

Intergovernmental Oceanographic Commission
Workshop Report No. 96



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Swedish Agency for Research Cooperation
with Developing countries

IOC-UNEP-WMO-SAREC
Planning Workshop on
an Integrated Approach
to Coastal Erosion, Sea-Level
Changes and their Impacts

Zanzibar, United Republic of Tanzania,
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1. OPENING

Dr M.A.K. Ngoile, Director of the Institute of Marine Sciences (IMS) of the University of Dar-es-Salaam (UDSM), welcomed the participants and offered his particular thanks to the Guest of Honour, His Excellency the Hon. Said Bakari Jecha, Minister for Information, Government of Zanzibar, noting his expression of commitment to environmental issues. Dr Ngoile said that IMS was honoured to be asked to host the Workshop. He expressed his particular thanks to those who had provided assistance in the organization and sponsorship of the Workshop, in particular the Intergovernmental Oceanographic Commission (IOC) and the Swedish Agency for Research Co-operation with Developing countries (SAREC). He stressed the importance of the subject matter of the Workshop at this time, noting the far-reaching economic implications.

Dr A. Tolkachev welcomed the participants on behalf of the Secretary IOC, Dr G. Kullenberg. He expressed his appreciation of the efforts of IMS in making the arrangements for the Workshop, outlining the history of events that led to its realization. Dr Tolkachev said that the IOC Regional Committee for the Co-operative Investigations in the North and Central Western Indian Ocean (IOCINCWIO), at its third session (Mauritius, 14-18 December 1992), had called on Member States to monitor and provide information to governments on coastal erosion and sea-level change. They recognized the need for the various disciplines to come together and work towards an integrated approach to understanding the systems to be able to provide advice to national authorities. Dr Tolkachev noted the opportunity for a wide regional scope in sea-level change studies in the Indian Ocean. He drew attention to the relevance of this Workshop to the Global Ocean Observing System (GOOS) project initiated by the IOC, in particular the GOOS modules concerning climate change and coastal issues. He acknowledged the valuable support provided for the Workshop by SAREC, also the sponsorship of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Finally, he thanked IMS and its Director, Dr Ngoile, for their arrangements for the Workshop.

Dr A. Granlund expressed his pleasure that SAREC has had the opportunity to co-sponsor this Workshop. He was particularly supportive of the interdisciplinary approach and the wide discussion that this afforded. He acknowledged the excellent organization that Dr Ngoile and IMS had achieved. Dr Granlund noted the importance of the region tackling its own problems and issues in achieving sustainable development. SAREC has noted with interest the progress made since the first marine regional meeting in Dar-es-Salaam in 1989. Dr Granlund said that he was confident that a momentum was now established. He hoped for an active Workshop and encouraged the participants to be active in their endeavours.

The Hon. Said Bakari Jecha, Minister for Information, Culture, Tourism and Youth, expressed his pride that Zanzibar had been chosen as the host for this Workshop. He extended his welcome to the participants, noting that such a gathering provided an excellent opportunity to meet and promote international understanding. The integrated approach was in line with the recommendations of UNCED Agenda 21. He recognized the heavy economic dependence of the region on its coastal zone, with many people reliant on its sustainable productivity. It was therefore important that scientists from the region consider the problems and advise governments on management issues. He said that pragmatic solutions were needed in efforts to protect the coastal zone. He hoped that the Workshop would achieve these objectives through a sharing of knowledge and experience within the whole region. The Honourable Minister observed that in all countries many different agencies were involved in coastal zone management. The problems needed to be tackled in an integrated manner, education as well as co-operation was essential. The Government of Zanzibar was aware of the vulnerability of small islands within the region, particularly in respect of the loss of coastal land. It awaited with great interest the outcome of the Workshop and expressed its willingness to implement its recommendations.

2. ADMINISTRATIVE ARRANGEMENTS FOR THE WORKSHOP

Dr M. Ngoile was designated as Chairman for plenary sessions and Dr A. Tolkachev acted as Secretary/Coordinator for the Workshop. Dr L. Lwiza was designated as Rapporteur for plenary sessions. The Chairmen and Rapporteurs of the individual working groups are given in Annex I (Programme of the Workshop).

The participants considered the structure of the Workshop mindful of the aim of achieving an integrated approach and approved the programme as given in Annex I. The List of Participants is given in Annex II.

