

**Intergovernmental Oceanographic Commission**  
*Reports of Meetings of Experts and Equivalent Bodies*



# **IOC Group of Experts on the Global Sea Level Observing System (GLOSS)**

**Fifth Session**

Pasadena, California, USA

19 - 21 March 1997

**UNESCO**

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Paris, 25 April 1997  
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## **1. ORGANIZATION OF THE SESSION**

### **1.1 OPENING OF THE SESSION**

Dr. Philip Woodworth, Acting Chairman of the GLOSS Group of Experts, opened the Session. He noted that the session had been preceded by an IGS/IOC/PSMSL sponsored Workshop on Methods for Monitoring Sea Level: GPS and Tide Gauge Benchmark Monitoring (March 17 and 18, 1997 in Pasadena, California, USA). He thanked the Jet Propulsion Laboratory for making the facility available.

Dr. Colin Summerhayes explained the unavoidable absence of the GLOSS Technical Secretary, Dr. Albert Tolkatchev, and noted that he would take on that responsibility as the representative of the IOC. He explained that as new Director of the GOOS Support Office he was greatly looking forward to meeting the GLOSS community, as it was important to see that the IOC's GOOS and GLOSS programmes were closely aligned. He reminded the Group of Experts that GLOSS can make an important contribution to the GOOS Climate and Coastal Modules, and this needs to be borne in mind in considering the items on the agenda.

### **1.2 ADOPTION OF THE AGENDA**

The Agenda (Annex I) was adopted by the Group. The List of Participants is shown in Annex II.

### **1.3 DESIGNATION OF RAPPORTEUR**

Dr. Lesley Rickards was elected as Rapporteur of the Session.

## **2. REVIEW OF GLOSS ACTIVITIES**

### **2.1 PROGRESS REPORT**

Dr. Woodworth presented the Progress Report (Doc. IOC/GE-GLOSS-V/6), which focused on the implementation of the plan of actions recommended by the Fourth session of the Group held in February 1995. Most of the actions had been completed. Training has been going very well, especially the Training Workshops on Sea-Level Observations and Analysis in Dehra Dun, India, and Buenos Aires, Argentina. The planned GPS workshop had been held. More effort is needed on outreach, telling people what GLOSS is all about. A review of the GLOSS network is still in progress. The revised GLOSS Station Handbook is now available on CD ROM and has been widely distributed.

Dr. Shetye noted that a series of papers would be prepared on sea-level studies undertaken as part of the Pilot Activity in the Indian Ocean.

New and outstanding actions are listed in Annex IV.

## **3 & 4. GLOSS AND SATELLITE ALTIMETRY SEA-LEVEL MEASUREMENT**

Items 3 and 4 on the Agenda were combined under this heading.

GLOSS is advancing the interaction between gauges, GPS and altimetry as complementary parts of a single system. The IGS/IOC/PSMSL Workshop on Methods for Monitoring Sea-Level: GPS and Tide gauge Bench Mark Monitoring was held in Pasadena, California, USA, 17-18 March 1997, to address this development by bringing together the GLOSS and GPS communities. Proceedings of the Workshop will be published as an IGS document.

Dr. Ruth Neilan presented a report on the workshop, including specific recommendations for the way forward (listed in Annex V). One output from these recommendations would be a Technical Manual on how to operate GPS at tide gauge stations. The Group discussed possible membership of the Technical Committee required to produce the Manual. The Chairman and Dr. Neilan will progress formation of the Committee. The Manual will take about a year to produce.

Dr. Christian Le Provost gave a brief presentation on the DORIS system to track different satellites. The DORIS beacons provide the ability to measure baseline position to within +/- 1cm, and could be linked to the GLOSS tide gauge network. The group accepted that DORIS provided an additional means to GPS for geodetically fixing tide gauges.

Members expressed concern about the formulation of Recommendation 1 (in Annex V), concerning the creation of a IGS Science Group, and the relation of such a group to GLOSS and IOC. The question was raised of who would be responsible for implementing GPS on tide gauges - IGS or GLOSS (through I-GOOS and IOC). After discussion **Recommendation 1 was adopted.** (Annex VI).

Dr. Gary Mitchum talked about progress in use of satellite altimetry measurements for monitoring global and regional sea-level variability and changes, in particular the success of altimetry in providing accurate sea-level measurements. Comparisons of satellite altimeters with tide gauges to correct for drift is an ongoing requirement. The altimetry and tide gauge communities are working well together to take this forward and derive useful products for users in GOOS and other programmes.

Altimeter data is publicly available on request. Altimetry is now included in GLOSS training courses. Information on how to access these data should be in the GLOSS Station Handbook and will be presented in the GLOSS Implementation Plan. Commercialization of data presents a problem in certain areas, and some authorities are reluctant to release tide gauge data.

## **5. DRAFT GLOSS IMPLEMENTATION PLAN**

The revision of the Plan had been identified as necessary by the Fourth meeting of the Group of Experts, to recognize substantial changes in technology, especially the increases in accuracy of altimetry and improvements and availability of GPS, and the enlargement of experience in operating tide gauges. It would replace the previous Plan prepared in 1990 (IOC Technical Series 35, UNESCO 1990), and would have a lifetime of at least 5 years.

The Group reviewed the draft GLOSS Implementation Plan (IOC/GE-GLOSS-V/10) chapter by chapter.

The Plan proposes a global tide gauge network similar to that in the 1990 Plan but with coverage refined as appropriate and reduced to approx 270 stations. A revised definition of the global core network (GCN), GLOSS97, will be produced. As large as practical a set of gauges would be equipped with GPS. A subset of the overall world wide network, whether GCN stations or not, designated GLOSS-LTT (Tide Gauges for Long Term Sea-Level Trends), will provide long term sea-level trends and accelerations. Another subset of gauges, based largely on islands and coupled with GPS named GLOSS-ALT (Tide Gauges for Altimeter calibration), will be designated for ongoing calibration of satellite altimeters. A further subset called GLOSS-OC (Tide Gauges for Ocean Circulation Monitoring) will be designated for monitoring aspects of global circulation. These GLOSS-OC stations will be especially useful for measuring sea-level (i) across straits, and (ii) along polar coasts. The three subsets will overlap. The GLOSS core network will be supplemented by regional sets of tide gauges. It is intended the core network will have a high level of inertia for the purpose of continuity; that is, older sites will not readily be exchanged for new ones.

The Plan calls for data to be managed in a distributed way through a series of International Centres, coordinated by a new body, the GLOSS Data Committee. These Centres will be at places like the UHSLC. At intervals the data will go to International Archiving Centres. It was agreed that a Data Committee would be formed to carry out the required intersessional work.

The Group expressed concern that data from the ASEAN tide gauge network was not being made available despite repeated requests, and recommended that the GLOSS Technical Secretary write to the countries concerned requesting access to the data.

The Group decided that chapter 8 needs a table of deliverables.

