Intergovernmental Oceanographic Commission
*Training Course Reports*
**23**

# IOC/WESTPAC Training Course on Numerical Modelling of the Coastal Ocean Circulation

Matsuyama, Japan
27 September - 1 October 1993

UNESCO

# *IOC Training Course Reports*

| No. | Title | Language versions |
|---|---|---|
| 1. | IOC Indian Ocean Region Training Course in Petroleum Monitoring<br>Perth, 18 February-1 March 1980 | English |
| 2. | IOC Regional Training Course for Marine Science, Technicians<br>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<br>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<br>Talence, France, 18 septembre - 4 octobre 1984 | French |
| 8. | IOC Regional Training Course on Marine Living Resources in the Western Indian Ocean<br>Mombasa, Kenya, 27 August - 22 September 1984 | English |
| 9. | IOC-UNESCO Summer School on Oceanographic Data, Collection and Management<br>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 |
| 11. | IOC-UNESCO Training Course on the Use of Microcomputers for Oceanographic Data Management<br>Bangkok, Thailand, 165 January - 3 February 1989 | English |
| 12. | IOC Advanced Training Course on Continental Shelf Structures Sediments and Mineral Resources<br>Quezon City, Philippines, 2-13 October 1989 | English |
| 13. | IOC/IODE Training Course on GF3 Data Formatting System<br>Obninsk, USSR, 14-24 May 1990 | English |
| 14. | IOC Training Course on Microcomputers and Management of Marine Data in Oceanographic Data Centres of Spanish-speaking Countries, Bogotá, Colombia, 21-30 October 1991 | English<br>Spanish |
| 15. | IOC Advanced Training Course on Nearshore Sedimentation and the Evolution of Coastal Environments, Kuala Lumpur, Malaysia, 17-29 February 1992 | English |
| 16. | First IOC Training Course on the Applications of Satellite Remote Sensing to Marine Studies<br>Caracas, Venezuela, 24-28 September 1990 | English |
| 17. | IOC-KMFRI-RECOSCIX (WIO) Regional Training Course on Microcomputer-based Marine Library Information Management, Mombasa, Kenya, 10-21 August 1992 | English |
| 18. | ROPME-IOC Regional Training Course on Management of Marine Data and Information on Microcomputers for the ROPME Region, Kuwait, 18-28 October 1992 | English |
| 19. | IOC-SOA Training Workshop on Environmental Effects on Benthic Communities<br>Xiamen, China, 19-23 October 1992 | English |
| 20. | IOC Training Course for the Global Sea Level Observing System (GLOSS)<br>directed to the African and South American Portuguese and Spanish-Speaking Countries<br>São Paulo, Brazil, 1-19 February 1993 | English |
| 21. | IOC-SSTC-SOA Training Course on Marine Information Management and ASFA<br>Tianjin, China, 19-30 October 1992 | English |
| 22. | First IOC/IOCARIBE-UNEP Training Course on Monitoring and Control of Shoreline Changes in the Caribbean Region<br>Port-of-Spain, Trinidad and Tobago, 21-30 July 1993 | English<br>Spanish |
| 23. | IOC/WESTPAC Training Course on Numerical Modelling of the Coastal Ocean Circulation<br>Matsuyama, Japan, 27 September - 1 October 1993 | English |

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# IOC/WESTPAC Training Course on Numerical Modelling of the Coastal Ocean Circulation

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TABLE OF CONTENTS


| SUMMARY REPORT | | Page |
|---|---|---|
| 1. | INTRODUCTION | 1 |
| 2. | PARTICIPANTS | 1 |
| 3. | CONDUCT OF WORKSHOP | 1 |
| | 3.1 OPENING | 1 |
| | 3.2 OUTLINE OF THE PROGRAMME | 1 |
| 4. | CLOSURE | 2 |
| 5. | CONCLUSION | 2 |

ANNEXES

| | |
|---|---|
| I | Course Programme |
| II | List of Participants |
| III | Lecture Notes |

## 1. INTRODUCTION

During IOC/WESTPAC Scientific Symposium at Penang, Malaysia, 2-6 December 1991, Japan made an offer to host and help organize a Training Course on Numerical Modelling of the Continental Shelf Circulation in the WESTPAC Region. The WESTPAC Sub-Commission and IOC welcomed the offer and decided to hold such a Training Course in Japan in Autumn 1993.

In response to this decision, the Training Course on Numerical Modelling of the Coastal Ocean Circulation was held at Matsuyama, Japan, from 27 September to 1 October 1993. The Course was hosted by the Laboratory of Coastal Oceanography, Department of Civil and Ocean Engineering, Ehime University, Matsuyama, Japan, under the co-sponsorship of the Intergovernmental Oceanographic Commission (IOC) and Professor Keisuke Taira, Ocean Research Institute, University of Tokyo.

The main purpose of the Training Course was to provide the trainees with basic knowledge of numerical modelling on coastal currents, to enable the trainees to carry out the numerical experiments on tide, tidal current, tide-induced residual current and wind-driven current in the coastal seas of their own countries.

