**Intergovernmental Oceanographic Commission**
*Training Course Reports*
**10**

# IOC-Unesco Regional Training Workshop on Ocean Engineering and Its Interface with Ocean Sciences in the Indian Ocean Region

Organized with the support of
the Department of Ocean Development,
Government of India

Ocean Engineering Centre,
Indian Institute of Technology,
Madras, 17 March-5 April 1986

Unesco

# *IOC Training Course Reports*

| No. | Title | Language versions |
|---|---|---|
| 1. | IOC Indian Ocean Region Training Course in Petroleum Monitoring, Perth, 18 February-1 March 1980 | English |
| 2. | IOC Regional Training Course for Marine Science, Technicians, Cape Ferguson, Queensland, 1-28 June 1980 | English |
| 3. | ROPME-IOC-UNEP Training Workshop on Oceanographic Sampling, Analysis, Data Handling and Care of Equipment, Doha, Qatar, 3-15 December 1983 | English |
| 4. | Stage COI d'initiation à la gestion et au traitement de l'information scientifique et technique pour l'océanologie, Brest, France, 28 novembre - 9 décembre 1983 | French |
| 5. | Curso mixto COI-OMM de formación sobre el Sistema Global Integrado de Servicios Oceánicos (SGISO), Buenos Aires, Argentina, 15 - 26 de octubre de 1984 | Spanish |
| 6. | Unesco-IOC-NBO Training Course on Tidal Observations and Data Processing, Tianjin, China, 27 August-22 September 1984 | English |
| 7. | Stage COI sur la connaissance et la gestion de la zone côtière et du proche plateau continental Talence, France, 18 septembre - 4 octobre 1984 | French |
| 8. | IOC Regional Training Course on Marine Living Resources in the Western Indian Ocean Mombasa, Kenya, 27 August-22 September 1984 | English |
| 9. | IOC-Unesco Summer School on Oceanographic Data Collection and Management Erdemli, Icel, Turkey, 21 September-3 October 1987 | English |
| 10. | IOC-Unesco Regional Training Workshop on Ocean Engineering and Its Interface with Ocean Sciences in the Indian Ocean Region Madras, India, 17 March-5 April 1986 | English |

TABLE OF CONTENTS

## 1. BACKGROUND AND OBJECTIVES

Recognizing the importance attached by Member States to ocean engineering in support of socio-economic development activities in the marine environment, the Working Committee for Training, Education and Mutual Assistance in the Marine Sciences (TEMA), at its Second Session held at the United Nations, New York (1977), adopted the Recommendation on "Ocean Engineering and Marine Technology in TEMA" (Recommendation TEMA-II.4) which called for actions to be taken to explore how TEMA related ocean engineering and marine technology activities can most effectively be organized under TEMA and made available to IOC Member States. The Fourth Session of the Working Committee for TEMA, held in Lisbon (Portugal), further encouraged Unesco and IOC to contribute to this field. The Regional Training Workshop on "Ocean Engineering and its Interface with Ocean Sciences", therefore, forms part of a series of activities aimed at promoting ocean engineering and marine technology in developing countries. The Indian Ocean and adjacent region was chosen for this purpose as the first region to be followed by similar and/or more specialized workshops on the subject in the other regions of the world. The expectation is that the Training Workshop will contribute to future development of the IOC programme on Ocean Science and Non-Living Resources (OSNLR).

The project on Regional Training Workshop on Ocean Engineering and its Interface with Ocean Sciences in the Indian Ocean Region, which was prepared by IOC jointly with the Ocean Engineering Centre (OEC), IIT, Madras, was submitted to the Department of Ocean Development (DOD), Government of India, early 1985, with the following aims and objectives: (i) to familiarize the participants with recent advances and trends in ocean scientific research and ocean engineering and related marine technology fields; (ii) to highlight the nature and the significance of interdisciplinary approach in ocean science and ocean engineering for the development of the marine environment and its resources; (iii) to highlight the role of new technologies in contributing to the advancement of marine scientific research and knowledge in frontier areas; and (iv) based on the overview of contemporary developments in ocean science and ocean engineering to identify ways and means to promote closer interaction between these disciplines at the national and regional levels.

Later, the IOC invited the Unesco Division of Marine Sciences to join its efforts in organizing this Training Workshop. The DOD having agreed to provide financial support for the major portion of the project, invited the Director-General of Unesco to hold this Training Workshop at OEC, IIT, Madras, from 17 March to 5 April 1986. In addition to financial support provided by IOC/Unesco under the Regular Programme for participants from developing countries of the region, at the request of IOC, the Governments of France, FRG and Norway, agreed to provide financial support to one expert each to deliver lectures on special topics and to participate in the conduct of the Training Workshop.

A detailed programme for the Training Workshop and other arrangements by a Steering Group established for this purpose by the IOC, which met at the Unesco Headquarters, Paris, from 24 to 26 October. The members of the Steering Group were as follows: Prof. Dr.-Ing. Gunther Clauss, Institut fur Schiffs-und Meerestechnik, Technische Universitaet, Berlin; Mr. Jean-Pierre De Loof, Directorate of Engineering & Technology, IFREMER, Centre de Brest; Mr. Ole Gunnar Houmb, Engineering Department,

Oceanographic Company of Norway A/s. Trondheim; Prof. Dr.-Ing. V.S. Raju, Ocean Engineering Centre, Indian Institute of Technology (IIT), Madras (India); Dr. S.M. Haq of IOC; and Dr. Dirk Troost of Unesco, Division of Marine Sciences.

Since it was decided that the participants to the Training Workshop should include oceanographers, such as marine geologists, marine geophysicists and physical oceanographers and engineers having interest and experience of working in marine areas, the major concern was to devise a course taking into consideration the capability of participants and their ability to absorb the information provided in different fields. It was also noted that a number of countries in the Indian Ocean region are currently involved in developing marine sciences, ocean services and ocean engineering. The course was designed and topics chosen, taking into consideration the limited capacity of both marine scientists and engineers in most countries of the region, the need to emphasize the importance of interfaces between ocean engineering, ocean science and ocean services, and to provide on one hand basic concepts on a particular field, followed by a more progressive treatment of the subject including recent developments trends in the two disciplines. The basic aspects and specialized information in certain topics were to be covered mostly by the Indian experts, which could serve as backstopping for other specialized aspects to be covered by foreign experts. A Round Table Discussion was proposed at the end of the Training Workshop to discuss the points reflected in the objectives.

This Report, which is prepared by Professor V. Raju, Co-ordinator of the Training Workshop jointly with Dr. S.M. Haq of IOC Secretariat, describes the arrangements for the course, the course details, the Round Table Discussion and the assessment of the Training Workshop by the participants.

## 2. OPENING OF THE TRAINING WORKSHOP

The Workshop was inaugurated by Professor L.S. Srinath, Director, Indian Institute of Technology IIT, at its Ocean Engineering Centre (OEC), Madras. In his speech, Professor Srinath emphasized the importance IIT, Madras, attaches to training programmes of this nature and gave an outline of the activities of the Institute in Continuing Educational Programmes. He stressed the importance of and need for co-operation among different institutions of the Indian Ocean region in training and research in the emerging area of Ocean Engineering and Sciences. Professor Srinath hoped that the participants would find their 3-week stay very useful and enjoyable and also this would lead to permanent bonds of friendship and co-operation between the participants and their institutions on one hand and the OEC, IIT, Madras, on the other. Professor Srinath also conveyed the greetings of Dr. S.Z. Qasim, Secretary, Department of Ocean Development, Government of India, who was originally to inaugurate, but was unable to do so, due to unavoidable circumstances and acknowledged the support given by him for organizing this Workshop and various other activities of the Ocean Engineering Centre.

Speaking on behalf of IOC/Unesco, Dr. S.M. Haq, Senior Assistant Secretary IOC, said that the Training Workshop provided a unique forum in the sense that it brought together oceanographers, meteorologists and engineers from the region to learn from each other's experience the recent

advances in ocean engineering and ocean science and technology in the context of ocean development activities. He outlined the role of IOC and the Unesco Division of Marine Sciences in promoting training, education and mutual assistance in the marine sciences. He expressed sincere thanks on behalf of the Director-General of Unesco, Chairman and the Secretary of the Intergovernmental Oceanographic Commission, to the Department of Ocean Development, Government of India, for holding this important Training Workshop in India and for providing the major funding to this programme, and to Professor Srinath, Director of IIT, for hosting it in the premises of IIT. He acknowledged with appreciation the financial support provided by the Governments of the Federal Republic of Germany, France and Norway, to enable eminent specialists from their countries to take part in this activity. He thanked both the national and foreign experts for their role in the conduct of the course, and expressed his best wishes and success to the participants in their deliberations.

Welcoming the guests and the participants, Professor C. Ganapathy, Head of the Ocean Engineering Centre, gave an outline of the activities of the Centre in the areas of teaching, research, consultancy and continuing educational programmes, and the unique feature of the Ocean Engineering Centre which provides extensive facilities and also interaction with the various user organizations in the country.

Finally, Professor Raju, the Course Co-ordinator, gave an outline of the programme of the Training Workshop (Annex I) and introduced the participants. The list of participants is given in Annex II. Dr. C.P. Vendhan, the joint course co-ordinator, gave the vote of thanks.

## 3. COURSE ARRANGEMENTS

For all local arrangements, the local Organizing Committee under the Chairmanship of Professor L.S. Srinath, Director, IIT, Madras, was responsible. All the participants were accommodated in Taramani Guest House of the IIT, Madras, and the external experts in the main Guest House. All the lectures/laboratory experiments were held in the Ocean Engineering Centre. The course programme is given in Annex I.

All the participants were issued with air travel tickets and they were received at the Airport in Madras. Also, daily transport from the place of stay to OEC and excursions to places of interest were also arranged.

### 3.1 PARTICIPANTS

In all 18 participants attended the Training Workshop representing 14 countries from the Indian Ocean and other regions, namely, China, Egypt, India, Indonesia, Malaysia, Madagascar, Mauritius, Pakistan, Philippines, Sri Lanka, Tanzania, Thailand and Turkey. They were qualified engineers or specialists in the disciplines of Physical Oceanography, Marine Geology or Marine geo-physics and Meteorology with adequate research experience. Names, addresses and fields of scientific interests of the participants are given in Annex II.

