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# ANALYSIS OF THE POSSIBLE ESTABLISHMENT OF AN IOC GROUP OF EXPERTS ON THE APPLICATION OF MARINE ACOUSTICS TO IOC PROGRAMMES

Following the instruction of the IOC Assembly at its Sixteenth Session, discussions and consultations with scientists and with members of the SCOR Working Group on Acoustic Monitoring of World Ocean were carried out by the IOC Secretariat. The reaction from them are identical: in order to meet with the requirements of scientific research and ocean services, (i) an IOC Group of Experts in this field is highly desirable with Terms of References formulated so as to take into account those of the SCOR Working Group; and (ii) co-operation and co-ordination between the SCOR Working Group and the IOC Group of Experts should and can be established from the beginning. The proposal is presented in this document for the consideration and decision of the Executive Council.

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## 1. BACKGROUND

Over the past 50 years the technology of marine acoustics has progressed rapidly. In the 1960s, the use of marine acoustics for oceanographic research and ocean exploitation began to receive attention. Since then considerable reserch and development efforts in marine acoustics have been made, which have resulted in a fairly strong scientific and technological expertise in this field. In the early 1980s the IOC held an Expert Consultation on Ocean Science for the year 2000 in Villefranche-sur-mer, France. It was suggested that the IOC and other related organizations arrange an international workshop on marine acoustics within the decade.

As a result of years of efforts made by IOC, in co-operation with many institutions and individual experts, the suggested Workshop finally became a reality in Beijing, China, 26-30 March 1990. The Workshop reviewed the present status of marine acoustics and the trends in the field, including research and applications, and recommended that a Group of Experts on Marine Acoustics be set up under IOC (IOC Workshop Report No. 68, 1990). Suggestions concerning the development of marine acoustic research and applications of marine acoustics to marine scientific research programmes were also made.

In considering these recommendations, the IOC Assembly, at its Sixteenth Session (Paris, 7-22 March 1991), discussed the possibility of establishing an IOC Group of Experts in this field, taking into account the establishment of a SCOR Working Group on Acoustic Monitoring of the World Ocean in the fall of 1990. The Assembly took note of the important review by the International Workshop on Marine Acoustics and instructed the Secretary IOC to further study the matter, in consultation with SCOR as a scientific advisory body to IOC, and to identify possible needs to be covered by an IOC Group of Experts and prepare specific and focussed draft Terms of Reference for such a Group. This should be presented to the Twenty-fifth Session of the IOC Executive Council (Paris, 10-18 March 1992) (Document SC/MD/97, paras. 141-150).

Following the decisions of the Assembly, herein are presented the results of the consultations and related information on the requirements of application of marine acoustic technique to various IOC programmes, and the needs for developping marine acoustic research on the bases of international and intergovernmental co-operation.

## 2. REQUIREMENTS

### 2.1 PROGRAMME REQUIREMENTS

As indicated in Table 1, the developments of various IOC programmes can make considerable use of and benefit from acoustic techniques. These can provide means to measure oceanographic parameters in both the open ocean and coastal areas and furnish information for improved understanding of the dynamics of the boundary layers at the sea surface and the sea-bed.

**The observations and measurements of physical variables of the ocean** are fundamental for understanding the behavior of and conditions in the ocean areas. To achieve this the acoustic techniques are particularly useful: first, the essentially non-invasive nature of acoustic radiation will not effect the oceanographic processes; and second, the integrative nature of the path between the acoustic source and receiver provide valuable techniques for observing the dynamic processes. For instance, understanding physical and dynamical processes in the boundary layers at the surface and the the sea-bed is important for the studies of exchange processes. The measurements in these boundary layers are notoriously difficult because of turbulence and small scale processes. Eddy viscosity are often used to model these regions, which requires depth profiles of both mean current and its variance or turbulent energy under a variety of wind, wave, and density conditions. Acoustic Doppler Current Profiler (ADCP) is now a well established technique to determine current profile. A very high frequency ADCP may resolve the turbulent shear flow near the sea-bed.