The Group congratulated the Chairman on producing the draft GLOSS Implementation Plan.

The Group requested the Chairman to finalize the draft Plan and to submit it to the XIXth Session of the IOC Assembly for approval.

The Group also noted on-going demand for a GLOSS Technical Secretary as described in the Implementation Plan and requested the Chairman to bring to the attention of the IOC Assembly **Recommendation 2** (Annex VI) **adopted by the Group**.

## **6. REPORTS OF SEA- LEVEL CENTRES, REGIONAL AND INTERNATIONAL ACTIVITIES**

### **6.1. SOUTH PACIFIC**

Mr. Bill Mitchell reported in the South Pacific Sea-level and Climate Monitoring Project, Phase II (Doc. IOC/GE-GLOSS-V/12.1), which developed as an Australian response to concerns raised by members of the South Pacific Forum over the potential impact of the Greenhouse Effect on climate and sea-level in the region. The NTF (National Tidal Facility) was awarded a contract in 1991 to manage the project, which involved 11 other countries, in each of which a monitoring station was installed. Phase II, the operational phase, began in July 1995 and runs for 5 years. It involves examination of sea-level trends, development of tidal models, measures of impacts and mitigation, studies of ecological and socio-economic impacts, and development of a policy response strategy.

22 people have been trained at NTF for 3 weeks. Their interests have mainly been in coastal management issues rather than climate, which has required adaptation of the training programme. A high level of interest has been shown in predicting tsunamis, and in modelling salt water intrusion into the freshwater lens under atolls as a consequence of sea-level rise. Data show that regional trends are dominated by El Nino events. The data are being made freely available.

It is intended and desirable that this should be a long term project. Results are pleasing so that continuance for a further 5 years is likely after Phase II is completed.

There is a possibility that Australia may take on management of some systems that NOAA may relinquish. One of the tide gauges that NOAA has asked Australia to take over is in Suva.

Mr. Mitchell further commented that a report on the Australian tide gauge and GPS network will be made available to the next issue of the GLOSS Bulletin.

### **6.2. IOCEA (West Africa)**

A brief report was tabled by Mr. Larry Awosika, the IOCEA GLOSS Coordinator (Doc. IOC/GE-GLOSS-V/12.2). Eight tide gauges were provided some time ago for the region by Sweden. Four were installed by a German consultant, but have now ceased working due to lack of parts and follow up. The other four were sent by Germany in August 1996 to Nigeria, Gambia, Guinea, and to Côte d'Ivoire. The provision of spare parts for equipment in the region continues to be a difficulty. The Coordinator felt that an IOC mission to the area was desirable to examine ways of improving the regional activity.

The Group rejected this idea because it was felt that there were not sufficiently qualified people in the area to manage the regional network proposed. Efforts will be made to train people to build up regional expertise, but this could not be done quickly; one or two people from the region may be trained in the course at Bidston. The Group went on to consider how best to run a regional network in the area and accordingly asked the Chairman to investigate this matter.

### **6.3. EUROPEAN DEVELOPMENTS**

Dr. Trevor Baker gave an update on the EuroGLOSS proposal.

Dr. Susanna Zerbini described the MedGLOSS programme, which has developed as a joint endeavour between IOC and CIESM. The goal is to develop a regional network for long term sea-level monitoring in the Mediterranean and Black Seas. The main scientific interests are (i) in absolute sea-level rise in relation to climate change, and (ii) in relative sea-level change caused by land subsidence (e.g. in the Nile delta). A preliminary meeting had been held in February 1996 in Monaco, and a MOU between IOC and CIESM concerning the MedGLOSS project had been signed in the summer of 1996. By this MOU, a joint IOC/CIESM Group of Experts on MedGLOSS was set up, chaired by

Dr. D. Rosen (Israel). The Group held its first session in Paris, 20-21 January 1997, and recommended to initiate the MedGLOSS Pilot Phase (Doc. IOC/GE-GLOSS-V/12.10). A workshop in Dubrovnik has been planned to take the project forward. As yet the route to funding is uncertain. MedGLOSS will begin its operational existence in April 1997 with a pilot project involving some 10 sites of the Mediterranean and Black Seas countries.

Dr. Erik De Min reviewed EOSS (the European Sea-Level Observing System), which aims (i) to coordinate the further implementation of geodetic techniques for sea-level monitoring and fixing tide gauge benchmarks, and (ii) to make agreements for the long term assembly, storage and exchange of data. 10 countries are involved, with some funding from the EC for meetings. EOSS work packages include: height reference systems and tide gauge fixing; mean sea-level determination; sea surface topography; tidal models and storm surge warning; and storage and exchange of data.

Dr. Claude Boucher presented documentation on EUREF (European Reference Frame) and EUVN (European Vertical GPS Reference Networks) which exist to improve the European geodetic reference frame for navigation and mapping by establishing a network of stations, now including a network of permanent GPS stations. EUVN is a new combination of reference, -levelling- networks and tide gauges. It connects selected European tide gauge stations to the levelling network. Data and products will be freely available.

Dr. Boucher also gave a brief presentation on ITRF (International Terrestrial Reference Frame) and IERS (International Earth Rotation Service). The operation and realisation of ITRF GPS stations is now in the hands of IGS. At a workshop in October 1996, IERS reviewed its own future mission, including measurements of the vertical, sea-level and related topics. IERS is expected to provide a proper reference frame, including the concerns of the oceanographic community. The next IERS Convention document (which defines everything for the geodetic community) will include a chapter relating to the definition of the geoid.

The presentations revealed that there now are several European endeavours to advance tide gauge and GPS work. The Group questioned the merit in having three separate and independent but apparently similar and overlapping programmes, and asked the representatives of the three projects to meet separately to see if some integration and/or coordination might be possible to provide an improved way forward.

Following the presentation of these reports, a Coordinating Committee was established and designated as the Euro GLOSS Committee (EGC); members were Drs. Baker, Boucher, Zerbini, and De Min. EGC will coordinate the various activities in Europe, global or regional, either with scientific (sea-level, tides etc) or technical objectives (vertical reference frames, coastal engineering, etc). For this purpose, EGC will contact the various present and future projects and organizations relevant to these topics (e.g. EOSS, SELF, Baltic Sea Project, EUREF/EUVN, EUROGAUGE, WEGENER and various national programmes). EGC will maintain a close cooperation with MedGLOSS (as it involves countries-members of IOC and CIESM of Europe, Middle East and North Africa), and will report regularly to GLOSS.

A pan-European proposal on these topics will probably be submitted for funding to the EC under the Vth Framework Programme.

#### 6.4. PSMSL

Dr. P. Woodworth gave a brief presentation on the PSMSL (Doc.IOC/GE-GLOSS-V/12.3). The data banking is going very well, as is the provision of training. There is a steady output of CD-ROMS. In future GPS data will be put into the data bank. POL is committed to keeping operational the tide gauges for which it is responsible in the UK and the South Atlantic.

