement for sea-surface observations as specified in the WWW Plan and Implementation Programme 1976-1979, and will provide oceanographic data required by GARP to continuously update information concerning sea surface temperature and sea ice.

49. The immediate objective is to obtain a minimum set of surface and sub-surface temperature data to the upper 500 m of the ocean on a regular basis with time and space scales necessary to define the major features of the world oceans and to support synoptic meteorology. Special attention will be given to providing support

to FGGE. IBON will later be expanded to include the measurement of other parameters as measuring techniques, instruments and resources become available.

Network of Stations

50. The chart on page 16 shows the required minimum distribution and density of observations believed to be necessary to define the major characteristics of the world's oceans. Approximate boundaries of the major water masses and the number of sampling points within each area are shown in figures as well. The positions of the sampling stations need not be geographically fixed, but should be distributed throughout each area and should not be co-linear. A recommended distribution is shown by the dots on the chart. A minimum coverage would be obtained by making one sounding per day at each station.

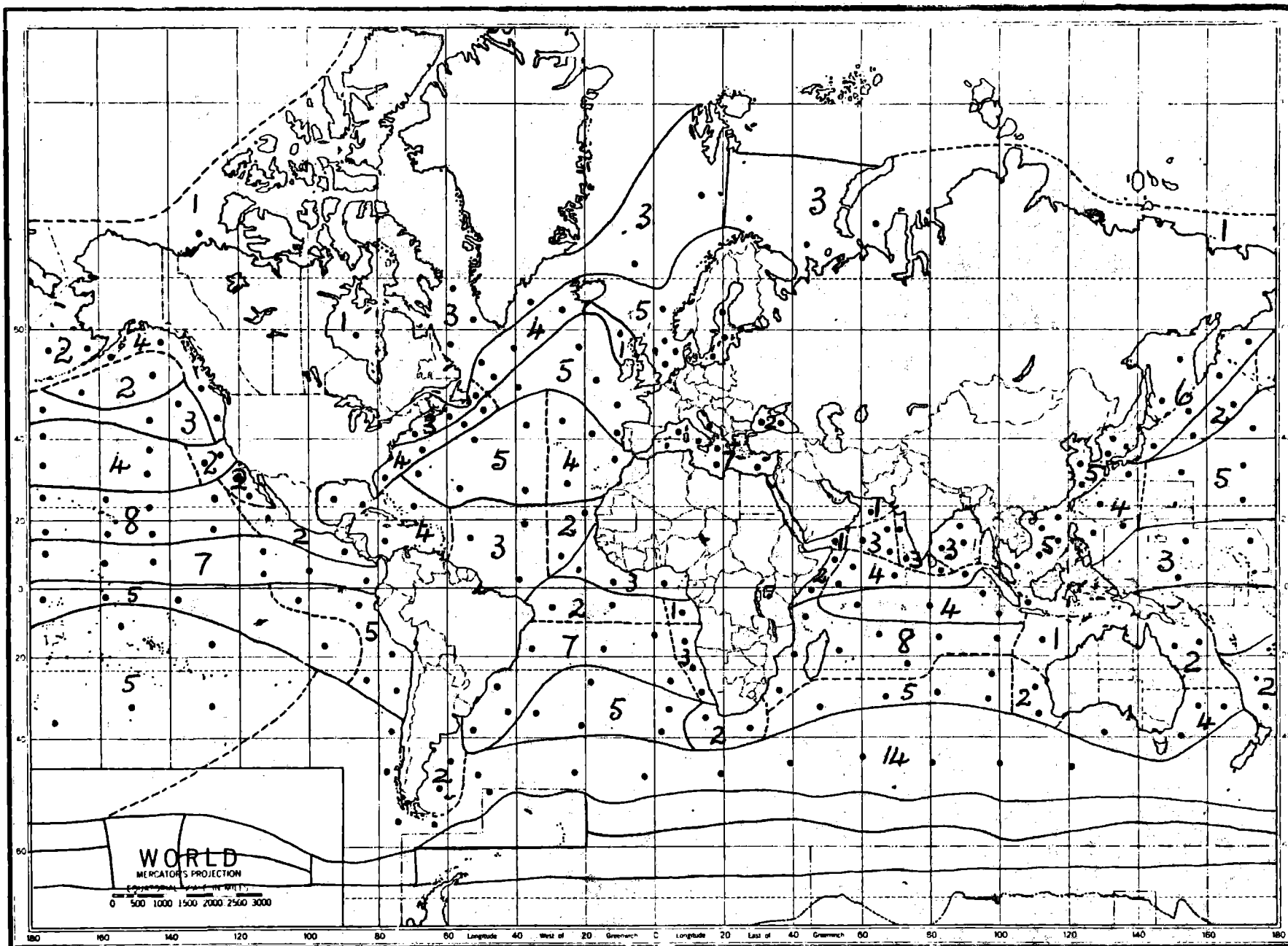
51. It is recognized that in the light of later data analysis, such an initial coverage may prove to be inadequate for some tasks. The statistical analysis of data will reveal the importance of mesoscale features and the design of the observing system may be modified accordingly. As a means of obtaining data on scales smaller than those indicated in the chart on page 16 and in order to provide spatial statistics on these smaller scales, it is recommended that wherever possible the basic system should be supplemented by more closely spaced observations. Some areas may already be identified as meriting additional emphasis. These are:

- (i) where linkage mechanisms with the atmosphere have been shown to be important;
- (ii) Hansen's influence points; *
- (iii) where present observational density is low;
- (iv) in regions of strong currents and strong horizontal thermal gradients.

52. A target rate of progress of implementation of the necessary coverage is shown in the table below:

Time	% of desired coverage attained overall	% of desired coverage attained in various ocean areas
Present	10	3 - 25
Before FGGE	20	6 - 50
1982	50	10 - 100

* Reference: HANSEN, W. Über den Entwurf Ozeanographischer Stationssysteme. Mittwil. Inst. Meereskunde, Univ. Hamburg, No. 13, 1970.