3. SPECIALIST INTRODUCTORY PRESENTATIONS

3.1 REVIEW OF COASTAL EROSION PROBLEMS IN THE REGION (A. Granlund)

Coastal erosion has been causing severe problems in the Western Indian Ocean Region during the last decade. Coastal erosion processes have occurred since the forming of the oceans. Today, however, erosion is caused not only by natural processes. As man has made more use of the coast for various activities such as fishing, especially using dynamite, for extracting construction materials and for tourism, erosion has been accelerated. Coastal erosion is causing severe damage and is expensive for governments dealing with tourism. The erosion is linked to the transport of sediment from one place to another driven by waves and winds. The abrasive effect of waves is enormous and large amounts of sediment are transported. Sediment transportation is a process that has been active throughout geological history. To fully understand sea-level fluctuations and coastal erosion, it is important to have a good knowledge of oceanographic factors and the present geological development of coastal environments.

Sea-level fluctuation is difficult to measure. Today, the accuracy of sea-level measurements enables the identification of long-term trends. The causes of these changes are not understood, but factors such as tectonic subsidence can result in sea-level and other oceanographic changes in a long term perspective. It is difficult to predict the future without a knowledge of the past. It is therefore important to build up baseline information over coastal areas that are vulnerable to erosion. These studies should aim to consider and integrate the many different aspects of coastal erosion and sea-level change. Actions to cope with coastal erosion should be recommended based on a multidisciplinary understanding. It is particularly important to distinguish between human activities and natural processes as contributors to coastal erosion.

3.2 SEA-LEVEL VARIATIONS AND CHANGES IN THE INDIAN OCEAN (G. Lennon)

The aim is to provide a brief overview of the climate change mechanism leading to a current understanding of the implications for sea-level trends. This survey includes reference to the many uncertainties that exist, not only of physical processes that control the mechanism but also of the decisions that need to be taken by the international community in decelerating the accumulation of greenhouse gases.

The considered opinion is that in recent historic time sea-level has been rising at a rate of 1.5 mm per year. The uncertainties underline the need for careful monitoring while the small magnitude of the signal places rigorous specifications on the instrumentation to be used. Conventional float-operated systems are under stress to achieve this target. They are not to be discouraged since they have been responsible for long-observed time series which must be continued. However, to select sensors matched to the specifications implies a resolution and accuracy of 1 mm with equivalent datum control.

The role of the Indian Ocean in the complex mechanism of ocean-atmosphere coupling is considered as are the valuable products which spin off from the search for trends. In fact, sea level is seen to be a powerful indicator of interannual climate variability with a potential to forecast drought cycles.

3.3 IOC-UNEP-WMO PILOT ACTIVITY ON SEA-LEVEL CHANGES AND ASSOCIATED COASTAL IMPACTS (S. Shetye)

The primary objective of this project is to enhance the capabilities of the countries of the Indian Ocean to monitor and analyze sea-level data. The project envisages the setting up of a network of Cells for Monitoring and Analysis of Sea level (CMAS). The task of the scientists associated with each CMAS will be to secure high quality sea-level data recorded in their region of responsibility and to analyze these data to understand the variability seen in the data. The details concerning implementation of the project are summarized in the IOC Document IOC/INF-908 (Draft Action Plan for Implementation in the Indian Ocean).

The following eight countries have now formally set up CMAS's: Bangladesh, India, Kenya, Madagascar, Malaysia, Republic of Maldives, Mauritius and Mozambique. It is expected that each one of these CMAS's will identify the research problems that are most common and will use sea-level and other relevant data to set up a framework for co-operation amongst CMAS's, IOC, UNEP, WMO and SAREC so that the goals set by each CMAS are met within a time-bound programme, and based on a commonly agreed approach.

3.4 STATUS OF THE GLOSS NETWORK IN THE IOCINCWIO REGION (M. Odido)

A total of seventeen GLOSS sea-level stations were proposed for the IOCINCWIO region. Of these, only three (Zanzibar, Dzaoudzi and Pointe des Galets) were operational at the beginning of the TOGA experiment in 1985. From 1986 several gauges were installed by the University of Hawaii (UH), within the framework of TOGA. These included Mombasa, Mogadishu, Port Louis, Rodrigues, Port Victoria and Agalega. Other gauges have also been installed at Inhambane, Pemba (Mozambique), Nosy Be, and Port Dauphin (Madagascar).

The status of the tide gauges in the region at the end of 1993 can be summarized as follows. Two tide gauges were installed but not operational at Port Victoria and Pointe des Galets. The stations in Aldabra and Farquar were not operational due to unsuitable sites for sea-level stations. The planned station in Mtwara was not installed. From the stations in Djibouti, Hafun and Mogadishu, no information was available. The remaining GLOSS stations in Mombasa, Zanzibar, Dzaoudzi, Nosy Be, Fort Dauphin, Port Louis, Rodrigues, Inhambane and Pemba were all installed and are operational. Thus, in summary, there are presently nine GLOSS operational stations in the region.

