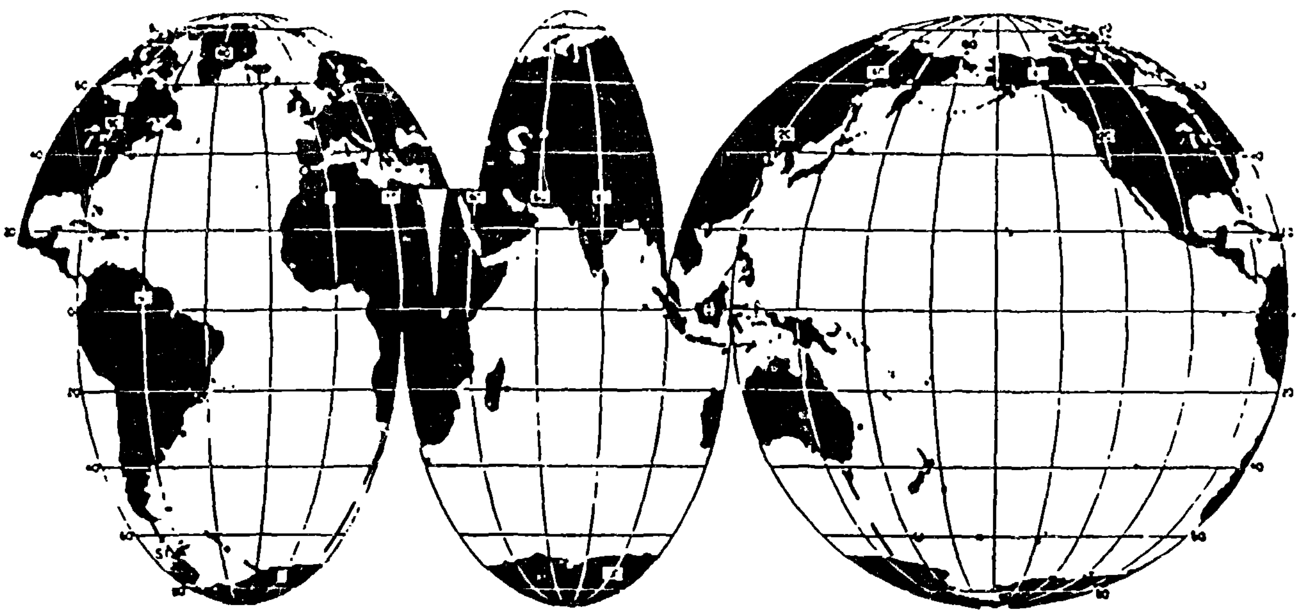
IOC/INF-833

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (of Unesco)

WORLD METEOROLOGICAL ORGANIZATION

GLOBAL OCEAN OBSERVING SYSTEM

STATUS REPORT ON EXISTING OCEAN ELEMENTS AND RELATED SYSTEMS



DECEMBER
1990

IOC/INF-833
Paris, 18 December 1990
English only
(with Executive Summary translated into
French, Spainish and Russian)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1 This report documents the status of implementation of intergovernmental systems for monitoring ocean variables. It is a compilation of information, intended as a first step to development of a long-term global ocean observing system, an initiative being undertaken in response to world-wide demands for a better understanding of ocean behavior and its role in the global environment.

2 In response to the UN General Assembly Resolution on the Protection of Global Climate for Present and Future Generations of Mankind and subsequent recommendations made by Working Groups of the Intergovernmental Panel on Climate Change, the Intergovernmental Oceanographic Commission (IOC) has initiated development of a comprehensive Global Ocean Observing System (Resolution XV-4 of the IOC Assembly, July 1989). The World Meteorological Organization (WMO) is co-operating with the IOC on this initiative. The Twenty-third Session of the IOC Executive Council in 1990 adopted Resolution XXIII-5 calling for a status report on the immediate requirements for an ocean observing system.

3 The Scientific and Technical Sessions of the Second World Climate Conference in October 1990 identified an urgent need to create a Global Climate Observing System to be built upon the existing World Weather Watch Global Observing System and the IOC-WMO Integrated Global Ocean Services System. Operational monitoring is a prerequisite for determining the role of the ocean in the earth's climate. Monitoring is similarly needed for developing other national and international environmental policies on such issues as pollution, commercial fisheries development, coastal zone management, and weather prediction. An ocean monitoring system should be viewed as a component of a global system for monitoring and predicting environmental change. The economic benefits of adequate predictions are estimated to be several hundred billion dollars.

4 Several expert consultations have been held, with recommendations to be forwarded to the IOC Committee on Ocean Processes and Climate and the Sixteenth Session of the IOC Assembly in 1991. Recommendations include preparation and annual update of a status report on existing elements of a global ocean observing system.

5 A CCCO-JSC Ocean Observing System Development Panel is charged with formulating the conceptual design of an operational observing system to monitor physical and other properties that determine ocean circulation and the response of the ocean to climate change. It will complete its work in December 1994.

6 Large-scale climate research programmes including TOGA and WOCE have identified the observational requirements for achieving their objectives. Although requirements may change in the coming decades as our knowledge and our need for knowledge increase, we can use the experience provided by these research programmes to establish initial parameters, processes, phenomena, and features to be measured over a long-term. The present urgency for a world ocean observing system will not permit us to wait for further research before embarking on implementation of a plan for operational monitoring.

7 **This Status Report includes a collation of requirements from existing and planned large-scale climate research programmes (TOGA, WOCE, JGOFS, GEWEX, WCDP, and polar programmes) and a description of existing ocean observing and data management systems of IOC and WMO. This is the first report of this nature and does not include an analysis of needs, specific strengths and weaknesses, etc. It is envisioned that in 1991 the scientific community will be invited to assist in conducting such analyses and in developing plans for implementation. Information contained in this report will be used as a basis. Systems described here include:**

(i) **World Weather Watch (WWW)**- the WMO international operational programme for gathering and distributing in real-time meteorological and related environmental data on a global scale. It manages the Global Telecommunications System (GTS), an increasingly automated network of point-to-point circuits for collecting and disseminating data. Its Global Observing System includes over 7,000 ships recruited by 49 countries who participate in a Voluntary Observing Scheme to provide marine meteorological information (including SST, waves, etc). Although WWW surface coverage is extensive, large voids exist over ocean areas, especially in the southern hemisphere. Polar-orbiting satellites are operated by 4 countries with plans underway for additional satellite series; geostationary satellites are also presently operated by 4 countries.

(ii) **Integrated Global Ocean Services System (IGOSS)**- the IOC-WMO system for the collection and exchange of oceanographic (surface and subsurface temperature, salinity, currents) data in real-time, operated jointly by the IOC and the WMO, using the GTS. Approximately 40,000 sub-surface observations and 5,000 salinity observations are transmitted annually. The IGOSS Ship-of-Opportunity Programme includes over 200 ships taking observations, many of which carry automated systems for automatically encoding and transmitting data via satellite. Substantial national commitments are needed to provide adequate coverage, particularly in the Indian and Southern Oceans, data-sparse areas.

(iii) **Global Sea Level Observing System (GLOSS)**- the IOC programme for the provision of standardized sea level data (both in near real-time and delayed mode) from a global network of stations. Presently about 200 of the 306 proposed stations are operational, with the support of 79 countries. A selected set is connected to a global geodetic reference system. Data is submitted to the Permanent Service for Mean Sea Level, which disseminates and analyzes sea level data, as well as to TOGA and WOCE sea level centers. Substantial efforts are needed to establish and maintain stations in the Arctic and Antarctic, as well as in Africa and on remote islands.

(iv) **Drifting Buoy Activities**- managed by the IOC-WMO Drifting Buoy Co-operation Panel. Approximately 600 buoys are now operated by 11 countries, with 35%-50% transmitting data in real-time via the GTS. That proportion is increasing.

(v) **International Oceanographic Data Exchange (IODE)**- the IOC programme which maintains procedures and fosters facilities for international exchange of ocean data through a network of national oceanographic data centers, designated national agencies, responsible national oceanographic data centres, and world centres. A total of 42 countries now have national data centres or designated national agencies. The marine data base of the World Data Centre system contains data from more than 2,250,000 observations from 61 countries, including oceanographic station data, bathythermograph observations, biological and marine geological data, and current measurements. The IOC has also developed a Marine Environmental Data and Information Referral System (MEDI), a data source guide which describes data sets available at data centers. Actions are being taken by IOC and WMO, through IGOSS and IODE, to create a timely and complete global ocean data and information base to support the World Climate Research Programme and national programmes.

(vi) **World Climate Programme**- promotes, under the auspices of WMO, internationally co-ordinated research and monitoring of climate variations or changes, including a Climate Change Detection Project initiated in 1989.

8 The United Nations Environment Programme (UNEP), IOC, and WMO are developing a Master Plan for long-term monitoring in the coastal zone that will contribute to efforts to assess climate change and its impacts. Parameters are to include physical, chemical, and biological variables. Data from existing systems would be used to the maximum extent possible.

9 The spectrum of international programmes to be involved in the Global Ocean Observing System is shown in Figure 1. In reviewing the extent of present monitoring by existing intergovernmental systems, substantial gaps can be seen in the essential coverage required. Present contributions of Member States and national institutions (in the form of ocean platforms and data transmitted for international exchange) permit implementation of 30 to 50% of the established plans for IGOSS, GLOSS, and drifting buoys. There is a diverse array of operational and research platforms operated by agencies and programmes with different missions and requirements, leading to the need for a comprehensive, integrated system. Oceanographic sensors for planned satellites are needed, additional drifting buoys need to be deployed, the proposed tide gauge network needs to be completed, and XBT coverage needs to be expanded. Systems are not now in place to take routine biological or chemical measurements. Data management also needs significant attention. Standards need to be established and training provided in processing, presenting, archiving, and exchanging marine data and data products.

10 Because of the magnitude of the cost involved in operating a world ocean observing system, planning must be done carefully, taking advantage of the broadest range of talent and participation. The system will require that operational oceanographic services be established at the national level and that they work closely with national meteorological services. By definition, it is an effort that can only be undertaken by intergovernmental means. As the ocean arm of the United Nations, the IOC is providing the leadership. Close co-ordination needs to be developed and maintained with the climate and environmental monitoring activities of the WMO and UNEP. It cannot be overemphasized that a major new commitment will be needed from Member States; and that all Member States should be involved for the regional and global benefit.

RESUME

1 Le présent rapport fait le point de la mise en place des systèmes intergouvernementaux de surveillance continue des variables océaniques. Il représente une synthèse de l'information nécessaire, dans un premier temps, pour élaborer un système mondial d'observation à long terme de l'océan et répondre ainsi à la nécessité, ressentie partout dans le monde, de mieux comprendre le comportement de l'océan et son rôle dans l'environnement planétaire.

2 Conformément à la résolution de l'Assemblée générale des Nations Unies sur la protection du climat mondial pour les générations présentes et futures et aux recommandations ultérieurement formulées par les groupes de travail du Groupe d'experts intergouvernemental pour l'étude du changement climatique, la Commission océanographique intergouvernementale (COI) a commencé à constituer un système mondial complet d'observation de l'océan (résolution XV-4 de l'Assemblée de la COI, juillet 1989). L'Organisation météorologique mondiale (OMM) collabore à cette initiative avec la COI. A sa vingt-troisième session, en 1990, le Conseil exécutif de la COI a adopté la résolution XXIII-5, dans laquelle il demande que soit établi un rapport sur les besoins immédiats concernant le système d'observation de l'océan.

3 Les participants aux séances scientifiques et techniques de la deuxième Conférence mondiale sur le climat, tenue en octobre 1990, ont jugé urgente la création d'un système mondial d'observation du climat à partir de l'actuel système d'observation de la Veille météorologique mondiale et du Système mondial intégré de services océaniques COI-OMM. La surveillance opérationnelle est indispensable pour déterminer le rôle de l'océan dans le climat de la planète. Elle constitue également un préalable à la mise au point d'autres politiques écologiques, nationales et internationales sur des questions telles que la pollution, le développement des pêches commerciales, la gestion des zones côtières et la prévision météorologique. Tout système de surveillance continue de l'océan doit être conçu comme un élément d'un système mondial de surveillance et de prévision des modifications de l'environnement. On estime à plusieurs centaines de milliards de dollars les retombées économiques de bonnes prévisions.

4 Plusieurs consultations d'experts ont eu lieu et leurs recommandations doivent être soumises au Comité de la COI sur les processus océaniques et le climat ainsi qu'à l'Assemblée de la COI à sa seizième session, en 1991. Ces recommandations comprennent notamment l'établissement et la mise à jour annuelle d'un rapport sur les éléments déjà existants d'un système mondial d'observation de l'océan.

5 Un groupe d'experts CCCO-CSM sur la mise en place du système d'observation de l'océan est chargé de définir la conception théorique d'un système d'observation opérationnelle destiné à suivre en permanence les propriétés physiques et autres qui déterminent la circulation océanique et la réaction de l'océan aux modifications du climat. Ce groupe achèvera ses travaux en décembre 1994.

6 Les programmes de recherche climatologique à grande échelle, notamment TOGA et WOCE, ont identifié les observations dont ils ont besoin pour atteindre leurs objectifs. Bien que celles-ci puissent changer dans les décennies à venir, au fur et à mesure qu'augmenteront notre savoir et nos besoins en connaissances, nous pouvons exploiter l'expérience acquise par ces programmes de recherche pour déterminer les premiers paramètres, processus, phénomènes et caractéristiques à mesurer à long terme. Il ne nous sera pas possible, compte tenu de l'urgence actuelle de la mise en place d'un système mondial d'observation de l'océan, d'attendre que les recherches aient progressé pour entreprendre l'exécution d'un plan de surveillance opérationnelle.

7 Le présent rapport récapitule les besoins des programmes existants et prévus de recherche climatologique à grande échelle (TOGA, WOCE, JGOFS, GEWEX, PMDC et programmes polaires) et décrit les systèmes actuels d'observation de l'océan et de gestion des données de la COI et de l'OMM. Ce document, qui est le premier de ce type, ne comprend pas une analyse des besoins, des points forts et des points faibles, etc. Il est envisagé d'inviter, en 1991, la communauté scientifique à apporter un concours à de telles analyses et à l'élaboration de plans de mise en oeuvre. Les informations figurant dans le présent rapport serviront de base à ce travail. Les systèmes décrits sont les suivants :

(i) Veille météorologique mondiale (VMM). Programme opérationnel international mis en place par l'OMM pour rassembler et diffuser des données météorologiques et les données correspondantes sur l'environnement en temps réel à l'échelle mondiale. La VMM gère le Système mondial des télécommunications (SMT), qui est un réseau de plus en plus automatisé de circuits point à point de collecte et de diffusion de données. Son système mondial d'observation comprend plus de 7.000 navires recrutés par 49 pays, qui participent à un programme d'observation volontaire pour obtenir des informations de météorologie marine (température superficielle de la mer, vagues, etc.). Bien que la couverture géographique de la VMM soit très large, elle comporte d'importantes lacunes sur les océans, en particulier dans l'hémisphère Sud. Des satellites à orbite polaire ont à ce jour été mis en service par quatre pays et de nouvelles séries de satellites sont en projet ; des satellites géostationnaires sont actuellement aussi exploités par quatre pays.

(ii) Système mondial intégré de services océaniques (SMISO). Système COI-OMM de collecte et d'échange de données océanographiques (température superficielle et subsuperficielle, salinité, courants) en temps réel, qui est exploité conjointement par la COI et l'OMM et fait appel au SMT. Ce système transmet annuellement quelque 40.000 observations subsuperficielles et 5.000 observations concernant la salinité. Le Programme de navires occasionnels du SMISO repose sur plus de 200 navires qui effectuent des observations et dont beaucoup sont équipés d'un dispositif de codage et de transmission automatique des données par l'intermédiaire de satellites. D'importants efforts sont nécessaires à l'échelle nationale pour assurer une couverture suffisante, en particulier dans les océans Indien et Austral, sur lesquels les données sont rares.

(iii) Système mondial d'observation du niveau de la mer (GLOSS). Programme mis en place par la COI pour fournir des données normalisées sur le niveau de la mer (à la fois en temps quasi réel et en différé) à partir d'un réseau mondial de stations. Sur les 306 stations envisagées, environ 200 fonctionnent actuellement, avec le soutien de 79 pays. Un certain nombre d'entre elles sont reliées à un système mondial de référence géodésique. Des données sont soumises au Service permanent du niveau moyen des mers, qui diffuse et analyse les données concernant le niveau des mers, ainsi qu'aux centres spécialisés de TOGA et WOCE. Des efforts substantiels sont nécessaires pour mettre en place et maintenir des stations dans l'Arctique et l'Antarctique, ainsi qu'en Afrique et dans les îles reculées.

(iv) Activités dans le domaine des bouées dérivantes. Gérées par le Groupe de coopération COI-OMM pour la mise en oeuvre des programmes de bouées dérivantes. Onze pays ont à ce jour mis en service quelque 600 bouées, dont 35 à 50 % transmettent des données en temps réel par l'intermédiaire du SMT. Cette proportion va en s'accroissant.

(v) Echange international des données océanographiques (IODE). Programme de la COI qui veille aux procédures et favorise le développement des services d'échange international de données océanographiques par l'intermédiaire d'un réseau de centres nationaux de données océanographiques, d'agences nationales désignées, de centres nationaux de données océanographiques responsables et de centres mondiaux. Au total, 42 pays disposent aujourd'hui de centres nationaux de données ou d'agences nationales désignées. La base de données océanographiques du Centre mondial de données contient des informations résultant de plus de 2.250.000 observations effectuées par 61 pays, au nombre desquelles des données provenant de stations océanographiques, des observations bathythermographiques, des données biologiques et de géologie marine ainsi que des mesures de routine. La COI a également mis en place un Système d'accès aux données et informations sur le milieu marin (MEDI), guide des sources de données qui décrit les séries de données accessibles dans les différents centres de données. La COI et l'OMM prennent actuellement des dispositions, par l'intermédiaire du SMISO et de l'IODE, pour créer une base mondiale de données et d'information océanographiques complète capable d'alimenter ponctuellement le Programme mondial de recherches sur le climat et les programmes nationaux.

(vi) Le Programme climatologique mondial. Encourage, sous les auspices de l'OMM, les recherches coordonnées à l'échelle internationale et la surveillance des variations et changements climatiques, y compris un projet de détection des changements climatiques, lancé en 1989.

8 Le Programme des Nations Unies pour l'environnement (PNUE), la COI et l'OMM mettent actuellement au point un plan directeur pour la surveillance à long terme des zones côtières, qui contribuera aux efforts déployés pour déterminer les modifications du climat et leurs répercussions. Au nombre des paramètres suivis figureront des variables physiques, chimiques et biologiques. Il sera, dans toute la mesure du possible, fait appel aux données provenant des systèmes existants.

9 Les divers programmes internationaux appelés à participer au Système mondial d'observation de l'océan apparaissent à la figure 1. Si l'on examine la situation des actuels systèmes intergouvernementaux de surveillance continue, on se rend compte qu'il existe d'importantes lacunes dans ce qui devrait être la couverture de base. Les contributions fournies actuellement par les Etats membres et les institutions nationales (plates-formes océaniques et données transmises aux fins de l'échange international) permettent la mise en oeuvre de 30 à 50 % des plans définis pour le SMISO, le GLOSS et les bouées dérivantes. Il existe toute une panoplie de plates-formes opérationnelles et de recherche exploitées par des agences et des programmes dont la mission et les besoins diffèrent, d'où la nécessité d'un système global et intégré. Il faut disposer de capteurs océanographiques pour les satellites en projet, accroître le nombre des bouées dérivantes, achever la mise en place du réseau de marégraphes prévu et étendre la couverture par XBT. Les systèmes nécessaires pour effectuer des mesures biologiques ou chimiques de routine ne sont pas encore en place. Il faut également porter une attention notable à la gestion des données. Enfin, il faut définir des normes et assurer une formation en matière de traitement, de présentation, d'archivage et d'échange des données et produits océanographiques.

10 Etant donné l'échelle des coûts d'exploitation d'un système mondial d'observation de l'océan, il convient de le planifier minutieusement en tirant parti de tous les éléments et de tous les apports possibles. Ce système exigera que des services océanographiques opérationnels soient mis en place au niveau national et qu'ils travaillent en étroite collaboration avec les services météorologiques nationaux. Il s'agit par définition d'une action qui ne saurait être menée qu'en faisant appel à des moyens intergouvernementaux. En sa qualité d'agence océanographique des Nations Unies, la COI en assure la direction. Une étroite coordination doit s'instaurer et être maintenue avec les activités de surveillance continue du climat et de l'environnement de l'OMM et du PNUE. On ne saurait trop souligner que les Etats membres devront prendre de nouveaux engagements majeurs et qu'ils devront tous profiter des retombées régionales et mondiales de cette action.

RESUMEN EJECUTIVO

1 Este informe da cuenta del estado de aplicación de los sistemas intergubernamentales de vigilancia de las variables oceánicas. Es una recopilación de información concebida como un primer paso hacia el desarrollo de un sistema de observación mundial del océano a largo plazo, iniciativa que se está emprendiendo para atender a la demanda mundial por lo que hace a un conocimiento más cabal del comportamiento del océano y su papel en el ambiente mundial.

2 En respuesta a la resolución de la Asamblea General de las Naciones Unidas sobre la protección del clima mundial para las generaciones presentes y futuras de la humanidad y en respuesta a subsiguientes recomendaciones formuladas por los Grupos de Trabajo del Grupo Intergubernamental de Expertos para analizar el Cambio Climático, la Comisión Oceanográfica Intergubernamental (COI) ha comenzado a desarrollar un Sistema Mundial Integrado de Vigilancia de los Océanos (Resolución XV-4 de la 15a. Asamblea de la COI, julio de 1989), con la cooperación de la Organización Meteorológica Mundial (OMM). El Consejo Ejecutivo de la COI en su 23a. reunión aprobó en 1990 la Resolución XXIII-5 en que pide la preparación de un informe sobre los requisitos necesarios para un sistema de observación de los océanos.

3 En las sesiones científicas y técnicas de la Segunda Conferencia Mundial sobre el Clima de octubre de 1990 se definió la necesidad urgente de crear un sistema mundial de observación del clima sobre la base del actual Sistema Mundial de Observación de la Vigilancia Meteorológica Mundial y el Sistema Mundial Integrado de Vigilancia de los Océanos (COI-OMM). La vigilancia operacional es requisito indispensable para determinar el papel del océano en el clima de la Tierra, y es necésaria asimismo para formular en el plano nacional e internacional, otras políticas ambientales como las relacionadas con la contaminación, el fomento de las pesquerías comerciales, la ordenación de las zonas costeras y el pronóstico meteorológico. Un sistema de vigilancia del océano se debería considerar un componente de un sistema mundial de vigilancia y previsión del cambio ambiental. Se estima que los beneficios económicos de previsiones correctas en este ámbito ascienden a varios centenares de miles de millones de dólares.

4 Se llevaron a cabo varias consultas de expertos, que formularon recomendaciones para remitirlas al Comité de la COI sobre los Procesos Oceánicos y el Clima y a la Asamblea de la COI en su 16a. reunión en 1991. Entre las recomendaciones figuran la preparación y la actualización anual del informe de situación sobre los elementos existentes de un sistema mundial de observación de los océanos.

5 Se ha encargado a un Panel JSC-CCCO para el Desarrollo del Sistema de Observación de los Océanos (OOSDP) que diseñe un sistema operacional de observación para vigilar las propiedades físicas y de otra índole que determinan la circulación oceánica y la reacción del océano al cambio climático. El Panel concluirá su labor en diciembre de 1994.

6 Los programas de investigación climática a gran escala, entre los cuales figuran TOGA y WOCE, han determinado las exigencias en materia de observación que se deben reunir para que puedan lograr sus objetivos. Aunque es posible que tales exigencias cambien en las próximas décadas a medida que aumenten nuestro conocimiento y nuestra necesidad de conocimientos, podemos aprovechar la experiencia obtenida gracias a estos programas de investigación para establecer los parámetros, los procesos, los fenómenos y las características iniciales que se han de ir midiendo a largo plazo. La actual urgencia de contar con un sistema mundial de observación de los océanos no nos permitirá esperar que se realicen nuevas investigaciones para iniciar la ejecución de un plan de vigilancia operacional.

7 **En este informe de situación se exponen las exigencias de los programas de investigación climática de gran escala existentes y previstos (TOGA, WOCE, JGOFS, GEWEX, PMOC y programas polares) y una descripción de los sistemas existentes de observación y gestión de datos oceánicos de la COI y la OMM. Se trata del primer informe de esta índole y no incluye un análisis de las necesidades, de determinados puntos fuertes y deficiencias, etc. Se prevé que en 1991 la comunidad científica sea invitada a participar en la realización de dicho análisis y en la preparación de planos de ejecución, sobre la base de la información contenida en este informe. Los sistemas que en él se reseñan son los siguientes:**

i) **Vigilancia Meteorológica Mundial** (VMM), programa internacional operacional de la OMM para acopiar y distribuir en tiempo real datos meteorológicos y los datos ambientales conexos a escala mundial. Este programa se sirve del Sistema Mundial de Telecomunicación (SMT), red cada vez más automatizada de circuitos de punto a punto para el acopio y la difusión de datos. El Sistema Mundial de Observación de la VMM cuenta con más de 7.000 barcos provenientes de 49 países que participan en un plan de observación voluntaria para aportar información meteorológica marina (SST, oleaje, etc.). Aunque la cobertura de superficie de la VMM es extensa, quedan grandes vacíos a través de áreas oceánicas, especialmente en el hemisferio sur. Hay 4 países que están explotando satélites de órbita polar y tienen planes para añadir más series de satélites; otros 4 países están actualmente utilizando satélites geoestacionarios.

ii) **Sistema Mundial Integrado de Servicios Oceánicos** (IGOSS), sistema COI-OMM de acopio e intercambio de datos oceanográficos en tiempo real relativos a la temperatura superficial y subsuperficial, a la salinidad y a las corrientes, de cuya gestión conjunta se encargan la COI y la OMM utilizando el SMT. Anualmente se transmiten 40.000 observaciones subsuperficiales y 5.000 de salinidad aproximadamente. El Programa de Buques que Colaboran Ocasionalmente del IGOSS cuenta con más de 200 barcos que efectúan observaciones, muchos de ellos equipados con sistemas automatizados para codificar y transmitir los datos automáticamente por satélite. Es preciso que los países se comprometan a prestar apoyo considerable a fin de lograr una cobertura suficiente, sobre todo en los Océanos Indico y Austral, áreas de las que se tienen escasos datos.

iii) **El Sistema Mundial de Observación del Nivel del Mar** (GLOSS), Programa de la COI para el suministro de datos normalizados sobre el nivel del mar (en tiempo real y en tiempo diferido) desde una red mundial de estaciones. Actualmente están en funcionamiento unas 200 de las 306 estaciones propuestas, con el apoyo de 79 países; un conjunto seleccionado está conectado con un sistema mundial de referencia geodésica. Los datos se remiten al Servicio Permanente del Nivel Medio del Mar, que difunde y analiza ese tipo de datos, y a los centros del nivel del mar de TOGA y WOCE. Será menester hacer esfuerzos considerables para establecer y mantener estaciones en el Artico y el Antártico, en el Africa y en islas remotas.

iv) **Actividades de boyas a la deriva**, de cuya gestión se encarga el Panel de Cooperación de Boyas a la Deriva COI-OMM. En este momento 11 países están utilizando unas 600 boyas, de las cuales 35%-50% transmiten datos en tiempo real a través del SMT (esta proporción va en aumento).

v) **Intercambio Internacional de Datos e Información Oceanográficos (IODE)**, programa de la COI que instaura procedimientos y fomenta servicios para el intercambio internacional de datos oceánicos mediante una red de centros nacionales de datos oceanográficos, instituciones nacionales designadas, centros nacionales responsables de datos oceanográficos y centros mundiales. En total, 42 países tienen actualmente centros nacionales de datos o instituciones nacionales designadas. La base de datos marinos del Sistema de Centros Mundiales de Datos contiene datos de más de 2.250.000 observaciones de 61 países, incluidos datos de estaciones oceanográficas, observaciones de batitermógrafos, datos biológicos y de geología marina, y de mediciones de corrientes. La COI ha establecido, además, un Sistema de Datos e Información relativos al Medio Marino (MEDI), guía de fuente de datos que indica el contenido de los conjuntos de datos disponibles en los centros de datos. La COI y la OMM están adoptando medidas, por conducto del IGOSS y el IODE, para crear una base mundial de datos oceánicos oportuna y completa en apoyo del Programa Mundial de Investigaciones Climáticas y los programas nacionales.

vi) El **Programa Mundial sobre el Clima** promueve, bajo los auspicios de la OMM, la investigación y la vigilancia -coordinadas internacionalmente- de las variaciones o los cambios climáticos, incluido un Proyecto de Detección del Cambio Climático iniciado en 1989.

8 El Programa de las Naciones Unidas para el Medio Ambiente (PNUMA), la COI y la OMM están desarrollando un plan rector para la vigilancia a largo plazo de la zona costera, que contribuirá a los esfuerzos encaminados a evaluar el cambio climático y sus repercusiones. Entre los parámetros se incluirán variables físicas, químicas y biológicas. Se utilizarían al máximo los datos de los sistemas existentes.

9 En la Figura 1 aparecen los diversos programas internacionales que participarán en el Sistema Mundial de Observación de los Océanos. Al examinar el alcance de la vigilancia actual por parte de los sistemas intergubernamentales existentes, se pueden observar lagunas considerables en la cobertura indispensable. Las contribuciones actuales de los Estados Miembros y de las instituciones nacionales -en forma de plataformas oceánicas y datos transmitidos para intercambio internacional- permiten aplicar entre 30% y 50% de los planes establecidos para IGOSS, GLOSS y boyas a la deriva. Dada la gran variedad de plataformas operacionales y de investigación cuya gestión corre por cuenta de organismos y programas que tienen diferentes misiones y necesidades, es preciso establecer un sistema integrado que lo abarque todo. Se necesitan sensores oceanográficos para los satélites previstos, hay que fondear más boyas a la deriva, completar la red propuesta de mareógrafos y expandir la cobertura de comprensión XBT. En este momento no hay sistemas instalados que permitan efectuar mediciones biológicas o químicas de rutina. También la gestión de los datos exige especial atención. Es menester fijar normas e impartir formación en tratamiento, presentación, archivo e intercambio de datos marinos y productos de los datos.

10 Dada la magnitud del gasto que supone el funcionamiento de un sistema mundial de observación de los océanos, la planificación ha de realizarse con sumo cuidado, aprovechando al máximo la competencia y la participación. Para ese sistema hará falta crear servicios oceanográficos operacionales en el plano nacional, y que dichos servicios trabajen en estrecho contacto con los servicios meteorológicos nacionales. Por definición, es un esfuerzo que sólo se puede emprender con medios intergubernamentales. La Comisión, en su calidad de órgano competente en asuntos oceánicos dentro del sistema de las Naciones Unidas, está ejerciendo el liderazgo, teniendo presente el imperativo de desarrollar y mantener una estrecha coordinación con las actividades de vigilancia del clima y del medio ambiente de la OMM y el PNUMA. Nunca se insistirá bastante en la necesidad de que los Estados Miembros renueven y refuercen su compromiso, y participen todos ellos en beneficio regional y mundial.

КРАТКОЕ ИЗЛОЖЕНИЕ

1 В настоящем докладе содержится документальная информация о ходе развития межправительственных систем мониторинга переменных параметров океана. Он представляет собой подборку сведений в качестве первого шага в деле создания долгосрочной глобальной системы наблюдения за океаном, как инициативы, предпринимаемой с целью удовлетворения ощущаемых во всем мире потребностей в лучшем понимании жизни океана и его роли в глобальной окружающей среде.

2 В соответствии с резолюцией Генеральной Ассамблеи ООН об "Охране мирового климата для нынешнего и будущих поколений человечества" и последующими рекомендациями, предложенными Рабочими группами Межправительственной группы экспертов по изменению климата, Межправительственная океанографическая комиссия (МОК) приступила к созданию всеобъемлющей Глобальной системы наблюдения за океаном (Резолюция XV-4 Ассамблеи МОК, июль 1989 г.). Всемирная метеорологическая организация (ВМО) сотрудничает с МОК в осуществлении этой инициативы. Двадцать третья сессия Исполнительного совета МОК в 1990 г. приняла резолюцию XXIII-5, призывающую подготовить доклад о требованиях, предъявляемых к системе наблюдения за океаном в краткосрочном плане.

3 В ходе научно-технических сессий Второй всемирной климатической конференции, состоявшейся в октябре 1990 г., была выявлена насущная потребность в создании Глобальной системы наблюдения за климатом на основе существующей Глобальной системы наблюдения Всемирной службы погоды и Объединенной глобальной системы океанических служб МОК/ВМО. Оперативный мониторинг является предпосылкой для определения роли океана в отношении климата Земли. Мониторинг также необходим для разработки других аспектов национальной и международной политики в отношении окружающей среды, таких, как загрязнение среды, развитие коммерческого рыболовства, освоение прибрежной зоны и прогнозирование погоды. Система мониторинга океана должна рассматриваться в качестве компонента глобальной системы мониторинга и прогнозирования изменения окружающей среды. Экономическая польза адекватных прогнозов исчисляется в несколько сотен миллиардов долларов.

4 Состоялось несколько консультаций экспертов, рекомендации которых предусматривается представить Комитету МОК по океаническим процессам и климату и шестнадцатой сессии Ассамблеи МОК в 1991 г. Рекомендации включают подготовку и ежегодное обновление доклада о положении дел в отношении имеющихся компонентов глобальной системы наблюдения за океаном.

5 Группе по развитию системы наблюдения за океаном ККИО-ОНК поручено разработать концептуальный проект оперативной системы наблюдения для мониторинга физических и иных параметров, которые определяют циркуляцию океана и его реакцию на изменение климата. Она завершит свою работу в декабре 1994 г.

6 В рамках крупномасштабных программ изучения климата, включая ТОГА и ВОСЕ, были определены потребности в наблюдениях для достижения их целей. Хотя в предстоящие десятилетия потребности могут изменяться по мере расширения наших знаний или наших потребностей

в знаниях, мы можем использовать приобретенный с помощью этих исследовательских программ опыт для установления первоначальных параметров, процессов, явлений и характеристик, подлежащих измерению в долгосрочной перспективе. Нынешняя острая потребность во всемирной системе наблюдения за океаном не позволит нам дожидаться результатов дальнейших исследований для перехода к осуществлению плана оперативного мониторинга.

7 В данном докладе о положении дел содержатся обобщенные сведения о потребностях в рамках существующих или планируемых крупномасштабных программ изучения климата (ТОГА, ВОСЕ, ДжГОФС, ГЕВЕКС, ВПКД и полярные программы), а также описание существующих систем МОК и ВМО по наблюдению за океаном и управлению данными. Он является первым докладом такого рода и не содержит анализа потребностей, конкретных сильных и слабых сторон и т.п. Предусматривается, что в 1991 г. научному сообществу будет предложено участвовать в проведении такого анализа и в разработке планов для дальнейшего осуществления. Содержащаяся в настоящем докладе информация будет использоваться в качестве основы. Здесь описываются следующие системы:

(i) Всемирная служба погоды (ВСП) - Международная оперативная программа ВМО по сбору и распространению метеорологических и смежных данных по окружающей среде в реальном масштабе времени на глобальном уровне. Под ее эгидой действует Глобальная система телекоммуникации (ГСТ), представляющая собой все более автоматизируемую сеть последовательных линий связи для сбора и распространения данных. Ее Глобальная система наблюдения включает 7 000 кораблей, предоставленных 49 странами, которые участвуют в Системе добровольного наблюдения в целях обеспечения морской метеорологической информации (включая ТПМ, волны и т.п.). Хотя ВСП проводит обширные наблюдения за поверхностью, существуют значительные пробелы в различных районах океана, особенно в южном полушарии. Четыре страны используют спутники на полярных орбитах и имеются планы в отношении дополнительных серий спутников; в настоящее время четыре страны также имеют геостационарные спутники.

(ii) Объединенная глобальная система океанических служб (ОГСОС) - система МОК-ВМО для сбора и обмена океанографическими данными (температура и соленость на поверхности воды и в подповерхностном слое, а также данные о течениях) в реальном масштабе времени, которая управляется совместно МОК и ВМО с использованием ГСТ. Ежегодно передаются результаты приблизительно 40 000 подповерхностных наблюдений и 5 000 измерений солености. Программа добровольных судов ОГСОС охватывает более 200 проводящих наблюдение судов, многие из которых снабжены компьютерными системами для автоматического кодирования и передачи данных через спутник. Для обеспечения надлежащего охвата районов, по которым имеются скудные данные, особенно в Индийском океане и южных океанах, требуется значительное содействие различных стран.

(iii) Глобальная система наблюдения за уровнем моря (ГЛОСС)- Программа МОК по обеспечению стандартизованных данных об уровне моря (как в реальном масштабе времени, так и в режиме задержки), получаемых от глобальной сети станций. В настоящее время при поддержке 79 стран действует около 200 из предложенных 306 станций. Отдельная группа станций соединена с глобальной геодезической справочной системой. Данные передаются в Постоянную службу среднего уровня моря, которая распространяет и анализирует данные об уровне моря, а также в центры по уровню моря ТОГА и ВОСЕ. Требуются значительные усилия для создания и обеспечения работы станций в арктическом и антарктическом районах, а также в Африке и на отдаленных островах.

(iv) Мероприятия с дрейфующими буями - осуществляются Группой сотрудничества по дрейфующим буям МОК/ВМО. В настоящее время 11 стран обеспечивают работу примерно 600 буев, причем 35-50% данных передаются с них в реальном масштабе времени через ГСТ. Этот показатель возрастает.

(v) Международный обмен океанографическими данными (МООД) - программа МОК, которая обеспечивает процедуры и создает условия для международного обмена океанографическими данными через сеть национальных центров океанографических данных, выделенных национальных учреждений, ответственных национальных центров океанографических данных и мировых центров. В целом в настоящее время 42 страны располагают национальными центрами данных или выделенными национальными учреждениями. Базы данных о морской среде системы Мировых центров данных содержат данные, полученные в результате более чем 2 250 000 наблюдений в 61 стране, включая данные океанографических станций, батитермографические наблюдения, биологические и морские геологические данные, а также измерения течений. МОК разработала также Справочную систему по источникам данных и информации о морской среде (МЕДИ), представляющую собой руководство по источникам данных, в котором описываются наборы данных, имеющиеся в центрах данных. МОК и ВМО проводят мероприятия через ОГСОС и МООД с целью создания глобальной базы актуальных и полных данных и информации об океане в поддержку Всемирной программы исследования климата и национальных программ.

(vi) Всемирная климатическая программа - содействует под эгидой ВМО проведению координируемых на международном уровне исследований и мониторинга колебаний или изменений климата, включая Проект определения климатических изменений, начатый в 1989 г.

8 Программа Организации Объединенных Наций по окружающей среде (ЮНЕП), МОК и ВМО разрабатывают Основной план долгосрочного мониторинга в прибрежной зоне, который будет содействовать мероприятиям по оценке климатических изменений и их последствий. В качестве параметров предусматриваются физические, химические и биологические перемменные. В максимально возможной степени будут использоваться данные, получаемые от существующих систем.

9 Комплекс международных программ, подлежащих включению в Глобальную систему наблюдения за океаном, представлен на схеме 1. При рассмотрении масштабов нынешнего мониторинга, осуществляемого имеющимися межправительственными системами, можно увидеть существенные пробелы в весьма важных требуемых охвата сферах. Нынешние вклады государств-членов и национальных учреждений (в виде океанических платформ и данных, передаваемых для международного обмена), позволяют осуществлять от 30 до 50% установленных планов для ОГСОС, ГЛОСС и дрейфующих буев. Имеется множество различных оперативных и исследовательских платформ, используемых учреждениями и программами с различными задачами и требованиями, что обусловливает потребность всеобъемлющей, комплексной системы. Необходимы океанографические датчики для планируемых спутниковых операций; требуется установка дополнительно дрейфующих буев; нужно завершить создание предложенной сети мареографов и следует расширить масштабы охвата ОБТ. В настоящее время созданы системы для проведения текущих биологических или химических измерений. Значительное внимание следует уделять также управлению данными. Необходимо установить нормативы и обеспечить подготовку кадров в области разработки, представления, архивации и обмена данными о морской среде и продуктами данных.

10 Ввиду огромных расходов, связанных с функционированием всемирной системы наблюдения за океаном, планирование должно проводиться весьма осмотрительно с использованием широчайшего участия большого круга талантливых людей. Для этой системы потребуется создание на национальном уровне оперативных океанографических служб и обеспечение того, чтобы они тесно взаимодействовали с национальными метеорологическими службами. С учетом самого характера этой деятельности она может быть проведена лишь с использованием межправительственных средств. Являясь океанографическим органом Организации Объединенных Наций, МОК обеспечивает руководство в этой области. Необходимо развивать и поддерживать тесную координацию с мероприятиями ВМО и ЮНЕП в области мониторинга климата и окружающей среды. Невозможно переоценить необходимость того, чтобы государства-члены вносили новый крупный вклад и чтобы все государства-члены принимали участие в этой деятельности в региональных и глобальных интересах.

1. PREFACE

The Intergovernmental Oceanographic Commission (IOC) at the Fifteenth Session of its Assembly (July 1989) decided to initiate the planning of a global integrated ocean observing system in co-operation with the World Meteorological Organization (WMO) and other appropriate UN organizations as part of a global system for monitoring and predicting environmental change. The WMO has supported this initiative in connection with requirements for global climate studies and assessments. The IOC Executive Council in March 1990 adopted a further resolution emphasizing the urgency of such an initiative and requested a status report on the immediate requirements for an ocean observing system as well as a plan to meet these requirements and an analysis of the problems foreseen in the implementation of a long-term systematic ocean observing system. The following report is a first step in responding to this request. It is a collation of requirements from existing and planned large-scale climate research programmes and a description of IOC and WMO-sponsored ocean observing and data management systems. A thorough evaluation needs to be done of i) the extent to which existing needs are being met, ii) an identification of steps to take to overcome present weaknesses, and iii) priority actions to be taken toward establishing a comprehensive system. It is expected that such work will be done in 1991.

The Intergovernmental Panel on Climate Change has recognized the need for systematic ongoing observations of the global ocean and has recommended the development and implementation of multinational systems to detect and monitor ocean and coastal zone changes and environmental and socioeconomic impacts of those changes. The Scientific/Technical Sessions of the Second World Climate Conference concluded that there is an urgent need to create a Global Climate Observing System built upon the World Weather Watch Global Observing System and the IOC-WMO Integrated Global Ocean Services System. Both space-based and surface-based components are needed.

Two papers have been prepared, one by Prof. R.W. Stewart and the other by Dr. D. James Baker, on the role of the ocean in climate change. Both emphasize the need for development of long-term systematic observations of the global ocean. Professor Stewart 1990 concludes that:

> *"The ocean plays a key, but frequently understated, role in determining the earth's climate. Indeed any possibility of predicting the evolution of climate beyond a few weeks demands that ocean behaviour also be taken into account. There is great promise that it may become possible to describe and predict many aspects of upper ocean behaviour with enough accuracy to improve long range weather and fisheries forecasts usefully. This promise can only be realized if appropriate data are collected regularly and disseminated promptly.*
> *With respect to sensitivity to, and contribution to, long term climate change: there is every reason to believe that the ocean is now changing, in response to climate changes over the last few hundred years (the Little Ice Age). It can be expected to change further as anthropogenic influences become increasingly marked. The effect of the ocean on the atmosphere could be either to moderate or to intensify these changes. It will certainly modify them."*

In order to develop the global ocean observing system, the IOC established in 1989 the *ad hoc* Group of Experts on an Ocean Observing System to work in close collaboration with the CCCO-JSC Ocean Observing System Development Panel. This group met in September 1990 and made the following recommendations which will be submitted to the Fourth Session of the IOC Committee on Ocean Processes and Climate and the Sixteenth Session of the IOC Assembly, both in March 1991.

(i) IOC should propose that an intergovernmental "protocol" (a formal international agreement) be attached to the Framework Convention on Climate Change to be signed in 1992. This protocol would foster the participation of governments in an ocean observing system.

(ii) A document should be completed to describe the benefits and rationale of a global ocean observing system as well as elements and general approaches and be provided to IOC and WMO subsidiary bodies for comment

(iii) An implementation plan should be developed in 1991 to support the proposed protocol and presented to the 1992 UN Conference

(iv) Initial emphasis should be on strengthening national contributions to present activities (e.g., IGOSS, GLOSS, DBCP, IODE, WWW), accelerating deployment of components of existing systems with a phased integration of new technology, satellite and *in situ*.

(v) IGOSS and IODE should consider establishing a Global Current Meter Pilot Project to emphasize the importance and uses of real-time current data

(vi) An Interagency Co-ordinating Group should be established to facilitate co-ordination of the ocean observing system among relevant groups

(vii) A "status report" should be prepared on ocean observing systems and updated annually.

Effective implementation and maintenance of such a system will demand substantial operational resources from governments beyond those presently committed. Additionally, better co-ordination among international organizations and existing international programmes will be needed in order to avoid duplication of effort and to most efficiently utilize resources.

Several expert consultations have led to the conclusion that initially such a system should concentrate on those variables that are required to monitor and predict climate change, recognizing that the importance of predicting change is equally valuable for predicting natural or anthropogenic change. The global ocean observing system is conceptually a component of a global earth information system with the immediate linkage through coupled ocean-atmosphere observation systems and models. Estimated benefits of adequate environmental predictions total hundreds of billions of dollars.