## 2. PARTICIPANTS

Participants from five countries attended the Course, namely from Indonesia, Vietnam, Philippines, China and two from Thailand. The List of Participants is attached as Annex II. The transportation and accommodation expenses for four participants were supported by IOC and the other two through Professor Taira's research fund. All participants have been working in the field of oceanography, and were all qualified for the Training Course.

The four lecturers were all from the Laboratory of Coastal Oceanography, Department of Civil and Ocean Engineering, Ehime University. For the past twenty years they have been engaged in numerical modelling of currents and material transport in the coastal sea and were suitably qualified for lecturing the Training Course.

## 3. CONDUCT OF THE WORKSHOP

### 3.1 OPENING

The Training Course was opened at the laboratory room of Coastal Oceanography, Department of Civil and Ocean Engineering, Ehime University at 09.15 hours on 27 September 1993 by Professor Tesuo Yanagi. In his opening address, Professor Yanagi welcomed the participants, expressed his appreciation to the IOC Assistant Secretary, Mr. Haiqing Li, for his efforts in organizing this Training Course, emphasized the importance of numerical modelling for a better understanding of the coastal sea processes in the WESTPAC region and stressed that the Course provided a good opportunity not only for the study of coastal oceanography, but also for establishing friendly contacts among scientists and institutions in different countries.

The IOC Assistant Secretary thanked Professor Yanagi for providing the room and personal computer facilities and expressed, on behalf of IOC, his appreciation of the efforts by Dr. Taira and Mr. Kenji Nakashima from the Ministry of Education, Science and Culture for his co-ordination between IOC and the Japanese authorities concerned. He welcomed the participants on behalf of the IOC and informed about the IOC and its WESTPAC activities and wished the Training Course all success.

### 3.2 OUTLINE OF THE PROGRAMME

The programme had been developed by experts from the Department of Civil and Ocean Engineering, Ehime University, in accordance with the requirements for graduated students from this department. The Course Programme is given as Annex I.

The following subjects were covered during the Training Course:

(i) relation between basic currents and material dispersion in the coastal sea;
(ii) characteristics of tidal current and tide-induced residual currents;
(iii) significance of vertical processes in the coastal physical, bio-chemical processes;
(iv) basic idea of finite difference one-dimensional wave equation;
(v) some examples of numerical simulation on the physical, chemical and biological processes in the coastal sea.

The trainees were satisfied with the teaching material and Course arrangements and were happy to have sufficient knowledge on the coastal processes. The trainees also reported on the progress of the study of coastal circulation in their countries.

The exercises were oriented towards acquisition of skills in numerical modelling of the coastal circulations. Participants were particularly interested in the use of the software for numerical calculation of the tide, tidal current and wind-driven current which was kindly provided by Mr. H. Tsukamoto, one of the lecturers. During practical exercises, trainees tried to simulate the tide, tidal current and wind-driven current in their own coastal regions. The results were satisfactory. Each trainee was provided with software for calculating tide, tidal current and wind-driven current.

## 4. CLOSURE

The Training Course on the Numerical Modelling of the Coastal Ocean Circulation was closed on 1 October 1993. Professor T. Yanagi congratulated the participants for the successful completion of the Course and thanked IOC for helping organizing and supporting it. He also expressed his sincere thanks to all the lecturers and all supporting staff for their work, and to all the trainees for their friendly co-operation. He hoped that the knowledge they had acquired during this Course would be useful and helpful in their future work at home.

## 5. CONCLUSION

The Training Course was well-organized, smoothly run and successfully conducted in a friendly atmosphere and its goals were achieved. The spirit of co-operation, enthusiasm and hard work displayed by the trainees was highly commendable. The length of the Course was considered to be adequate, the facilities sufficient, and teaching material - theoretical and practical - satisfactory.

Finally, the participants expressed the hope that similar training course would be held again in the WESTPAC region in the near future.

# ANNEX I

## COURSE PROGRAMME

**Monday - 27 September**

| | |
|---|---|
| 09.15 - 09.30 | Opening Ceremony |
| 09.30 - 11.45 | Lecture on Dynamics of Coastal Circulation (Tetsuo Yanagi) |
| 13.15 - 15.00 | National Reports by the participants on the Progress of Study on Coastal Circulation |
| 15.15 - 16.45 | Lecture on Examples of Numerical Experiments in the Coastal Sea (Tetsuo Yanagi) |

**Tuesday - 28 September**

| | |
|---|---|
| 09.15 - 11.45 | Lecture on Significance of Vertical Structure in the Coastal Processes (Hidetaka Takeoka) |
| 13.15 - 16.30 | Lecture on Exercise on One-Dimensional Wave Equation (Yutaka Isoda) |

**Wednesday - 29 September**

| | |
|---|---|
| 09.15 - 16.45 | Exercise on Numerical Simulation (Y. Isoda, A. Isobe and H. Tsukamoto) |

**Thursday - 30 September**

| | |
|---|---|
| 09.15 - 16.45 | Exercise continued |

**Friday - 1 October**

| | |
|---|---|
| 09.15 - 11.45 | Exercise continued |
| 13.15 - 16.30 | Presentation of Results and Discussion by all participants |
| 16.30 - 16.45 | Closure |
| 17.30 - 20.00 | Farewell Reception |

# ANNEX II

## LIST OF PARTICIPANTS

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# ANNEX III

## LECTURE NOTES

**DYNAMICS OF SHELF CIRCULATION** (Tetsuo Yanagi)

When we inject some material in the coastal sea, it is advected by the tidal current and dispersed by turbulence in the time scales of several hours. Then the material is advected by the residual flow with go-and-back motions due to the tidal current. The residual flow is defined as the averaged flow during the tidal period and the main components of residual flow in the coastal sea are considered to be tide-induced residual current, density-driven and wind-driven current.