The Group recommends continued support for PSMSL activities in support of GLOSS.

#### 6.5. SOUTHERN OCEAN

Mr. Rupert Summerson presented a report on the activities of the Southern Ocean Sea- Level Centre (SOSLC) (Doc. IOC/GE-GLOSS-V/12.4) at the NTF, demonstrating the spread of gauges around the Southern Ocean. Several of the sites now have GPS. New sites are planned in New Zealand.

The Group emphasized the importance of sea-level observations in the Southern Ocean for the study of the Antarctic Circumpolar Current and climate studies. The Group expressed its satisfaction at the advances made by the SOSLC and recommended that the funding support for its activity be continued.

## 6.6. INDIAN OCEAN PILOT PROJECT ON SEA-LEVEL CHANGES AND ASSOCIATED COASTAL IMPACTS

Dr. Satish Shetye reported on the Pilot Project sponsored by the IOC in the Indian Ocean (Doc. IOC/GE-GLOSS-V/12.5), and involving several countries. The Pilot Project was designed to encourage analysis of data collected in the region, and to provide training. Data were especially released for the purpose by the Survey of India to Indian scientists. The project has been going on for 5 years, and a training workshop was held in November 1995 at the Survey of India, Dehra Dun. The project includes a study of sea-level variability along the Indian coast, funded by the Indian Department of Ocean Development.

The Group felt that there was a need for other countries to be doing similar work in the Indian Ocean, perhaps under the technical leadership of India, so that the Indian experience gets applied to other regions. **Recommendation 4 was adopted.** (Annex VI).

## 6.7 INDIAN OCEAN SEA-LEVEL NETWORKS

The Group of Experts on GLOSS expressed concern about the long term future of the network of GLOSS stations in the Indian Ocean. It was suggested that the IOC should be acting with the regional states to develop proposals for GEF or similar funding, taking heart from the success of the OAS in getting GEF funds for sea-level measurements in the Caribbean. There was an extended discussion about how to achieve this in the apparent absence of a suitably legally constituted regional body which could act as the contracting agent to deal with the GEF. Dr. Pugh agreed to investigate the status of the IOMAC group led by Sri Lanka and Tanzania. Dr. Bill Mitchell agreed to find out details of other similar regional bodies.

Expressing similar concern about the long term future of the Indian Ocean network, Dr. Gary Mitchum expressed the view that the CMAS structure (see section 6.6.) could logically be extended to include a more active role in the measurement, as well as the analysis, of sea-level data in the region. Dr. Shetye was requested to give some thought to this suggestion and report to the Chairman on his proposals.

## 6.8. SOUTH AFRICA

A report on South African activities prepared by Dr. Howard Waldron (Doc. IOC/GE-GLOSS-V/12.6) was presented by the Chairman. The South African programme to develop tide gauges had not worked well, and South Africa had now purchased commercial systems. There was some concern that these may not be the best for scientific purposes, and that they should be supplemented by some more reliable systems.

## 6.9. IOCARIBE

The report prepared by Dr. G. Maul, IOCARIBE Regional Coordinator for GLOSS, was presented by Dr. Wolfgang Scherer (Doc. IOC/GE-GLOSS-V/12.7). 18 tide gauges tied in to a communications network are being installed as the result of a successful (multi-million dollar) bid to the GEF for resources to support a long term study of climate change in the Caribbean region. The proposal had been developed by the Organization of American States.

The Group felt that there was an important example here for the IOC, and that the IOC needs to develop mechanisms to tap into GEF funds for regional developments. **Recommendation 5 was adopted.** (Annex VI).

## 6.10. WOCE SEA-LEVEL DATA CENTRES

Dr. Mark Merrifield reported on the activities of the WOCE fast delivery data centre at the University of Hawaii Sea-Level Centre, and restructuring of the management of the NOAA/NOS tide gauges. NOAA/NOS will continue to manage the gauges at Hawaii and Bermuda. Some stations will be transferred to Australia; others will be transferred to UHSLC, who will try to find new managers for some of them, e.g. Argentina for the Argentina coastal stations.

Dr. Lesley Rickards reported the WOCE delayed mode data centre in the BODC (Doc. IOC/GE-GLOSS-V/12.11). This covers 150 tide gauges from 20 countries. A new staff member has been employed, which will enable the WOCE ACCLAIM (Southern Ocean) data set to be handled more effectively. WOCE data is now available, and being accessed, on the Web. CD ROMs carrying the data will be produced early in 1998 for participants at the WOCE Scientific Conference in May 1998.

Recognizing the high quality performance of the two WOCE sea-level data centres and recognizing that WOCE data collection phase is drawing to a close, the Group recommends that these two centres should continue operation and be used by future science programmes like CLIVAR, and that the expertise developed at these centres should not be lost.

#### 6.11. RUSSIAN FEDERATION

A report tabled by Dr. Oleg Zilbershtein (Doc. IOC/GE-GLOSS-V/12.12) was read by the Chairman. Russia has a number of sites but can only provide data from 5 stations in future. GLOSS had asked for stations to be emplaced in the Arctic, and requested a Baltic site as a GLOSS site. It appears that although several stations are active the data are not being processed so are not available to the PSMSL.

POL expressed its wish to install a gauge on a Russian Antarctic site.

#### 6.12. EAST AND SOUTH CHINA SEAS

Dr. C. K. Shum presented a paper (Doc. IOC/GE-GLOSS-V/12.8) and talk about a proposal for monitoring sea-level change in the East and South China Seas. The object is to establish a long term observational system to monitor absolute sea-level change and to measure land subsidence (relative sea-level change).

The Group encouraged Dr. Shum to continue developing the project, and suggested that he contacts IOC-WESTPAC and also the NEAR-GOOS community to entrain them in the planning process and benefit from their advice and interest.

#### 6.13. VIETNAM

IOC had supported the training of two Vietnamese specialists in India. India planned to provide a tide gauge and to install it in Vietnam, but has not yet done so. Vietnam has been advised by the IOC Secretariat to contact the Department on Ocean Development (DOD) of India about the matter before involving IOC further. The Group felt that large amounts of funding for this project were not a priority.

#### 6.14. IAPSO/CMSLT GLOBAL DATA BASE

Dr. Christian Le Provost tabled a paper and talked about the IAPSO tidal constant data base project. At the Fourth Session of the Group, it was decided that a reference global data base of harmonic constituents should be compiled from model data. The model data bank can then be used to test the validity of actual observations and vice versa. A progress report was presented. The project must be completed soon.

The WOCE tidal constants will be included on the forthcoming WOCE CD-ROM.