A global overview of existing sea-level observations was prepared by IOC and PSMSL, *inter alia* to provide information for the Small Islands Developing States Conference (1994), and is published as Document IOC/INF-954, 1994.

3.5 GOOS COASTAL PILOT MONITORING ACTIVITIES AND GLOSS (A. Tolkachev)

IOC has initiated the development of the Global Ocean Observing System (GOOS) in collaboration with WMO, UNEP and ICSU. This initiative was supported by the Second World Climate Conference (1990) and UNCED (1992). The objective of GOOS is to ensure global, permanent, systematic observations adequate for forecasting climate variability and change; for assessing the health or state of the marine environment and its resources, including the coastal zone; and for supporting an improved decision-making and management process, which takes into account potential natural and man-made changes in the environment and their effects on human health and resources.

The planning presently encompasses five modules: (i) Climate Monitoring, Assessment and Prediction; (ii) Monitoring and Assessment of Marine Living Resources; (iii) Monitoring of the Coastal Zone Environment and its Changes; (iv) Assessment and Prediction of the Health of the Ocean; and (v) Marine Meteorological and Oceanographic Operational Services. GOOS will be developed from existing operational and scientific data-gathering systems such as IGOSS, DBCP and GLOSS. GLOSS, operated and maintained by some 80 countries, constitutes an important operational element of GOOS and will, *inter alia*, provide input to Climate and Coastal modules of GOOS.

The coastal pilot monitoring activities, initiated by the joint efforts of IOC, UNEP, WMO and IUCN, address variables and phenomena that are both economically important and sensitive to climate change, such as coral reefs, mangrove communities, plankton community structure and coastal circulation. One of the pilot activities initiated in the Indian Ocean addressing Monitoring of Sea-level Changes and Associated Coastal Impacts will be considered at this workshop. These pilot activities are recognized as a contribution to GOOS, and GOOS Coastal Module, in particular.

Many countries of the Indian Ocean participate actively in the Sea-level Pilot Monitoring activity, GLOSS, coastal erosion studies and other international programmes, co-ordinated by IOC and other international agencies. It is expected that the Workshop will help to link more closely national interests related to coastal zone management and international activities within the Global Ocean Observing System.

4. FORMULATION OF SCOPE AND OBJECTIVES

The participants agreed on the following objectives for the Workshop:

- (i) to help provide practical outputs that are useful to governments, making clear statements of the socio-economic justification for programmes of research into coastal erosion and sea-level change;
- (ii) to ensure that proposals take into account as far as possible socio-economic constraints;
- (iii) to identify outputs that are likely to be of immediate interest to policy makers, mindful of the benefits of discussing such identified outputs with policy makers;
- (iv) to provide clear scientifically based information;
- (v) to make proposals for education in the environmental issues related to coastal and sea-level change;
- (vi) to take a positive attitude in making recommendations, particularly in the provision of unpalatable advice to governments;
- (vii) to aim at identifying possible options open to managers and planners, noting benefits and disadvantages as appropriate, for example as they would affect tourism;
- (viii) to ensure that proposed monitoring and survey programmes take account of the urgency of the need for management action; time-scales should be appropriate and realistic;
- (ix) to emphasize the implications of scientific results, identifying the applications of outputs to facilitate good practice in coastal zone management; and
- (x) to propose and emphasize the use of indigenous expertise in the execution of coastal erosion and sea-level changes activities with a view to motivating local experts.

5. NATIONAL PRESENTATIONS

Participants from each country summarized the work undertaken by their respective countries relating to coastal erosion and sea-level change in the Indian Ocean region. The list of national presentations is given in Annex III. It is intended that all presentations will be published in the Supplement to this Report.

6. RESULTS OF THE WORKING GROUPS

6.1 WORKING GROUP ON COASTAL EROSION

The Group was chaired by Dr E. Odada and Dr R. Arthurton was designated as Rapporteur. The Group reviewed the present activities of the countries of the region in the study of coastal erosion and formulated proposals on the development and implementation of a Pilot Study on Coastal Erosion in the region.

The participants in the Working Group on Coastal Erosion agreed on the following action points:

- (i) Justification and background information
 - (a) that participating countries ensure that the problem of coastal erosion, as it affected their coasts, was clearly quantified in terms of the lengths of coast affected and, if possible, the rates of coastal recession;
 - (b) that participating countries made a clear statement of the socio-economic consequences of coastal erosion;

Recommendation: That a regional prospectus should be prepared that presents a clear statement to governments of participating countries of the problems of coastal erosion.