It is apparent that a lot of programmes can benefit from application of the technique, including the development of the Global Ocean Observing System (GOOS), the Tropical Ocean and Global Atmosphere (TOGA), the World Ocean Circulation Experiment (WOCE), the Ecosystem Dynamics and Living Resources (EDLR) and the Global Ocean Ecosystems Dynamics (GLOBEC) and others dealing with physical and dynamical processes.

**Determination of the content and distribution of suspended particles in the water column** comprises an important part of marine environment research and monitoring including for transportation of sediments. By using a very high frenquency ADCP, the transport and deposition of particles may be determined, especially in coastal waters and the near-bottom layer. This characteristic may be applied to the studies of coastal erosion, water quality analysis and control, and monitoring the outflow of sewage. These techniques could be used in the programmes of marine pollution research and monitoring, coastal zone studies and other activities. These applications are not well established in the on-going programmes, especially in developing countries.

**Acoustic data transmission** properties of seawater are important for a wide range of human underwater activities. Most of the underwater acoustic data transmission systems that are available offer bit rates of 10-500 bits/sec over a distance of a few kilometers. For oceanography, the existing systems are used for control of submerged equipment and can also be used to transmit data from submerged equipment for measurements of ocean currents and temperature. These observations and measurements are now employed in various programmes, especially those using buoys to measure oceanographic parameters, e.g. TOGA, WOCE, IGOSS, GLOSS and GOOS.

Acoustics can also be applied to many other ocean-related activities as indicated in the IOC Workshop report No. 68, such as positioning of research vessels and oceanographic equipment of the sea surface, in the water column and on the sea floor, ocean acoustic topography and imaging. Almost all on-going IOC programmes can use the development of acoustic techniques, e.g. ocean mapping, OSLR, OSNLR and above-mentioned programmes. However, to meet requirements from these international programmes, a close co-operation and co-ordination in the field of acoustics, in both the acoustics research itself and its application to oceanography, is necessary and appears to be an urgent task for the oceanographic communities.

## 2.2 TECHNICAL REQUIREMENTS

In order to achieve the requirements of the IOC programmes and associate relevant activities, technical requirements should be considered as an important aspect for application of acoustics.

Acoustic Monitoring of bubbles, as an example, is potentially a very valuable technique for monitoring the dynamic near-surface layers of the sea. Bubbles, which are injected into the sea mainly by breaking waves, rapidly give up their injection momentum to the sea and the resulting bubble clouds are then carried around passively by the turbulent water. However, the air bubbles only exist in the ocean in a very short time period, so the measurement and monitoring become complicated. A standard methodology and procedure would be needed in order to ensure comparable results.

Some specified actions and requirements to achiveve this are given in Table 2.

## 2.3 RESOURCES REQUIREMENTS

For the initial period, the financial requirements will be about 20,000 US$ for organizing Experts meeting, preparing necessary programme plan guidelines and related documents. Required staff-time in the IOC Secretariat would be about 1/4 professional and possibly some consultancy.

## 3. INTERNATIONAL AND INTERGOVERNMENTAL CO-OPERATION

Efforts have been made by national and international institutions and organizations to ensure appropriate benefits from using acoustic techniques in oceanographic observations. An appropriate application of acoustics, as an effective but scientifically and practically complicated means, requires co-operation and co-ordination of various programme efforts.

In this connection, SCOR has established Working Group 96 on Acoustic Monitoring of the World Ocean with the following terms of reference:

(i) To study the existing methods of large-scale acoustic tomography of the ocean and indentify those which can benefit from international collaboration.

(ii) To evaluate the opportunities for international collaboration in the use of acoustic techniques for monitoring global climate in the ocean.

(iii) To assess other methods and theories relating to investigation of the ocean by means of observations of sound propagation over long distances.

(iv) To prepare a report to SCOR on the scientific prospects for large-scale acoustic tomography.