Accuracy and Resolution

53. It is essential that the measurements should be made with sufficient accuracy to make them operationally useful but with due account for the increased cost needed to attain high accuracy. An indication of the useful degrees of accuracy of three essential parameters is given below. Values indicated are representative on a scale of about 50 km.

	Marginally Useful	Desirable for Water Mass Analysis	Optimum Accuracy Needed to Implement IBON
Sea Surface Temperature	3°C	0.5°C	0.25°C
Mixed Layer Depth	20 m or 10% whichever is larger	10 m	5 m
Temperature Gradient below Mixed Layer	2°C/100 m or 20% whichever is larger	1°C/100 m or 20% whichever is larger	5%

Observational Platforms

54. The following ocean data acquisition platforms are considered as essential during the period 1977-1982:

- (a) oceanographic and meteorological research ships;
- (b) ocean weather ships;
- (c) WMO voluntary observing ships and ships of opportunity;
- (d) ocean data buoys;
- (e) coastal and island stations;
- (f) satellites and aircraft.

Oceanographic and Meteorological Research Ships

55. Oceanographic and meteorological research ships are the most reliable data source for ocean parameters required in the IGOSS observing systems. It is of

particular importance that during the implementation period 1977-1982 participating nations endeavour to have as many as possible sea temperature and salinity observations taken aboard their ships and transmitted on a real-time basis. Reports from research ships participating in scientific experiments and special oceanographic investigation will greatly contribute to the improvement of the data coverage of the IGOSs observing system.

Ocean Weather Ships

56. Oceanographic observations are carried out aboard most of the presently-operated ocean weather ships. WMO Members concerned are encouraged to continue these observations and arrange for sea temperature and salinity observations to be transmitted on a real-time basis.

WMO Voluntary Observing Ships and Ships of Opportunity

57. WMO voluntary observing ships and ships of opportunity will remain a primary source of sea temperature data throughout the implementation period 1977-1982. Therefore it is important that Member States make every effort to increase the number of observing ships carrying out sea temperature observations. In recruiting such ships, account should be taken of the areas or routes on which the ships are normally plying in relation to the proposed IBON reference network of stations.

Ocean Data Buoys

58. The use of moored and free drifting buoys as synoptic oceanographic data acquisition platforms is certainly feasible and will soon offer the potential to expand the data base of the IGOSs observing system. Buoys have been undergoing tests for years in several countries. Moored buoys may provide useful data and they can be placed in remote areas, outside of shipping lanes where it is not practical to divert merchant ships and for which data are needed for analysis and prediction purposes. Efforts should be continued to develop and deploy operational ocean data buoys.

59. Drifting buoys, while not capable of accommodating the full range of observations that can be obtained from moored buoys, may, for the near future (5 to 10 years), become a useful form of buoy system to deploy. Firstly, they are relatively cheap to purchase. Secondly, they are expendable, thereby not requiring maintenance visits. Thirdly, their sensing packages are uncomplicated, within the state of the art. Fourthly, they can be launched with limited training and facilities. Drifting buoys have, however, more complex communication problems because buoy locations must also be calculated. Drifting buoys are being considered for use in FGGE as one of the special observing systems, particularly for southern circumpolar waters where clouds persist and surface conditions cannot be often sensed by satellite. The results of the FGGE will provide an indication on the usefulness and feasibility of drifting buoys for operational use in IGOSs.

Coastal and Island Stations

60. Participating nations should be encouraged to select coastal and island stations and equip them so that they can obtain observations useful for IGOSs purposes. In particular, measurements should be made of sea levels, waves, ice, water temperature and the complementary meteorological observations. Such stations will be important observing stations for pollution monitoring as well. Incorporation of the coastal and island data should be considered when required for IDPSS product formulation.

Satellites

61. Monitoring of the ocean from space is now foreseen as one of the advancements in operational data acquisition that will make additional data available for IGOSs use on a routine basis by 1980. Satellites have yet to play a major role in monitoring and assessing oceanic conditions. However, as sensors and instruments have been developed, it has become apparent that much important and useful data on the ocean can be gathered from space platforms. Under relatively cloud-free conditions, sea surface temperature can be derived from infra-red measurements from satellites and some tracking of major ocean currents can be accomplished. Experimental satellite products such as hemispheric sea surface temperature analyses and current and water mass depiction charts have undergone tests and are proving to be useful additional components of services which already make use of surface, sub-surface and airborne observational elements. The advance made towards incorporating satellite observational techniques in operational service programmes is one technological development that should have a great impact on IGOSs. Member States developing and operating satellite systems are encouraged to make processed data available to others participating in IGOSs.

62. The requirements of the IBON for the data and information which can be obtained from existing and planned satellite systems are as follows:

- (a) sea surface temperature
- (b) surface thermal detail (fronts)
- (c) surface wind field
- (d) surface wave statistics
- (e) currents
- (f) upwellings
- (g) open ocean tides
- (h) storm surge
- (i) icebergs and ice cover
- (j) ocean colour
- (k) floating pollutants

Further Studies and Development Work Required

63. A consequence of the mixed nature of the IBON observing system (satellite, aircraft, buoy, ship) is that a particular variable may be measured by several very different techniques. It is important that these data should be comparable without

complex processing. A particular example is the measurement of sea surface temperature by various systems at the surface and by satellites which themselves employ different methods from one another. Difficulties arise in the assimilation of these various data which reduce the usefulness of the data set in practical applications. Problems are also caused by the lack of compatibility between different satellite communication systems and it is important that there should be agreement on common standards in order that surface data collection platforms can work through a variety of satellites without duplication of transmitting equipment.

64. Costs can be reduced by careful choice of the variables measured and by restricting the accuracy and resolution demanded to that strictly required. Careful scrutiny of the use made of the various data in deriving service products will probably lead to the elimination of some data now reported.

65. There is the urgent need for introducing semi or fully automatic data acquisition systems. The desirable attributes of such systems are that they should:

- (a) be compact, to minimize interconnections;
- (b) have an automatic communication system;
- (c) have long "mean time between failures" to eliminate the necessity of servicing at sea;
- (d) have stability of calibration to obviate adjustment at sea.