Recommendation: That IOC, in collaboration with donor agencies, examine ways of funding a regional prospectus on the problems of coastal erosion.

- (ii) Objectives and outputs
 - (a) participating countries should aim to prepare a geologically based classification of their coasts, extensively indicating the relative vulnerability to erosion of soft, unconsolidated sediments and lithified material;
 - (b) based on an extensive appraisal by desk study and supporting fieldwork, countries should select study sites that also provide opportunities for study contributions from a wide range of disciplines;
 - (c) countries should aim at assessing the sources and sinks of the coastal sediments of their selected study site and report on the regimes of sediment transport; this assessment should include the production of a habitat map for the site;
 - (d) countries should aim at characterizing the hydrodynamic conditions affecting their selected study site, noting their variation over a variety of time-scales and climatic conditions;
 - (e) countries should review the socio-economic aspects of the study site, noting anthropogenic activities that may affect the sedimentary and hydrodynamic regimes;
 - (f) countries should aim at making realistic recommendations for protective or remedial action in respect of coastal erosion at the study site.

Recommendation: That countries should select study sites that provide opportunities for input from a wide range of disciplines based on an extensive appraisal of their coastlines.

Recommendation: That IOC be approached with a request to facilitate, in co-operation with governments and donor agencies and the Private Sector, the implementation of a Pilot Study on Coastal Erosion.

(iii) Methodology

The participants of the Working Group agreed on the implementation of a structured approach to the methodology as follows:

- (a) literature review - based on geological records, meteorological data, historical records, admiralty charts and socio-economic data;

- (b) shoreline evolution - analysis based on topographic maps, admiralty charts, aerial photographs, remote sensing data and field observations;
- (c) measurement networks - including positioning system, sampling and analyses, beach and dune profiling, wind measurements, long-shore currents, wave characteristics, sediment transport, and causes and effects of beach erosion;
- (d) socio-economic impacts - impact assessments of activities such as beach sand extraction, sea wall construction; also assessments of the effects of erosion on property.

The Working Group agreed that much of the methodology could be carried out successfully without the need for sophisticated and expensive equipment. It had noted several examples of improvisation. There were several instances, however, where the need for assistance in the provision of additional equipment was recognized.

Some participants reported that their countries had already made significant progress in applying the methodology as outlined.

Recommendation: **That participating countries should implement a structured methodology following those recommendations approved by IOC.**

(iv) Resources

The Working Group considered the resources necessary and available to carry out the Pilot Study on Coastal Erosion as envisaged. Participants reviewed the financial constraints and human resource limitations in their respective countries. In some cases, the institutional framework was lacking. The Working Group agreed on the need for each country to identify a lead institution for the project and to establish a team representing the various required disciplines.

In considering the requirements for training of researchers and technicians, the Working Group agreed that regional networking was of particular importance. The sharing and transfer of skills within the region on an exchange basis was seen as an aim, benefitting trainer and trainee alike. The specialist training of geologists, oceanographers and engineers in sedimentology and hydrodynamics was another way of building up the regional expertise. Input from external consultants was envisaged for short-term supervision, particularly at the start of the project as well as in the compilation and analysis of data.

Recommendation: **That IOC should invite that participating countries to identify a lead institution as well as an interdisciplinary Task Team to execute the Pilot Studies in their respective countries.**

(v) Collaboration and co-ordination

The Working Group shared the view that there was a need to be more aware of the on-going and proposed projects within the region that may be relevant to the Pilot Study on Coastal Erosion. Countries need to be informed of the activities of groups operating under different donor funding arrangements, in order to make the best use of resources.

Recommendation: **That IOC and collaborating agencies seek to ensure the co-ordination of various activities relating to the coastal zone, and in particular to coastal erosion, utilizing as far as possible the existing facilities of the Regional Office for Science and Technology in Africa (ROSTA).**

6.2 WORKING GROUP ON SEA-LEVEL CHANGE

The Working Group was chaired by Dr S. Shetye and Mr M. Odido was designated as Rapporteur.

The Working Group reviewed the present and planned activities of the designated Cells for Monitoring and Analysis of Sea Level (CMAS) within the framework of the IOC-UNEP-WMO Pilot Activity on Sea-Level Changes and Associated Coastal Impacts in the Indian Ocean.

The following countries have established CMAS: Bangladesh, India, Kenya, Madagascar, Malaysia, Maldives, Mauritius and Mozambique (see Annex IV). In addition, it is expected that Tanzania will be setting up a CMAS soon. Seychelles has agreed to support the activities proposed under the Pilot Activity by making sea-level data from its stations available to interested researchers. Australia also expressed an interest in the activities of CMAS.

The Working Group agreed that it would be desirable for each CMAS to bring in as many tide gauges as possible in its network. Each CMAS should acquire the capability to compute tidal constituents, detided sea levels and make at least a preliminary attempt at explaining the main features seen in detided sea-level records. The Group emphasized the need to link the benchmarks and datums of the sea-level stations to the national precision level framework.

Participants in the Working Group on Sea-Level Change agreed on the following action points:

(i) Capacity building

Most of the CMAS do not have the capability to analyze sea-level data and prepare products for various categories of users. **The Working Group recommended that each CMAS should have at least one physical oceanographer.** During the first period 1994/1995, priority should be given to short-term training on analysis of sea-level data and maintenance of tide gauges.

Dr Lennon drew the attention of the Working Group to such courses offered in Australia. The Working Group requested the IOC Secretariat to get in touch with the Australian International Assistance Bureau and explore the possibility of getting assistance from its programmes for the Indian ocean to strengthen the capacity of the CMAS.

The scientist in charge of CMAS for India indicated that their CMAS can offer training in tide prediction and maintenance of tide gauges. In addition to the training requirements, several tide gauges also need to be installed or upgraded. A summary of the requirements of each CMAS is given in Table 1.

Table 1: Requirements for Advice, Assistance and Training of CMAS Specialists

COUNTRY	TIDE GAUGES NEW (1)	TIDE GAUGES UPGRAD E (2)	CONSULTA NT	TRAININ G SHORT (3)	TRAINING LONG (4)	REMARKS
Bangladesh	1	1	+	1		
India				2		
Kenya	1	1		2	2	(3) possibly in TOGA/SLC
Madagascar		1		1	1	(3) possibly in TOGA/SLC
Malaysia					1	
Maldives				2		(3) possibly in India
Mauritius	1			1		
Mozambique				2	2	
Seychelles				1		
Tanzania				1	1	Australia underway

Short-term training should be given priority in 1994.

- (1) *number of new tide gauges required*
(2) *number of tide-gauges to be upgraded*
(3) (4) *number of persons to be trained*

(ii) CMAS Newsletter

Keeping in view the fact that the activities under the CMAS network will be the first organized effort in the Northern and Western Indian Ocean to use sea-level data to help understand the oceanography of the region, it is necessary at this stage to provide a mechanism for dissemination of information concerning operations of different CMAS, developments in software and measurement technologies, etc. **The Working Group therefore recommended that a newsletter covering the activities of the CMAS be launched.** Dr Lennon informed the Working Group about the existence of a newsletter covering sea level news in Australia and will provide the contact address to any CMAS which is interested in receiving a copy.

The Working Group suggested that Dr Kamazima Lwiza, Marine Sciences Research Center, State University of New York, be requested to take the responsibility for establishing the newsletter which should be published

biannually. The Working Group requested the IOC Secretariat, in collaboration with Dr Lwiza, to explore the possibility of publishing a newsletter for the region starting 1994.

(iii) PSMSL data holdings

The PSMSL has in its holdings monthly mean sea-level data from the Indian Ocean region. The Working Group felt that it would be highly desirable to undertake a study of these data to understand the dominant oceanic signals contained in these data. Dr Shetye was requested to undertake this exercise taking note of previous work in the area. All CMAS are also encouraged to undertake analysis of data available from PSMSL and other sources.

(iv) Special problem areas

The scientist in charge of the Bangladesh CMAS, Mr Abdul Matin Mondal, informed the Working Group of the special problem existing in his country in maintaining the tide-gauge network due to serious erosion and siltation arising from heavy flooding. He requested the services of a consultant to assist in identifying an appropriate site for the sea-level station.

(v) Application of sea-level studies towards society needs

The analysis of sea level for tidal predictions was one of the first practical applications of the science of oceanography. Today, such analysis is an indispensable tool of service to the worldwide maritime activities. The CMAS network is an effort to strengthen the capabilities of the participating countries in the use of this tool. In addition, it envisages that the results of the analysis proposed under this programme will help in the following:

- (a) It is now recognized that low-lying regions often experience episodes of sudden increase in sea level, leading to the loss of property and life. One such event occurred in Mauritius between 31 May and 1 June 1987, when very huge waves reached the coast at spring tide and caused flooding and serious erosion on the beaches. These events cannot be forecast on the basis of tidal predictions alone. To understand them requires an understanding of the physical oceanography of the region. Study of detided sea level is an important element of this. The Working Group therefore strongly encouraged such studies. **It further recommended that each CMAS undertakes studies relating to extreme events and communicate their findings to concerned authorities.** These will then act as a guide in policy formulation for avoiding damage to life and property due to extreme events.
- (b) Sea-level variability and associated tidal circulation has significant implications in the process of sedimentation and erosion in the region. Each CMAS is therefore strongly encouraged to interact with researchers studying such problems so that knowledge gained from sea-level analysis become available to other disciplines.

(vi) Use of other data

One of the principal goals of the CMAS network is to create an awareness that sea level is an important oceanographic variable that can be measured relatively easily. The sea level is linked not only to the working of the oceans but also to the global climate. It was felt that, in addition, it would be desirable to tap other sources of information on how the sea level has varied in the past. The **Working Group therefore recommended that each CMAS make an effort to:**

- (a) **identify historical tide-gauge records and keep the CMAS community informed about its availability;**
- (b) **use available satellite-based altimeter data in interpretation of tidal data;**
- (c) **examine possibilities of using non conventional techniques to construct sea-level variability over the past few hundred years in the region.**

(vii) Future enlargement of the CMAS network

The Working Group strongly urged the IOC Secretariat to make renewed efforts to encourage countries that have not established a CMAS to do so. It was felt that an enlarged CMAS network would be of great benefit to the

countries bordering the Western and Northern Indian Ocean which, in the last few years, have shown increased interest in marine sciences.

(viii) Co-ordination mechanism for the CMAS network

The Working Group recommended that a Task Team on the Pilot Activity on Monitoring Sea-Level Changes and Associated Coastal Impacts in the Indian Ocean be set up to oversee the working of the CMAS network. This Task Team will consist of the scientists in charge of all constituent CMAS. The Working Group also recommended that Dr Shetye be the Co-ordinator of the Pilot Activity to advise and assist the IOC Secretariat in the implementation of the recommendations of the Task Team.

(ix) Next meeting of CMAS researchers

The Working Group felt that researchers involved with the CMAS Network should meet in about a year from now to evaluate the progress of the Pilot Activity, present results of activities undertaken during the first year of operation and take up corrective measures if needed to facilitate smooth functioning of the network.

The scientist in charge of the CMAS-India offered to host this meeting at Dehra Dun, India. The Working Group recommended that the IOC Secretariat accept this offer.

7. RESPONSES AND RECOMMENDATIONS

The Planning Workshop on an **Integrated Approach to Coastal Erosion, Sea-level Changes and their Impacts** presented recommendations to the Intergovernmental Oceanographic Commission for follow-up workshops within the subject areas of **Coastal Erosion** and **Sea-level Rise**. The compiled recommendations from the working groups are as follows:

- (i) **that a regional prospectus should be prepared that presents a clear statement to governments of participating countries of the problems of coastal erosion.**
- (ii) **that IOC, in collaboration with donor agencies, examine ways of funding a regional prospectus on the problems of coastal erosion.**
- (iii) **that countries should select study sites that provide opportunities for input from a wide range of disciplines based on an extensive appraisal of their coastlines.**
- (iv) **that IOC, in co-operation with governments and donor agencies and the Private Sector, be approached with a request to facilitate the implementation of a Pilot Study on Coastal Erosion.**
- (v) **that participating countries should implement a structured methodology following recommendations approved by IOC.**
- (vi) **that IOC should invite the participating countries to identify a lead institution as well as an interdisciplinary Task Team to execute the Pilot Studies in their respective countries.**
- (vii) **that IOC and collaborating agencies seek to ensure the co-ordination of various activities relating to the coastal zone, and in particular to coastal erosion, utilizing as far as possible the existing facilities of the Regional Office for Science and Technology in Africa (ROSTA).**

For the IOC-UNEP-WMO Pilot Activity on Monitoring of Sea-Level Changes and Associated Coastal Impacts, the Planning Workshop recommended that each Cell of Monitoring and Analysis of sea level (CMAS) should have at least one physical oceanographer within its unit. The Workshop also recommended that a newsletter covering the activities of the CMAS should be launched using the WINDOW Newsletter. The Workshop further recommended that each CMAS undertake studies relating to extreme events and communicates their findings to concerned authorities.

The Workshop recommended that each CMAS make an effort to:

- (i) **identify historical tide-gauge records and keep the CMAS community informed about their availability;**
- (ii) **use available satellite-based altimeter data for the interpretation of tidal data;**
- (iii) **examine possibilities of using non-conventional techniques to construct sea-level variability over the past few hundred years in the region.**

The Workshop recommended that a Task Team be set up to oversee the working of the CMAS network under the Pilot Activity. The Workshop also recommended that Dr Shetye be the Co-ordinator of the Pilot Activity on Monitoring of Sea Level and Associated Coastal Impacts in the Indian Ocean to advise and assist the IOC Secretariat in implementing the recommendations of the Task Team. The Workshop also requested the IOC to provide assistance to the countries participating in the Pilot Activity in training their specialists in sea-level analysis and in providing instruments.

