



## Report of the Nippon Foundation – POGO Visiting Professor at NIO – Kochi (India)

**Visiting Professor:** Prof. Trevor Platt, FRSC, FRS, Bedford Institute of Oceanography, Canada

**Host and Institute:** Dr. KKC Nair, National Institute of Oceanography Regional Centre, Kochi, India

**Title:** Calculation of Regional-Scale Primary Production for Indian Waters and Application to Ecosystem Dynamics

**Period:** December 2004 – March 2005

**Prof. Trevor Platt, FRSC, FRS  
Bedford Institute of Oceanography  
Canada**

### **Preamble:**

The training programme was the first of the Nippon Foundation – POGO Visiting Professorships to be executed. The idea of proposing the Visiting Professorship emerged during a personal visit by Dr. Platt to NIO-Kochi. The Scientist-in-Charge at NIO-Kochi (Dr. KKC Nair) explained the major programme underway at NIO Kochi related to the long-term evaluation of the marine living resources of the waters of the North Indian Ocean, with emphasis on the Exclusive Economic Zone of India. The programme had a very high participation by research fellows. The recognised need at the Centre to train their young scientists on quantitative approaches to Biological Oceanography and on the use of satellite technology and bio-optical methods to study large-scale features of the marine ecosystem was also highlighted. Timing was of essence, since the majority of senior scientists at NIO-Kochi are to retire in 2005, precipitating the need for rapid recruitment of young trained personnel to ensure the viability of the Centre. The discussions led subsequently to the plan, fully endorsed by the new director of NIO, Dr. Satish Shetye, to apply for a Nippon – Foundation POGO Visiting Professorship to Kochi, in which Prof. Platt was proposed as the Visiting Professor. The NIO-Kochi proposal was one of the two that was selected for the Visiting Professorship in 2004.

### **Selection of Trainees:**

The opportunity afforded by the Visiting Professorship at Kochi was advertised widely (see announcement in Appendix 1), and the applications received were scrutinised by a small selection committee. All the applicants from NIO were admitted, and many applicants from other institutes in India engaged in oceanographic work, as well as three applicants from outside India, from the Indian Ocean region (from Tanzania, Thailand and Vietnam). When there were last-minute drop-outs, they were replaced by other participants. The names and affiliations of all the participants who attended the training programme are provided in Appendix 2. The trainees had varied backgrounds, ranging from fisheries (Meena Kumari, Grinson George), biodiversity (Ravidas Nayak, Siddhi Prabhukonkar, Sahana Hegde), physical oceanography (Ravindra Naik, Suriyan Saramul), biological oceanography (Margareth Kyewalyanga), zoology (Habib Rehman), statistics (KV Jayalakshmi), chemical oceanography (Maheswari Nair), satellite remote sensing (KH Rao, Mini Raman), and mathematics (Shovanlal Roy). There was also diversity in the level

of experience. Some of them were new research fellows (Nimit Joshi, CK Shiju, Habib Rehman), others had many years' experience and held high-level positions in their institutes (Meena Kumari, Hanumanth Rao, Mini Raman). Therefore, the programme was organised with individual mentoring complemented by general lectures for all participants, so that the needs of all participants could be met. The senior participants were encouraged to take leadership roles, and help with the organisation and teaching.

### **Scope of the Training**

The training was built around the use of remotely-sensed data on ocean colour as a tool for the analysis of the marine ecosystem. Dr. Platt was assisted by a small team of other experts. The course also covered the bio-optical bases of ocean colour, the retrieval of pigment biomass, the calculation of primary production and the interactions between physical and biological processes in the ocean. This material was then used as the starting point for the quantitative analysis of marine ecosystems at all trophic levels, with particular reference to the Arabian Sea and the Bay of Bengal.

**Course content:** The syllabus included:

- Theory and application of submarine optics, especially that part relevant to pigments of phytoplankton and the colour of the ocean
- Use of remotely-sensed data on ocean colour as a basis for the calculation of primary production at the regional scale
- Application of results of these calculations to analysis of the regional ocean ecosystem at all trophic levels
- Response of the biological system to climate change and potential feedbacks
- Interactions between mixed-layer dynamics and ecosystem processes
- Fundamentals of analysis and modelling of ecosystem variables
- Interpretation of results in context of larger questions of the day, including collapsing fisheries
- Preparation of results for publication in the open literature

The first two weeks of the course were devoted to learning the basis of acquisition and manipulation of ocean-colour imagery, as captured by instruments carried on satellites on space. This material was taught by Linda and Peter Payzant, colleagues from the Bedford Institute of oceanography. They gave lectures and practical sessions, including problems for the participants to solve, based on imagery available from NASA. In addition, Mini Raman (Space Applications Centre, Ahmedabad), instructed the participants on the use of data from the Indian Space Research Organisation.

In parallel with the instruction on image analysis, Dr. Platt began to work with the students on the design of the research projects that would occupy them throughout the training period. This activity was organised by groups, some five in all. Each group was required to write a scientific proposal for the work to be undertaken. Training was also given on making oral presentations of scientific material. Each trainee was then required to give a short talk to the group on a scientific topic. The group was encouraged to give constructive criticism of these talks, such that the collective experience was very positive for all concerned.