The EEC has also included Underwater Acoustics in its programme on Marine Science and Technology 1991-1994 (MAST-II) to:

(i) develop acoustic techniques to assist marine science (e.g. 3D-imaging, tomography, navigation, obstacle evidance especially for use on the continental shelves and under the ice);

(ii) develop wideband, efficient acoustic sources and receivers, as well as the necessary electronics and algorithms for geosciences and oceanography;

(iii) improve the communications, especially in shallow water, under the ice and other difficult conditions.

As mentioned above, IOC has initiated studies in the field of application of marine acoustics to ocean sciences and services through the Workshop, Beijing, China, 26-30 March 1990. The present status of marine acoustics, including research and applications, and trends in marine acoustics have been comprehensively reviewed and further international collaboration has also been recommended to the IOC Assembly at its Sixteenth Session.

Several requirements indicated in the previous sections are not covered, technically and geographically, by the SCOR or MAST programmes, e.g. medium scale and small scale processes, and short period phenomena which are also affecting strongly the marine environments. Other aspects in this field, such as probing the seabed sediments, data transmission, data base on acoustics for both oceanographic models and acoustic models, are important for both the oceanographer and the acoustician.

## 4. CONCLUSION

Following the instruction at its Sixteenth Session of the IOC Assembly, discussions and consultations were carried out by the IOC Secretariat with related scientists and with members of the SCOR Working Group. The reaction from them are identical: in order to meet with the requirements of scientific research and ocean services, (i) an IOC Group of Experts in this field is highly desirable with Terms of References formulated so as to take into account those of the SCOR Working Group; and (ii) co-

operation and co-ordination between SCOR Working Group and IOC Group of Experts should and can be established from the beginning.

The proposed Terms of Reference are presented in the Annex to this document. They have been drafted in consultation with the experts.

## REFERENCES

1. IOC Worshop Report No. 68 - International Workshop on Marine Acoustics, Beijing, China, 26-30 March 1990.

2. Summary Report of the Sixteenth Session of the IOC Assembly, Paris, 7-22 March 1991.

3. B. McCartney, Ocean Measurements Using Acoustics, pp 89-97, Proceedings of International Workshop on Marine Acoustics, March 1990.

4. Li Yunwu, On Perspective of Using Acoustics to probe Ocean Environment.

5. G. Sandsmark, Hi Speed Underwater Acoustic Data Transmission, a Brief Review .

6. Marine Science and Technology 1991-1994 (MAST-II).

**Table 1.** **Requirements which may be achieved by Application of Marine Acoustics to IOC Programmes**

| Programme | Requirements | Responsed by |
|---|---|---|
| Global Ocean Observing System (GOOS) | Current Measurements;<br>Observation of Internal & Surface Waves;<br>Buoy positioning;<br>Data transmission; | IOC<br>WMO |
| Ocean Science in Relation to Living Resources (OSLR) | Determination distribution of fish and plankton; | IOC<br>FAO |
| Ocean Science in Relation to Non-Living Resourses (OSNLR) | Sediment probing;<br>Sub-bottom profiling | IOC<br>UN(OALOS) |
| Ocean Mapping | Topography of sea bottom;<br>Ship positioning | IOC<br>IHO |
| Global Investigation of Pollution in Marine Enviroment (GIPME) | Monitoring of sewage outflow;<br>Detection of Oil spill and other pollutants | IOC |
| Integrated Global Ocean Services Systems | Positioning submerged equipment;<br>Data transmission. | IOC<br>WMO |
| Tropical Ocean and Global Atmosphere (TOGA) | Ocean current measurements;<br>meterolcgical observation; | WCRP |
| World Ocean Circulation Experiment (WOCE) | Ocean current measurements; | WCRP |

| | | |
|---|---|---|
| Coastal Ocean Circulation Dynamics and Fluxes (COCDYF) | coastal current measurements; suspended matter observations; topography/morphology | IOC |
| Global Sea-level Observing System | Data transmission. | IOC |