The Workshop invited all national institutions participating in the coastal erosion and sea-level pilot activities to ensure close working interaction among the scientists designated for those activities with a view to achieving an integrated approach in developing national programmes relating to the integrated management and sustainable development of the coastal zone.

The Workshop invited IOC, in co-operation with UNEP, WMO and SAREC, to continue supporting the pilot activities considered and recommended by the Workshop which will develop a basis for systematic observations in the coastal zone as an important component of the Global Ocean Observing System.

8. CLOSURE

Mr Saleh Sadik Osman, Principal Secretary, Ministry of Agriculture, Livestock and Natural Resources, attended the closing ceremony and, in his closing statement, emphasized the importance of the results of the Workshop regarding coastal erosion problems, sea-level changes and their associated impacts, which are of great concern to many countries in the region, with a view to formulating an integrated approach to solving such problems. He referred to Agenda 21 and the Convention on Climate Change adopted by UNCED which call upon countries to co-operate in organizing systematic observations in the world oceans and coastal zone with a view to providing reliable assessment and prediction of changes in the coastal areas. Such information is important to national authorities when dealing with coastal zone management issues. He wished to encourage strengthening co-operation among countries of the region in tackling these problems. He thanked IOC, SAREC, UNEP and WMO for the support provided to the Workshop.

All participants expressed their thanks to Dr Ngoile for his efficient conducting of the Workshop as Chairman, and also to the staff of the Institute of Marine Sciences for hosting the Workshop so generously.

Finally, Dr Ngoile thanked the participants, the representatives of IOC and SAREC, and the distinguished guests for their inputs and support towards the successful outcome of the Workshop. He declared the Workshop closed at 16.00 on 21 January 1994.

ANNEX I

PROGRAMME OF THE WORKSHOP

MONDAY, 17 JANUARY

MORNING

1. **Opening Ceremony**

Welcome Address

Dr. M.K. Ngoile, Director, Institute of Marine Sciences

Address

Dr. A. Tolkachev, IOC

Address

Dr. A. Granlund, SAREC

Opening Speech

Hon. Said Bakari Jecha, Minister for Information, Culture, Tourism and Youth

2. **Administrative Arrangements**

Election of the Chairman of the Workshop and of a Rapporteur

Local Arrangements

Programme and Timetable of the Workshop

3. **Scope and Objectives of the Workshop**

Review of Coastal Erosion Problems in the Region

Dr. A. Granlund, SAREC

Sea-Level Variations and Changes in the Indian Ocean

Prof. G. Lennon, The Flinders University of South Australia

IOC-UNEP-WMO Pilot Activity on Sea-Level Changes and Associated Coastal Impacts

Dr. S. Shetye, National Institute of Oceanography, India

AFTERNOON

Status of the GLOSS Network in the IOCINCWIO Region

Mr. M. Odido, Kenya Marine and Fisheries Research Institute

GOOS Coastal Pilot Monitoring Activities and GLOSS

Dr. A. Tolkachev, IOC

Formulation of the Scope and Objectives of the Workshop

TUESDAY, 18 JANUARY

MORNING

National Presentations on Coastal Erosion
Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania

AFTERNOON

National Presentations on the Activities of Cells for Monitoring and Analysis of Sea Level (CMAS)
India, Kenya, Madagascar, Malaysia, Maldives, Mauritius
IOC Workshop Report No.96
Annex I - page 2

WEDNESDAY, 19 JANUARY

MORNING

National Presentations on the Activities of Cells for Monitoring and Analysis of Sea Level (CMAS)
Bangladesh, Mozambique

Formation of Sessional Working Groups on Coastal Erosion and Sea-Level Changes

AFTERNOON

Meeting of Sessional Working Group on Coastal Erosion

Meeting of Sessional Working Group on Sea-Level Changes

THURSDAY, 20 JANUARY

MORNING

Meeting of Sessional Working Group on Coastal Erosion

Meeting of Sessional Working Group on Sea-Level Changes

AFTERNOON

Meeting of Sessional Working Groups

Drafting of recommendations and actions plans
Plenary Session

FRIDAY, 21 JANUARY

MORNING

Review of the conclusions and recommendations of the Sessional Working Groups
Plenary Session