Great emphasis is placed on the need to minimize servicing, adjustment and calibration. In most cases the cost of a data acquisition system totalled over its lifetime is dominated by the maintenance element.

TELECOMMUNICATION ARRANGEMENTS

Purpose and Principles

66. The purpose of the IGOSS telecommunication arrangements is to ensure the rapid and reliable collection, exchange and distribution of ocean data originating from the IGOSS observing system, and of processed information available from the IGOSS Data Processing and Services System, and is operated in accordance with the following principles:

- (a) IGOSS observational data and processed information are exchanged over the Global Telecommunication System of the World Weather Watch:
 - (i) the National Meteorological Service responsible for the operation of a telecommunication centre on the GTS be it a World Meteorological Centre (WMC) or a Regional Telecommunication Hub (RTH) or a National Meteorological Centre (NMC) is also responsible for both the transmission to and reception from the GTS of IGOSS observational data and processed information;
 - (ii) the WMO standard telecommunication procedures specified in the Manual on the GTS should be applied for the handling of IGOSS observational data and processed information;
 - (iii) where non-GTS circuits are used procedures applicable to these circuits should be followed.
- (b) Methods and capabilities to be used for the transmission of ocean data from ODAS to the shore should include those offered by the following:
 - (i) International Maritime Mobile Service;
 - (ii) Radio communication using HF bands allocated by the ITU World Administration Radio Conference;
 - (iii) Geostationary meteorological satellites through their International Data Collection System;
 - (iv) Polar orbiting satellites;
 - (v) Communication satellites, such as International Maritime Satellite System (INMARSAT).

Collection and Exchange of BATHY and TESAC Reports

67. The collection and exchange of BATHY and TESAC reports involves the following four stages:

- (a) Ship to coastal radio station or earth station;

- (b) Coastal radio station or earth station to National Meteorological Centre (NMC) or an Oceanographic Data Processing and Service Centre (OPC);
- (c) NMC or OPC to an appropriate GTS centre for data insertion in the GTS;
- (d) Over the GTS, from a GTS centre to national oceanographic or meteorological centres.

Relevant detailed procedures are specified in the Guide to Operational Procedures for the Collection and Exchange of Oceanographic Data (BATHY and TESAC) (IOC Manuals and Guides No.3).

Methods of Data Collection

68. Collection of marine environmental data from various ocean based platforms will be carried out by the following four methods:

- (a) International Maritime Mobile Service: This Service is used for the collection of marine meteorological reports from WMO voluntary observing ships and similarly of BATHY and TESAC reports for IGOSS. These reports are defined by the ITU Radio Regulations as "meteorological radiotelegrams" and should bear a specified service instruction and paid service indicator. WMO publishes a list of coastal radio stations designated by its Member States for the reception of ship reports, including BATHY and TESAC reports, free of charge. Watch-keeping hours aboard single operator ships and the increasing traffic in the Maritime Mobile Service, especially in HF communications, have been two main areas of difficulty affecting the timely and efficient collection of ship reports. To overcome these difficulties, introduction of new technology, such as the direct printing system with selective calling devices and satellite data collection system, should receive urgent attention.
- (b) Communication using six HF bands allocated by the World Administrative Radio Conference: The ITU World Administrative Radio Conference (WARC 1967) allocated six HF bands each 3.5 KHz in width in the 4, 6, 8, 12, 16 and 22 KHz ranges for the transmission of ocean data. In response to a WARC decision and in order to assure the rational utilization of the allocated bands, procedures have been established whereby the IOC and WMO Secretariat jointly act as a co-ordinating body for their use. Frequencies reserved and/or allocated to various countries are recorded in the Agreed Interim Frequency Utilization Plan which is kept updated and circulated to all WMO and IOC Member States. The WARC-1974 decided that the present allocation of the six HF bands should be maintained without change until the next Administrative Conference in 1979. Therefore, the existing arrangements for the utilization of the frequencies should continue to apply at least until then.

(c) Satellite Data Collection System:

- (i) Data collection from buoys, ships and remotely located platforms will be possible via geostationary and polar orbiting meteorological satellites during the present implementation period (1977-1982). The geostationary meteorological satellites to be launched by the European Space Agency (ESA), Japan, the USSR and the USA in support of the First GARP Global Experiment (FGGE) and expected to continue in support of the World Weather Watch will have an International Data Collection System. This system should also be used for the collection of IGOSS observational data. A similar system will also be available on polar orbiting meteorological satellites.
- (ii) The International Maritime Consultative Organization (IMCO) is undertaking a project for establishing an International Maritime Satellite System (INMARSAT) which is intended for providing, amongst others, an effective service for the collection and distribution of navigational, meteorological, hydrographic and oceanographic information, including transmission by direct printing and/or facsimile.
- (d) Very High Frequency Transmission: Very high frequency transmissions (VHF) make it possible to set up short-distance links (within sight); they are being used for the collection of data from moored buoys situated close to coastlines.

Dissemination of Products to Users

69. Dissemination of products to users is to be arranged on a national basis using the national meteorological telecommunication network of the GTS and/or other appropriate telecommunication circuits.

IGOSS DATA PROCESSING AND SERVICES SYSTEM (IDPSS)

Purpose and Principle

70. IGOSS has stimulated observation of the ocean environment and the regular collection and exchange of these data in real-time. The IDPSS provides the basis for an international data processing and services system for the provision of oceanographic analysis and prediction products. The purpose of the IDPSS is to make available to users the basic processed observational data and analyses needed for real-time and near real-time applications. This system is intended to provide a common basis for the operations of the various oceanographic centres which have been established to meet the particular user requirements of an area. The functions of the various centres will not affect the status of any international commitment of countries to give support to shipping and air/sea rescue nor to determine the manner in which members execute these responsibilities.