Under the joint sponsorship of the UNEP, IOC, and WMO, a draft proposal has been prepared for long-term monitoring of coastal and near-shore phenomena. This system will complement the Global Ocean Observing System. It will insure that measurement frequency, spatial resolution, and parameter selection will be adequate in the area most likely to be affected first by anthropogenic influences. It will also complete the suite of observations necessary for global numerical models. The proposal will be considered at a meeting of experts to be organized jointly by UNEP, IOC, and WMO in December 1990. The IOC Executive Council in March 1990 noted that the plan for a global coastal zone observing system should be developed in close harmony with the global ocean observing system.

The IOC and WMO Secretariats acknowledge the contributions made to this report by senior scientists, including those involved in major large-scale research programmes, particularly TOGA and WOCE, and by John W. Sherman, NOAA, who provided extensive information on international satellite plans.

2. PRESENT INSTITUTIONAL STRUCTURES

2.1 INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

The Intergovernmental Oceanographic Commission (IOC) is a functionally autonomous body within the United Nations Educational, Scientific and Cultural Organization (Unesco). The purpose of the Commission is to promote marine scientific investigations and related ocean services, with the view to learning more about the nature and resources of the oceans through the concerted action of its members. At present 116 countries are members of the Commission. These Member States are not necessarily the Member States of Unesco, since membership of the Commission is open to any Member State of any of the organizations of the United Nations system.

The IOC collaborates closely with other international organizations that are interested in aspects of the oceans and their resources including related development and management aspects. In accordance with its Statutes, the Commission "shall give due attention to supporting the objectives of the international organizations with which it collaborates. On the other hand, the Commission may request these organizations to take its requirements into account in planning and executing their own programmes".

The Commission has been recognized as a joint specialized mechanism of the United Nations system in the fields of marine science and ocean services. The Commission has been also recognized by the United Nations Convention on the Law of the Sea as "the competent international organization" for marine scientific research.

FAO, WMO, IMO, the UN itself and Unesco formalized special responsibilities of the Commission through the adoption in 1969 of the agreement on the Inter-Secretariat Committee on Scientific Programmes Relating to Oceanography (ICSPRO). Through the ICSPRO Agreement, these organizations took "a step forward in broadening the base of the IOC so that the Commission can fulfill its function as an effective joint specialized mechanism". Agreements between the IOC and UN Organizations and other co-operating bodies include:

- Aide-Memoire on Joint Action by UNESCO and FAO in the Field of Marine Science and Fisheries (1968).

- Memorandum of Understanding between the International Atomic Energy Agency and the IOC on Marine Environmental Protection (1982).

- Memorandum of Understanding between the IOC and the International Council for the Exploration of the Sea (1983).

- Memorandum of Understanding between the International Hydrographic Organization and the IOC (1984).

- Memorandum of Understanding between the IOC and the Comision Permanente del Pacifico Sur (1984).

- Memorandum of Understanding between the International Commission for the Scientific Exploration of the Mediterranean Sea and the IOC (1984).

- Memorandum of Understanding between IOC and the Scientific Committee on Oceanic Research (of ICSU)(1984).

- Principles Governing Co-operation between Unesco and the International Council of Scientific Unions (ICSU) on the Development of the Oceanographic Component of the World Climate Research Programme through the IOC and SCOR (1984).

- Memorandum of Understanding on Co-operation between the United Nations Environment Programme and the IOC (1987).

Advisory Bodies to the Commission:

- Advisory Committee on Marine Resources Research (ACMRR)
- Engineering Committee on Oceanic Resources (ECOR)
- Scientific Committee on Oceanic Research (SCOR)

Major programmes and working bodies of the IOC are diagrammed in Figure 2. Co-operation of IOC with other international organizations on specific programmes and activities is depicted in Table 1.

In regard to its activities in the field of ocean observations and data exchange, a function of the Commission is to "promote, plan and co-ordinate observing and monitoring systems on the properties and quality of the marine environment, as well as the preparation and dissemination of processed oceanographic data and information, and assessment studies". Since its establishment in 1960, IOC has been dealing with the planning and development of elements of a future ocean observing system in co-operation with WMO and development of an international system for exchange of oceanographic data and information. At present IOC co-ordinates either alone or jointly with WMO, the following major ocean observing and data management systems:

(i) The Joint IOC-WMO Integrated Global Ocean Services System (IGOSS), a world-wide, operational service system providing physical oceanographic data and information for various marine users (since 1975). (Described further in Section 4.2)

(ii) The IOC Global Sea Level Observing System (GLOSS) for collection and dissemination of sea-level data from the international network of GLOSS stations (since 1985). (Described further in Section 4.3)

(iii) The Joint WMO-IOC Drifting Buoy programme aimed at promoting the world-wide use of drifting buoys for collection and dissemination of marine meteorological and some oceanographic observations as a part of global ocean observing system (since 1985). (Described further in Section 4.4)

iv) The International Oceanographic Data Exchange (IODE) which comprises an international network of oceanographic data centers, international procedures and forms for data collection and exchange and provision data/information services to participating countries. (Described further in Section 4.5).

All ocean observing and data management systems are based on the principle of voluntary participation of Member States in recognition of mutual benefit in such co-operation. Each includes internationally-accepted procedures for data acquisition and transmission for international exchange. Each programme also includes data collection in international centers for the processing, analysis and preparation of data products, to be made available to participating countries. To support its ocean services programmes, the IOC organizes specific training, education, and mutual assistance in the marine sciences and services to enable developing countries to participate actively in those programmes and to get maximum scientific and practical benefit from those programmes.

2.2 WORLD METEOROLOGICAL ORGANIZATION (WMO)

The WMO is a specialized agency of the United Nations whose basic mission is to facilitate world-wide co-operation in the establishment of networks of stations for taking meteorological observations as well as hydrological and other geophysical observations related to meteorology, and to promote the establishment and maintenance of appropriate centers and systems. It was established in 1951, superseding a non-governmental International Meteorological Organization. The WMO includes 160 Members. Six regional associations co-ordinate implementation of activities at the regional level.

Regional Association I	-	Africa
Regional Association II	-	Asia
Regional Association III	-	South America
Regional Association IV	-	North and Central America
Regional Association V	-	South-West Pacific
Regional Association VI	-	Europe

The basic programme of the WMO is the World Weather Watch, initiated in 1961. It is cited as a unique achievement in international co-operation, an integrated global system composed of national facilities and services owned and operated by individual countries for the collection, analysis, and distribution of weather and other environmental information.

Eight technical commissions, composed of experts designated by Members, address global implementation aspects and further development of WMO activities in specific technical areas. These include a Commission for Marine Meteorology, a Commission for Climatology, and a Commission for Basic Systems (CBS). The CBS is responsible for establishing and refining codes and formats to permit the rapid and efficient exchange of large amounts of data. The WMO organization structure is depicted in Figure 3.

Activities at the national level are co-ordinated through National Meteorological and Hydrological Services, which are operated by all WMO Members. These organizations provide basic services of observations, data collection and dissemination; data processing and preparation of forecasts, warnings, and climatological advisories; and dissemination of forecasts and specialized information to a wide variety of users.

At the Forty-first Session of the WMO Executive Council in June 1989, a resolution (Res. 11) was passed calling for the development and implementation of a global operational ocean observing system to be undertaken jointly with IOC. A timetable was requested as well as a list of actions to be undertaken within available budgetary resources.

Relevant activities of the WMO are described in Section 4.

2.3 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

The Intergovernmental Panel on Climate Change (IPCC) was formed by the United Nations Environment Programme and the WMO in 1988 to provide a basis for the development of a realistic and effective international strategy for addressing climate change. Reports of the three IPCC Working Groups have been completed; independent conclusions of each group call for an ocean monitoring programme in order to narrow the uncertainties, address the impacts, and respond to them. In the June 1990 report called "Scientific Assessment of Climate Change" prepared by **Working Group 1**, the Introduction describes the role of the ocean:

"The oceans play a central role in shaping the climate through 3 distinct mechanisms. Firstly, they absorb carbon dioxide and exchange it with the atmosphere. Secondly, they exchange heat, water vapour, and momentum with the atmosphere. Wind stress at the sea surface drives the large-scale ocean circulation. Water vapour, evaporated from the ocean surface, is transported by the atmospheric circulation and provides latent heat energy to the atmosphere. The ocean circulations in their turn redistribute heat, fresh water and dissolved chemicals around the globe. Thirdly, they sequester heat, absorbed at the surface, in the deepest regions for periods of a thousand years or more through vertical circulation and convective mixing.
Therefore, any study of the climate and how it might change must include a detailed description of processes in the ocean together with the coupling between the ocean and the atmosphere."

This same report states that :

"systematic ongoing observations of the global ocean are needed"........."A comprehensive ocean and ice observing system requires:

a) satellite observations of the ocean surface temperature, wind and topography, sea-ice concentration and chlorophyll content (ocean colour), and of the topography of the Antarctic and Greenland ice sheets, by an international array of space platforms in suitable orbits around the earth;
b) an international operational upper-ocean monitoring programme, to determine the time and space dependent distribution of heat and fresh water in upper ocean layers, seasonal variations and long-term trends; and
c) an international programme of systematic sea-level and deep-ocean measurements, at suitable time and space intervals, to determine the state of the ocean circulation, ocean volume, and transport of heat."

Recommendations by **Working Group 2** to address potential impacts on the ocean and coastal zone include:
"Development and implementation of multinational systems to detect and monitor expected environmental and socioeconomic impacts of ocean and coastal zone changes"

In addressing measures to adapt to global climate change, **Working Group 3**, the Response Strategies Working Group, lists options which :
"would be most effective if undertaken in the short term, not because there is an impending catastrophe, but because there are opportunities to avoid adverse impacts by acting now - opportunities which may not be as effective if the process is delayed. These options include:

<u>Development and implementation of a global ocean observing network</u>, for example through the efforts of the IOC, WMO, and UNEP to establish a co-ordinated international ocean observing network that will allow for accurate assessment and continuous monitoring of changes in the world's oceans and coastal areas, particularly sea level and coastal erosion."

2.4 CO-ORDINATION AMONG INTERNATIONAL STRUCTURES

Figure 3 diagrams the structure of the cognizant international organizations and working bodies involved in ocean observing system development and co-ordination. In addition to the 2 predominant intergovernmental organizations described above, the International Council of Scientific Unions, a non-governmental organization, in 1986 launched the International Geosphere-Biosphere Programme (IGBP), a study of the links between the biological, chemical, and physical processes in the whole Earth system and the interactions between the different parts of it. The IGBP provides a framework for a wide range of interdisciplinary programmes. It is developed in close co-operation with other international scientific programmes, some of which are core projects and are described below,- e.g., JGOFS and GEWEX. Also, the United Nations Environment Programme (UNEP) sponsors the Global Environmental Monitoring System (GEMS) to promote the co-ordination and collection of environmental data and INFOTERRA, the International Environmental Information System, a mechanism for nations to gain access to environmental information. IOC and WMO have increased their level of co-ordination with UNEP in view of the number of common interests and goals.

2.5 NATIONAL STRUCTURES

All Members of the WMO, as noted above, have a national governmental organization responsible for meteorological services. It is important to note that very few countries have a single comparable structure for oceanic services. A total of 41 countries have, however, designated a National Oceanographic Data Center.

Each Member State of IOC designates national agencies or institutions to participate in the activities of IOC. Member States of IOC also designate an action address for correspondence on all matters related to the activities of IOC. In addition, for each programme, as a rule, Member States designate a national co-ordinator or contact point (e.g., a national co-ordinator for IGOSS, GLOSS, IODE). Marine activities cover a wide spectrum of scientific and practical interests. Relevant agencies and institutions are hydrographic services, meteorological or hydrometeorological services, fisheries agencies, national science and technology agencies, national academies of sciences, and universities. Some Member States have established national oceanographic committees or commissions for internal co-ordination of IOC activities.

3. REQUIREMENTS FROM EXISTING AND PLANNED LARGE-SCALE CLIMATE RESEARCH PROGRAMMES

Recognizing that international research programmes are not established for the purpose of defining long-term observational requirements, the knowledge and experience gained should nevertheless be tapped for such an endeavor. In January 1990, the IOC Secretariat asked senior representatives of various international research programmes to provide insight into the identified requirements for long-term systematic ocean observations. An extract of these responses follows:

3.1 TROPICAL OCEAN-GLOBAL ATMOSPHERE (TOGA)

The objectives of the TOGA Programme are:

(i) to gain a description of the tropical oceans and the global atmosphere as a time dependent system, in order to determine the extent to which this system is predictable on time scales of months to years, and to understand the mechanisms and processes underlying its predictability;

(ii) to study the feasibility of modelling the coupled ocean-atmosphere system for the purpose of predicting its variations on time scales of months to years; and

(iii) to provide the scientific background for designing an observing and data transmission system for operational prediction if this capability is demonstrated by coupled ocean-atmosphere models.

Through an intensive international effort, to a large degree, the first TOGA objective has been achieved during the first 5 years of TOGA, 1985-1989. Significant progress has also been made toward achieving the second objective. However, the following issues must be addressed before the third objective can be realized:

- o Particular problems exist in the warm pool regions (i.e., SST is greater than 28°C) of the tropical oceans.

o In the warm pool estimates of the heat balance at the surface leave an unexplained heat flux of 60-80 watts per square meter, enough to warm the upper ocean by about 2 degrees C per month. Thus, there is great difficulty in understanding the heat budget of the warm pool.

o Ocean models generally overestimate the temperature of the warm pool by about 3 degrees C, probably resulting from a considerable sensitivity to air-sea heat fluxes.

o Atmospheric models have been shown to be extremely sensitive to even very small sea surface temperature variations where the SST is warm.

The TOGA Scientific Steering Group (SSG) has defined 2 groups of data requirements: atmospheric data and oceanic data. The latter group contains those requirements needed to determine the circulation and heat storage of the tropical oceans and to characterize their response to atmospheric forcing. Horizontal and vertical scales, time resolution, and measurement accuracy for global data sets have been defined as shown in Table 3.

Relevant "**atmospheric parameters**" are:

Atmospheric Surface Pressure
Surface stations and data from the Voluntary Observing Ship (VOS) programme can help achieve the requirement of 1,200 km resolution. However, additional surface pressure observations from automatic stations or drifting buoys are required in the extra-tropical latitudes of the Southern Hemisphere to adequately resolve the evolution of the 30-60 day mode and the Southern Oscillation.

Global Sea Surface Temperature
Thirty day averages of SST over 5 degrees latitude/longitude squares are required over the global oceans with a 0.5 K accuracy. Determination of global SST depends heavily on the measurements of satellite-based infrared and microwave sensors. However, measurements from drifting buoys and ships are also required for validation of satellite retrievals.

Tropical Sea Surface Temperature
Since prediction of SST is a central objective of TOGA, there is need for better resolution and accuracy of SST measurements in the tropical ocean basins. Satellite retrievals from this area suffer considerable contamination from the presence of clouds, tropospheric moisture content and stratospheric aerosols. Therefore, additional *in situ* observations from drifting buoys, moored buoys, and VOS are critical for meeting the requirements for adequate monitoring of tropical SST variations. Fifteen-day averages over 2 degrees latitude x 2 degree longitude areas with 0.3 K accuracy are required.

Surface Wind Over the Tropical Ocean
Tropical surface wind stress is one of the most important variables to be determined for TOGA. Data from anemometers on moored buoys will be of crucial importance in supplementing data from WWW surface stations and VOS. The required accuracy is .01 Pa for mean monthly values averaged over 2 degrees latitude by 10 degrees longitude areas. Expressed in terms of wind speed, the corresponding accuracy is 0.5 m/sec.

Net Radiation at the Surface
The net radiative input to the upper ocean layer is a very significant component of the overall heat balance of this layer and ultimately controls the prediction of the SST. TOGA data requirements are expressed in terms of mean values of the incoming short-wave radiation flux only. The required accuracy is 10 watts/m2 for monthly averages in each 2 degree latitude by 2 degree longitude box in the tropical zone. The WCRP Surface Radiation Budget Project, beginning in 1990, will attempt to compute this quantity from available data on a global scale. Eventually it is hoped that long-wave radiation flux will be obtained to similar accuracy.

Surface Humidity
The required accuracy for water vapour mixing ratios near the surface is 0.5 x 10-3 for mean monthly values averaged over 2 degrees latitude x 10 degrees longitude areas.

Surface Air Temperature
The required accuracy for monthly averaged surface air temperature measurements over 2 degrees latitude by 10 degrees longitude areas is 0.5 K.

Oceanic parameters are:

Tropical Sea Level
A basin-wide network of tide gauge stations is required in each tropical ocean to resolve oscillations in sea level. The required accuracy is 2 cm for one- day averages. In addition, the advent of satellite altimetry has made it possible to map basin-wide sea level anomalies with an accuracy of a few centimeters for time scales of 10 days or longer.

Tropical Ocean Sub-Surface Temperature
Knowledge of the ocean sub-surface thermal structure is necessary to assess the transport of heat, for calculation of geostrophic currents, and to monitor space-time evolution of various large-scale ocean features. The minimum required horizontal resolution is 1.5 degrees latitude by 5 degrees longitude at seven levels between 0 and 500 meters except in the western parts of the basins where 750 meters depth data is required. On a monthly time scale, the required accuracy is 0.25 K. In the equatorial wave guide higher temporal resolution is required.

Tropical Ocean Salinity
Direct measurements of salinity are required to resolve near-equatorial, rapid time scale, changes in salinity associated with phenomena such as westerly wind bursts, and to monitor broader, deeper, and presumably slower salinity changes outside the equatorial region. Surface salinity should be measured wherever possible along VOS lines. In addition, subsurface salinity should be sampled along selected VOS lines and along regularly repeated hydrographic sections. Near-equatorial moorings should be equipped with temperature and salinity sensors to capture higher frequency variations. Rigorous studies have not yet been carried out to determine the optimal time and space resolution for sampling. The accuracy requirement for monthly averaged surface salinity over 2 degrees latitude by 10 degrees longitude areas is 0.03 parts per thousand.

Tropical Ocean Surface Circulation
The most sensitive product for verification of the model simulations of tropical ocean dynamics will be the measured velocity field of the upper ocean layer. The tropical ocean surface circulation requirement for monthly averages over 2 degrees latitude by 10 degrees longitude is 0.1 m/sec.

Sub-Surface Equatorial Currents
For the purpose of understanding equatorial ocean dynamics in response to atmospheric forcing over the region, time series of direct measurements of velocity profiles are considered essential along the equator at 40 degrees longitude spacing. The accuracy requirement is 0.1 m/sec at the time the currents are being measured. At least 5 levels of information above 250 m per mooring are desirable.

The observing systems for the parameters described above are listed in Table 4. The TOGA ocean monitoring programme rests heavily on the 3 ocean basin XBT network. Despite the success of the system, there continues to be a shortfall of probes deployed per year. The TOGA Implementation Plan calls for 30,000 probes to be dropped per year. In 1990 it appears that only 17,000 will be available, a shortfall of 13,000 probes. The SSG has determined that in some regions, specifically where mean precipitation exceeds evaporation, XCTD's rather than XBT's will have to be deployed in order to define the subsurface salinity structure. An urgent priority is to increase national commitments to supply and deploy XBT and XCTD probes. The TOGA *Ad Hoc* Panel of Experts has also expressed concern that at least 40% of the XBT observations made in the tropical oceans are not reported in near real-time and are thus lost to the operational ocean models.

Plans are to extend the existing array of Atlas thermistor moorings along the equator in the Pacific to the so-called TAO II (The Thermal Array in the Ocean II) configuration. Additionally, the SSG has suggested that a five-mooring current array become part of the TOGA monitoring effort in the western Pacific. At the same time a large number of Lagrangian drifting buoys are being deployed annually in the Pacific. The annual requirement of drifting buoys is 230. Only 150 are now being deployed.

Although considerable progress has been made in setting up the TOGA sea level network, there is a shortfall of about 20% over the 3 tropical oceans. The statistics for each of the oceans are:

	Planned		Existing
Pacific	95	88	
Indian	60	40	
Atlantic		40	29
TOTAL		195	157

In order to provide surface data in the data-sparse southern oceans for the calibration of satellite data, a large number of surface drifting buoys are deployed each year. Commitments now exist for 50 of the 100 buoys needed annually.

In conjunction with the study needed of the warm pool regions of the tropical oceans, the second half of the TOGA Programme will include a Coupled Ocean-Atmosphere Response Experiment (COARE). An Intensive Observation Phase (IOP) will be held in the western Pacific from November 1992 through February 1993. For a year prior to and following the IOP, the regular networks will be enhanced, an oceanographic network will be established, and radiation monitoring equipment will be installed. An initial assessment of the resources required for COARE are shown in Table 5.

In order to emphasize the second and third scientific objectives of TOGA, prediction of interannual variability will be a major focus during the second half of the TOGA period. Given the large number of scientific and technical tasks remaining, the SSG has recommended that these tasks can best be approached by forming a climate modelling center or centers. Such a center, or centers, would require the same resources and capabilities as the European Center for Medium-Range Weather Forecasting. Beyond their developmental role, such centers would provide guidance for developing a global ocean observing system.

TOGA data management requirements are to: (i) provide sufficient quality control flags such that research users can appraise the utility of individual observations or derived quantities, (ii) provide data within a time frame appropriate to the data and the uses to be made of them, (iii) provide data, data products, as well as their quality control flags and documentation, in readily accessible formats to interested scientists and organizations in all countries, (iv) preserve backup data sets in such a way that derived quantities can be re-computed in case of a change in algorithms or parameters, (v) set standards for products to be derived from data sets in close collaboration with data managers and scientific users, (vi) maintain enough flexibility in the data management system to account for evolving scientific priorities while assuring a consistent data set for the duration of the programme, and (vii) collect relevant historical and current TOGA-related data from participating countries. TOGA data centers are listed in Section 4.5.

3.2 WORLD OCEAN CIRCULATION EXPERIMENT (WOCE)

The goals of WOCE are (i) to develop models useful for predicting climate change and to collect the data necessary to test them, and (ii) to determine the representativeness of the specific WOCE data sets for the long-term behaviour of the ocean, and to find methods for determining long-term changes in the ocean circulation. The WOCE Implementation Plan contains details of the experimental elements of WOCE, data management, the modelling programme, and tables of resource needs. The major observational components of the WOCE Field Programme are:

(i) Full depth, hydrographic/tracer survey, the WOCE Hydrography Programme (WHP), covering the entire ocean once,

(ii) Repeat hydrography, to at least 1,500 meters, to provide temporal information,

(iii) Global deep float releases employing a mixture of pop-up and acoustically-tracked floats,

(iv) Satellite altimetry calibrated with a sparse global sea-level network,

(v) Moored arrays and special float releases to map transequatorial exchange and western and eastern boundary currents, deep boundary currents and exchanges between basins, and the vertical structure of the eddy field,

(vi) Enhancement of surface meteorological measurements to validate satellite-derived wind and sea surface temperature measurements,

(vii) A surface layer programme using surface velocity drifters, standard hydrographic measurements, XBTs, CTDs, moored and drifting temperature and temperature/salinity chains,

(viii) Eddy-resolving XBT/XCTD sections to determine the variation of the strength of the major oceanic gyres on seasonal and interannual time scales.

The major WOCE resource requirements are shown in Table 6. WOCE XBT depth requirements are 1,000 meters along western boundaries and in high latitudes and 750 meters elsewhere. In the Atlantic 22 XBT lines are required (monthly, 2 XBTs per day), in the Indian Ocean 17 lines, and in the Pacific 13 high density lines (seasonal, 12 XBTs per day) as well as the lower density sampling undertaken by TOGA, described in Section 3.1 above. WOCE sea level sites are discussed in Section 4.3.2 and are depicted in Table 20.

WOCE needs to estimate the seasonal evolution of heat and salt content of the upper ocean in order to test and validate ocean models. There is serious concern that the air-sea flux estimates will contain large uncertainties due to problems with both the initial data and the parameterization. Storage of heat and salt will provide a first order estimate of the overall consistency of those estimates. Salinity measurements are needed in the upper 1000 meters of the water column. Much better coverage and data exchange is needed than presently exists. Because there is no method for obtaining salinity profiles from ships of opportunity, these data must be obtained using conventional CTD instrumentation from research or other mission-oriented vessels. In regions such as the North Atlantic and Pacific Oceans, CTD profiles are now taken by fisheries, military, and other organizations, but are not being exchanged, or are being exchanged very slowly internationally and are being collected in a manner (or with instrumentation and techniques) that provides inadequate precision and accuracy. In mid to high latitudes salinity is a dominant component of the seasonal and interannual variation in the upper and intermediate layers, but an understanding cannot be obtained without a far better distribution of temperature and salinity profiles in the upper 1,000 meters of the water column.

WOCE will measure the transport of a number of the major currents using mooring arrays, tide gauges, and electric cables. In addition, satellite altimeter data are presently providing unique information concerning the variability of such currents over a much larger range of space and time scales. The main satellite sensors contributing to WOCE are shown in Table 7. Most of the mooring arrays have, as one of their scientific goals, the design of techniques or arrays that can carry out long-term monitoring of the current with much reduced resources. In a few cases, such as in the Florida Straits, one can now estimate the transport from the cable very inexpensively.

WOCE stresses the importance of data management for the creation and assembly of data sets, the preparation of catalogues, and the dissemination of data sets to users. Data Assembly Centres have been established for drifting buoy data, upper ocean thermal data, and sea level data. Additionally, a Data Information Unit provides referral services for locating WOCE data sets. The locations of WOCE Centres are listed in Section 4.5.

3.3 POLAR PROGRAMMES

The IAPSO Commission on Sea Ice has indicated the need for :

(i) Arctic buoy measurements such as now taken by the U.S. Office of Naval Research using drifting, ice-mounted, satellite-tracked data buoys

(ii) Beaufort and northern Greenland seas, using moored, upward-looking sonar (not now measured)

(iii) Ice cover and distribution from SSM/I, planned by NASA

(iv) Ice motion, being discussed by NASA

(v) Antarctic- undefined.

The German Alfred-Wegener Institute for Polar and Marine Research has identified the need for:

(i) Horizontal grid of about 100 km and with a sampling interval of 5-10 days and atmospheric quantities on a similar grid but on a daily interval

(ii) Sea ice - extent, concentration, thickness, velocity, surface albedo, surface net radiation

(iii) Atmosphere - Surface wind stress, surface air pressure, near surface air temperature, near surface air moisture

(iv) Ocean - Mixed layer currents, temperature, salinity and depth and changes of the first three quantities across the pycnoline.

Generally speaking, a continuous satellite observation programme forms the backbone of a long-term sea ice and ocean surface monitoring scheme. Additionally, considerable international efforts are needed to support satisfactory long-term surface buoy and subsurface upward-looking sonar programmes in Arctic and Antarctic waters.

The most valuable information on sea ice extent and its time variations is obtained from satellite passive microwave radiometers (since 1972). Less certain, but still useful, are ice concentration estimations from the same data source. Past attempts to determine the age of ice floes and their thickness with the aid of any remote sensing device are unsatisfactory. The World Climate Research Programme is making an effort to implement ice thickness monitoring programmes using moored upward-looking sonars in key positions in both polar regions. Logistics support is needed to deploy and maintain this equipment. An Antarctic drifting buoy programme, similar to the Arctic buoy programme maintained by the U.S., needs to be established. Surface stations are needed to provide full coverage of atmospheric surface data (air pressure, air temperature, and possibly wind velocity), sea surface and/or ice surface temperatures, mixed layer depth, ice thickness, and snow depth. Ice motion is obtained from the time sequence of the buoy positions. Buoys of this kind have been deployed recently in the Antarctic with good success.

3.4 JOINT GLOBAL OCEAN FLUX STUDY (JGOFS)

The goal of the Joint Global Ocean Flux Study (JGOFS) is to "determine and understand on a global scale the processes controlling the time varying fluxes of carbon and associated biogenic elements in the ocean, and to evaluate the related exchanges with the atmosphere, sea floor, and continental boundaries". JGOFS requires a network of time series stations at which regular measurements of key properties and processes are made at bi-weekly or monthly intervals, or continuously if automated sensors are available. For logistical reasons, most stations must be near islands or coastal nations with well-equipped laboratories. Stations are needed in tropical oligotrophic waters, higher latitude regions, coastal, upwelling, and boundary current regions. Once established, these sites will provide the means to describe the time-varying behavior of the physical, ecological, and biogeochemical system in each area. They will also provide material for calibrating and validating biogeochemical models. Measurements to be taken at long time series stations have not been defined, but sediment traps are considered necessary.

3.5 GLOBAL ENERGY AND WATER CYCLE EXPERIMENT (GEWEX)

The objectives of the GEWEX Programme are:

(i) to determine the hydrological cycle and energy fluxes by means of global measurements of observable atmospheric and surface properties;

(ii) to model the global hydrological cycle and its impacts on the atmosphere and ocean;

(iii) to develop the ability to predict the variations of global and regional hydrological processes and water resources, and their response to environmental change; and

(iv) to foster the development of observing techniques and data management and assimilation systems, suitable for operational applications to long-range weather forecasts, hydrology, and climate predictions.

The GEWEX Programme has requirements for monitoring the heat and salinity content of the upper ocean on a global scale, with temporal and spatial resolution consistent with the needs to derive surface fluxes of heat and water vapor, changes in storage and upper ocean transports, as critical components of the global heat and water cycles. Deficiencies in present observing systems are cited as:

(i) heat content in the Southern Oceans and parts of the Northern Hemisphere ocean

(ii) salinity throughout the global ocean.

Actions requested include:

(i) surface salinity measurements by Voluntary Observing Ships

(ii) further development and deployment of XBTs with the addition of expendable temperature-conductivity probes

(iii) development of suitable salinity sensors for unattended operation on buoys of other automatic vehicles.

Also cited as long-term needs are more drifting buoys with thermistor chains and salinity sensors in data sparse regions and instrument development for the salinity sensors.

3.6 WORLD CLIMATE DATA PROGRAMME

The goal of the World Climate Data Programme (WCDP), one of four components of the World Climate Programme described further in Section 4.8, is to insure timely access to reliable data which are exchangeable in an acceptable format to support climate applications, impact studies, and research. The WCDP has established the following requirements for the construction of global baseline data sets:

(i) Standard synoptic and climatological observations including sea surface temperature and subsurface measurements at a density of ten reporting stations per 250 square kilometers

(ii) Sea surface temperature grid point data set, data blended to half degree lat-long grid

(iii) Upper air observations taken at standard times from as many sites as practical

World Climate Programme data are derived from the World Weather Watch synoptic network (described in Section 4.1), with additional quality control standards applied prior to use of the data base. Following the Second World Climate Conference in November 1990, this activity was re-named the World Climate System Monitoring Programme.

3.7 SUMMARY OF VARIABLES AND PROCESSES TO BE MONITORED

In 1990, a review was made of parameters, processes, features, and phenomena that need to be included in a comprehensive ocean observing system to meet climate-related needs. Initial conclusions are that it will be helpful to be able to describe the state of all the general circulation gyres, especially their major currents and the state of the upper layer (mixed layer and thermoclines and haloclines). More precisely, we need to know the heat and salt content of the upper ocean, and the horizontal advection of heat and salt. We need to know the air-sea transfers of momentum, heat, and moisture. It will be essential to determine air-sea transfers of particles and gases. And it may be important to monitor the heat and salt fluxes from the sea floor.

Similarly, we need to know the major river discharges, both their volume and property (e.g., sediments, nutrients, and pollutants) fluxes. For some purposes, we would like to resolve all of the major oceanic fronts and eddies. For others, we would like to know the intensity and quality of all the major upwelling centers and regions. Undoubtedly, we need to track the position of the polar ice edge and probably keep track of the polar ice thickness.

For the purpose of documenting climate variability and climate change, it will be essential to detect changes in water mass properties and the rates of water mass formation. In addition to knowing the state of major circulation gyres and currents, intergyre and interbasin exchanges, and changes therein, may be of interest. Such signals need to be detected against a background of seasonal and interannual variability, which, of course, need documentation.

Emphasis is needed on the means to monitor the formation of subsurface water masses-- their locations, rates, and consequent transfers to the interior of the ocean of gases, particles, heat, and salt. Hence, a focused research question concerns the degree to which satellite and acoustic remote sensing systems, when applied to data-assimilative models, can accurately estimate such water mass formation, and the kinds and numbers of direct observations that are needed to achieve acceptable accuracies for a defined purpose.

An inescapable topic is that of space-time resolution and the attendant tradeoffs. Because the scales of variability vary geographically for dynamical reasons, it may be possible to design a 'smart' (optimal) strategy. For example, though the upper ocean, equatorial ocean, and coastal ocean are very responsive to synoptic scale atmospheric forcing, and, thus, need to be sampled relatively rapidly in space and time, the same is not generally true for the bulk of the ocean interior.

The choice of domain is closely related to the resolution topic. One extreme is to undertake the entire global domain and resolve it only coarsely with available resources, and then to refine the resolution as the demand grows, as resources increase, or new technologies are acquired. The other extreme is to choose a domain small enough to adequately resolve the energetic and relevant scales, and to expand the domain as more resources or new technologies become available. The first strategy has the advantage of providing a global product immediately though it may not be of much use. The second strategy has the advantage of proceeding correctly, and presumably usefully, at least somewhere.

Clearly, a priority suite of variables, which will become comprehensive as the system expands, must be identified. For the first step, listed below are the highest priority items:

Surface:

PHYSICS	BIOLOGY	CHEMISTRY
air temperature	pigment concentration	dissolved oxygen
atmospheric pressure	plankton concentration	marine aerosols
currents		pCO_2
precipitation/evaporation		
relative humidity		
salinity		
sea level/dynamic topography		
tides		
water temperature		
waves		
winds		

A somewhat different suite of variables needs to be determined for the interior of the ocean:

PHYSICS	BIOLOGY	CHEMISTRY
absolute pressure	phytoplankton biomass	CO_2
currents	primary productivity	dissolved
salinity	secondary productivity	oxygen
vertical velocity	zooplankton biomass	nutrients
		pollutants
		radionuclides
		trace elements

Table 8 shows the parameters now being observed and exchanged internationally within existing ocean observing and data management systems as well as large-scale international research programmes.

4. EXISTING AND PLANNED GLOBAL OCEAN OBSERVING AND DATA MANAGEMENT SYSTEMS

4.1 WORLD WEATHER WATCH (WWW)

4.1.1 Description of Functions

The WMO World Weather Watch is a co-ordinated world-wide system whose primary purpose is to make available, within the agreed system, meteorological and other environmental information required for both applications and research. It is the only international operational programme established to gather and distribute in real-time meteorological and related environmental data on a global scale. The WWW incorporates frequent and regular observation of a wide range of meteorological and related geophysical elements from thousands of locations on land, sea, and air as well as outer space; the rapid collection and exchange of the observational data; the preparation of information in a variety of forms describing the current and forecast conditions; and the dissemination of this information.

The objectives of the WWW are:

(i) To implement and operate by Members a world-wide integrated system for the collection, processing, and rapid exchange of meteorological and related environmental data, analyses, and forecasts.

(ii) To make available, both in real-time and non-real-time, as appropriate, observational data, analyses, forecasts and other products to meet the needs of all Members, of other WMO Programmes and of relevant programmes of other international organizations;

(iii) To arrange for the introduction of standard methods and technology which will enable Members to make the best use of the WWW System and ensure an adequate level of services.

Core elements of the WWW are:

The Global Observing System consisting of facilities and arrangements for making observations at stations on land and at sea, and from aircraft, meteorological satellites and other platforms. The surface-based sub-system is composed of regional basic synoptic networks, other observational networks of stations on land and at sea, aircraft meteorological observations, climatological stations, agricultural meteorological stations, and special stations. A network of Voluntary Observing Ships (VOS) also participate. The space-based (satellite) sub-system is composed of the near-polar-orbiting and geostationary meteorological satellites. At present, there are some 9,500 stations on land, 7,000 ships, 220 fixed and drifting buoys, 600 radar stations, 3,000 aircraft, and a system of at least 4 orbiting and 5 geostationary satellites, all of which generate daily approximately 8 million characters of alpha-numeric data.

The Global Data Processing System consisting of World, Regional/Specialized and National Meteorological Centres to provide processed data, analyses, and forecast products;

The Global Telecommunications System (GTS), as shown in Figure 4, is composed of an increasingly automated network of telecommunication facilities for the rapid, reliable collection and distribution of observational data and processed information. This integrated system of point-to-point circuits, meteorological telecommunication centres, and data distribution systems is organized on a 3-level basis:

The Main Telecommunication Network which links together the World Meteorological Centres (located in Melbourne, Moscow, and Washington) and the Regional Telecommunication Hubs (located in Algiers, Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Jeddah, Nairobi, New Delhi, Offenbach, Paris, Prague, Sofia, and Tokyo).

The Regional Meteorological Telecommunication Networks which consist of an integrated system of links interconnecting national, regional, and global centres

The National Meteorological Telecommunications Networks which enable the national meteorological services to collect observational data and to receive and distribute processed products on a national level

The capacity of the Main Telecommunication Network of the GTS, while not unlimited, is sufficient to meet all expected requirements for the global exchange of conventional oceanographic data during the next decade.

WWW support functions consist of:

(i) **WWW Data Management** to co-ordinate, manage, and monitor the flow of data and products within the WWW system in accordance with international standards to assure their quality and timely delivery to meet Members' individual needs and those of other WMO programmes;

(ii) **WWW System Support Activity** to provide guidance, scientific and technical information, and training to those involved in the planning, development, and operation of WWW components; and to initiate, co-ordinate, and evaluate various WWW co-operative activities and support actions.

Three other components of the WWW are the **Instruments and Methods of Observation Programme** which aims to improve the accuracy of the data and the standardization of meteorological instruments and techniques, and to incorporate new technological developments; the **Tropical Cyclone Programme**; and **WMO Satellite Activities.** The long-term objectives of the Satellite Activities are to: i) insure co-ordination and continuity of the operational meteorological satellite programmes, and ii) strengthen Members' capabilities to receive and effectively use satellite data and products. The Executive Council Panel of Experts on Satellites is the focus for overall co-ordination of satellite matters, formulating policy, providing guidance useful for interaction with other United Nations and international organizations, and determining requirements, methods, and systems for satellite data.

4.1.2 Status of Present Activities and Future Plans

Table 9 identifies the data that are needed to obtain optimum results from numerical weather prediction techniques by the late 1990s. Table 10 lists the basic set of global observational data required to be met by the Global Observing System (GOS) by the late 1990s. Both are contained in the WMO Third Long-Term Plan. The GOS, although extensive, contains large voids in the surface-based system over ocean areas, polar, and desert regions.

Surface-based - Table 11 lists, by country, the number of ships that participated in the Voluntary Observing Ship Scheme in 1988. Figures 5 and 6 depict a typical one month coverage by Voluntary Observing Ships which collect and transmit at standard synoptic hours reports containing observations of some or all of the following parameters: surface barometric pressure, surface wind, surface air temperature, dewpoint, cloud amount and height, weather, SST, sea state, sea ice, and icing. Through conventional HF radio communications, 327 coastal stations accept ships' weather reports without charge to ships. Four INMARSAT Coast Earth Stations covering the Atlantic Ocean region, 2 covering the Indian Ocean region, and 4 others covering the Pacific Ocean region accept weather reports from ships equipped with Ship Earth Stations without charge to ships. About 20% of participating ships have such equipment. As a result of the implementation of the Global Maritime Distress and Safety System, virtually all ocean-going ships will be equipped with INMARSAT communications equipment by the end of this decade. The number of Voluntary Observing Ships has been decreasing at the rate of about 2-4% per year due to the decrease in the number of transoceanic ships. WMO officials believe that it is not possible to increase the number of participating ships for this reason. Between 3,000 and 4,000 ships' weather reports are received daily at major WWW telecommunications and data processing centres. Ships have been recruited by 49 WMO members and are managed nationally through networks of Port Meteorological Officers.

The operational drifting buoy programme comprises over 200 active buoys transmitting about 2,000 reports via the GTS in a 24-hour period. The location of buoys and the transmission of data via satellite are carried out through the ARGOS system, a co-operative undertaking between CNES (France), NOAA (USA), and NASA (USA). The use of local user terminals, such as those established in Australia, Canada, Denmark, France, Norway, and Saudi Arabia, has enhanced the usefulness of the Argos System for operational meteorological purposes. These activities are described in more detail below under Section 4.4.

Automatic marine stations, on moored buoys or fixed platforms, are being used to an increasing extent to obtain meteorological, oceanographic, and other environmental data. Many countries are operating, testing, or planning automatic or semi-automatic observing or recording stations on buoys, marine platforms, light vessels, oil and gas platforms, mobile drilling rigs, mobile ships, etc. It is estimated that about 80 moored buoys, mostly around North America, and 60 fixed platforms, mostly around Europe, now serve as automatic weather stations.

Two Ocean Weather Ships are presently operational as ocean stations: one operated by the U.K. normally at 59 degrees north, 20 degrees west, and one operated by Norway at 66 degrees north, 02 degrees east. They make and transmit a full suite of surface and upper air meteorological observations, as well as surface and sub-surface oceanographic data. The long-term future of these platforms is uncertain.

Satellite-based - Satellite observations, which began just over 30 years ago, have a special importance over the oceans. Currently polar orbiting satellites are operated by France, India, Japan, the USA, and the USSR. Geostationary satellites are operated at different locations over the Equator: by the European Satellite Consortium (EUMETSAT/ESA)- 0 degrees East, India- 74 degrees East, Japan- 140 degrees East, and the USA- 75 degrees West and 135 degrees West. Each of these satellites carries a variety of sensors allowing derivation of sea surface temperature, atmospheric pressure, and cloud temperature. In addition to transmitting imaging data in the visible and infra-red bands, these provide a substantial capacity for data relay of surface observations.

Twenty polar-orbiting satellites or satellite series with the capability to support marine meteorology and physical oceanography are planned for launch during the decade of the 1990s. They will have more than 40 sensors. Table 12 summarizes the array of remote sensing systems that are to be introduced or expanded during the next decade. Tables 13 through 15 provide an more specific listing of satellite measurements from operational, planned/proposed, and EOS satellites. Brief descriptions of several national and regional satellite initiatives are given below.

ADEOS - In 1995 Japan expects to launch the Advanced Earth Observing System (ADEOS) which will include an ocean color and temperature scanner, an advanced visible and near-infrared radiometer, and a scatterometer. This initiative has been preceded by the MOS-1 activities, described below.

Cosmos-1500 Series - The USSR Cosmos series, also designated as the OKEAN series, began in 1983 and carried a side-looking radar system and a visible imaging system. The OKEAN series began in 1988 and includes a side-looking radar, a scanning microwave radiometer, a nadir-viewing microwave spectrometer, and optical-mechanical scanners. A specific feature of the OKEAN series is the possibility of direct data reception by users having simplified hardware and software for data processing.

ERS Series - The European Space Agency (ESA) will fly 2 Earth Remote Sensing Satellites (ERS) that provide a 3-day repeat cycle for 3 instruments: an active microwave instrument that acts as a scatterometer, a synthetic aperture radar, and a wave spectrometer; an along-track scanning radiometer and microwave sounder that provides sea surface temperature; and a radar altimeter. The first satellite, ERS-1, is to be launched in April or May 1991. Plans for ERS-2 include measurement of some ocean color in addition to sea surface temperature. All data and products will be archived by ESA at 4 processing and archiving facilities: in the UK, France, Italy, and Germany.

FY-1b - The first Chinese State Meteorological Administration satellite Feng-Yuen-1 (meaning wind-cloud) was launched in 1988 but was a victim of early failure. Feng Yuen 1-b was launched as the second satellite in this series in September 1990.

Geodetic Satellite Follow-on - The first Geosat was launched in 1985 by the U.S. Navy and operated for nearly 5 years. A single altimeter comprised the payload of this satellite which demonstrated the operational use of satellite altimetry to measure sea surface topography, ocean currents and eddies, ice edge detection, surface wind speed, and significant wave height. The follow-on system to Geosat is designated as the Geodetic Satellite Follow-On and will include a Geosat-class altimeter. One is to be launched in 1994 and one in 1997.

JERS-1 - The National Space Development Agency and the Ministry of International Trade and Industry of Japan will launch in mid-1992 the first Japan Earth Resources Satellite (JERS-1) consisting of a synthetic aperture radar and a visible and near-infrared radiometer/shortwave infrared radiometer.

Landsat Series - The Landsat Series is operated by the Earth Observations Satellite Company in the U.S. under the auspices of NOAA. Landsat-4 and Landsat-5 are presently operational, with Landsat-6 planned for launch in late 1991. Applications for estuaries and wetlands have been demonstrated by these high spatial resolution systems. The principle sensors on Landsat-4 and -5 are the multispectral scanner and the thematic mapper.

Meteor Series - The USSR State Committee for Hydrometeorology began operation of the polar-orbiting satellite system, Meteor-2, in 1975. To date, 18 satellites of this type have been launched. The system comprises 2-3 satellites continuously operating in a near-polar orbit with an on-board instrument package of 3 television-type visible and infrared scanners, an 8-channel scanning radiometer, and a device for measuring radiation flux densities in the near-earth space. Objectives are to obtain meteorological observations, measure sea surface temperatures and sea ice, and assess the condition of vegetation.

MOS Series - The first Japanese Marine Observation Satellite (MOS-1) was launched in 1987 in a sun-synchronous orbit with a 17-day repeat. The 3 sensors are a multispectral electronic self-scanning radiometer, a visible and thermal infrared radiometer, and a microwave scanning radiometer. The objective of the programme is to observe the state of the sea surface and the atmosphere.

NOAA Series - The U.S. National Oceanic and Atmospheric Administration (NOAA) has operated polar-orbiting, earth observation satellites for approximately 30 years. These systems have provided free access to real-time data collected through automatic picture transmission systems or the advanced high resolution picture transmission. Presently NOAA-10 and NOAA-11 are operating, with continuing improvements expected through the 1990s. NOAA-12 will be launched in 1991. This series carries as second generation advanced very high resolution radiometer, a second generation high resolution infrared sounder, a stratospheric sounding unit, a microwave sounding unit, a solar backscatter UV experiment, an earth radiation budget experiment, and a space environment monitor.

