Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

International Meeting of Scientific and Technical Experts on Climate Change and Oceans

Malta, 19-21 July 1991

UNESCO

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In this Series, entitled

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fo' 'h Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
3. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of «El Niño» *(Also printed in Spanish)*
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping *(Also printed in French and Spanish)*
12. Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica *(Spanish only)*
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources *(Also printed in French and Spanish)*
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans *(Also printed in French)*
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities *(Also printed in Spanish)*
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
36. First Consultative Meeting on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of « El Niño » *(Also printed in Spanish)*
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN (OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic *(Also printed in French)*
54. Third session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico *(Also printed in Spanish)*
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
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59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications
60. Second Session of the IOC Group of Experts on the Global Sea-level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercalibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
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1. OPENING

1.1 WELCOMING

1 The International Meeting of Scientific and Technical Experts on Climate Change and Oceans was opened by Prof S. Busuttil, Director-General of the Foundation for International Studies at 10:00, 19 July 1991. He characterized the meeting as serving to identify what actions in relation to the oceans, should be undertaken by States as part of the process of mitigating the adverse effects of climate change.

2 Prof Busuttil referred to the background documentation proposed for the meeting which identified several needs which require attention. He expressed the wish that the meeting evaluate these and possibly others on a purely scientific basis. The meeting's deliberations should result in a meeting statement which would be useful in elucidating the role of the ocean in climate change and promoting necessary elements through the work of the Intergovernmental Negotiating Committee (INC) on a Framework Convention on Climate Change.

1.2 STATEMENT FROM THE SECRETARY, INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

3 Dr Gunnar Kullenberg recalled that the importance of the ocean in climate change was recognized by the WMO-UNEP Intergovernmental Panel on Climate Change and at the Second World Climate Conference, Geneva, 28 Oct - 9 Nov 1990. He noted that the role of the oceans in climate change was more than the impact on sea level change. The oceans store and transport large amounts of heat as well as serve as a reservoir and a sink of greenhouse gases. He stressed that a holistic approach involving the interaction of the atmosphere, land surface/including vegetation, the cryosphere and the oceans was needed to address questions such as what we know and what we don't know about the earth climate system and its prediction. Continued close collaboration between WMO, UNEP and IOC would be needed in the future to address these questions.

1.3 STATEMENT BY DEPUTY PRIME MINISTER AND MINISTER OF FOREIGN AFFAIRS AND JUSTICE

4 H. E. Prof G. De Marco addressed the meeting. He supported efforts to ensure that the future International Convention on Climate Change recognizes the obligation of States to protect and preserve the global climate. He referred to Malta's initiative at the United Nations (UN) concerning climate as the common heritage of mankind. He noted that the UN General Assembly had unanimously characterized climate change as the common concern of mankind. Mechanisms should be contained in the convention which would allow states to cooperate on a global basis and, as appropriate, on a regional basis, in developing effective response strategies to climate change. The tackling of the problems of climate change should bear in mind the total Global Climate System which includes atmosphere, land, cryosphere and the oceans. An effective international strategy to protect the climate, must consider adequately the major role which the oceans play in the global climate system and its expected impact which includes a serious impact on the oceans' living-resources and their growth cycles. The allowable catches of species which are an important source of livelihood to millions of persons - will have to be reexamined in the light of the forecasted effects of climate change.

5 A number of important and valuable research programmes which consider the issue of the role of the oceans in the global climate system include the Tropical Ocean and Global Atmosphere (TOGA) programme, the World Ocean Circulation Experiment (WOCE), and the Joint Global Ocean Flux Studies (JGOFS). The future Convention should contain provisions that encourage such research and provide for adequate participation of developing States, which very often lack the necessary resources. Channels for assistance have to be devised which will ensure that in the consideration and examination of these global issues there is universal participation.

6 It was in this respect, that the meeting was described as being of paramount importance. It was hoped that as a result of this meeting a concise, but comprehensive, authoritative review of the current State of knowledge on the role of oceans in relation to climate change and variability would be produced.