**Table 2.** **Requirements of Specified Actions identified at the International Workshop on Marine Acoustics (March 1990)**

| Requirements | Specified Actions and Technical Needs | Responsibility |
|---|---|---|
| Applications of marine acoustics to the IOC programme | Identify gaps of knowledge with suggestions on the areas to be studied. | IOC G.E.<br>SCOR W.G. |
| | Fomulate guidelines on methods and procedures for using acoustic equipment in measurements and in data procession, especially ADCP | IOC G.E.<br>SCOR W.G. |
| | Allocation and intercalibration of the frequencies of the equipment. | IOC G.E.<br>Others |
| | Provision of reliable data for use in both oceanographic models and acoustic models | IOC G.E. |
| Establishment of marine acoustic data bases associated with internationai and national oceanographic data bases | Establish acoustic data bases, including noise levels. | IOC G.E.<br>SCOR W.G.<br>Other Organ. |
| | Standardize oceanographic input data for acoustic propagation models. | " |
| | Establish a procedure for data quality control. | " |

| Requirements | Specified Actions and Technical Needs | Responsibility |
|---|---|---|
| Training courses in marine acoustics for scientists and technicians from developing countries.<br><br>Advanced Study Institute and international exchanges of scholars and advanced students | Identify gaps in knowledge. Organize courses, including finding necessary resources for training, both expertise and financial, as well as facilities.<br><br>Prepare necessary reference materials. | IOC G.E.<br><br>IOC G.E.<br>Other Organ.<br><br>IOC G.E. |
| A focus for international collaborations | To establish a Group of Experts on Application of Marine Acoustics to various programmes;<br><br>To consult with other international organizations on possible co-operation in this field | IOC<br><br>IOC G.E.<br>SCOR W.G.<br>Other Organ |
| Information exchange and intercomparisons between possibly overlapping research areas and applications | To follow up the development of various programmes sponsored by organizations and institutions<br><br>To provide necessary advice to marine science communities. | IOC G.E.<br><br>IOC G.E.<br>SCOR W.G. |
| Resources surveys by acoustic means, using inter-agency contacts | To interface with the OSLR programme and provide scentific and technological advice to Member States | IOC G.E. |

# PROPOSED TERMS OF REFERENCE FOR AN IOC GROUP OF EXPERTS ON THE APPLICATION OF MARINE ACOUSTICS (GEMA)

## FUNCTION

The Group of Experts is established as a subsidiary body of the Intergovernmental Oceanographic Commission (IOC) in order to meet the scientific and technical needs for development and application of marine acoustics. The GEMA will carry out the following functions:

(1) provide scientific and technical advice to the IOC Member States and Subsidiary Bodies on the development and application of marine acoustics and use in the IOC programmes;

(2) review the requirements as identified by the IOC on-going programmes, especially on medium and small scale processes, for applying marine acoustics to these programmes;

(3) formulate guidelines on standard methods and procedures for employing acoustic techniques to various research programmes and related observing systems, such as TOGA, WOCE, OSLR, OSNLR, Ocean Mapping and GOOS;

(4) co-ordinate international co-operation on application of marine acoustics with other international organizations;

(5) assist with identification of training, education, and mutual assistance needs as well as equipment requirements, and organize related training so as to ensure efficient and cost-effective application of the technique;

(6) advise on, and review as necessary, the need to establish an acoustic frequencies allocation mechanism within IOC;

(7) liaise closely with other relevant Groups of Experts for development of the IOC programmes and with the SCOR Working Group on Acoustic Monitoring of the World Ocean, and the programme implementation; and

(8) report to the IOC Committee on Ocean Processes and Climate (OPC) on the progress of its activities;

## SCIENTIFIC AND TECHNICAL ADVICE

In discharging its tasks, the Group will be guided by the Assembly and the Executive Council of IOC.

## COMPOSITION

The Group will be composed of specialists from Member States, selected in their personal capacity for their scientific and technological expertise.

## ORGANIZATION OF SESSIONS

The GEMA shall hold its sessions at the dates and places which be recommended by the Group and arranged by the Secretary IOC. Session shall normally be held every 12 months.