NPOP Series (EOS - A and -B) - NASA has proposed a lengthy list of candidate instruments, subject to change, for its Earth Observing System (EOS) missions, now scheduled for 1997. These include an advanced scatterometer, a multi-angle imaging spectro-radiometer which will measure tropical ocean phytoplankton pigment concentrations, global geophysical information retrieval with a prototype high resolution microwave spectrometer sounder, and an altimeter to assist in determining the general circulation of the ocean and its variability by combining sea level with internal density field measurements of the ocean and models of ocean circulation. EOS is a series of very large polar platforms and combines both the observational measurements and the research and interpretation of data. The objective of EOS is to provide earth observation capability in the atmospheric, oceanographic, and land sciences, and in solar terrestrial research. It is part of the "Mission to Planet Earth" to study the relationships and feedback mechanisms from the sun to the center of the earth.

SeaWIFS - The application of ocean color is important to physical oceanography because it significantly extends satellite observations of ocean currents and eddies, transport mechanisms, and water mass detection. Although ocean color is typically limited to measurements of material in the upper tens of meters of the ocean surface, other satellite wavelengths penetrate the ocean surface only to tens of micrometers. Based on the experience of the Coastal Zone Color Scanner flown in the 1970s, the wavelength specifications of the next generation ocean color sensor have been identified by NASA as SeaWiFS. It is scheduled for operation in late 1992.

SPOT Series - Developed by France with the participation of Sweden and Belgium, these polar satellites provide a ground resolution in the 10-20 m range, with the possibility of stereoscopic viewing and excellent geometric accuracy. At present SPOT-1 and -2 are operational. SPOT has proven its capabilities to detect underwater features in near-shore areas. The remainder of the series, SPOT-3 and -4, are guaranteed until the year 2000 with the same sensor characteristics.

The EC WMO Panel of Experts on Satellites has developed a consolidated set of requirements for all WMO programmes, taking into account the feasibility of measurement by satellite. This listing is a basis on which satellite operators can build systems. The WMO is now expanding this listing to include all environmental satellite needs and a review of the ocean satellite data requirements is in progress.

Telecommunications - As part of the evolution of the WWW system, in 1990 plans were developed to improve the distribution of data and products, with the following objectives and plans set out for the period of 1992-2001:

(i) A review of global, regional, and national aspects of the GTS structure to meet the needs for a more cost-effective GTS capable of meeting increased requirements for data exchange

(ii) A review of telecommunications procedures and protocols used to lead to a more flexible and efficient GTS

(iii) A study to co-ordinate implementation of GTS circuits and centres, including data collection and dissemination on the national, regional, and global levels

(iv) Further development of GTS arrangements for exchanging environmental and other data required for reducing the impact of natural disasters and environmental accidents

(v) Support for the Global Atmosphere Watch

(vi) Development of specific solutions for the organization, implementation, and operation of the GTS in data sparse areas where the GTS is now deficient due to adverse conditions.

4.2 INTEGRATED GLOBAL OCEAN SERVICES SYSTEM (IGOSS)

4.2.1 Description of Functions

The Integrated Global Ocean Services System (IGOSS) is the operational network for the global collection and exchange of ocean data, products, and services. IGOSS was established in 1967 jointly by the IOC and the WMO and consists of national facilities and services provided by Member States. The purpose of IGOSS is to make available to Member States data and information required to provide efficient and effective ocean services for both operational and research applications. IGOSS promotes, co-ordinates, and develops the international arrangements necessary for the timely acquisition and exchange of data, the provision of services, and the dissemination of products in the form of observations, analyses, and forecasts. IGOSS data requirements originate from a need to obtain a better understanding of ocean conditions for marine weather forecasting, fisheries research, commercial fishing, navigation, and pollution control as well as for climate-related studies. These requirements vary because of the multi-purpose nature of IGOSS.

The structure of IGOSS is as follows:

The **IGOSS Observing System** consists of the facilities and arrangements contributed by participating countries for obtaining standardized oceanic observations from research ships, ships-of-opportunity and voluntary observing ships, tide gauges, ocean weather stations, buoys, fixed platforms, satellites, and aircraft.

Variables observed by the IGOSS Observing System are identified in Table 8. An important component of this system is the network of ships-of-opportunity, commercial vessels that take and transmit oceanographic observations, comparable to the WMO Voluntary Observing Ship Scheme, described in Section 4.1.2 above. Although, as noted above, IGOSS includes tide gauge and buoy measurements, these activities are described in the following sections (the Global Sea Level Observing System and the Drifting Buoy Co-operation Panel) because they are administered separately.

The **IGOSS Data Processing and Services System** consists of the international operational data processing and services system of National, Specialized, and World Oceanographic Centres for the processing of operational observational data and the provision of products, services and operational data exchange activities to various user groups. National Oceanographic Centres provide quality control, transmit data, and prepare products in accordance with national priorities. Specialized Oceanographic Centres collect and process data from the GTS and/or other sources, perform quality control, and prepare specified products. World Oceanographic Centres receive data from the GTS, perform quality control, and prepare global products. The list of IGOSS Specialized and World Oceanographic Centres is given in Section 4.5.

The **IGOSS Telecommunications Arrangements** consist of the facilities of the World Weather Watch Global Telecommunication System (GTS) and other arrangements necessary to rapidly and reliably collect and distribute data and processed information. The National Meteorological Service responsible for the operation of a telecommunication center of the GTS is also responsible for both transmission to and reception from the GTS of IGOSS observational data and processed information. Section 4.1.2 above contains a description of the GTS. Methods used for transmission of data to the shore include the international Maritime Mobile Service, radio communication using exclusive HF bands, geostationary and polar-orbiting environmental satellites, communications satellites, and Very High Frequency transmissions.

IGOSS is co-ordinated through a Joint IOC/WMO Committee for IGOSS which oversees several subsidiary groups, programmes, and projects as shown in Figure 7.

4.2.2 Status of Present Activities and Future Plans

The BATHY/TESAC component of IGOSS, launched in 1972, is now the major element of the IGOSS system. The "BATHY" refers to temperature vs. depth profiles collected using XBT's or MBT's; the "TESAC" (Temperature, Salinity, Conductivity) portion constitutes measurements taken with Conductivity/Temperature/Depth equipment. In 1989 a total of 38,615 BATHY messages and 5,444 TESAC messages were transmitted via the GTS; the daily average was 121 messages. Countries contributing the majority of these data were: Australia, Canada, China, France, GDR, FRG, Japan, USSR, UK, and USA. Table 17 indicates the number of subsurface temperature (BATHY) and salinity (TESAC) measurements that were exchanged via the GTS for the period of 1984 through 1989. In 1989 the daily average number of BATHY observations was 106.

The maps given in Figures 9 through 12 depict the location of the BATHY and TESAC data collected for the month of July 1990, using 2 different map projections. Figures 13 and 14 provide the number of those observations by Marsden Square. The present IGOSS Plan and Implementation Programme (1989-1995) emphasizes that coverage needs to be increased in the Atlantic, Indian, and Southern Oceans while recognizing that the Pacific Ocean is not as densely sampled as is desirable. As a result of the TOGA activities, much of the real-time XBT data collected is concentrated in the tropics. Attention is being given to options for sampling in the Southern Oceans, possibly by using Antarctic supply vessels or fishing vessels. As noted below in the discussion of the Drifting Buoy Co-operation Panel, there is some hope that drifting buoys will soon be able to reliably transmit subsurface data through suspended thermistor chains.

In 1989 approximately 200 ships (both research and merchant) from 23 countries contributed to the collection of IGOSS data. Many of these ships carried XBT systems which receive, store, and transmit data accurately and quickly; they can electronically digitize XBT profiles and encode messages for satellite transmission. These systems are modular, small in size, and can be easily installed and removed from ships. In addition, a few ships carried acoustic Doppler current profilers which directly measure the vertical profile of ocean currents with very high spatial resolution. They can be mounted on the hull of a ship for continuous measurement along the cruise track and can produce real-time profiles of horizontal velocity (relative to the ship) continuously in time throughout the upper 250 meters. This results in a "TRACKOB" observation which includes surface salinity, temperature, current direction, and current speed along the ship's track as it travels. Figure 15 depicts the locations of these observations in July 1990. The expanding use of automatic observing and data transmission capability has led to an increase in the number of observing ships because of the reduced requirements for manual effort on board the vessels and at coastal stations; data quality also has improved. Since 1987 however, budget limitations have restricted the expansion of these activities and in some cases have caused a reduction in the amount of data over the previous few years, as shown in Table 16, due to a lack of XBT probes.

Recently standard track lines have been established-- Figures 16 through 18-- that have also been adopted by TOGA and WOCE activities. Using these lines as a guide for the required sampling areas, Member State commitments are needed for provision of ships, equipment, and XBT probes. The IGOSS Plan and Implementation Programme (1989-1995) calls for equipping 500 ships with automatic data formatting and reporting systems which will report both subsurface temperature and ship drift current observations via satellite. Other actions identified include increasing the amount of real-time data from retrievable profiling CTD systems, expanding drifting buoy networks, and equipping more ships with acoustic Doppler current profilers.

The lack of salinity measurements transmitted in real-time has caused concern, as noted under the discussion of WOCE above (Section 3.2) and has resulted in recommendations for some research vessels (e.g., fisheries) to transmit data collected by these mini, non-expendable CTD devices used in coastal studies and fisheries investigations. Presently only the USSR and Canada regularly transmit any salinity data.

Within the framework of IGOSS and WWW, IOC and WMO regularly prepare Information Service Bulletins on Non-Drifting Ocean Data Acquisition Systems. These reports contain information on fixed ocean data buoys, lighthouses, light vessels, observing towers and platforms, oil rigs, and land-based automatic stations which have been allocated international ocean data buoy identifier numbers. For each, the meteorological and oceanographic variables measured are given.

Moored data buoys are maintained by Australia, Canada, China, France, Ireland, Japan, UK, and the USA. In 1988 approximately 100 were transmitting data in real-time, mainly via the Argos System. Sea level and drifting data buoys are discussed below under GLOSS and DBCP.

A total of 18 Member States have designated National Oceanographic Centres as listed in Section 4.5. Specialized Oceanographic Centers have been designated by Argentina, Australia, France, Japan, USSR, and USA. World Oceanographic Centers function in the USSR and USA. Direct links between the real-time data exchange network of IGOSS and the data archival system of IODE are made possible through Responsible National Oceanographic Data Centers for IGOSS operated by Argentina, Canada, Japan, UK, USSR, and USA.

An increasing quantity and variety of real-time or near real-time products are being prepared, some under the aegis of TOGA, many for global change studies. To a large extent, these results are an outcome of increasing collaboration between scientists and operational teams. An example of such results is the Climate Diagnostics Bulletin, produced monthly by the NOAA Climate Analysis Center which presents products developed using oceanic and atmospheric data sets for near real-time analyses. In 1990 French research organizations began publication of a monthly bulletin called "Bulletin de l'Ocean Atlantique Tropical" which provides products describing the thermal structure of the upper tropical Atlantic in near real-time. It is a French contribution to TOGA. Annually IOC and WMO publish a summary listing of all oceanographic products prepared by national centers. The 1988 listing contained 79 subsurface products, 46 surface products, and 156 surface meteorological products; these are prepared by 50 different Member States. Table 18 lists the number of oceanographic and meteorological products prepared by each national centre in 1988. Product needs, development, standards, and distribution are aspects which will be addressed at an IGOSS Products Seminar and Workshop to be held in April 1991.

In addition to pilot projects for sea level and subsurface temperature products, IOC and WMO in 1989 established an IGOSS-IODE Global Temperature-Salinity Pilot Project to demonstrate the IGOSS-IODE end-to-end data management capability. This effort, further described in Section 4.5, will increase the collaboration between IGOSS and IODE activities. Additional priorities for IGOSS include increasing attention to quality control; a Task Team was established in 1989 to review quality control procedures for automated systems. Standardization is also important to facilitate the exchange of data. The feasibility of establishing a similar pilot project for current measurements is being studied.

In order to more effectively realize the potential of remote sensing capabilities for IGOSS data collection and product preparation, IGOSS and the WMO Commission on Marine Meteorology have established a Joint *ad hoc* Group of Experts on Satellite Remote Sensing. This group is to develop recommendations to satellite operators with regard to formats and methods for data delivery and to data centers with regard to processing and application of these data.

Priorities for telecommunications improvements include the implementation of a flexible bit-oriented code for transmission of data in binary form on the GTS. The widespread use of this Binary Universal Form for Data Representation (BUFR) will be accomplished in the 1990s and will enable the GTS to maintain the capability to handle future requirements for ocean data exchange.

4.3 GLOBAL SEA LEVEL OBSERVING SYSTEM (GLOSS)

4.3.1 Description of Functions

The Global Sea Level Observing System (GLOSS) is an international system, co-ordinated by IOC, to provide high-quality standardized sea level data from a global network of sea level stations. This network is to monitor changes in sea level due to global warming and indications of ocean circulation patterns and climate variability as well as to contribute to other international and regional research programmes and national practical applications. Seventy-nine countries participate in GLOSS and have designated national GLOSS contacts. Regional GLOSS Co-ordinators have also been designated by IOC regional bodies. The IOC Group of Experts on GLOSS provides advice to IOC on the implementation of GLOSS.

4.3.2 Status of Present Activities and Future Plans

The GLOSS Implementation Plan, prepared in consultation with TOGA and WOCE activities and adopted by the IOC Assembly at its Fifteenth Session (1989), provides details regarding the its structure and implementation. GLOSS includes:

The global network of 300 permanent sea-level stations, as shown in Figure 19, for obtaining standardized sea level observations. This forms the primary framework to which regional and national sea-level networks can be related. About two thirds of the GLOSS stations are operational. Establishment and/or up-grading of about 100 additional conventional tide-gauges is required to achieve the global coverage. Particular efforts are required to install and maintain GLOSS stations in the Arctic Ocean and the Southern Ocean. Part of the GLOSS network located in the tropical zone is considered as the TOGA sea-level network. A set of 65-70 GLOSS stations constitutes the WOCE array needed for support for satellite altimetry and for estimate of transport variations through straits. WOCE sea level sites are identified in Figure 20.

A manual on sea-level measurement and interpretation was published by IOC in five languages (English, Russian, Spanish, French, Portuguese) in 1985 in order to unify procedures for sea-level measurements and analysis and assist those member states who wish to install, improve, or reactivate their sea-level stations. Expert consultations organized by IOC in 1988 and 1990 considered the techniques and technology for making sea-level measurements in hostile regions, including Arctic and Antarctic regions and high-energy wave environments. Their conclusion is that, with careful site selection, technology exists and is affordable to make sea-level measurements in such hostile conditions.

Data collection for international exchange with unified formats and procedures which may include near-real-time data collection. The flow of sea-level data from the GLOSS network includes the following major streams (See Figure 21):

(i) submission of monthly mean sea-level values to the Permanent Service for Mean Sea Level (PSMSL); hourly and monthly mean values should be made available by national authorities as required for scientific analysis. Sea level data from 200 GLOSS stations are available at PSMSL (although for different time periods). The major problems are irregular data supply and poor worldwide communications.

(ii) submission of sea-level data on a real or near real-time basis to specialized international sea-level data analysis centres established within the framework of TOGA and WOCE programmes, IGOSS Sea Level Programme in the Pacific. A total of 80 stations in the Pacific submit data in an operational mode to the SOC for the Pacific. Preparations are under way to launch the IGOSS Sea Level Pilot Projects for the North and Tropical Atlantic and to develop a plan for similar projects in the Southern Oceans.

(iii) final submission of sea-level data from the GLOSS network and specialized sea-level analysis centres and their archives to the World Data Centres (Oceanography).

Data analysis and product preparation required for scientific and/or practical applications. Several international centres collect and disseminate sea level data and prepare sea level products:

(i) The Permanent Service for Mean Sea Level (PSMSL), Proudman Oceanographic Laboratory, Bidston Observatory, established in 1933, is charged with the collection, dissemination, and analysis of mean sea-level data. The computer data bank holds series from over 1,000 stations. A catalogue of all data held by PSMSL was published in 1987.

(ii) The TOGA Sea Level Centre, established in 1985 at the University of Hawaii, collects sea-level data in the form of hourly, daily, and monthly sea-level heights, in the TOGA area between 30° N and 30° S in the Pacific. The data set, updated annually, includes 971 station years through 1988 from 94 stations.

(iii) Two WOCE Sea Level Data Assembly Centres (DACs) are being established -- at the University of Hawaii (USA) and at the Proudman Oceanographic Laboratory, Bidston (U.K.) -- for global analysis and merging of satellite altimetry data and computing the state of the world ocean circulation and preparing further derived products.

(iv) The Specialized Oceanographic Centre (SOC) for the IGOSS Sea Level Programme in the Pacific, established in 1984 at the University of Hawaii, collects data monthly from 78 Pacific sea level stations and prepares and disseminates sea-level products which are valuable for scientific analysis of climate-related ocean processes. An example of such products is given as Figure 22.

(v) The Specialized Oceanographic Centre for the IGOSS Sea Level Pilot Project in the North and Tropical Atlantic, established in 1989 in Canada's Marine Environmental Data Service, is now planning the project. When operational the Centre will receive, process and control the quality of monthly mean data from sea level stations covering the Atlantic Ocean from 65° N to 30° S.

Assistance and training for establishing and maintaining sea level stations as part of GLOSS and improving national sea level networks. In order to set up the GLOSS network and ensure permanent operation of GLOSS stations, systematic assistance on a long-term basis should be provided to developing countries (through IOC TEMA and/or bilateral and multilateral assistance mechanisms) to enable them to participate actively in GLOSS. Eight countries (USA, UK, China, Portugal, France, Sweden, Germany, Australia) have already provided such assistance by providing instruments, installing tide gauges, training of technicians and provision of documents related to GLOSS. More than 30 specialists have been trained at the annual sea level training courses organized since 1984 by Proudman Oceanographic Laboratory with the support of IOC. A sea level training course for French-speaking countries was organized by France with the support of IOC in September 1990.

A selected set of GLOSS tide gauge bench marks shall be accurately connected to a global geodetic reference system, i.e., the conventional terrestrial reference frame, established by the International Earth Rotation Service (IERS). The presently employed technology for sea-level measurements is inadequate for determining long-term trends in absolute sea-level needed to understand long-term climate changes as well as tectonic movements. The development of new geodetic techniques based on Very Long Baseline Interferometry, the Global Positioning System and absolute gravity measurements has made it possible to link a network of tide gauges to a highly accurate global reference system. By distinguishing sea level changes from land rise or subsidence, this global reference system will ultimately provide the first measure of absolute as opposed to relative sea level changes. Within the GLOSS Network about 100 absolute sea-level stations would be required, preferably on open coasts which are more representative of open ocean conditions.

Table 18, prepared by PSMSL, summarizes **the overall operational status of GLOSS**. Stations are categorized for each "responsible country", defined as the country that will operate the gauge as given in the GLOSS Implementation Plan. "Operational" stations are those for which PSMSL has received recent monthly and annual data, checked the data, and included them in the data bank. Data is available from most GLOSS stations located in Europe, North America, Australia, India, and the Pacific; most GLOSS stations for which PSMSL is lacking data are located in Africa, South America, Indonesia, Southern Ocean, and Antarctica. Figure 23 depicts the status of each station, according to the 4 defined categories.

4.4 DRIFTING BUOY ACTIVITIES

4.4.1 Description of Functions

The Drifting Buoy Co-operation Panel (DBCP), established jointly by IOC and WMO, provides a mechanism for co-operation in all aspects of drifting buoy operations. Its objectives are to: 1) encourage the optimum use of any drifting buoy deployments being undertaken world-wide and increase the amount of drifting buoy data available to meet the objectives of major WMO and IOC programmes, and 2) encourage and support the establishment of action groups in particular programmes or regional applications to effect the desired co-operation in drifting buoy activities. The DBCP maintains a summary of drifting buoy data requirements, a catalogue of existing drifting buoy programmes, and a list of focal points for national contributions; it identifies sources of data not currently reported on the GTS and is implementing a real-time quality control system.

4.4.2 Status of Present Activities and Future Plans

There are presently approximately 600 drifting buoys operated by 11 countries (Australia, Canada, Germany, France, Japan, Netherlands, New Zealand, Norway, South Africa*, UK and the USA). All of these utilize the Argos communications and data processing system. About 10% have no sensors and are used as Lagrangian tracers only. Most of the others measure at least air pressure and/or sea surface temperature. Of those, 35%-50% transmit the data via the GTS. Table 19 shows the total number of drifting buoys per country and the portion of those buoys reporting on the GTS for the period of February 1990. Figure 24 indicates, by Marsden square, the number of reports received at the Paris Hub during May 1990. Figures 25 through 28 are regional track charts that plot the month's movement of the reported buoys that passed position and quality control checks. Since at least two-thirds of the buoys are presently funded by research programmes, a significant portion of the data are considered confidential by the buoy owners. Within the context of a proposed global ocean observing system, the question of the origin of funds is critical. Other obstacles of a technical nature hinder scientists from sending their data via the GTS. Problems relating to data processing in the Argos system are being studied and are expected to be overcome within the next few years.

Although data quality continue to be uneven, there has been a gradual improvement in the quality of the data transmitted via the GTS this past year. For example, some 84% of reported air pressure data are now considered acceptable and the mean of the RMS pressure errors has fallen to almost 2hPa compared with 3hPa for 1988. The Argos Data Processing Centre is now designing a new data processing system which will be more flexible and more effective than the present one.

*The Government of the Republic of South Africa has been suspended by Resolutions 38 (cg-VII) and 2/74/4 (Twentieth Session of the General Conference of Unesco) from exercising its rights and enjoying its privileges as a Member of WMO and Member State of IOC, respectively.

A 1988-1989 study conducted indicates that the lifetime of drifting buoys, as measured by the lifetimes of their air pressure sensors, was as follows:

Lifetime over 18 months	-	23%
Lifetime of 12-18 months	-	13%
Lifetime of 6-12 months	-	31%
Lifetime of less than 6 months	-	33%

The US and France have conducted tests using thermistor chains on drifting buoys. These experiments have shown that presently the chain can be maintained for only about 3 months because the chain attachment becomes brittle. New attachment techniques are being studied which may prove more resistant.

The Panel has taken an active interest in the development of an atmospheric pressure sensor for installation on WOCE drifting buoys, large numbers of which will be deployed for its Surface Velocity Programme. It is hoped that, through the encouragement of the DBCP, a significant number of WOCE drifters will be upgraded by meteorological agencies to measure atmospheric pressure.

The Responsible National Oceanographic Data Centre (RNODC) for Drifting Buoy Data is located in Canada. The data is maintained in a data base structure. The number of messages archived per year by the RNODC is shown in Figure 29. In addition, the French National Oceanographic Center operates the IGOSS Specialized Oceanographic Center for Drifting Buoy Data.

In 1990 IOC and WMO began publishing quarterly bulletins containing information on buoy identifiers, location of deployment, latest location, variables measured, and data availability.

Institutions or organizations in 10 countries participate in the European Group on Ocean Stations (EGOS), founded in 1988 as a follow-on to COST-43. The purpose of EGOS is to foster the continuation of the joint drifting and fixed buoy programmes established by COST-43.

4.5 INTERNATIONAL OCEANOGRAPHIC DATA AND INFORMATION EXCHANGE (IODE)

4.5.1 Description of Functions

The IODE system was established in 1960 to enhance marine research, exploration, and development by facilitating the exchange of oceanographic data and information among participating Member States of IOC. The IOC provides standard forms for coding and reporting data, encourages the preparation of data catalogues, and assists in developing national oceanographic data centres. Within the IOC, guidance on data and information on the international scale is the responsibility of the IOC Committee on IODE. Procedures, responsibilities, and facilities for international exchange of oceanographic data under the IODE system are described in the IOC Manual on international oceanographic data exchange (currently being updated by the IODE Committee).

The prediction of climate, the exploitation of the resources of the sea, development of coastal states' EEZs, the protection of the sea from pollution, all depend on the analysis of very large quantities of accurate data. Swift access to these data gives politicians, scientists, and engineers the ability to make effective decisions. If measurements made at great cost are used only once, that is clearly very wasteful; if the data are stored and used repeatedly, all nations will benefit. The scientific and historical value of such geophysical data lie in the fact that, once lost, they can never be recovered in detail, since the Earth system is constantly changing and evolving.

Data and information management is considered an integral part of any international research and monitoring programme. The economic benefit of obtaining data by exchange rather than by actual collection is obviously large. With the advance of oceanography from a science dealing with local processes to one which is also studying ocean basins and global processes, researchers depend critically on the availability of an international data exchange system to provide data and information from all available sources. IODE is such a system.

The fundamental principle of the IODE system is that national institutions, international programmes, and individual scientists contribute data voluntarily to the data centres of the IODE system for the benefit of all. Users of the IODE system can then obtain free of charge or at a very low price data, data products, or data inventory information. Responsibilities of IODE data centers - NODCs, RNODCs, and WDCs for Oceanography - are described in IOC Manuals on IODE. Data exchanged internationally are those collected by national programmes, international co-operative expeditions and programmes, and other oceanographic programmes of international interest. The IODE network includes the following elements:

National Oceanographic Data Centres (NODCs)/Designated National Agencies (DNAs). NODCs provide the contact with the oceanographic programmes in a Member State and from those programmes compile the data and make it available for exchange. In addition to the responsibilities for data collection, processing, quality control, archiving, and dissemination of data nationally according to national procedures, the NODCs are charged with the responsibility for conducting international exchange. Some Member States that have not established a NODC have instead officially assigned the responsibility of international oceanographic data exchange to some other agency within the Member State. These agencies are referred to as Designated National Agencies. More than 40 countries have established NODCs or DNAs.

Responsible National Oceanographic Data Centres (RNODCs). The RNODC scheme was developed to enable the international exchange system to accommodate the increasing variety and volume of data being collected. The RNODC is a national centre responsible for assisting the WDCs. This assistance may be provided directly to the WDCs in support of their mission, directly to other Member States to assist them with particular requirements for data provision or retrieval, or to an international scientific programme. Usually a RNODC will provide a combination of these services. Details on the establishment and accreditation of an RNODC are described in the Guide for Responsible National Oceanographic Data Centres.

World Data Centres for Oceanography (WDCs). WDCs for Oceanography, established within the ICSU WDC system, are also recognized as part of the IODE system. Co-ordination of IOC and ICSU activities in this field is provided through close interaction between the IOC Committee on IODE and the ICSU WDC Panel. The WDCs for Oceanography receive oceanographic data and inventories from NODCs, RNODCs, marine science organizations, and individual scientists, freely exchange data, publications, and inventories between themselves and provide, upon request, copies of data, inventories, and publications to NODCs/DNAs, to RNODCs, and to international co-operative programmes in exchange, or with a charge not to exceed the cost of providing the service.

There are a number of co-operating data centres of other international organizations such as Service Hydrographique of ICES and the Permanent Service for Mean Sea Level as well as centres established to analyze data from international scientific programmes such as TOGA, WOCE, JGOFS, and IGBP. A guiding principle is that all oceanographic data sets generated by global science programmes should be banked with the WDCs. The list of all national and international oceanographic data centres is shown in Table 20.

4.5.2 Status of Present Activities and Future Plans

The Committee on IODE has established close working contacts with data management groups of TOGA, WOCE, JGOFS, IGBP, and relevant data/information management activities of such organizations as WMO, ICES, FAO, UN, UNEP, and ICSU. Global ocean science programmes have a strong incentive to develop their own data management schemes to serve their immediate objectives. Nevertheless, many data sets are or will be common to many of the programmes. Many problems concerning data handling (e.g., formatting, quality control, data tracking) may also be common. There is a need for a central data co-ordination system in order to ensure proper co-ordination of environmental data flow, collection and archiving, their easy access to scientists and governments and to avoid duplication of efforts both on national and international levels. IODE answers such problems.

For the purpose of exchange of data between IODE centres and also between these centres and their users, IODE has developed the GF3 formatting system. GF3 is a fully operational, sophisticated formatting system. Magnetic tapes, floppy disks and other carriers can be used. It is amenable to automatic processing. It has available a powerful and growing supporting software system written in the Fortran language. Data transferred in GF3 are better documented and are more useful to secondary users. The GF3 formatting system and its supportive software system, GF3 Proc are described in IOC Manuals and Guides No. 17 "GF3 - A General Formatting System for Geo-Referenced Data". This is a six volume series that describes all aspects of GF3.

As of 1988 the international marine data base system on the level of the WDCs, Oceanography, contained data for more than 2,250,000 observations. It includes data from more than 960,000 oceanographic stations, 505,000 bathy-thermographs, 135,000 biological observations and 660,000 current measurements. The data available cover more than 17,000 research cruises and include data from various international programmes (IGY, FGGE, WCRP, MONEX, BIOMASS, TOGA, KER, SECTIONS, etc.) Sixty-one countries provided data to WDCs.

WDC-A develops automated catalogue systems which can be utilized to produce a common hard copy WDC (Oceanography) catalogue existing data holdings of WDCs A, B and D (Oceanography) and to make catalogues, data bases available on-line.

The activities of IODE at providing information on the availability of oceanographic data, planned and completed research cruises and oceanographic data collected on research cruises. A diagram of the IODE data flow is given in Figure 30. To monitor data availability, special mechanisms have been developed which include:

(i) **National Oceanographic Programmes (NOP)**
NOPs serve the purpose of informing other IOC member states of the intention to conduct research cruises or research programmes. NOPs submitted by member states to IOC secretariat are widely circulated. The NOP announcement is prepared in a relatively free-form format and includes the following information about a planned oceanographic cruise-ship name, geographical area, date span for the cruise, name of the programme, operating agency comment. The committee on IODE recognized that the ship schedule database operated within the OCEANIC on-line information system at the University of Delaware, USA provides a good basis for a more practical and usable approach to the distribution of NOPs. Actions are under way to make appropriate arrangements between the IOC and the authorities responsible for OCEANIC.

(ii) **Cruise Summary Report** (former ROSCOP form)
This is a general purpose form for reporting on measurements and samples collected at sea. It is used to support a global, first level, inventory of data collected at sea and to provide ready access for scientists, programme managers and data managers alike to timely information on who has collected what, when and where. The resulting global summaries of measurements made will be available to scientists and planners through WDCs and NODCs and to the Programme Offices of international programmes. The cruise summary report forms are available in the IOC secretariat in English and Russian and are to be published in French and Spanish.

The IOC offers service to Member States through the **Marine Environmental Data and Information Referral System** (MEDI). MEDI provides a multi-disciplinary source guide to the availability and creation of marine environmental data. Participants in the MEDI system prepare simple free text entries to record information pertinent to the system and send them to IOC. Further information on a MEDI entry can be received from the IOC Secretariat.

The MEDI system now contains entries from 35 data centres (24 countries and 2 international organizations) describing 207 data sets, almost all available in machine readable form. In view of the development of a Directory Interchange Format (DIF) by IGBP, the system has been recently modified to make it compatible with the DIF. Similar in concept to MEDI is a European Directory of Marine Environmental Data Sources, being developed by the British Oceanographic Data Centre.

The Global Temperature Salinity Pilot Project (GTSPP) is being initiated by IOC in co-operation with WMO in order to promote, improve, and standardize the temperature and salinity data management mechanisms which presently exist in both the IGOSS (real-time and near real-time exchange) and IODE (delayed mode data exchange) systems. This is to be accomplished through co-operative efforts to acquire as much of the available temperature-salinity data as practical from both real-time and delayed-made data sources and assess the quality of this data for the user community to assist with climatic and other global research projects. The project will develop a continuously up-dated data base to improve the quality of the global data set and stimulate data flow. Thus far 5 participating countries (USA, USSR, France, Australia and Canada) are involved in developing the GTSPP. International co-ordination is handled by an IODE-IGOSS Steering Group on the GTSPP. The GTSPP Project Plan and the GTSPP Quality Control Manual are available from the IOC and WMO Secretariats.

Other activities and projects of IODE include:

(i) Development of a software package for oceanographic data processing and exchange on microcomputers. Known as the "OCEAN-PC" project, this is a joint IGOSS-IODE undertaking, particularly to support developing country scientists and centres.

(ii) Support for the establishment of NODCs/DNAs in the developing countries and organization of training courses for specialists in marine data and information management.

(iii) Provision of relevant historical data sets and participation in the data management, distribution and final archiving of data sets produced by the global climate programmes, such as WOCE, TOGA, JGOFS and IGBP.

(iv) Expansion of the network of RNODCs and NODCs/DNAs with increased speed and efficiency of data exchange.

(v) Participation in planning and development of data management schemes for the global ocean observing system.

(vi) Addition to the IODE system of new data types.

(vii) Development of improved information services.

(viii) Increase in services to marine information systems, notably through the joint FAO-IOC-UN/ASFIS.

Overall co-ordination of the IOC activities is provided by the IOC Committee on IODE. The Committee has established several groups of experts and Task Teams to deal with specific projects and activities, as shown in Figure 31. Participating Member States have designated national co-ordinators for IODE to ensure close interaction between the Committee and national oceanographic data/information management activities. The list of IODE national co-ordinators and the structure and composition of the IOC Committee on IODE and its subsidiary bodies are given in the IODE Handbook, up-dated every 2 to 3 years.

4.6 WMO APPLICATIONS OF METEOROLOGY PROGRAMME

4.6.1 Description of Functions

This programme sets out the activities of WMO necessary to respond to user requirements in the fields of agriculture, aeronautical, and marine meteorology. One component, the **Marine Meteorology and Associated Oceanographic Activities Programme**, promotes and co-ordinates a) marine meteorological and oceanographic services for the high seas, coastal, and port areas; b) marine observing systems in support of the World Weather Watch, marine meteorological services, and climate monitoring, research, and prediction; and c) the application of marine climatological information including for the World Climate Programme and for planning marine activities.

4.6.2 Status of Present Activities and Future Plans

The programme recognizes the increasing need for real-time ocean data and services. These services are carried out through IGOSS, described above in Section 4.2. Presently the 2 major problems in providing marine meteorological and oceanographic services are a) inadequacies, in both space and time, in marine data coverage, for data from the marine atmosphere, at the atmosphere-ocean interface, and below the sea surface and b) coupled with these inadequacies, growing demands from the user community for marine services specifically tailored to user requirements, involving ever-greater precision and detail.

The sophistication of marine services is expected to increase in response to various needs. A major and significant advance has been the development of satellite technology for both marine observations and marine communications. Advances in *in situ* observational techniques for marine parameters will also enhance the precision and reliability of ships' observations, thus further increasing the importance of the Voluntary Observing Ship Programme. In 1982 a study was done to determine the portion of marine data held by the US National Climate Data Centre that was transmitted in real-time. As shown in Figure 32, of the 155,247 observations taken in a one month period, only 80,406 were exchanged in real-time.

A Marine Climatological Summaries Scheme was established in 1964 whereby oceans are divided into 8 areas of responsibility, allocated to 8 Member States, for the purpose of collecting, quality controlling, and archiving ships' weather reports and preparing marine climatological summaries, beginning with the year 1961. All meteorological centres operating Voluntary Observing Ships are responsible for processing the data in accordance with standardized procedures and submitting them to the responsible centre (See Figure 33). It is estimated that 40 to 50 million individual ships' meteorological reports have been archived since 1960 under this scheme.

A complementary project, the Historical Sea-Surface Temperature Data Project, provides for the collection and summarization of SST and related marine climatological data for the period of 1861 through 1960 in international exchange formats. Ships' data collected by the FRG, Netherlands, UK and the USA form the basis of this set of data holdings, and the data are available from national centers in those countries. These data have also been incorporated into global marine data archives in the UK and the USA.

4.7 HYDROLOGY AND WATER RESOURCES PROGRAMME

The objective of the WMO Hydrology and Water Resources Programme is to ensure the assessment and forecasting of the quantity and quality of water resources both for different sectoral uses and for hazard mitigation. Its scope includes measurement of basic hydrological elements from networks of meteorological and hydrological stations, hydrological forecasting, and development and improvement of relevant methods, procedures, and techniques.

4.8 WORLD CLIMATE PROGRAMME

The World Climate Programme (WCP) promotes the improvement in the understanding of climate processes through internationally co-ordinated research, and the monitoring of climate variations or changes. It also promotes the use of climate information to assist economic and social planning and development. The four components are: the **World Climate Data Programme, the World Climate Applications Programme, the World Climate Impact Studies Programme, and the World Climate Research Programme**. The last component is carried out jointly by WMO and the International Council of Scientific Unions, whereas the climate impact studies are co-ordinated by the United Nations Environment Programme. The World Climate Data Programme has developed a personal-computer based CLImate COMPuter system (CLICOM) to be installed in countries around the world as a basic data management tool. The system is designed to perform data entry, quality control, storage and retrieval, data inventories, and basic climatological product preparation. The goal is to have this system operational in over 100 countries by 1991 and in all countries by 1997. Companionably, the World Climate Data and Information Referral Service (INFOCLIMA) was established in 1986 to provide a central reference point for data sources. The latest INFOCLIMA catalogue contains 1031 data set descriptions from 268 data centers in 112 countries.

The **Working Group on Sea Ice of the Commission on Marine Meteorology** addresses both WWW and World Climate Programme requirements for sea ice data. Although the resolution, accuracy, and frequency requirements for sea ice data have not yet been determined for WWW purposes, the requirements of the World CLimate Research Programme- 30 km and 3 days- are generally accepted. Rapid advances in measurement techniques have deferred definition. This Working Group has developed a Global Digital Sea Ice Data Bank in support of World Climate Programme requirements; World Data Centers A and B for Glaciology in Boulder, Colorado, and Leningrad are used, with data archived in SIGRID format. Archival began in 1990 with first priority being given to the 1980-1990 decade.

In 1989 the WMO Commission for Climatology initiated a **Climate Change Detection Project** to provide reliable analyses of climate trends and variability and an authoritative evaluation of the climate state for decision-making purposes. The project will attempt to collect more climate data with well-documented station information (metadata) and to process them using uniform (objective) procedures. It is envisioned that the project will be an international focus for co-ordinating the construction of composite data sets, including satellite and *in situ* observations of land, air, water and oceans, and their use for climate change detection. A meeting of experts will be convened in late 1990 to develop a long-term strategy and methodology for the selection of parameters and their required observational accuracies. The focus will be to provide information required to validate global climate change model predictions.

4.9 GLOBAL ATMOSPHERE WATCH

The Global Atmosphere Watch is primarily a land-based atmospheric composition monitoring network that incorporates the existing Global Ozone Observing System and the Background Air Pollution Monitoring Network. It will consist of about two dozen observatories of global importance and a few hundred stations of regional importance. This programme could be augmented if platforms could be used that are to be designated for the global ocean observing system.

4.10 LONG-TERM MONITORING SYSTEM OF COASTAL AND NEAR-SHORE PHENOMENA RELATED TO GLOBAL CLIMATE CHANGES

The UNEP, IOC, and WMO are now developing a draft proposal for long-term monitoring in the coastal zone which will contribute to national, regional, and global efforts to assess climate change and its environmental and socio-economic impacts and to develop and implement policies and measures to mitigate the undesirable effects of those impacts. Parameters would include physical, chemical and biological variables. The plan stresses that data from existing systems, such as those described above, will be used to the maximum extent possible. The proposed system will be a framework. Categories of sites are proposed as: a) global baseline sites, b) regional baseline sites, and c) national sites. The first two will be located at a distance from direct anthropogenic influences. The third will provide site-specific data on changes. This proposed system is viewed as complementary to the global observing system. Some of the parameters to be measured at the global and regional stations will be the same as those established for the global ocean observing system.

5. NEW TECHNOLOGY

5.1 SATELLITES

Satellite observations and satellite data links are significant components of an ocean observing system. Global coverage of critical surface variables needs to be provided on a continuous basis by satellite ocean remote sensing. Fortunately, the opportunity for increased satellite earth observation data exploitation is tremendous. By the year 2001 the volume of environmental satellite data available will increase by two orders of magnitude. Sensors will provide data of improved accuracy, resolution, and in more wave bands, which will allow more comprehensive monitoring of oceanographic parameters.

Synthetic aperture radar (SAR) technology has revolutionized the capability to observe sea ice. In the next decade the SAR will reduce the horizontal resolution available to users from one kilometer to tens of meters which will, for example, improve sea ice analysis and forecasting.

Recent advances in satellite processing capabilities, both at central sites and direct readout sites, allow expanded utilization of satellite data. These capabilities include improved imagery resolution, soundings, communications, new sensors, new satellites, and processing. The greatly increased availability of small inexpensive computers is allowing more data users to manipulate data and prepare products. Training is needed in new sensor parameters and how to apply these data to user needs. The IOC is developing training programmes to assist users in applying remote sensing to specific needs. The increase in the flow of remotely sensed data will make it necessary to develop methods to reduce this volume into products for immediate use and exchange.

Several national level programmes are being planned to better define the dynamic processes of the earth's environment. Section 4.1.2 and Table 12 through 15 describe the status of satellite planning activities.

Additionally, satellite-based communications systems have extensive marine applications. The ARGOS system, flown on the NOAA polar-orbiting satellites, collects and locates data from ocean platforms. The geostationary meteorological satellites collect data from platforms with known locations. And the INMARSAT system of dedicated satellites collects ships' weather reports and disseminates meteorological information for commercial shipping purposes.

5.2 AUTOMATED SHIPBOARD DATA COLLECTION SYSTEMS

Automated systems are now available to receive, store, and transmit meteorological and oceanographic data accurately and quickly using satellite communications. These systems are small in size, modular, and are easily installed and removed from ships. They provide a direct interface to expendable bathythermograph (XBT) probes and automatically encode a GTS message in the proper format. As the number and capabilities of these systems increase, it is expected that significant improvements will be seen in both the amount and the quality of real-time ocean data.

5.3 NEXT GENERATION WATER LEVEL MEASUREMENT SYSTEMS

The Next Generation Water Level Measurement Systems (NGWLMS), now installed at several of the 300 GLOSS locations, are a major upgrade of the standard water level gauge. Developed by the U.S. National Oceanic and Atmospheric Administration (NOAA), NGWLMS take advantage of an acoustic sensor to measure the water surface instead of the conventional float and bubbler method. This sensor, coupled with the implementation of new geodetic techniques based on the Global Positioning System and Very Long Baseline Interferometry, has created the opportunity to measure the absolute global sea level. NGWLMS use a microprocessor-based data collection and recording subsystem which improves data quality and permits frequent data transmission to a central facility via the Geostationary Operational Environmental Satellite (GOES) System. Up to 14 ancillary sensors may be installed.

5.4 AUTONOMOUS VEHICLES

Robotic vehicles and platforms are expected to supplement and eventually replace ships in furnishing the conventional observations required for GOOS. These intelligent autonomous submerged vehicles are capable of sampling physical, chemical, and biological parameters. It is envisioned that autosub hydrography can be deployed for trans-ocean sections to measure the fluxes of heat, water, and chemicals carried by ocean currents around the world. Concentrated surveys of the seasonal boundary layer can be undertaken at particular climate-sensitive locations.

5.5 ACOUSTIC TOMOGRAPHY

Previously applied in medicine and in geology, tomography employs beams of energy to create a three-dimensional image of the area traversed. In 1979 two American scientists proposed that it be adapted to measuring the physical properties of the ocean, and instruments were developed to conduct experiments. The concept is based on the fact that sound radiating along the deep ocean acoustic wave guide can be detected over a great range. The mean temperature and along track current between 2 hydrophones can be diagnosed from the time taken for a pulse of sound to propagate each way between them. Some information about the vertical distributions of temperature and current speed can be derived from the slightly different travel times of sound undulating over different depth ranges along the wave guide. A feasibility study of this technique will be undertaken in 1991 using sound paths from Heard Island in the southern Indian Ocean.

5.6 FLOATS

Subsurface floats provide velocity observations which improve the description of general circulation but have not to date been used for basin-scale inferences. The WOCE experiment is supporting research to improve float technology. Satellite-tracked multi-cycle, pop-up autonomous Lagrangian Circulation Explorer floats are now operational, having been successfully deployed in the Antarctic in January 1990. Sound-fixing and ranging floats (RAFOS) have been operational for several years but are now undergoing substantial redesign to improve reliability and cost-effectiveness. RAFOS float experiments in support of WOCE are scheduled for 1992.

5.7 EXPENDABLE CTDs

Expendable Conductivity/Temperature/Depth (XCTD) Profiling Systems are now produced which can collect salinity profiles to 1,000 meters from ships underway. The system consists of a data acquisition system, launchers, and expendable probes. Intercomparison tests conducted with the cable-lowered CTD systems have proven reliable enough for XCTD systems to be made commercially available.

5.8 PLANKTON MONITORING

Plankton monitoring is used as an indicator of changes in plankton communities over time and space and may be used as a baseline for determining the impact of climate changes on fisheries populations. Self-contained automatic plankton recorders are towed by ships-of-opportunity along fixed routes at monthly intervals. Since 1931 a Continuous Plankton Recorder Survey has provided data from the North Atlantic and North Sea, the only marine ecological survey operated routinely on an ocean-basin scale. Ten countries have participated in this survey. In view of funding shortages which threaten the continuation of this work, international support is being solicited.

Table 1. Major Programmes and Activities of the IOC

Programme/Activity/ International Body	Sponsoring Agencies	Other Participating Organizations
1. OCEAN SCIENCE		
1.1 OCEAN AND CLIMATE		
1.1.1 Committee on Ocean Processes and Climate (IOC/OPC)	IOC	WMO, SCOR, JSC
1.1.2 Committee on Climatic Changes and the Ocean (CCCO)	SCOR/IOC	JSC
1.1.3 Intergovernmental TOGA Board	WMO/IOC	JSC, CCCO, SCOR
1.1.4 Intergovernmental WOCE Panel	IOC/WMO	CCCO, JSC, SCOR
1.2 OCEAN SCIENCE IN RELATION TO LIVING RESOURCES (OSLR)		
1.2.1 Guiding Group of Experts on OSLR	IOC/FAO	
1.3 OCEAN SCIENCE IN RELATION TO NON-LIVING RESOURCES (OSNLR)		
1.3.1 Guiding Group of Experts on OSNLR	IOC/UN/OALOS	CCOP, SOPAC
1.4 OCEAN MAPPING		
1.4.1 Consultative Group on ocean mapping	IOC	IHO
1.4.2 Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO)	IOC/IHO	
1.5 MARINE POLLUTION RESEARCH AND MONITORING		
1.5.1 Committee for the Global Investigation of Pollution in the Marine Environment (GIPME)	IOC/UNEP	IMO, IAEA, ICES, WMO, FAO, WHO
2. OCEAN SERVICES		
2.1 Committee for the Integrated Global Ocean Services System (IGOSS)	IOC/WMO	
2.2 Drifting Buoy Co-operation Panel (DBCP)	WMO/IOC	EGOS, ARGOS
2.3 Group of Experts on Global Sea Level Observing System (GLOSS)	IOC	IHO, IAPSO
2.4 Ad Hoc Group of Experts on Global Ocean Observing System	IOC	WMO, CCCO, JSC
2.5 Committee on International Oceanographic Data and Information Exchange (IODE)	IOC	ICSU, WMO, FAO, ICES, UN
2.6 International Co-ordination Group for the Tsunami Warning System in the Pacific (ITSU)	IOC	IUGG
3. REGIONAL SUBSIDIARY BODIES		
3.1 Sub-Commission for the Caribbean and Adjacent Regions (IOCARIBE)	IOC	UNEP, FAO
3.2 Regional Committee for the Southern Ocean (IOCSOC)	IOC	SCAR, WMO, CCAMLR
3.3 Sub-Commission for the Western Pacific (WESTPAC)	IOC	CCOP, SOPAC
3.4 Regional Committee for the Co-operative Investigation in the North and Central Western Indian Ocean (IOCINCWIO)	IOC	
3.5 Regional Committee for the Central Indian Ocean (IOCINDIO)	IOC	
3.6 Regional Committee for the Central Eastern Atlantic (IOCEA)	IOC	
3.7 Working Group on the investigations of EL NINO	IOC/WMO/CPPS	
4. TRAINING, EDUCATION AND MUTUAL ASSISTANCE IN THE MARINE SCIENCES (TEMA)		
4.1 Committee on TEMA	IOC	WMO, FAO, UNEP, UNDP, UNESCO

Table 2. Participation of International Organizations and Their Bodies in Ocean Observing and Data Management Systems

Table 2.

Participation of International Organizations & Their Bodies in Ocean Observing and Data Management Systems

GOVERNMENTAL		MIXED SPONSORSHIP		NON-GOVERNMENTAL	
UN System: UNEP, WMO, Unesco/IOC				ICSU-SCOR	
IOC	•Committee on Ocean Processes and Climate (IOC/OPC) •Committee on International Oceanographic Data and Information Exchange (IOC/IODE) •Group of Experts on Global Sea Level Observing System (GLOSS) **•Ad hoc Group of Experts on Global Ocean Observing System (GOOS)** •IOC Regional Bodies (IOCARIBE, IOCEA, IOCINCWIO, IOCINDIO, WESTPAC, IOC/SOC)	ICSU-WMO	•Joint Scientific Committee for World Climate Research Programme (JSC/WCRP)	ICSU	•Special Committee for International Geosphere-Biosphere Programme (IGBP)
		SCOR-IOC	•Committee on Climatic Changes and the Ocean (CCCO)	SCOR	•Science Committee on Joint Global Ocean Flux Study (JGOFS)
		JSC-CCCO	•Scientific Steering Group on World Ocean Circulation Experiment (WOCE)		•Executive Committee on JGOFS
UNEP-WMO	•Intergovernmental Panel on Climate Change (IPCC)	JSC-CCCO	•Scientific Steering Group on Tropical Ocean and Global Atmosphere Programme (TOGA)		
WMO	•Commission for Marine Meteorology (CMM) •Commission for Basic Systems (CBS) •Commission for Climatology (CCL)	JSC-CCCO	**•Ocean Observing System Development Panel (OOSDP)**		
		ICSU-WMO	•Scientific Steering Group for Global Energy and Water Cycle Experiment (GEWEX)		
IOC-WMO	•Committee on Integrated Global Ocean Services System (IGOSS) •Drifting Buoy Co-operation Panel (DBCP) •CMM-IGOSS Ad Hoc Group on Ocean Satellites & Remote Sensing •Intergovernmental WOCE Panel •Intergovernmental TOGA Board •Steering Group on the IODE-IGOSS Global Temp[erature-Salinity Pilot Project (GTSPP)				
UNEP-IOC WMO	**•Long-Term Global Monitoring System of Coastal and Near-shore Phenomena related to Climate Changes (GCNSMS)**				

Table 3. TOGA Data Requirements

Parameter	Horizontal (Vertical) Resolution	Time Resolution	Accuracy
1. Upper Air Winds	500 km (two levels 900 and 200 mb)	1 day	3 m/sec
2. Tropical Wind Profiles	2500 km (100 mb)	1 day	3 m/sec
3. Surface Pressure	1200 km	1 day	1 mb
4. Total Column Precipitable Water	500 km	1 day	0.5 g/cm^2
5. Area Averaged Total Precipitation	2° lat x 10° long	5 days	1 cm
6. Global SST	5° x 5°	30 days	0.5 K
7. Tropical SST (1)	2° lat x 2° long	15 days	0.3 K-0.5 K
8. Tropical Surface Wind (2)	2° lat x 10° long	30 days	0.5 m/sec
9. Tropical Surface Wind Stress(2)	2° lat x 10° long	30 days	0.01 Pa
10. Surface Short-Wave Radiation	2° lat x 10° long	30 days	10 Watts/m^2
11. Surface Humidity	2° lat x 10° long	30 days	0.5 g/kg
12. Surface Air Temperature	2° lat x 10° long	30 days	0.5 K
13. Tropical Sea Level	(3)	1 day	2 cm
14. Tropical Ocean Sub-surface Temperature and salinity	(4)	(4)	(4)
15. Tropical Ocean Surface Salinity	2° lat x 10° long	30 days	3 x 10^{-5}
16. Tropical Ocean Surface Circulation	2° lat x 10° long	30 days	0.1 m/sec
17. Subsurface Equatorial Currents	40° long (5 levels)	as recorded	0.1 m/sec

(1) The combined space/time resolution and accuracy specification is not feasible at present. Priority is then given to the space/time sampling requirements. The higher accuracy requirement applies to waters above 25°C.

(2) While the accuracy requirements given are for 30-day averages, daily values are required for resolution of 30-60 day oscillations.

(3) As permitted by the existence of suitable sites and satellite altimetry.

(4) See discussion in Section 3.1.

Table 4. Observing Systems for Atmospheric and Oceanic Parameters Identified by TOGA

Observing systems for atmospheric parameters

Parameter	Observing systems	Phenomenon observed
Upper air winds and tropical wind profile	Rawinsonde, Doppler wind profilers, Aircraft, Geostationary satellites	Rotational wind field, Divergent motion in the tropics, Monsoon variability, El Niño, wind anomalies for diagnosing - Southern Oscillation - 30-60 day oscillation
Humidity (total precipitable water)	Radiosonde, Rawinsonde, Satellite remote sensing	Convective heating
Surface pressure	WWW surface station, VCS, Drifting and moored buoys	Southern Oscillation and 30-60 day oscillation, El Niño
Surface winds/ wind stress	WWW island and coastal station, VOS, Moored buoys, Satellite remote sensing	Surface fluxes of momentum, Monsoon variability, El Niño, wind anomalies for diagnosing - Southern Oscillation - 30-60 day oscillation
Precipitation	CLIMAT raingauge network, Satellite remote sensing	Rainfall pattern
Global sea surface temperature	VOS, Drifting and moored buoys, Satellite remote sensing	Surface temperature pattern

Observing systems for oceanic parameters

Parameter	Observing systems	Phenomenon observed
Tropical sea level	Tide gauges, Satellite altimeters, XBTs, Drifting thermistor chains, Moored temperature sensors	Variability of thermocline and ocean surface topography, Surface geostrophic currents, Response to wind stress and barometric pressure
Tropical ocean subsurface temperature	XBTs, Drifting thermistor chains, Moored temperature sensors	Variability of ocean heat storage
Tropical ocean salinity	CTDs, Surface sampling, XCTDs	Variability of ocean density, stratification and upwelling
Sub-surface and near-surface current velocity	Drifters, Moored current meters, Current profilers	Surface and sub-surface ocean currents
Tropical sea surface temperature	Drifting and moored buoys, VOS, Satellite remote sensing	Anomalous ocean circulation events, Upwelling

Table 5. Initial Requirements for TOGA COARE

OCEANOGRAPHIC OBSERVATIONAL SYSTEM REQUIREMENTS

Time Period	ATLAS (moorings)	PCM	CM	Met (buoys)	CTD/ SeaSoar (cruises*)	Micro-Structure (cruises)	Drifters
Pre-COARE	15	2	3	12	2	1	75
IOP	15	6	5	20	3	3	100
Post-COARE	10		3	13	1		75

*cruises are nominal 30-day cruise

OCEANOGRAPHIC OBSERVATIONAL REQUIREMENTS FOR TOGA COARE

Periods	SHIPS					AIRCRAFT	
	ATLAS (mooring maintenance cruises)	PCM	CM	hydro survey	mixing	WP-3D	Electra
Pre-COARE	3 (3x30)*		2 (10+20)		1(30)		
IOP		1(14)	1(20)	3(2x90)	1(40)	80 hrs.	40 hrs
Post-COARE	2(2x30)	1(14)	1(15)				

*2 cruises, 2 ships, 30 days long each

INTERFACE OBSERVATIONAL REQUIREMENTS FOR TOGA COARE

Periods	IN SITU OBSERVATIONS			SATELLITE OBSERVATIONS			
	Surface Met Buoys	High Quality Ship Met	Eddy Correlation Fluxes	AVHRR	GMSobs	DMSP	TOPEX
Pre-COARE	18			all data	3-hrly	all data	
IOP	20	5		all data	1-hrly	all data	wave forms
Post-COARE	13			all data	3-hrly	all data	GDR's

Table 6. Major WOCE Resource Requirements

Observational Element	Requirement
WHP - One Time Survey	10.4 ship years, based on 270 days at sea per year
Repeat Hydrography and Time Series	15.0 ship years, based on 270 days at sea per year
Subsurface Floats	ca 3 500
Surface Drifters	ca 4 000
Moorings (current meters, Thermistor chain, pressure gauges, Upward-ADCP)	ca 350
Sea level stations	40
XBT standard (750m)	5000/y besides the on-going TOGA programme
XBT deep (1000m)	11500/y besides the on-going TOGA programme
XCTD	depending on technical availability
ADCP	depending on no. of research vessels/VOS available also ca. 40 moored ADCP
Altimetry/Scatterometry	several satellite missions over the next ten years

Table 7. Main Satellite Sensors for WOCE

(Anticipated lifetimes shown by arrows)

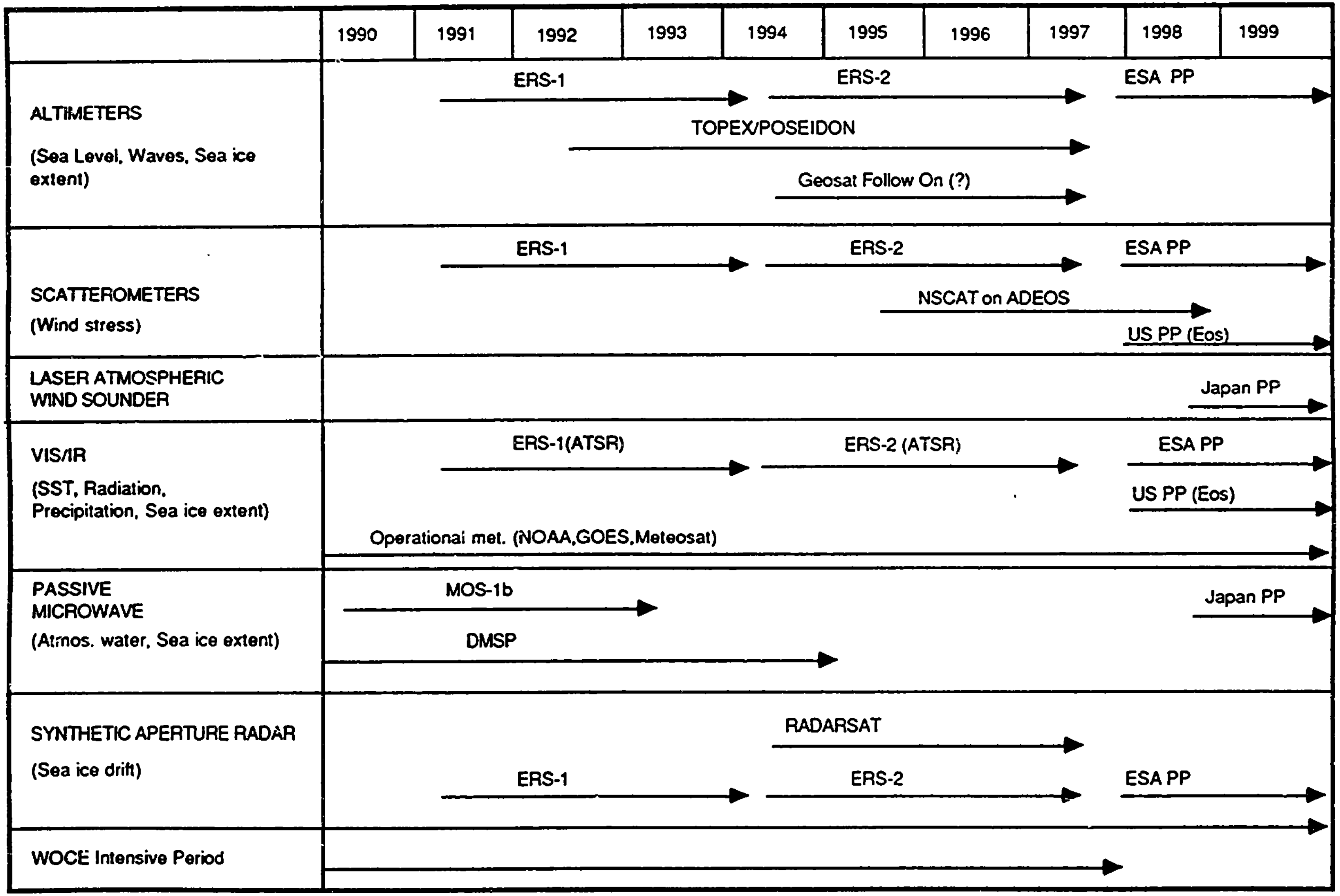


Table 8. Matrix of Parameters Proposed and Those Presently Measured

GOOS	Existing/Planned Ocean Systems									Large Scale Research Prog						
PARAMETERS	IGOSS	DBCP	GLOSS	WWW	IODE	GAW	GCNSMS	WCDP	MPM	TOGA	WOCE	JGOFS	GEWEX	IGBP	PP	OSLR
ATMOSPHERE	■	■	■	■	■	■	■	■		■	■		■	■	■	
Winds				■	■					■	■				■	
Atmospheric pressure	■	■	■	■						■	■				■	
Precipitation				■						■			■			
Relative humidity				■	■					■			■		■	
Air temperature	■	■		■	■					■					■	
Radiation				■						■						
OCEANOGRAPHIC	■	■	■	■	■		■	■	■	■	■	■			■	
Physical Oceanography	■	■	■	■	■			■		■	■	■			■	
Sea Surface Temperature	■	■		■	■					■	■		■	■		■
Sub-Surface Temperature	■	■			■					■	■		■		■	
Surface/sub surface Salinity	■				■					■	■		■		■	
Currents	■	■			■					■	■				■	
Sea-level/Dynamic Topography	■		■				■			■	■					
Tides			■		■					■	■					
Sea Ice				■				■			■					
Marine Biology					■		■					■		■		■
Pigment Concentration																
Plankton Concentration																
Primary Productivity																
Secondary Productivity																
Phytoplankton Biomass																
Zooplankton Biomass																
Marine Chemistry					■		■		■		■	■		■		
DO																
PCO2						■						■				
Marine Aerosols						■						■				
Nutrients																
Pollutants						■	■		■							
Radionuclides																
Trace Elements																

Table 8. Ocean/atmosphere parameters proposed for inclusion in global ocean observing system and parameters presently being measured and exchanged within existing observing and data management systems and international research programmes.

Table 9. World Weather Watch- Data Needed to Obtain Optimum Results from Numerical Weather Prediction by the Late 1990s

Element	Horizontal resolution	Vertical interval	Observational error (rms)	Minimum frequency observation
Upper-air observations				
Temperature (1) and wind	100 km (2) ---------- 50 km	500 m to 2 km (3) 1 km to 15 km 3 km to 30 km	TEMP: ±0.5-1.0°C tropo. ±1.0-2.0°C strato. WIND: ±1-2 m s^{-1} tropo. ±2-3 m s^{-1} strato.	4 per day
Relative humidity	100 km (2) ---------- 50 km	5 layers to 10 km ---------------- 500 m to 2 km 4 layers to 10 km	±10%	4 per day
Surface observation p(4), T, T_D State of surface (5) Wind	100 km ------ 50 km		P: ± 1 hPa T: ± 0.5°C V: ± 1 m/s	8 per day
Soil temperature down to 1 m	300 km		± 1.0°C	1 per day
Sea-surface temperature (SST)	100 km (6)		± 0.5°C	Instantaneous measurements averaged over three days
Ocean mixed layer: T and salinity (for ocean/atmosphere coupled models)	100 km (6)		± 0.5°C	Instantaneous measurements averaged over three days

global
----------------: ----------
regional

Notes:

(1) Radiance measurements are possible alternatives to the retrieved temperatures.
(2) Satellite measurements will supply the 50-100 km resolution data, global coverage required on the GTS; additional observations for regional needs obtained by direct readout from satellite.
(3) Satellite radiance measurements are not capable of such resolution. The stated numbers are couched in terms of what is desirable for the models. Satellites are expected to be able to produce 10-15 real layers. Radiosonde observations should be transmitted in sufficient detail to completely describe the temperature/humidity structure of the atmosphere in the vertical. Geopotentials at standard levels should also be computed and transmitted from radiosonde observations for use in quality-control procedures.
(4) In addition to the exchange of mean sea-level pressure, pressure measured at station level should be exchanged globally.
(5) State of surface includes precipitation, soil moisture, soil temperature, emissivity, albedo and snow and ice coverage with a resolution. accuracy and frequency based on common requirements determined by WMO technical commissions. One observation per day is probably sufficient.
(6) Mostly via satellite measurement. 50 km desirable in areas of boundary currents, upwelling and near the Equator.

Table 10 - BASIC SET OF GLOBAL OBSERVATIONAL DATA REQUIRED AND TO BE MET BY THE GOS BY THE LATE 1990S **
(BOTH *IN SITU* OBSERVATIONS AND REMOTELY SENSED DATA)

	Horizontal resolution	Vertical resolution	Observational error (rms)	Frequency of observation
i. Upper-air temperature [T]	250 km (A)	10 layers in troposphere 5 layers in stratosphere	0.5-1°C trop. 1-2°C strat.	2-4 per day
ii. Upper-air wind vector [V]	250 km	10 layers in troposphere 5 layers in stratosphere	1-2 m s^{-1} trop. 2-3 m s^{-1} strat.	2-4 per day
iii. Upper-air relative humidity [RH]	250 km	4 layers	10%	2-4 per day
iv. Sea-surface temperature [T_s]	250 km	-	0.5°C with systematic differences among observing systems eliminated on 3 day averages	Instantaneous measurements averaged over 3 days
v. Surface pressure [P] Temp. [T, Td] Wind vector [V]	250 km *	-	 ± 1 hPa ± 0.5°C temp. ± 1-2 m s^{-1}	4 per day
State of surface & soil	*	*	*	*
vi. Satellite imagery (B)	At least 3 km horizontal resolution of imagery	At least 3 layers - low, middle, high and cloud top height	To be determined; will be function of latitute for geo-stationary satellites	8 per day

(A) Tropics: 500 km resolution sufficient for temperature.

(B) Satellite imagery included here because of its use in computing vertical motion and divergence fields, as well as for determination of synoptic distribution of water vapour, precipitable water and cloudiness.

* Includes precipitation, soil moisture, soil temperature, emissivity, albedo, snow and ice coverage. Resolution, accuracy and frequency not yet determined, information required from other technical commissions.

** Table 10 defines a basic set of the global observational data requirements which generally can be met by the GOS and, therefore, should be used in the design and implementation of the GOS.

Table 11. List of Countries and Summary Table of Ships Participating in the VOS Programme - 1988

COUNTRY	Selected ships			Supplementary ships			Auxiliary ships	Country totals
	(1) Merchant ships	Trawlers	Totals	Merchant ships	Trawlers	Totals		
1	2	3	4	5	6	7	8	9
Argentina	75	-	75	10	-	10	-	85
Australia	82	-	82	11	-	11	4	97
Bangladesh	9	-	9	2	-	2	-	11
Belgium	66	-	66	-	-	-	-	66
Brazil	6	-	6	176	-	176	150	332
Bulgaria	6	-	6	28	-	28	-	34
Canada	125	-	125	-	-	-	346	471
Chile	2	-	2	-	-	-	-	2
China	40	-	40	-	-	-	-	40
Cuba	4	-	4	-	-	-	-	4
Danemark	19	-	19	4	-	4	30	53
Finland	-	-	-	13	-	13	-	13
France	162	-	162	-	-	-	-	162
German Democratic Republic	142	22	164	-	-	-	-	164
Germany, Federal Republic of	352	9	361	53	1	54	34	449
Greece	2	-	2	-	-	-	18	20
Hong Kong	63	-	63	25	-	25	1	89
Iceland	-	-	-	30	-	30	18	48
India	20	-	20	187	-	187	36	243
Indonesia	-	-	-	14	-	14	16	30
Ireland	7	-	7	-	-	-	-	7
Israel	38	-	38	-	-	-	-	38
Italy	13	-	13	-	-	-	-	13
Jamaica	1	-	1	-	-	-	-	1
Japan	184	-	184	39	-	39	2	225
Kenya	-	-	-	1	-	1	13	14
Korea, Republic of	-	-	-	67	-	67	-	67
Malaysia	34	-	34	14	-	14	16	64
Netherlands	129	-	129	145	10	155	-	284
New Caledonia	1	-	1	-	-	-	-	1
New Zealand	41	-	41	3	-	3	12	56
Norway	29	-	29	-	-	-	-	29
Pakistan	9	-	9	2	-	2	5	16
Philippines	34	-	34	8	-	8	7	49
Poland	108	-	108	57	-	57	75	240
Saudi Arabia	15	-	15	83	-	83	2	100
Singapore	44	-	44	-	-	-	-	44
South Africa *	37	-	37	-	-	-	-	37
Spain	47	-	47	-	-	-	6	53
Sri Lanka	14	-	14	-	-	-	-	14
Sweden	42	-	42	-	-	-	35	77
Switzerland	7	-	7	1	-	1	-	8
Tanzania, United Republic of	4	-	4	3	-	3	14	21
Thailand	4	-	4	-	-	-	-	4
Union of Soviet Socialist Republics	1406	-	1406	-	-	-	-	1406
United Kingdom of Great Brit. & N. Ireland	438	3	441	7	1	8	3	452
United States of America	430	-	430	342	-	342	501	1273
Yugoslavia	95	-	95	83	-	83	-	178
TOTALS	4404	34	4438	1408	12	1420	1344	7202

Note:

(1) Includes special ships

---

* The Government of the Republic of South Africa has been suspended by Resolution 38 (Cg-VII) from exercising its rights and enjoying its privileges as a Member of WMO

Table 12. Current and Planned Satellite Systems in Support of Marine Meteorology and Physical Oceanography (1990-2010)

SENSORS versus APPLICATION ← | → SENSORS versus SATELLITES AND TIME

Application	Altimeter	Infrared Imager	IR/µwave Sounder	Lidar Wind Sounder	Microwave Imager	Ocean Color Scanner	Radar	Scatterometer	Visible Imager	Country or Agency	Satellite System	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000-2010
Atmospheric Temperature		◢	● ◢						◢	USA	NOAA Series	■	■	■	■	■	■	■	■	■	■	■
Atmospheric Water Vapor/Moisture	●	●	●		●		◢		● ◢	USSR	Cosmos Series	■	■	■	■	■	■	■	■	■	■	■
Marine Geodesy/Sea Surface Topography	●		◢		◢				◢	USA	DMSP Series	■	■	■	■	■	■	■	■	■	■	■
Marine Weather Observations	◢	● ◢	◢				◢	◢	● ◢	ESA	ERS Series	■	■	■	■	■	■	■	■			
Ocean Currents/ Circulation	●	◢							◢	USSR	Meteor Series	■	■	■	■	■	■	■	■			
Ocean Color/Water Mass	●	◢			◢	●			◢	Japan	MOS Series	■	■	■	■	■	■	■				
Precipitation Profiles		◢	●		●				◢	China	FY-1b	■	■	■								
Precipitation Rates	●		●	◢	●		●		◢	USA	UARS		■	■	■							
Sea Ice Cover and Extent	●	●			●		● ◢		● ◢	Japan	JERS-1			■	■	■						
Sea Ice Type/Distribution/Dynamics	◢				●		●			USA	Geosat Follow-On					■	■	■	■	■	■	■
Sea Surface Temperature		● ◢							◢	USA	Landsat Series	■	■	■	■	■	■					
Sea Surface Winds	●							●	◢	France	SPOT Series	■	■	■	■	■	■	■	■	■		
Significant Wave Height	● ◢		◢				●			USA/France	TOPEX/Poseidon			■	■	■	■					
Storm Monitoring and Warning	●	●	●	●	●	◢		●	●	USA	SeaWiFS			■	■	■	■	■				
Upper Atmospheric Winds			●	●			◢			Canada	Radarsat					■	■	■	■	■	■	
Upper Atmospheric Composition			●	●		◢		◢	● ◢	Japan	ADEOS						■	■	■	■		
Wetlands/Esturine Monitoring		● ◢			◢	●	◢		●	USA	TRMM							■	■	■	■	
	◢	◢	◢		◢	◢	◢	◢	◢	ESA	EPOP								■	■	■	■
	◢	◢	◢		◢	◢	◢	◢	◢	USA	NPOP								■	■	■	■
		◢		◢	◢		◢		◢	Japan	JPOP								■	■	■	■

(Calendar Year)

Legend for Support to Marine Meteorology and Physical Oceanography::

◢ = Sensor Manifested on Satellite (Use right hand Portion of Table) = ⟶

● = Sensor Application to Marine Meteorology and Physical Oceanography (Use left-hand Portion of Table) = ⟵

Note that this table is NOT to be read from left to right. The black dot represents the sensor and the application relationship; the shaded triangle represents the sensor and the satellite relationship. For example, in the applications for ocean currents and circulation, the altimeter is an appropriate sensor as indicated by the black dot; altimeters are found on the ERS series, the Geosat follow-on, TOPEX/Poseidon, etc. so that these satellites support the ocean currents ans circulation applications. It is incorrect to infer that the Meteor series, located on the same line as Ocean Currents/Circulation, can make those measurements.

Table 13. Overview of Current Satellite Measurements

	NOAA TIROS-N (-10(G) and -11(H)) (U.S.A.)	GOES-7 (U.S.A.)	DMSP (U.S.A.)	Meteosat 1-4 (ESA)	METEOR-2, -3 (U.S.S.R.)	GMS 1-4 (Japan)	INSAT IA-D (India)	Landsat-4, -5 (U.S.A.)	SPOT (France)	IRS (India)	Geosat (terminated 1.5.90) (U.S.A.)	MOS (Japan)	Nimbus-7 (remaining instruments) (U.S.A.)	ERBS (U.S.A.)
Meteorological Observations, Weather	●	●	●	●	●	●	●							
Storm Monitoring and Warning		●		●		●	●							
Search and Rescue	●	●												
Orbit Determination														
Geodesy, Gravity Fields											●			
Earth Surface Magnetic Fields														
Plate Motion and Crustal Deformation														
Surface Soil Moisture			●											
Land Surface Composition								●	●	●				
Land Surface Biological Activity	●				●			●	●	●		●		
Surface Topography								●	●	●		●		
Surface Temperature	●	●		●	●	●	●					●		
Snow and Ice Cover	●		●		●			●	●					
Sea Ice Cover	●		●		●			●	●		●			
Sea Surface Winds			●								●			
Ocean Topography, Waves											●			
Ocean Circulation														
Oceans-Lakes Biological Activity (Color)								●	●			●		
Aerosols													●	●
Tropospheric Winds		1●		1●		1●	1●							
Tropospheric Composition														
Cloud Properties	●	●	●	●	●	●	●							
Atmospheric Temperature	●	●	●		●								●	
Atmospheric Moisture	●	●	●	●	●							●		
Precipitation/Ice Profiles			●											
Precipitation Rate			●											
Lightning														
Upper Atmospheric Winds		1●		1●		1●	1●							
Upper Atmospheric Composition													●	●
Ozone Monitor	2●												●	●
Particles and Fields Environment	●	●	●			●								
Ionosphere			●											
Earth Radiative Balance	3●												●	●
Solar Irradiation	3●												●	●
Telecommunications		●					●							

KEY

o No global coverage after October 3, 1989
1- NOAA-10 only
2- NOAA-11 only
3-Calculated from cloud motions

Table 14. Overview of Planned/Proposed Satellite Measurements: 1990 - 1995

	NOAA TIROS-N (D,I to M) (U.S.A.)	GOES I to M (U.S.A.)	Landsat-6 (U.S.A.)	ERS-1 (ESA)	JERS-1 (Japan)	Radarsat (Canada)	ADEOS (Japan)	UARS (U.S.A.)	TOPEX POSEIDON (U.S.A.)	LAGEOS 2 (Italy U.S.A.)	MFE Magnolia (Italy U.S.A.)
Meteorological Observations, Weather	●	●									
Storm Monitoring and Warning		●									
Search and Rescue	●	●									
Orbit Determination				●					●		
Geodesy, Gravity Fields									●	●	
Earth Surface Magnetic Fields											●
Plate Motion and Crustal Deformation										●	
Surface Soil Moisture											
Land Surface Composition			●	●	●	●	●				
Land Surface Biological Activity	●		●	●	●	●	●				
Surface Topography			●	●	●		●				
Surface Temperature	●	●		●			●				
Snow and Ice Cover	●		●	●	●	●					
Sea Ice Cover	●		●	●	●	●					
Sea Surface Winds				●		●	●		●		
Ocean Topography, Waves				●					●		
Ocean Circulation									●		
Oceans/Lakes Biological Activity (Color)			●				●				
Aerosols											
Tropospheric Winds		1 ●		●							
Tropospheric Composition											
Cloud Properties	●	●									
Atmospheric Temperature	●	●						●			
Atmospheric Water Vapor, Moisture	●	●		●				●			
Precipitation/Ice Profiles											
Precipitation Rate											
Lightning											
Upper Atmospheric Winds		1 ●						●			
Upper Atmospheric Composition								●			
Ozone Monitor	4 ●						●	●			
Particles and Fields Environment	●	●						●			
Ionosphere									●		
Earth Radiative Balance											
Solar Irradiation		●						●			
Telecommunications		●									

Table 14. Overview of Planned/Proposed Satellite Measurements: 1990 - 1995 (Cont.)

	TRMM (U.S.A. Japan)	ARISTOTELES (ESA)	GOMS (U.S.S.R.)	Meteosat-5, -6 (ESA)	DMSP ongoing (U.S.A.)	INSAT-II (India)	GMS-5 (Japan)	FY-1 (People's Republic of China)	FY-2 (People's Republic of China)	CBERS (China, Brazil)
Meteorological Observations, Weather			•	•	•	•	•	•	•	
Storm Monitoring and Warning				•		•	•			
Search and Rescue										
Orbit Determination										
Geodesy, Gravity Fields		•								
Earth Surface Magnetic Fields			•							
Plate Motion and Crustal Deformation		•								
Surface Soil Moisture					•					•
Land Surface Composition										•
Land Surface Biological Activity										•
Surface Topography			•							•
Surface Temperature				•		•	•	•	•	
Snow and Ice Cover					•					•
Sea Ice Cover					•					
Sea Surface Winds					•					
Ocean Topography, Waves										
Ocean Circulation										
Oceans/Lakes Biological Activity (Color)										
Aerosols										
Tropospheric Winds				1 •		1 •			•	
Tropospheric Composition							•			
Cloud Properties	•		•	•	•	•	•	•	•	
Atmospheric Temperature					•		•			
Atmospheric Water Vapor, Moisture			•	•	•				•	
Precipitation/Ice Profiles	•				•					
Precipitation Rate	•				•					
Lightning										
Upper Atmospheric Winds				1 •		1 •	•			
Upper Atmospheric Composition										
Ozone Monitor										
Particles and Fields Environment			•		•		•		•	
Ionosphere					•					
Earth Radiative Balance										
Solar Irradiation			•							
Telecommunications						•				

KEY

1 Calculated from cloud motions

4 NOAA-I, -K -M only

Table 15.
Overview of EOS Satellite Measurements

	NASA Polar Platform 1 (EOS-A) 705 km (U.S.A.)	NOAA Free Flyer 824 km (U.S.A.)	Solar Flight of Opportunity (U.S.A.)	Space Station Attached Payloads 400 km (U.S.A.)	NASA Polar Platform 2 (EOS-B) 705 km (U.S.A.)	ESA Polar Platform 1 ** (EPOP-M1) 824 km (ESA)	ESA Polar Platform 2 ** (EPOP-N1) 705 km (ESA)	Japanese Polar Platform ** (JPOP) 800 km (Japan)
Meteorological Observations, Weather	•	•				•		
Storm Monitoring and Warning		•				•		
Search and Rescue		•				•		
Orbit Determination	•				•	•		
Interior Earth Structure					•			
Plate Motion and Crustal Deformation	•				•	•		
Surface Soil Moisture, Wetlands Extent	•			•		•	•	
Land Surface Composition	•			•		•	•	•
Land Surface Biological Activity Phenology and Physiological State	•			•		•	•	•
Surface Topography	•					•	•	
Surface Temperature	•	•		•	•	•	•	•
Snow and Ice Extent and Character	•	•		•		•	•	•
Sea Ice Extent, Character, and Motion	•	•		•		•	•	•
Sea Surface Winds	•			•		•	•	•
Ocean Waves					•	•		
Ocean Circulation				•	•	•		
Oceans and Lakes Biological Activity	•			•		•		
Aerosols	•				•			•
Tropospheric Winds						•	•	•
Tropospheric Composition	•			•	•	•	•	
Cloud Properties	•	•		•	•	•	•	
Atmospheric Temperature	•	•		•	•	•	•	
Atmospheric Water Content	•	•		•	•	•	•	•
Precipitation Rate	•			•		•	•	•
Lightning	•			•				
Upper Atmospheric Winds	•				•			
Upper Atmospheric Composition	•	•			•		•	
Particles and Fields Environment	•	•			•	•		
Ionosphere	•				•			
Earth Radiative Budget	•	•		•		•		
Solar Output	•	•	•					

Based on a chart compiled by Hughes-Santa Barbara Research Center   ** Tentative List (Not Complete)

Table 16. IGOSS BATHY and TESAC Data Transmitted: 1984 - 1989

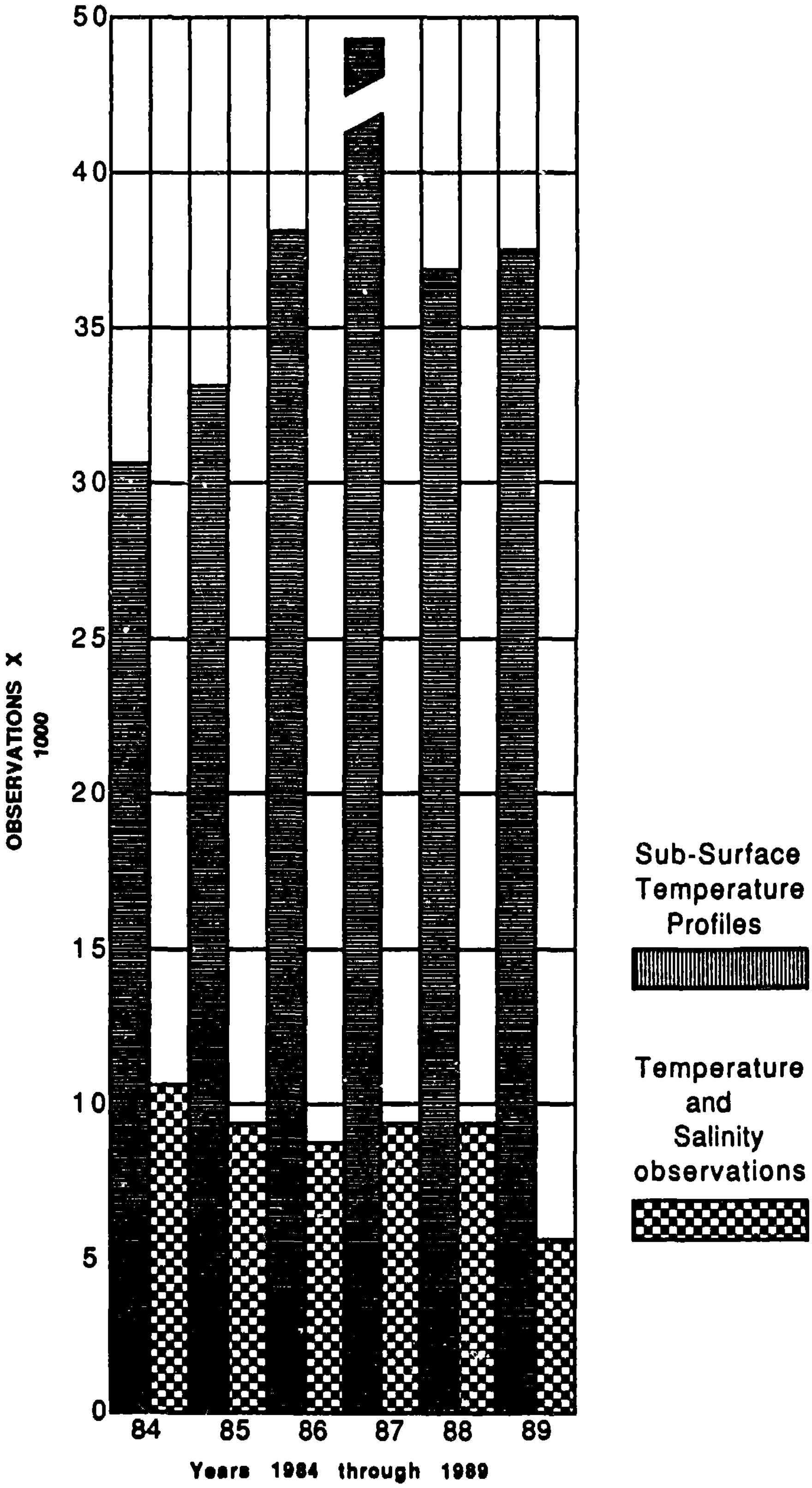


Table 17. Number of IGOSS Oceanographic and Meteorological Products Prepared by Each National Centre- 1988

	Sub-surface products (data, analysis, summaries)	Surface products (data, analysis, forecasts, summaries)	Surface meteorological products (analysis, forecasts, warnings, data, summaries)
Algeria	-	1	-
Argentina	2	2	3
Australia	5	8	6
Brazil	2	3	2
Bulgaria	-	2	5
Canada	12	20	8
Chile	-	2	-
China	5	26	1
Colombia	1	1	-
Denmark	5	9	-
Ecuador	1	2	-
Egypt	-	-	3
Fiji	-	2	6
Finland	-	8	-
France	1	13	2
German Democratic Republic	-	4	2
Germany, Federal Republic of	12	11	3
Greece	-	2	1
Guatemala	-	2	1
Hong Kong	-	3	6
Iceland	-	1	-
India	-	-	19
Indonesia	1	1	-
Ireland	1	1	-
Israel	-	2	-
Japan	4	27	1
Kenya	-	1	2
Madagascar	1	1	-
Malaysia	-	7	2
Malta	-	-	1
Mauritius	-	3	1
Morocco	-	3	1
Netherlands	2	6	2
New Caledonia	-	-	2
New Zealand	-	8	5
Norway	-	3	2
Peru	4	3	3
Qatar	-	4	1
Republic of Korea	2	2	-
Saudi Arabia	-	1	1
Senegal	3	3	1
Sweden	2	12	3
Thailand	3	4	2
Trinidad and Tobago	-	2	2
Turkey	-	2	1
USSR	2	15	14
United Kingdom	-	18	12
USA	4	32	25
Uruguay	2	3	3
Yugoslavia	1	3	1
Total	79	289	156

Table 18. STATUS OF GLOSS STATIONS (as of September 1990)

Category 1: "Operational" stations for which the latest data is 1986 or later

Category 2: "Probably Operational" stations for which the latest data is within the period 1976-1985

Category 3: "Historical" stations for which the latest data is earlier than 1976

Category 4: For which no PSMSL data exist

Country/Territory	Category 1	Category 2	Category 3	Category 4
ANGOLA				1
ARGENTINA		2	3	2
AUSTRALIA	1	12	6	3
BAHAMAS				2
BANGLADESH			1	
BELAU	1			
BRAZIL	1	2	3	4
CAMEROON				1
CANADA		8		
CAPE VERDE			1	
CHILE	2	2	3	2
CHINA	4	1		
COLOMBIA	3			
CONGO		1		
COOK ISLANDS	2			
COSTA RICA			1	1
COTE D'IVOIRE		1		
CUBA	3			
DEM. PEOPLE'S REP. OF KOREA	1			
DENMARK	2			2
DJIBOUTI			1	
ECUADOR	2			
EGYPT	1		1	
EL SALVADOR				1
FED. MICRONESIA	4			
FIJI	1			
FRANCE	6	2		7
FED. REP. OF GERMANY	1			
GHANA		1		
GUINEA				1
HAITI			1	
HONG KONG	1			
ICELAND	1			
INDIA	3	3	1	1
INDONESIA	1		5	3
IRELAND	1			1
JAMAICA			1	
JAPAN	9			2
KENYA	1			
KIRIBATI	4			
MADAGASCAR	1			1
MALAYSIA	2			
MALDIVES			1	1
MARSHALL ISLANDS	1		1	
MAURITANIA				1
MAURITIUS	1			2
MEXICO	2	5	1	

MOROCCO				1
MOZAMBIQUE				2
MYANMAR			2	
N. MARIANA ISLANDS	1			
NAURU	1			
NEW ZEALAND	3			4
NIGERIA			1	
NORWAY	3	1		3
OMAN				2
PAKISTAN		1		1
PANAMA		1		1
PAPUA NEW GUINEA	1	1		2
PERU	1			
PHILIPPINES	4			
PORTUGAL	4			
PUERTO RICO	1			
REPUBLIC OF YEMEN			1	1
SAO TOME/PRINCIPE				1
SENEGAL			1	
SEYCHELLES		2		
SIERRA LEONE				1
SINGAPORE	1			
SOLOMON ISLANDS	1			
SOMALIA				2
SOUTH AFRICA*	3			1
SPAIN	1		1	1
SRI LANKA		1		
SWEDEN	1			
THAILAND	2			
TONGA				1
TRINIDAD & TOBAGO	1			
TUVALU	1			
UNITED KINGDOM	5	1	1	7
UNITED REPUBLIC OF TANZANIA	1		1	
UNITED STATES OF AMERICA	26	2	2	3
UNION OF SOVIET SOC REPS	8			5
URUGUAY			1	
VENEZUELA				2
VIETNAM				1
TOTALS	**133**	**50**	**42**	**81**

* The Government of the Republic of South Africa has been suspended by Resolutions 38(Cg-VII) and 2/74/4 (Twentieth Session of the General Conference of Unesco) from exercising its rights and enjoying the privileges as a Member of WMO and Member State of IOC, respectively.

Table 19. **Number of Drifting Buoys by Country and Those Reporting via GTS**
February 1990

ORGANIZATION	COUNTRY	TOTAL	GTS
NOAA-AOML	USA	134	111
MSA-Hydro Dept	Japan	43	4
US Navy	USA	45	7
Scripps Inst	USA	43	0
NOAA-NDBC	USA	31	19
NOAA-PMEL	USA	40	0
IFM-Kiel	Fed Rep of Germany	18	0
Woods Hole Inst	USA	33	4
Univ Hannover	Fed Rep of Germany	13	12
CMM	France	12	5
BCM	Australia	11	10
Exxon	USA	9	0
Univ Wash	USA	9	0
Battelle	USA	8	0
IFREMER	France	8	0
Hor Mar Inc	USA	7	0
Fish Agency	Japan	7	0
Met Svc	New Zealand	6	4
Univ Hamburg	Fed Rep of Germany	6	0
Marine Lab	Australia	6	0
Meteo Inst	Norway	6	0
Weather Bureau	South Africa*	5	5
Met Office	United Kingdom	5	0
Bedford Inst	Canada	5	0
Atm Env Svc	Canada	4	0
Coast Guard	USA	4	3
Inst Ocean Sci	Canada	4	0
US Army	USA	4	0
Sverdrup Tech	USA	3	0
China Sea Bur	China	3	0
Alfr Weg Inst	Fed Rep of Germany	3	0
Marine Bio As	United Kingdom	3	0
Polar Res Lab	USA	3	0
KNMI	Netherlands	3	2
Polar Inst	Norway	3	0
Inst Mar Res	Norway	3	0
Naval School	USA	1	0
Others		43	5
TOTAL		594	191
(% OF TOTAL)			(32.2)

* The Government of the Republic of South Africa has been suspended by Resolutions 38(Cg-VII) and 2/74/4 (Twentieth Session of the General Conference of Unesco) from exercising its rights and enjoying the privileges as a Member of WMO and Member State of IOC, respectively.

Table 20. National and International Ocean Data Centres

1. INTERNATIONAL OCEANOGRAPHIC DATA EXCHANGE

1.1. World Data Centres for Oceanography

WDC-A	(Oceanography)	USA (Washington)
WDC-B	(Oceanography)	USSR (Obrinsk)
WDC-D	(Oceanography)	People's Republic of China (Tianjin)
WDC-A	(Marine Geology and Geophysics)	USA (Boulder)
WDC-B	(Marine Geology and Geophysics)	USSR (Gelendjhik)

1.2. Responsible National Oceanographic Data Centres (RNODC)

- RNODC Drifting Buoy Data	Canada
- RNODC's IGOSS	Japan, USA, USSR (NODCs)
- RNODCs for Marine Pollution Monitoring	Japan, USA (NODCs)
- RNODC for instrumented and remotely-sensed wave data	UK
- RNODC for Development of Acoustic Doppler Current Profiling (ship-mounted) Data Management	Japan
- RNODC for the IOC WESTPAC	Japan
- RNODC for the Southern Ocean	Argentina
- RNODC - Formats	ICES
- RNODC for MEDALPEX	USSR

2. INTEGRATED GLOBAL OCEAN SERVICES SYSTEM

2.1. World Oceanographic Centres (IGOSS)

USSR (Moscow)
USA (Washington)

2.2. Specialized Oceanographic Centres (SOCs)

- SOC South Atlantic (South of 20°S)	NODC, Argentina
- SOC Indian Ocean and Pacific Ocean (South of 20°N)	NODC, Australia Bureau of Australian Meteorology
- SOC for Drifting Buoy Data	Service Central d'Exploitation de la Meteorologie, Paris France
- SOC for the Pacific Ocean	JMA, Japan
- SOC for the IGOSS Sea Level Programme in the Pacific	University of Hawaii, Honolulu, Hawaii, USA

Table 20 (Cont.)

3. **NATIONAL IODE AND IGOSS CENTRES** (National Oceanographic Data Centres (NODCs)/Designated National Agencies contribute to IODE; National Oceanographic Centres (NOCs) or National Meteorological Centres with Corresponding Functions contribute to IGOSS)

	IODE NODCs/DNAs	IGOSS NOCs
Argentina	NODC	NOC
Australia	NODC	NOC
Brazil	NODC	NOC
Bulgaria	NODC	
Canada	NODC	NOC
Chile	NODC	NOC
China	NODC	
Colombia	NODC	
Democratic People's Republic of Korea		NOC
Ecuador	NODC	NOC
Egypt	NODC	
Finland	DNA	NOC
France	NODC	NOC
Germany	NODC	NOC
Ghana	DNA	
Greece	NODC	
Guatemala	NODC	
Iceland	NODC	NOC
India	NODC	
Italy	NODC	
Japan	NODC	NOC
Kenya		NOC
Mexico	NODC	
Morocco	NODC	
Netherlands	NODC	
Norway	NODC	
Pakistan	NODC	
Peru	NODC	NOC
Philippines	NODC	
Poland	NODC	
Portugal	DNA	
Republic of Korea	NODC	
Romania	DNA	
Spain	NODC	
Sweden	DNA	NOC
Tanzania	DNA	
Trinidad and Tobago	DNA	
Turkey	DNA	
USSR	NODC	NOC
United Kingdom	NODC	
United States of America	NODC	NOC
Uruguay	NODC	
Venezuela	NODC	
VietNam	NODC	

4. Permanent Service of Mean Sea Level (PSMSL) — Proudman Oceanographic Laboratory, Bidston UK

Table 20 (Cont.)

5. OCEANOGRAPHIC DATA CENTRES OF THE TOGA PROGRAMME

- Global Sea Surface Temperature	Washington, D.C. (USA)
- TOGA Sub-Surface Data Centre	Brest (France)
- Tropical Sea Level Data Centre	Honolulu, Hawaii (USA)
- TOGA Marine Climatology Data Centre	Bracknell (UK)

6. OCEANOGRAPHIC DATA CENTRES OF THE WOCE PROGRAMME

6.1. Drifter Data Centres

- NOAA, Miami, Florida (USA)
- Scripps Institute of Oceanography, La Jolla, California (USA)
- MEDS, Canada

6.2. Upper Ocean Thermal Data Assembly Centres

- NODC, Brest (France)

6.2.1. Global Supporting National Centres

- NODC, USA
- NODC, Australia

6.2.2. Regional

- Scripps Institute of Oceanography, USA
- NOAA, Miami, Florida USA
- CSIRO, Hobart, Australia

6.3. Sea Level Data Assembly Centres

- University of Honolulu, Hawaii, USA
- Bidston Observatory, UK

6.4. Data Information Unit

- University of Delaware, Lewes, Delaware, USA

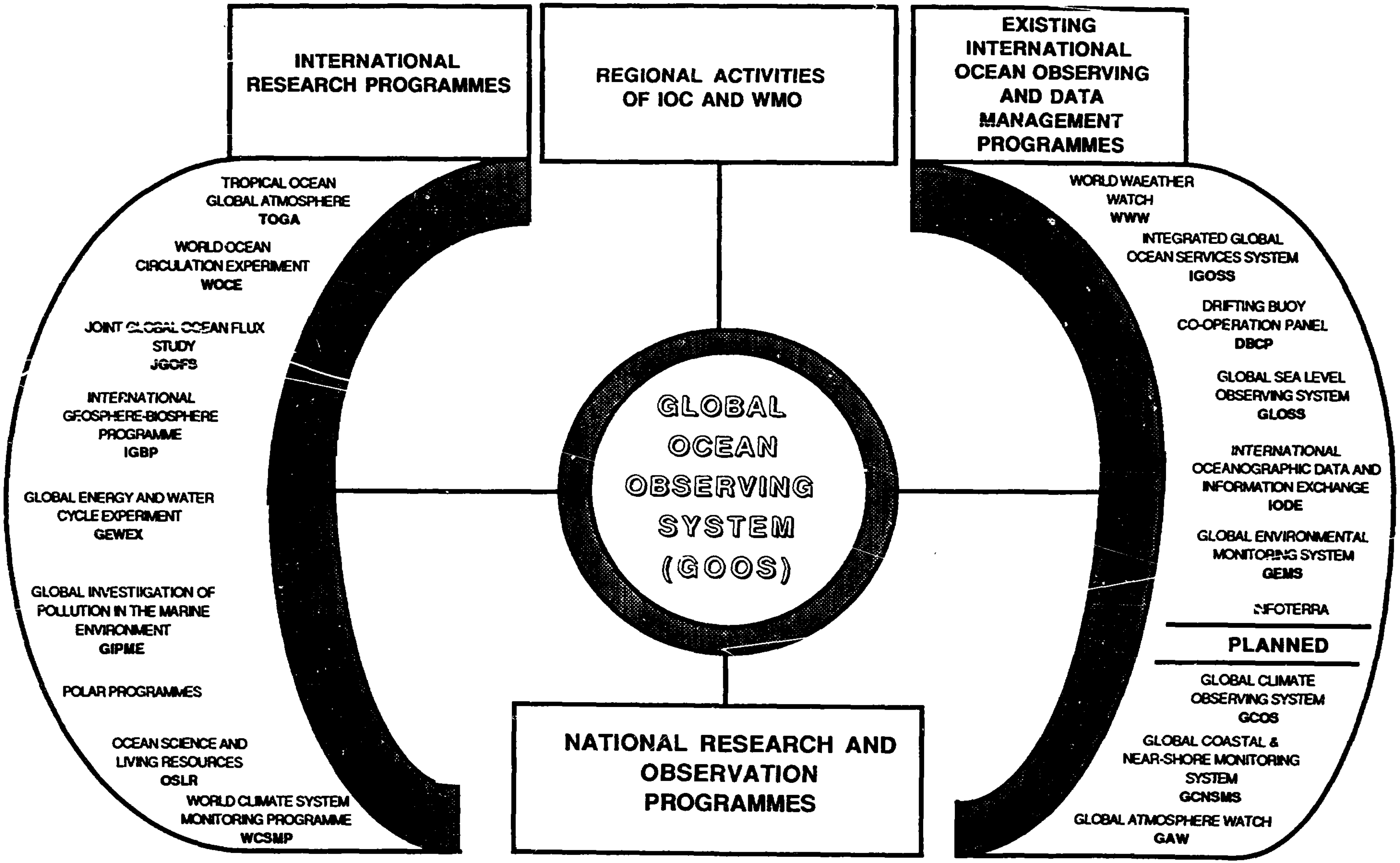


Fig. 1. RELATIONSHIP OF GLOBAL OCEAN OBSERVING SYSTEM (GOOS) TO OTHER PROGRAMMES

Fig. 2. Organization Structure of the IOC

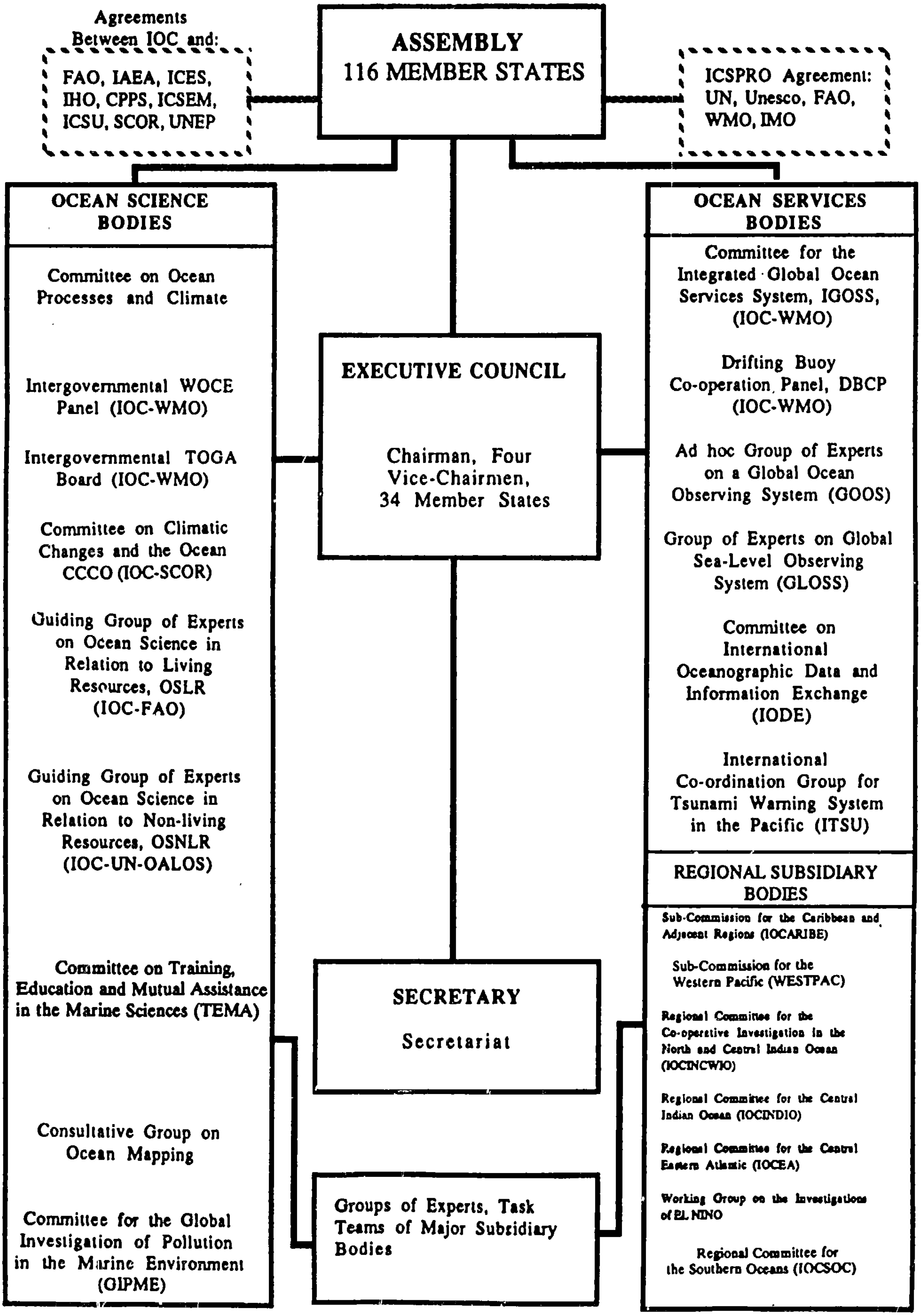
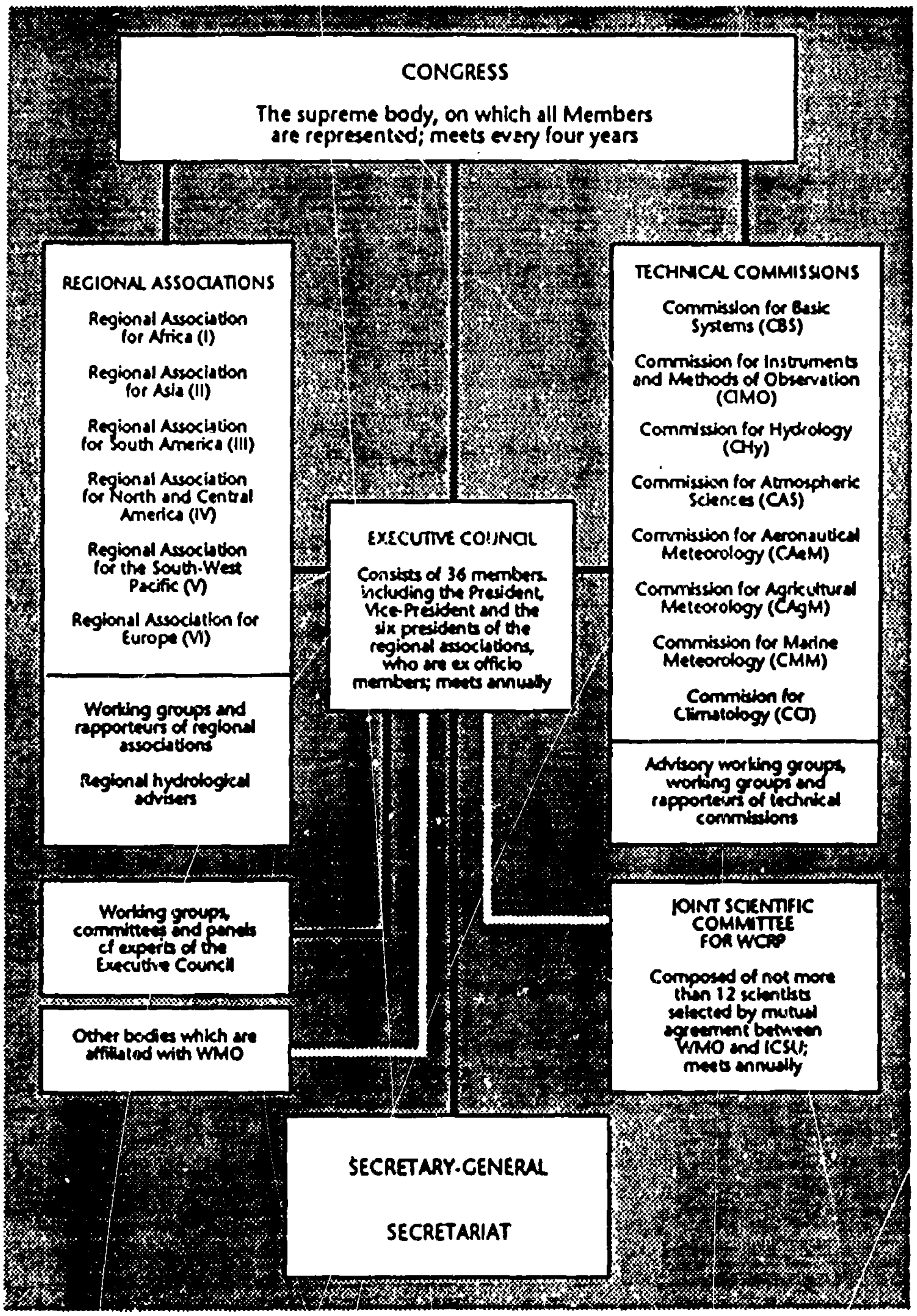


Fig. 3. Organization Structure of the WMO



IMPLEMENTATION OF THE GLOBAL TELECOMMUNICATION SYSTEM

MISE EN OEUVRE DU SYSTEME MONDIAL DE TELECOMMUNICATIONS

EJECUCION DEL SISTEMA MUNDIAL DE TELECOMUNICACION

ОСУЩЕСТВЛЕНИЕ ГЛОБАЛЬНОЙ СИСТЕМЫ ТЕЛЕСВЯЗИ

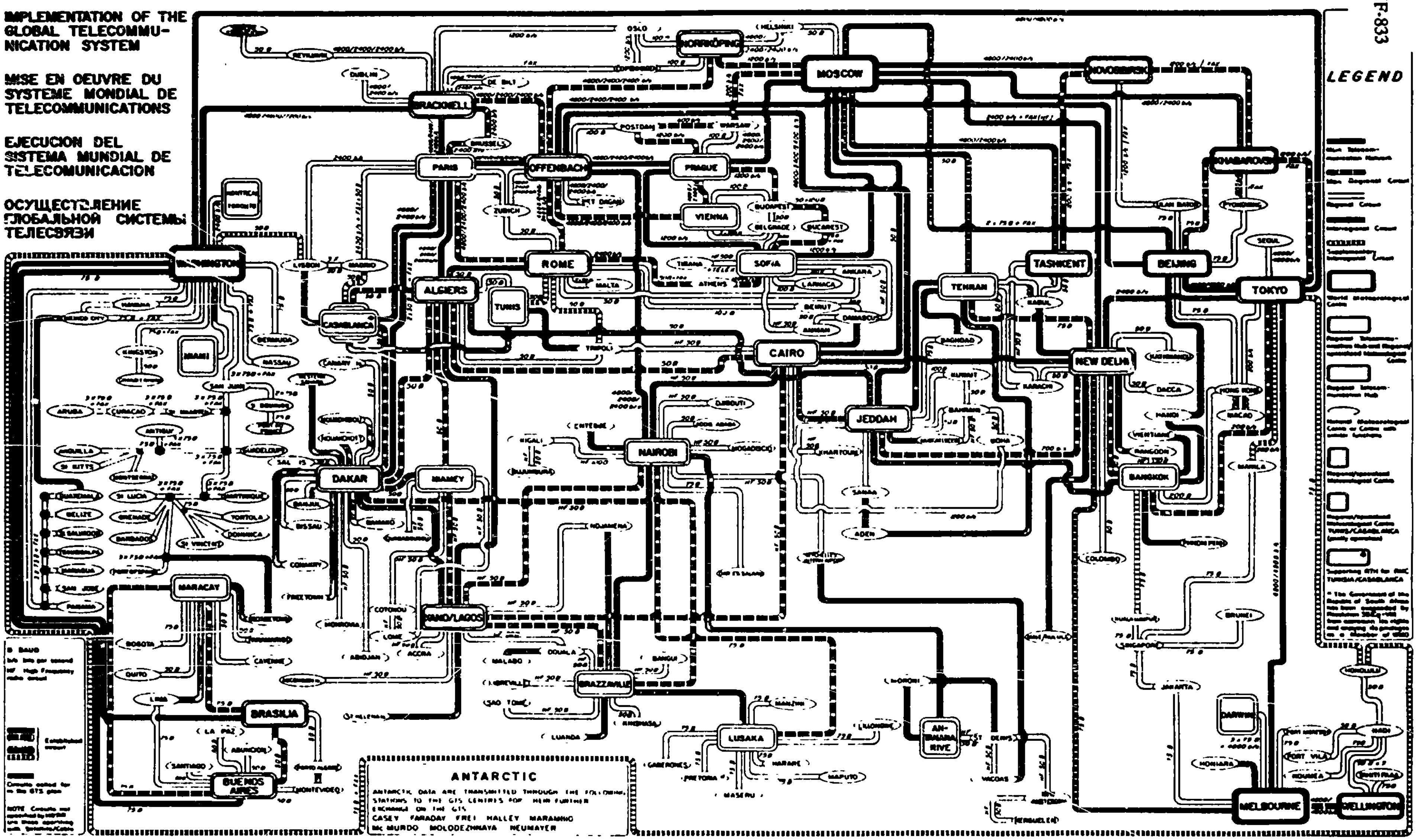


Fig. 4. Global Telecommunications System Network

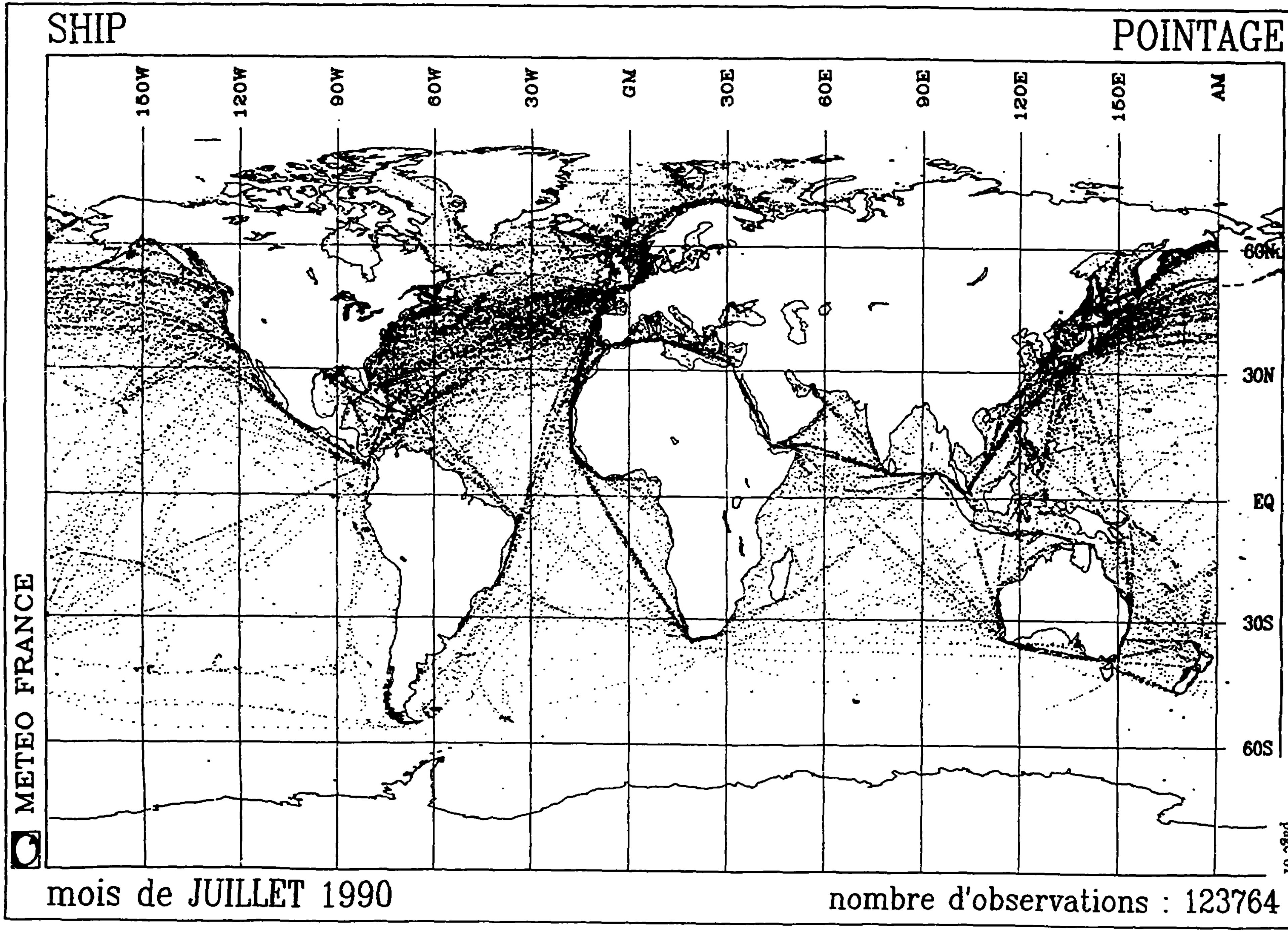


Fig. 5. VOS Data Locations - July 1990

SHIP

CARRE MARSDEN

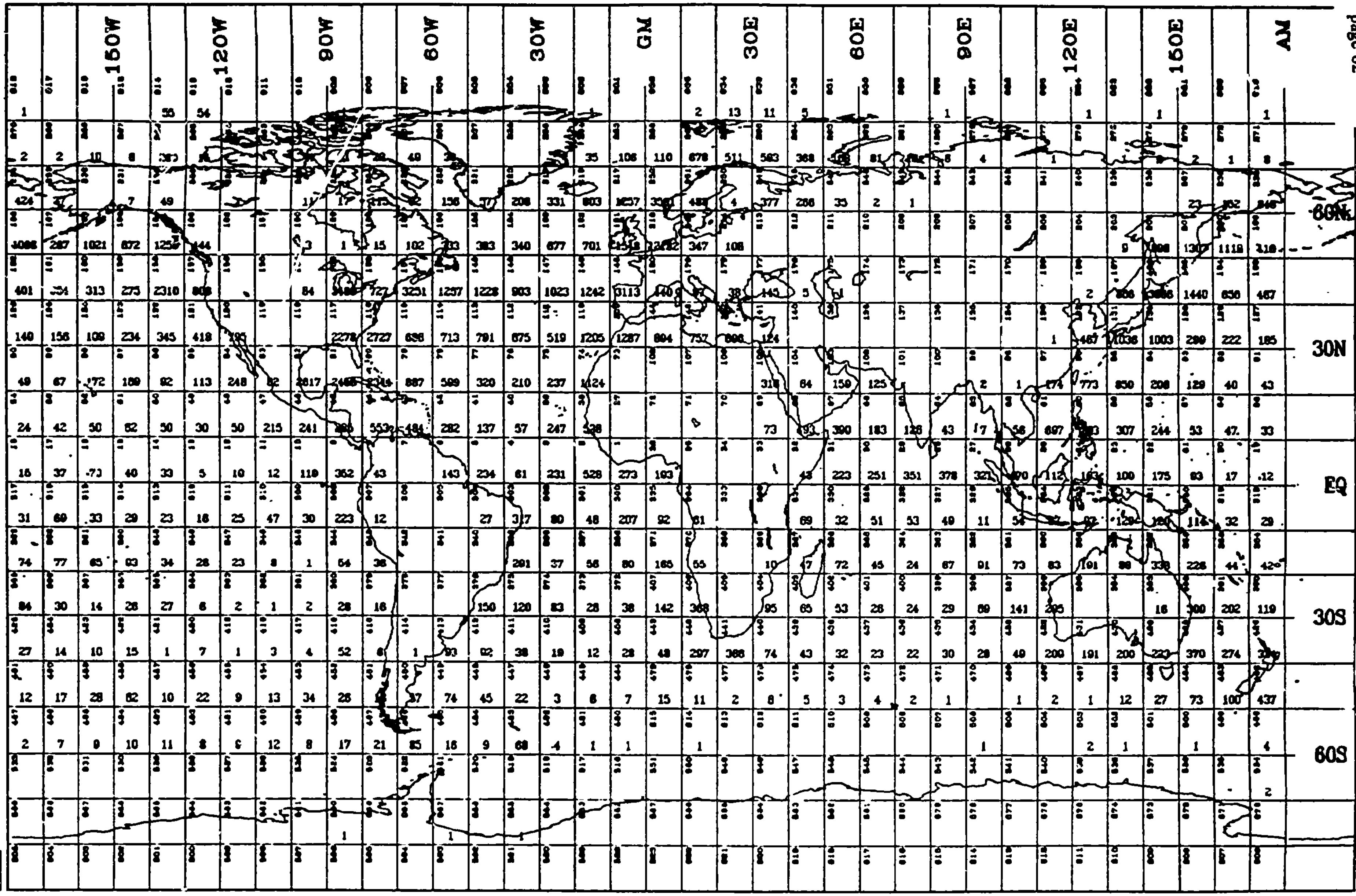


Fig. 6. VOS Data Locations - July 1990 - By Marsden Square

METEO FRANCE

mois de JUILLET 1990

nombre d'observations : 123764

THE INTEGRATED GLOBAL OCEAN SERVICES SYSTEM (IGOSS)

STRUCTURE

IGOSS OBSERVING SYSTEM (IOS)
- *Surface Based:
  - -Ships
  - -Buoys
  - -Coastal Stations & Offshore Platforms
- *Space-based
- * [Sub-surface]

IGOSS DATA PROCESSING & SERVICES SYSTEM (IDPSS)
- *National Oceanographic Centers (NOC)
- *Specialized Oceanographic Centers (SOC)
  - -data type
  - -*Specific process/programme type*
- *World Oceanographic Centers (WOC)

IGOSS TELECOMMUNICATIONS ARRANGEMENT (ITA)
- *Surface Based
  - -International Maritime Mobile Svc. (IMMS)
  - -Exclusive HF Bands
  - -VHF Transmissions
- *Satellite Based
  - -International Maritime Satellite (INMARSAT)
  - -Argos System
  - -Data collection system (DCS) of the geo-stationary met. satellites

SUPPORTING ELEMENTS OF IGOSS
- *IGOSS Training and Assistance
- *IGOSS Research and Development
- *IGOSS Monitoring
- *IGOSS Information Exchange

ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

Joint IOC/WMO Committee for IGOSS (71 Member States)

Subsidiary Bodies
- IGOSS Group of Experts on Operations and Technical Applications (GE/OTA)
  - Task Team on Quality Control Procedures for Automated Systems (TT/QCAS)
- IGOSS Group of Experts on Scientific Matters (GE/SM)
- Joint CMM-IGOSS Ad Hoc Group on Ocean Satellites and *Remote Sensing (OSRS)*

Specific Programmes and Projects

- IGOSS BATHY/TESAC Operational Programme (B/T) including IGOSS XBT Ship-of-Opportunity Programme (XBT/SOOP)
- IGOSS Sea-Level Programme in the Pacific (ISLP-Pac)
- IGOSS Sea-Level Pilot Project in the North and Tropical Atlantic (ISLPP-NTA)
- IGOSS Pilot Project on Altimetric Sea-Surface Topography (IPAST)
- IGOSS Sub-Surface Thermal Structure Pilot Project (ISTPP)
- IGOSS-IODE Global Temperature Salinity Pilot Project (GTSPP)

Fig. 7. Structure of IGOSS

Fig. 8. **PRESENT CONTRIBUTIONS OF IGOSS TO THE GLOBAL OCEAN OBSERVING SYSTEM**

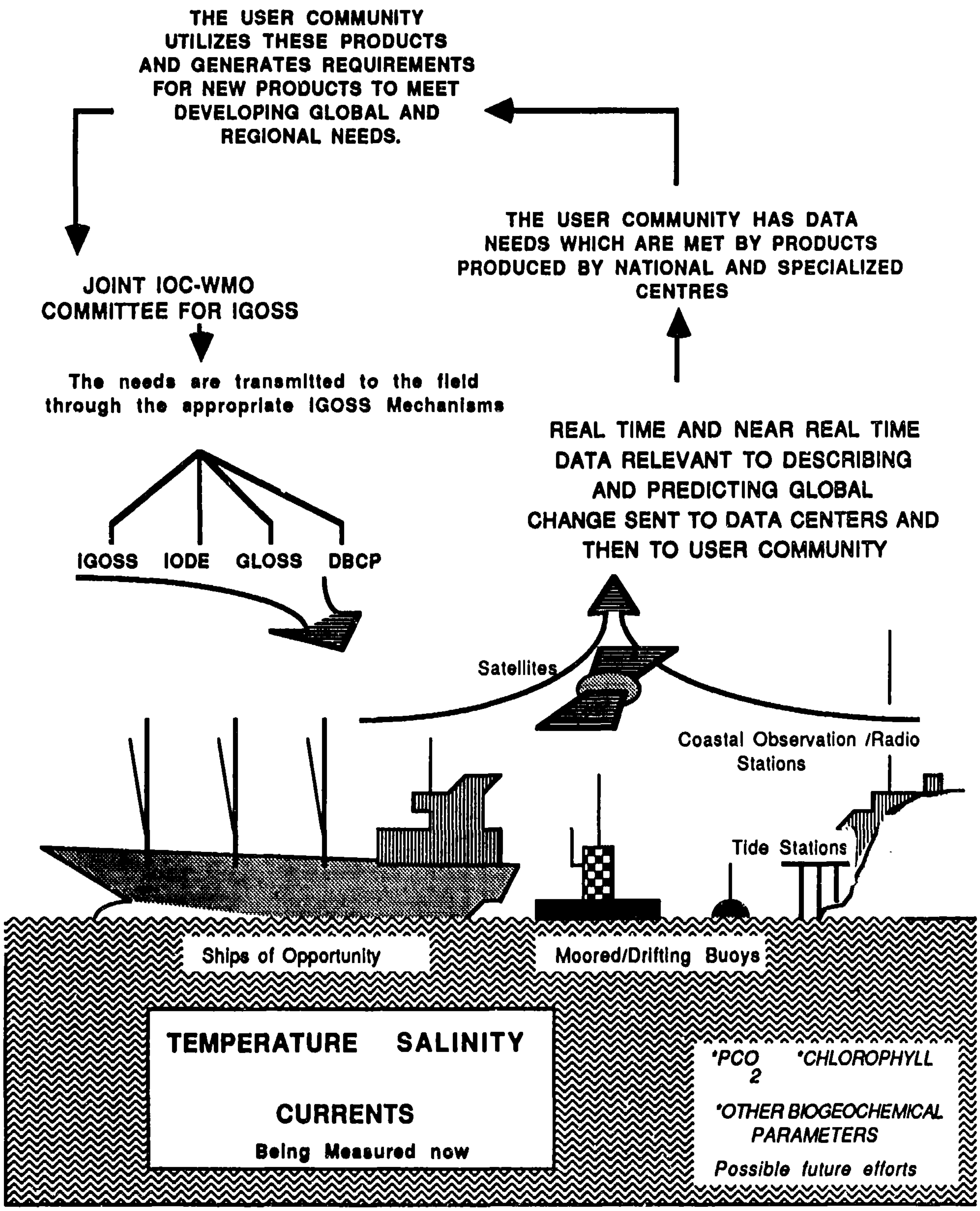
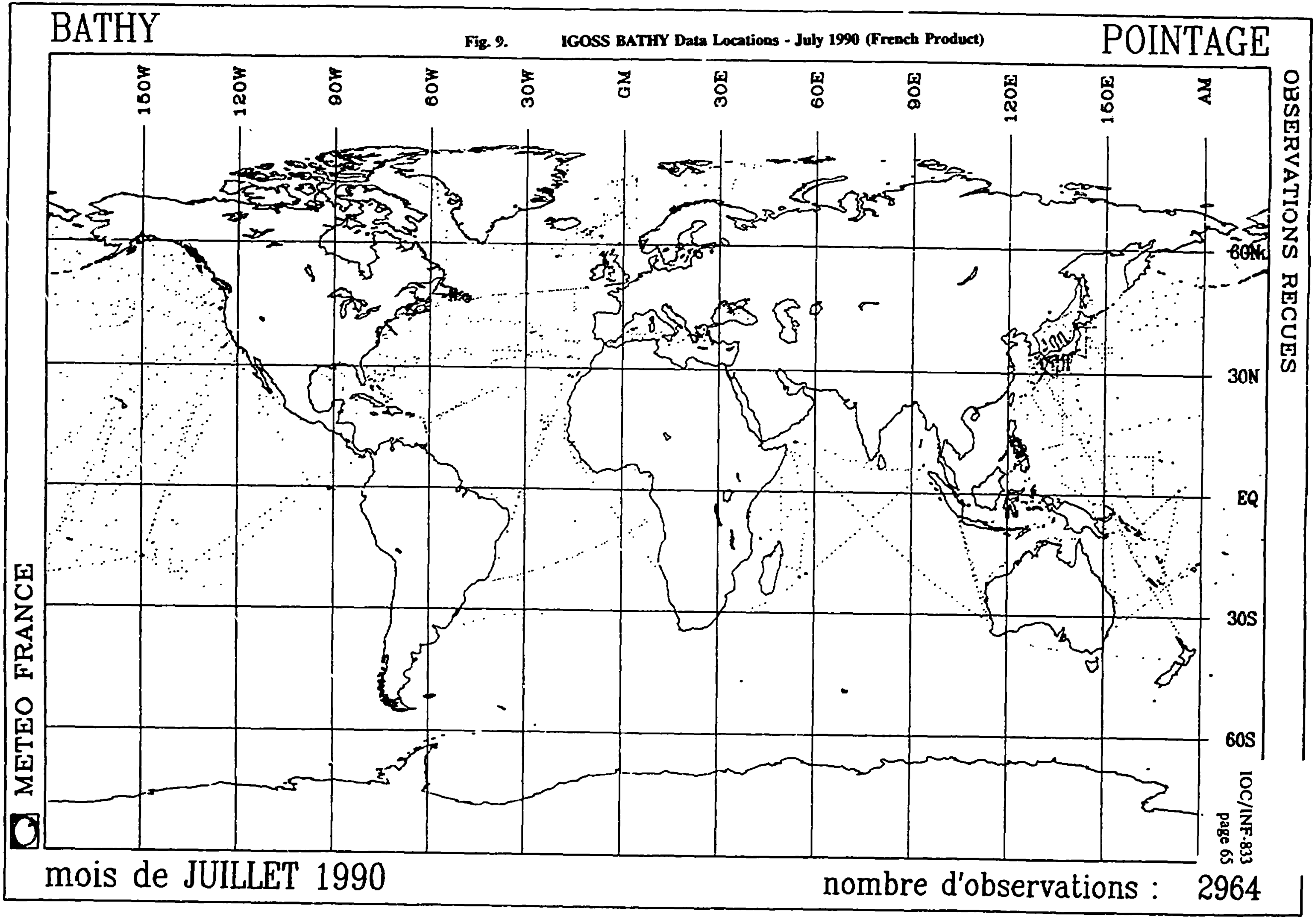
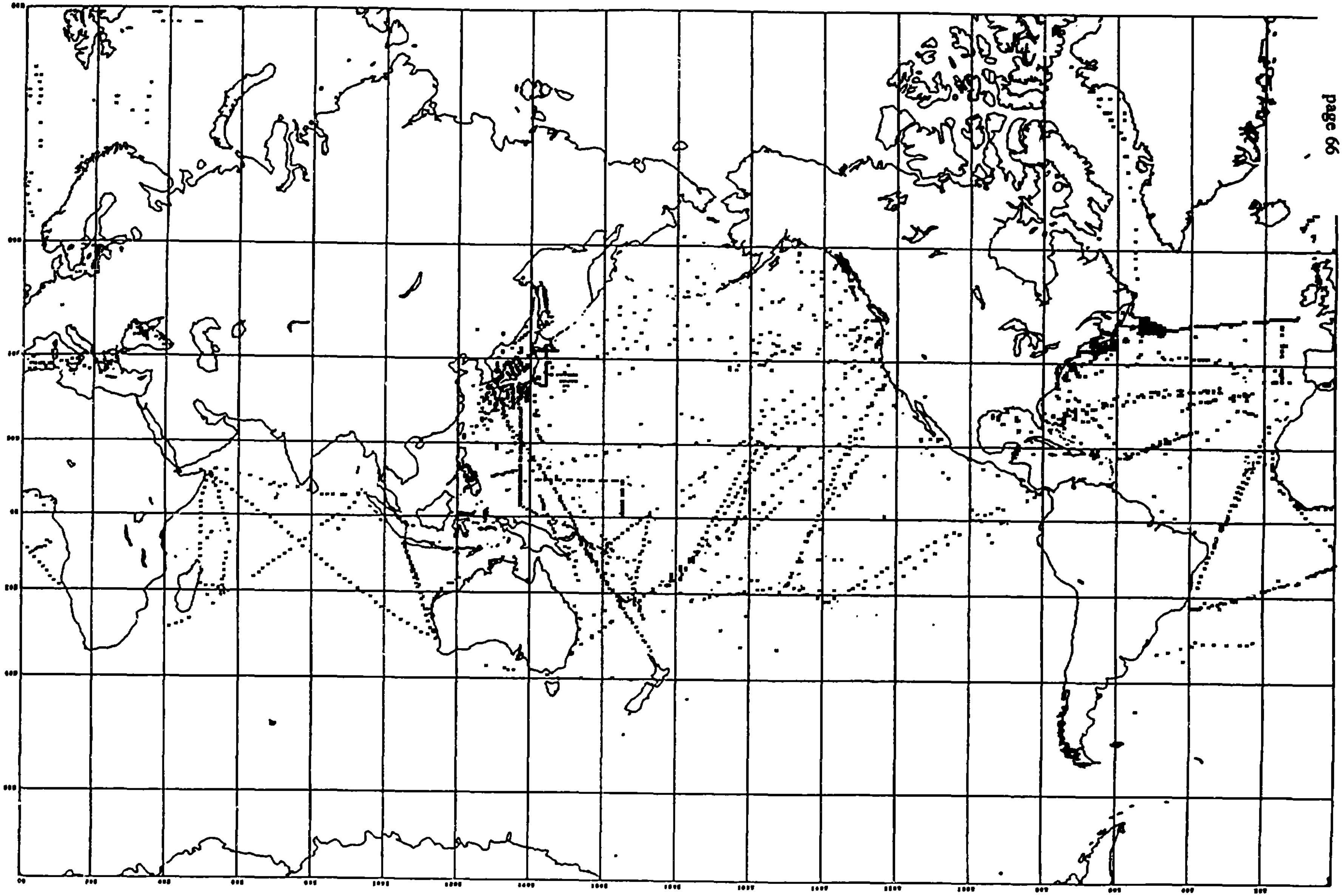


Fig. 9. IGOSS BATHY Data Locations - July 1990 (French Product)





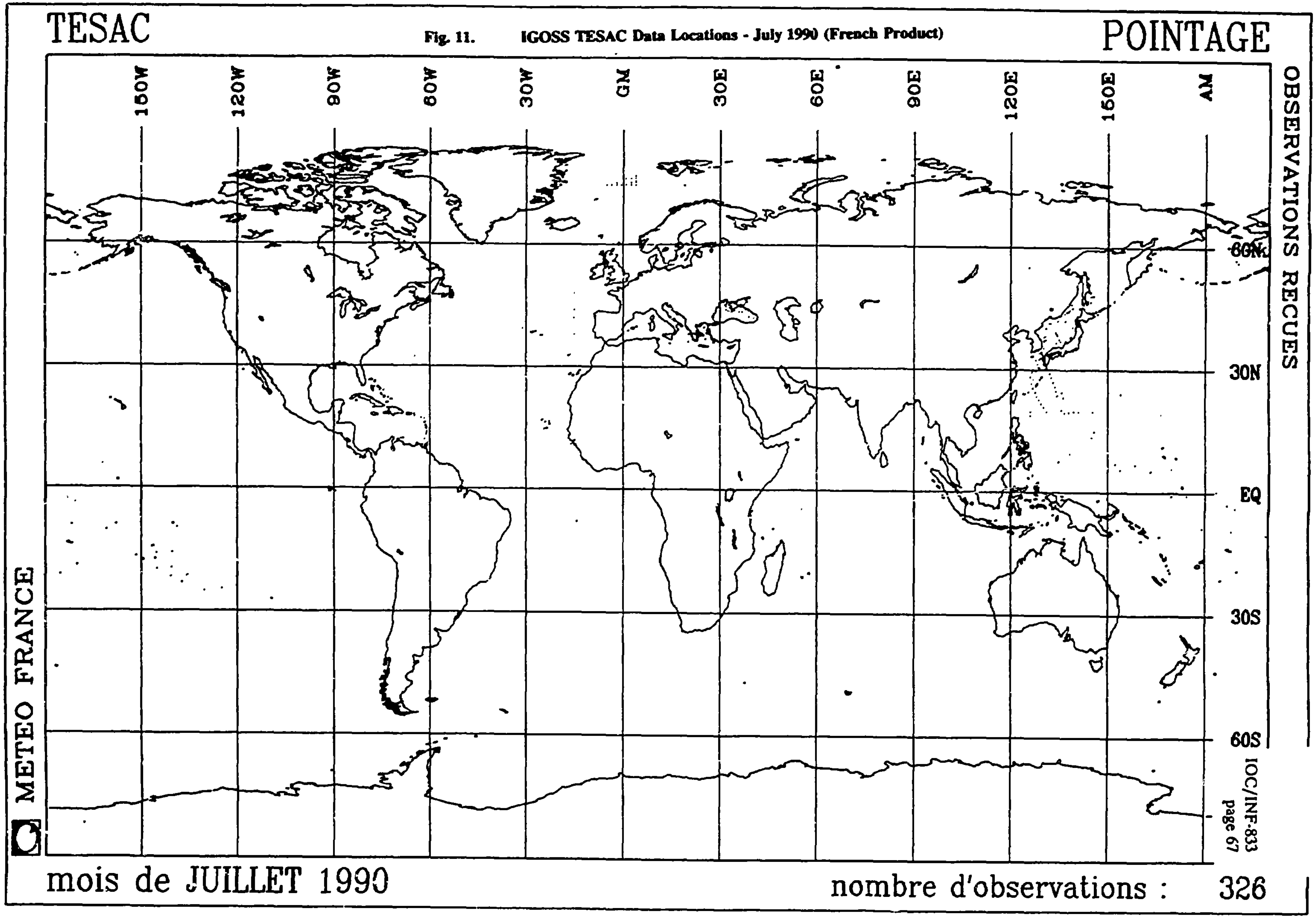
GEOGRAPHICAL DISTRIBUTION OF BATHY REPORTS FOR JULY 1990

IGOSS SOC FOR THE PACIFIC OCEAN

THE JAPAN METEOROLOGICAL AGENCY

Fig. 10. IGOSS BATHY Data Locations - July 1990 (Japanese Product)

Fig. 11. IGOSS TESAC Data Locations - July 1990 (French Product)



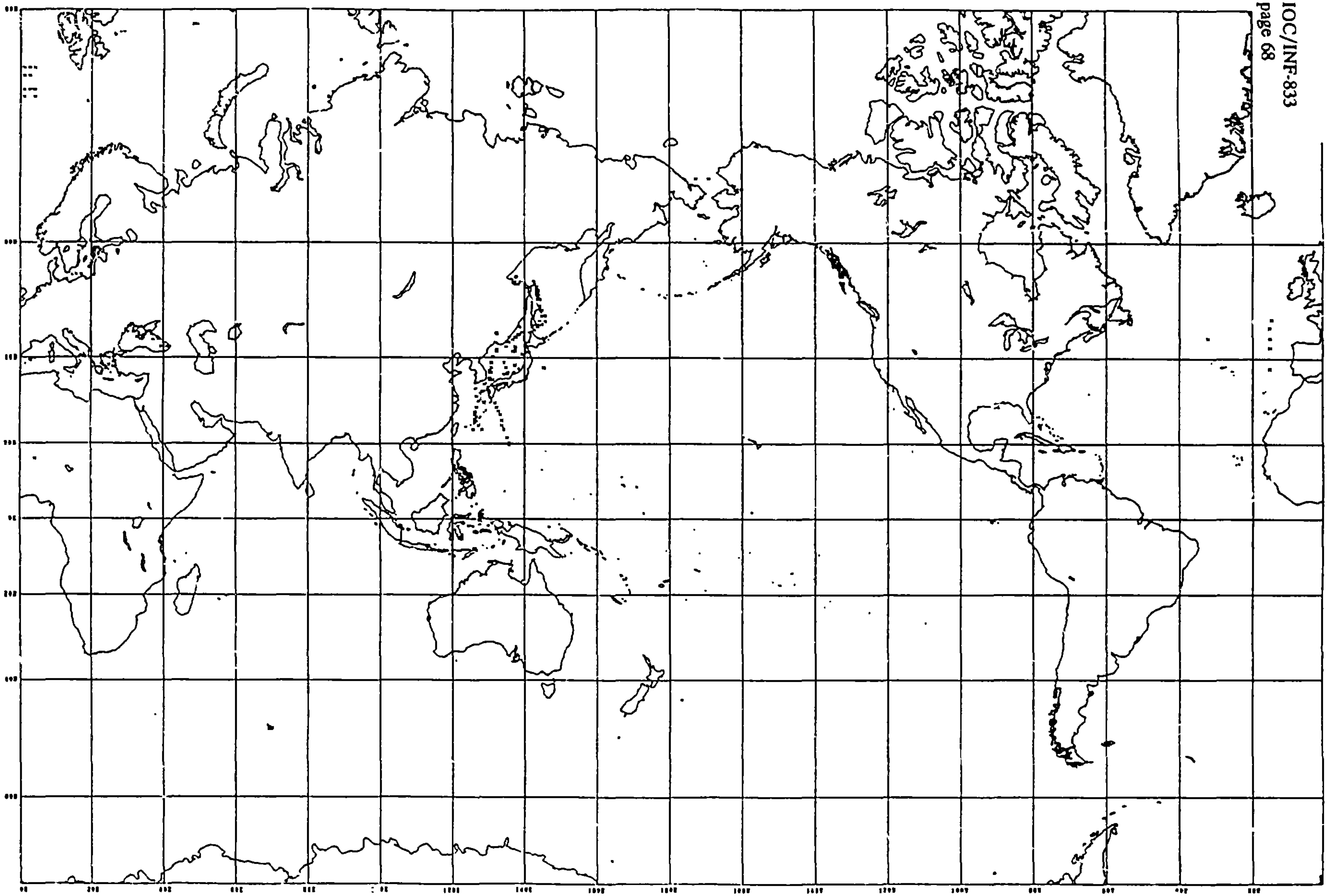
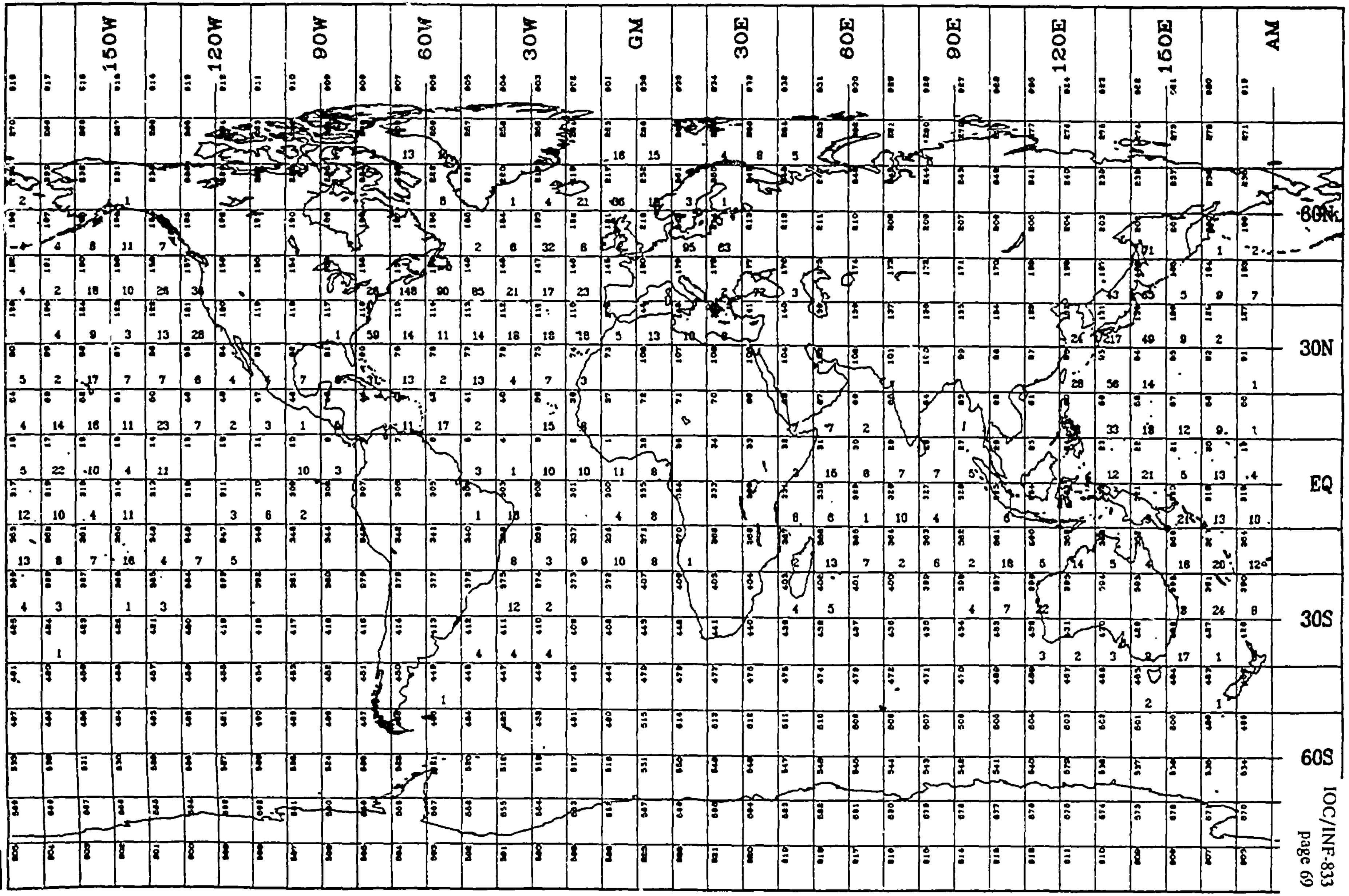


Fig. 12. IGOSS TESAC Data Locations - July 1990 (Japanese Product)

BATHY

Fig. 13. **IGOSS BATHY Data Locations - July 1990 - by Marsden Square**

CARRE MARSDEN



OBSERVATIONS RECUES

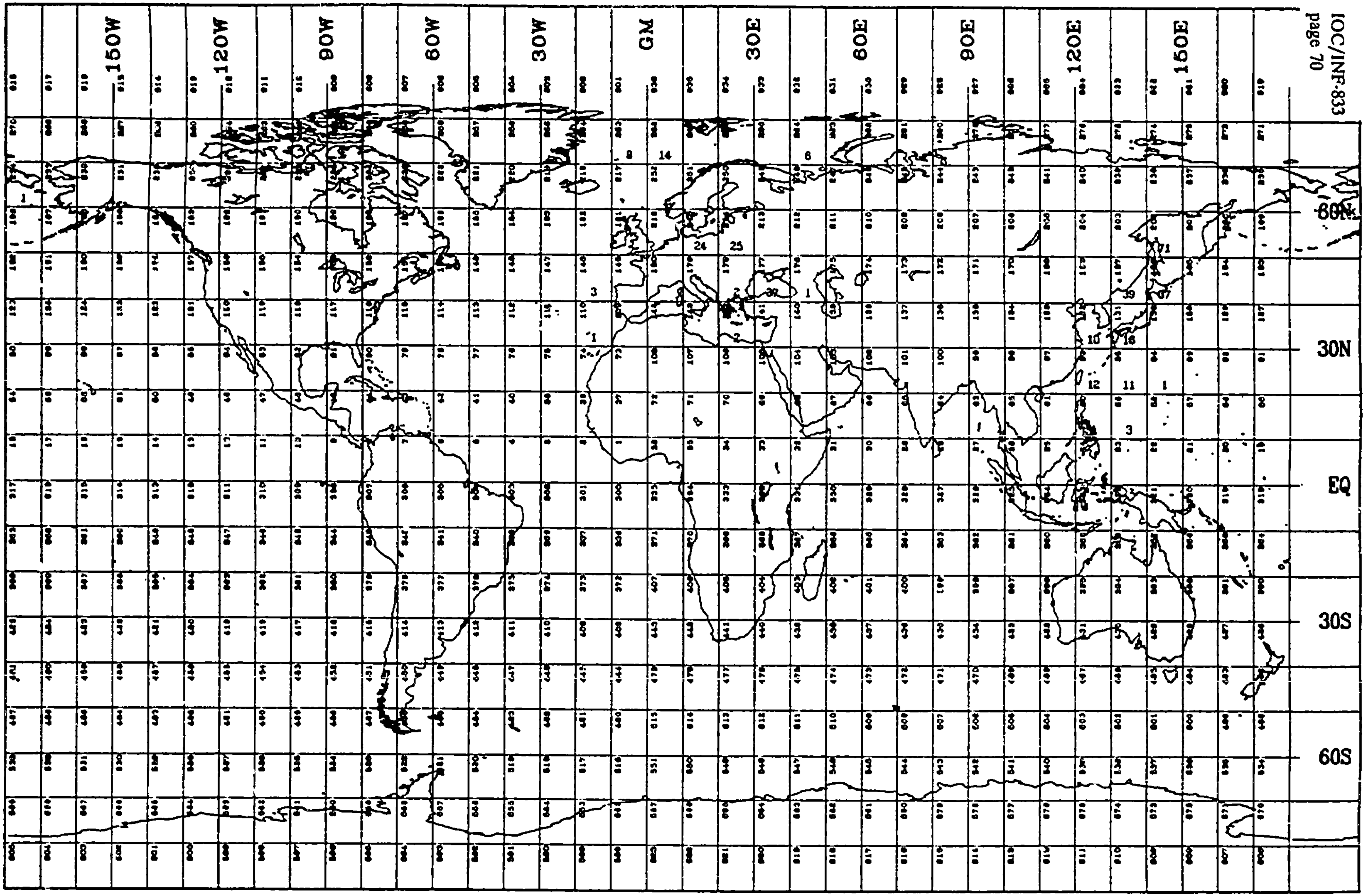
METEO FRANCE

mois de JUILLET 1990

nombre d'observations : 2964

TESAC

Fig. 14. IGOSS TESAC Data Locations - July 1990 - by Marsden Square



METEO FRANCE

ATIONS RECUES

mois de JUILLET 1990 nombre d'observations : 326

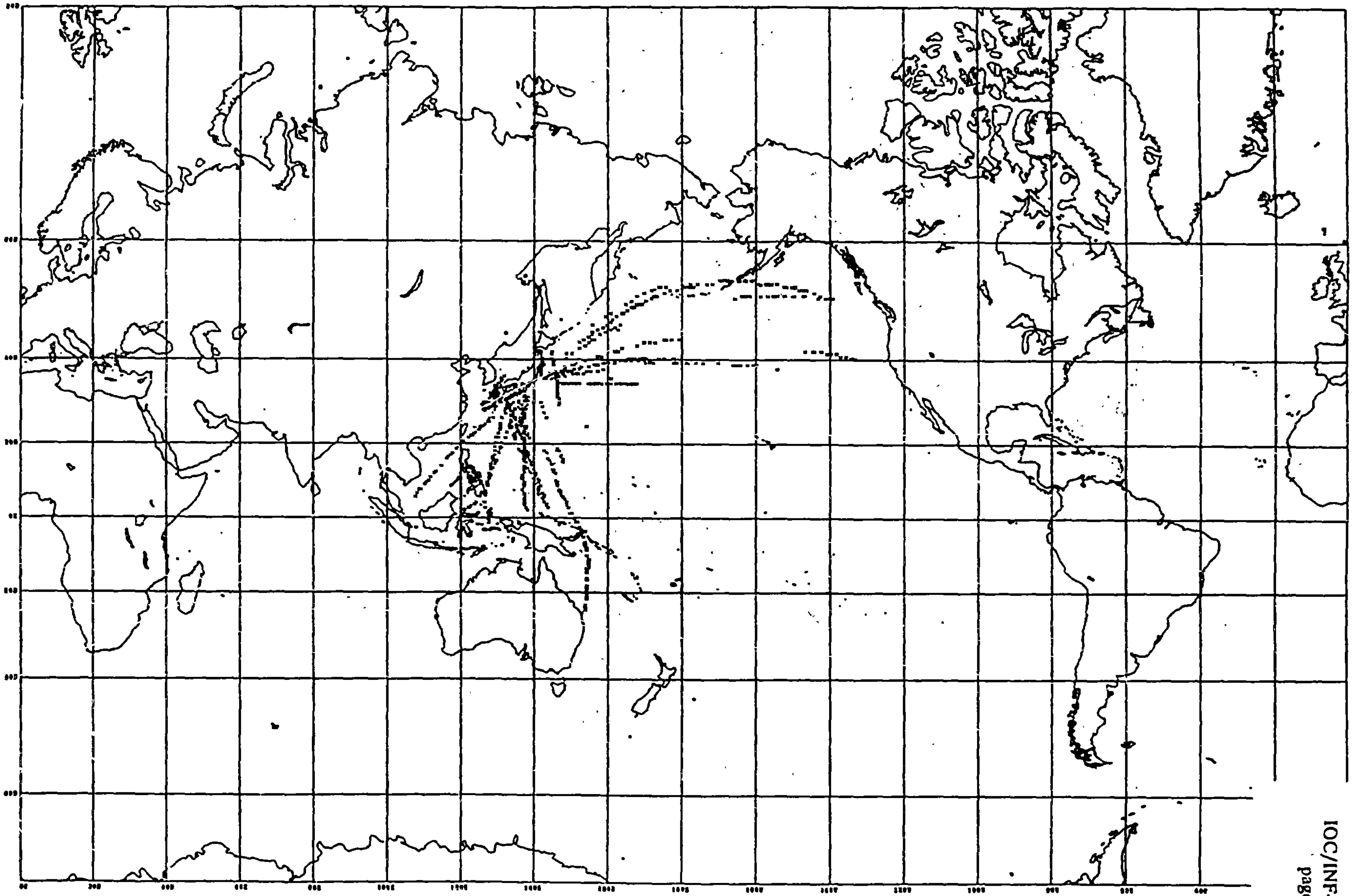
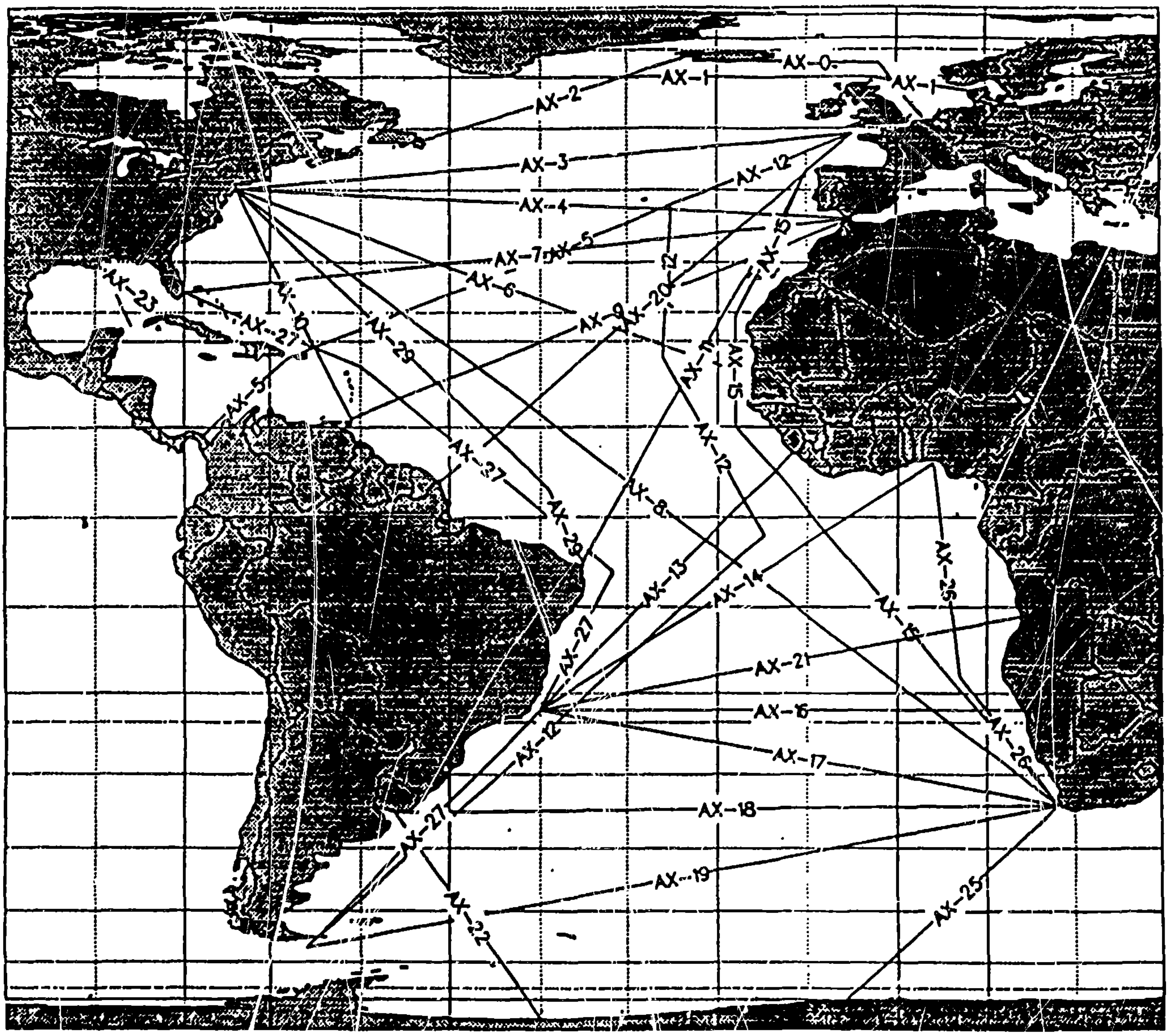


Fig. 15. IGOSS TRACKOB Data Locations - July 1990

Fig. 16. IGOSS Standard Track Lines- Atlantic



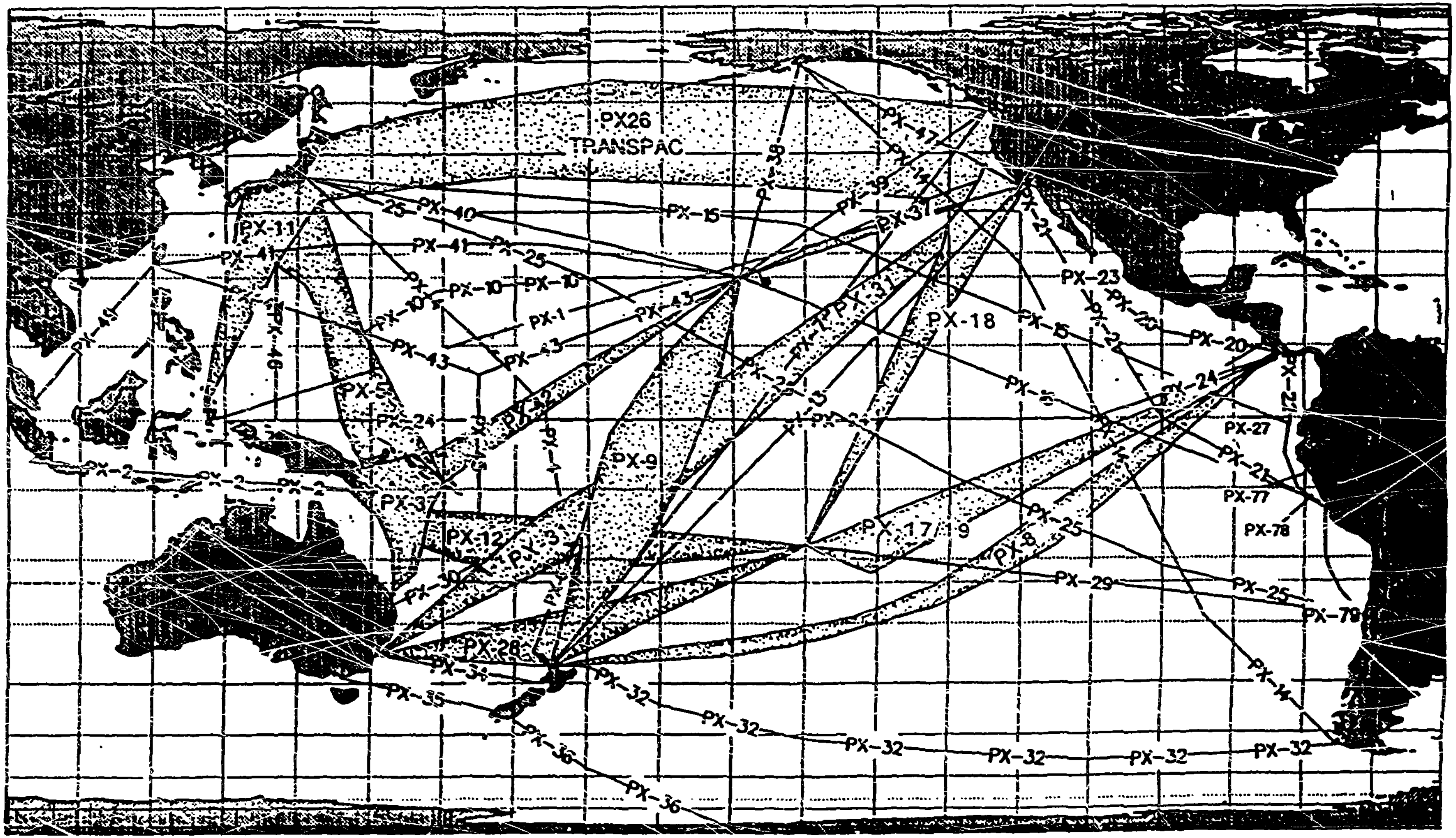
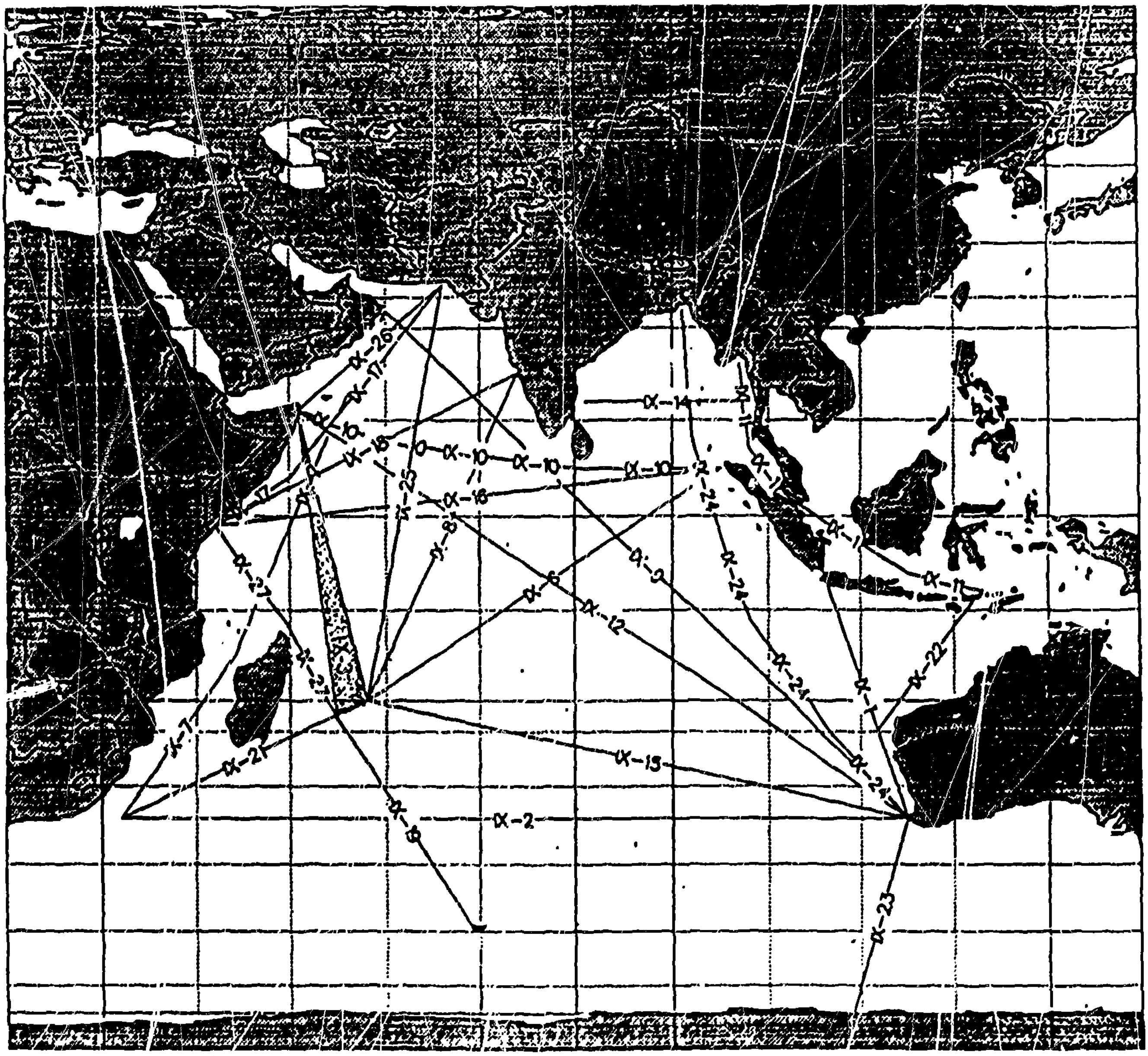


Fig. 17. IGOSS Standard Track Lines- Pacific

Fig. 18. IGOSS Standard Track Lines- Indian



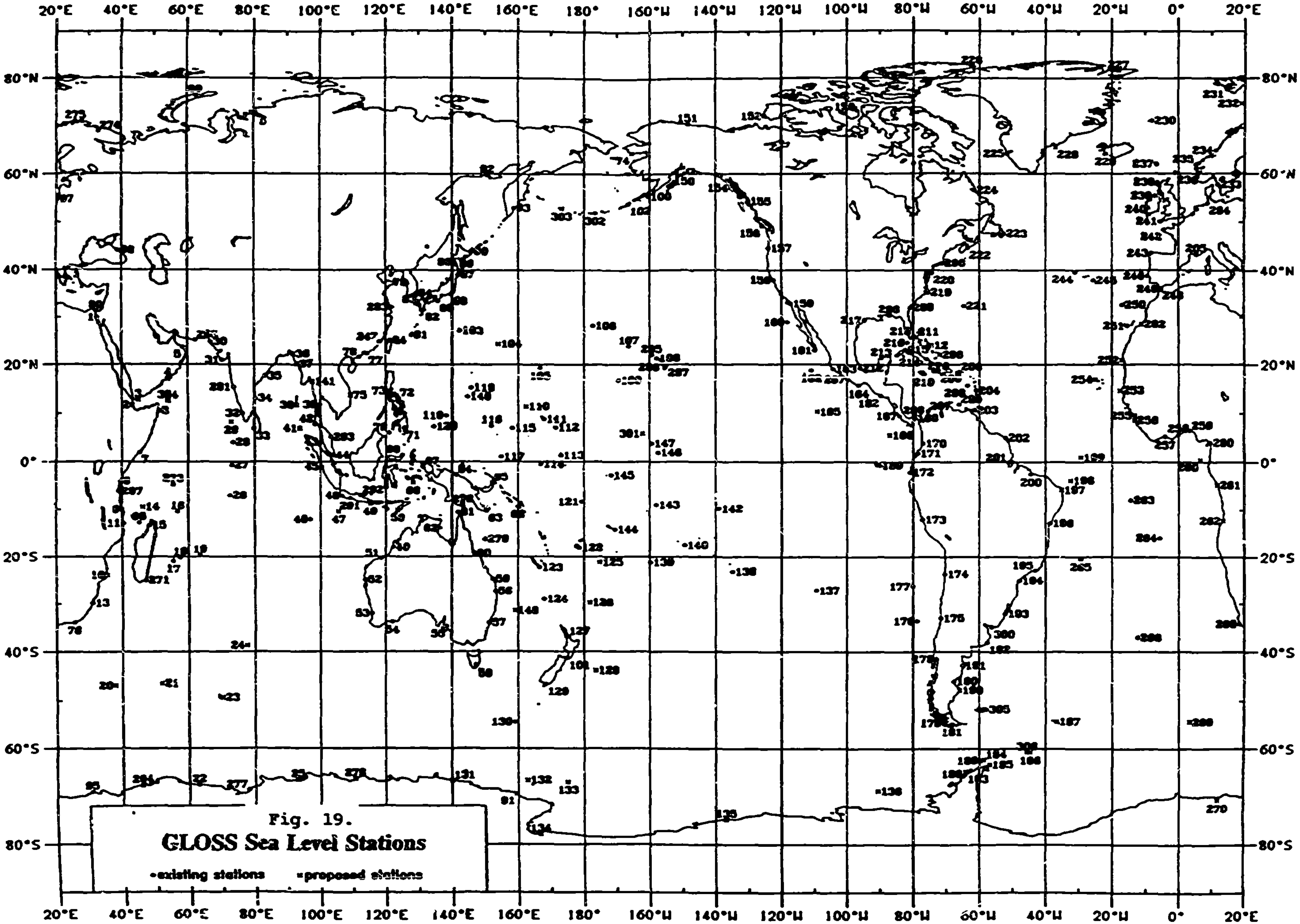
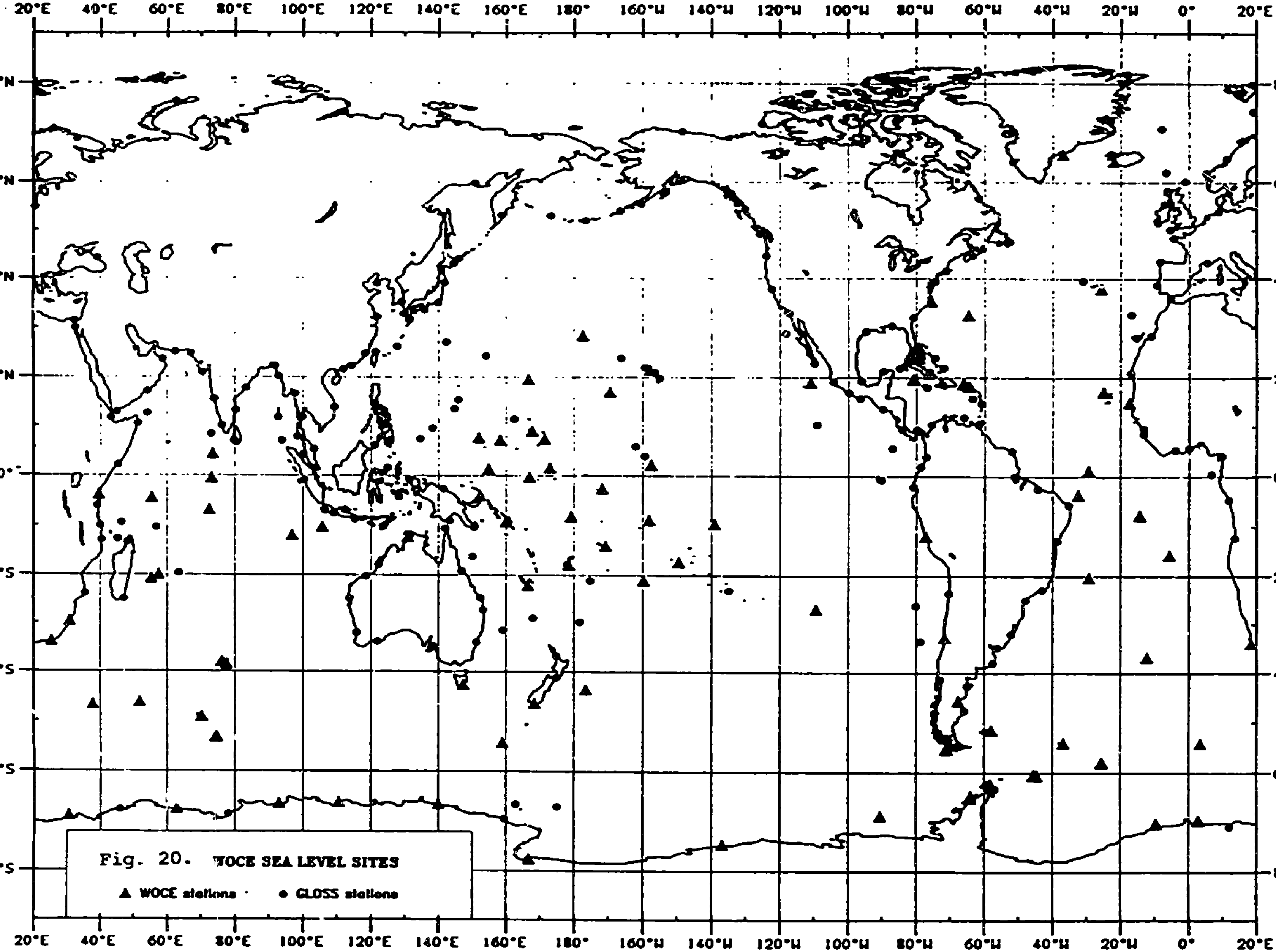


Fig. 19.
GLOSS Sea Level Stations

Fig. 19. Map of GLOSS Sea Level Stations

Fig. 20. WOCE Sea Level Sites



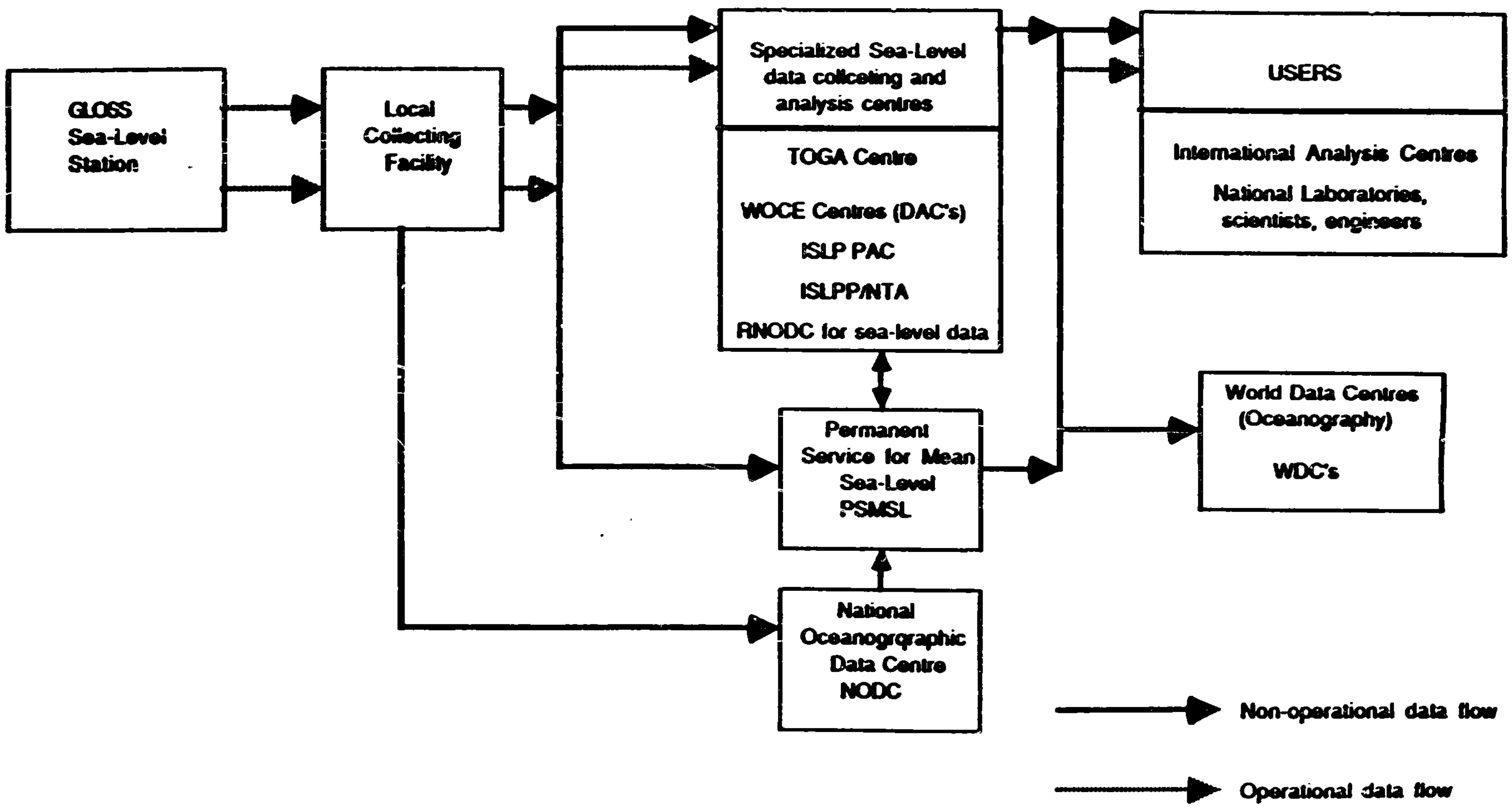
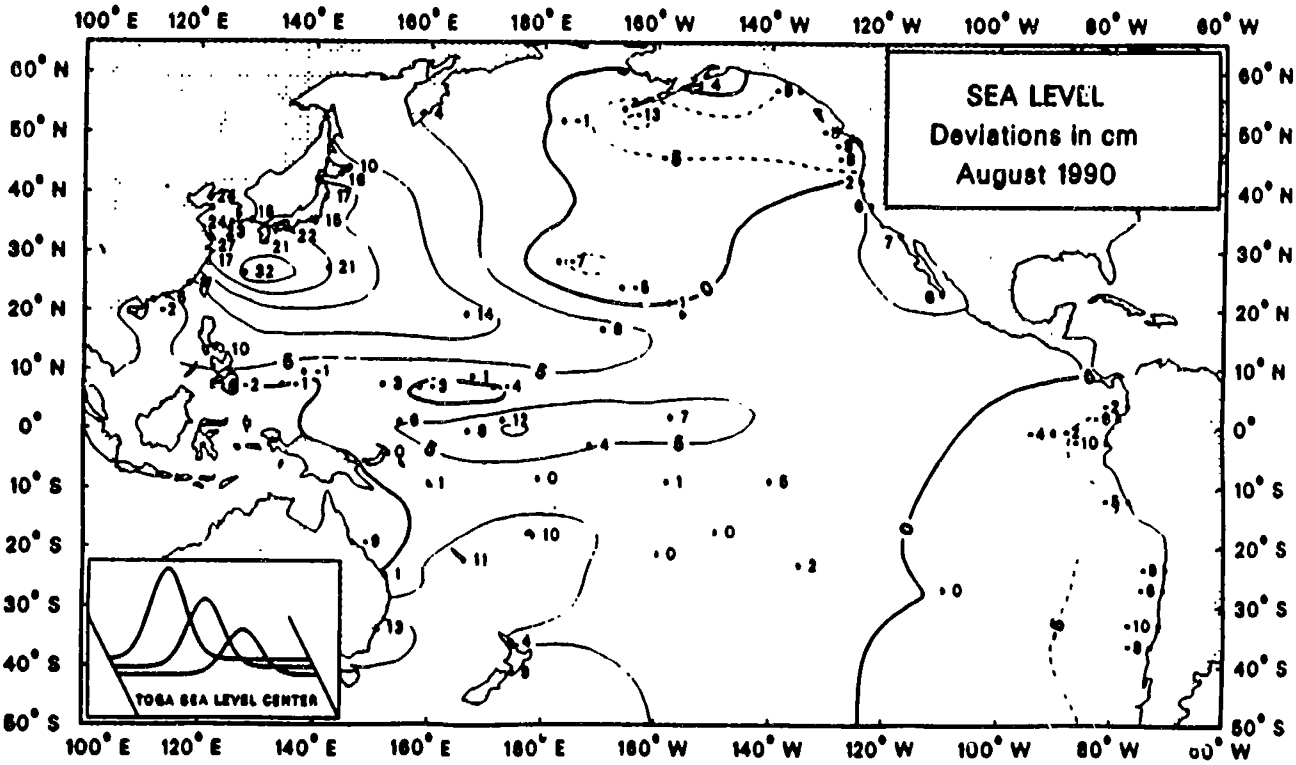
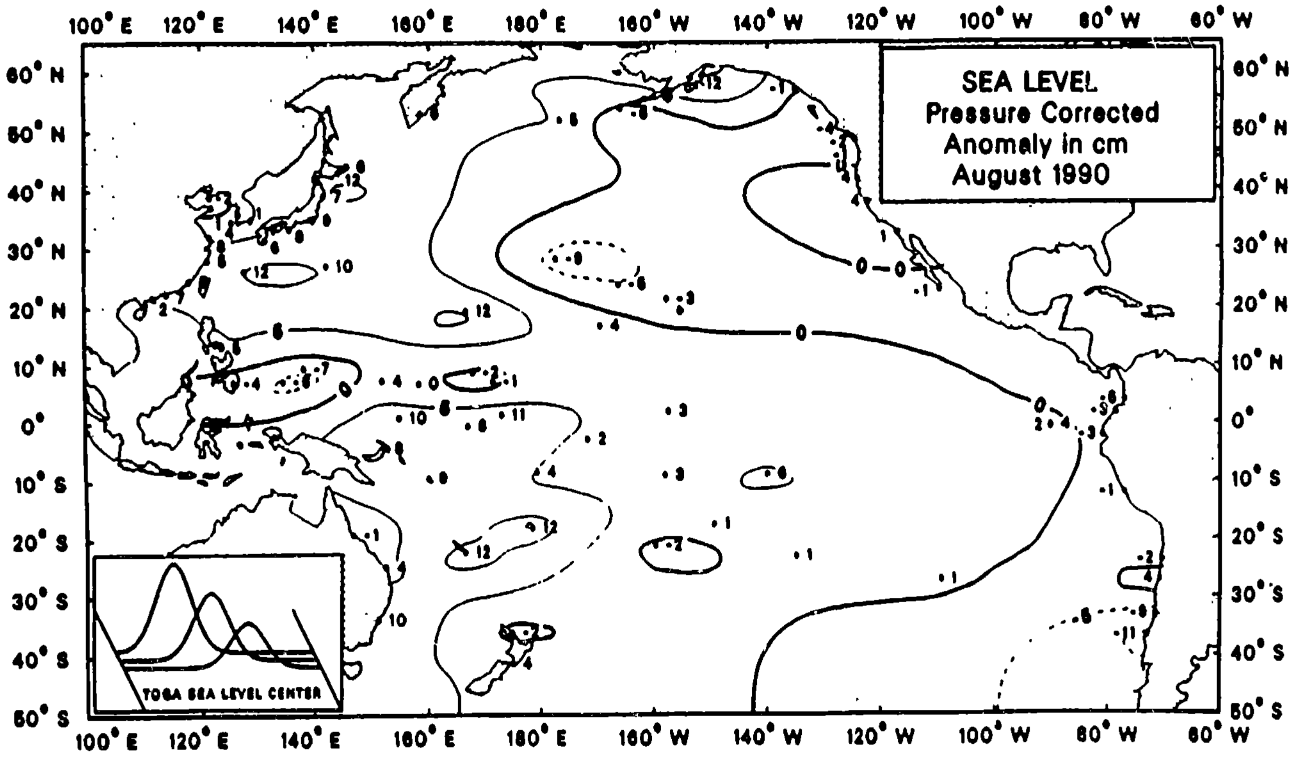


Fig. 21. Flow of GLOSS Sea Level Data

Fig. 22. Example of GLOSS Product from the Pacific



Deviation of sea level from the 1975 to 1986 mean sea level.



Anomaly of sea level from the 1975 to 1986 mean AUGUST sea level adjusted for atmospheric pressure.

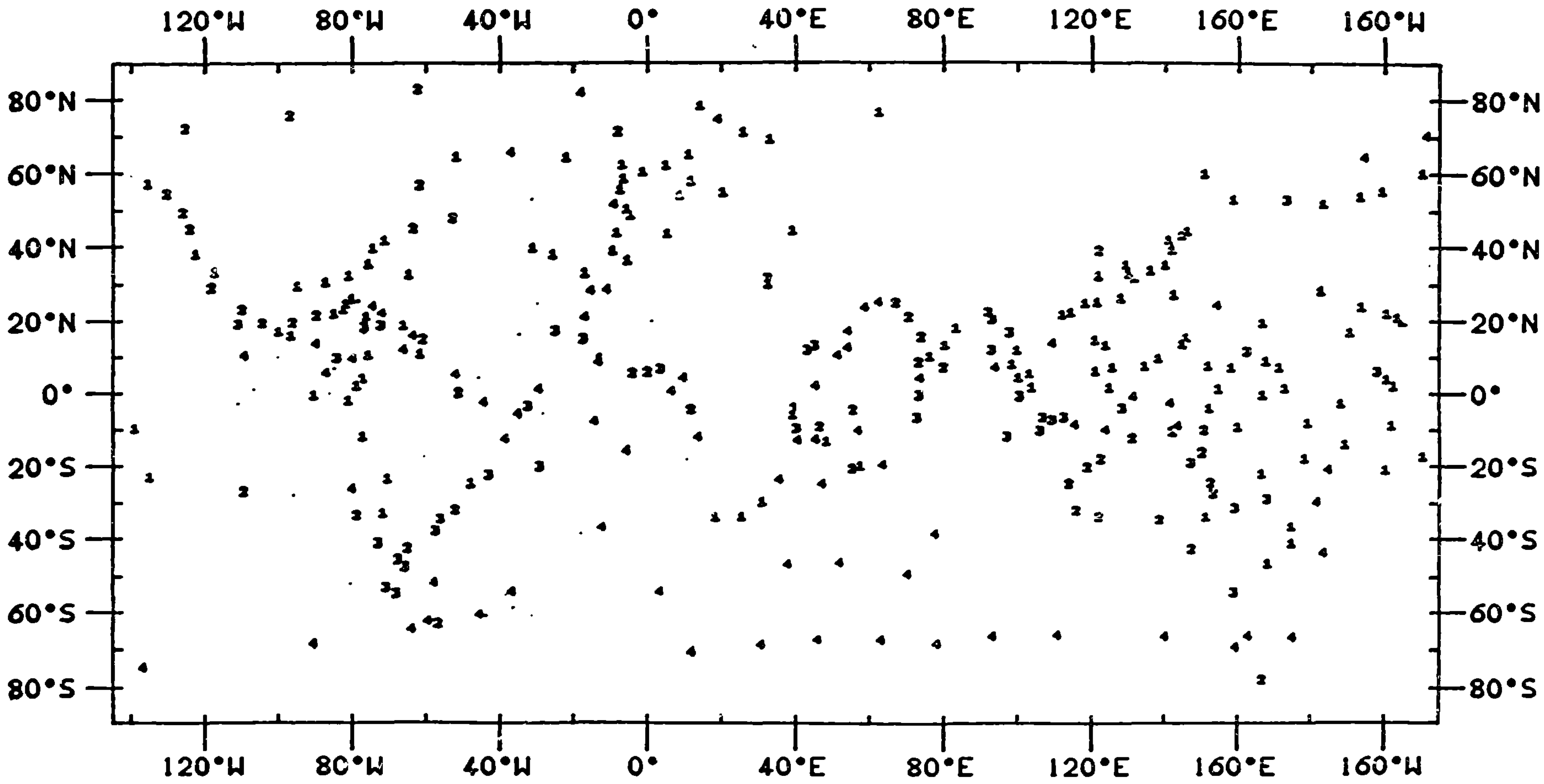


Fig. 23. Map Indicating the Status of GLOSS Stations

DRIBU - Bouees derivantes

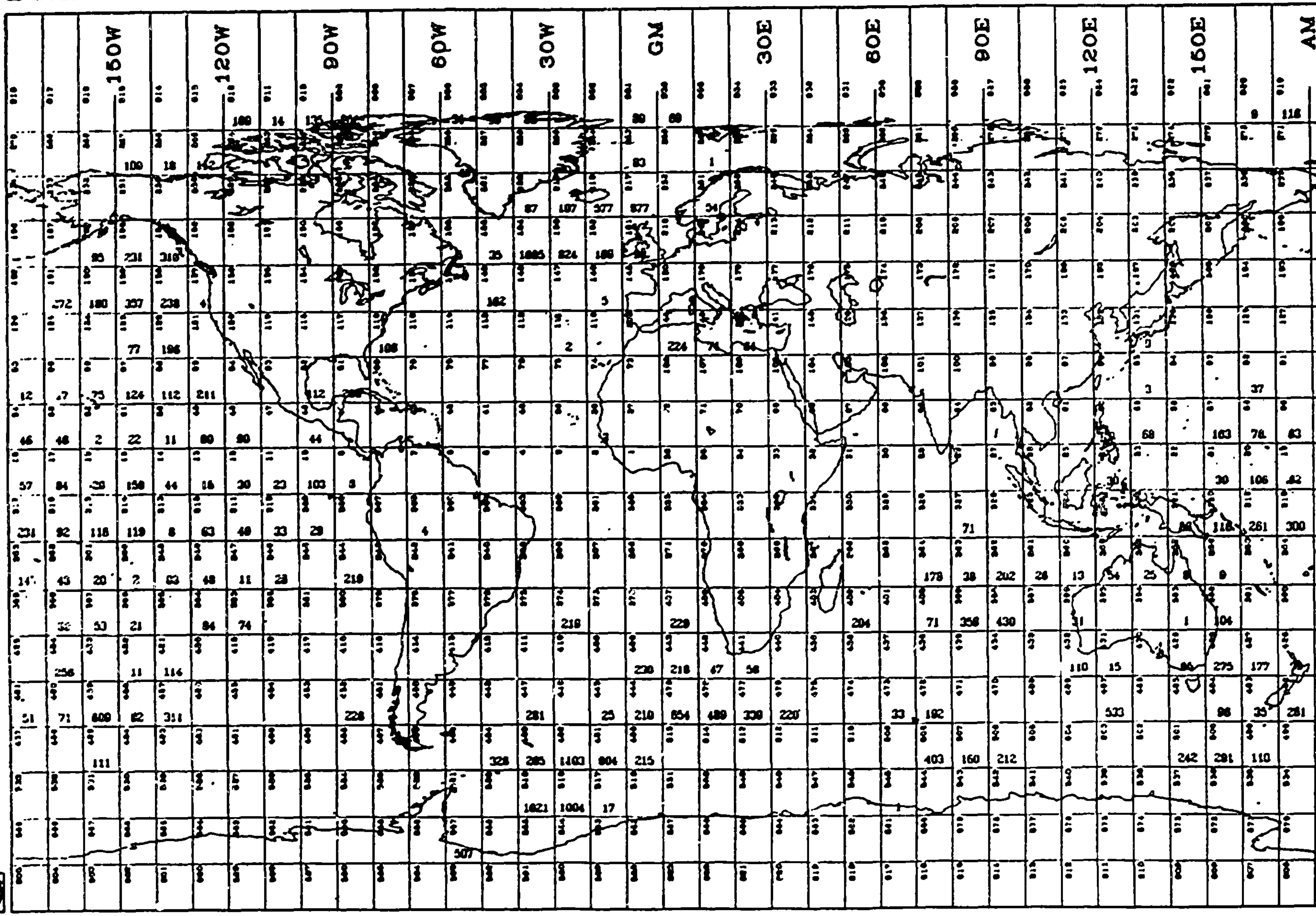


Fig. 24. Drifting Buoy Reports Transmitted via GTS by Marsden Square

METEO FRANCE

SMISO

mois de MAI 1990

r. mbre d'observations : 28216

DRIBU May/Mai 1990

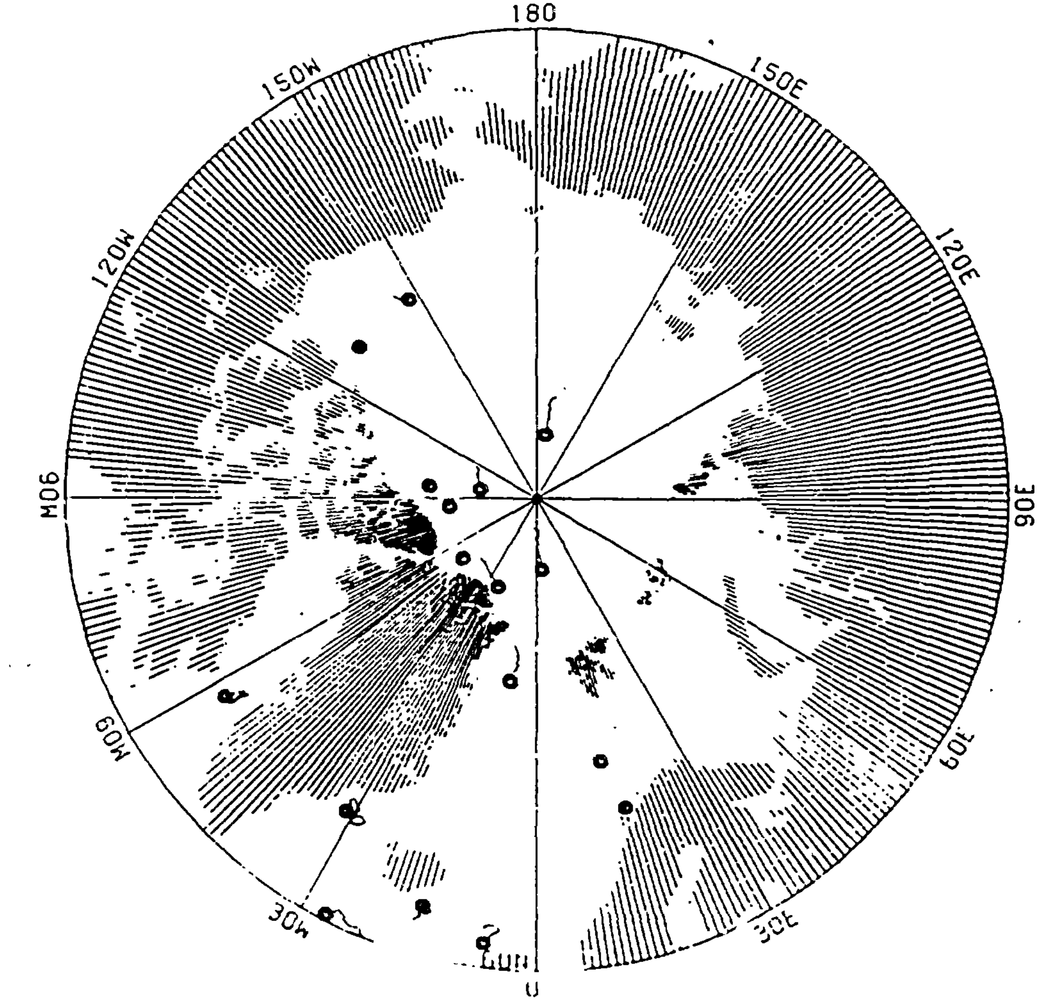


Fig. 25. Drifting Buoy Reports Transmitted via GTS by Region

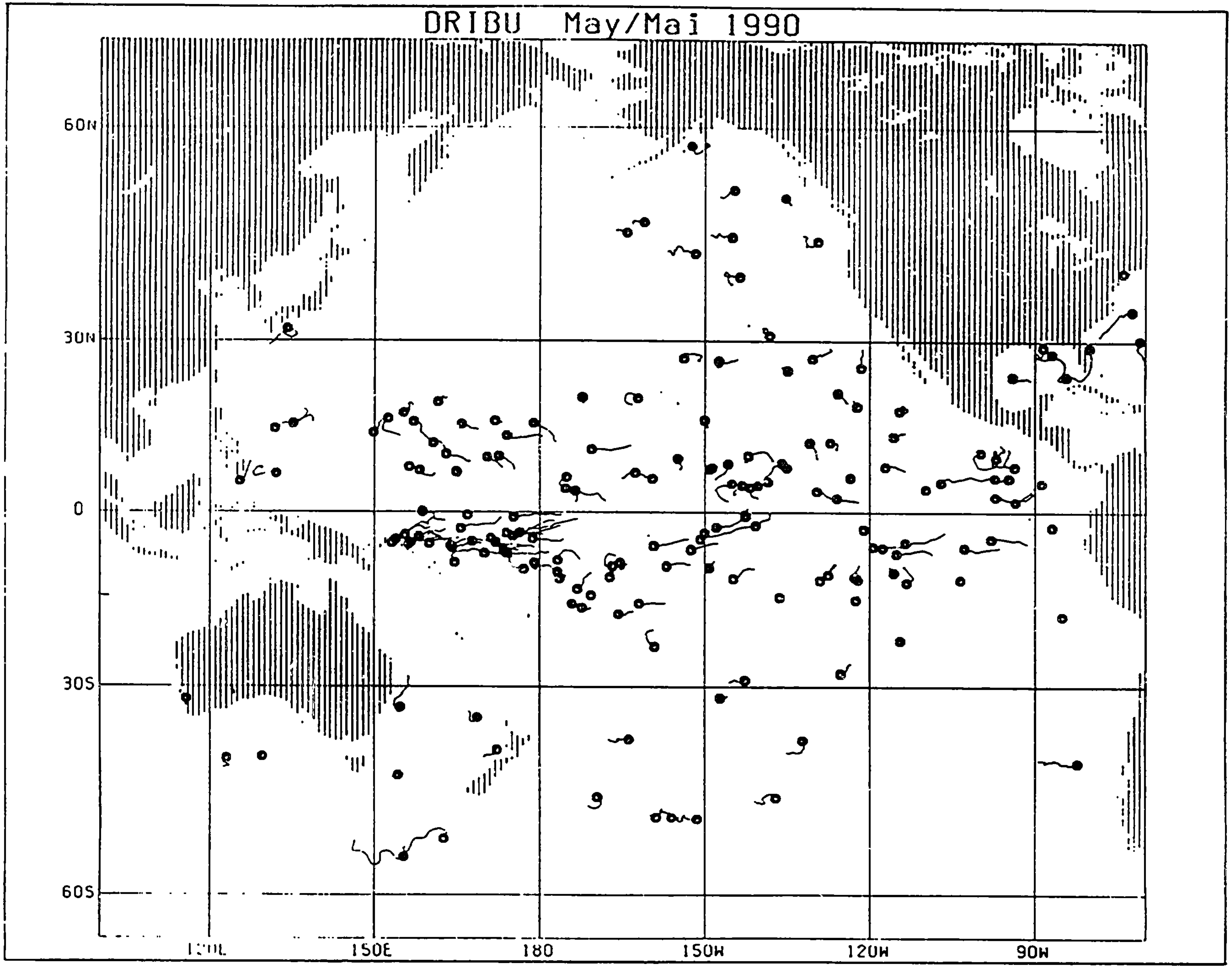


Fig. 26. Drifting Buoy Reports Transmitted via GTS by Region

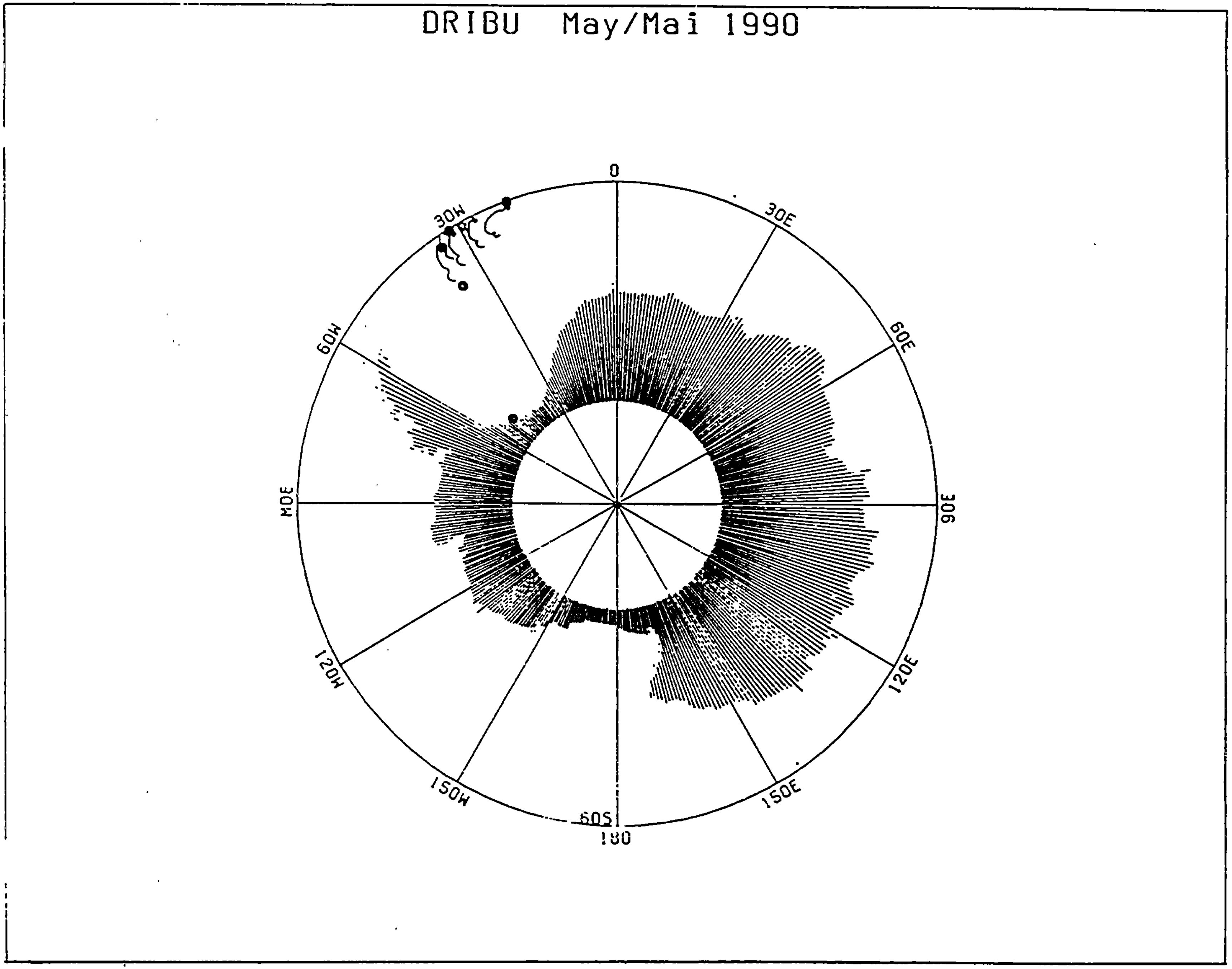


Fig. 27. Drifting Buoy Reports Transmitted via GTS by Region

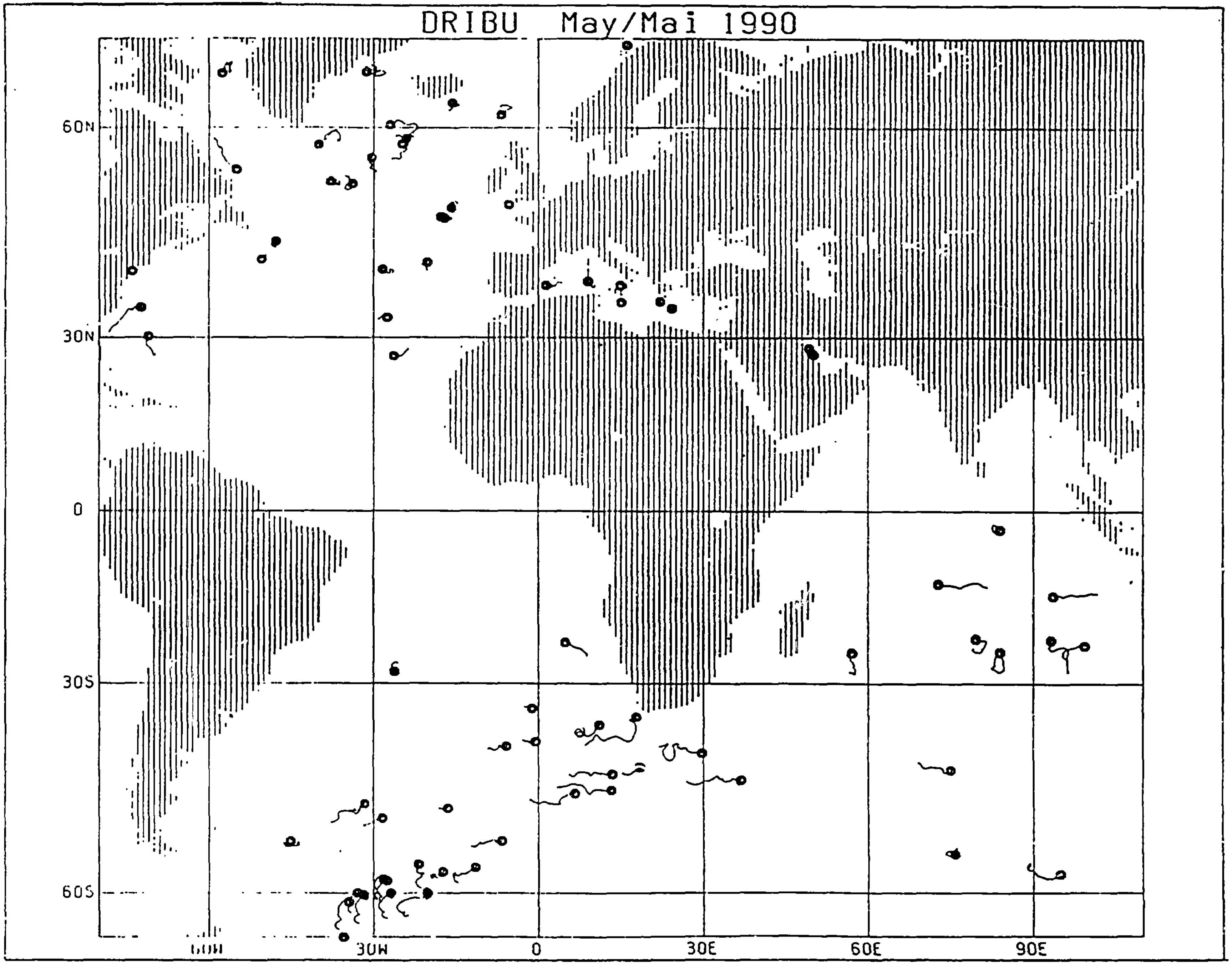


Fig. 28. Drifting Buoy Reports Transmitted via GTS by Region

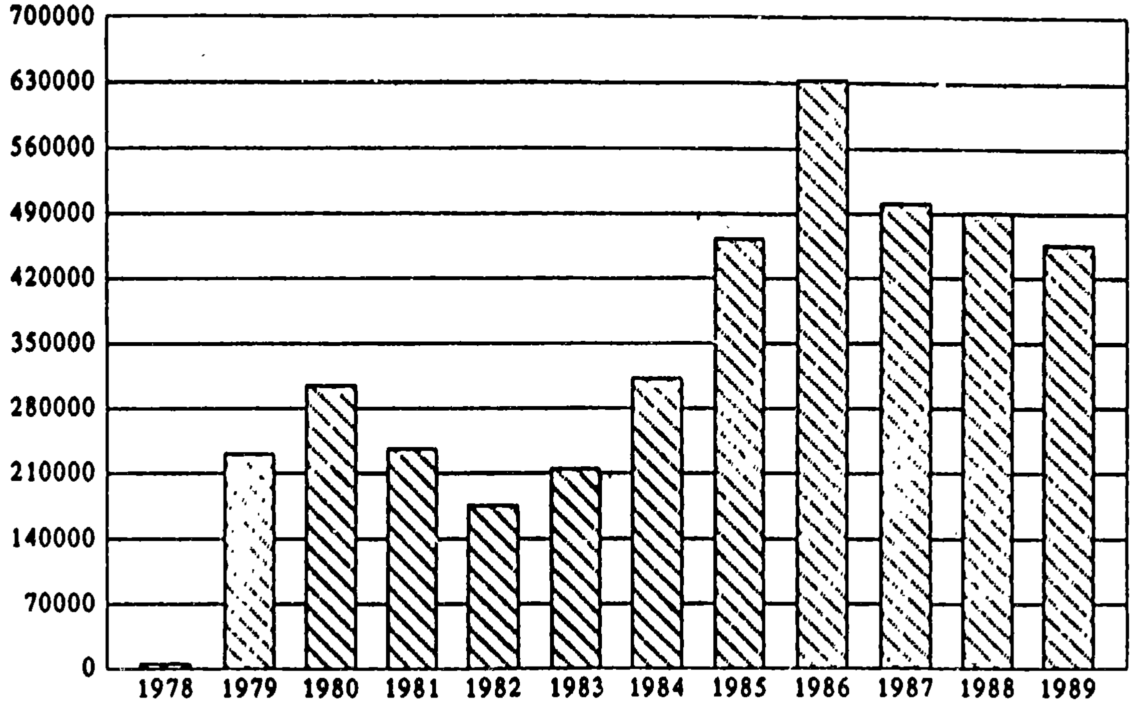


Fig. 29. Drifting Buoy Messages Archived by Year

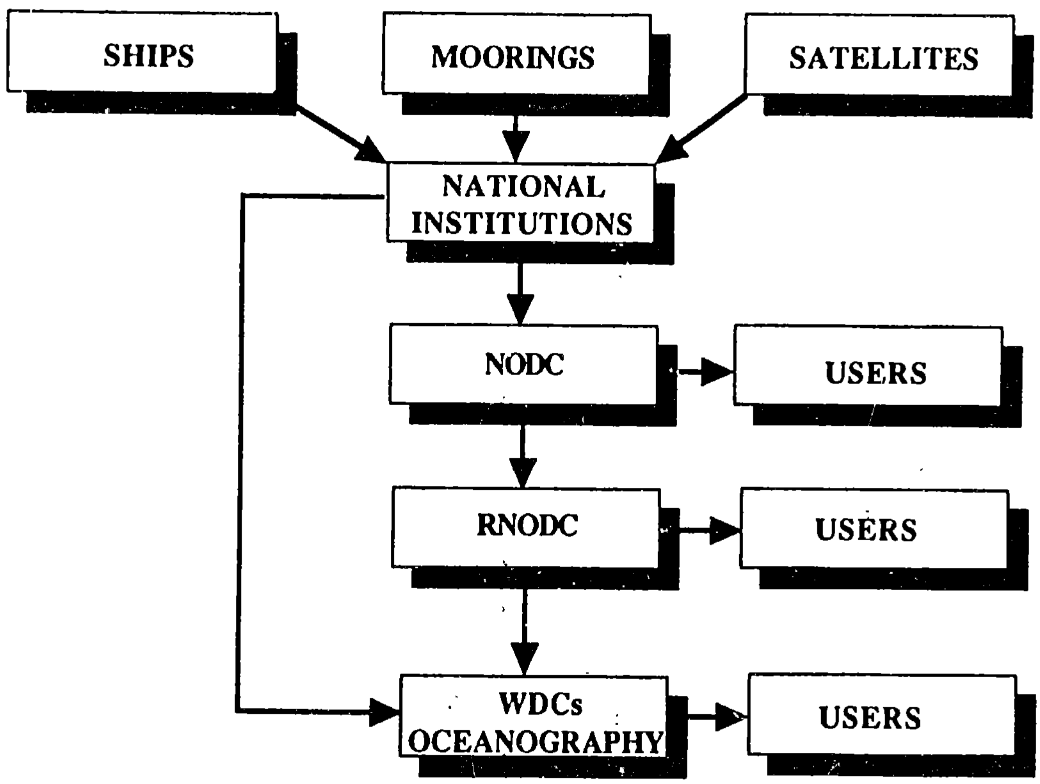


Fig. 30. IODE Data Flow

IOC COMMITTEE ON INTERNATIONAL OCEANOGRAPHIC DATA AND INFORMATION EXCHANGE (IODE)

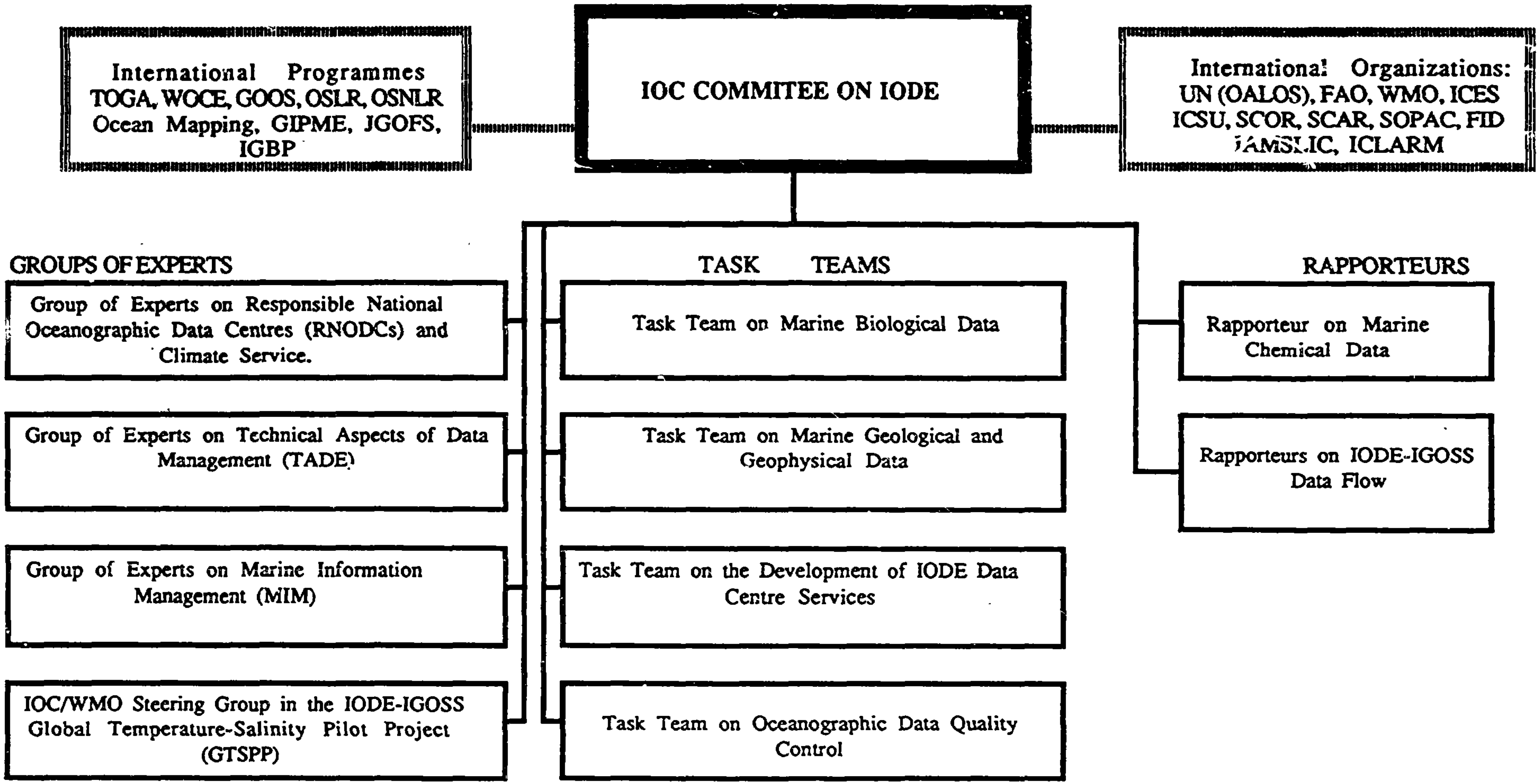


Fig. 31. Structure of IODE

JULY 1982

REAL-TIME (TOP) 80406 NON-REAL-TIME (BOTTOM) 74841

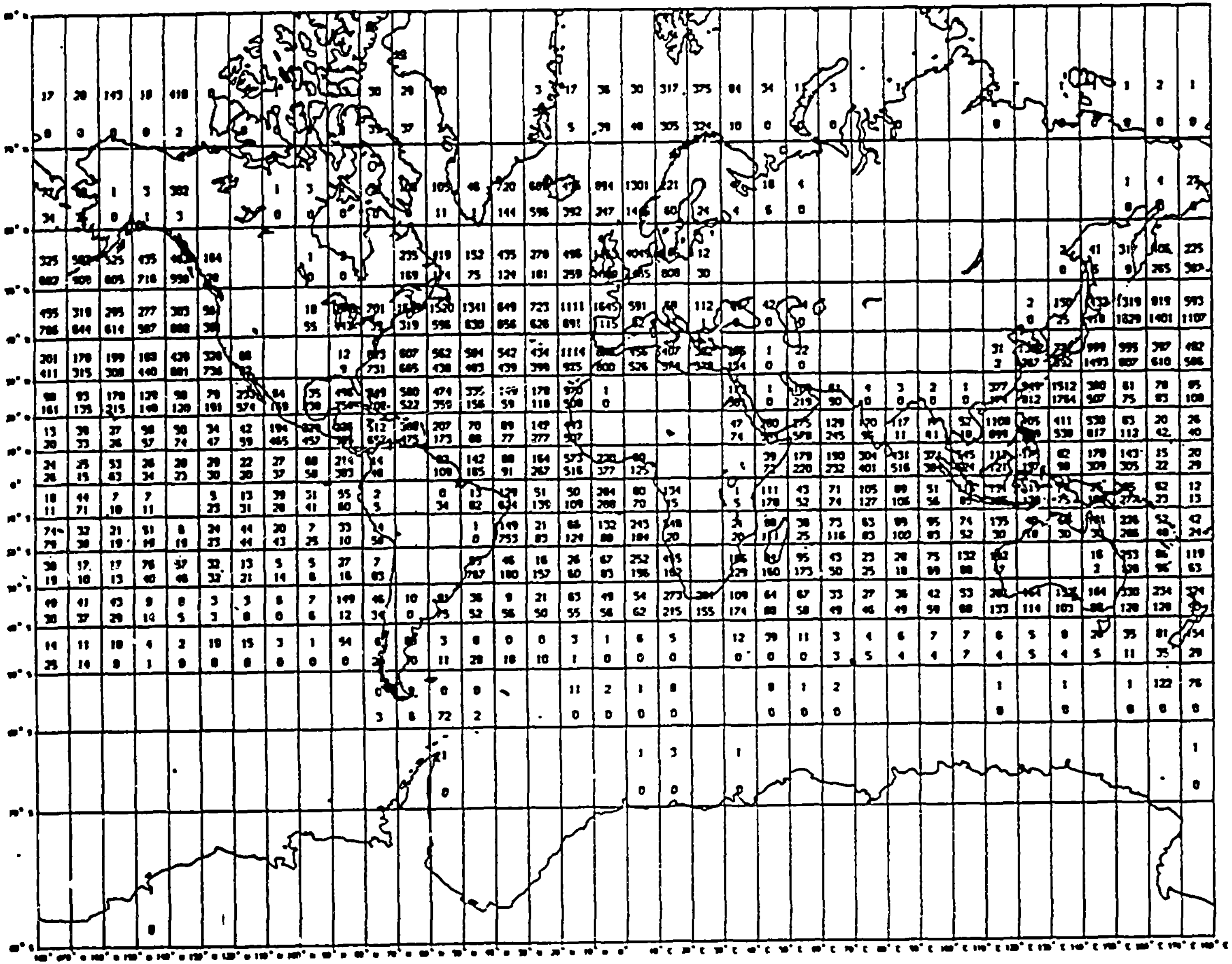
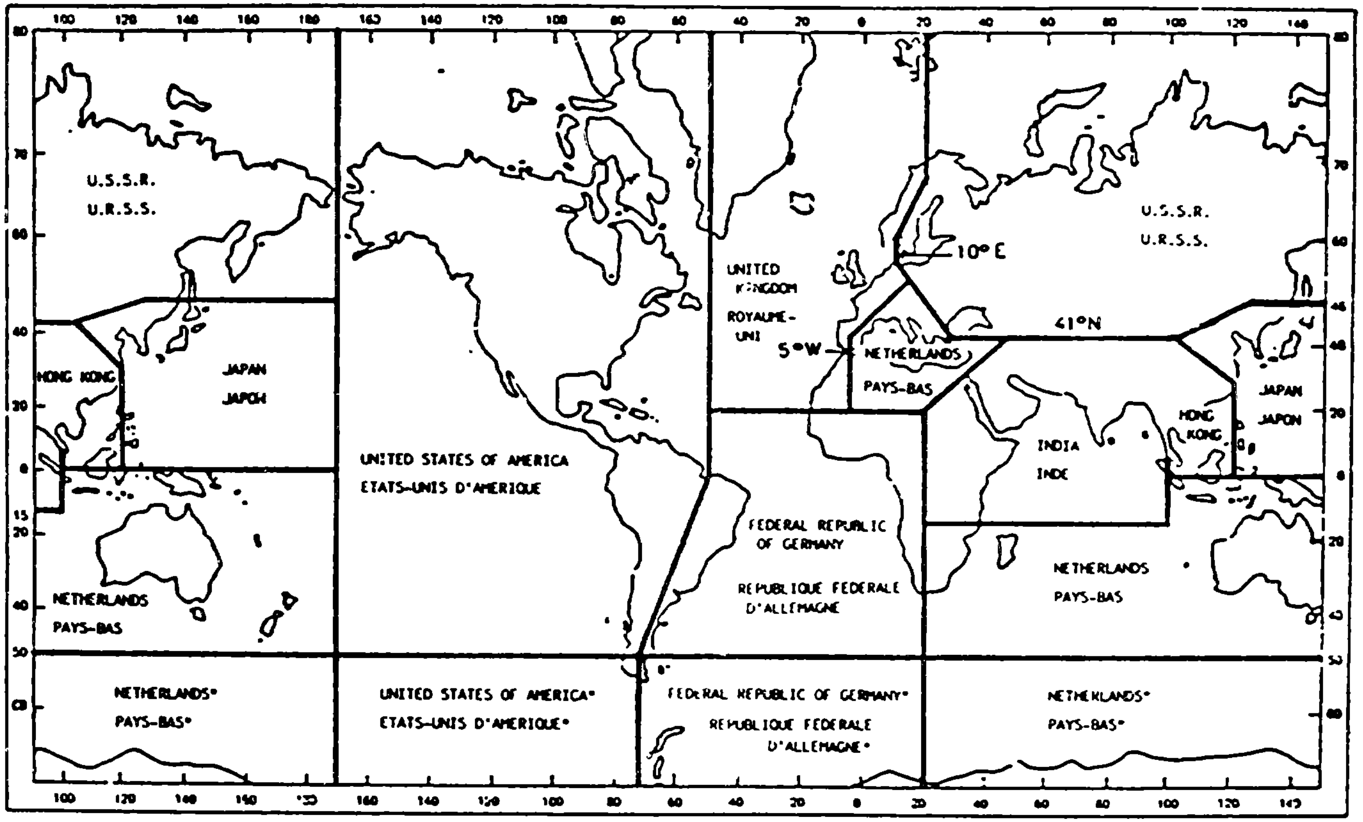


Fig. 32. Number of Observations Transmitted In Real-Time vs. Total Archived

Fig. 33. Responsible Centres for Marine Climatological Summaries

AREAS OF RESPONSIBILITY AND RESPONSIBLE MEMBERS FOR MARINE CLIMATOLOGICAL SUMMARIES



* The U.S.S.R. is responsible for the compilation of a complete data set and the preparation of the summaries for these sea areas.

ANNEX I

LIST OF ACRONYMS

ACMRR	Advisory Committee on Marine Resources Research
ADCP	Acoustic Doppler Current Profiler
ADEOS	Advanced Earth Observing System
ASFIS	Aquatic Sciences and Fisheries Information System
BATHY	Bathymetric (temperature vs. depth profile) (Code Form)
BIOMASS	Biological Investigation Of Marine Antarctic Systems and Stocks
BUFR	Binary Universal Form for Data Representation
CBS	Commission for Basic Systems
CCCO	Committee on Climatic Changes and the Ocean
CCL	Commission for CLimatology
CDROM	Compact Disc Read Only Memory
Cg (WMO)	WMO Congress
CLICOM	CLImate COMputer System
CLIMAT	(Code form for monthly means and totals from a land station)
CMM	Commission for Marine Meteorology
CNES	Centre National d'Etudes Spatiales
COARE	Coupled Ocean-Atmosphere Response Experiment
COST-43	European Co-Operation in the Field of Scientific and Technical Research - Project 43
CPPS	Comision Permanente del Pacifico Sur
CSIRO	Commonwealth Scientific Industrial and Research Organization (Australia)
CTD	Conductivity-Temperature-Depth
DAC	Data Assembly Centre

DBCP	Drifting Buoy Co-operation Panel
DMSP	Defense Meteorological Satellite Programme
DNA	Designated National Agency
DO	Dissolved Oxygen
EC	Executive Council
ECOR	Engineering Committee on Oceanic Resources
EGOS	European Group on Ocean Stations
EOS	Earth Observing System
EPOP	ESA POlar Platform
ERS	Earth Remote-Sensing Satellite
ESA	European Space Agency
EUMETSAT	EUropean METeorological SATellite Organization
FAO	Food and Agriculture Organization of the United Nations
FGGE	First GARP Global Experiment
FID	International Federation for Information and Documentation
FY	Feng-Yuen
GAW	Global Atmosphere Watch
GCNSMS	Global Coastal and Near-Shore Monitoring System
GCOS	Global Climate Observing System
GEMS	Global Environmental Monitoring System
GEOSAT	GEOdetic SATellite
GEWEX	Global Energy and Water Cycle EXperiment
GIPME	Global Investigation of Pollution in the Marine Environment
GLOSS	Global Sea Level Observing System
GMS	Geostationary Meteorological Satellite
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System
GOS	Global Observing System

GF3	General Format 3
GTS	Global Telecommunications System
GTSPP	Global Temperature-Salinity Pilot Project
HF	High Frequency
IAEA	International Atomic Energy Agency
IAMSLIC	International Association of Marine Science LIbraries and Information Centres
IAPSO	International Association for the Physical Sciences of the Ocean
ICES	International Council for the Exploration of the Sea
ICLARM	International Centre for Living Aquatic Resources Management
ICSPRO	Inter-Secretariat Committee on Scientific Programmes Relating to Oceanography
ICSU	International Council of Scientific Unions
ICSEM	International Commission for the Scientific Exploration of the Mediterranean Sea
IERS	International Earth Rotation Service
IGBP	International Geosphere-Biosphere Programme
IGOSS	Integrated Global Ocean Services System
IGY	International Geophysical Year
IHO	International Hydrographic Organization
IMMS	International Maritime Mobile Service
IMO	International Maritime Organization
INFOCLIMA	World Climate Data and Information Referral Service
INFOTERRA	International Environmental Information System
INMARSAT	INternational MARitime SATellite Organization
INSAT	Indian National SATellite System
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Sub-Commission for the CARIBBEan and Adjacent Regions
IOCEA	IOC Regional Committee for the Central Eastern Atlantic

IOCINCWIO	IOC Regional Committee for the Co-operative INvestigation in the North and Central Western Indian Ocean
IOCINDIO	IOC Regional Committee for the Central INDIan Ocean
IOCSOC	IOC Regional Committee for the Southern OCean
IODE	International Oceanographic Data and Information Exchange
IPAST	IGOSS Pilot Project on Altimetric Sea Surface Topography
IPCC	Intergovernmental Panel on Climate Change
ISLP-Pac	IGOSS Sea Level Programme in the Pacific
ISLPP-NTA	IGOSS Sea Level Pilot Project in the North and Tropical Atlantic
ISTPP	IGOSS Sub-Surface Thermal Structure Pilot Project
ITA	IGOSS Telecommunications Arrangements
ITSU	International TSUnami Warning System
JERS	Japan Earth Resources Satellite
JGOFS	Joint Global Ocean Flux Study
JMA	Japan Meteorological Agency
JPOP	Japanese POlar Platform
JSC	Joint Scientific Committee (of the World Climate Research Programme)
KER	Kuroshio Exploitation and Utilization Research
MBT	Mechanical BathyThermograph
MEDALPEX	MEDiterranean ALPine EXperiment
MEDI	Marine Environmental Data Information Referral System
MIM	Marine Information Management
MONEX	MONsoon EXperiment
MOS	Marine Observation Satellite
MPM	Marine Pollution Monitoring
NASA	National Aeronautics and Space Administration (U.S.)
NGWLMS	Next Generation Water Level Measurement System
NOAA	National Oceanic and Atmospheric Administration (U.S.)

NODC	National Oceanographic Data Center
NOP	National Oceanographic Programme
NPOP	NASA POlar Platform
NWP	Numerical Weather Prediction
OALOS	Office of Ocean Affairs and the Law Of the Sea (United Nations)
OOSDP	Ocean Observing System Development Panel
OPC	Ocean Processes and Climate (IOC Committee)
OSLR	Ocean Science and Living Resources
OSNLR	Ocean Science and Non-Living Resources
OTA	Operations and Technical Applications
PSMSL	Permanent Service for Mean Sea Level (U.K.)
RAFOS	Sound Fixing and Ranging Floats
RMS	Root Mean Squared
RNODC	Responsible National Oceanographic Data Center
ROSCOP	Report on Observations/Samples Collected by Oceanographic Programmes
SAR	Synthetic Aperture Radar
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research
SECTIONS	Energetically Active Zones of the Ocean and Climate Variability
SOC	Specialized Oceanographic Centre
SOPAC	SOuth PACific Applied Geoscience Commission
SPOT	Satellite Pour l'Observation de la Terre
SSG	Scientific Steering Group
SSM/I	Special Sensor Microwave/Imager
SST	Sea Surface Temperature
TADE	Technical Aspects of Data Exchange
TESAC	TEmperature, SAlinity, and Conductivity (Code form)
TEMA	Training, Education, and Mutual Assistance in the Marine Sciences

TOGA	Tropical Oceans and Global Atmosphere
TOPEX	Ocean Topography Experiment
TRACKOB	TRACK OBservation (Code form)
UARS	Upper Atmosphere Research Satellite
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
VOS	Voluntary Observing Ship
WCDP	World Climate Data Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WCSMP	World Climate System Monitoring Programme (formerly World Climate Data Programme)
WDC	World Data Centre
WESTPAC	IOC Sub-Commission for the WESTern PACific
WHP	WOCE Hydrographic Programme
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch
XBT	EXpendable BathyThermograph
XCTD	EXpendable Conductivity-Temperature-Depth (Probe)

ANNEX II

REFERENCES

Baker, D. James, 1990. World Ocean Circulation and Climate Change: Research Programmes and a Global Observing System, paper presented at the Second World Climate Conference.

Second World Climate Conference, Final Conference Statement, Scientific/Technical Sessions, 7 November 1990

IOC/INF 811, The Ocean and Climate, March 1990, by Robert W. Stewart

Report of the Fifteenth Session of the Assembly, Intergovernmental Oceanographic Commission, 4-19 July 1989

Report of the Twenty-Third Session of the Executive Council, Intergovernmental Oceanographic Commission, 7-14 March 1990

Intergovernmental Panel on Climate Change, Policymakers Summary of the Scientific Assessment of Climate Change, June 1990

Intergovernmental Panel on Climate Change, Scientific Assessment of Climate Change, June 1990

Intergovernmental Panel on Climate Change, Policymakers Summary of the Potential Impacts of Climate Change, June 1990

Intergovernmental Panel on Climate Change, Policymakers Summary of the Formulation of Response Strategies, June 1990

World Meteorological Organization Forty-First Session of the Executive Council, 5-16 Jun 1989, Abridged Report with Resolutions, WMO-No. 723

TOGA International Implementation Plan, Third Edition, 1 February 1990, ITPO-No. 1

World Ocean Circulation Experiment, Vol.1, Detailed Requirements, WCRP-II, July 1988, WMO/TD No. 242

WOCE Newsletter Number 9, March 1990

IGOSS Plan and Implementation Programme 1989-1995, WMO No. 725

Composition of IGOSS, IOC/INF-812, May 1990

Bulletin Ocean Atlantique Tropical, CNRS, ORSTOM, IFREMER, Vol.1 No. 6, 1990

Joint IOC/WMO Circular Letter IGOSS Sp. 89-59, Subject: Third Status Report on IGOSS Implementation, 31 March 1989

Third WMO Long-Term Plan Part 1 (Draft), Cg-XI/Doc. 10, Appendix D), August 1990

World Weather Watch Programme, EC-XLII/Doc. 6 (22.XII.1989)

World Weather Watch Programme, Cg-XI/Doc. 3 (8.VIII.1990)

The WMO Applications of Meteorology Programme 1988-1997, Second WMO Long-Term Plan Part II Volume 4 (WMO - No. 694)

World Weather Watch Fourteenth Status Report on Implementation 1989 (WMO - No. 714)

WMO Satellite Activities, WMO Executive Council, EC-XLII/Pink 35, 20.VI.1989

The World Meteorological Organization Annual Report 1988 (WMO - No. 713)

The World Meteorological Organization Annual Report 1989 (WMO - No. 734)

World Climate Programme; Climate Change Co-ordination Activities; The Report of the President of CCl, WMO EC-XLII/Doc. 50, ADD. 1 (2.V.90)

Commission for Marine Meteorology, Working Group on Sea Ice, Fifth Session, 1-5 August 1988, Final Report

Commission for Marine Meteorology, Abridged Final Report of the Tenth Session, 8-17 February 1989, WMO (No. 716)

User's Guide to the Data and Summaries of the Historical Sea Surface Temperature Data Project, 1985 (WMO/TD-No. 36)

INFOCLIMA Catalogue of Climate System Data Sets, WMO/TD- No. 293, April 1989

Composition of IGOSS, IOC/INF-812, 18 May 1990

Guide to Operational Procedures for the Collection and Exchange of IGOSS Data, IOC Manuals and Guides No. 3, 1984, Second Revised Edition, Amendment No. 1, 1989.

Global Sea-Level Observing System (GLOSS) Implementation Plan (IOC Technical series no. 35, 1990)

GLOSS Brochure (1990)

Workshop on Sea-Level Measurements in Hostile Conditions (Bidston, UK, 28-31 March 1988)(IOC Workshop Report No. 54. Unesco, 1988)

Manual on Sea Level Measurements and Interpretation (IOC Manuals and Guides No. 14) Unesco 1985

TOGA Notes, Nova University Oceanographic Center, Fall 1990, Number 1

IOC Group of Experts on the Global Sea-Level Observing System (GLOSS) (First session) Proudman Oceanographic Laboratory, Bidston, U.K., 19-23 June 1988 (IOC reports of meetings of Experts and Equivalent Bodies, Unesco, 1989)

IOC/WMO Drifting Buoy Co-operation Panel, Third Annual Report (1989)

Regular Information Service Bulletin on Non-Drifting Ocean Data Acquisition Systems (ODAS). (IOC-WMO/IGOSS-WWW), Thirteenth Issue, August 1990

Quarterly Information Service Bulletin on Drifting Data Buoys, IOC-WMO, First Issue, Second Quarter 1990

Guide to Drifting Data Buoys, IOC Manuals and Guides No. 20, 1988, Unesco

RNODC Drifting Buoy Report, DBCP-VI/Doc. 15, 27 September 1990

Manual on International Oceanographic Data Exchange (IOC Manuals and Guides No. 9, Unesco 1976) presently being up-dated.

IODE Handbook (IOC, 1988 Unesco (presently being up-dated).

How to Prepare a MEDI Entry (The IOC/INF-742 rev. Paris, 11 May 1990).

Cruise Summary Report (Form IOC, 1990) (available in English, French, Russian, Spanish).

IOC Committee on International Oceanographic Data and Information Exchange, Thirteenth Session, New York, USA, 17-24 January 1990 (IOC Reports of Governing and Major Subsidiary Bodies, UNESCO 1990)

General Formatting System for GEO-Referenced Data (IOC Manuals and Guides No. 17).

Vol 2 Technical description of the GF3 Format and Code Tables (1987, Unesco)

Vol 4 User Guide to the GF3-PROC Software (1989, Unesco)

Vol 6 Quick reference sheets for GF3 and GF3-PROC (1989, Unesco)

Guide to Establishing a National Oceanographic Data Centre, (IOC Manuals and Guides No. 5, IOC, 1975)

Guide for Responsible National Oceanographic Data Centres (IOC Manuals and Guides No. 9, Annex II, 1982)

Draft Proposal for a Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Global Climate Change, UNEP-IOC-WMO

Earth Observing System, 1990 Reference Book, Goddard Space Flight Center, NASA

Russin, Eugene M., Thomas M. Mero, and Stephen K. Gill, "NOAA's Water Level Measurement System for the Nineties and Beyond," Proceedings of Marine Instrumentation '90, February 27-March 1, 1990

Spindel, Robert C. and Peter F. Worcester, "Ocean Acoustic Tomography," *Scientific American*, October 1990, pp. 94-99

Woods, John A Global Ocean Observing System, presented to the WMO Commission for Basic Systems, 1 October 1990

U.S. WOCE Implementation Plan 1990, Implementation Plan Number 2, July 1990

Monitoring the Health of Our Oceans, A Proposal for the Future Support and Development of the Continuous Plankton Recorder Survey in the North Atlantic, Fisheries Laboratory, Ministry of Agriculture, Forestry, and Fisheries, U.K., 1989

NATIONAL AGENCIES PARTICIPATING IN OCEAN OBSERVING SYSTEMS

November 1990

CONTACTS	IGOSS	DBCP	GLOSS	IODE
ALGERIA				
Mr. El-Hafid Tabet-Aoul Directeur Technique Laboratoire d'Etudes Maritimes 30, rue Asselah Hocine ALGER	+			
Mr. Moulay-Youcef Cherif Ouazzine Institut National des Sciences de la Mer et de l'Aménagement du Littoral (ISMAL) Jetée Nord - ALGER B.P. 90, Alger 1er Novembre Tel: 62 73 19 / 62 66 59				+
ANGOLA				
Mrs. Maria de Fatima Jardim Director, Centre des Recherches Maritimes Ministere des Pêches LUANDA			+	
ARGENTINA				
Lic. Andres Jorge Lusquinos Servicio de Hidrografia Naval Montes de Oca 2124 1271 BUENOS AIRES			+	
Instituto Antarctico Argentino Dir. Nacional del Antarctico Cerrito 1248 1010 BUENOS AIRES			+	
Mr. A.J. Lusquinos Servicio de Hidrografia Naval Armada Argentina Av. Montes de Oca 2124 1271 BUENOS AIRES	+			
Mr. Carlos Daniel Carbone Navy - Servicio Hydrografia Avda. Montes de Oca 1271 Buenos Aires Tel: (54-1) 21 - 0061/69 Tlx: 21338 RACEL AR Attn. Jeserhidro				+

AUSTRALIA				
Dr. G.M. Homes Secretary, Permanent Committee on Tides and Mean Sea Level (PCTMSL) Canberra Operational Facility Hydrographic Branch P.O. Box E33 QUEEN VICTORIA TERRACE, ACT 2600 Tel: 525085 Tlx: AA 62230 NATMAP FAX: (062) 516806			+	
School of Surveying Attn: SNAP (Dr. Chris Rizos) University of New South Wales P.O. Box 1 KENSINGTON 2033 Tel: 6974182 Tlx: AA 26054 FAX: +6126626616			+	
Prof. G.W. Lennon School of Earth Sciences Flinders University of South Australia BEDFORD PARK SOUTH AUSTRALIA 5042 Tel: (08) 275.2298 or 275.2212 Tlx: 89624 FLINDU AA FAX: (08) 2752676			+	
Capt. J.S. Compton Hydrographer Royal Australian Navy Department of Defence (NAVY) CANBERRA ACT 2600	+			
Mr. W. Selesnew Australian Bureau of Meteorology G.P.O. Box 1289K MELBOURNE, Vic. 3001	+			
Mr. Ben John Searle Head, Science & Oceanography Australian Oceanographic Data Centre P.O. Box 1332 NORTH SYDNEY, NSW 2090 Tel: (02) 925 48 70 FAX: (02) 925 48 35 Tlm: B.SEARLE				+
AUSTRIA				
Prof. Dr. P. Steinhauser Zentralanstalt für Meteorologie und Geodynamik Hohe Warte 38 A-1190 WIEN	+			
BAHAMAS				
Dr. George A. Maul (IOCARIBE) NOAA Atlantic Oceanographic and Meteorological Laboratory 4301 Rickenbacker Causeway MIAMI, FLORIDA 33149, USA			+	

BANGLADESH				
Mr. A. Hena Chief Hydrographer Hydrographic Dept. Biwta Building, Ground Floor 141-143 Motijheel Commercial Area DHAKA-2			+	
BARBADOS				
Dr. Gillian Cambers Coastal Conservation Project The Garrison ST. MICHAEL			+	
BELGIUM				
The Director Institut Royal Météorologique de Belgique 3, avenue Circulaire B-1180 Bruxelles Brabant	+			
BRAZIL				
Directoria de Hidrografia e Navegacao Marinha do Brasil Divisao de Oceanografia, Setor de Mares (DHN-312) Rua Barao de Jaceguay s/no. - CEP 24040 - NITEROI, RIO DE JANEIRO Tel: 719 26 26/170 FAX: (021) 717 0423			+	
Departamento do Geofisica (Same Address as above)	+	+		
Commandant Persio Soares Souto Directeur Diretoria de Hidrografia e Navegaçao (DHN) (Same Address as above)				+
CAMEROON				
Délégation Générale de la Recherche Scientifique et Technique Comité National Permanent de l'Homme et de la Biosphère B.P. 1816 YAOUNDE			+	
Mr. J.B. Nagamini Météorologie Nationale Direction de la Météorologie Nationale 33 rue Ivy B.P. 186 DOUALA	+			

CANADA				
Director-General Marine Sciences and Information Directorate 200 Kent Street (12th Floor, Centennial Towers) OTTAWA, ONTARIO K1A OE6			+	
Mr. G.M. Yeaton Chief, Tides Currents & Water Levels Canadian Hydrographic Service Dept. of Fisheries & Oceans Room 241, 615 Booth Street OTTAWA, ONTARIO K1A OE6			+	
Mr. R.B.L. Stoddart Department of Fisheries and Oceans MEDS, Science 12th Floor, 200 Kent Street OTTAWA, ONTARIO K1A OE6	+			
Dr. A.D.J. O'Neill Regional Director Atlantic Region Atmospheric Environment Service 1496 Bedford Highway BEDFORD, Nova Scotia B4U 1E4		+		
Dr. J. Garrett Head, Ocean Physics Institute of Ocean Sciences Department of Fisheries P.O. Box 6000 SYDNEY, British Columbia V8L 4B2		+		
Dr. John Ronald Wilson Director Marine Environmental Data Service Dept. of Fisheries & Oceans 200 Kent Street OTTAWA, Ontario K1A OE6 Tel: (613) 990 02 64 Tlm: R.WILSON.MEDS				+
Mr. J. Robert Keeley Marine Environmental Data Services Dept. of Fisheries & Oceans 200 Kent street OTTAWA, Ontario K1A OE6 Tel: (613) 990 02 46 Tlm: R.KEELEY				+
CAPE VERDE				
Direccao General da Marinha e Portos B.P. 7 SAN VICENTE			+	

CHILE				
Mr. Carlos Bari Director Instituto Hidrografico de la Armada Casilla 324 VALPARAISO Tel: 251056 Tlx: 230362 HIDRO CL			+	
Capt. F. Espinosa Simonetti Comite Oceanografico Nacional (CONA) Errazuriz 232, Casilla 324 VALPARAISO	+			
Lt. Felix Ricardo Espinoza Head Oceanographic Department National Oceanographic Data Center Casilla 324, Valparaiso Tel: (32) 25 10 56 Tlx: 230362 HIDRO CL FAX: (32) 25 32 83 Tlm: TOGA.CHILE				+
CHINA				
Department of Marine Monitoring and Forecast State Oceanic Administration 1 Fuxingmenwai Avenue BEIJING			+	
National Oceanographic Data Centre 118 Qi Wei Road, Hedong District, TIANJIN P.O. Box 74 TIANJIN			+	
Mr. Yang Huating Senior Engineer China Institute for Marine Development Strategy No.6 Dahuisi, Haidianqu BEIJING 100081	+			
Division of Station and Buoy Department of Marine Monitoring and Forecast State Oceanic Administration 1, Fuxingmenwai Avenue BEIJING		+		
Dr. Hou Wenfeng Director CNODC & WDC-D Oceanography Institute of Marine Scientific & Technological Information State Oceanic Administration (SOA) P.O. Box 74 118 Qiwei Road Hedong District, TIANJIN Tel: 24 41 62 Tlx: 23138 NODC CN				+

COLOMBIA				
Mr. Jorge Ivan Valencia Franco Subdirector de Estudios e Investigaciones Instituto Colombiano de Hidrologia, Meteorologia y Adecuacion de Tierras (HIMAT) Apartado Aereo No. 20032, BOGOTA D.E. Tlx: 44345 HIMAT FAX: 57-2842402			+	
Mr. J.I. Valencia-Franco Instituto Colombiano de Hidrologia, Meteorologia y Adecuacion de Tierras (HIMAT) Apartado Aereo No.20032, BOGOTA	+			
CONGO				
Mr. M.F. Guerdat Directeur Centre ORSTOM POINTE-NOIRE			+	
Centre de Recherches Océanographiques B.P. 1286 POINTE-NOIRE			+	
COSTA RICA				
Instituto Geografico Nacional Apartado 2272, SAN JOSÉ			+	
Ing. Jorge E. Coen Universidad Nacional, Departamento de Fisica Apartado 86, HEREDIA			+	
Mr. J.C. Fallas Sojo Instituto Meteorologico Nacional Apartado 7-3350, SAN JOSÉ	+			
COTE D'IVOIRE				
Centre de Recherches Océanographiques ORSTOM 29, rue des Pêcheurs B.P. V-18 ABIDJAN			+	
Département des Sciences de la Terre Université National B.P. 322 ABIDJAN			+	
CUBA				
Instituto de Oceanologia Ave. 1ra. 18406 Rpto. Flores Municipio Playa CIUDAD DE LA HABANA			+	

CYPRUS				
Mr. A. Demetropoulos Head, Fisheries Department Tagmatarchou Pouliou 5&7 NICOSIA	+			
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA				
Mr. Jong Dek San Korean National Oceanographic Data Centre of Hydrometeorological Service of DPR of Korea P.O. Box 100 PYONGYANG			+	
Mr. Ri Zu O Head Oceanographic Department Hydrometeorological Service of the Democratic People's Republic of Korea (Same Address as above)	+			
DENMARK				
Det Danske Meteorological Institut Lyngbyvej 100 DK - 2100 KOBENHAVN O Tel: 01-292-100 Tlx: 27138 METIN DK FAX: 451271080			+	
The Royal Danish Administration of Navigation and Hydrography Nautical Division Esplanaden 19 DK - 1263 COPENHAGEN K			+	
Dr. O. Bedsted Andersen Geodaestik Institut Geodaestik Afdeling 1 Gamelehave Alle 22 DK - 290 CHARLOTTENLUND			+	
Mr. B. Rasmussen Danish Meteorological Institute (Same Address as above)		+		
DOMINICAN REPUBLIC				
Ing. A. Cocco Quezada Oficina Nacional de Meteorologia Apartado Postal No.1153 Santo Domingo, D.N.	+			
ECUADOR				
The Director Instituto Oceanografico de la Armada Departamento Ciencias del Mar Casilla 5940 GUAYAQUIL	+	+	+	

EGYPT				
The Director Institute of Oceanography and Fisheries Academy of Scientific Research and Technology 101 Kasr El-Ainy Street CAIRO			+	
The Director Suez Canal Research Center Suez Canal Authority ISMAILIA			+	
Mr. G.H.I. Afifi The Meteorological Authority P.O. Box 11784 CAIRO	+			
ETHIOPIA				
Mr. Workineh Degefu Ethiopian National Meteorological Services Agency P.O. Box 1090 ADDIS ABABA	+			
FIJI				
Mr. J. Kotobalavu Secretary of Foreign Affairs Department of Foreign Affairs Prime Minister's Office SUVA			+	
FINLAND				
Mr. H. Grönvall Senior Scientist Finnish Institute of Marine Research P.O. Box 33 SF-00931 HELSINKI	+			
FRANCE				
Direction du Service Hydrographique et Océanographique de la Marine (EPSHOM) Etablissement Principal B.P. 426, 13 rue du Chatellier 29275 BREST CEDEX Tlx: 940568 HYDRO BREST			+	
Dr. Christian Le Provost Directeur de Recherche au C.N.R.S. Institut de Mécanique de Grenoble Domaine Universitaire - B.P. N° 53X 38041 GRENOBLE CEDEX Tel: (33) 76.82.50.00 Tlx: 980668 HYMEGRE F FAX: (33) 76.82.50.01			+	
Dr. M. Fieux Laboratoire d'Océanographie Physique 43, rue Cuvier 75231 PARIS CEDEX 05			+	

FRANCE (continued)				
Territoire des Terres Australes et Antarctiques Françaises (TAAF) 34 rue des Renaudes 75017 PARIS Tel: 47.66.93.43			+	
Le Directeur ORSTOM 213 rue La Fayette 75480 PARIS CEDEX 10			+	
Mr. C. Boucher Institut Géographique National Service de Géodesie, Nivellement et Météorologie 2 avenue Pasteur 94160 SAINT-MANDE Tel: (1) 43.74.12.15			+	
Mr. G. Legoff Chef, Subdivision de prévision marine Service central d'exploitation de la Météorologie 2, avenue Rapp 75340 PARIS CEDEX 07	+	+		
Mr. G. Stanislas National Co-ordinator IODE IFREMER Technopolia 40, 155 rue Jean-Jacques Rousseau 92138 ISSY-LES-MOULINEAUX Tel: (331) 46 48 21 00 Tlx: 631912 F Tlm: G.STANISLAS FAX: (331) 46 48 22 24				+
GERMANY				
Dr. E. Pansch Deutsches Hydrographisches Institüt Section M13, Postfach 301220 D-2000 HAMBURG 36 Tel: (040) 3190 452 or 3190 1 Tlx: 0211 138 BMVHH D FAX: (040) 3190-5150			+	
Dr. G. Giermann Alfred-Wegener-Institute for Polar and Marine Research Postfach 120161, Columbusstrasse D-2850 BREMERHAVEN			+	
Prof. D. Kohnke Deutsches Hydrographisches Institut Bernhard-Nocht-Str. 78, Postfach 30 12 20 D-2000 HAMBURG 36	+			
Prof. Dr. Wolfgang Krauss Institut für Meereskunde de Universität Kiel Düsterbrooker Weg 20 D-2300 KIEL 1		+		

FEDERAL REPUBLIC OF GERMANY (continued)				
Mr. Christoph Brockmann Head, National Oceanographic Data Centre Deutsches Hydrographisces Institut Bernhard-Nocht-Strasse 78 D-2000 Hamburg 36 Tel: (40) 3190 5202 Tlx: 215448 FAX: (40) 3190 5150 Tlm: DOD.HAMBURG				+
GHANA				
Dr. I. Abu Director, Survey Department P.O. Box 191, Cantonments ACCRA			+	
Mr. M. Armah Deputy Director, Fisheries Department (Marine) Headquarters P.O. Box 630 ACCRA	+			
GREECE				
Hellenic Navy Command Hydrographic Service ATHENS TGN 1040		+	+	
Mr. Alexander Maratos Deputy-Director National Center of Marine Research Aghios Cosmas, Hellinikon 16604 ATHENS Tel: 9820214 Tlx: 224135 NCMR GR FAX: 30 9833095	+			+
GUATEMALA				
Ing. Estuardo Velasquez V. Director General Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia 70 Avenida 14-57 Zona 13 GUATEMALA, C.A.			+	
Mr. E.H. Sanchez Benett Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia (INSIVUMEH) (Same Address as above)	+			
GUINEA				
Dr. S. Konate Directeur, Centre de Recherches Scientifiques de Conakry-Rogbané B.P. 561 Rogbané, CONAKRY			+	
GUYANA				
Cde Persaud Chief Surveyor Ministry of Works and Transport Kingston GEORGETOWN	+			

HAITI				
Mr. Emmanuel Brog Secrétaire d'Etat des Finances et des Affairos Economiques Palais des Finances PORT-AU-PRINCE			+	
HONG KONG				
The Director Royal Observatory 134A Nathan Road KOWLOON			+	
ICELAND				
Mr. G. Bergsteinsson Iceland Hydrographic Service Rostholf 7094, 127 REYKJAVIK			+	
Dr. S.A. Malmberg Hafrannoknastofnunin Skulagata 4 REYKJAVIK	+			
Permanent Representative of Iceland with WMO Director, Icelandic Meteorological Office Bustadavegue 9 150 REYKJAVIK		+		
INDIA				
The Director Geodetic and Research Branch Survey of India 17 E.C. Road DEHRA DUN 248001			+	
The Secretary, Department of Ocean Development Attn. Dr. Yash Pal, Secretary, Dept. of Science and Technology Mahasagar Bharan, Block 12 CGO Complex Lodi Road NEW DELHI 110003	+		+	
Mr. J.S. Sarupria Data & Information Division National Institute of Oceanography (NIO) Dona Paula, GOA - 403 004 Tel: 6253-56, 5988 Tlx: 0194-216 NIO IN 0194-316 MGG IN Cbl: OCEANOLOGY				+
INDONESIA				
Indonesian Hydro-Oceanographic Service Center for Oceanographic Research & Development Jalan Pasir Putih 1, Ancol Timur JAKARTA 1442			+	

INDONESIA (continued)				
National Mapping Agency Bakosurtanal, km 46 Jl. Raya Jakarta-Bogor Cibinong BOGOR			+	
Dr. A.G. Ilahude Center for Oceanological Research & Development - LIPI Jalan Pasir Putih 1, Ancol timur P.O. Box 580/JAK JAKARTA 11001	+			
Mr. Bambang Santoso Soedibjo Research & Development Centre for Oceanology Jl. Pasir Putih I, Ancol Timur P.O. Box 580, DAK JAKARTA 11001 Tel: (62 21) 68 38 50 Tlx: 62875 PDII IA FAX: 62 21 68 19 48 Cbl: LONAS				+
IRELAND				
Cmdt. M.C. Walsh Oifigna Suirbhreachta Ordanais Pairc au Fhionnuisce Baile Atha Cliath DUBLIN Tel: 01-213171 or 210121 Tlx: 30126 Tlg: "Ordsur Dublin"			+	
Ocean Services Section EOLAS The Irish Science & Technology Agency Glasnevin DUBLIN 9 Tel: 01-370101 Tlx: 32501 FAX: 379620			+	
Mr. W.G. Callaghan Meteorological Service Department of Tourism and Transport Glasnevin Hill DUBLIN 9		+		
ISRAEL				
Mr. A. Teitelman Head, Department for Marine Meteorology Israel Meteorological Service P.O. Box 25 BET-DAGAN 50250	+			
ITALY				
Dr. C. Lusetti Istituto Idrografico della Marine Passo Observatorio, 4 16 134 GENOVA Tel: 265 451 Tlx: 270435 MARIDRI			+	
Mr. A. Brambati Osservatorio Geofisico Sperimentale (OGS) P.O. Box 2011 34016 TRIESTE	+			

ITALY (continued) Prof. Mario Astraldi Istituto dinamica Grandi Masse Stazione Oceanografica c/o CREA C.P. 316, LA SPEZIA 19100 Tel: 39 187 536 301 Tlx: 27 12 68 FAX: 39 187 536 213				+
JAMAICA The Director Survey Department P.O. Box 493 KINGSTON			+	
JAPAN Dr. Ryozo Tatehira Director, Marine Department Japan Meteorological Agency 3-4 Otemachi-1, Chiyoda-ku TOKYO 100 Iwao Noguchi The Director Ocean Surveys Division Hydrographic Department Maritime Safety Agency 5-3-1 Tsukiji, Chuo-ku TOKYO 104 Tel: (03) 541-3811 Tlx: 0252 2452 HDJODC J Mr. N. Asada Director Marine Department Japan Meteorological Agency 3-4 Otemachi-1, Chiyoda-ku TOKYO 100 Mr. Masao Matsuzaki Head, Oceanographical Division Marine Department Japan Meteorological Agency 1-3-4 Ohte-machi, Chiyoda-ku, TOKYO 100 Mr. Shin Tani Chief International Programmes Group Japan Oceanographic Data Center (JODC) 5-3-1, Tsukiji 5-chome, Chuo-Ku, TOKYO 104 Tel: +81-3-541-3811 - Ext. 732 Tlx: 252 2452 HD JODC J FAX: +81-3-545-2885 Tlm: T.MORI				
KENYA Mr. M.O. Odido Kenya Marine and Fisheries Research Institute Mombasa Laboratory P.O. Box 81651 MOMBASA			+	

KENYA (continued)				
Mr. J.W. Muhoro Kenya Meteorological Department Port Meteorological Office P.O. Box 98512 MOMBASA	+			
Mr. A.J. Mafimbo Port Meteorologist P.O. Box 98512 MOMBASA		+		
MADAGASCAR				
Le Directeur Centre National de Recherches Océanographiques B.P. 68 207 NOSY-BE Tel: 613-73 Cbl: CCEAN NOSYBE			+	
Mr. L.C. Rasolofomanana Service Météorologique National de Madagascar B.P. 1254 ANTANANARIVO (101)	+			
MALAYSIA				
Director of Mapping Direktorat Pemetaan Negara Bangunan Ukur, Jalan Gurney 50578 KUALA LUMPUR			+	
Hydrographic Directorate Department of Navy, Ministry of Defence Jalan Padnag Tembak 50634 KUALA LUMPUR Tel: KL 2921333 or 2353075 Tlx: KEMTAH MA 30289			+	
Dr. Lim Joo Tick Director, Weather Forecasting Malaysian Meteorological Service Jalan Sultan 46667 PETALING JAYA, Selangor	+			
MAURITANIA				
Dr. M. Ba Directeur, Centre National de la Recherche Océanographique des Pêches (C.N.R.O.P.) B.P. 22 NOUADHIBOU Tel: 45124 or 49035 Tlx: 415 CNROP			+	
MAURITIUS				
Meteorological Services Headquarters VACOAS Tel: 861031 Tlx: 4722 METEO IW Cbl: METEO MAURITIUS	+		+	
Mr. A.W. Oodally Meteorological Service VACOAS		+		

MEXICO				
Vice-Admiral Gilberto Lopez Lira Secretaria de Marina Direccion General de Oceanografia Jefatura X11-100 - RAC-342/86 MEXICO, D.F.	+		+	
C. Capitan de Navio I.M.N.F.E. Olivares Acosta Comision Intersecretarial de Investigacion Oceanografica de la Direccion General de Oceanografia Naval Secretaria de Marina MEDELLIN No.10, 5o. piso, Col. Roma C.P. 06700 México, D.F.				
Mr. Victor Flores Permanent Delegation of Mexico to the United Nations 2, UN Plaza, 28th Floor NEW YORK, NY 10017 USA Tel: (212) 752 0220 FAX: (212) 688 8862				+
MONACO				
Centre Scientifique de Monaco 16, boulevard de Suisse MC 98030 MONACO CÉDEX	+			
MOZAMBIQUE				
Mr. Sesaluxo Emilio N. Gaveta Director, the National Service of Navigation Hydrology and Buoyage MAPUTO			+	
Mrs. Lidia Po Director Instituto de Investagacao Pesqueira P.O. Box 4603 MAPUTO			+	
MOROCCO				
Dr. Mohammed Rami Le Directeur Institut Scientifique des Pêches Maritimes 2 rue Tiznit, B.P. 21 CASABLANCA Tel: 222090 Tlx: 23823 M FAX: 266967			+	
NETHERLANDS (The)				
The Chief Director Royal Netherlands Meteorological Institute (KNMI) P.O. Box 201 3730 AE DE BILT	+			

NETHERLANDS (The) (continued)				
Mr. A.T.F. Grooters Royal Netherlands Meteorological Institute Postbus 201 3730 AE DE BILT		+		
Dr. D.M.A. Schaap Director Marine Information Service (MARIS) Koopmansstraat 1, 2288 BC Rijswijk, Z-H Postbus 5807, 2280 HV RIJSWIJK, Z-H Tel: 070-949500 tst. 252/253 Tlx: 33782 RWSNZ FAX: 070-900691 Tlm: MARIS.OFFICE				+
NEW ZEALAND				
The Tidal Officer Royal New Zealand Navy Hydrographic Office P.O. Box 33-341 TAKAPUNA			+	
Mr. J.S. Hickman Director New Zealand Meteorological Service P.O. Box 722 WELLINGTON	+			
Permanent Representative of New Zealand with WMO Director, New Zealand Meteorolgoical Service P.O. Box 722 WELLINGTON		+		
NIGERIA				
The Director Nigerian Institute for Oceanography and Marine Research (NIOMR) Victoria Island P.M.B. 12729 LAGOS			+	
NORWAY				
Norges Sjokartverk Klubbgt 1 Postboks 60 4001 STAVANGER Tel: (04) 53 21 60 Tlx: 73 689 NSKV N FAX: (04) 52 78 72			+	
Norwegian Polar Research Institute P.O. Box 158 1330 OSLO LUFTHAVN			+	

NORWAY (continued)				
Statens Kartverk Geodesidivisjonen Monserudveien 3500 HONEFOSS			+	
Geophysics Institute University of Bergen St. Alle Gaten 70, New Line N-5007 BERGEN Tel: 05-226200			+	
Norsk Oseanografisk Komite Sandakerveien 90 N-0483 OSLO 4			+	
Dr. A. Grammeltvedt Director Norwegian Meteorological Institute P.O. Box 320 - Blindern 0314 OSLO 3	+			
Permanent Representative of Norway with WMO Director, Det Norske Meteorologiske Institutt P.O. Box 320, Blindern N-0314 OSLO 3		+		
Mr. Reidar S. Leinebo Norsk Oseanografisk Datasenter (NOD) Institute of Marine Research Nordnes Parken 2 P.O. Box 1870/72 N-5024 BERGEN Tel: +53 27 169 Tlx: 42297 OCEAN N FAX: 32 13 59 Tlm: NODS.NORWAY Cbl: METEOCEAN				+
OMAN				
Marine Science & Fisheries Centre P.O. Box 467 MUSCAT Tel: 740061/2/3 Tlx: 5503 AGRIFISH ON			+	
Council for Conservation of Environment and Water Resources P.O. Box 5310 RUWI Tel: 704 344 or 704 346 Tlx: 3590 ENVRMNT ON			+	

PAKISTAN				
Dr. G.S. Quraishee Director, National Institute of Oceanography 37-K, Block 6, P.E.C.H.S. KARACHI 29 Tel: 43 43 08 Tlx: 24681 NIO PK Tlg: OCEANOLOGY KARACHI			+	
Mr. A. Hussain Director Forecasting and Climatology Headquarters Office 34 J Block 6 Pechs P.O. Box 8017 KARACHI 29	+			
The Director Centre of Excellence in Marine Biology University of Karachi c/o Pakistan National Commission for Unesco Block VIII Civic Centre G-6 ISLAMABAD		+		
REPUBLIC OF PANAMA				
Dr. Epinenides Diaz Research Biologist Departmento de Evaluacion Pesquara Direccion General de Recursos Marinos Apartado 3318 PANAMA 4			+	
Mr. Joseph A. Brady Acting Chief Meteorological and Hydrographic Branch Panama Canal Commission BALBOA			+	
PAPUA NEW GUINEA				
Department of Transport and Civil Aviation Hydrographic Section Marine Division P.O. Box 457 KONEDOBU			+	
PERU				
Contralmirante Jorge de Alquila Sanchez Director Direccion de Hidrografia y Navegacion de la Marina Camarra 500 Chucuito Casilla Postal 80 CALLAO			+	
Cap. de Corbeta H. Soldi S. Direccion de Hidrografia y Navegacion de la Marina (Same Address as above)	+	+		

PERU (continued) Capitan de Corbeta César del Carmen de la Torre Servicio Nacional de Meteorologia e Hidrologia Avenida Republica de Chile 295 Apartados 1308 4862 LIMA		+		
PHILIPPINES Conrado M. Santos Bureau of Coast and Geodetic Survey P.O. Box 1620 MANILA			+	
POLAND Dr. K. Rozdzynski Institute of Meteorology and Water Management Maritime Branch ul. Waszyngtona 42 81-342 GDANSK	+			
PORTUGAL Mr. Jose Torres Sobral Technical Director Instituto Hidrografico Rua das Trinas 49-P-1296 LISBOA CODEX			+	
QATAR Mr. Issa Hussain Al-Majed Director Department of Meteorology P.O. Box 8658 DOHA	+			
REPUBLIC OF KOREA Office of Hydrographic Affairs 1-17, 7ga, Hangdong Chung-gu INCHON			+	
Mr. Kim Kyun-Hyun Director General Fisheries Research and Development Agency Yeongdo-Gu PUSAN 606	+			
SALVADOR (EL) The Director General Instituto Geografico Nacional "Ingeniero Pablo Arnoldo Guzman" Apartado Postal No. 247 SAN SALVADOR			+	
AMERICAN SAMOA Ministry of Transport Marine and Shipping Division P.O. Box 1607 APIA			+	

SAO TOME AND PRINCIPE				
Secretaria de Estado das Pescas ANA CHAVES			+	
SAUDI ARABIA				
Mr. R.M. Romaih President Meteorology and Environmental Protection Administration (MEPA) P.O. Box 1358 JEDDAH 21431	+			
Mr. Saleh Omar Baazim Director of Observations and System P.O. Box 1358, MEPA JEDDAH		+		
SENEGAL				
Mr. Diafara Toure Coordinateur du Programme Environnement Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT) B.P. 2241 DAKAR Tel: 34 05 34 or 34 05 36			+	
Mr. A.M. Ly Direction de la Météorologie Nationale Ministère de l'Equipement 8257 DAKAR-YOFF	+			
SEYCHELLES				
Ministry of National Development Dept. of Lands, Planning and Survey P.O. Box 199 Independence House PORT VICTORIA			+	
Mr. Patrick Hoareau Rawindsonde Station P.O. Box 181 Victoria MAHE			+	
Mr. F. Bijoux Ag. Senior Meteorological Officer Directorate of Civil Aviation Ministry of Tourism and Transport P.O. Box 181 MAHÉ	+			
SIERRA LEONE				
Institute of Marine Biology and Oceanography Furah Bay College University of Sierra Leone FREETOWN			+	

SINGAPORE				
Mr. Wilson Chua Hydrographer Port of Singapore Authority 7 Keppel Road 02-28 Tanjong Pagar Complex SINGAPORE 0208			+	
SOLOMON ISLANDS				
Mr. F. Bugotu Permanent Secretary Ministry of Foreign Affairs and International Trade P.O. Box G.10 HONIARA			+	
SOMALIA				
Ministry of Fisheries P.O. Box 438 MOGADISHU			+	
Mr. Ahmed Hagi Ali Adani The General Manager Somali Ports Authority P.O. Box 935 MOGADISHU Tlx: 999 611 SSAMOG SM			+	
Mr. A.K. Farah Hersi Marine Research Unit Ministry of Fisheries P.O. Box 438 MOGADISHU	+			
SPAIN				
Mr. Garcia Moron Servicio de Mareas Instituto Espanol de Oceanografia (IEO) Avenida de Brasil, 31 28020 MADRID Tel: 597-44-43 Tlx: 44460 IEOD E			+	
Mr. D.F. Fernandez Diaz Seccion de Datos Oceanograficos Instituto Espanol de Oceanografia Avenida de Brasil, 31 28020 MADRID Tel: 597-44-43 Tlx: 44460 IEOD E			+	
Mr. J. Gomez Gallego Instituto Espanol de Oceanografia C/Alcala, 27-4° 28014 MADRID	+			

SRI LANKA				
Mr. S.R. Amarasinghe Director, Coastal Conservation Coast Conservation Dept. Maligawatta Secretariat COLOMBO 10			+	
Dr. H.V. Dayananda Chief Engineer (Research) Tilak Ekanayake Sri Lanka Ports Authority COLOMBO 1			+	
SWEDEN				
Swedish Meterological and Hydrological Institute Folkborgsvagen 1 S-60176 NORRKOPING Tel: +4611 1580 00 Tlx: 64400 SMHI S FAX: 170207 or 170208			+	
Mr. H. Dahlin Swedish Meteorological and Hydrological Institute (SMHI) 601 76 NORRKÖPING	+			
Mr. Jan Szaron Swedish Meteorological & Hydrological Institute (SMHI) P.O. Box 2212 S-403 14 GÖTEBORG Tel: 46 31 63 03 30 Tlx: 27108 NATFISH S FAX: 46 31 130 44				+
TANZANIA				
Mr. Haji Adam Haji Director, Department of Lands and Surveys P.O. Box 811 ZANZIBAR			+	
THAILAND				
Hydrographic Department Royal Thai Navy BANGKOK 10600			+	
Mr. N. Rananand Director-General Meteorological Department 612 Sukhumvit Rd. BANGKOK 10110	+			

TRINIDAD AND TOBAGO				
Mr. Francis L. Charles Head, Trinidad and Tobago Hydrographic Unit P.O. Box 1104 PORT-OF-SPAIN			+	
Mr. C.E. Berridge Carribean Meteorological Organization P.O. Box 461 PORT-OF-SPAIN	+			
Dr. D. Ramsaroop Institute of Marine Affairs CHAGUARAMAS	+			
TUNISIA				
Mr. B.M. Chedly Institut National de Météorologie BP 22 TUNIS-CARTHAGE	+			
TURKEY				
Harita Genel Komutanligi Geodezi Dairesi Dikimevi ANKARA			+	
Mr. S. Senhan Devlet Meteoroloji Isleri Genel Mudurlugu P.K. 401 ANKARA	+			
UNION OF SOVIET SOCIALIST REPUBLICS				
Mr. B. Khimitch USSR State Committee for Hydrometeorology 12 P. Morozov Street MOSCOW 123376 Tlx: 411117 RUMS SU	+		+	
Dr. V. Smirnov Deputy-Director, All-Union Research Institute of Hydrometeorological Information - World Data Centre 6 Koroleva Street OBNINSK, KALUZHSKAYA OBLAST 249020 Tel: (095) 546 39 10 Tlx: 412633 INFOR SU FAX: 2556684			+	+
Arctic and Antarctic Research Institute 38 Bering Street LENINGRAD 199226 Tel: 352-03-19 Tlx: 121423 NILAS SU FAX: (812) 352.26.88			+	
Dr. P. Agafonov Secretary Oceanographic Committee of the Soviet Union 11 Gorky Street MOSCOW 103009 Tel: 229.25.72 Tlx: 411241 SU Tlg: MOSCOW OCEAN			+	

UNION OF SOVIET SOCIALIST REPUBLICS (continued)				
Dr. E.A. Kulikov USSR State Committee for Hydrometeorology and Control of Natural Environment Marine Department 12 Pavlik Morozov Street 123376 MOSCOW D-376		+		
UNITED ARAB EMIRATES				
Mr. H.E. Mohamed Yahya Al-Suweidi Permanent Representative of the UAE with WMO Assistant Undersecretary for Civil Aviation Ministry of Communications P.O. Box 900 ABU DHABI		+		
UNITED KINGDOM				
Mr. G.A. Alcock Proudman Oceanographic Laboratory Bidston Observatory BIRKENHEAD, MERSEYSIDE L43 7RA Tel: 051 653 86 33 Tlx: 628591 OCEAN G FAX: 051 653 62 69			+	
Dr. David T. Pugh Institute of Oceanographic Sciences Brook Road Wormley, GODALMING, SURREY GU8 5UB Tel: (428) 79 41 41 Tlx: 858833 OCEANS G Tlm: D.PUGH FAX: (428) 79 30 66			+	
Capt. G. MacKie Marine Superintendent Meteorological Office London Road BRACKNELL Berks RG12 2SZ	+			
Mr. P.G. Collar Institute of Oceanographic Sciences Brook Road Wormley, GODALMING, Surrey GU8 5UB		+		
Dr. Meirion Tudor Jones British Oceanographic Data Centre Proudman Oceanographic Laboratory Bidston Observatory BIRKENHEAD Merseyside L43 7RA Tel. +44 (51) 653 8633 Tlx: 628591 OCEANB G FAX: +44 (51) 653 6269 Tlm: BODC.UK				+
Dr. Nicholas C. Flemming Chairman IODE Institute of Oceanographic ciences Deacon Laboratory, WORMLEY, Godalming, Surrey GU8 5UB Tel: 042-879 4141 Tlx: 858833 OCEANS G FAX: 042879-3066 Tlm: N.FLEMMING				+

UNITED STATES OF AMERICA				
Prof. Klaus Wyrtki University of Hawaii at Manoa Department of Oceanography 1000 Pope Road MSB 307 HONOLULU, HAWAII 96822 Tel: (808) 948.76.33 Tlx: 650 2478678 Tlm: K.WYRTKI			+	
Mr. Bruce Douglas Chief, Geodetic R&D Laboratory NOAA/NOS ROCKVILLE, MD 20852 Tel: (301) 320-3145 FAX: (301) 468-5714 Tlm: NOAA.GEOSAT			+	
Mrs. V.K. Tippie Assistant Administrator, National Ocean Service NOAA 1825 Connecticut Avenue N.W., Suite 607 WASHINGTON, DC 20230 Tel: 202/377-4699 Tlx: 7402219 or 7401831 SCOT UC FAX: 202/673-5178	+			
Mr. Glenn D. Hamilton National Data Buoy Center, NOAA NSTL, Mississippi 39529		+		
Mr. Gregory W. Withee Director National Oceanographic Data Centre (NODC) National Oceanic & Atmospheric Administration (NOAA) National Environmental Satellite Data & Information Service 1825 Connecticut Avenue N.W. WASHINGTON, DC 20235 Tel: (202) 673 55 94 Tlx: 7401815 FAX: (202) 673 55 86 Tlm: G.WITHEE				+
URUGUAY				
Mr. Jorge di Lorenzi Servicio de Oceanografia, Hidrografia, Meteorlogia de la Armada Capurro 980 MONTEVIDEO			+	
Mr. C. Martino Departamento de Oceanografia Servicio de Oceanografia, Hidrografia y Meteorologia de la Armada (SOHMA) Capurro 980 MONTEVIDEO	+			
Capitan de Corbeta (C/G) Ricardo Dupont Servicio de Oceanografia, Hidrologia y Meteorologia de la Armada Departamento de Ayuda a la Navegacion Capurro 980, Casilla de Correo 1381, MONTEVIDEO		+		

VENEZUELA				
Instituto Oceanografico de Venezuela Universidad de Oriente Apartado de Correos 245, CUMANA Tlx: 93152 UDONS VE			+	
Capitan Jesus E. Moretti-Russian Direccion de Hidrografia y Navigacion Apartado Postal 6745, CARACAS			+	
Mr. M. Capaldo Mena Observatorio Cagigal La Planicie, 23 de Enero, CARACAS, D.F.	+			
VIET NAM				
Mr. Dang Ngoc Thann Centre National de Recherches Scientifiques du Viet Nam, HO CHI MINH CITY			+	
Hydrometeorological Service No. 4 Dang Thai Than St., HANOI			+	
Département Général de la Météorologie Tong cue Khi tuong Thuy van HANOI			+	
YUGOSLAVIA				
Institute of Oceanography and Fisheries P.O. Box 114 58001 SPLIT	+			
Mr. Vlado Dadic Institute of Oceanography & Fisheries Setaliste Mose Pijade 63 58000 - SPLIT Tel: (58) 46 688 FAX: (58) 46 593				+
Dr. S. Lakos Pomorski Meteoroloski Centar Prilaz VIII korpusa 11 P.O. Box 44 58001 SPLIT	+			
ZAIRE				
Mr. Mbwangi-Mpanzu Chef de la Liaison Maritime Direction de la Météorologie Département des Transports et de la Météorologie B.P. 4715 KINSHASA	+			