#### 6.15. GLOBAL SEA LEVEL NETWORK FOR CLIMATE

Dr. Wolfgang Scherer and Dr. Vivian Gornitz presented a US proposal for a global sea-level network in support of research and operational studies of climate change and variability, which would serve the purposes of GOOS/GCOS and CLIVAR. The proposal had been formulated by an *ad hoc* scientific steering group, who intends to organize an international workshop in June 1997 to discuss the scientific objectives and ascertain which sites would be most appropriate for these objectives. The main objective would be to derive information on climate variability at seasonal, interannual and centennial scales. The project would focus on (i) tropical regions (ENSO, Indian Ocean monsoons, Atlantic dipole); (ii) extra-tropical gyre circulation; (iii) high latitudes; (iv) straits and passages; (v) long term trends. A number of sites with good quality records have been identified, but they are unevenly distributed geographically.

The Group remarked that data from the ASEAN tide gauges would be extremely valuable for this project. The Group decided that this new concept should be encouraged, and at the appropriate time included in the GLOSS Implementation Plan. Members were asked to feed comments on the proposal to the scientific steering group. The SSG was asked to bring the results of the project back to GLOSS VI.

## 6.16. NORWAY

Mr. John Sunsdby reported that the Norwegian Mapping Authority is planning to establish tide gauges and GPS receivers on Jan Mayen and Bear Island in the Arctic. There are also tide gauges with long records around the Norwegian coast, which are not instrumented with GPS receivers. The Group of Experts expressed great interest in the Norwegian developments and considered that Bear Island, which has no gauge at all, was a very important site, as is Jan Mayen; tide gauges with GPS receivers should be installed there. It would be very useful if GPS receivers could be installed in due course also at several of the long term sites.

The Group recommended that Norway:

- (i) establish the new tide gauges with GPS receivers on Bear Island and Jan Mayen Island, and
- (ii) begins installing GPS receivers at tide gauge sites with long time series records (40-60 years) on the Norwegian mainland coast.

## 6.17. REGIONAL COORDINATORS

The Group expressed concern that not all of the GLOSS Regional Coordinators were active.

The Group requested that the Chairman and IOC undertake a review of present GLOSS Regional Contacts with a view towards their possible replacement by more active individuals where necessary.

## 6.18. NEWSLETTERS AND BROCHURES

The GLOSS Bulletin is now on the Web. The Proudman Oceanographic Laboratory (POL) has agreed to produce issue 5; thereafter, responsibility for the Bulletin will pass to the National Tidal Facility of Australia (NTF).

Funds have been found to enable the Afro-America GLOSS Newsletter to continue to be published by the University of Sao Paulo (USP) for another two years. The USP is encouraged to investigate a Web version.

As mentioned earlier, the GLOSS Station Handbook is available on CD-ROM.

## 7. TEMA

The GLOSS Training Seminar Workshop on Sea-Level data Analysis was held at the Geodetic and research Branch of the Survey of India, Dehra Dun, India in November-December 1995 for countries of the Indian Ocean region. It involved "hands on" training in addition for formal lectures by international and resident (SOI) lecturers. All attendees were actively involved in sea-level data acquisition and it was felt that solid grounds had been made for future regional collaboration.

The GLOSS Training Seminar Workshop on Sea-Level Observations and Analysis in Argentina in November 1996 was also a great success although it concentrated more on formal presentations, including impacts of sea-level changes and coastal policy making. One good outcome was that the people met each other, which underlines the role of the IOC acting as a catalyst for fostering regional interactions. This led to useful discussions on how to standardize tide gauge datums within and between countries. Another outcome was the realization that it would be desirable, if funds could be found, to bring some people to laboratories in developed countries for advanced training.

The participants in the Workshop held in Argentina had discussed the future development of sea-level activities in the region. Prof. Mesquita (USP) was appointed to coordinate future interactions which may include further technical workshops. Several participants, including the Cuban participant, emphasized the need for assistance in establishing national sea-level systems for measuring and analysing sea-levels.

The Group then held an extended discussion on the priorities for future GLOSS training. One course will be funded this year at Bidston, mostly for people from Mediterranean countries, on the practicalities of tide gauge installation and management.

Dr. Summerhayes reported that there is a proposal by the GOOS Capacity Building Committee to rationalize the IOC's approach to TEMA such that coherent training packages could be developed in response to regional requests that might well lead to attractive proposals for external funding by, for instance, GEF. If this change came about it might change the way in which IOC thought about future GLOSS training programmes. **Recommendation 6 was adopted.**

## 8. SEA-LEVEL OBSERVATIONS FOR THE GOOS CLIMATE MODULE

Dr. Neville Smith, Chairman of the OOPC (Joint to GCOS-GOOS-WCRP Ocean Observations Panel for Climate), gave a presentation on the need for linkage between GLOSS and the OOPC and other groups concerned with climate change. He proposed that GLOSS was the prime system for implementation and maintenance of sea-level networks, CLIVAR's UOP was the source of scientific advice on observational requirements, and OOPC was the prime source of scientific advice on requirements for integration of sea-level measurements into operational baseline ocean observing systems.

The Group of Experts on GLOSS remains a key element of the structure, responsible for synthesizing requirements for climate research programs, GOOS, GCOS, and other areas, and provide the scientific interface through to implementation. These linkages have important implications to the Terms of Reference of the GLOSS GE, as noted below in section 10.

The Group agreed that GLOSS should interact closely with other groups and that it would be desirable for the Chairman of GLOSS to attend appropriate J-GOOS meetings. Already there was good liaison developing between the Chairs of OOPC and GLOSS, and in future there would be a regular exchange of documents between the two groups to assist in planning. It was recommended that J-GOOS regularly consult the GLOSS GE. The Group decided that it would not be necessary for the Chairman to attend the next J-GOOS meeting, but that as GOOS evolved the GLOSS Implementation should evolve to ensure that it was consistent with GOOS requirements. The Group agreed it had been extremely useful to have the meeting attended by both the representative of the OOPC and the Director of the GOOS Support Office, to help cement these important linkages.

Dr. Smith reminded the Group that sea-level would be an important theme of the GCOS Participants meeting scheduled for early 1998 and involving the preparation of a number of glossy brochures describing "end-to-end" services. One such brochure would be needed for sea-level and the GLOSS Group of Experts was invited to participate in its production. In addition OOPC and GLOSS will arrange for joint publication of a background report detailing some of the scientific considerations behind the GLOSS Implementation Plan.

It was also noted that GLOSS was important for the Coastal Module of GOOS, in which data on water levels was required for Natural Hazard Mitigation, Safe Navigation, and a Sustainable Healthy Environment. As the Coastal Module of GOOS developed and matured it was anticipated that links to GLOSS would become apparent at the global, regional and local level. The Group welcomed that potential development and wished to interact with J-GOOS to ensure that GLOSS was fully involved in the design of the Coastal Module. It was noted that there are several groups working on changes in sea-level and water levels at coasts (eg J-GOOS, CMM, LOICZ, and GTOS), and it was recommended that GLOSS liaises with these other bodies to ensure that GLOSS activities took their activities into consideration.