3.2 INSTRUCTORS

All the instructors for Orientation and basic lectures came from the Ocean Engineering Centre and allied Departments of IIT, Madras. Special lectures were delivered by the invited speakers from FRG, France, Norway and India. The names with affiliations are given in Annex III.

3.3 COURSE OUTLINE

The programme is essentially comprised of:

(i) Orientation and special lectures on ocean resources and ocean energy, offshore structures, coastal engineering and port structures, marine instrumentation and data handling.

(ii) Laboratory demonstration of experiments, including methodology and techniques relevant to selected ocean engineering and oceanographic fields.

(iii) Ship-board experience and demonstration of measurement of ocean parameters onboard the Fisheries Ocean Research Vessel FORV SAGAR SAMPADA.

(iv) Group discussions and presentation of review reports by participants on the state-of-the-art relevant to Ocean Engineering activities in their respective countries, followed by discussions.

(v) Evaluation of the Regional Training Workshop by individual participants.

The full text of the Orientation lectures were handed over to the participants at the start of the Workshop itself in the form of Volume-I. For special lectures, some hand-outs were given during the lecture and the full text in the form of Volume-II subsequently. The lectures were given in the mornings from 8.30 a.m. to 12.45 p.m., interrupted by 15 minutes tea break. Afternoon sessions from 2.30 to 5.30 p.m., were mostly devoted to laboratory demonstrations of experiments, group discussions, presentation of review reports by the participants, etc.

One and a half days were spent for ship-board training on the research vessel FORV SAGAR SAMPADA and two afternoons were spent for visiting Madras Port and some coastal areas south of Madras.

## 4. COURSE DETAILS

4.1 LECTURES

Introductory Lecture on Ocean Resources and Ocean Engineering Aspects

The lecture provided the basic information about sea bed, including the continental shelf, slope, rise and their relative coverages in terms of percentage of areas. The description of the nature and types of non-living resources were given from beach and shallow waters, and those buried in deep sediments and in the underlying rock as well as from sea water. In each case, their occurrence, prospects of exploitation were

discussed. Particular reference was made to the occurrence of mineral resources including oil and gas, gold, platinum, illmenite, zircon, titanite, sand and gravel, calcium carbonate, phosphates, potash and those extracted from sea water including minerals, such as salt and magnesium and fresh water. A detailed reference was also made to the non-conventional source of ocean energy, in particular the most promising ones namely, waves, tides and ocean thermal energy (OTEC) are briefly considered. Methodology and engineering aspects practiced in the exploration and exploitation of these resources, including research vessels, ships, a variety of offshore structures, harbour structures, coastal protection works, ocean energy structures, materials, were discussed.

Introduction to Physical Oceanography

The lecture dealt with the principle of physical properties of ocean waters, the general flow pattern in the ocean and the mathematical description of the flow field generated by the forces acting on the ocean waters. A brief review of the methods of measurements of physical properties of major interest such as temperature, salinity and density, their distribution in ocean waters and the reasons for their variability was presented. Particular reference was made to the research and development activities in the field of physical oceanography in India.

Introduction to Geological Oceanography

The lecture covered general characteristics of oceans-topographical variations, continental margins, ocean basin with reference to their origin and mineral resources, marine sediments - their origin nature and classification. Marine minerals like Placers, Phosphorites, Sulphide deposits, offshore hydrocarbon deposits, Polymetallic nodules, their origin and occurrence. Various geophysical techniques and their suitability were discussed, including:(i) gravimetric; (ii) magnetometric; (iii) seismographic; (iv) electrical; (v) geothermal; (vi) radiometric. The scheme of exploration, regional geophysical surveys, identification of sites for additional and detailed work - underwater photography, submersible and drilling investigations. Exploration and commercial development of offshore mineral wealth.

Offshore Structures

The lecture described and discussed different types of offshore structures for exploration of ocean resources with particular reference to oil & gas. The relevant ocean parameters and their influence on the design and installation of these structures were highlighted. The structures considered included fixed structures like jacket platforms and gravity platforms, floating structures which include drill ships and semi-submersibles. Recent developments for larger water depths like guyed towers and tension leg platforms are also considered. The procedures adopted for determination of the wave and other forces on the structures were outlined. The methods of installation were briefly explained.

Dynamic Analysis of Fixed Offshore Structures

The lecture covered offshore structures such as deep water jackets, concrete gravity platforms, guyed towers, jackup platforms have some of their characteristic vibration frequencies closer to the frequencies of wind-generated waves with significant energy level. Thus the structures'

dynamic response, the behaviour characterizing the stiffness of the structure, the mass, consisting of structural as well as hydrodynamic added mass, and the damping representing energy dissipation within the structure and the fluid and foundation media were discussed in detail. The requirements of models for studying dynamic analysis of the above mentioned properties as well as the loading, predominantly due to waves were referred to. Explanation was given of the use of both frequency domain and time domain methods of dynamics analysis for predicting the response of the structure. In both the cases, a non-determinate description of the wave climate and hence the loading was adopted. The major goals of global dynamic analysis were described in the context of: a) the calculation of extreme value statistics under wave and earthquake loads; and b) the level crossing statistics required for fatigue analysis.

Positioning Fixing in the Sea

The lecture dealt with the importance of position fixing in the sea which played a dominant role in the spectrum of offshore activities. For positioning in the sea which is almost related to fixed points on land, various methods like intersection of angles by sextant, close range methods, shore control methods, electromagnetic positioning system, acoustic and artificial satellites were explained. Reference was made to the location of depth normally by hydrographic surveying technique as well as to the need for taking precautions measures, due to the complexity and logistics involved at the planning and preparation stages. Reference was also made to the comparatively higher costing of ship time, personnel and transportation of equipment than surveying hardware.

Ocean Energy

The lecture described solar radiation and solar power of $10^{16}$W which is received by the earth continuously. The ocean constitutes 71% of the earth surface and acts as a natural collector of this huge amount of energy that are made available in many different ways. The forms in which the ocean energy could be tapped such as Ocean Thermal Energy, Wave Energy, Tidal Energy, Marine Currents and Marine biomass Energy were described. Special reference was given to the possibility of harnessing Ocean Thermal Energy, Wave Energy and Tidal Energy. The lecture also discussed the principles of energy conversion, world wide activity with special reference to the activities being carried out in India relating to Ocean Thermal Energy Conversion (OTEC), Wave Energy and Tidal Energy. Reference was given to the world wide OTEC potential of about 10 million MW and in India around 50,000 MW, as well as the details of the feasibility study conducted for installing I MW experimental OTEC plant in one of the islands of the Lakshadweep group. Similarly, the world wide wave power potential of around $45 \times 10^{15}$W; and in India of about 40,000 MW, was discussed along with the details of the work done by the Wave energy group at IIT, Madras, on a multi-purpose barrier type wave energy system which incorporates the Oscillating Water Column type of wave energy device. On Tidal Energy, various possible modes of tidal power development were discussed. Finally, the various scientific inputs required for ocean energy development were listed and discussed.

Deep Sea Mining

The lectures described the historical account of the deep sea metallic nodules containing valuable metals since they discovered during the voyage of H.M.S. Challenger during the period 1873 to 1876. Various estimates of metallic nodules in the sea were given amounting to hundreds of billions of tons. Description was given of the nodules of economic interest and their high content of valuable metals like nickel, copper and cobalt. The average size from (2 to 4 cm) and density of coverage on the sea bed (5 to 25 $kg/m^2$). These nodules are found at depths of around 3,000 to 4,000 m. The major problems of mining these deep sea nodules found at the depth of 3,000 to 4,000 m, including their collection from a large area of the open seas and transporting them across a water depth were discussed.

The lecture also discussed some of the practical mining systems like deep sea line drag, continuous bucket, air lift and hydraulic lift. A new system known as the capsule pipeline system proposed recently which appeared very promising was referred to. Finally, a design for the nodule collector to move over the soft ocean bed, to pick and to clean them and then to feed them into the intake of a lifting system was described.

Research Vessels and Observations at Sea

The lecture discussed the merits and limitations of different platforms available for oceanographic observation studies, the importance of research ships for observation at sea. A brief history of important ocean expeditions and the trend in ship design, and fittings was given.

The criteria were spelt out in some details for the selection of a research ship - the objective, range and area of data collection, the cruising range and endurance, cost of acquisition, running and maintenance, the sea-keeping and position-keeping quality, free board and deck space requirements, laboratory layout and fittings, essential ship equipment and deck machinery and their layout, as well as scientific equipment. Some typical research vessels such as AGOR class of USA, DISCOVERY II OF U.K., SAGAR KANYA and SAGAR SAMPADA of India were described. Guidelines for planning and execution of oceanographic cruises were given.

Materials for Marine Structures

The lecture described the requirements of exploration and exploitation of ocean resources and the understanding required of the engineering design criteria for the various ocean structures. Reference was made to various factors governing the choice of the materials both in terms of strength and corrosion deterioration related parameters to establish the design life of the structure. An overview of the environment and the criteria for the selection of materials in the aggressive ocean environment and the criteria for the selection of materials in the aggressive ocean environment was given. The adoptability and limitations of the materials generally used for ocean structures Steel, Aluminum, Titanium, Concrete, were discussed. Some of the new material developments in the field of Polymer Concrete Composites were introduced. The characteristics of these materials along with their technology for production and application were discussed.

Marine Corrosion and Fouling

The lecture explained the mechanism of marine corrosion as influenced by chemical, physical, biological, engineering and time parameters. The variation of these parameters with depth was discussed. The marine corrosion phenomena at splash zone and immersed zone was highlighted. For minimizing the corrosion, the various control measures adopted like impressed current system, sacrificial anode system and their design procedures for offshore steel structures were explained. The effect of rust products in concrete structures which results in palling was highlighted and the corrosion protection, the necessary precautions and methodology of monitoring required were outlined.

Oceanographic Instruments

The lecture explained the different ocean parameters required for oceanographic research and engineering applications. The problems faced in the fabrication of measurement systems arising out of hydrostatic pressure, corrosion and fouling in seawater were described with typical solutions. The requirements from the point of view of the user, for designing an instrument as well as the factors governing its design were spelt out in detail. A generalized system configuration described the transducer, the signal conditioner, the signal processor, the display/telemetry system, the ancillaries, power supply. A survey of typical oceanographic instruments was given from the early times to contemporary usage for the measurement of the following parameters-temperature, salinity, depth, sound velocity, irradiance and optical extinction coefficient, speed and direction of ocean currents, wave heights, period and direction. A typical multi-sensor, digital data acquisition system was described. Instruments used for collection of samples of water, bottom sediments and cores, biological samples were also described.