Therefore we have to understand the characteristics of tidal current, tide-induced residual current, density-driven and wind-driven current in order to forecast the dispersion of material in the coastal sea.

The tidal phenomena in the coastal sea is governed by the incoming tidal wave from the open ocean. It behaves as a progressive wave or a stationary wave in the coastal sea. The relation of phase between tide and tidal current is completely different in both types of waves. Therefore we have to understand which types of behaviour does the tidal wave take in the coastal sea to be a problem.

The tide-induced residual current is induced by the non-linearity of tidal current in relation to the complex geometry of the coastal sea. It is barotropic current and exists throughout the year but it changes the magnitude in the spring-neap tidal cycle.

The density-driven current is induced by the horizontal density gradient in the coastal sea and it is essentially baroclinic, that means, it has the vertical structure. The horizontal density gradient is induced by the buoyancy input from rivers, open ocean through the sea surface. Therefore the seasonal variation of the density-driven current is expected to be very large.

The wind-driven current is induced by wind stress on the sea surface. The wind is changeable in the time scale of a few days and the wind-driven current has large variability. The monsoonal wind induces the seasonal variation of the wind-driven current. When the stratification develops, the wind-driven current has the baroclinic structure.

For the residual flow in the large scale of the coastal sea, whose spatial scale is larger than the Rossby radius of deformation length or internal radius of formation length, the Colioris force becomes effective.

We can reproduce tidal current, tide-induced residual current, density-driven current and wind-driven current with use of three-dimensional numerical model which includes suitable parameters and also can forecast the material dispersion in the coastal sea by introducing the chemical and biological processes in the numerical model.

**SIGNIFICANCE OF VERTICAL STRUCTURE IN COASTAL PROCESSES** (Hidetaka Takeoka)

Most of the participants of this programme are concerned with the numerical simulation on currents such as tidal or wind-induced currents. Such horizontal currents are, of course, primary factors in coastal seas, and should be well investigated in the early stage of coastal sea research. In the advanced stage, however, phenomena related to vertical structures of the coastal sea become more and more important, and numerical models help in understanding such vertical structures. To stimulate the participants' interest in the vertical structure, the following three topics were presented.

(i) **Tidal Front and Primary Production**

Tidal front is generated due to spatial difference in the intensity of vertical mixing. In the frontal region, often appears a chlorophyll concentration maximum. Sufficient nutrients must be supplied to the frontal region for such a maximum to be formed or maintained. Our observation in the Sea of Iyo suggests that a part of the nutrients is supplied not by the vertical mixing but by the density current intruding from the mixed region into the middle layer of the stratified region.

(ii) **Kyucho in the Bungo Channel**

Kyucho is a Japanese term which means a sudden and swift current. The Kyucho in the Bungo Channel is a kind of density current intruding from the Pacific Ocean into the Bungo Channel looking the coast to its right side. Generation of this Kyucho is controlled by the temporal change in the intensity of vertical mixing.

(iii) **Nitrogen Transport Model Including Lower Level Ecosystem**

Bioelements such as nitrogen and phosphorus usually stay longer time in coastal sea than river water or dissolved matter. Vertical shear in the horizontal current and the transformation of bioelements between dissolved and particulate forms cause such a longer residence time of bioelements. This mechanism is called "coastal trapping" and is verified by numerical model including lower level ecosystem.

**EXERCISE ON ONE-DIMENSIONAL WAVE EQUATION** (Yutaka Isoda)

In this exercise, the tidal waves, i.e., long-waves, was used as an example for the most simple numerical model. At first, it was explained that waves could be represented by the momentum and continuity equations, and the finite difference form of these equations and some boundary conditions were shown. Then the following two types of training exercises were carried out.

One is the hand-on experiment of one-dimensional wave equation. This experiment does not use the personal computer and only uses human resources. All members (12 persons) including six graduate students in the laboratory were divided into two groups and competed with each other for the calculation accuracy of wave forcing problem. This exercise provided a good opportunity not only for the study of simulation techniques, but also for establishing contacts among young scientists participating in the workshop and the graduate students in the laboratory.

The other is the numerical experiment on one-dimensional wave equation using the personal computer with the BASIC-Programme. Under some ideal conditions, the features of progressive and standing waves can be brought to the screen of the computer as an animation. The physical characteristics of these waves play an important role in the tidal phenomena on the Asian marginal seas. Furthermore, the importance of the artificial open boundary conditions, e.g., in the case of coastal boundary, deep sea boundary and radiation conditions was emphasized.