## 9. PLAN OF ACTION FOR 1997 - 1999

### 9.1. REVISED TERMS OF REFERENCE

The Group reviewed its Terms of Reference adopted by the XX1st Session of the IOC Executive Council in 1988 by Resolution EC-XXI.2 and proposed its revision for approval by the IOC Assembly. **Recommendation 3 was adopted.** (Annex VI).

### 9.2. OLD AND NEW ACTIONS

The action list from the previous GLOSS meeting was reviewed and it was agreed that all significant items had been dealt with. The Group prepared a Plan of Action for 1997-1999, as shown in Annex IV.

### 9.3. VOTES OF THANKS

The Group offered warm thanks to Dr. David Pugh (former Chairman) and Dr. Albert Tolkathev (retired GLOSS Technical Secretary) for their dedication and many services to GLOSS over the years. The Group also thanked Drs. Neilan and Zumberge of the IGS Central Bureau for the hospitality, Mrs. Van Scoy for administrative support Mr. Melbourne for the formal invitation to visit JPL. Their efforts contributed enormously to make the session a success.

Drs. Rickards and Summerhayes were thanked for their services as Rapporteur and Technical Secretary respectively, and the Group wished Dr. Colin Summerhayes success in his new post as Director of the GOOS Support Office.

**10. ELECTION OF CHAIRMAN**

It was proposed, and accepted unanimously by the Group, that Dr. Philip Woodworth be elected as the Chairman of the GLOSS. Dr. Woodworth agreed to serve in that position.

The Group praised Dr. Woodworth's efforts in preparing the Implementation Plan; the amount and quality of his work on this had been outstanding, and the Group were very pleased with his performance in his Acting capacity.

**11. ADOPTION OF THE REPORT**

The report of the meeting was adopted as it appears in this document.

**12. DATE AND PLACE OF THE NEXT SESSION**

The Group recommended to hold its Sixth Session in early 1999. The exact dates and place of the next meeting should be considered and proposed by the Chairman in consultation with the IOC Executive Secretary at a later stage.

**13. CLOSURE**

The Chairman closed the Session at 16.00 on 21 March 1997.

ANNEX I

**AGENDA**

- 1. ORGANIZATION OF THE SESSION**
  - 1.1. OPENING OF THE SESSION
  - 1.2. ADOPTION OF THE AGENDA
  - 1.3. DESIGNATION OF THE RAPPORTEUR
- 2. REVIEW OF GLOSS ACTIVITIES**
- 3. GEODETIC FIXING OF GLOSS TIDE GAUGE BENCH MARKS**
- 4. GLOSS AND SATELLITE ALTIMETRY SEA-LEVEL MEASUREMENTS**
- 5. DRAFT GLOSS IMPLEMENTATION PLAN**
- 6. REPORTS OF SEA-LEVEL CENTERS, REGIONAL AND INTERNATIONAL ACTIVITIES**
- 7. TEMA RELATED ACTIVITIES**
- 8. SEA-LEVEL OBSERVATIONS FOR THE GOOS CLIMATE MODULE**
- 9. PLAN OF ACTION FOR 1997-1999**
- 10. ELECTION OF CHAIRMAN**
- 11. ADOPTION OF THE REPORT**
- 12. DATE AND PLACE OF THE NEXT SESSION**
- 13. CLOSURE**

ANNEX II

LIST OF PARTICIPANTS

INVITED EXPERTS

Dr. Trevor BAKER  
Proudman Oceanographic Laboratory  
Bidston Observatory  
Birkenhead, Merseyside L43 7RA  
United Kingdom  
Tel: (44 151) 653 8633  
Fax: (44 151) 653 6269  
E-mail: tfb@pol.ac.nk

Mr. Claude BOUCHER  
IGN/ENSG  
Institut Géographique National  
Laboratoire de Recherche en Géodésie (LAREG)  
94160 Marne-la-Vallée  
France  
Tel: 01 64 15 32 50  
Fax: 01 64 15 32 53  
E-mail: BOUCHER@ENSG.IGU.FR

Dr. Erik DE MIN  
Survey Department  
Ryhswaterstaat  
P.O. Box 5023  
NL - 2600 GA Delft  
The Netherlands  
Tel: (31 15) 2691 467  
Fax: (31 15) 2135 456  
E-mail: e.j.dmin@mdi.rws.minvenw.nl

Dr. Lee-Lueng FU  
MS 300-323  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA 91109  
USA  
Tel: (1 818) 354 8167  
Fax: (1 818) 393 6720  
Email: llf@pacific.jpl.nasa.gov

Dr. Vivien GORNITZ  
Goddard Institute for Space Studies  
2880 Broadway  
New York NY 10025  
USA  
Tel: (1 212) 678 5566  
Fax: (1 212) 678 5552  
E-mail: CCVMG@NASAGISS.GISS.NASA.GOV

Cdr. Michael JOHNSON  
Office of Global Programs  
NOAA  
1100 Wayne Ave, suite 1210  
Silver Spring, MD20910  
USA  
Tel: (1 301) 427 2089 x62  
Fax: (1 301) 427 2073  
E-mail: johnson@ogp.noaa.gov

Dr. Christian LE PROVOST  
Directeur de Recherche  
Equipe de Modelisation  
des Ecoulements Océaniques et des Marées  
Laboratoire des Ecoulements  
Géophysiques et Industriels  
BP 53X  
38041 Grenoble Cedex  
France  
Tel: (33) 04 76 82 50 65  
Fax: (33) 04 76 82 52 71  
E-mail: clp@img.fr

Dr. Mark MERRIFIELD  
Director  
UH Sea Level Centre  
University of Hawaii  
1000 Pope Road  
MSB 307, Honolulu  
Hawaii 96822-2336  
USA  
Tel: (1 808) 956 6161  
Fax: (1 808) 956 2352  
E-mail: markm@iniki.soest.hawaii.edu

Mr. William MITCHELL  
National Tidal Facility  
The Flinders University of South Australia  
Mark Oliphant Bldg, Science Park Adelaide,  
Laffer Drive, Bedford Park, Adelaide SA 5042  
Australia  
Tel : (61 8) 8201 7525  
Fax : (61 8) 8201 7523  
e-mail : bill@pacific.ntf.flinders.edu.au

Dr. Gary MITCHUM  
Department of Marine Sciences  
University of South Florida  
140 Seventh Ave, South St Petersburg  
Florida 33701  
USA  
Tel:  
Fax:  
E-mail: mitchum@lolo.marine.usf.edu

Mrs. Ruth NEILAN  
IGS Central Bureau  
International GPS Service for Geodynamics  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA 91109, California  
USA  
Tel: (1 818) 354 8330  
Fax: (1 818) 393 6686  
E-mail: [igscb@igscb.jpl.nasa.gov](mailto:igscb@igscb.jpl.nasa.gov) (IGS)  
[ren@cobra.jpl.nasa.gov](mailto:ren@cobra.jpl.nasa.gov) (personal)

Dr. Steve NEREM  
Dept. Of Aerospace Engineering &  
Engineering Mechanics  
WRW 313B  
The University of Texas at Austin  
Austin, Texas 78712  
USA