Coastal Engineering

The lecture described the beach equilibrium concept and the factors affecting it. It was discussed how certain costs are influenced by rapid shifting of the shoreline, landward or seaward, at a noticeable pace. Several factors that affect the shore stability and the influence of each of them on the shore processes were considered. The basic mechanism of shore erosion and two examples of shore erosion problems on the Indian coast with case history were also discussed. The various effects were considered in a quantitative way. For solving practical problems, empirical relations were given whenever available.

Port and Harbour Structures

Description was given of the different types of maritime structures like wharves, jetties, breakwaters, docks, shipway, entrance channels, submarine pipelines, marine outfall, intake structure form the component parts of the marine terminal system. Necessary mechanical handling, storage, refrigeration and other auxiliary facilities were described. Different types of marine terminals, various component parts of terminal system and their salient design features were highlighted. Types of interaction to be considered in the design of near shore structures were discussed. The Role of Network analysis in planning and construction of ports and harbour structures was also considered.

Remote Sensing and its Applications to Ocean Development

The lecture described the main aspects concerned with coastal zone management in tropical regions with particular reference to remote sensing applications. The coastal engineering applications were discussed, including a study of bathymetry, circulation and dispersion of water masses, geomorphology and sedimentary nature of the sea bed, detection of silt accumulation, cartography of wet lands and land use along the coast, detection of swamps and silt marshes, wave spectrum measurements, the quality of water and marine life. The feasibility and limitations of remote sensing for study of these parameters were discussed. Few case studies were also presented.

Seabed Soils and Marine Foundation

The lecture highlighted the different aspects of seabed soils and marine foundations, offshore soil exploration including in situ testing and marine foundation (piles, caissons, seabed anchors, etc.). Current techniques of seabed sampling, in situ testing both for shallow depth (less than 30 m) and for greater depths up to 200 m were considered. Different types of samplers and in situ testing methods using surface ships, submersible tethered platforms and submersibles were explained. Suitability of the different techniques for different conditions were discussed. Also, different types of seabed anchors namely gravity anchors, embedment anchors and special anchor types and their suitability were discussed. Finally, gravity and pile foundation for offshore structures and various considerations regarding suitability, choice and stability were dealt with.

4.2 SPECIAL LECTURES

Offshore Activities Related to Oil and Gas in India

This special lecture was in 3 parts namely, a) building India's offshore capabilities and industry; b) Engineering problems of offshore production system - special problem of Bombay High development; c) Post-design engineering work for offshore projects. The performance of Indian offshore oil and gas activity including the construction of various offshore platforms were outlined. The strategies of development which include mastering of the core technology, acceleration of activities and long range plan are highlighted. The problems associated with engineering and construction were discussed using the Bombay High Offshore area for illustration. Finally, the importance of carrying out R & D on engineering for fabrication, transportation and installation which was hitherto unexplored, was explained and emphasized.

Ocean Environment and Offshore Structures

The lecture outlined the various technologies involving design of offshore structures namely, oceanography, foundation engineering, structural engineering, including welding and fabrication, marine civil engineering involving installation, navigation and naval architecture involving floatation, buoyancy, towing, launching. Environmental forces and their effect on structures were discussed. Explanation was given of offshore oil fields of India, Indonesia and Malaysia and in the North Sea. Various criteria for suitability were highlighted, giving examples to how wave forces can influence cylinders and of motion of semi-submersibles due to waves and various aspects of stability.

Data Collection and Analysis for Ocean Industry with Practical Examples

The lecture outlined the instrumentation used for wave data collection and the Norwegian experience over the last 2 decades in the North Sea. The usefulness and limitations of the indirect wave data (ship observations, hindcasting models) and data from direct measurements were discussed. Procedure generally adopted for evaluation of wave data and wave statistics were presented and effect of wave groups considered. Finally, long-term and extreme wave statistics which are vital for the safety of the structures and the various models available for prediction were discussed.

Ocean Thermal Energy Conversion

The lecture presented the strategy being adopted for the development of Ocean Thermal Energy Conversion by IFREMER, Centre de Brest, France. The work done for the pilot power plant to be used at test site to perfect, estimate and optimize the elements of the future production power plants as well as the results of the site survey were presented. Description was given of the site chosen at the Port of Papeete in Tahiti and of the surveys including measures on the thermal resources, currents, waves, soil characteristics, etc., carried out. The techniques included deployment of towed vehicle and manned submersibles. The technology and development of subsystem were presented which included turbo alternator, heat exchangers, ammonia circuit and cold water system. The materials for the various components and the anchoring of the cold water pipe were discussed and finally the cost estimates were given.

Remote Sensing Technology - State-of-the-Art

The presentation summarized the state-of-the-art of remote sensing technology as applicable in maritime context. Techniques and instrumentation and their utilization, potential for future development were discussed on the basis of examples. The spectrum of instruments and techniques was discussed, including photography using a variety of cameras, non-imaging electro-optical sensor (visible and infrared), electro-optical frame imaging sensors (video technology) mechanical scanners which include very high advanced resolution radio meter, visible and infrared spin scan radio meter, landsat multi-spectral scanner, coastal zone colour scanner, multi-detector electro-optical imagery system, high resolution visible band instruments, lasers, passive and active micro-wave sensors and synthetic aperture radar.

Deepsea Minerals

The lecture overviewed the types of deepsea minerals, including a comprehensive account of the polymetallic nodules and their distribution in the Indian Ocean. Reference was made to their mineral composition and economic potentials of these resources in the region.

4.3 EXPERIMENTAL DEMONSTRATIONS

The participants were exposed to various laboratory experimental techniques through demonstrations, using the extensive facilities and expertise available at the Ocean Engineering Centre. The topics covered were: i) Studies on waves characteristics of regular and random waves; (ii) Wave Forces on structures (a) on cylinders and (b) on large bodies; (iii)

Behaviour of structures under waves: Twin-Hull Semi-submersibles and Articulated towers; (iv) Wave Energy Studies - performance of Oscillating Water Column Wave Energy Device; (v) Structural Model Studies - Stress Concentration Factors in Tubular joints, Dynamic response of Lattice Towers; (vi) Ship Model Studies - Resistance of Ship Hulls, Studies in Towing Tank; (vii) Marine Soil Tests - Cyclic Triaxial Tests, Free Fall Penetrometer, Quick Sand Phenomena.

All the participants were given hand-outs describing the various experiments and their significance to facilitate effective comprehension of the experiments by the participants.

### 4.4 PANEL DISCUSSIONS

The Panel Discussions were arranged on the following topics: (i) Offshore Engineering with Dr. A.K. Malhotra, Professor G. Claus and Prof. V.S. Raju, as experts; (ii) Environmental data collection with Mr. O.G. Houmb and Professor J.P. De Loof, as experts.

These panel discussions enabled the participants to get expert views on additional topics of their interest and also clarifications on some of the topics covered during the lectures. There was a lively participation right through.

### 4.5 SHIP BOARD EXPERIENCE

The Department of Ocean Development made available the Fisheries Ocean Research Vessel SAGAR SAMPADA to enable the participants to have ship board experience and exposure to the various instruments and techniques used for collection of ocean data. During a cruise on this Research Vessel, the techniques of measurements of parameters like salinity, temperature, depth, collection of water and seabed samples and other measurements were demonstrated. This was a unique opportunity to the participants to get exposed to a very modern research vessel. The specifications of FORV SAGAR SAMPADA are given in Annex IV.

## 5. ROUND TABLE DISCUSSION

The purpose of the Round Table Discussion was to provide a forum for the exchange of views amongst the experts and participants on the achievement of the Training Workshop and to reflect on future strategies that need to be developed in order to assist the developing countries of the Indian Ocean region to strengthen national and regional capacities in ocean engineering and ocean sciences in the context of ocean development activities. The Round Table Discussion was chaired by Professor Cronan and assisted by Professor Raju, Professor Claus, Mr. Hombe, Mr. De Loof and Dr. Haq. Attention of the participants was drawn once again to the aims and objects of the Training Workshop referred to earlier (see Background and Objectives).

## 5.1 GENERAL

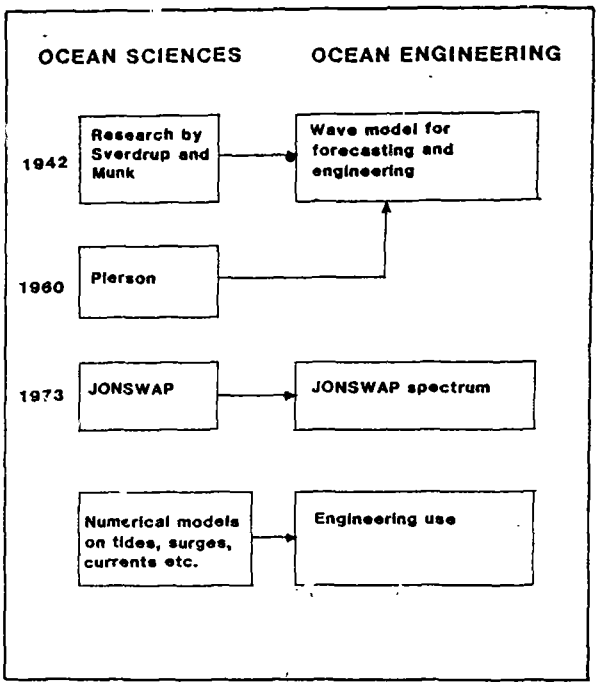
The term "ocean development" has often been used to denote all activities, including ocean sciences, ocean engineering and related marine technology, directed to resource exploration and exploitation and the use of ocean space. The underlying guiding principle in all these activities has been that these be conducted in a manner that insure the preservation of the marine environment without detriment to its quality and the resources with which it abounds. From the statements given by the participants, it became apparent that in some countries, such as China, Indonesia, India, Malaysia, Philippines and Thailand, ocean development programmes and activities, over the years, have evolved from fisheries oriented needs towards mineral resources exploitation. In some of these countries exploitation of these resources has brought about new adjustments to their priority needs which have progressively involved the strengthening of their marine scientific and technological capability demanded by these new situations.