71. Products produced by the IDPSS will be useful in the following (not listed in priority order):

- (i) shipping operations;
- (ii) engineering operations at sea;
- (iii) fisheries research and operations;
- (iv) aqua-culture operations;
- (v) evaluating the consequences of man's activities in the sea, such as oil spills, atomic power plant location, deep water port location, waste disposal and other modifications to existing systems;
- (vi) oceanographic research;
- (vii) atmospheric prediction models and climate modelling.

Organization of the IDPSS

72. The IDPSS will be composed of three types of centres. These types, with their distinguishing characteristics, are:

- (i) World Oceanographic Centres (WOC). These centres provide processing on a global and/or hemispheric, and major ocean basin scale. They collect and process IGOSS observations received over the GTS from specialized and national centres. They offer oceanographic products such as sea surface temperature and mixed layer analyses to any participating nations interested.
- (ii) National Oceanographic Centres (NOC). These centres are organized to satisfy the requirements of the particular nations' users. They will receive products from the world centres as needed in support of their service programmes. They will monitor IGOSS data collection from sources within their nation;
- (iii) Specialized Oceanographic Centres (SOC). SOCs are established when required by participating nations for data processing and the provision of products for users in their countries. This type includes centres which are specialized in the processing of certain ocean parameters and which serve, through their products the particular needs within a well-defined ocean area or sea.

A SOC could be a national centre or one established as a joint effort of several countries and will be included in the system only when a willingness has been expressed to adhere to IGOSS objectives. These specialized centres will be treated the same as national centres for IDPSS purposes, with the World Centres taking full account of their specialized needs for synoptic oceanographic support.

73. The Global Observing System of the World Weather Watch (WWW) and IGOSS will produce large amounts of marine environmental data. As in meteorology, speed in processing oceanographic observational data in the form of analyses and prognoses is essential. To begin with, the ocean thermal and density structures of the upper layers will be analysed. Eventually, ocean current observations and analyses will be included

as the IDPSS develops. Considering the scarcity and high cost of observations of temperature and salinity in the ocean, it is also necessary to have efficient systems for data storage and retrieval for both real-time and archival uses.

Specified Functions of WOCs for 1977-1982

74. Real-time processing functions:

WOCs will:

- (i) receive observations and prepare analyses of sea surface temperature according to the specifications set out below;
- (ii) receive observations and prepare analyses of temperature at fixed levels for the upper ocean;
- (iii) prepare edited collections of observations in standard and special formats for users; and
- (iv) execute quality control procedures.

75. Non-real-time processing functions:

WOCs will:

- (i) document procedures for quality control and exercise quantity control procedures;
- (ii) provide IGOSs Responsible National Ocean Data Centres (IRNODC's) with collections of sub-surface data in standard formats;
- (iii) publish descriptive material fully explaining methods of analysis;
- (iv) prepare product analyses for routine periodic exchange;
- (v) provide processed products for research uses;
- (vi) provide opportunities for exchange visits.

The forms in which data are processed for climatological and research purposes should be such that it can be published. Data which are needed for large-scale investigations should be readily available in a convenient format for machine processing.

Specifications for Initial WOC Products

76. The initial products for exchange will be the sea surface temperature at points of the numerical weather grid in common use at the time of the initial exchange and the mixed layer depth for the same points. Each of these initial products is now described in operational terms.

77. Additional requirements for oceanographic information on a regular basis will include sea surface temperature and the temperature structure with depth down to 500 metres on a grid of one degree latitude dimensions. It is logical to begin the exchange between the WOCs and the NOCs and SOC's with products which are somewhat less comprehensive than those needed for the 1978-1982 time period. Specifications for these products are as follows:

- (i) sea surface temperature (SST)
 - (a) sea surface temperature from open ocean areas (i.e. 100 km from land or ice, and greater than 200 m water depth);
 - (b) scalar variable;
 - (c) range - 5°C to 40°C ;
 - (d) temperature of the surface sea water layer to 1 metre depth;
 - (e) grid point values are to be in degrees and tenths;
 - (f) data points will be at grid spacing commonly used;
 - (g) 100 km spacing by 1978, northern hemisphere to start, later globally;
 - (h) isoline charts with contours at 4°C with 2°C spacing optional in flat gradient areas;
 - (i) polar projections for areas at latitudes higher than 20° to 30° . Mercator projections for areas at lower latitudes and as one which may be used for global coverage;
 - (j) internally WOCs may produce charts with different characteristics;
 - (k) daily analysis;
 - (l) exchanged once/day;
 - (m) day-to-day difference fields and indications of diurnal variations will be maintained as much as possible;
 - (n) mean charts may be prepared as required (e.g. 5 day, 10 days, 1 month);
- (ii) mixed layer depth (MLD)
 - (a) mixed layer depth - depth of surface layer of homogeneous temperature;
 - (b) computer definition - increasing levels of depth from the surface are considered until a temperature 2°C colder than the surface temperature is reached. Then the last significant level considered is established as the MLD. If the entire profile is within 2°C of SST then the MLD is the depth of the profile's bottom depth;
 - (c) grid point field - depth will be defined to the nearest 10 metres;
 - (d) information on existence and day-to-day persistence of transients (i.e. shallow minor thermoclines due to surface heating) should be maintained when feasible;

- (e) analyses, using WMO Code Form FM 47-V-GRID, should be exchanged daily over the GTS;
- (f) initially (1977-1978) analysis will be confined to the northern hemisphere with global analysis available later (1978-1980).

78. Where possible, analysis of a parameter will be based on corrected data and will be prepared using computer methods. In producing the analysis, it is desirable to make broad use of observational data obtained from all available platforms including ships, aircraft, buoys and satellites. The results of the analysis may be presented either in graphical form or as a field of data at fixed grid points and as a list of accepted, rejected and interpolated data. The distribution of the results of the analysis should be through the international GRID code or graphically. Forecast of variations of a parameter in time should be made using numerical models for presentation in digital and/or graphic form.