Center for Space Research  
3925 West Braker Lane, #200  
Austin, Texas 78759-5321  
USA  
Tel: (1 512) 471 5573 (CSR main line)  
(1 512) 471 5696 (voice CSR+Campus)  
Fax: (1 512) 471 3570 (CSR)  
(1 512) 471 4070 (campus)  
E-mail: [nerem@csr.utexas.edu](mailto:nerem@csr.utexas.edu)

Dr. David PUGH  
Southampton Oceanography Centre  
Empress Dock  
Southampton SO14 3ZH  
United Kingdom  
Tel: (44 1703) 59 6611  
Fax: (44 1703) 59 6395  
E-mail: [ntp@mail.soc.soton.ac.uk](mailto:ntp@mail.soc.soton.ac.uk)

Dr. Lesley RICKARDS  
British Oceanographic Data Centre  
Bidston Observatory  
Birkenhead, Merseyside, L43 7RA  
United Kingdom  
Tel: (44 151) 653 8633  
Fax: (44 151) 652 3950  
E-mail: [ljr@pol.ac.uk](mailto:ljr@pol.ac.uk)

Dr. Wolfgang SCHERER  
Office of Ocean & Earth Sciences N/OES  
National Ocean Service, NOAA  
1035 East West Highway, Station 6167  
Silver Spring, MD 20910  
USA  
Tel: (1 301) 713 2981  
Fax: (1 301) 713 4392  
E-mail: [wscherer@nos.noaa.gov](mailto:wscherer@nos.noaa.gov)

Dr. Satish SHETYE  
Physical Oceanography Division  
National Institute of Oceanography  
Dona-Paula, Goa 403 004  
India  
Tel: (91 832) 22 1322/22 6253 (Office)  
(91 832) 22 6460 (Residence)  
Fax: (91 832) 22 3340/22 1360/22 9102  
E-mail: [shetye@csnio.ren.nic.in](mailto:shetye@csnio.ren.nic.in)

Dr. Neville SMITH  
Bureau of Meteorology Research Centre  
150 Lonsdale St., Box 1289K  
Melbourne, Vic. 3001  
Australia  
Tel: (61 3) 9669 4434  
Fax: (61 3) 9669 4660/9669 4699  
E-mail: [nrs@bom.gov.au](mailto:nrs@bom.gov.au)

Mr. Rupert SUMMERSON  
Bureau of Resource Sciences  
P.O. Box E11  
Kingston, ACT 2604  
Australia  
Tel: (61 6) 272 4615  
Fax: (61 6) 272 4687  
E-mail: [rsummer@henn.nric.gov.au](mailto:rsummer@henn.nric.gov.au)

Mr. John SUNDSBY  
Geodetic Institute  
Norwegian Mapping Authority  
N-3500 Honefoss  
Norway  
Tel: (47 32) 11 81 00  
Fax: (47 32) 11 81 01  
E-mail: [john.sundsby@gdiv.statmact.no](mailto:john.sundsby@gdiv.statmact.no)

Dr. Philip WOODWORTH  
Proudman Oceanographic Laboratory  
Bidston Observatory  
Birkenhead, Merseyside L43 7RA  
United Kingdom  
Tel: (44 151) 653 8633  
Fax: (44 151) 653 6269  
E-mail: [plw@pol.ac.uk](mailto:plw@pol.ac.uk)

Prof. Susanna ZERBINI  
Dipartimento di Fisica  
Settore di Geofisica  
Universita Degli Studi di Bologna  
Viale C. Berti Pichat, 8  
40127 Bologna  
Italy  
Tel:  
Fax:  
E-mail: [ZERBINI@astbo1.bo.cnr.it](mailto:ZERBINI@astbo1.bo.cnr.it)

Dr. Victor ZLOTNICKI  
MS 300-323  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA 91109  
USA

Tel: (1 818) 354 8167  
Fax: (1 818) 393 6720  
Email: vz@pacific.jpl.nasa.gov

Dr. James F. ZUMBERGE  
Jet Propulsion Laboratory 238-600  
4800 Oak Grove Drive  
Pasadena, CA 91109-8099  
USA

Tel: (1 818) 354 6734  
Fax: (1 818) 393 6720  
E-mail: jfz@cobra.jpl.nasa.gov

## **SECRETARIAT**

Dr. Colin SUMMERHAYES  
Director  
GOOS Project Office  
IOC/UNESCO  
c/o Southampton Oceanography Centre  
Empress Dock  
Southampton, SO14 3ZH  
United Kingdom

Tel: (44 1703) 59 6020  
Fax: (44 1703) 59 6554  
E-mail: c.summerhayes@soc.soton.ac.uk

ANNEX III  
LIST OF DOCUMENTS<sup>1</sup>

<b>Document Code</b>	<b>Title</b>
IOC/GE-GLOSS-V/1 prov.	Provisional Agenda
IOC/GE-GLOSS-V/1 Add.prov.	Provisional Timetable
IOC/GE-GLOSS-V/2	Annotated Provisional Agenda
IOC/GE-GLOSS-V/3 prov.	Draft Summary Report of GLOSS-V (to be prepared during the Session)
IOC/GE-GLOSS-V/4 prov.	Provisional List of Documents (this document)
IOC/GE-GLOSS-V/5 prov.	Provisional List of Participants
IOC/GE-GLOSS-V/6	Progress report on GLOSS activities since GLOSS-IV
IOC/GE-GLOSS-V/7	Satellite altimetry measurements
IOC/GE-GLOSS-V/8	Conclusions of the GPS/IOC/PSMSL Workshop on geodetic fixing of Tide gauge Bench marks
IOC/GE-GLOSS-V/9	Sea-Level observational component of the GOOS Climate Module
IOC/GE-GLOSS-V/10	Draft GLOSS Implementation Plan
IOC/GE-GLOSS-V/11	GLOSS Status
IOC/GE-GLOSS-V/12	Activities of Sea-Level centers; regional and national activities

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<sup>1</sup> For reference only. No stocks of these documents are maintained, except for the Report.