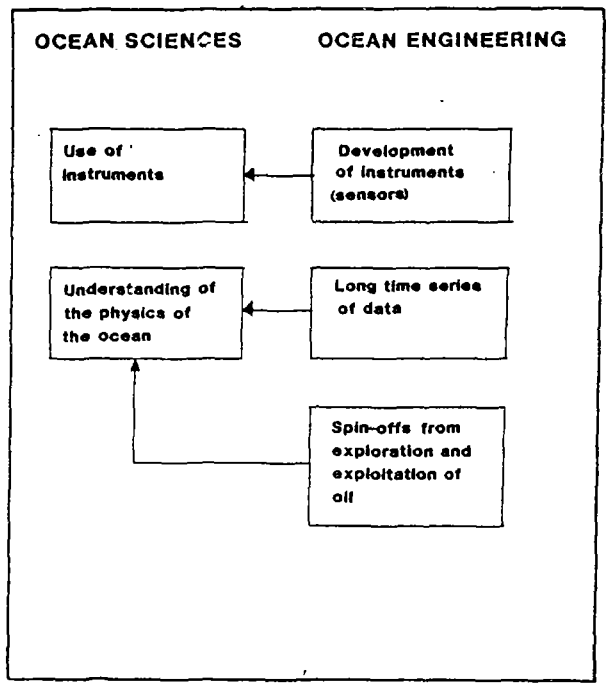
A number of participants pointed out the differing levels of marine scientific capability in the countries of the region. Although marine scientific research has been given some attention by their respective governments during the past several years, ocean engineering and marine technology as such, have tended to be neglected. Lack of expertise in these fields and inadequate interaction between researching and teaching institutions in marine science and engineering is considered to be the major hampering factor in the adoption of a multidisciplinary approach that many development activities and marine problems required. This has consequently led many countries to depend on assistance from outside, at a very high price, for their ocean development programmes.

## 5.2 NEED FOR INTERFACE BETWEEN OCEAN ENGINEERING AND OCEAN SCIENCE

Science is defined as a systematized knowledge derived from observations and experimentation carried out concerning the nature of processes and resources while engineering/technology is the science or study of the practical or industrial art. In other words, technology is applied science. Although in historical perspectives, scientific and technological culture evolved somewhat independently, mutually benefitting from each other, technological innovation, for instance, has often been the logical consequence of scientific discoveries. Scientific discoveries likewise are greatly influenced by technological advances. In view of the special nature of marine environment, it was considered that "ocean engineering" could neither be developed nor applied in isolation. It should be built on adequate scientific base and hence the two disciplines, in their application to ocean development programmes and activities, were considered interdependent and complementary. This is exemplified in several discussions on various topics held during the Training Workshop (See Figure 1).

Three main aspects of ocean development activities and marine problems were identified where the interface between the disciplines of ocean engineering and ocean sciences were considered indispensable:



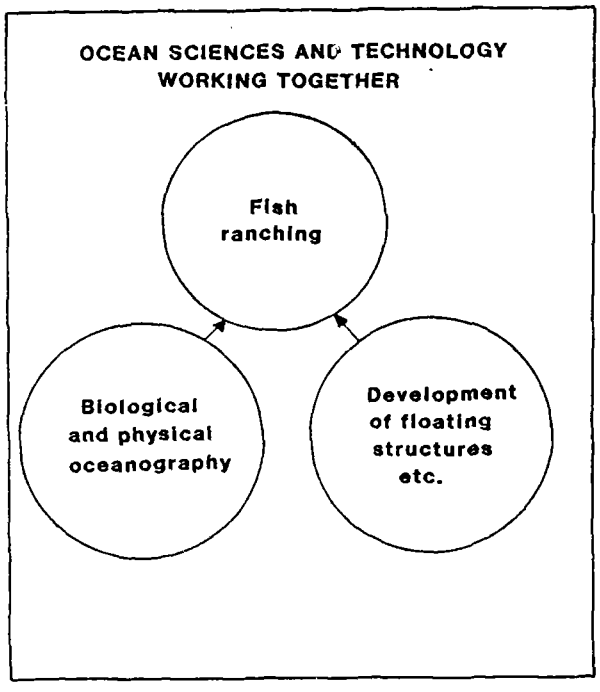




Figure 1 Examples of interactions between ocean science and ocean engineering

(i) Exploration and exploitation of marine resources including: living resources such as aquaculture, fisheries, mangrove and others; and non-living resources, such as minerals, oil and gas, placers deposits and deep-sea polymetalic nodules; the non-conventional sources of energy such as tidal and wave energy and ocean thermal energy conversion; and the coastal zone which by itself serves as a very important resource to many coastal and island states, and where socio-economic activities are often highly concentrated.

(ii) Activities such as construction of coastal and offshore structures, port and harbour development.

(iii) Solution of marine problems resulting from natural factors such as river discharges, storm surges, coastal erosion and accretion and those resulting from expanding socio-economic activities which often cause pollution of the marine environment and coastal degradation.

To elaborate the close relationship between the two disciplines, examples were given of how decisions taken by certain countries in favour of, for instance, construction of coastal structures against the background of inadequate scientific knowledge had adversely affected the sediment transport system in the near-shore zone, and thereby caused coastal erosion in one area and accretion in the other. Similarly, even in designing, fabrication, construction, installation and maintenance of offshore structures or for setting up of a pipeline, one of the basic points considered essential was to acquire scientific data relating to geomorphology of the sea floor and long-term sea conditions. Other scientific considerations such as regular monitoring of meteorological and oceanographic parameters for the maintenance of such structures, once they were installed, was considered an essential part of the whole activity. Satisfactory modelling of various coastal and offshore systems, on which future development activities could be based, is heavily dependent on the availability of scientific information and data. A further example was the initial Deepsea Drilling Project, 1968-1984, which was funded internationally by several countries such as USA, U.K., FGR and USSR, and which had scientific objectives, but involved complex marine technology.

## 5.3 WHO SHOULD DEVELOP OCEAN ENGINEERING AND OCEAN SCIENCES

The question was raised as to who should develop ocean science and ocean engineering. It was arguable whether the developing countries should be involved in all aspects of ocean science, ocean engineering and technology. It was suggested that marine science and ocean engineering should be developed in accordance with the nature of the resource potential or marine problems in view. Coastal engineering, for instance, was considered essential when port and harbour development and the extensive use of coastal zone in support of socio-economic build-up was being planned or already in progress. Similarly, if fish are the most abundant resource, then it is logical that all aspects of fishery science and technology need to be developed. Countries with wider continental shelf have no prospects for Ocean Thermal Energy Conversion (OTEC); the wider continental shelf, on the other hand, might offer possibility of fishery and mineral resources, including oil and gas and other sources of non-conventional energy such as wave and tidal energy. The example of France was quoted where soon after it was ascertained that there was no prospect for offshore oil and gas in coastal areas, the ocean engineering activities were directed to harness

other resources, including tidal energy from the River Rance, aquaculture in coastal embankments, and to provide coastal protection and beach development in support of tourism.

For marine scientific research it was likewise suggested that this should be developed by a country in the context of the development and management of its marine resources and the marine environment as a whole, and with due regard to the country's capacity to provide the necessary support for continuing research, suitable personnel and infrastructure.

The special case of island states which depend substantially on marine economy was discussed. Many island states are forced into a situation where they have no choice but to build up most of their economies in the vicinity of the coast. Regular surveillance of near shore areas, including monitoring of ocean parameters such as currents, waves and tides, and socio-economic impact assessments, seemed to be of crucial importance to the future of the islands. However, it was recognized that their ability to build up the required marine scientific and engineering capacity to deal with the development activities or to solve marine problems, often seemed to be limited because of a shortage of trained and skilled manpower and of resources. Academic research, in most instances, is beyond their capacity. It was suggested that, while a critical mass of trained scientists and engineers might always be desirable, the island states could benefit considerably through closer co-operation with bigger neighbouring states, including the sharing of facilities and expertise for the management of marine environment.

Finally, it was suggested that if a country wishes to develop marine science, ocean engineering and related technology, the most appropriate approach would be to prepare a Marine Science Country Profile reflecting the scope of these fields in the context of national development, the planned and ongoing programmes of developments of the government in marine areas and the institutional framework and manpower available in science and technology within which marine science and ocean engineering work could be prosecuted. Such information was considered extremely valuable to decision makers in the government, to the scientific community and to aid-giving agencies, both at the national and international level(s), planning for financial support to marine scientific and technological research and development activities.

## 5.4 STRATEGY FOR THE DEVELOPMENT OF OCEAN ENGINEERING AND OCEAN SCIENCE

The question was raised as to what kind of strategies should be considered by the countries of the region for building up the required national capabilities in ocean engineering and related marine technology.

Ocean engineering and ocean science are regarded by many countries as an expensive undertaking. The activities, more often than not, should be motivated towards developing marine resources including ocean space as a means to enhance their economic potential, the exports of resources, foreign exchange earning and employment opportunities.

Once a country is able to identify a resource potential or a marine problem affecting the environment and the resources, the marine scientific and ocean engineering requirements can be formulated to suit these specific targets.

For any marine activities to be initiated, planned and developed, whether they are related to construction of coastal or offshore structures, to the setting up of a pipeline or to harnessing a particular marine resource, the scientific survey and support services at all stages of planning and development are considered an integral part of the given development venture.

One of the pressing needs of the region that was recognized, is to establish ocean engineering teaching and research in the universities, if possible, in conjunction with the marine sciences. For ocean engineering, it is suggested that persons with a basic degree in civil engineering and with a strong background in soils, structures and hydrodynamics, could be very successful in this field.

For any project to be planned and developed, the availability of basic marine scientific information and oceanographic data was considered a prerequisite. In planning marine research and ocean engineering, high priority should be given to the development or strengthening of marine information and data infrastructure and to providing services for the benefit of the user community. In this context, it was pointed out that many foreign firms currently involved in the exploitation of marine resources in the countries of the region had collected an enormous quantity of scientific data which could be of great value to the scientific community. It was suggested that the relevant authorities in each country should be requested to assist in making available such data on demand to the scientists for analysis and further studies.

Attention was also drawn to the fact that many countries in the region were increasingly acquiring research vessels to undertake marine science in response to their growing needs but that their ability to effectively utilize this important and very costly tool was limited.