1.4 CO-CHAIRMEN AND RAPPORTEUR

7 Prof S. Busuttil and Dr G. Kullenberg were appointed Co-Chairmen of the meeting. Mr R. Godin, Secretary of the joint SCOR-IOC Committee on Climatic Changes and the Ocean was designated as the rapporteur for the Plenary session.

1.5 ADOPTION OF THE AGENDA

8 Prof S. Busuttil reviewed the results of a preparatory meeting held in Malta, 8-10 June 91 which identified the aims of this meeting as the preparation of an authoritative scientific review or guide on the role of the ocean in climate change and variability including what is known, what is not known, and what needs to be addressed. Issues should also be identified which relate to the impact of climate change. The meeting's results will be presented to the Government of Malta which may wish to present it to the Third Session of the Intergovernmental Negotiation Committee, Nairobi, 9-20 September 91.

9 Dr G. Kullenberg reviewed the documentation for the meeting which included a working paper entitled *THE OCEANS AND CLIMATE* which was prepared by the IOC in co-operation with WMO and UNEP and included brief notes provided by the UN/OALOS and FAO. Dr Kullenberg also reported on his recent consultations with the Chairman of the Intergovernmental Panel on Climate Change (IPCC), Dr B. Bolin.

10 Prof Busuttil and Dr Kullenberg addressed questions by some participants regarding the capacity of their representation at the meeting. It was noted that all participants were invited to participate at this meeting in their personal capacity as scientific and technical experts or in the case of Secretariat participants in their capacity as experts of their respective organizations. One participant wished to be identified as an observer.

11 It was noted that the IPCC is focussing on terrestrial aspects of climate change and is not addressing the effects of climate change on marine living resources. The IPCC could also benefit from greater knowledge about the ocean and a more holistic addressal of sea level change, e.g., is the island sinking or will sea level rise from a change in ocean currents, thermal expansion, or lower salinity.

12 The draft agenda was adopted as Annex I. Participants are listed in Annex II.

2. STRATEGY ON ADVANCING THE RECOMMENDATIONS OF THE MEETING

13 Prof D. Attard, Head of the Malta Delegation to the Intergovernmental Negotiating Committee (INC) on a Framework Convention on Climate Change introduced a strategy on advancing the recommendations of the meeting which was described as follows:

Motivate the political process of the Intergovernmental Negotiating Committee on a Framework Convention on Climate Change:

(i) by stating that the problems of climate change are interrelated and should be treated by the INC as a whole,

(ii) by articulating why it is important to conduct ocean climate research, through the development of an authoritative concise scientific statement of consensus which identifies where the uncertainties lie, the knowledge that we currently have and what we need to obtain in order to reduce the uncertainties of climate predictions in a way that governments can see the need and the importance of conducting research and systematic observations, e.g. harbour development, frequency and intensity of tropical and extratropical cyclones, and accelerated coastal erosion, inundation and contamination of aquifers,

(iii) to recognize the need to support ocean and climate change research and systematic observations as an urgent priority, and

(iv) to advance the precautionary principle to include mechanisms to increase intergovernmental support for ocean and climate research and systematic observations where developing countries will participate on a universal basis. Their participation may be facilitated through support and partnership provided through multilateral agreements from the developed world so as to enable full participation of the developing states.

14 The INC would decide how and where to use the statement. The meeting would also propose to the Government of Malta a draft article on the role of the ocean for possible inclusion in the proposed Framework Convention on Climate Change.

3. THE OCEANS AND CLIMATE: MAJOR SUBJECT AREAS

15 Two working groups were established to develop a statement regarding the oceans and climate which would serve the strategy identified in section 2 above. The results of their deliberations, including identified needs are attached as Annex III. The meeting agreed on the following draft article on the role of the oceans for inclusion in the proposed Framework Convention on Climate Change:

ROLE OF THE OCEANS IN CLIMATE CHANGE

States shall co-operate, directly or through competent international organizations (such as the IOC and WMO), for the purpose of promoting

studies, undertaking programmes of scientific research and systematic observations and encouraging the exchange of information and data required with respect to the role of the oceans in climate change. States shall also endeavour to participate actively in regional and global programmes designed to acquire such knowledge.

4. CLOSURE

16 The meeting conveyed to the Government of Malta its gratitude for the invitation and hosting of the meeting by sending a cable to Prof G. De Marco, the Deputy Prime Minister and Minister for Foreign Affairs and Justice. The cable expressed the participants' honour and pleasure at having received an invitation and the opportunity to formulate a concise scientific guide on the role of the oceans in climate moderation, climate change and variability. The meeting was adjourned at 13:00 on 21 July 1991.

ANNEX I

AGENDA

Friday, 19 July

1. Election of Co-Chairpersons and Rapporteur for the Plenary Session

2. Discussion in Plenary of:

   Subject Area I
   Oceans as a Source and Sink of Greenhouse Gases

   Subject Area II
   Sea-level Rise and Climate Change

   Subject Area III
   Impacts of Climate Change on Marine Living and Non-Living Resources

   Subject Area IV
   Climate Change and Variability

Saturday, 20 July

1. Division into two sub-groups, for subject areas I & IV and II & III

2. Appointment of a Chairman and Rapporteur for each sub-group

3. Drafting a report for each subject area in each sub-group

4. Plenary Session:

   (a) Presentation of the results of the sub-groups
   (b) Discussion

Sunday, 21 July

1. Work in sub-groups

2. Plenary: Drafting a recommendation to be submitted to the INC

ANNEX II

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ANNEX III

THE OCEANS AND CLIMATE

The problems of climate change are closely interrelated and need to be considered as a whole, if the current efforts by the INC are to succeed effectively. This approach should be reflected in the proposed Framework Convention on Climate Change. The oceans play a key role in determining the earth's climate. Any possibility of predicting the evolution of climate beyond a few weeks demands that ocean behavior be taken into account. There is great promise that it may become possible to describe and predict many aspects of upper ocean behavior with enough accuracy to improve long range weather, sea-surface layer conditions, storm surges and fisheries forecasts usefully. This promise can only be realized if appropriate data are collected regularly and disseminated promptly, and relevant studies are undertaken to ensure early realization of the applications which are of benefit to nations.

There is every reason to believe that the ocean is now changing in response to climate changes over the past few hundred years (the Little Ice Age). It can be expected to change further as anthropogenic influences become increasingly marked.

To determine how the ocean is changing now we must have systematic and repeated measurements at all depths throughout the ocean. To predict its future evolution will require models supported by a regular influx of new data.

New structures both internationally and in many countries nationally will have to be established to meet the needs. Climate change will have an impact on oceanic processes which have implications e.g. for fisheries, coastal zone developments, human settlements and fresh water resources.

There is a requirement therefore to meet the following:

i. the need to follow-up the acknowledgement by the Second World Climate Conference (SWCC) of the role of the oceans in the climate system by commitment to implementation of on-going global-regional research programmes (e.g., the Tropical Ocean and Global Atmosphere [TOGA] programme, the World Ocean Circulation Experiment [WOCE], and the Joint Global Ocean Flux Study [JGOFS]) and related research to reduce uncertainties in predictions; the related data and process studies are definitely needed for improving the models. Specific scientific activities relating to the oceans which should be enhanced due to the implications for many nations and regions of the related phenomena include:

   - El Niño and its influence on world-wide weather anomalies,
   - Relationship of sea surface temperatures in the Atlantic and rainfall in the Sahel, and
   - Changes in air-sea interaction and sea surface temperatures which could affect frequency, intensity and distribution of tropical and extratropical cyclones in the event of global warming.

ii. the need to ensure timely exchange of data and related products on the international level, of material obtained both through research and routine observation programmes;

iii. the need for a gradual establishment of an adequate Global Ocean Observing System, as part of a Global Climate Observing System, including the appropriate mechanism for data and products exchange;

iv. the need for transfer of appropriate technology to help ensure building of capacity, including infrastructure, financial and human resources, to help ensure adequate involvement and participation in global-regional programmes and observing system(s), and ability to independently interpret and use related data and products, including those obtained from exchange;

v. the need to ensure adequate consideration of ocean processes and resources in socio-economic national planning and development.

The major subject areas of the ocean and climate change are (1) Role of the Oceans as a Source and a Sink for Greenhouse Gases, (2) Sea-Level Rise and Climate Change, (3) Impacts of Climate Change on Marine Living and Non-Living Resources and (4) Climate Change and Variability. Each of these topics is discussed below in general terms of what is known and what needs to be done:

1. Role of the Oceans as a Source and a Sink for Greenhouse Gases

What Is Known?

* On time scales of less than 1000 years the oceans are the major reservoir of the two most abundant greenhouse gases: water vapor and carbon dioxide.

* Oceanic studies using tracers such as anthropogenic tritium, carbon-14, and chlorofluorocarbons reveal the importance of the deep ocean in taking up greenhouse gases during the past several decades.

* In the simplest terms, three aspects of the oceans must be considered in assessing their uptake of greenhouse gases: solubility in surface waters (the upper 150 m); the amounts of deep waters formed each year; the amounts of intermediate waters formed each year.

* Increased open-water in the Arctic such as leads, polynya, and reduced sea-ice cover will increase the evaporative flux of water to the polar atmosphere.

* A significant fraction (35 + or - 10 %) of the anthropogenic carbon dioxide emissions of the past 100 years has been taken up by the oceans.

* As the oceans take up carbon dioxide their pH decreases and their capacity to take up further carbon dioxide is reduced.

* As the temperature of surface ocean waters increases they release carbon dioxide to the atmosphere.

* During photosynthesis, phytoplankton convert carbon dioxide to organic carbon thereby enhancing the uptake of carbon dioxide by the oceans.

* The gravitational settling of biological particles in the ocean is a significant factor in the global carbon cycle.

* The marine environment plays a significant role in the global cycle of methane.

* Marine phytoplankton produce dimethyl sulfide that can be a source of atmospheric aerosols and thereby influence the formation of water droplets in the atmosphere.

* Anoxic marine sediments with rapid accumulation rates provide a record of ocean variability on the time scales of years, decades and centuries.

What Is Presently Being Done?

* Information on the transport of carbon and other elements from surface waters to depth in the ocean by biological processes is being obtained by the Joint Global Ocean Flux Study (JGOFS).

* Oceanic time-series of selected chemical and biological parameters has been initiated by JGOFS at locations near Hawaii and near Bermuda to document the changes that occur in the ocean.

* Measurements of the carbon dioxide system in the global ocean are being made during the World Ocean Circulation Experiment (WOCE) in order to provide improved assessment of this major carbon reservoir in the 1990s.

* Investigations are underway of oceanic processes involving greenhouse gases that will lead to improved chemical and biological models of their behavior in the ocean.

* Certain historical and on-going time-series data sets have become increasingly valuable due to our concern about global climate change; examples include the California Cooperative Fisheries Investigations (CalCOFI) and the North Atlantic Continuous Plankton Recorder (CPR) work.

* Geochemical studies of ice cores, of Pleistocene coral reef deposits, and of oceanic sediments are providing invaluable information about past climate variations.

* Analytical methods are being standardized and intercalibrated to provide global consistency in ocean chemical measurements.

What Needs To Be Done?

* We need to improve the reliability of our estimates of the amount of anthropogenic carbon dioxide being taken up by the oceans, and then we need to monitor this uptake on a regular basis.

* We need to determine the importance of coastal ecosystems in the global cycles of carbon and methane. In the case of methane the importance

and variability of clathrate [1] deposits in coastal sediments needs to be determined.

* We need to determine the retention times of Greenhouse Gases in the oceans.

* We need to establish national, regional, and global programmes for long-term systematic monitoring of selected Greenhouse gas parameters such as their emissions to the atmosphere, their concentrations in coastal and oceanic waters, and their deposition in marine sediments.

* A global evaluation should be made of the calcium carbonate compensation depth[2] (both past and present) and its variation with climatic conditions in order to determine the time-scales over which this portion of the carbon cycle interacts with atmospheric carbon dioxide.

* We need to improve our recognition of non-linear, episodic changes in oceanic Greenhouse gases, rather than assuming gradual, linear changes.

2. Sea-Level Rise and Climate Change

Noting UN General Assembly Resolution 44/206 of December 1989, on possible adverse effects of sea-level rise on islands and coastal areas:

What Is Known?

* Global sea-levels have risen by the order of 15 cm in the past 100 years.

* Locally, sea-level changes are strongly affected by land movements and local oceanography and meteorology in addition to the global sea-level changes.

What Is Not Known

* Exactly how increased global temperatures will influence future sea-levels. The IPCC, under its severe scenario, the Business-as-usual[3] emissions scenario, "... estimates an average rate of global mean sea-level rise of about 6 cm per decade over the next century (with an uncertainty range of 3-10 cm per decade), mainly due to thermal expansion of the oceans and the melting of some land ice."

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[1] Methane clathrates are formed by methane and water at low temperature and elevated pressure. They are a solid phase formed within sediments and soils. They are similar to ice in that if the temperature increases or the pressure decreases, they "melt or sublime" releasing the methane as a gas and the water as a liquid.

[2] The calcium carbonate compensation depth (CCD) is a level in the ocean (presently at about 4000 m) above which calcium carbonate particles tend to accumulate in the seafloor sediments, and below which these particles tend not to accumulate due to the dissolution of the calcium carbonate. The CCD reflects a balance between calcium carbonate deposition and dissolution which can be a sensitive indicator of changes in oceanic conditions.

[3] Under the IPCC Business-as-Usual scenario, i.e., little or no control imposed on emissions of greenhouse gases, the average rate of increase of global mean temperature during the next century is expected to be about 0.3°C per decade (with an uncertainty range of 0.2°C to 0.5°C per decade).

* The relative vulnerability of areas, regions and countries to anthropogenically induced sea-level changes, due to a lack of full understanding of natural processes affecting sea level, e.g. tectonically induced sea-level changes may reverse or enhance those due to global temperature rise at the local level.

* How local changes in weather patterns will affect probabilities of flooding through changed frequencies and intensities of storms.

* The implication of sea-level rise on species diversity in coastal zones is not known.

What Needs To Be Acquired?

* Reliable estimates of local changes in sea-level and patterns of flooding, over at least 50 year periods, to use an manage coastal areas in a sustainable manner, ant to plan for and adapt to climate induced sea level variations.

* Reliable estimates of global changes in sea level, to analyze and predict climate change and the impacts of climate change.

What Needs To Be Done?

* Develop and fully implement the GLOSS global sea-level measuring system and related satellite based remote sensing systems for sea-level, tectonic movements and the geoid.

* Analyze for trends by removing local ocean variability.

* Develop a full scientific understanding of the mechanisms of long-term sea-level change.

* Ensure that all maritime nations have the capability to measure and interpret their local sea-level variations, in the context of national needs and global climate processes.

3. Impacts of Climate Change on Marine Living and Non-Living Resources

What Is Known?

* Coastal zones represent the interface between atmospheric, terrestrial and oceanic systems resulting in poorly understood, complex ecosystem processes.

* The impacts of climate change and sea-level rise in coastal areas will be diverse and extensive. The IPCC reports indicate the nature and wide variety of these impacts.

* Recent studies indicate the existence of biological "switch mechanisms" which result in abrupt non-linear responses to various physical climatic and oceanic factors, such as the bleaching and mass mortality of corals in response to raised temperatures; the regression of mangrove systems in response to reduced land-based sediment inputs; changes in planktonic community composition in response to changed nutrient levels and water temperature.

* Low-lying coastal and archipelagic areas are among the most vulnerable areas of the worlds surface to the impacts of climate change and sea-level rise. This sensitivity reflects the combined effects of changes to oceanic, terrestrial and atmospheric parameters most of which are anticipated to have adverse socio-economic consequences.

What Is Not Known.

* We cannot accurately predict the scale and direction of many changes at a local level. For example changes to local rainfall patterns, run-off volumes and coastal salinity or changes in which coastal circulation may be altered by larger scale changes in ocean circulation.

* Due to our present inadequate understanding of many ocean processes and their relationship to biological processes in marine and coastal areas unsuspected impacts and abrupt changes must be considered as a very real possibility, for example, the existence of threshold responses or biological switch mechanisms other that those which have already been identified.

* Until these uncertainties are reduced our ability to predict the magnitude of potential impacts on a local , national and regional level is severely constrained leading to problems of long-term planning and impact mitigation.

What Needs To Be Done?

* Management of the impacts of climate change and of sea-level rise in coastal zones requires regional based predictions of future oceanic and atmospheric conditions as they effect sea-level, storm frequency and intensity; wave set up, currents, rainfall pattern and freshwater run-off, sediments, water chemistry and living marine resource distribution and abundance amongst others.

* Such predictions are required to determine the scale of identified impacts on coastal population and societies, and in extreme cases to determine their long-term viability and vulnerability.

* Locally, nationally, and regionally applicable models of physical, chemical and biological processes in the ocean are required to provide the predictive capability needed for sustainable management and use of oceans and coastal areas.

* Improved methodologies for impact identification and assessment are required and assistance needs to be provided to developing countries in identifying response options and estimating the costs of their application and implementation.

* Improved education, training, public awareness and information flow are needed to sensitize governments to the risks of climate change and sea-level rise and for facilitation of collaborative efforts to address the climate change issue. In particular, impact studies on the sovereign rights of the coastal states to benefit from the economic exploitation in the exclusive economic zone need to be done

How To Get There

* Strengthen large scale global monitoring and research of ocean and atmospheric processes to reduce as a contribution to reducing uncertainties at regional and local levels.

* Enhanced local and national level capabilities and capacities in marine science and coastal environmental management.

* Adoption of integrated approaches to programmes of research, monitoring and management at national, regional and international levels.

* Enhanced commitment at all levels to climatic change impact assessment and its co-ordination with the World Climate Impact Assessment and Response Strategies Programme within the World Climate Programme.

4. Climate Change and Variability

The ocean covers over 70 percent of the Planet Earth. It has great inertia and heat content which has profound effects on climate variability. These variations occur on many scales. We are already aware of the moderating effect of the ocean on the daily and seasonal time scales.

It is now being recognized that the ocean moderates climate variability on many time scales. There is interannual (year to year) variability, such as El Niño Southern Oscillation (ENSO) events, and interdecadal variability in addition to long term climate change.

What Is Known?

* The oceans are a moderator of extreme climate variability on seasonal to interdecadal time scales

* The oceans store and redistribute large amounts of heat causing long term variability such as El Niño events; monsoon variations, droughts, floods, etc. Besides atmospheric variability, the variation in oceanic processes has impact on such areas as fisheries, coastal zone development, human resources and freshwater management.

* The ability to forecast interannual and interdecadal climatic variability has significant economic benefits to all countries.

* Recent understanding of oceanic temperature variations are being used to forecast climatic events in all tropical and semi-tropical regions. It is anticipated that knowledge of oceanic variations will improve the prediction of tropical storm frequency, intensity and paths, related surface wave climates and other climatic variations.

What Is Presently Being Done?

* The Tropical Ocean and Global Atmosphere (TOGA) programme is a major project of the World Climate Research Programme (WCRP). The major objectives of TOGA are: (1) 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; (2) 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 (3) 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. TOGA implementation was initiated in 1985 and is scheduled for completion in 1995. TOGA has been highly successful in beginning to provide forecasting skill in seasonal and annual time scales.

* The World Ocean Circulation Experiment (WOCE) is a major project of the WCRP and the largest scientific study of the ocean ever attempted. Using satellites, dozens of ships and thousands of instruments it will take a comprehensive global "snapshot" of the physical properties of the ocean for use in developing numerical models of ocean circulation and physical processes. WOCE implementation began in 1990 and is scheduled to be completed by 1997. Additional national commitments are needed to accomplish all its objectives.

* The Joint Global Ocean Flux Study (JGOFS) is an established Core Project of the International Geosphere Biosphere Programme (IGBP). The objectives of JGOFS are (1) 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; and (2) To develop a capability to predict on a global scale the response of oceanic biogeochemical processes to anthropogenic perturbations, in particular those related to climate change.

* The Global Energy and Water Cycle Experiment (GEWEX) is a major project of the World Climate Research Programme with the objective of observing and modelling the global hydrological cycle and interactions of the atmosphere with the underlying land and ocean surfaces. It currently lacks a significant oceanic component.

* The Global Ocean Euphotic Zone Study (GOEZS) is an important newly proposed study and a potential Core Project of the IGBP. GOEZS is at an early stage in the detailed planning development.

* The World Climate Programme (WCP) consists of four components: (1) Data - to monitor the climate system, detecting climate change and assisting developing countries in climate measurements and data management; (2) Applications - to develop and exchange methods for using information on climate and climate changes to improve efficiency and safety of many human activities; (3) Impacts - to assess effects of global warming on major economic sectors; and (4) Research - to provide better understanding of the processes in the climate system to better predict global warming due to greenhouse gases, and make seasonal predictions of climate for drought warnings and other purposes.

* The Arctic Climate System Study is a newly proposed project of the WCRP to study the circulation of the Arctic ocean; including the sea-ice, energy and fresh water budgets of the region encompassing the Arctic Ocean.

* SECTIONS is an on-going project of the USSR initiated in 1981 with the objective to investigate the role of the ocean in short-term climate change and variability. The programme includes systematic seasonal oceanographic and meteorological observations from research vessels, in some key oceanic areas, called energetically active zones of the ocean (EAZOs) in the tropical and north Atlantic and the north Pacific Oceans. It also includes development and improvement of ocean and ocean-atmosphere models and methods for four-dimensional analysis of oceanographic data.

What Needs To Be Done?

* Establish an ability to predict interannual and interdecadal ocean variability, and its interaction with changes in the other components of the climate system.

* Enhance regional, national and international programmes to observe systematically, ocean temperature, salinity and winds over the ocean to create long-term time series to be integrated into comprehensive data sets; i.e., implement the Global Ocean Observing System (GOOS) as part of the Global Climate Observing System (GCOS). This should include the development of low-cost automated salinity measurement systems so as to permit an order of magnitude increase in the number of salinity observations per year and the expansion of the surface-layer heat-monitoring programme through augmentation of available expendable bathythermographs (XBTs).

* Implement a global 4 dimensional data assimilation system for the ocean in order to organize the oceanic data into global and regional grided data fields.

* Expand the study of the global fresh-water budget to include the role of the ocean.

* Implement operational forecasting of climate variability associated with ENSO and longer time scales as possible.

ANNEX IV

GLOSSARY OF ACRONYMS AND SPECIAL TERMS USED IN THIS REPORT

CalCOFI	California Co-operative Fisheries Investigations
CCCO	Joint SCOR-IOC Committee on Climatic Changes and the Ocean
CCD	Calcium Carbonate Compensation Depth
CPR	Continuous Plankton Recorder
EAZO	Energetically-Active Zones of the Ocean
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GCOS	Global Climate Observing System
GEWEX	Global Energy and Water Cycle Experiment
GLOSS	Global Sea-Level Observing System
GOEZS	Global Ocean Euphotic Zone Study
GOOS	Global Ocean Observing System
IGBP	International Geosphere-Biosphere Programme
INC	Intergovernmental Negotiating Committee (on a Framework Convention on Climate Change)
IOC	Intergovernmental Oceanographic Commission of UNESCO
IPCC	Intergovernmental Panel on Climate Change
JGOFS	Joint Global Ocean Flux Study
OALOS	Office for Ocean Affairs and the Law of the Sea (UN)
SCOR	Scientific Committee on Oceanic Research
SECTIONS	On-going project of the USSR to investigate the role of the ocean in short-term climate change and variability
SWCC	Second World Climate Conference
TOGA	Tropical Ocean and Global Atmosphere Programme
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCP	World Climate Programme
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
XBT	Expendable Bathythermograph