ANNEX IV

PLAN OF ACTIONS 1997 - 1999

No.	Actions	Responsible	Date
1.	Presentation of GLOSS GE-5 report and Implementation Plan to IOC Assembly and I-GOOS for approval	Chairman/Secretariat	1997
2.	Publication of the revised GLOSS Implementation Plan	Secretariat	Oct 1997
3.	Implementation of recommendations from IGS/PSMSL GPS workshop	IGS/PSMSL/others	1997
4.	Publication of GPS Workshop Proceedings	IGS/PSMSL	Jul 1997
5.	Preparation and publication of "IOC Manual 3 (GPS)" (This depends on the work of the Technical Committee formed by the IGS Workshop)	IGS/PSMSL/IOC	1998
6.	Establish Scientific Group for TGBM's and GPS	IAG/IAPSO	1997
7.	A further complete set of correspondence to all GLOSS Contacts and a revision of the GLOSS network of tide gauges as an essential preliminary to the production of the next issue of the GLOSS Handbook CD-ROM	PSMSL/BODC/IOC	1997
8.	Preparation of up-dated GLOSS Handbook CD-ROM as part of WOCE Sea Level Centres CD-ROM	BODC/UHSLC/PSMSL/ NODC/IOC	1997-1998
9.	Intersessional GLOSS Data Management Committee set up to facilitate data management and distribution	Chairman/Secretariat	1997
10.	Continued support of PSMSL activities re. GLOSS development	Secretariat	1997-1999
11.	Continued production of the GLOSS Bulletin on the world wide web	POL/NTF	1997-1999
12.	Continued Afro-America GLOSS News USP is further to be asked to investigate a "free" web version of the AAGN	USP	1997-1999
13.	Organize training courses/workshops including POL course June 1997 for Mediterranean countries Other courses to be investigated as per GE-5 meeting report	Secretariat POL/Secretariat IOC	1997-1999
14.	IOC to keep as far as possible copies of training materials/lectures from courses as a guide to preparation of new courses. Copies should be obtained of materials from all courses in last 4 years	Secretariat	1997-1998
15.	Support where possible of GLOSS regional activities	Secretariat	1997-1999
16.	Assist countries to make proposals for GLOSS and sea-level impacts projects to GEF. Arrange meeting at 1997 Assembly of IOC	Secretariat/Pugh/Mitchel I	1997-1998
17.	Information paper on sea-level measurements in the Arctic Ocean (This is carried over from GE-4)	Bolduc/Zilbershtein/IOC	1998

No.	Actions	Responsible	Date
18.	Resolution of fate of missing 4 gauges delivered to West Africa	Secretariat	1997
19.	Investigation of possibility of exchange of data from the ASEAN tide gauge network	Secretariat	1997
20.	Review designation and activities of Regional GLOSS Coordinators	Chairman/Secretariat	1997
21.	Following from previous item, review how best the IOCEA network be coordinated	Chairman	1997
22.	Investigate multi-national funding for a Technical Consultant for GLOSS	Chairman/Secretariat	1997-1998
23.	NOAA prioritisation study of gauges for climate	Scherer/Johnson/Gornitz	1997
24.	Production of an IAPSO/GLOSS tidal constants data set	Le Provost and others	1997
25.	Short sea-level brochure in cooperation with OOPC for the GCOS Participants Meeting	Secretariat	Jan 1998
26.	Preparation and printing of a new GLOSS brochure	Chairman/Secretariat	1998
27.	Joint activities with J-GOOS/OOPC in design/planning and implementation of the sea-level component of the GOOS Climate Module. May include occasional participation at J-GOOS meetings	Chairman	1997-1998
28.	Arrange joint publication of a background report with OOPC on scientific rationale for GLOSS	Le Provost	1998
29.	Continuation and development of 2 WOCE Sea-Level Centres and Southern Ocean SLC	UHSLC/BODC NTF	1997-1999
30.	Investigate subsequent experience of trainees at the Dehra Dun training workshop and possible temporary visits at oceanographic laboratories in the region	Shetye	1997
31.	Extend Pilot Phase of Indian Ocean CMAS to other countries	Shetye/Secretariat	1997-1999
32.	Resolution of the EuroGLOSS/EPTN/MedGLOSS/EOSS overlap of projects	Boucher	1997
33.	Arrangements for next full meeting: GLOSS-VI Session and interim meeting as required	Chairman Secretariat	early 1999 late 97/98

ANNEX V

**SUMMARY RECOMMENDATIONS**  
**of the "WORKSHOP ON METHODS FOR MONITORING SEA-LEVEL"**  
Pasadena, California, USA, 17 - 18 March 1997

1. FOR THE PURPOSE OF MONITORING AND UNDERSTANDING LONG TERM CHANGES IN SEA LEVEL, including the contribution of land motion to these changes, this group recommends that:

Science Working group(s) be formed that interface with the IGS or are components of the IGS, at the Associate Analysis Centre level (such as the Regional Network Analysis Centres RNACC), following all conventions established by the IGS Densification Project. (See this report for details.)

2. FOR THE PURPOSE OF MONITORING THE DRIFT OF SATELLITE ALTIMETERS it is recommended that:

Approximately 10 additional stations be incorporated into the IGS Global Analysis and Data Flow.

IN ORDER TO REALIZE THE ABOVE OBJECTIVES, it is further recommended that:

- (iii) The IGS, in cooperation with the International Earth Rotation Service (IERS), produce vertical velocity estimates to be updated annually in addition to a height time series derived from GPS, expressed in the International Terrestrial Reference Frame (ITRF);
- (iv) A working group on the free exchange of data be formed that includes representation from the GPS and Sea Level communities, for the purpose of establishing necessary data links;
- (v) That science working groups that are established to address these developments ensure their representation under the umbrella of International Association for the Physical Sciences of the Ocean (IAPSO) and the International Association of Geodesy (IAG), including IGS, IERS, IAG Subcommittee on Sea Level and Ice Sheets and the IAPSO Commission on Mean Sea Level and Tides;
- (vi) A Technical Working Group be constituted to set up recommended standards and specifications for operating GPS at Tide Gauge sites, in collaboration with the IGS working group on "Site Specifications and Network Operations".

This Working Group will consider, document and make recommendations on the following types of tide gauge and site specific information:

- (a) making measurements for precise ties (e.g., between the GPS, the tide gauge, the tide gauge benchmarks, the local reference networks, etc.);
- (b) data handling of the survey tie information;
- (c) site stability aspects;
- (d) monumentation techniques;
- (e) collocation philosophy and observing methods (continuous measurement rationale);
- (f) absolute gravity measurements for complementary information on vertical crustal movements and mass redistribution;
- (g) environmental parameters, meteorological sensors, ancillary measurements, etc.

ANNEX VI

**RECOMMENDATIONS OF THE FIFTH SESSION OF THE IOC GROUP OF EXPERTS ON GLOSS**

**Recommendation IOC-GLOSS-V/1:**

The GLOSS Group of Experts

**Emphasizes** the importance of positioning tide gauges bench marks within the ITRF to distinguish changes of mean sea-level from local vertical land movements;

**Endorses** the recommendations of the joint IGS/PSMSL Workshop (attached as Annex V to this report);

**Recommends** that IAG and IAPSO cooperate to establish the Science Working Group for Tide Gauge Datums to interact at the Associate Analysis Centre level with the IGS;

Further **recommends** that this Science Working Group also considers the issues relating to the establishment of data links;

**Invites** the Science Working Group and the Technical Working Group on Site Specifications to report developments on a regular basis to the Group of Experts on GLOSS with a view to further facilitating the work at an intergovernmental level;

Equally **recommends** that other space geodetic systems also establish precise ties to tide gauge bench marks; furthermore noting the role of DORIS (TOPEX/POSEIDON, JASON, ENVISAT) and PRARE (ERSZ) that there should be established precise ties between them and tide gauges.