A number of participants pointed out that, at present, exploitation of mineral resources in their countries was being carried out by foreign firms which in turn hire foreign engineers, technologists and scientists for the purpose. This approach had often proven to be very costly in economic terms for the poor countries in the region. Although the involvement of foreign expertise was considered an essential element in the initial stage of planning and development of a given activity, it was nevertheless suggested that national development planning should take into account, from the very inception of the activity, a provision for progressive involvement of national institutions and personnel throughout the successive stages of development of a project in order to foster technological transfer and to develop self-reliance in dealing with indigenous problems. It was proposed that if a country discovers resources such as petroleum and gas in an appreciable quantity, it should try to organize marine science and ocean engineering so that local scientists and engineers could become effectively involved in the venture and thus benefit from foreign expertise and facilitate the transfer of relevant technology. The case of oil and gas development in India, as reflected in the special lecture on the subject during the Training Workshop, was quoted as an excellent example, where at the initial stage of planning, provision was made to involve local engineers and marine scientists who, through a process of "reverse engineering", acquired in a decade the necessary engineering and technological skills for prospecting the resources as well as for providing the required scientific support for this industry which was now being controlled and managed by Indian nationals.

One of the reasons for the inadequate involvement of local engineers and marine scientists in ocean development programmes and activities, was attributed to the lack of a marine science and technology policy in many countries which could ensure provision of an effective linkage between the institutions producing trained scientists and engineers and the ones (e.g., industries) involved in marine development activities. To cope with such a situation, it was strongly emphasized that in each country a high level co-ordinating mechanism must be created at the national level, if it does not already exist, in order to ensure effective utilization of manpower and facilities in ocean science, ocean services, engineering and technology, at all stages of the planning and development of a marine activity. Such a linkage is likely to be highly cost-effective, may result in substantial foreign exchange savings and enable the country concerned to develop the self-reliance needed to become scientifically and technologically independent to deal with indigenous marine development problems.

## 5.5 MARINE TECHNOLOGY IN SUPPORT OF MARINE RESEARCH

The role of marine technology in promoting marine research capability for ocean observing systems was discussed at length. Attention was focussed on recent advances in technology that have revolutionized ocean observing techniques and have thus added a new dimension to the acquisition of marine scientific information and oceanographic data about sea floor and sea conditions that are of particular relevance to the development process. Reference was made to devices such as: probes, sensors, transducers and other techniques employed in position fixing, and of drifting buoys, remote sensing, and satellite used for collecting oceanographic data about the sea temperature, surface winds, significant wave heights, the directional and frequency distribution of the surface wave spectrum, sea-level changes and geological features. Reference was made to side scan acoustic techniques capable of providing topography of the sea floor covering an area of about 20,000 square miles in a working day. Rapid advances in these techniques are reported to pose two major problems for the developing countries of the region: one of access and the other of the use for application in environmental studies and development fields, including the preparation of predictive models for various coastal and offshore systems.

## 5.6 TRAINING

It was recognized that the most pressing need of the region in the ocean science and related technology is the training of manpower. Several suggestions were made to overcome this problem. Attention of the participants was drawn to several international agencies offering training fellowships to scientists and engineers from the developing countries. The same suggestions made in this regard included the fellowships offered by the Norwegian Agency for International Development (NORAD) as part of the regular training course of about one year duration offered each year in the field of civil engineering; the training programme held each year in coastal engineering by the Delft Hydraulics Laboratory in The Netherlands, and similar opportunities in the U.K. It was proposed that countries like India, which had acquired high level competence in ocean engineering fields, should provide training to engineers from the region. Participants strongly endorsed a proposal that IOC and Unesco should periodically hold individual and group training courses in multidisciplinary fields, including ocean engineering and ocean sciences for the benefit of countries of the region. One emerging problem facing a number of countries in the region was the

operation and management of research vessels which they had either already been acquired or in the process of being acquired. IOC was requested to hold a special training programme on the use of this important facility.

In the final analysis, it was concluded that self-reliance amongst scientists, engineers and technologists, the effective national co-ordinating mechanism to use all available national resources efficiently, and the political will of the Governments concerned were considered as some of the key elements in the achievement of national goals in marine affairs.

## 6. CONCLUSIONS AND RECOMMENDATIONS

The Round Table Discussion recognized that development and management of marine resources and the marine environment in the countries of the Indian Ocean region are beset with numerous scientific and technological problems, the solution of which require, among other things, scientific and technological input to the development process.

It also recognized that the major obstacles to the development of national capabilities in ocean engineering and technology in the region chiefly result from:

(i) lack of expertise and adequate institutional bases for training and research in the field of applied oceanography and ocean engineering in most of the countries;

(ii) lack of appreciation for the role that indigenous capability in ocean engineering, and its interface with ocean science, can play in planning, development and implementation of all activities in ocean space under national jurisdiction;

(iii) lack of inadequate or effective co-ordinating mechanisms at the national level to promote the use of indigenous capabilities and human resources in ocean science and engineering in the development process.

The Round Table Discussion, therefore, recommended that countries of the Indian Ocean region should:

(i) accord high priority to the establishment of post graduate teaching and research in ocean engineering and marine technology in their respective Universities;

(ii) develop marine science and technology country profile which should provide the scope of these fields in the context of ocean development programmes. Such information would be extremely valuable to the decision makers in the government, the scientific community and to the aid-giving agencies, both at the national and international levels;

(iii) provide strong support to national research and development (R & D) activities in marine fields by strengthening marine scientific research capability, and its interface with ocean engineering activities, in order to facilitate participation of scientists/engineers in all stages of planning, development and management of marine resource and the marine environment;

(iv) establish or strengthen the existing national co-ordinating mechanism in order to:

(a) ensure effective use of all expertise and facilities available at national marine science and engineering institutions in the ocean development programme;

(b) assist the governments to establish a marine science and technology policy;

(c) liaise effectively with regional and international organizations to facilitate the participation of nationals in co-operative research.

(v) provide effective linkage between producers of trained marine scientists and ocean engineers with the user of marine technology so as to be mutually beneficial. In this respect encourage effective involvement of local expertise in marine science and ocean engineering with foreign firms already engaged by some countries for exploitation of resource or related activities, so as to foster scientific and technological transfer as well as to develop self-reliance in those activities;

(vi) establish co-operative networks in ocean engineering and ocean science at the regional level with the purpose of promoting mutual co-operation, exchange of visits by experts and sharing of common services, such as marine information and oceanographic data and research vessels.

The Round Table Discussion also recommended that IOC, Unesco and other international organizations should organize periodically multidisciplinary training courses in the selected fields of ocean engineering and ocean science for the benefit of the countries of the region, and make available, upon request of the countries, services of experts to assist in the development of teaching and research facilities in the universities and other marine science and technological institutions.

## 7. EVALUATION OF THE TRAINING WORKSHOP BY THE PARTICIPANTS

At the end all the participants were given a questionnaire aimed at the assessment of the Training Workshop. The following is the summary of their comments and suggestions.

The participants unanimously expressed their satisfaction on the outcome of the Training Workshop. The title chosen was most appropriate considering the rapid advance in ocean science and ocean engineering and technology taking place in the present time and the need to have a greater insight into these two disciplines. Some participants suggested that the Training Workshop provided a unique forum for oceanographers and engineers

to come out of their isolated compartments and to discuss in their countries the importance of the interactions between these disciplines. In their view, this was the most important achievement which contributed to its success.

Highlighting the courses offered, it was stated that the lectures were delivered by qualified experts, which though in some instances were too specialized in nature and posed some difficulties for some to comprehend, nevertheless, they were educative, instructive and reflected the recent trends in the development of ocean engineering and ocean science and their complementary role.

Specific Comments

Some participants did acknowledge the difficulty in organizing a multidisciplinary training course, such as this, to cater fully to the needs of oceanographers, engineers and meteorologists in the short duration. They, however, made the following specific comments/suggestions which in their view would be useful in future planning of such Training Workshops.

(i) More time should have been given for: group discussions, laboratory experiments and demonstrations, presentation and discussion of review papers by participants and discussions among participants and experts on case studies. These comments were carefully considered by the Organisers or Course Co-ordinator and it was felt that the above would have been feasible only if the total duration of the course had been increased by a week.

(ii) Lectures in Ocean Engineering sometimes were too specialized and posed some difficulty in understanding. This was to be expected with a heterogeneous group consisting of Engineers and Oceanographers.

(iii) Demonstration on board the research vessel should also have focussed attention on position fixing and on instrumentation. This would have been possible with a half-a-day more on the research vessel.

A number of participants strongly endorsed the idea that such multidisciplinary course should be periodically held in specialized fields, such as coastal engineering, ocean energy, remote sensing, data collection.

Some participants suggested that senior government officials/ administrators' responsible for decision making ocean development programmes and activities should have been invited to participate at least in the concluding session of the Training Workshop.

Finally, all participants expressed their great appreciation to the organizing Committee of the Training Workshop, the professional and administrative staff of the Ocean Engineering Centre of the IIT, for the excellent arrangements made in terms of accommodation, transportation, food and social activities.

## 8. CLOSURE OF THE TRAINING WORKSHOP

In concluding the Session, Professor Sri Nath expressed his satisfaction on the achievements of the Training Workshop. He expressed his appreciation to all the experts for their valuable contributions to its success and he hoped that the participants had found the deliberations and discussions beneficial to their future work.

Dr. S.M. Haq, on behalf of IOC/Unesco, expressed once again their appreciation to Professor Sri Nath for hosting this important forum and providing all facilities for it in the premises of IIT. On behalf of all the participants and experts, he expressed very sincere thanks to Professor V.S. Raju, Co-ordinator of the Training Workshop, for the excellent arrangements made by him and the Organizing Committee for the conduct of the course as well as for all the excellent arrangements made during the Training Workshop. He expressed sincere appreciation and thanks to all the professional and administrative staff of the Ocean Engineering Centre for their untiring efforts, efficient handling of all matters concerning the course, their willing co-operation and support that they had given to all the participants throughout the duration of the Training Workshop.