Development Aims for WOCs

79. The WOCs should endeavour to develop and adapt research models for operational analyses and interactive predictions of the atmosphere-ocean system for up to one or two weeks into the future. These models should include predicted ocean temperature structure as an output, and will have realistic first approximations to atmosphere-ocean energy exchange mechanisms. Further they should develop and adapt research models for ocean motion and circulation which will accept water level and current observations and predict these as long as possible (2-5 days) into the future.

Specifications for NOCs and SOCs

80. To provide a useful contribution to the IDPSS, centres should:
- (i) use uniformly accepted formats or codes for input of the original data;
 - (ii) make its products available on request to users outside its area of concern in a form compatible with general international standards. Besides distribution of its own products, NOCs are responsible for making available the products of WOCs to those requiring them. These may be in the original form or as modified by the NOC;
 - (iii) endeavour to provide additional products in its field of speciality, when requested, on the basis of user requirements arising through the IDPSS;
 - (iv) store data in a format compatible with those specified in the Manual on IGOSS Data Archiving and Exchange;
 - (v) publish selected data if required;
 - (vi) co-operate in the training programme conducted within the framework of IGOSS;
 - (vii) exercise strict quantity and quality control procedures.

Quality Control

81. The basic elements of quality control of BATHY and TESAC data obtained through the GTS system consist of the detection of errors occurring during the production and coding of the data, and of errors and distortions which creep into the text of the bulletins during transmission along the telecommunications channels.
82. The responsibility for primary quality control of transmitted observational data rests with national centres which eliminate such crude errors as: distortion of vessel position co-ordinates, incorrect ordering of groups in the report, substitution of initial figure of the groups and errors caused by the telecommunication line. Primary control also includes correction of group indicators in the bulletin and the number of figures in the group. It is desirable that national services use similar procedures for control of their observations and make provision to ensure that data entered into the GTS in the form of bulletins be made error free.
83. Quality control procedures should be an integral part of the operational programmes but efforts should be made to minimize delay of transmitted data to processing centres. In order to ensure high quality product outputs, data processing centres must eliminate errors which were not detected during data control at national centres and which arose in bulletins through the fault of the telecommunication system. Reliability control of the parameter under observation (temperature, salinity, waves, current, etc.) should be carried out at the processing centres by objective analysis of the distribution range of the parameter concerned.

The Exchange of Processed Data

84. The data received at WOCs via the GTS from national centres is transferred onto magnetic tape for further processing (analysis/forecast). The collected data bulletins are combined for each individual ocean region, part of the ocean or individual basin for further processing and return transmission to national centres. In addition, the data is entered on the appropriate form for further transmission and processing in non-real-time at IGOSS Responsible National Oceanographic Data Centres (IRNODCs) and National Oceanographic Data Centres (NODCs).
85. The NOCs and WOCs on the basis of the data collected, and using objective analysis and numerical forecasting methods, issue products (analyses/forecasts) in response to the needs of users and other centres. For the sake of greater operational effectiveness in receiving the processed products, exchange between centres is done in international GRID code numerical form. At the request of the centres, the exchange may be done using combined data forms which have undergone primary processing for individual regions of the world oceans.

Archiving and Exchange

86. Observational data (BATHY and TESAC) received by NOCs and SOCs should be transferred by them in non-real-time, in appropriate form for further periodical processing to IRNODCs. IRNODCs should carry out the procedures for archiving and exchange of data in accordance with the Manual on IGOSS Data Archiving and Exchange.

DATA ARCHIVING AND EXCHANGE

Purpose

87. From the earliest stages of intergovernmental planning for IGOSS, it was recognized that most data collected in conjunction with IGOSS would be of permanent value and that arrangements should be made for their preservation, beyond their initial operational use. Consequently guidelines for archiving and exchange of data were developed. These are contained in the Manual on IGOSS Data Archiving and Exchange.

88. One basic objective of the system prescribed by the Manual is to establish complete archives of the IGOSS data in its shipboard encoded form within less than six months from the time of collection. The primary role of the World Data Centre System in the IGOSS scheme is to maintain various indexes to the archived IGOSS data. Normally however, much of the IGOSS data, which have been shipboard encoded, will be carefully processed in greater detail and with greater accuracy by land-based activities. This conventional type of data is exchanged through the NODCs and the WDC (Oceanography) in accordance with the procedures stipulated in the IOC Manual on International Oceanographic Data Exchange (IODE).

BATHY and TESAC Data

89. The Manual is primarily concerned with BATHY and TESAC reports and offers procedures for their handling and disposition. BATHY and TESAC reports coded on shipboard on standard IGOSS BATHY and TESAC logs reach archiving centres via two separate routes:

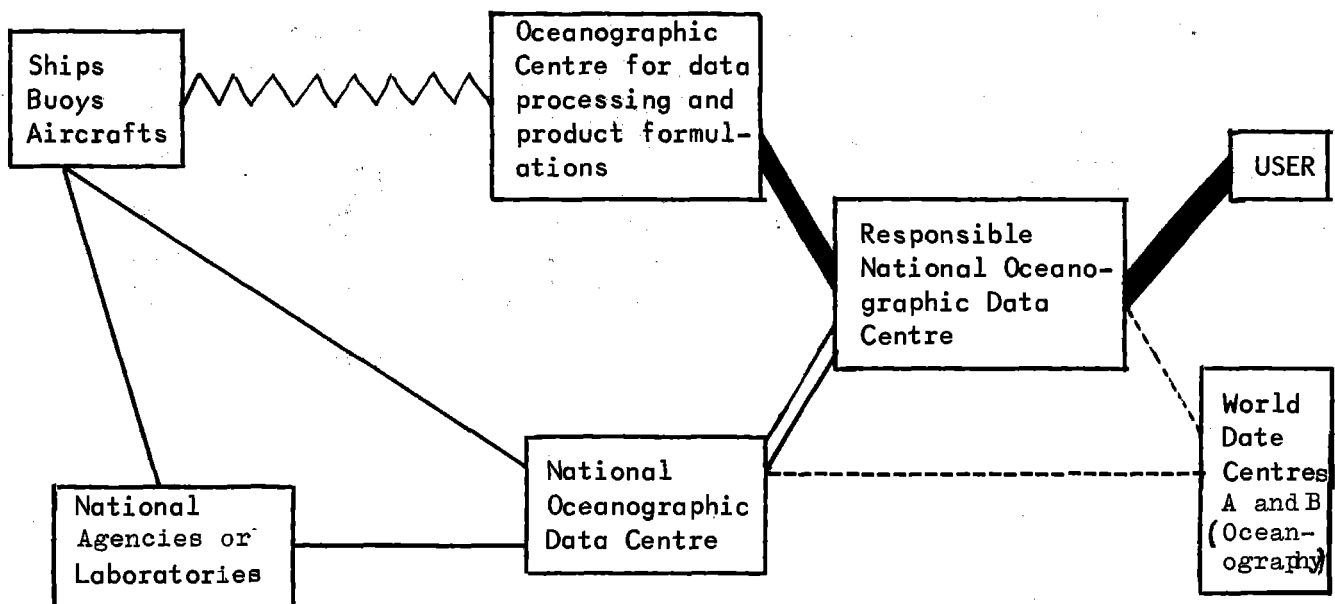
- (a) Logs are mailed to the appropriate National Oceanographic Data Centre (NODC) or its equivalent. The NODCs process the data on the logs into a standard archival format for IGOSS data, the OCEAN SYNDARC Format, and transmit them to one of the IGOSS Responsible NODCs (IRNODCs). The IRNODCs are certain NODC's which have assumed the responsibility to maintain complete archives of IGOSS data for specified regions of the world's oceans and to provide exchange and other services to the "secondary" (i.e. non-operational) user community.
- (b) The BATHY and TESAC reports, telecommunicated in international Code Forms FM 63 and 64 and transmitted through the GTS are to be recorded on suitable technical carriers (e.g. magnetic tape) by the Oceanographic Centres and delivered at weekly intervals to the nearest IRNODC. The IRNODCs will, subsequently, compile a comprehensive OCEAN SYNDARC formatted archival file.

Future Developments

90. In the period 1977 to 1982, it is anticipated that there will be three major developments within the framework of IGOSS which will require expansion or modification of the present scheme for IGOSS Data Archiving and Exchange:

IGOSS Data Archiving and Exchange System

(BATHY and TESAC)



~~~~~ Telecommunicated BATHY and TESAC Reports

----- Inventories

———— BATHY and TESAC Logs

===== Tapes, Cards, etc. (OCEAN SYNDARC)

———— Tapes of BATHY and TESAC Reports,  
Data summaries, analyses products

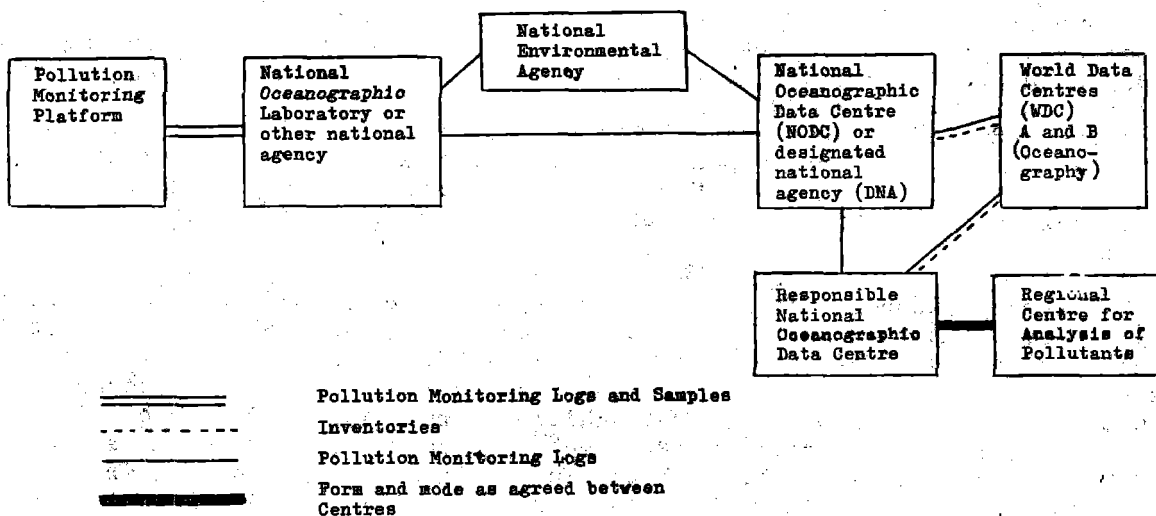
- (i) New Data - The broadening of programmes, either directly stemming from IGOSS or utilizing IGOSS for their support, to include new types of data such as surface currents and telecommunicated data from platforms other than ships, i.e. satellites and buoys and data from marine pollution monitoring programmes;
- (ii) IDPSS - The implementation of the IDPSS and the establishment of National, Specialized and World Oceanographic Centres and their operational capabilities will most probably have a profound effect both on the archiving procedures for BATHY and TESAC data as well as for other telecommunicated data;
- (iii) IGOSS Archival Services - With the growth of the IGOSS archival data banks, there will be a corresponding growth in the range of services offered by the IRNODCs. At the same time there may well occur an increase in the number of IRNODCs and a realignment of their areas of responsibility.

#### Marine Pollution Data

91. Data collected through the Pilot Project on Marine Pollution (Petroleum) Monitoring are not intended for radio transmission. The data obtained from observations using standardized techniques are recorded on standard IGOSS logs and forwarded to national agencies by mail. The data are then transmitted to NODCs or their equivalent and finally to the IRNODCs. The urgency of the data flow to IRNODCs depends on the type of data, e.g., data on visually observed pollutants may be required to flow rapidly, whereas data on, say, dissolved hydrocarbons need not be handled so quickly. Having regard to the complexity of these collection procedures, close monitoring is called for and an effective liaison established with IODE.

#### Marine Pollution Monitoring Pilot Project Data

##### Archival and Exchange System



Note: This scheme will further be elaborated in co-operation with the IOC Working Committee on International Oceanographic Data Exchange in the course of development and implementation of the Marine Pollution Monitoring Pilot Project

### Satellite and Aircraft Data

92. At this stage, information concerning the type of sea surface temperature data likely to be available from direct reading equipment in satellites and aircraft is incomplete. This data should be held in centres specializing in the archiving of such data and not included in IGOSS archives. Inventories of the information held can be kept at IRNODCs. The procedures for archiving this important data demand further study and IGOSS must work closely with the IOC Working Group on IODE on this matter.

### Other Data

93. The archival procedures for simple types of data such as surface currents which are recorded similar to temperature and salinity data on standard shipboard Logs and telecommunicated using standard international code forms, would be essentially the same as for the BATHY and TESAC reports. An increase in data recorded and telecommunicated automatically is expected during the next phase of IGOSS. The main sources of such data will be surface and sub-surface sensors mounted on buoys and fixed platform, but may also include bathythermograph and other data automatically encoded on board ships. This data is highly desirable from an IGOSS archiving point of view. It is telecommunicated and subsequently transmitted via the GTS in standard international codes, transferred from Oceanographic Centres to IRNODCs on computer-compatible carriers, and converted into an OCEAN SYNDARC archival format. There being no "Logs", no time-consuming digitization and related processing would be required.

### Archival and Exchange of Products

94. The planned implementation of the IDPSS and its associated NOCs, SOC's and WOC's will result in major benefits to the "secondary" users by broadening and strengthening of the IGOSS Data Archiving and Exchange scheme. The most notable of these benefits is expected to be in the area of improved quality of archived data, generation of archivable data summaries and products, and greater efficiency of the archive-related processing.

95. One of the functions of the WOC's and NOC's is to apply statistical and analytical quality control to data received as an integral part of producing synoptic analyses and prediction products. It would therefore be highly advantageous for the IGOSS Archiving Centres i.e. NODCs and IRNODCs, to receive their telecommunicated data from the WOC's and/or NOC's after these have been subjected to quality control rather than before. This arrangement would not preclude efforts at further quality control of the data by NODCs and IRNODCs. The intercomparison of data from diverse sources such as ship SSTs and satellite SSTs is an example of an IDPSS control service.

96. For many secondary user requirements, data summaries may actually be of greater interest than the basic data. Decisions on what to archive at IRNODCs in the way of products will have to be based on a careful review of potential long-term user requirements and the nature, attributes, and volume of the products as they evolve within the IDPSS framework. The judicious archiving of data products is one approach to encompass auxiliary data from multiple sources. For instance, satellite-sensed SST data are certain to be utilized in digital or image form in order to enhance conventional SST analyses, but are poorly suited for archiving within the context of IGOSS. The archiving of analysis products would, in a sense, preserve the effect of such high volume or specialized data sets for numerical analyses without the need to place them into the IGOSS Archiving Scheme.

### Archival Services

97. The IGOSS Archival Centres, especially the IRNODCs, though not operating in a "real-time" mode, can provide oceanographic services. The principal functions of the IGOSS RNODCs are defined in the Manual on IGOSS Data Archiving and Exchange. With the expected growth in the volume of data in their data bases and with improved geographic coverage of data, the IRNODCs will eventually be in a position to provide certain additional services on a routine or occasional basis. These will fall into three broad categories:

- i. Data summaries and analyses encompassing archived data from time periods of greater duration than those used by the WOCs, SOC's and NOCs. Most operational products of the latter will be based on time periods of days or at most perhaps one to four weeks. The IGOSS RNODCs archives would furnish the appropriate source for monthly, seasonal or annual data summaries.
- ii. Preparation of special, near-operational, or delayed mode products for specified regions based on the telecommunicated data. The capabilities of the IRNODCs may be used to augment the services provided in the context of the IDPSS. For example, in a certain region there may be an operational need for analyses based on a grid spacing, time period of averaging, contour interval or depth level, other than those provided by the IDPSS.
- iii. Services to users of non-telecommunicated data and data documentation. For types of data such as are being generated by the Pilot Project on Marine Pollution (Petroleum) Monitoring, the IRNODCs may be the most suitable IGOSS component to provide data and services to agencies conducting regional and global assessments and analyses.

### MARINE POLLUTION MONITORING PROGRAMME

98. In response to a recommendation of the UN Conference on the Human Environment, IOC and WMO have agreed jointly to undertake design, planning and development of a marine pollution monitoring programme as a function of IGOSS. Actions have already been made in this direction and they have received substantial support from UNEP in view of the close relationship of this programme with activities aimed at establishing a Global Environmental Monitoring System. The Seventh World Meteorological Congress stated that attempts should also be made to meet requests for monitoring pollutants in addition to oil within the framework of IGOSS. As a first step in this regard, IGOSS will concentrate on the monitoring of background pollution in the open ocean.

99. The objectives of the IGOSS marine pollution monitoring programmes are to organize, through international co-operation, systematic observations of marine pollution to obtain information about long-term changes and trends in the levels of pollutants which can endanger human health, have a harmful effect on living organisms or which influence the exchange of energy and matter between ocean and atmosphere.

This information should contribute to the formulation of mass balance relations which can then be used to develop the scientific basis for the periodic assessment of the state of pollution of the world's oceans and to assist in decisions on the need for regulatory action to control marine pollution.

100. It is envisaged that the following pollutants should be monitored within these programmes:

- (a) Chlorinated hydrocarbons;
- (b) Heavy metals;
- (c) Petroleum and petroleum products;
- (d) Surface active substances;
- (e) Transuranic elements.

101. The marine pollution monitoring programmes should be planned and carried out in co-ordination with the Global Investigation of Pollution in the Marine Environment (GIPME) and the WMO network of regional and baseline stations for monitoring air pollution at background levels and as a part of the Global Environmental Monitoring System of UNEP. Close collaboration is required between relevant IGOS bodies, the IOC Working Committee for GIPME, GESAMP and the WMO Executive Committee Panel on Atmospheric Pollution.

102. A number of development efforts will be required to achieve a comprehensive ocean monitoring programme. Particular attention during this period should be given to:

- (a) Further development of regional marine pollution monitoring programmes, e.g. in the Mediterranean.
- (b) Design and development of a system for monitoring background levels of selected pollutants in open ocean waters.
- (c) Development of Pilot Projects, similar to the Pilot Project on Marine Pollution (Petroleum) Monitoring for the monitoring of pollutants other than oil.
- (d) Further development of international procedures for the exchange of marine pollution data particularly with the IOC Working Committee on IODE.
- (e) Intercomparison of sampling and sample preservation methods and of sample analysis methods particularly with the Working Committee for GIPME and GESAMP.
- (f) Provision of assistance to developing countries to enable them to participate actively in the programme particularly with the IOC Working Committee on TEMA.

## TRAINING AND EDUCATION PROGRAMME

103. To create a global system, efforts must be made by IOC and WMO to involve as many countries as possible. Particular attention in this regard should be given to the training of specialists in the developing countries in the diverse aspects of the work associated with IGOSS, both on the national and international level. Training should be provided on oceanographic and marine meteorological observation techniques, instrument installation and maintenance, data processing, analysis and prediction of oceanic processes, and user application of products and services. The collection, preservation and analysis of samples of sea water for the purposes of monitoring of marine pollution should also be included.

104. These activities should be further developed through the existing mechanisms in IOC and WMO: the IOC Working Committee on Training, Education and Mutual Assistance (TEMA), the WMO Executive Committee Panel on Education and Training, the Division of Marine Science of UNESCO and the WMO Secretariat. The major task of TEMA is to develop and recommend programmes for training, education and mutual assistance as well as appropriate mechanisms for the implementation of these programmes.

105. During the period 1977-1980 attention should be given to the identification of special requirements for training and education for existing IGOSS operational programmes and projects, initially the BATHY/TESAC operational programme and the marine pollution monitoring project. The training and education programme may include: training courses and seminars; shipboard training; participation of specialists from developing countries in the work of IGOSS Data Processing Services Centres and marine chemical laboratories; preparation of textbooks, Manuals and Guides on various aspects of IGOSS Programmes; and participation of specialists in seminars and workshops related to IGOSS.

106. The use of UNDP, UNEP, VAP and IOC trust funds will be required to plan and implement the IGOSS training programme.

## RESEARCH AND DEVELOPMENT

### Scales and Processes

107. It is recognized that an understanding of oceanic mechanisms and their interactions through a range of time and space scales, even if only empirical, is necessary before oceanic predictions are attempted. Pilot studies, both in terms of ongoing or finite scientific experiments or as limited tests of specific IGOSS component operations, should always be undertaken. These pilot studies need not necessarily involve advanced technology but may be based on simple widely available techniques. The purposes of such studies should be:

- (a) to obtain a quantitative basis for ocean data network design;
- (b) to improve our knowledge of oceanic mechanisms, their interactions, and their relative dynamic importance;
- (c) to develop methods for processing and analyzing the data that will be collected in IGOSS. The difficulties of large-scale ocean data handling should not be underestimated.



108. Studies and experiments directed at defining the structure and behaviour of thermal anomalies and the development of diurnal and seasonal variations of the thermocline for an ocean basin are of considerable importance to the development of IGOSS. Time and space scales of variability are aspects of these studies that will have a great impact in the design of any form of global monitoring network. Studies of the onset and variation of upwelling and related predictive models - and also air-sea interaction studies aimed at predicting small-scale and large-scale processes, particularly in the lower atmosphere and upper ocean - are being conducted. These experiments are aimed at elucidating fundamental physical processes that will form the basis of predictive models. Considerable importance is placed on work in physical oceanography at intermediate scales (days to weeks and tens of kilometres). Experiments are taking place in an area of weak currents which indicate horizontal scales of the order of 100 kilometres and typical speeds of the order of 30 cm/sec for the daily-averaged surface currents. The importance of smaller-scale processes in many problems is also recognized, but not enough is known about them to take them into account explicitly in the design of a global network.

109. The continuing need for examination of the problem of the development of network design criteria by scientists competent in statistical sampling is recognized. The design of a global network of stations, for example, should be subject to a statistical analysis of scales of variability, keeping in mind the use to which the data provided by the network is to be put. Studies of time and space scales of variability must be linked to the variable under consideration.

#### Techniques and Methodology

110. Research priorities in techniques and methodology should be specified in relation to the desired application, bearing in mind the limitations imposed by the scales of variability of the relevant parameters in the ocean. Questions on the siting of baseline stations, key regions, and standard sections should be decided by consideration of the processes that they are intended to elucidate, rather than by technological or logistic considerations. Some improvements in the operations of IGOSS can be made with reasonable economy, for instance by improvement and standardization of sensors used by ships. More effective use of these and similar observing platforms depend less on research than on better organization, increased funds and on some further engineering developments. For example, improved methods could be provided for measuring sea-surface temperature; improved logs could be fitted to ships with high navigational capability so as to allow better estimates of near-surface currents; underway profiling devices could be developed to sample plankton, temperature, salinity, etc.; and the use of expendable bathythermographs could be increased.

111. Models, both mathematical and analogue are being developed in several countries. These aim at representing marine phenomena and circulation on various scales. The most important contribution to these models would be in the development of techniques and methods for satisfactory incorporation of processes, of which the scales are smaller than the sampling grid. There will also be a need for monitoring their output, by direct comparison of observations and predictions for suitably chosen parts of the model or by checking the simulated integrated effects against observed values.

Approach

112. The responsibility for the studies and experiments which would lead to the solution of the problems cited in the previous paragraphs lies with Member States. They are urged to undertake research programmes to facilitate the development of IGOSS. In doing so, the international mechanisms already in existence for co-ordinating and designing research programmes, such as LEPOR, SCOR and GARP, should be used whenever possible.

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