**Recommendation IOC/GLOSS-V.2:**

The Group of Experts

**Considering** the high level of intersessional activity required by the GLOSS Implementation Plan, it is clear that there is an ongoing demand for a GLOSS Technical Secretary with duties as described in Chapter 11 of the Plan,

**Bearing** in mind the retirement of Dr. Albert Tolkatchev, the present Technical Secretary, at the end of February 1997, and his continuance as a consultant which is planned to be terminated at the end of the IOC Assembly,

**Noting** the importance of GLOSS as one of the key IOC contributions to the embryo GOOS programme and the rapid development of GOOS as we approach the proposed Heads of Agencies meeting in 1998,

**Noting** also that the XXVIIIth session of the IOC Assembly by Resolution XVIII-13 instructed the IOC Executive Secretary to investigate the establishment of a dedicated post in the Secretariat to develop GLOSS and related sea-level studies and applications,

**Recommends** that the IOC Assembly at its XIXth session give its strongest possible endorsement to the proposal that the permanent UNESCO post of the GLOSS Technical Secretary be continued, that recruitment into the post proceed rapidly, and the IOC Executive Secretary be instructed to take all possible actions to ensure the continuity of the present high level of activity required for the continued success of the GLOSS programme;

**Noting** the role of the Technical Coordinator to the success of the DBCP programme,

the Group also **recommends** that the IOC Executive Secretary identify resources for a Technical Secretary to assist in the implementation of this new plan.

**Recommendation IOC/GLOSS-V.3:**

The Group of Experts

**Noting** that present Terms of Reference of the Group were adopted by the IOC Executive Council in 1988 by Resolution EC-XXI.2,

**Noting** also that the IOC Executive Council in 1992 at its XXVth Session decided that the Committee on Ocean Processes and Climate be replaced by the IOC Committee for GOOS (I-GOOS), and that IOC, WMO and ICSU decided in 1993 to establish the Joint GOOS Scientific and Technical Committee (J-GOOS),

**Recommends** that the IOC Assembly approve the revised Terms of Reference of the Group as follows:

The IOC Group of Experts on GLOSS shall:

- (i) Advise the IOC on the implementation of the GLOSS System, at global and regional levels;
- (ii) Work closely with J-GOOS and its subsidiary bodies and advise I-GOOS on the integration of GLOSS into a global ocean observing system;
- (iii) Update the GLOSS Implementation Plan regularly;
- (iv) Ensure proper liaison with international research programmes and relevant international organizations;
- (v) Provide advice on the development of TEMA components of GLOSS, regarding training of specialists, provision of instruments, their installation and maintenance, and data evaluation and interpretation;
- (vi) Report periodically to I-GOOS and the IOC governing bodies.

**Recommendation IOC/GLOSS-V.4:**

The Group of Experts

**Noting** developments in the pilot phase of the Pilot Activity on sea level changes and associated coastal impacts in the Indian Ocean, and the improved understanding of ocean processes which has resulted from the CMAS (Cell for Monitoring and Analysis of Sea-Level) in the Indian Ocean countries,

**Encourages** other countries in the region to further cooperate in the next phase of the Pilot Activity, through the development of further CMAS.

**Recommendation IOC/GLOSS-V.5:**

The Group of Experts

**Urges** the IOC to act as a catalyst, taking active steps to understand the Global Environmental Facility (GEF) proposal process, and using that understanding to assist regions to develop focused proposals to attract GEF funds to support major regional projects involving GLOSS and GOOS.

**Recommendation IOC/GLOSS-V.6:**

The Group of Experts

**Considering** the value of recent training workshops in Dehra Dun (1995) and Buenos Aires (1996) in building regional links among the participants,

**Recommends** that the IOC Secretariat investigate the needs and possible external funding of training workshops on sea-level observations and analysis in the 1998-1999 period in South America (Sao Paulo, Brazil), IOCEA ( West Africa), IOCINCWIO (East Africa), South-east Asia and the countries of former Soviet Union.

ANNEX VII

**LIST OF ACRONYMS**

ACCLAIM	Antarctic Circumpolar Current by Levels and Island Measurements
ASEAN	Association of South-East Asian Nations
BODC	British Oceanographic Data Centre
CIESM	Commission Internationale pour l'exploration scientifique de la mer Méditerranée
CLIVAR	Climate Variability and Predictability
CMAS	Cells for Monitoring and Analysis of Sea-Level
CMM	Commission on Marine Meteorology
DOD	Department of Ocean Development (India)
DORIS	Doppler Orbitography and Radio positioning Integrated by Satellites
EC	European Commission
EGC	EuroGLOSS Committee
ENSO	El Nino/Southern Oscillation
EOSS	European Sea-Level Observing System
EUREF	European Reference Frame
EUVN	European Vertical GPS Reference Network
GCN	Global Core Network
GCOS	Global Climate Observing System
GEF	Global Environmental Facility
GLOSS	Global Sea-Level Observing System
GLOSS-ALT	GLOSS Network for Altimeter Calibration
GLOSS-LTT	GLOSS Network for studies of Long-Term Sea-Level Trends
GLOSS-OC	GLOSS Network for Ocean Circulation Monitoring
GOOS	Global Ocean Observing System
GPS	Global Positioning System
I-GOOS	IOC-WMO-UNEP Committee for the GOOS
IAPSO	International Association for the Physical Sciences of the Ocean
ICSU	International Council of Scientific Unions
IERS	International Earth Rotation Service
IGS	International GPS Service for Geodynamics
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Sub-Commission for the Caribbean and Adjacent Regions
IOCEA	IOC Regional Committee for the Central Eastern Atlantic
IOCINCWIO	IOC Regional Committee for the Co-operative Investigation in the North and Central Western Indian Ocean
IOMAC	Organization for Indian Ocean Marine Affairs Co-operation
ITRF	IERS Terrestrial Reference Frame
J-GOOS	Joint Scientific and Technical Committee for GOOS
MOU	Memorandum of Understanding
NEAR-GOOS	North East Asian Regional GOOS
NOAA	National Ocean and Atmosphere Administration (USA)
NOS	National Ocean Service
NTF	National Tidal Facility (Australia)
OAS	Organization of American States
OOPC	Ocean Observations Panel for Climate
PSMSL	Permanent Service for Mean Sea-Level
SELF	Sea-Level Fluctuations Geophysical Interpretation and Environmental Impact
SOSLC	Southern Ocean Sea-Level Centre
SSG	Scientific Steering Group
TEMA	Training Education and Mutual Assistance
UHSLC	University of Hawaii Sea-Level Centre
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

WCRP	World Climate Research Programme
WECENER	Working Group of European Geoscientists for the Establishment of Networks for Earth Science Research
WESTPAC	IOC Sub-Commission for the Western Pacific
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment