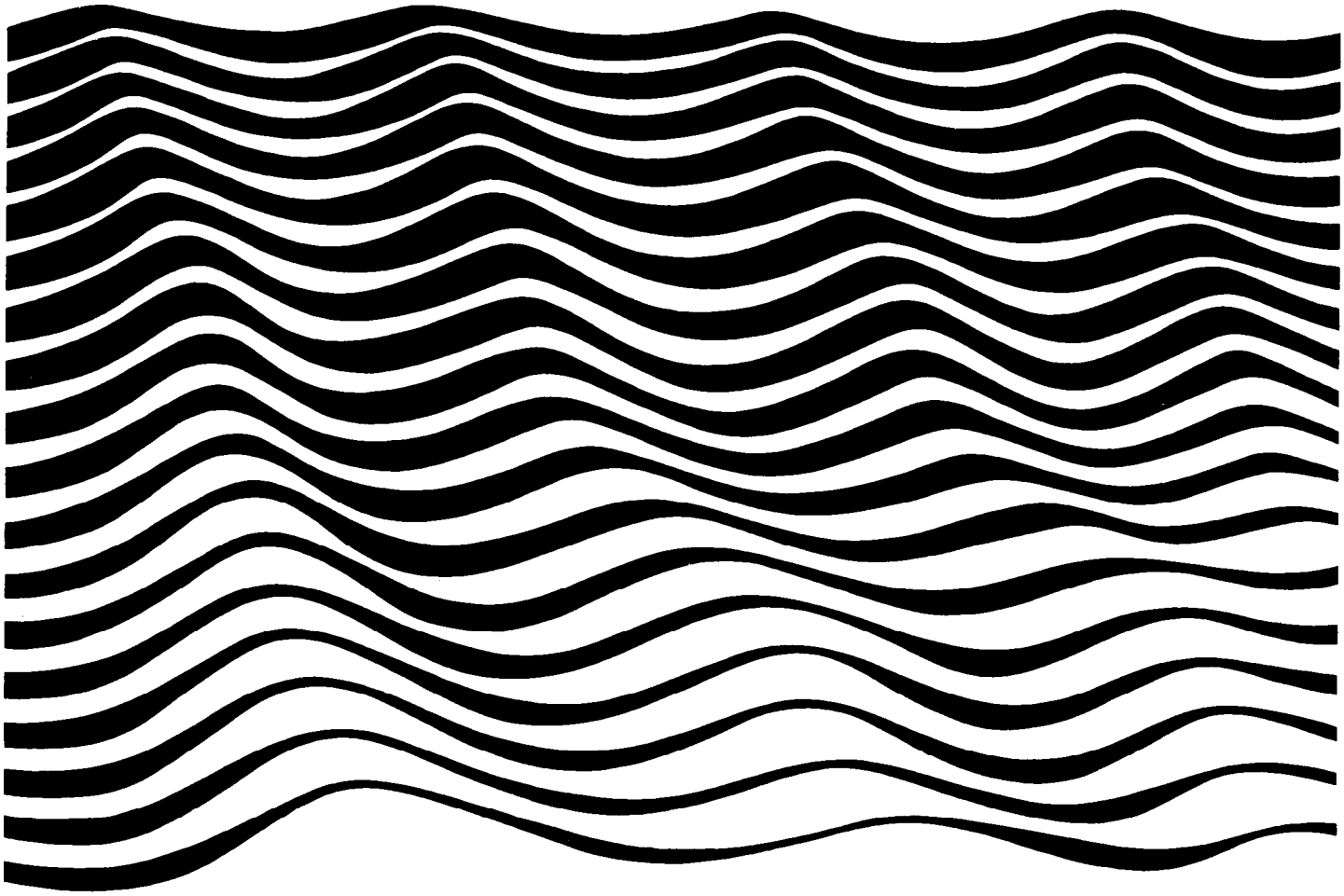
Unesco reports
in marine science 61

Original

Impact of expected climate change on mangroves

UNEP-UNESCO Task Team
Report of the First Meeting
Rio de Janeiro
1-3 June 1992



UNESCO 1993

UNESCO REPORTS IN MARINE SCIENCE

For availability in microfiche form please write to:
UNESCO (DIT/AM), 7, place de Fontenoy, 75352 Paris 07 5P, France.
Out of stock titles are listed on the back cover.

No.		Year
4	Syllabus for training marine technicians. Report of an IOC/UNESCO workshop held in Miami, Florida, 22-26 May 1978. Available in English, French, Russian and Spanish	1979
5	Marine science syllabus for secondary schools. Report of an IOC workshop held at United World College of the Atlantic, United Kingdom, 5-9 June 1978. Available in Arabic, English, French, Russian and Spanish	1979
6	Organization of marine biological reference collections in the Mediterranean Arab countries. Expert meeting held in Tunis, 20-23 September 1978. Available in Arabic, English and French	1979
8	The mangrove ecosystem: Human uses and management implications. Report of a UNESCO regional seminar held in Dacca, Bangladesh, December 1978. English only	1979
9	The mangrove ecosystem: scientific aspects and human impact. Report of the seminar organized by UNESCO at Cali, Colombia, 27 November-1 December 1978. Available in English and Spanish	1979
10	Development of marine science and technology in Africa. Working Group of Experts sponsored by ECA and UNESCO, Addis Ababa, 5-9 May 1980. Available in English and French	1980
14	Marine science and technology in Africa: present state and future development. Synthesis of UNESCO/ECA survey missions to African coastal states, 1980. Available in English and French	1981
15	Fishery science teaching at the university level. Report of a UNESCO/FAO workshop on university curricula in fishery science, Paris, May 1980. Available in Arabic, English, French, Russian and Spanish	1981
20	Quantitative analysis and simulation of Mediterranean coastal ecosystems: The Gulf of Naples, a case study. Report of a workshop on ecosystem modelling, Ischia, Naples, Italy, 28 March to 10 April 1981. Organized by the United Nations, Educational, Scientific and Cultural Organization (UNESCO) and the Stazione Zoologica, Naples. English only	1983
21	Comparing coral reef survey methods. A regional UNESCO/UNEP workshop, Phuket Marine Biological Centre, Thailand, December 1982. English only	1983
22	Guidelines for marine biological reference collections. Prepared in response to a recommendation by a meeting of experts from the Mediterranean Arab countries. Available in English, French and Arabic	1983
23	Coral reefs, seagrass beds and mangroves: their interaction in the coastal zones of the Caribbean. Report of a workshop held at West Indies Laboratory, St Croix, U. S. Virgin Islands, May 1982. English only	1983
24	Coastal ecosystems of Latin America and the Caribbean. The objectives, priorities and activities of UNESCO's COMAR project for the Latin America and Caribbean region, Caracas, Venezuela, 15-19 November 1982. Available in English and Spanish	1983
25	Ocean engineering teaching at the university level. Recommended guidelines from the UNESCO/IOC/ECOR workshop on advanced university curricula in ocean engineering and related fields, Paris, October 1982. Available in English, French, Spanish, Russian, Arabic and Chinese	1983
26	Global survey and analysis of post-graduate curricula in ocean engineering. English only	1984
28	Oceanographic modelling of the Kuwait Action Plan (KAP) Region. Report of symposium/workshop, University of Petroleum and Minerals, Dhahran, Kingdom of Saudi Arabia, 15-18 October 1983. English only	1984
29	Eutrophication in coastal marine areas and lagoons: a case study of 'Lac de Tunis'. Report prepared by Dr M. Kelly and Dr M. Naguib. English only	1984
30	Physical oceanography of the Eastern Mediterranean: an overview and research plan. Report of a workshop held in Lerici, La Spezia (Italy), September 1983. English only	1984
31	MABAHISS/John Murray 50th anniversary: Marine science of the North West Indian Ocean and adjacent waters. Report of a symposium on the occasion of the 50th anniversary of the MABAHISS/John Murray Expedition (1933/34), University of Alexandria, Egypt, 3 to 7 September 1983. English only	1985
32	L'estuaire et la mangrove du Sine Saloum. Résultats d'un Atelier régional UNESCO-COMAR tenu à Dakar (Sénégal) du 28 février au 5 mars 1983. French only	1985
33	Coral taxonomy. Results and recommendations of a regional UNESCO (COMAR)/UNEP workshop with advanced training Phuket Marine Biological Centre, Thailand, 10-26 February 1984. English only	1985
34	Bibliography on coastal lagoons and salt marshes along the Southern Mediterranean coast (Algeria, Egypt, Libya, Morocco, Tunisia). Available in Arabic, English and French	1985
35	Physical oceanography of the Eastern Mediterranean (POEM): A Research Programme. Reports of the Organizing Committee Meeting, Paris, August 1984, and the Scientific Workshop, Lucerne, October 1984. English only	1985
36	Méthodologie d'étude des lagunes côtières. Résultats d'un atelier régional réuni à Abidjan du 6 au 11 mai 1985. French only	1986
37	Principles of Geological Mapping of Marine Sediments (with special reference to the African continental margin). Available in English and Russian	1986
38	Marine Sciences in CMEA countries. Programme and results of co-operation. Available in English and Russian	1986
39	Development of marine sciences in Arab Universities. Meeting of experts held at the Marine Science Station Aqaba, Jordan, 1-5 December 1985. Available in Arabic, English, French	1986
40	Human induced damage to coral reefs. Results of a regional UNESCO (COMAR) workshop with advanced training, Diponegoro University, Jepara and National Institute of Oceanology, Jakarta, Indonesia, May 1985. English only	1986
41	Caribbean coastal marine productivity. Results of a Planning Workshop at Discovery Bay Marine Laboratory, University of the West Indies, Jamaica, November 1985. English only	1986
42	The application of digital remote sensing techniques in coral reef, oceanographic and estuarine studies. Report on a regional UNESCO/COMAR/GBRMPA Workshop, Townsville, Australia, August 1985. English only	1986
43	Quaternary coastal geology of West Africa and South America. Papers prepared for the INQUA-ASEQUA Symposium in Dakar, April 1986. Available in English only	1987
44	Physical oceanography of the Eastern Mediterranean (POEM): Initial Results UNESCO/IOC First POEM Scientific Workshop, Erdemli, Turkey, 16-20 June 1986. English only	1987