AFTERNOON

Closing Ceremony

Address
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ANNEX II

LIST OF PARTICIPANTS

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ANNEX III

LIST OF SUBMITTED PAPERS AND DOCUMENTS

Document Code

Title

SUBMITTED PAPERS

- National Report on the Status of Coastal Erosion, Sea-Level Changes and their Impacts, Tanzanian Case (Dr Medard K.D. Mutakyahwa, Mr Yohana W. Shaghude, Mr Shufaa K. Mohamed)
- National Report on the State of Coastal Erosion in Mauritius (Dr L. Joottun in collaboration with D. Gangapersad, S. Ragoonaden, K. Dunpath, I. Ujohha)
- Status of Coastline Changes in Kenya and its Implications on Sustainable Coastal Zone Development and Management (by Dr E. Okemwa, Mr K. Kairu, Mr T. Munyao)
- Seychelles: Coastal Erosion, Sea-Level Changes and their Impacts (Nirmal Jivan Shah)
- Beach Erosion North of Dar-es-Salaam (Dr Kamazima M. M. Lwiza)
- Seychelles National Report on Coastal Erosion (Mr V. Tilly)
- Coastal Erosion in Kenya. A Case Study of the Mombasa-Diani Area (Mrs Pamela Atieno Abuodha)
- Littoral Sediment Management (Dr Otavio Sayao)
- Regional Aspects of Coastal Erosion in West Africa. The Case of the Bight of Benin (Mr J. Wellens-Mensah)
- CMAS Activities - Maldives - Status Report (Mr A. Naseer)
- Activities of Mauritius in the Monitoring and Analysis of Sea Level (Mr S. Ragoonaden and Mr B.H.J. Dunpath)
- Report on Kenya Marine and Fisheries Research Institute - CMAS Activities (Mr M.O. Odido)
- Report on the Activities of the Marine Research Section of the Ministry of Fisheries and Agriculture of Maldives (Mr A. Naseer)
- Report on the Activities of the Malaysian Cell for Monitoring and Analysis of Sea Level (Mr Chan Peng Yue)
- Activities of the Cell for Monitoring and Analysis of Sea Level (CMAS) of India (Dr B.C. Roy)

- Report on Bangladesh Coast and Sea-Level Variations (Mr Abdul Matin Mondal)
- CMAS Activities in Mozambique (Mr David Chemane)
- Sea-Level Measurement and Data Processing in Madagascar (Mr N.T. Razakafoniaina)
- Sea-Level Variations and Changes in the Indian Ocean (Prof. G.W. Lennon)
- Review of Coastal Erosion Problems in the Region (Dr A. Granlund)
- Status of GLOSS Network in IOCINCWIO Region (Mr Mika O. Odido)
- GOOS Coastal Pilot Monitoring Activities and GLOSS (Dr A. Tolkachev)

INFORMATION/REFERENCE DOCUMENTS

- | | |
|--|--|
| IOC Manual and Guides No.14
Vol. I and II | Manual on Sea Level Interpretation and
Analysis |
| IOC Workshop Report No.77 | IOC-SAREC-KMFRI Regional Workshop on Causes and
Consequences of Sea-Level Changes on the Western Indian Ocean
Coasts and Islands (Mombasa, Kenya, 24-28 June 1991) |
| IOC/INF-908 | IOC-UNEP-WMO Pilot Activity on Sea Level Changes and
Associated Coastal Impacts - Draft Action Plan for
Implementation in the Indian Ocean |
| IOC Workshop Report No.81 | Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality
Control (Paris, 12-13 October 1992) |
| IOCINCWIO-III/3 | IOC Regional Committee for the Co-operative Investigation
in the North and Central Western Indian Ocean, Third
Session (Vacoas, Mauritius, 14-18 December 1992) |
| IOC/INF-914 | Outline of the project proposal on coastal erosion in the
Western Indian Ocean region - scientific appraisal and
management (Dr R.S. Arthurton) |
| - | International Science Initiatives Directed at Assisting ICZM
(Dr Gunnar Kullenberg, Coastal Zone '93, The Hague,
November 1993) |
| IOC Circular Letter No. 1397 | Global Sea Level Observing System (GLOSS) - 1993 - Definition and
Status Report |
| - | Summary of the IOC-UNEP-WMO Coastal Monitoring Pilot
Activities |
| - | GLOSS Summary |
| IOC Workshop Report No.93 | IOC-UNEP Workshop on Impacts of Sea-Level Rise due to Global
Warming (Dhaka, Bangladesh, 16-19 November 1992) |
| - | List of CMAS and Designated Scientists. |

ANNEX IV

LIST OF CELLS FOR MONITORING AND ANALYSIS OF SEA LEVEL (CMAS)

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