ANNEX I

**PROGRAMME OF THE TRAINING WORKSHOP**

| Day & Date | 8.30 - 10.30 a.m. | COFFEE BREAK | 10.45-11.45 | 11.45-12.45 | LUNCH BREAK | 2.30 - 5.00 p.m. |
|---|---|---|---|---|---|---|
| March 17 Monday | Registration:9.00-9.45 Welcome & Introduction 9.45 - 10.30 | | Audiovisual on OEC & Lecture I : Ocean Resources (VSR) | | | Visit to facilities of Ocean Engineering Centre |
| March 18 Tuesday | Lecture IV: Offshore Structures (CG) | | Lecture II: Physical Oceanography (RM) | Lecture III: Geological Oceanography (SPS) | | Lab Work : Properties of Random Waves/Stress Concentration in tubular joints |
| March 19 Wednesday | Lecture XI: Coastal Engineering (HR) | | Lecture V: Position Fixing (MRP) | Lecture IX: Materials (KGB) | | Lab Work : Random wave forces on piles/triaxial test on soils |
| March 20 Thursday | Lecture VI: Ocean Energy (MR) | | Special Lecture : Ocean Environment and Offshore Structures (GC) | | | Lab work : Diffraction around large cylinder/Free fall penetrometer |
| March 21 Friday | Lecture VI : Ocean Mining (MR) | | Special Lecture : Offshore activities related to oil gas in India (AKM) | | | Group discussion on : Offshore Engineering Experts: AKM, GC & VSR |

| Date & Date | 8.30 - 10.30 a.m. | COFFEE BREAK | 10.45-11.45 | 11.45-12.45 | LUNCH BREAK | 2.30 - 5.30 p.m. |
|---|---|---|---|---|---|---|
| March 24 Monday | V I S I T T O | | MADRAS HARBOUR | | | & MAHABALIPURAM COAST |
| March 25 Tuesday | Special Lecture: Ocean Environment & Offshore Structures (G.C.) | | Lecture VIII: Ocean Mining (M.R.) | Lecture IX: Marine Corrosion (MRP) | | C R U I S E |
| March 26 Wednesday | C R U I S E | | C R U I S E | | | C R U I S E |
| March 27 Thursday | Lecture IV: Offshore Structures (CPV) | | Special Lecture: Model Studies, Floating Structures (G.C.) | | | Laboratory Demonstration |
| March 28 Friday | Lecture XIII: Remote Sensing (IVM) | | Lecture XII: Ports & Harbour Structures (MRP) | | | Special Laboratory Class |
| March 30 Sunday | Lecture XIV: Marine Foundations (VSR) | | Special Lecture: Deep Sea Pipelines, Oil Skimming System (GC) | | | |

| Day & Date | 8.30-9.30 a.m. | 9.30-10.30 | COFFEE BREAK | 10.45 - 12.45 | LUNCH BREAK | 2.30 - 5.30 p.m. |
|---|---|---|---|---|---|---|
| March 31 | Lecture IX: Marine Corrosion (MRP) | IOC Programs (SMH) | | O T E C (J.P.D.) | | Review reports from participants |
| April 1 Tuesday | Tidal Energy, Submersibles (J.P.D) | | | Data collection and analysis for Ocean Industry (O.G.H) | | Environmental Data collection Group Discussion Experts: OGH & JPD |
| April 2 Wednesday | Remote sens-ing (JPD) | Lecture VII: Ocean Mining (MR) | | Ocean Sciences & Offshore Engineering (OGH) | | Review reports from partitipants |
| April 3 Thursday | Lecture III: Geological Oceanography (SPS) | Lecture X: Oceanographic instruments (DS) | | Norwegean Wave Energy programme (OGH) | | Laboratory work and individual discussions |
| April 4 Friday | Lecture VIII: Research Vessels (DS) | Ocean Mining (D.S.C) | | Oeean Mining (D.S.C) | | Concluding Session starts at 2.00 p.m. |

V.S.R. - Prof. V.S. Raju
C.G. - Prof. C. Ganapathy
R.M. - Dr. R. Mahadevan
SP.S. - Dr. SP. Subramanian
H.R. - Prof. H. Raman
M.R.P. - Prof. M.R. Pranesh

K.G.B. - Dr. K. Ganesh Babu
M.R. - Prof. M. Ravindran
G.C. - Prof. G. Clauss
A.K.M. - Dr. A.K. Malhotra
C.P.V. - Dr. C.P. Vendhan
I.V.M. - Dr. I.V. Muralikrishna

S.M.H. - Dr. S.M. Haq
J.P.D. - Prof. J.P. De Loof
O.G.H. - Dr. O.G. Houmb
D.S. - Prof. D. Srinivasan
D.S.C. - Prof. D.S. Cronen

ANNEX II

**LIST OF PARTICIPANTS**

A. M. Fanos
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(field of specialization: physical oceanography, ocean engineering relevant to hydrology, meteorology and harbour survey)

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Esham Bin Salam
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(field of specialization: marine technology: marine power plant, ship structure vibration and ship design)

J. Sodusta
Asst. Professor
Department of Meteorology and Oceanography
College of Science
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(field of specialization: marine meteorology and physical oceanography)

Mr. Soegiono
Dean, Faculty of Marine Technology
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(field of specialization: marine technology, model testing of field offshore structures, naval architecture and ship building)

K. Sudarsan
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(field of specialization: geology, bedform morphologies of continental shelf, estuaire and coastal sciences)

ANNEX III

## LIST OF INSTRUCTORS

### A. INSTRUCTORS FROM IIT MADRAS

Dr. K. Ganesh Babu
Asst. Professor
Ocean Engineering Centre
(field of interest: structures and materials)

Dr. C. Ganapathy
Professor & Head
Ocean Engineering Centre
(field of interest: ocean structures)

Dr. R. Mahadevan
Asst. Professor
Ocean Engineering Centre
(field of interest: physical oceanography)

Dr. M. R. Pranesh
Principal Scientific Officer
Ocean Engineering Centre
(field of interest: marine corrosion, geotechnical engineering)

Dr. Ing. V. S. Raju (Course Co-ordinator)
Professor
Ocean Engineering Centre
(field of interest: marine geotechnical engineering, ocean energy)

Dr. H. Raman
Professor
Hydraulic Engineering Laboratory and Head,
Department of Civil Engineering
(field of interest: coastal engineering)

Dr. M. Ravindran
Associate Professor
Ocean Engineering Centre
(field of interest: ocean energy, mining)

Dr. D. Srinivasan
Visiting Professor
Ocean Engineering Centre
(field of interest: physical oceanography, instrumentation)

Dr. S. P. Subramaniam
Asst. Professor
Ocean Engineering Centre
(field of interest: marine geology)

Dr. C. P. Vendhan (Joint Course Co-ordinator)
Asst. Professor
Ocean Engineering Centre
(field of interest: ocean structures)

## B. EXTERNAL EXPERTS

Prof. Dr. Ing. G. Clauss
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Prof. Dr. D. S. Cronan
Department of Geology
Imperial College of London
London,
United Kingdom
(field of interest: deep sea minerals)

Mr. O. G. Houmb
Manager, Engineering Department
Oceanographic Company of Norway A/S
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Norway
(field of interest: ocean sciences and offshore engineering)

Mr. Jean-Pierre de Loof
Director
IFREMER
Centre de Brest BP 357
Brest, Cedex
France
(field of interest: OTEC, tidal energy, submersibles)

Dr. A. K. Malhotra
Former Member (Offshore)
Oil and Natural Gas Commission
Bombay
India
(field of interest: offshore structures, offshore activitiers related to oil and gas in India)

Dr. I. V. Muralikrishna
Scientist
National Remote Sensing Agency
Hyderabad
India
(field of interest: remote sensing and its applications to ocean development)

## C. IOC SECRETARIAT

Dr. S. M. Haq
Senior Assistant Secretary
Intergovernmental Oceanographic Commission
Unesco
7, Place de Fontenoy, 75700 Paris
France

ANNEX IV

## Characteristics of the FORV SAGAR SAMPADA Research Vessel

**FORV SAGAR SAMPADA**, a multipurpose fisheries and oceanographic research vessel is owned by the Department of Ocean Development, Government of India and was commissioned in November 1984.

Principal Particulars:

| | |
|---|---|
| Overall length | 71.50 m |
| Length b.p. | 63.00 m |
| Breadth moulded | 16.40 m |
| Depth to main deck - Deck 4 | 9.00 m |
| Depth to freeboard deck - Deck 3 | 6.40 m |
| Draught | 5.60 m |
| Dead weight | 1140.0 tons |
| Gross tonnage | 2661.0 tons |
| Net tonnage | 798.0 tons |
| Speed at 2285 BHP | 13.4 knots |
| Capacities: | |
| Fuel Oil | 425.4 cu.m |
| Gas Oil | 14.3 cu.m |
| Fresh Water | 204.4 cu.m |
| Water Ballast | 466.5 cu.m |

Accommodation for 59 persons of crew and scientists.

Laboratories and Research Facilities:

(i) The main physical, chemical and biological laboratories with full range of testing equipment;

(ii) Wet and dry fish laboratory for handling fresh catch and preparation of specimens;

(iii) Carbon$^{14}$ laboratory for measuring primary production in the sea.

Instruments:

(i) Photometric autoanalyser for measurements of nutrients

(ii) Spectrophotometer for measurement of nutrient chlorophyll a.o. pigments

(iii) Spectrophotometer for measurement of chlorophyll

(iv) Titrator for titration

(v) Microbalances

(vi) Recorders for quantaeters measuring light quanta.

Hydrographic Area:

All sampling of water and operation of physical probes is made by a winch with 2 drums with 10,000 m and 4,000 m cables respectively.

Meteorological Buoy:

- with sensors for observation such as pitch, roll, heave, heading, wind speed, direction, water and air temperature, VHF communication to ship;

- electronic data processing (EDP) system for the decentralized system with six desk top computers and a combined data recording system.

Additional Facilities:

Drawing office with copying facilities, dark room, archives, electro-technical and mechanical workshops for service to all instruments and equipment on board.

# CERTIFICATE

participated and successfully completed the Regional Training Workshop on Ocean Engineering and its Interface with Ocean Sciences, organised by IOC/UNESCO in cooperation with Department of Ocean Development, Government of India, at the Ocean Engineering Centre, Indian Institute of Technology, Madras, India, during 17 March – 5 April, 1986.

DR. MARIO RUIVO
Secretary, Intergovernmental
Oceanographic Commission
UNESCO, Paris

DR. S. Z. QASIM
Secretary
Dept. of Ocean Development
Govt. of India New Delhi

DR. L. S. SRINATH
Director
Indian Institute of Technology
Madras

ANNEX VI

**SUMMARY OF PRESENTATIONS BY PARTICIPANTS**

**CHINA** (Mr. Ye Yincan and Mr. Chen Min-Jan)

Along the 18,000 Km coastline bordering Bohai Sea, Yellow Sea, East China Sea and South China Sea, China has more than 5,000 islands with wide continental shelf abundance in marine resource. Over twenty research organizations are currently involved in ocean engineering works. Marine Resources: In the field of oil and gas, the first well was drilled in South China Sea in 1963; since 1977 joint surveys with foreign firms were initiated. At present, 28 sets of mobile drilling rigs and more than 10 geophysical research vessels are engaged. Rough estimates indicate the completion of 230 wells and the discovery of 6 large offshore oil-bearing basins. East China Sea has probably the largest undeveloped oil resources in the world. In the field of fisheries, China has 2-2 billion MU of offshore fishing grounds with an annual catch of about 3 million tons. Aquaculture is a rapidly developing activity. China has altogether 135 harbors and the estimated volume of freight traffic in 1985 exceeded 300 million tons. The ocean fleet visited 420 harbors in 100 countries. Works on tidal power started in 1950. Since then, more than 40 stations have been built accounting for the total energy production exceeding 900 million kilowatts. Works on other sources of energy from wave, current, temperature and salinity differences are still in progress. Commercial extraction of salt from sea water in 1980 estimated to be 13 million tons. The major ocean engineering research includes: (a) studies on situation from major rivers on widely distributed mud flats and harbors; (b) development of sand gravel beaches on rocky shores since 1950; (c) management of estuaries of Yangtze River, Yellow River, Qiatang River and Pearl River, including studies of mouth bars, scour channels, bifurcation, deformation of tidal waves, circulation in estuaries and application of model testing and new techniques such as remote sensing applied to estuarine research; (d) designing and study of offshore structures since 1977, including the construction of jack-up drilling platform, BOHAI-I, single pointed mooring systems, 500 tons of fixed crane vessels, fixed drilling platform and semi-submersible drilling platform, KANTAN-II. Several factories are now involved in building and production of platforms for foreign companies; and (d) underwater construction techniques, including in-cabin model tests of 120 and 302 helium-oxygen saturated deep diving device carried out at sea in 1981, testing of diving devices in oil exploitation and sub-marine operation within diving depth of 60-70 m.

**EGYPT** (Dr. A.M. Fanos)

This presentation mainly dealt with the major problems of the Egyptian Nile delta coast. The Nile coast situation on the Southern Eastern part of the Mediterranean, 430 Km in length, extends from Alexandria in the west to El-Arish in the east. The Nile delta was built from the sediments brought by its seven branches during the past thousands of years at a rate of $35 \times 10^6$ to $50 \times 10^6$ tons/year. The erosion of the coast, particularly in Rosetta and Ras El Bar, was noted since the beginning of the Nineteenth Century, due to erection of the

barrages, regulators, low Aswan Dam and to the increased water usage for permanent irrigation. With the construction of High Aswan Dam in 1964, the erosion increased under the combined action of waves and currents and resulted in a loss of Summer resorts at Rosetta, Beltim, Ras El Bar and El Gamil, a loss of important land strip separating lakes from salt water, if destroyed, might turn them into salt water lagoons and affect the fisheries and industries in the southern part of the lake. Although the coastal erosion-sedimentation problem realized in 1950, the collects of scientific data started in 1962, followed by the UNDP/Unesco support to coastal erosion project in 1972 which led to the establishment of Coastal Research Institute under the Ministry of Irrigation. The work is in progress since 1971 in collection of field data from Abu Quir to Port Said, including 70 hydrographic profiles; wave recordings; nearshore and long-shore current measurements and near lake outlets; water level variations from which profile analysis of erosion and accretion quantities and processing of all other data are being carried out and studied. Existing problems identified include erosion of important places such as the Alexandria beaches, Abu Quir Sea well and Rosetta area and land strip between the sea and lake at Brullus, El-Arish harbour, Ras El-Bar, and some parts of Port Said, flooding and sedimentation of other important areas along the coast. The coastal erosion problems constitute the major serious problem for Egypt with implications for socio-economic development in the coastal area. Protection measures based on scientific data are expected to be developed.

**INDIA** (Mr. K. Sudarsan)

India has a long coastal belt of 6,500 km. The escalating demand for hydrocarbons, minerals, energy and food has necessitated the exploration and development of offshore fields. Major potentials for offshore areas of oil and gas are the Gulf of Cambay, Bombay High, Bay of Bengal and Andaman and Nicobar Islands. In 1970, the first major effort to explore oil was initiated, and in 1975 the first commercially successful oil was discovered in Bombay High. The offshore oil production is carried out by a number of public sector undertakings, including the Oil and Natural Gas Commission at Bombay, Engineers India Limited at New Delhi (E & L), Mazagon Dock Limited (MDL) at Bombay, and the Hindustan Shipyard Limited at Visakapatnam. The basic design of an offshore structure includes fabrication, installation and commissioning by these organizations. Although the offshore activities like exploration, transportation and installation, design of complicated underwater structures, underwater maintenance, inspections and repairs are being carried out by foreign commercial firms, continued and concerted efforts are being made to indigenize the technical know-how in these activities. India has developed certain expertise in underwater foundation engineering, underwater towed system, pipelaying and manganese nodule explorations, apart from attempts at generating electricity from tide, wave and ocean thermal energy conversion. Research in ocean science and engineering are being carried out at the academic and research institutions, like IIT, the National Institute of Oceanography, National Research Laboratories and Fisheries related institutions and a number of universities.

Apart from the oil production platform, there is an increasing involvement in collection of oceanographic, meteorological and acoustical data through surface buoys and sub-surface buoys. Several problems of the maintenance of harbour structures, sea-going vessels and engineering equipment caused by corrosion and biofouling required to be studied. Coastal erosion is one of the major problems along the Kerala coast and in other areas in Karnataka, Maharashira, Tamil Nadu, Andhra Pradesh, Orissa and the west Bengal. Oceanographic and other causative factors are to be precisely determined in order to provide protection measures.

**INDONESIA** (Dr. Otto S.R. Ongkosongo; Mr. Soegiono)

Indonesia is a tropical archipelago formed of about 13,800 islands. The total land area is approximately of 5 million square Km; the coastline is 81,000 Km and the area of exclusive economic zone 2.7 million square Km. Considering the vast area of the sea under natural jurisdiction, marine science and technology are important for the development. Major marine resources of Indonesia include fishery, tin mining and offshore oil and gas production. At present, 300 offshore oil platforms are in operation as compared with only 7 in 1970. Since the first discovery of offshore oil in Cinta field in south west Sumatra in 1970, there has been a rapid increase in the exploration and exploitation activities. So far, 50 sedimentary basins have been located and only 13 have been developed. The Indonesian State Oil Enterprise (PERTAMINA) is the main organization which, in co-operation with 39 foreign oil companies, is involved in oil and gas explorations. Indonesia over the years has made considerable progress in offshore manufacturing of oil and gas processing equipments and offshore industry, including the construction of offshore platform, production facilities which at present are undertaken by the local industries, such as the PT Krakatan Steel, and PT Jaya Pari Steel, the Bakrie and Brothers Pipe Industries and other yards engaged in shipbuilding plates of offshore structures, pipeline and different types of mooring buoy processing equipment. In addition, more than 7 domestic companies are involved in building offshore structure, and several inspection companies are responsible for safety of offshore structure and installations. At present, oil and gas constitute 50% of the gross national products, and will continue to remain the mainstay of the national economy. The Faculty of Marine Technology of the Surabaya Institute of Technology, established in 1982, is mainly responsible for the naval architecture, marine engineering and offshore engineering; the latter area has been recently initiated.

Indonesia is faced with numerous marine problems resulting from the increasing use of coastal areas and those from a variety of natural factors and human activities. Dredging is applied widespread for new canalization, irrigation, and reducing inundation. Mining of clastic sediments and other mineral resources, mainly tin, are intensively carried out. Shore-based OTEC plant feasibility studies have been carried out at the North Coastal Bali Island. The other problem in the coastal area results from: changes in land uses, for instance, in the form of rice farming, that increase the sediment load in rivers; coastal erosion due to dredging, coastal sand and shells quarrying, mangrove defrostation and reclamation of land; accretion; pollution from domestic and industrialized waste, particularly in

Jakarta and Surabaya; Sea water encroachment and subsidence, mainly due to irrational exploitation of ground water and construction of skyscrapers; inundation from rains and volcanic activities attributing to abnormal high tidal level.

Marine scientific research, at present, are largely concentrated in the field of biology and fisheries. Marine research in marine geology, mining, physical oceanography, chemical oceanography and marine meteorology is either inadequate or non-existent. About 4 universities are providing teaching and research in marine sciences, 10 others provide specialized training in fisheries and six others are planning to develop marine science.

The Indonesian Committee for Marine Research has been formed and the State Ministry of Research and Technology has recently highlighted the importance of marine environment to be the focus point in the coming years. The Government has planned the acquisition of new research vessels and marine institutions are expected to expand marine research in the country.

**IRAN** (Dr. M.R. Bannazddeh - Mehani)

Iran has 2052 km coastline along the border of the Persian Gulf in the south and shares the Caspian Sea in the north with a coastline of 604 Km. The Caspian Sea is mostly used for fisheries and beaches for recreation. Important ports include Khoram Shah Khomymi, Bushar, Bander, Bandor Abas; there are plans to build a major port and harbour in Bond Chabeha.

The Gulf coast of Iran has been a site of great socio-economic activities. Major onshore and offshore activities, including oil exploration, oil production, platforms, port and harbour constructions, two shipyards, atomic power plant in Bushar, Fisheries Company and many factories to back up the expanding import and export activities. Several universities are involved in marine science and teaching and research, including Arvaz University, Petroleum and Mining University, Shraz University, Shahid Bonar University, Zahedan University and University of Khozestan.

**MADAGASCAR** (Mr. Ratomahenina O.R.J.)

Madagascar has a total coastline of about 4,200 km and an Exclusive Economic Zone of about 330,000 $km^2$. The major coastal development areas are in Toamasin, which is one of the main ports in Antsiranana, where naval construction is in progress; in Mahajanga which provides the base for a naval school, and the Nosy-Be Island which has the Nosy-Komba Park and several other beaches for tourists. At present, fisheries constitute one of the main activities. Reference was made to the activities of the National Oceanographic Centre at Nosy-Be, which undertakes research in all disciplines of oceanography and fisheries. Major activities include regular study of hydrographic parameters, marine pollution, tidal currents, fisheries, mainly shrimps and pelagic fishes; tuna and others associated activities, including experimental fishing and fishing techniques. The Department of marine geology is being developed to study ocean topography and mineral resources.

**MAURITIUS**

Mauritius has an EEZ area of about 1.6 x $10^6$ square miles, including the outer islands of Rodriguez, Agilega and St. Brandan, rich with food and mineral resources. The fishing industry has been the main economic activity, but plans are being made to explore other resources from EEZ. The meteorological station was set up to monitor significant changes in climatic conditions, particularly during the tropical cyclone, including waves and swells data essential for coastal development, and for providing support to prospecting of oil in EEZ area near St. Brandan. A wave energy project was devised; the scheme was based on the overspilling of waves over an inclined concrete ramp and the collected water to pass through low head turbines before returning to the Sea. The university of Mauritius was involved in study of significant wave height and the power generated. Further, ocean engineering studies would be required on the strength and permeability of the reef and to improve efficiency of overspilling at the resistance of ramp to cyclones. Plans for OTEC are proposed and, in this context, more scientific data and bathymetric profiles.

**PAKISTAN** (Mr. Kalimur Rahman)

Pakistan has a coastline of about 825 km and an EEZ of about 300,000 square km. The total area of the continental shelf is about 30,000 square km. Coastal area development along the sind and Bahichistan Coasts have been receiving considerable attention in recent years. On the sind coast, apart from Karachi, the second major Mohamad Bin Qasim Port has been completed a few years ago, which can handle ships up to 75,000 DWT, and provide support to the big steel mill built in the hinterland several years ago. A number of ports and fishery harbors were built and are planned for Somiani, Gackan, Pasni, Ormara on the Baluchistan Coast.

Marine fishery is one of the main resources being exploited at present. The fish industry is very well developed. Mass scale upwelling along the coast during S.W. monsoon contribute to high fishery yield. The coastal area of sind, which is characterised by creeks provides suitable sites for aquaculture.

Initial surveys of the continental shelf have indicated prospects for oil and gas, and efforts are continuing jointly with foreign companies to search for these resources.

Karachi is not only the biggest port, but also the largest industrial city of Pakistan. Apart from industries, there are coastal installations, noteworthy, among them are the Atomic Power Station, the Shipyard, the Oil Refinery Steel Mill, which have outlets to the sea. Some of the major problems include increasing marine pollution of the coastal embankments and creeks resulting from domestic/industrial waste and tankers traffic, and erosion and siltation of the coastal area resulting from discharge from the river Indus, coastal drift, and other activities such as deforestation of mangroves.

Marine and coastal engineering are highly developed which respond not only to the country's growing needs, but also on demand to the neighouring states, which include the supply of large cargo vessels, as well as expert services for ports and harbour development. Ocean engineering, as such, is less developed.

A number of scientific institutions/organizations are involved in research and development activities. These include National Institute of Oceanography, Institute of Marine Biology of the University of Karachi, Oil and Gas Development Corporation of Pakistan, Mineral Development Corporation, Marine Fisheries Departments, Pakistan Council of Scientific and Industrial Research and the NED Engineering University, Karachi. The Government has recently decided to enhance increased support to ocean development programmes. Improved co-ordination of these institutions in the context of ocean development programmes are being developed through the creation of a National Oceanographic Commission.

**THE PHILIPPINES** (Mr. Jaime Sodusta)

The Philippines, an archipelago of 7,100 islands has a total area of 299,400 km2 and coastline of 12,958 km. and lies in the typhoon and earthquake belts. Dubbed as the "Pearl of the Orient Seas", the Philippine waters abound with rich marine resource potentials including fisheries, seaweeds, mangroves and corals comprise its living resources. Non-living resources being exploited include oil exploration (Palawan), coal mining (Semirara), salt production and use of the beaches for recreation. The Philippines also has a vast OETC and wave energy potential. Some of the major environmental problems facing the Philippines include domestic and industrial wastes, compounded by oil spills and mine tailings are the major sources of marine pollution, increased sedimentation in Manila bay and beach erosion (Puerto Azul), and marine ecology threatened by blast fishing, siltation in coral reefs and excessive mangrove cutting.

The University of the Philippines provides specialized teaching and research in marine science and meteorology. Ocean engineering is not offered as a formal degree. There is a general lack of oceanographic information despite several research vessels which is attributed to: (1) absence of an integrated research programme and data collection system at national level, (2) high cost of operation and maintenance of vessel, (3) and general low priority of government to scientific research. Studies therefore revolve around microscale and nearshore processes. Large scale phenomena are pursued using less expensive but equally useful techniques like numerical modelling. Satellites and remote sensing technology are also utilized.

In order that vast potentials be exploited to the fullest the creation of "a critical mass" of trained manpower in ocean engineering and ocean science, capable of affecting the "political will" of the government toward self sufficiency in food and energy, would be needed.

**SRI LANKA** (Mr. B.S. Kahawita)

Sri Lanka has a coastline of over 1,700 km. Nearly one third of the coastline is subjected to varying degrees of coastal erosion. Coastal engineering deals mainly with beaches, harbors, rivers and lagoon outfalls. The main activities include : (i) preparation of the coastal erosion management plan aimed at developing a short-term and a long-term plan (1986-2000) for solution of problems through the development and investigation within this field; (ii) preparation of coastal zone management plan under the coast conservation Act No. 57 of 1981 to ensure orderly and balanced utilization of coastal resources; (iii) coastal protection works through Groynes, revetments, sea wall and sand nourishment scheme; and (iv) development and maintenance of harbors, such as those of Colombo, Galle and Trincomalee. In these and other fishery harbors, dredging is carried out , particularly to remove siltation problems associated with ocean engineering, including exploration and production of petroleum and minerals on the ocean floor, sewerage outfall projects and provision of facilities for unloading of petroleum products. Studies are being carried out to collect information for future developments, including seismic studies to facilitate the design of long-term for coastal protection, programme of wave and current measurement, bathymetry and model studies.

**TANZANIA** (Mr.K.M.M. Lwiza and Mr. C.Z. Kaaya)

Tanzania has a coastline of about 750 km and an EEZ of approximately 274,00 $km^2$. The Government has long recognized the importance of the ocean and hence adopted a marine policy. The multinational oil companies have been carrying out exploration in the sedimentary basins for the past 30 years, which led to the discovery of large gas deposits at Songo Island and Munazi Bay near Mtwera, which is expected to be developed soon. Marine resources currently being exploited include fish, salt extraction through solar evaporation. Aquaculture for prawns and seaweed are being considered at various places. Port and harbour developments have been undertaken in Dar-es-Salaam, Tanga, Zanzibar and Mtwara. Other activities include servage discharging pipes, submarine electric cables, extensive human settlement, tourist hotels and beaches for tourism. Coastal erosion is a growing, but complex problem involving several factors. The Kuanduchi, for instance, which is a commercially important area, posed with serious coastal erosion, apparently caused by a number of factors including: destruction of reef due to the dynamite for fishing which, in turn, causes lowering of resistance to wave action; and the extraction of minerals and exploitation of sand and gravel. Gryones were introduced previously to control the erosion, but were ineffective. Rearrangements of Gryones were proposed, based on scientific studies carried out, which indicated that sediment transport becomes intensive either under the impact of a long shore drift or under the intense wave action during the north-east monsoon, particularly at Silversand.

The major difficulties in the development of coastal and offshore resources arise from the shortage of trained scientists in marine geology, physical and chemical oceanography. No facility exists for ocean engineering studies in the country. Institutions involved in marine activities include Tanzania Fisheries Research Institute, established in 1985, Kunduchi Fisheries Institute, Mbegani Fisheries Development Centre, Dar-es-Salaam Maritime Training Unit and the University of Dar-es-Salaam, which, through its biology departments and Institute of Marine Sciences, provide postgraduate teaching and research in marine biology.

**THAILAND** (Mr. Suiya Supatanasinkasem)

Thailand has a long coast which extends to the South China Sea and the Andaman Sea. Its coastline on the gulf of Thailand is 1,875 km and that on the Andaman Sea 740 km. The gulf provides resources such as fishery, aquaculture and natural gas. A record of 66,000 tons of fish caught in the gulf was reported in 1970, which tended to decline due to intensive exploitation. Pollution is also blamed to be the factor causing the decline of the number of fish in the area. Though natural hazard hardly affects the coastal areas due to relatively weak wind, the marine pollution is believed to be a growing serious problem resulting from development of industry in the upper and eastern part of the gulf. More than 300 tons/day of BOD loading is estimated to be discharged into the gulf from domestic and industrial sources. The latter source, according to studies undertaken by many organizations, is contributing to the increase of several heavy metals in the gulf of Thailand. Measures are being taken to control pollution through the construction of central treatment plants. Beside many government agencies which have responsibility for implementing marine policy, several universities are involved in the conduct of research in the fields of oceanography and ocean engineering, including universities such as Chulalongkorn University, Prince Sonkhla University, Sri Nakarin Wiwot University and the Asian Institute of Technology.

**TURKEY** (Mr. Abdi Kukner)

Turkey has a long coastline of about 6,000 km and is surrounded by the Black Sea in the north-east, the Sea of Manmora in the north-west, Aegean Sea in the west and the Mediterranean in the south. Research in shipbuilding has been traditional for centuries. There are 35 active shipyards. Apart from marine engineering, Turkey has developed capability for coastal and offshore engineering, harbour development, including planning, designing, construction and operation of ports and harbors, coastal protection works, sewage disposal and waste management and multiple use of coastal zone areas. Some of the recent activities in these fields include the extension of Mersin, Izmir from Istanbul harbour. Apart from marine fisheries, plans for petroleum and mineral resources are underway in certain areas. Marine pollution resulting from domestic and industrial wastes is a growing problem, particularly in Izmir Bay, because of rapid industrial growth. There are seven academic and research institutions in Turkey which are involved in ocean science, ocean engineering and technology

works. These include: the Naval Architecture and Ocean Engineering of the Technical University of Istanbul, Bosphores University, Department of Naval Architecture of Star University, Naval Academy, Institute of Ocean Engineering and Ocean Technology in Izmir, Aegean University and the Institute of Marine Science of the Middle Eastern Technical University. These institutions are principally involved in teaching and research in shipbuilding, marine hydrodynamics, ocean engineering, port and coastal engineering, ocean technology, and all disciplines of ocean sciences.