UNESCO reports
in marine science 61

Impact of expected climate change on mangroves

UNEP-UNESCO Task Team
Report of the First Meeting
Rio de Janeiro
1-3 June 1992

UNESCO 1993

ISSN 0253-0112

Published in 1993
by the United Nations Educational,
Scientific and Cultural Organization,
7, place de Fontenoy, 75352 Paris 07 SP
Printed in UNESCO'S workshops.

PREFACE

UNESCO Reports in Marine Science are designed to serve specific programme needs and to report on developments in projects conducted in the context of UNESCO's marine science-related activities.

Designed to serve as a complement to the *UNESCO Technical Papers in Marine Science*, the systematic distribution of *Reports is* **restricted to libraries** of oceanographic institutions and governmental authorities, and documentation centres. Individual requests from specialists will, however, be examined by the Marine Information Centre and dealt with on a selective basis.

Requests for specific titles or additions to the mailing list should be addressed to:

Marine Information Centre
UNESCO
1 rue Miollis
75732 Paris Cedex 15
France

ABSTRACT

This report summarizes the results of the first meeting of the UNEP-UNESCO Task Team on the Impact of Expected Climate Change on Mangroves held in Rio de Janeiro, Brazil, 1-3 June 1992, prior and within the spirit of UNCED. At the meeting, the Task Team was established. The meeting considered the existing publications and recommendations related to climate change and its monitoring in the coastal zone. The major lines of activities to achieve scientific and applied objectives related to climatic impact of mangroves were determined.

RESUME

Le présent rapport résume les résultats de la première réunion de l'Equipe spéciale PNUE-UNESCO sur les incidences des changements climatiques attendus sur les mangroves qui a été organisée à Rio de Janeiro (Brésil) du ler au 3 juin 1992, préalablement à la CNUED et dans l'esprit de cette conférence. L'Equipe spéciale a été créée lors de cette réunion même. Les participants ont examiné les publications et recommendations existant sur les changements climatiques et sur leur surveillance dans la zone côtière. Les activités visant la réalisation de certains objectifs de recherche et d'application scientifiques relatifs aux effets du climat sur les mangroves ont été définies dans les grandes lignes.

RESUMEN

En este informe se resumen los resultados de la primera reunión del Equipo de Tareas PNUMA-UNESCO sobre las Repercusiones del Cambio Climático Previsto en los Manglares, celebrada en Río de Janeiro (Brasil) del 1 al 3 de junio de 1992, antes de la CNUMAD e inspirándose en el espíritu de ésta. El Equipo de Tareas se creó durante la reunión, en la que se examinaron las publicaciones y las recomendaciones actuales relacionadas con el cambio climático y su vigilancia en las zonas costeras. Los participances definieron en sus líneas generales las actividades tendentes a alcanzar los objetivos científicos y prácticos que se plantean en relación con las repercusiones climáticas de los manglares.

РЕЗЮМЕ

В настоящем докладе кратко излагаются результаты первого совещания Целевой группы ЮНЕП–ЮНЕСКО по воздействию ожидаемых климатических изменений на мангровые заросли, состоявшегося в Рио–де–Жанейро, Бразилия, 1–3 июня 1992 г., т.е. до ЮНСЕД, но в духе этой конференции. На этом совещании была создана Целевая группа. На нем были рассмотрены имеющиеся публикации и рекомендации в отношении климатических изменений и их мониторинга в прибрежной зоне. Были определены основные направления деятельности для достижения научных и практических целей, связанных с климатическим воздействием на мангровые заросли.

مستخلص

يلخص هذا التقرير نتائج الاجتماع الأول لفريق العمل المشترك بين برنامج الأمم المتحدة للبيئة (يونيب) واليونسكو بشأن تأثير التغير المتوقع في المناخ على أشجار المنغروف، الذي عقد في الفترة من ١-٣ يناير/كانون الثاني ١٩٩٢ في ريو دي جانيرو بالبرازيل قبل انعقاد مؤتمر الأمم المتحدة المعني بالبيئة والتنمية استنادا الى أهداف هذا المؤتمر. وقد أنشيء الفريق في أثناء هذا الاجتماع. ونظر المشاركون في المطبوعات والتوصيات المتوافرة بشأن تغير المناخ ومراقبته في المناطق الساحلية. وتم تحديد الاتجاهات الكبرى للأنشطة الرامية الى تحقيق الأهداف العلمية والتطبيقية المتعلقة بتأثير المناخ على المنغروف.

摘　　要

本报告综述了遵照联合国环境与发展会议精神于1992年6 月1 --3 日在巴西，里约热内卢召开的环境规划署--教科文组织关于预计气候变化对红树植物影响的工作队第一次会议的结果。会上成立了工作队，审议了现有的有关沿海地区气候变化及其监控的出版物和建议，并确定了在气候对红树植物之影响方面进行科学与应用研究的主要活动方针。

TABLE OF CONTENTS

Page

FOREWORD

The United Nations proclaimed at its General Assembly (28 October 1982) that nature shall be respected, genetic viability on earth shall not be compromised, conservation shall be practiced, sustainable management shall be utilized by man and nature shall be secured against degradation. A major international effort is now under way to understand the interacting physical, chemical and biological processes that govern the global environment. Relative sea-level rise is among those recognized negative consequences, which may effect socio-economic structures and activities in future. The environmental problems associated with the potential impact of expected climatic changes may prove to be among the major problems facing the marine environment and adjacent coastal areas.

In this context, UNEP, through its Oceans and Coastal Areas Programme Activity Center (OCA/PAC) launched a number of activities designed to assess the potential impact of climate change and to assist governments in the identification and implementation of suitable policy options and response measures which may mitigate the negative consequences of the impact.

To this end, and in order to study in particular the possible effects of the expected climate change and sea-level rise on the mangrove ecosystems (common for large coastal areas, especially in tropical zones), UNEP invited UNESCO, through its Major interregional project on research and training leading to the integrated management of the coastal marine systems (COMAR), to co-operate in the establishment and co-sponsorship of a Global Task Team on the impact of climate change on mangroves.

A preparatory meeting was convened by UNESCO on behalf of the two organizations, to discuss the feasibility of establishing a Joint Task Team on the potential impact of climate change on mangroves, Bangkok, 18-22 November 1991). The International Society for Mangrove Ecosystems (ISME) was invited to be associated with the study.

Based on the results of the Preparatory Meeting, the first meeting of the UNEP-UNESCO Task Team was held in Rio de Janeiro (Brazil) from 1 to 3 June 1992, within the spirit of UNCED.

This document presents the results of the discussions as well as the recommendations related to the fulfillment of the Task Team aims.

1. SUMMARY

The formation and first meeting of the UNEP-UNESCO (COMAR) Task Team on the Impact of Expected Climate Change on Mangroves took place in Rio de Janeiro, Brazil between 1 and 3 June 1992. The Task Team established its terms of reference after consideration of the Report of the Preparatory Meeting that had been held in Bangkok in November 1991. The Task Team also gave detailed consideration to the report of the UNEP-IOC-WMO-IUCN Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change, Pilot Projects on Mangroves and Coral Reefs that had been held in Monaco in December 1991.

The Task Team agreed that in order to achieve its objectives, it would on the first place undertake three initiatives:

- First: to carry out an analysis of the literature to prepare an overview of certain aspects of expected global change on mangrove ecosystems and the probable effects on the exploitation of the system, with the aim of identifying policy options and suitable response measures.

- Second: to prepare three specific case studies involving low island, arid coast and deltaic sites. It was considered that these sites would provide a representative range of mangrove habitats and would provide experience of experimental design, data collection and analysis, that would be invaluable for the successful establishment of a long-term mangrove monitoring system.

- Third: to prepare a position paper on the theoretical and technical basis for data acquisition, experimental design and the analysis of data, including possible modelling approaches, that could be used for the development of the specific case studies and the long-term monitoring programme concerned with mangrove ecosystems.

An important role of the Task Team would be to advise on the design, development and operation of the proposed global monitoring of the effect of climate change on mangroves.

The Task Team also resolved to collaborate closely with other similar Task Teams so that information and experiences could be shared.

Finally, the Task Team agreed that it is embarking on task that requires a long-term commitment if there was to be a positive outcome and it requested UNEP and UNESCO to seek appropriate support.

2. OPENING OF THE MEETING

The meeting was opened at 0900 on Monday 1 June 1992 by Professor Colin Field as the Chairman of the meeting and the Task Team Coordinator. He welcomed the participants and expressed his appreciation of the willingness of several of them to be present at short notice. The Chairman explained that the meeting had been convened on behalf of UNEP and UNESCO (COMAR) as a follow up to the preparatory meeting that had been held in Bangkok in November 1991. He also explained that the report of the preparatory meeting had been adopted as a basis for the future work of the Task Team.

3. FORMAL ESTABLISHMENT OF TASK TEAM

The Chairman proposed that the group that had been gathered together in Rio de Janeiro should formally constitute the Task Team as they represented the required spread of scientific disciplines and geographical interests. The meeting agreed with this suggestion and resolved that: “the Task Team should be comprised of the members shown in Annex 1.“

4. ADMINISTRATIVE ARRANGEMENTS

4.1 Adoption of agenda

The proposed agenda as shown in Annex 2 was adopted.

4.2 Conduct of meeting

The Chairman reviewed the literature that was available to the meeting which consisted of the report of the preparatory meeting of the UNEP-UNESCO Task Team (Bangkok November 1991) and the UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change, pilot projects on mangroves and coral reefs (Monaco, 9-13 December 1991). He further proposed Dr Donald Macintosh to be Rapporteur of the session considering Phase 1 of the task, Dr Barry Clough to be Rapporteur of the session considering Phase 2 of the task and Dr Bjorn Kjerfve to be Rapporteur of the session considering Phase 3 of the task. These arrangements were agreed by the meeting.

5. TERMS OF REFERENCE

The Chairman drew the attention of the meeting to the Terms of Reference contained in the Report of the Preparatory Meeting. After discussion, the following Terms of Reference were adopted by the meeting:

(a) To prepare an overview based on the best available knowledge of the potential impact of expected climate change on mangrove ecosystems;

(b) To prepare selected case studies using the best available knowledge for specific regions;

(c) To prepare on the basis of (a) and (b) a statement of possible policy options and response measures which may mitigate the negative consequences of the impact of climate change on mangrove ecosystems and their associated socio-economic structures;

(d) To design a detailed and specific plan for the implementation and execution of a global long-term mangrove ecosystem monitoring programme;

(e) To include in the plan referred to in (d):

(i) selection of critical parameters to be measured in long term monitoring;
(ii) guidelines and procedures for analysis and synthesis of the collected data;
(iii) design of experiments to be carried out in conjunction with the monitoring programmes;
(iv) selection and justification of three suitable primary mangrove sites for comparative study in the programme; and consideration of associated secondary sites;
(v) evidence of appropriate governmental financial and logistic local support for sites identified in (iv);
(vi) identification of existing or planned monitoring programmes that would be pertinent to the present task and establishment of links with other relevant international programmes;
(vii) a provisional budget for the monitoring and study programme.

6. INTRODUCTION

The Chairman referred to the Report of the Preparatory Meeting of the Task Team (Bangkok, 18-22 November 1991) and indicated that the report had been endorsed and would be published as a MARINF/88 UNEP-UNESCO information document. The contents of the report therefore established the background for the present Task Team meeting. The agreed terms of reference indicated that the Task Team had three main objectives:

(a) To produce an overview of existing literature to estimate potential impact of climatic changes on mangrove ecosystems and their associated socio-economic structures;

(b) To propose specific case studies;

(c) To advise on the design and implementation of a long-term global monitoring system.

The Task Team had to consider these objectives and decide on how they might be best achieved.

Dr Marc Steyaert (UNESCO) then discussed the report of the UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change, Pilot Projects on Mangroves and Coral Reefs (Monaco, 9-13 December 1991). He outlined the five modules of the Global Ocean Observing Systems (GOOS) and indicated the pilot phase activities of the coastal module. In particular, Dr Steyaert explained that two pilot phase activities were to be developed involving the monitoring of coral reef ecosystems and mangrove communities. He went on to explain the discussion that had taken place on the development of an operational plan for the implementation of long-term monitoring of mangrove and coral reef ecosystems. He reported that the meeting had supported the view that the UNEP-UNESCO Task Team on the impact of expected climate change on mangroves could potentially be used as a review body for evaluation of the proposed pilot phase activities.

The Task Team, several members of which had attended the Monaco meeting, then considered in detail Annex III of the UNEP-IOC-WMO-IUCN Report which dealt specifically with mangrove communities. The Task Team welcomed the initiative to establish a long-term global monitoring system for monitoring mangrove communities and supported the aims outlined in Annex III. It noted the intention to publish a manual of approved monitoring methodologies for mangrove communities based partly on an ASEAN-Australian manual and partly on an University Sains Malaysia manual.

The Task Team expressed interest in receiving copies of the documents so that it could comment on the contents, as the majority of the members were not familiar with these publications. The Task Team supported the other two proposed outputs from the long-term monitoring programmes but the view was expressed that scientific analysis and synthesis were important outcomes from the data collected and that the testing of hypotheses was an important facet of the experimental design of the monitoring programme. In particular, it was important to design the outcome of the long-term monitoring programme so that the effects of the predicted global changes could be distinguished from anthropogenic effects and effects due to other natural local climate changes. The resolution of these different effects was seen as a challenging task.

The Task Team had some difficulty with the concept of global, regional and national sites as it felt that all chosen sites would have national connotations. However, it endorsed the concept of choosing some sites where the effects of direct anthropogenic influences were reduced to a minimum. It also strongly endorsed the use of existing networks, such as those established by COMAR, as a basis for any long-term monitoring system.

The Task Team generally agreed with the scientific guidelines that had been proposed for site selection. However, it was felt that more scientific discussion was required with respect to each of the parameters listed. For instance, it was felt that mangrove communities at the far extreme of mangrove distribution may or may not be the first to show responses to climate change as they are likely to be the most dynamic natural mangrove systems and that the nature of sea-level rise at these latitudes is uncertain. There was also debate on the significance of tidal range in terms of the impact of sea-level rise. The Task Team noted the examples of possible countries for inclusion in a pilot phase monitoring of mangroves and the view was expressed that a more clearly defined rationale was required before the sites could be considered scientifically selected.

There was considerable discussion of the section on parameters and in particular the various stages that had been proposed. The view was expressed that mapping of the selected sites was a key factor and that micro-topographical information was particularly important. A well defined benchmark to assess sea-level rise was also considered a fundamental requirement. The use of data from the National Oceanic and Atmospheric Administration (NOAA) programme was mentioned. The Task Team requested more information on the disposition of the GLOSS tidal gauge network, though it was pointed out that proximity to a GLOSS tide gauge was not absolutely essential if there were adequate local arrangements. The view was also expressed that a five year time interval for monitoring a selected site may be too long, particularly for a site that was highly dynamic. The suggestion was made that there should be site- specific monitoring cycles.

The efficacy of sampling frequency along transect lines, measuring species composition by burrow density and sedimentation rate by inserted stakes was queried. The Task Team also expressed concern about the way parameters had been prioritized into three stages without much apparent justification.

Finally, the Task Team expressed the view that quality control of the data obtained from any long-term monitoring programme was crucial to the usefulness of such a programme. They also expressed the view that the analysis, synthesis and interpretation of the data obtained, consistent with an experimental design, was an essential element in any such programme.

The meeting recommended that: “the Task Team should have a close advisory role in the design, development and operation of the global monitoring system proposed by the IOC-WMO-UNEP sponsored Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change, a component of the Global Ocean Observing System (GOOS), particularly concerning the Pilot Project on Mangrove”.

7. PHASE 1: Overview of existing literature to estimate potential impact of climate changes on mangrove ecosystems and their associated socio-economic structures

7.1 Background

Based on the assessment by the UNEP/WMO Intergovernmental Panel on Climate Change (IPCC), the climate change which can be expected is warming at a rate of 0.3°C per decade, to reach a 1°C increase by 2025 and 3°C by 2100. Sea-level is expected to rise at a rate of 6cm per decade, with an uncertainty range of 3-10cm, to reach an average 20cm rise by 2030 and 65cm by 2100. If fossil fuel emissions of carbon dioxide continue at 1990 levels the concentration of carbon dioxide in the atmosphere will have increased by 50% by the year 2100.

There is a sufficient literature on mangroves and the magnitude and impact of expected climate change to enable the preparation of an overview on certain aspects of expected climate change on mangrove ecosystems. The recent publications on climate change by the Intergovernmental Panel on Climate Change (IPCC) and a review by Ellison (in press) provide useful baseline studies for this task.

There are several mangrove bibliographies and databases which can be searched for information. Although the mangrove literature is extensive, it must be stressed that the great majority of mangrove references give little or no data on this topic, or at best, provide indirect information. Moreover, while some subjects are adequately covered, the literature is particularly weak in the multidisciplinary field in terms of the impact of climate change at the ecosystem level. The objective, therefore, is not to produce a bibliography on the effects of climate change on mangroves, but a balanced synthesis and interpretation of practical use from the very scattered published information available.

The main consequences of climate change that are likely to affect the structure and function of mangrove ecosystems and individual species are sea-level rise, climatic warming,

changes in precipitation and changes in the frequency or intensity of hurricanes (typhoons); productivity may also be changed because of higher levels of carbon dioxide in the atmosphere (Ellison, in press). It is clear that very careful synthesis and interpretation of the available information is required as these climatic effects will occur in combination with each other and also interact with anthropomorphic impacts on mangrove ecosystems.

Phase 1 will review both the expected impact of climate change on the mangrove system and the probable effects on exploitation of the system for forestry, fisheries, aquiculture, agriculture, and general habitation. While the conclusions from the overview will be general rather than specific, some very useful indicators of climate change effects can be derived to guide policy options and suitable response measures in terms of coastal systems and the human communities and populations that depend on them.

7.2 Methodology

It is proposed that a small group will be formed from members of the Task Team that will be assigned the task of editing individual contributions into a coherent overview document. Contributions will be sought from members of the Task Team and other recognized experts in selected areas.

Recognizing the subject areas most pertinent to the impact of climate change on mangrove ecosystems and the range of expertise available, the overview will examine the impact on the mangrove ecosystem of the following:

Climatic changes
- Temperature
- Precipitation and related phenomena
- Storm effects
- Increase in carbon dioxide

Relative sea-level change
- Holocene record
- Inundation
- Sedimentation/erosion processes

Salinity

Biological Impact
- Changes in distribution and zonation
- Mangrove flora-species effects
- Mangrove fauna-species effects

Interaction with human pressures on mangroves
- Habitation
- Forestry
- Agriculture
- Fisheries
- Aquiculture

Overall impact at the ecosystem level

priorities for future research and monitoring

As regional differences are expected in terms of climatic factors (especially storm occurrence and frequency), species composition and human influences on the mangroves including management priorities, the overview will include some additional regional coverage of selected topics.

The following regions merit this selective coverage: Indian Ocean, including Red Sea and Persian Gulf Southeast Asia Pacific Islands Atlantic/Caribbean.

7.3 Outcome

The overview together with an executive summary will be prepared in the first six months from the acceptance of this report to be completed in time for the next meeting of the Task Team. The overview will be published in UNEP's Regional Seas Report Studies and series and will serve as a working report with the immediate objective of assisting the development and implementation of phases 2 and 3 of the project. In view of the intended time-scale and objectives of the overview, the output will be a short report suitable for publication, probably not exceeding 50 typed pages.

7.4 Conclusion

The meeting recommended that:

"An analysis of the literature be undertaken to prepare an overview of certain aspects of expected global climate change on mangrove ecosystems. Contributions should be sought from members of the Task Team and other experts in the field. The review should be completed prior to the next meeting of the Task Team. The editorial board for the review to consist of Colin Field (convenor), Don Macintosh, Bjorn Kjerfve and Alejandro Yanez-Arancibia."

8. PHASE 2: Specific case studies

8.1 Background

Consistent with the views expressed in the Report of the Preparatory Meeting of the UNEP/UNESCO (COMAR) Task Team, consideration has been given to implementing site-specific case studies involving discrete mangrove ecosystems that would allow the testing of particular experimental designs, the trial of measuring methodologies and the preliminary collection of data. Specific case studies would also enable the examination of preliminary hypotheses. It is considered that the implementation of specific case studies would yield significant scientific information that could be used in the design and refinement of any long-term global monitoring of mangrove ecosystems.

Initial examination of the basis for site-specific case studies indicated that possible experimental sites could fall into three broad ecosystem categories, low island, arid coast and well developed estuarine or deltaic mangrove ecosystems. It is recognized that some mangrove systems do not fall into these categories.

8.2 Definition of experimental site categories

8.2.1 Oceanic low island

An island whose elevation is close to sea level, which is not influenced by fluvial processes (i.e. without significant terrigenous or allochthonous freshwater inputs). Such an island will have an oceanic location and will be dominated by marine influences. The low elevation of these islands will make mangrove habitats particularly susceptible to increase in tidal level. The mangrove community is likely to be less complex than that on a humid mainland coast.

8.2.2 Arid coast

A mainland coastal area not moderated by major fluvial influences and in a region of low rainfall and high potential evapotranspiration. In such regions mangroves experience significant temperature, salinity and water stress and therefore are likely to demonstrate an early response to climate change. The mangrove community in these environments is relatively simple structurally and floristically.

8.2.3 Deltaic

An estuarine environment dominated by substantial freshwater inputs and high ambient relative humidity. Such a system will have high biological diversity and biomass, and a relatively complex forest structure. Deltaic systems are probably representative of the majority of mangrove forests worldwide.

8.2.4 Other mangrove ecosystems with unique features

There are some mangrove ecosystems that do not fall conveniently into the above categories which have unique features that may be of value in discerning the impact of climate change on coastal regions. These include, for example, lagoonal systems and open coastal fringe mangroves.

8.3 Criteria for selection

The following primary criteria for site selection have been formulated in order of priority:

(a) Quality of the existing scientific database. This should include recent climatic and scientific data, historical information for at least 20 years and, where possible, stratigraphic records. There should also be available good regional topographic maps to at least 1/100,000, and preferably 1/50,000, aerial photography and satellite imagery.

(b) Presence of ongoing related scientific activity supported by local and national authorities.

(c) An existing logistic capability, including ease of access, general logistic support, accommodation and working facilities (eg research laboratory or other convenient facilities).

(d) The probability of establishing effective bilateral commitments for support.

(e) Presence of a functional and reliable tide gauge, preferably with records for at least the past 5 years. However, this was not a primary criterion since a tide gauge could be installed under the auspices of the project.

8.4 Suggested sites based on the selection criteria

8.4.1 Oceanic low island sites

(a) Grand Cayman, (Caribbean Region)

General description: The central mangrove swamp on Grand Cayman extends over some 40km2, with seaward margins on the protected North Sound, at 19°20'N, 81°15'W. Grand Cayman is limestone to maximum elevation of 20m, with no rivers. The tidal range is 28cm, and 60cm at springs. Mangrove zonation shows some structural complexity, but is broadly a *Rhizophora mangle* seaward margin, with inner zones of *Avicennia germinans, Laguncularia racemosa* and *Conocarpus erectus.*

Existing scientific database: The swamp communities have been mapped at 1:25,000 scale to show community structure and canopy height in great detail, and permanent transects across the swamp were initially surveyed from 1967 and again in the 1980's, with elevation work. This work was carried out by the Mosquito Research and Control Unit (MRCU). The East End and Lower Valley fresh water lenses discharge into the landward margins of the swamp, and hydrogeological monitoring has been carried out by the Cayman Island (CI) Water Authority for over 10 years. Temperature and rainfall data exist from the 1950's. Stratigraphy has been studied by C. Woodroffe and others, swamp community structure studied by Fred Burton (Cayman National Trust) and M. Brunt (MRCU).

Ongoing research activity: MRCU continues research in the mangroves, and the Director of the Natural Resources Unit, David Vousden, has agreed to establish the central mangrove swamp as a UNEP-IOC Long-Term monitoring site.

Logistic capability: MRCU is part of the Government Natural Resources Unit, which has laboratory facilities in Georgetown, staff, vehicles, boats and equipment.

Bilateral collaboration: Interest has already been expressed in participating in this program. It is a possibility that the UK Overseas Development Administration (ODA) be approached to create a position with resources to carry out the work of the project. ODA has previous involvement with MRCU.

Tide gauge data: There is a GLOSS tide gauge established since 1976, located in the North Sound.

(b) Tongatapu Island, Tonga

General description: The largest mangrove swamp in Tonga is at FoIaha, in the western margins of the central Fanga 'Uta lagoon, Tongatapu Island (21010'S, 175°1O'W). Tongatapu is a low limestone island, to a maximum 65m, with no rivers. The area is about 2km2, there is clear zonation within the swamp from *Rhizophora mangle* at the lagoon margin, with *Bruguiera gymnorrhiza* and *Excoecaria agallocha* zones. The tidal range in the lagoon is reduced by restricted circulation at this location to some 40cm, and the lagoon is variably brackish (Salinity is of about 25 ppt).

Existing scientific database: Zonation has been mapped, elevations determined along a central transect, and stratigraphy and paleoecology examined in 1987 by J. Ellison. Circulation in the lagoon has been studied by Zann, Kimmerer and Brock in 1983.

Ongoing research activity: There are no research programs known at the present time that directly concern the swamp.

Logistic capability: The Tonga Government has a Research Farm at Vaini, with laboratories and equipment, with assistance from Germany. There is no work on the mangroves presently at this facility.

Bilateral collaboration: Australian International Development Assistance Bureau (AIDAB) is presently carrying out a study of the Fanga 'Uta lagoon for design of a future management plan. It is possible that they may be interested in this project at Folaha.

Tide gauge data: A tide gauge has very recently been installed.

8.4.2 Arid coastal sites

(a) Makran Coast, Pakistan

General description: Between the Indus Delta and Miani Hor on the Makran coast there are about 200km of coastline where the mangrove communities are dominated by *Avicennia marina.* Other important species present include *Rhizophora* spp. and *Ceriops tagal.* Tree heights range up to 30m. This area contains 3 or 4 seasonal rivers or wadis that dry out during the dry season. Tidal range is 3-4m.

Existing scientific database: Ecological and hydrological data are available for several areas and several years in the region, and meteorological data are available for Karachi (Port of Qasim and others). Extensive historical records for at least the past 100

years are available. Good remote sensing data and topographic maps are available for the area.

Ongoing research activity: Ongoing research is being carried out by the Forestry Department, Province of Sind, and by the University of Karachi Institute of Marine Science (Institute of Marine Sciences, Reference Collection laboratory, Oceanographic Institute), Zoological Survey of Pakistan, and the Remote Sensing Agency. This includes the revegetation and restoration of degraded former mangrove areas along some parts of the coast. Nursery facilities are available and extensive propagation trials are underway. There appears to be a strong institutional and governmental commitment to ongoing research in the area. This is reflected, for example, in the revival five years ago of the former Division of Coastal Forestry (mangroves).

Logistic capability: Parts of this area are close to Karachi and easily accessed by road. Laboratory facilities are available at all the above-mentioned institutions. Boats and other logistic support are available including those of the fisheries.

Bilateral collaboration: Past experience suggests that the Pakistan Government would be willing to enter into bilateral arrangements.

Tide gauge data: Tide gauge data are available for at least one part of the coastline. The length of records is not known.

(b) Saloum, Senegal

General description: Extensive mangrove areas in the vicinity of Saloum, consisting mainly of *Rhizophora mangle, Rhizophora racemosa, Avicennia africana* or *Avicennia nitida,* with some *Conocarpus erectus* and *Laguncularia racemosa.* The tidal range is 1-1.5m.

Existing scientific database: Substantial scientific database, including remote sensing images, topographic maps and meteorological data.

Ongoing research activity: Senegal is a major site for the UNESCO/UNDP COMARAF Project. Other ongoing research is being carried out by the French Government's ORSTOM project, and the Centre for Oceanographic Research, Dakar University.

Logistic capability: Well equipped laboratories are available in Dakar, approximately 150 km from Saloum. Hotel accommodation and boats are available at Saloum.

Bilateral collaboration: Strong bilateral collaboration is likely.

Tide gauge data: Reliable tide gauge data are available for Dakar. Another tide gauge is planned for the Saloum area.

8.4.3 Deltaic (estuarine) sites

(a) Maranhão, Brazil

General description: Mangroves in this area extend along about 460km of coast with a tidal range of about 7m. The area has many small rivers and is characterized by small, funnel-shaped embayments called Rias. Some parts experience tidal bores. The area supports very extensive mangrove forests of *Rhizophora mangle, Avicennia germinans, Laguncularia racemosa* and *Conocarpus erectus* of more than 30m in height. Sediments are muddy.

Existing scientific database: Reliable background meteorological, ecological and other data such as topographic maps and remote sensing data are available for the area.

Ongoing research activity: The "Universidade Federal de Maranhão" at Sao Luis is continuing an active programme on mangrove ecology that was commenced 5-10 years ago.

Logistic capability: Logistic support is available through the "Universidade Federal de Maranhão". Laboratory facilities are not available on site, but are available at Sao Luis. Hotel accommodation is available in the area. Boats are available for charter.

Bilateral collaboration: Limited support possible from the Government of Brazil.

Tide gauge data: Reliable tide gauge data are available.

(b) Usumacinta/Terminos Lagoon, Mexico

General description: Usumacinta/Terminos Lagoon is located in the southern Gulf of Mexico and spans 500km of coastline of the States of Campeche and Tabasco. The tidal range averages 0.45m. The area is characterized by a humid tropical climate, strong river discharge, extensive areas of tidal wetlands and an annual rainfall of 2000-3000mm, falling mainly between June and October. The area has extensive well developed forests of *Rhizophora mangle* and *Avicennia germinans* of more than 30m in height, together with *Laguncularia racemosa* and *Conocarpus erectus*. The deltaic sediments are mainly of terrigenous origin.

Existing scientific database: Good background information in the form of a database, topographic maps, GIS and satellite imagery are available, in some cases for the past 30 years.

Ongoing research activity: Extensive ongoing research is being carried out by Epomex, a Program of Ecology, Fisheries and Oceanography of the Gulf of Mexico, and the Estacion El Caemen of Marine Research.

Logistic capability: Logistic support and laboratory facilities are available through the Epomex Program, universities and coastal marine laboratories in Campeche and Ciudad del Carmen. Convenient hotel accommodation is available.

Bilateral collaboration: Epomex has established cooperative arrangements with Institutions from Europe, Australia, Southeast Asia, N. America, Central America, S. America, the Caribbean zone and Mexico. It may be possible to extend some of these contacts.

Tide gauge data: Reliable tide gauge data are available.

(c) Phang nga Estuary, Thailand

General description: Located in southern Thailand, Phanga nga Estuary is now a national park with extensive mangrove development along about 100km of coastline. The area is characterized by well developed forests of a mixture of mangrove species dominated by *Rhizophora* spp. and *Avicennia* spp. with heights of up to 25m. The tidal range is about 2m.

Existing scientific database: The area has been the subject of a number of ecological and hydrological studies giving rise to a good existing database. Also available are remote sensing data and good topographic maps.

Ongoing research activity:. Ongoing research activities are being carried out by various Thai Government agencies and by the Phuket Marine Biological Station.

Logistic capability: On site laboratory and accommodation facilities are available, as are boats. Logistic and other support are available through the National Research Council, Royal Forest Department, National Parks, Fisheries Department and Phuket Marine Biological Station.

Bilateral collaboration: Strong prospective support from the Thai Government is indicated. The Australian-ASEAN mangrove programme is also active in this region.

Tide gauge data: Reliable tide gauge data are available.

8.5 Outcome

One site from each of the above categories should be chosen after negotiation between UNEP/UNESCO(COMAR) and each of the respective countries with nominated sites.

It is proposed that independent assessors will be contracted by UNEP/UNESCO (COMAR) to visit each of the sites selected to assess the suitability of that site and to prepare a specific proposal and workplan. In preparing the proposal and workplan consideration will need to be given to the scale of the study and the selection of local study sites according to local conditions. Site assessments and the ensuing workplan should be completed in time for consideration by the Task Team at its second meeting.

Prior to the site visit by independent assessors it would be desirable to request an individual familiar with each of the nominated sites to prepare a preliminary description for that site.

8.6 Conclusion

The meeting recommended that:

“Three site visits, selected from the nominations in this report and based on the criteria indicated, should be commissioned for establishing a pilot phase of the study programme. Each visit to provide a report on the suitability of the site for specific case studies and a proposal for a specific study programme consistent with the guidelines indicated in this report”.

9. PHASE 3: Design of site-specific case studies and a long-term monitoring programme

9.1 Background

On the assumption that climate change during the next 100 years will occur according to the IPCC “business-as-usual” scenario, that is a 0.3°C per decade increase in temperature, a 6cm rise in global mean sea level per decade, and an increase of the carbon dioxide concentration in the atmosphere of 15.9 ppmv per decade, the problem is what impacts are likely to occur in mangrove ecosystems in different parts of the world.

The Task Team indicated (section 6, page 5) its support for establishing a long-term global monitoring system for monitoring mangrove ecosystems and commented on the approach that had been proposed.

Questions to be resolved:

(a) Is there an effect on mangroves due to a global climate change?

(b) How climate change will potentially impact mangrove ecosystems on short time scale (2-3 years), intermediate time scales (10-30 years), and in the long term (100 years)?

(c) What is the best estimate for detection of climate change in various mangrove parameters at the different sites?

(d) How can climatic and anthropogenic impacts on mangrove systems be distinguished from each other and separated from currently occurring environmental processes?

To detect climate change signals in mangrove systems over a century is in all likelihood feasible. However, the detection of such signals on short (a few years) and intermediate (decades) time scales is likely to be more problematic since most changes in mangrove systems are likely to be due to anthropogenic stresses or natural environmental processes. A successful and effective long-term monitoring and study programme to detect climate change signals in mangrove systems must strike a balance between data monitoring, experiments, modelling exercises, and systematic analysis and synthesis of the total available information.

To make this programme feasible and affordable, it will be necessary to focus on measurement and determination of those simple parameters that are most likely to show detectable changes in the mangrove system, and at the same time provide data on the mangrove system. As much as possible, the programme should focus on automatic measurements, techniques, and procedures, and whenever possible use remote sensing techniques with collection of field data by conventional techniques as a means of calibration and verification. A reasonable definition of spatial impact change on the mangrove environment could be defined as detectable change on a minimum area equal to one pixel (10-30m).

9.2 Minimum prerequisite requirements

As a prerequisite to begin measurements of variables and calculations of parameters at the mangrove sites, it is initially necessary to:

(a) Select an appropriate geomorphological unit with a well developed mangrove system and available infrastructure to serve as the study site;

(b) Select a study site, where the evolution of the site has already been well studied, extensive mangrove data exist and are available, meteorological time series and summaries have been compiled, some aerial photographs and satellite images are available, and for which there exists a topographic map covering the system to the scale of 1:100,000 or better;

(c) Carry out a detailed historical investigation of what has happened at the mangrove site during the past 50-100 years. Interviews with old people from the area and scrutiny of newspaper accounts and aerial photographs could be useful. It may also be useful to study the geological history of the site and to carry out investigations on marine sediments using pollen of mangrove vegetation as biogeographical or stratigraphical markers;

(d) Construct a digital base map of the mangrove system in a Geographical Information System (GIS), using the 1:100,000 topographic map. The digital GIS base map will be used to determine the extent of the mangrove system, import satellite images and scanned aerial photographs, and to overlay distributions of parameters. Thus, the GIS digital base map will serve as the database to integrate all types of spatial data and ascertain changes in mangrove system parameters through change detection techniques via remote sensing and conventional field measurements;

(e) Locate or install one or more high-quality tide gauges at the mangrove site or nearby, making sure that the vertical datum of the tide gauge meets the quality requirements of either a GLOSS or NOAA GSL site. The data collected at the tide gauge should be readily available to the mangrove researchers.

9.3 Parameters to be measured and determined

The minimum number of parameters needed to be measured or determined at each mangrove site include:

PARAMETERS	MEASUREMENTS	METHODOLOGY
(a) Rate of relative sea level change	Water elevation measurements on at least an hourly basis from a tide gauge for which a reliable vertical datum exists	NOAA publications, IOC publications. Pugh, 1987
(b) Sedimentation or erosion rates	Rate of sedimentation by 210Pb and marker horizons repeated every five years; for erosion retreat of coastline and determination relative to the fixed datum every five years.	Patrick and Delaune for 210Pb; Day et al. for marker horizons; UNESCO-UNEP manual: Methodology for assessment and control of coastal erosion (1989)
(c) Topography and bathymetry	Assessment of elevation and depth distribution on a sufficiently find scale to identify micro-topography changes of the order of 5cm by topographical survey of GPS remote sensing techniques, repeated every five years.	NASA publications for remote sensing techniques. Survey manual for traditional techniques.
(d) Quality of deposited sediments	Physical and chemical characteristics of sediments, including grain size, mineralogy (composition and texture), total carbon, and total sulphur content.	USDA manual
(e) Climatology	Measurement of rainfall, temperature, humidity, isolation, evapotranspiration, and wind speed and direction on a daily basis at a minimum of one site, including determination of P/E ratio and assessment of extreme weather-climate events. Application of standard statistics and time series analysis techniques.	WMO guidelines; statistics text; time series analysis text; SAS and Statgraphics computer programme and manuals

1 See Annex 3.

(f)	Hydrology	Determination of runoff, tidal regime, wave exposure, and wave climate on a seasonal basis, including an assessment of the degree of fluvial vs. marine influence and an assessment of extreme hydrology events annually	USGS manuals; NOAA manuals; CERC 1987, Kjerfve, 1990
(g)	Groundwater salinity and salt intrusion	Measurements of subsurface salinity by a network of piezometers seasonally in the mangrove system and adjacent upland margins	IHP/UNESCO manuals
(h)	Plant and animal parameters	Plant and animal species composition and distribution mapped onto the digital base map, structure and productivity of the mangrove forest by conventional and remote sensing methods, including calculation of vegetation index (R/IR band ratio and others) and ground trusting repeated seasonally	UNESCO Snedaker manual; UNESCO remote sensing techniques; biological techniques manual
(i)	Anthropogenic changes and impacts	Use of remote sensing, GIS, ground truth observations, and field measurements and surveys to determine major anthropogenic activities repeated every five years to detect major changes in the mangrove system	NASA; remote sensing handbooks; occasional papers, UNESCO remote sensing; fisheries techniques; techniques for evaluation of socio-economic change

9.4 Experimental design and analysis

In order to use the data collected optionally, it is necessary to have a careful experimental design. In turn, the experimental design should reflect a number of plausible hypotheses that need to be tested. The major problem in determining the effect of climatic change on mangroves is to distinguish natural local changes and changes due to anthropogenic impacts from global changes in climate.

The challenge is to develop a document detailing possible hypotheses and experimental designs that can serve as the scientific basis for the UNEP-UNESCO(COMAR) specific case studies on expected climatic impact on mangrove ecosystems. Such a document could also eventually be of immense value in the design and analysis of a long-term global monitoring system.

As a preliminary step, a small (ad hoc) working group needs to meet and evaluate the relevant literature, such as concept papers (Holligan: IGBP, 1990) and methodology manuals (Australia-ASEAN methods manual).

9.5 Outcome

The outcome of this study would be a document that would detail techniques, methods and references and would also critically examine experimental design, analysis of data, basic hypotheses and concepts. The document would also suggest various possibilities for modelling the problem of the effect of climate change on mangroves.

9.6 Conclusion

The meeting recommended that:

"A position paper be prepared on measurement, experimental design and analysis of data that could be used to help develop the selected specific case studies. It should include possible hypotheses to be tested and modelling approaches that could be utilized. The paper to be available for consideration at the second Task Team meeting. A small group consisting of Bjorn Kjerfve (convenor), Barry Clough, Don Macintosh and Sanga Sabhasri were asked to undertake the task. It is anticipated that the experiences gained from the design and experience of specific case studies could be used to advise the related global monitoring programme."

10. FUTURE ACTIVITIES OF THE TASK TEAM

The meeting gave consideration to its future activities and decided that three major tasks had been identified: a literature review, the selection of specific sites for case studies and preparation of a statement on measurement, experimental design and analysis, as well as possible policy options and response measures which may mitigate the negative consequences of the impact of climate change on mangrove ecosystems; and that these tasks could be completed in less than a year after the acceptance of this report. There was agreement that the second meeting of the Task Team should have available to it the reports that had been identified as being the outcome of the three phases of the project.

Considering its Terms of Reference, in particular para "c", the Task Team will prepare a "statement of possible policy options and response measures which may mitigate the negative consequences of the impact of climate change on mangrove ecosystems and their associated socio-economic structures".

The meeting recommended that:

"A second meeting of the Task Team should be held in nine months time, preferably at the location of one of the selected study sites."

The meeting also recommended that:

"UNEP and UNESCO(COMAR) be advised that as the Task Team was considering global processes with a far reaching perspective, that it expects to be able to operate on a long-term basis so that it can offer continuous and consistent advice. In order to achieve this objective the Task Team requested that consideration be given to further necessary support subsequent to the second meeting of the Task Team. "

The meeting then discussed its relationship with other comparable groups as it was aware of the establishment of other Task Teams. It was agreed that a close relationship with other Task Teams should be established and that there should be every effort to share information and experiences.

The meeting recommended that:

"The Chairman should make contact with other established Pilot Activities Task Teams, particularly the Task Team on Coral Reefs, to coordinate activities and to share information and experiences. "

11. RESOURCES

The meeting gave preliminary consideration to the resources that would be required to support the proposed workplan and the second meeting of the Task Team. A tentative breakdown was arrived at as follows:

(a) **Phase 1:** Literature Review and preparation of overview. Total:US $6,500 (Literature acquisition US $3,000; Editorial Committee to finalize report (2 days) US $2,000; Preparation costs US $1,500).

(b) **Phase 2:** Specific case studies. Total: US $30,000 (Three site visits at US $10,000 per visit and preparation of report and study plan).

(c) **Phase 3:** Experimental design and analysis. Total US $8,500 (Meeting of sub-group in Thailand in late November 1992, as three of the members will be in the region, site visit to Phang-nga Bay and preparation costs).

(d) Next meeting of the Task Team. Total US $35,000.

The estimated total cost of the four activities that have been recommended by the Task Team amounts to US $80,000.

12. ADOPTION OF THE REPORT OF THE MEETING

The report of the meeting including the annexes was considered and adopted by the participants.

13. CLOSURE OF THE MEETING

In closing the meeting the Chairman thanked the participants for their constructive comments, diligence and tolerance during the meeting. He also expressed on behalf of the participants their thanks to UNEP and UNESCO for convening and supporting the meeting and to the International Society for Mangrove Ecosystems (ISME), who had enabled the attendance of several of the participants. He also expressed special appreciation of the assistance that Marc Steyaert had given to the organization and conduct of the meeting. The meeting concluded at 1600 hrs on Wednesday 3 June 1992.

Annex 1

UNEP/UNESCO TASK TEAM MEETING ON IMPACT OF EXPECTED CLIMATE CHANGE ON MANGROVES

TASK TEAM MEMBERS

NAME	ADDRESS	POSITION
S Al-Numairy	Higher Environmental Committee Ministry of Health P O Box 1853-DUBAI United Arab Emirates	Secretary General
Peter R Bacon	Zoology Department University of the West Indies Mona, Kingston 7 Jamaica	Senior Lecturer
Claude Caratini	French Institute BP 33 Pondicherry 605001 India	Head Palinology Department
Barry Clough	Australian Institute of Marine Science PMB 3 Townsville, Qld, 4810 Australia Tel: 61-77-789211 Fax: 61-77-725852	Senior Research Scientist
Salif E Diop	Coordinator COMARAF Project c\o BREDA. P O BOX 3311 Dakar, Senegal	Professor at the University of Dakar
Joanna Ellison	Bermuda Biological Station for Research Ferry Reach GE 01 Bermuda	Graduate Intern
Colin Field	City Polytechnic of Hong Kong 83 Tat chee Avenue Kowloon, Hong Kong Tel: 788 9000 Fax: 788 9020 E-mail: CDFIELD@ CPHKVX.BITNET	Professor and Associate Director (Chairman)

Bjorn Kjerfve	Marine Science Program & Dept of Geological Sciences, Belle W Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia SC 29208, USA Tel: 1-803-777-2572 Fax: 1-803-777-4600	Professor of Marine and Geological
Luiz Drude de Lacerda	Dept of Geochemistry Universidade Federal Fluminense Niteroi 24210, RJ Brazil Tel: 021-7171313 Fax: 021-7174553	Head of Graduate Program in Environmental Geochemistry
Donald J Macintosh	Institute of Aquiculture University of Stirling Stirling FK9 4LA Scotland, UK Fax: 010-44786 72133	Lecturer in Tropical Aquiculture
Sanga Sabhasri	196 Phaholyothin Road Chatuchak Bangkok 10900 Thailand	Chairman, Executive Board National Research Council
Marta Vannucci	Rua Florida 1133-apt84 S Paulo-SP-04565 Brazil Tel: 55 11 530 3309 and Sector 29-N°1164-NOIDA 201-303-UP-INDIA Tel: 91 11 89-21685	retired from UNESCO
Alejandro Yanez-Arancibia	Program of Ecology Fisheries and Oceano-graphy of the Gulf of Mexico (EPOMEX), University of Campeche Ap postal 520 Campeche 24030, Campeche Mexico Tel: 52(981) 11600 52(981) 66589 Fax: 52(981) 65954	Scientific Director, Professor of Ecology and Management of Tropical Estuaries, Estuarine Nekton Community dynamics

OTHER PARTICIPANTS

UNESCO

Marc Steyaert	Office of the Inter-governmental Oceano-graphic Commission and Marine Related Issues UNESCO 1, rue Miollis 75015 Paris France Tel: 331 4568 3968 Fax: 331 4783 5940	Senior Specialist

OBSERVERS

Shigeyuki Baba	College of Agriculture University of the Ryukyus Senbaru, Nishihara Okinawa 903-01, Japan Tel: 098-895-2221 Fax: 098-895-2864	Assistant Professor and ISME Secretariat
Yoshihiro Kohda	Dept of Bio-Production College of Agriculture University of the Ryukyus Senbaru, Nishihara Okinawa 903-01, Japan Tel: 098-895-2221 Ext. 2901 Fax: 098-895-2864	Professor and Executive Secretary of ISME

Annex 2

First Meeting

of UNEP-UNESCO Task Team

on

Impact of Expected Climate Change on Mangroves

Rio de Janeiro, 1-3 June 1992

A G E N D A

Monday 1 June 1992

09:00	Opening remarks by Chairman
09:15	Formal establishment Task Team Adoption of Agenda Appointment of Rapporteurs
09:30	Discussion of nature of task, the agreement between UNESCO and UNEP, the pilot Activity 6 of the UNEP/WMO/IOC 'Long-term Monitoring System of Coastal and Near-shore Phenomena related to Climate Change" and the role of the Task Team as an advisory body on monitoring of mangroves
10:30	Coffee break
11:00	Initial consideration of Phase 1 - overview of existing literature to estimate potential impact of climatic changes on mangrove ecosystems and their associated socio-economic structures
11:30	A possible approach to Phase 1
12:30	Lunch
14:00	Continued discussion of Phase 1 - Scope of study - Workplan and timetable - Allocation of responsibilities - Consideration of outcome

15:30	Coffee break
16:00	Preliminary drafting of position on Phase 1
17:00	Close

Tuesday, 2 June 1992

09:00	Initial consideration of Phase 2 - specific case studies: - Well Developed Deltaic Site - Low Island Site - Arid Coast Site
11:00	Coffee break
11:30	General discussion of Phase 2
12:30	Lunch
14:00	Continued discussion of Phase 2 Scope of study Workplan and timetable Allocation of responsibilities Consideration of outcome
15:30	Coffee break
16:00	Preliminary drafting of position on Phase 2
17:00	Close

Wednesday, 3 June 1992

09:00	Initial consideration of Phase 3 - design of specific case studies and a long-term monitoring programme
10:30	Coffee break
11:00	Continued discussion of Phase 3 - Scope of study - Workplan and timetable - Allocation of responsibilities - Consideration of outcome
12:30	Lunch
14:00	Drafting of final report
15:30	Coffee break
16:00	Adoption of final report
17:00	Closure of the meeting

Annex 3

LIST OF SELECTED REFERENCES

Appleby, P.G. &F. Oldfield, 1992. Application of lead-210 to sedimentation studies, pp. 731-783. In Uranium-series disequilibrium: applications to earth, marine and environmental science. M. Ivanovich & R.S. Harmon (eds.), Clarendon Press, Oxford. 910 pp.

UNESCO, 1992. Application of marine and coastal image data. MARINF/83. Paris. 101 pp.

Buchanan, T.J. & W.P. Somers, 1969. Discharge measurements at gaging stations. Chapter A8. Techniques of Water-Resources Investigations of the United States Geological Survey. Book 3. Applications of Hydraulics. U.S. Government Printing Office, Washington, DC. 65 pp.

CERC (US Army Coastal Engineering Research Center), 1977. *Shore protection manual.* Three volumes. US Government Printing Office, Washington, DC.

Delaune, R. D., W.H. Patrick & R.J. Buresh, 1978. Sedimentation rates determined by ^{137}Cs dating in a rapidly accreting salt marsh. *Nature 275: 532-533.*

France, A.S, 1988. *Tides, fundamentals, analysis, and prediction.* FCTH, Fundação Centro Tecnológico de Hidráulica, São Paulo. 249 pp.

Kjerfve, B., 1990. *Manual for investigation of Hydrological processes in mangrove ecosystems.* UNESCO/UNDP, New Delhi, India. 79 pp.

Krishnaswami, S., L.K. Benninger, R.C. Aller, K.L. von Damm, 1980. Atmospherically-derived radionuclides as tracer of sediment mixing and accumulation in near-shore marine and lake sediments: evidence from ^{7}Be, ^{210}Pb, ^{23}Pu, ^{240}Pu. *Earth and Planetary Science Letters 47.*

Méthodologie d'inventaire et de contrôle de l'Erosion côtière dans la région de l'Afrique de l'Ouest et du Centre. 1988. UNEP (OCA)/WACAF IG.2/INF.6.

NOS/NOAA, 1976. *Manual of tide observations.* Coast and Geodetic Survey (now: National Ocean Service, NOS/NOAA). Publication no. 30-1, a revision of Special Publication no. 196. Washington, DC. 72 pp.

NOS/NOAA, 1976. *Manual of harmonic constant reductions.* Cost and Geodetic Survey (now: National Ocean Service, NOS/NOAA), Special Publication no. 260, originally printed 1962. Washington, DC. 74 pp.

Pugh, D. T., 1987. *Tides, Surges and Mean Sea Level: A Handbook for Engineers and Scientists.* John Wiley & Sons, New York. 472 pp.

Schureman, P., 1941. *Manual of harmonic analysis and prediction of tides.* Coast and geodetic Survey (now: National Ocean Service, NOS/NOAA). Special Publication 98. Washington, DC. 331 pp.

UNESCO REPORTS IN MARINE SCIENCE

Cont'd on inside of back cover
Cont'd from inside of front cover

No.		Year
45	Marine science teaching and training at first degree (undergraduate) level. Recommended guidelines from a UNESCO workshop on university curricula, Paris, November 1986. Available in Arabic, Chinese, English, French, Russian and Spanish	1987
46	Comparison between Atlantic and Pacific tropical marine coastal ecosystems: community structure, ecological processes, and productivity. Results and scientific papers of a UNESCO/COMAR workshop, University of the South Pacific, Suva, Fiji, 24-29 March 1986. English only	1987
47	Temperate coastal systems of Latin America. Report on meeting on COSALC Pilot Project No. VII, November 1986. Spanish only	1987
48	Coastal marine ecosystems of Africa. Objectives and strategy of the COMARAF Regional Project English only	1988
49	Eutrophication in the Mediterranean sea: receiving capacity and monitoring of long-term effects. Report and proceedings of a Scientific Workshop, Bologna, Italy, 2 to 6 March 1987. Sponsored by: UNESCO, FAO, UNEP, Regione Emilia Romagna and University of Bologna. English only	1988
50	Marine Geology of the West African shelf zone. Available in English and Russian	1988
51	Physical oceanography of the Eastern Mediterranean (POEM): Programme for 1988/89. English only	1988
52	Year 2000 challenges for marine science training and education worldwide. Available in Arabic, Chinese, English, French, Russian and Spanish	1988

No.		Year
53	Physical oceanography of the Eastern Mediterranean (POEM): The intercalibrated POEM data set and the emerging picture of the circulation, POEM Scientific Workshop, Trieste, Italy, 31 May-4 June 1988. English only	1990
54	Relative sea-level change: a critical evaluation. UNESCO (COMAR) Working Group on Mean Sea-Level Rise and its Influence on the Coastal Zone. English only	1990
55	Physical oceanography of the Eastern Mediterranean (POEM): The new phenomenology of the Eastern Mediterranean. POEM Scientific Workshop, Cambridge, Massachusetts, USA, 29 May-2 June 1989. English only	1991
56	Geological and geophysical investigations in the Mediterranean and Black Seas. Initial results of the 'Training through Research' Cruise of RV Gelendzhik in the Eastern Mediterranean and the Black Sea (June-July 1991). English only	1992
57	Physical oceanography of the Eastern Mediterranean (POEM): The scientific plan for the second phase of POEM. Fourth POEM Scientific Workshop, Venice, Italy, August-September 1990. English only	1992
58	Geological development of the Sicilian-Tunisian Platform. Proceedings of the International Scientific Meeting held at the University of Urbino, Italy, 4-6 November 1992. English only	1993
59	Artificial radioactivity of the Black Sea. English only	1993
60	Inventory of innovative learning materials in marine science and technology. English only	1993

UNESCO REPORTS IN MARINE SCIENCE

Title of numbers which are out of stock

No.		Year
1	Marine ecosystem modelling in the Eastern Mediterranean. Report of a UNESCO workshop held in Alexandria, Egypt, December 1974. English only	1977
2	Marine ecosystem modelling in the Mediterranean. Report of the Second UNESCO Workshop on Marine Ecosystem Modelling. English only	1977
3	Benthic ecology and sedimentation of the south Atlantic continental platform. Report of the seminar organized by UNESCO in Montevideo, Uruguay, 9-12 May 1978.	1979
7	Coastal ecosystems of the Southern Mediterranean: lagoons, deltas and salt marshes. Report of a meeting of experts, Tunis, 25-27 September 1978.	1979
11	Programa de Plancton para el Pacífico Oriental. Informe final del Seminario Taller realizado en el Instituto del Mar del Perú. El Callao, Perú, 8-11 de septiembre de 1980.	1981
12	Geologia y geoquimica del margen continental del Atlantico Sudoccidental. Informe final del Taller de Trabajo organizado por la UNESCO en Montevideo, Uruguay, 2-4 de diciembre de 1980.	1981
13	Seminario Latinoamericano sobre Enseñanza de la Oceanografía. Informe final del Seminario organizado por la UNESCO en São Paulo, Brasil, 17-20 de noviembre de 1978.	1981

No.		Year
16	Marine and coastal processes in the Pacific: ecological aspects of coastal zone management. Report of a UNESCO seminar held at Motupore Island Research Centre, University of Papua New Guinea, 14-17 July 1980.	1981
17	The coastal ecosystems of West Africa: coastal lagoons, estuaries and mangroves. A workshop report, Dakar, 11-15 June 1979.	1981
18	Coral reef management in Asia and the Pacific: some research and training priorities. Report of a UNESCO workshop held in Manila, Philippines, 21-22 May 1981. English only.	1982
19	Mareas rojas en el Plancton del Pacífico Oriental. Informe del Segundo Taller del Programa de Plancton del Pacífico Oriental, Instituto del Mar Callao, Perú, 19-20 de noviembre de 1981. Spanish only	1982
27	Productivity and processes in island marine ecosystems. Recommendations and scientific papers from the UNESCO/IOC sessions on marine science co-operation in the Pacific, at the XVth Pacific Science Congress, Dunedin, New Zealand, February 1983. English only	1984