Also, Dr. Platt began a course of lectures and tutorials dealing with the theory and application of ocean-colour remote sensing, ocean biogeochemistry, physiological ecology of phytoplankton and analysis of the pelagic ecosystem. Tutorials were given on the use of basic mathematical tools for the analysis of the marine ecosystem, and for marine optical studies. Besides academic subjects and practical demonstrations, training was given in design of research programmes, preparation and delivery of scientific talks, and preparation of scientific papers for publication in

the open literature. The students were also taken on a field trip to view the damage caused by the Dec. 26 tsunami in the neighbouring areas, and to make a contribution to the relief effort. Besides the Visiting Professor, the following participated in the instruction: Shubha Sathyendranath (marine optics), Linda and Tony Payzant (satellite data processing), Marie-Helene Forget (measurement of primary production, absorption spectrum and pigment separation by HPLC) and Vivian Lutz (physiology of photosynthesis). Individual lectures were given by Satish Shetye (oceanography of the North Indian Ocean), KKC Nair (living marine resources programme), K. Radhakrishnan (operational oceanography in India), Shailesh Nayak (remote sensing for coastal management), T Suresh (processing of Indian data on ocean colour), PA Lokabharathi (marine microbiology), and GK Pillai (marine pelagic fisheries of India).

**Format of the course:** Lectures on theoretical fundamentals were complemented by practical demonstrations of analyses of satellite data on ocean colour, and *in situ* field sampling and laboratory analyses of water properties important for the interpretation of remotely-sensed data on ocean colour (phytoplankton absorption, photosynthesis-irradiance parameters, pigment composition using HPLC). In addition, participants worked with the Professor on the design and execution of some five small research projects, as well as on the analysis and interpretation of data, on presentation of results at seminars and on preparation of research papers. Application of relevant mathematical methods for the analysis of marine ecosystems was encouraged. The goal was for the trainees and professor to work together as a team, and to develop strategies for establishing long-term successful observations and research in biological oceanography of the Indian Ocean region.

## Equipment

After evaluating the needs for equipment at NIO-Kochi essential for the success of the training programme, and for establishing a viable research and observational programme in the future, some specialised equipment was procured for the centre as part of the NF-POGO Visiting Professorship Programme. The participants were trained on the use and interpretation of the equipment, and most of the equipment was used in the research projects that the trainees executed. Discussions were held with the authorities at NIO on issues regarding the maintenance and operation of the equipment after the completion of the training programme.

In evaluating the training programme, it cannot be stressed too strongly that access to the equipment was absolutely essential to the success of the training programme, and was rated very highly by the participants among the benefits from the training programme. This equipment is seen as critical to the training itself and also to the continuation of work in the subject area by the trainees. The equipment should be seen as a national (perhaps even regional) resource, to be maintained in good order by NIO (Kochi).

Director, NIO has agreed that NIO will take responsibility for maintaining the equipment, and will ensure that all participants in the programme will have access to the equipment in the future. Dr. Maheswari Nair has been put in overall charge of the Nippon Foundation equipment in Kochi. The particulars of major equipment gifted, and recommendations for the future are given in Appendix 3.

## Duration of the Training Programme

The training programme was conducted in two phases, the first phase was executed over one month (from Nov. 5 to January 8), and the second phase was for two months (February – March). Two of the foreign participants (Mr. Suriyan Saramul and Mr. Phan Minh Thu) stayed in India during the break period, and used that time to visit NIO (Goa) and to work on their research projects and the web site, and to generally extend their training. The other trainees returned to their regular duties. Three months was the minimum period required to provide the extensive training that was delivered. The length of the training was also instrumental in developing an *esprit de corps* among the participants, an essential ingredient for the success of future collaboration among the trainees. The duration of the training could have been extended usefully,

if opportunity had existed. At the same time, the participants had other pressing responsibilities to their projects, and other demands on their time, such that it would have been difficult to plan for a longer programme, at least in continuous mode. Thus, considering all aspects related to organisation of such a programme, the time period of three months appeared optimal.

### **Research Projects**

From the very beginning of the training programme, the participants were encouraged to form small groups, and formulate short research projects that could be executed within the three months of training. In the end, four groups were formed, and they took up projects related to: the influence of phytoplankton on the mixed-layer dynamics of Central Arabian Sea; bio-optical properties of phytoplankton in the Kochi backwaters; a re-examination of the Arabian-Sea paradigm regarding the distribution of zooplankton; influence of phytoplankton on variability in sardine catch off the south-west coast of India; primary production modelling for the South West Indian Ocean. The results were presented to the Director of NIO in a seminar organised by the participants, towards the end of the training programme. It was decided that the completed work will be written up by the participants for publication in appropriate journals.

### **Teaching Material**

The participants were given text books, reprints and software, to enhance their learning. These and other books were also supplied to the library of NIO-Kochi. Furthermore, Phan Minh Thu, one of the participants, also developed a web-site as additional resource of teaching material (details provided in Appendix 4).

### **Follow-up Action**

One of the objects of the programme was to develop a sense of community and shared goals for the younger generation of scientists engaged in ecosystem analysis and research in the Indian Ocean. This seems to have been very successful, and should provide an excellent basis for future collaboration. With this in mind, the participants have organised themselves into a network for ease of communication and interaction after the end of the training.

The NIO-Kochi regional centre is at a transition point as the scientist-in-charge, Dr. KKC Nair, will retire in June 2005. The Director, NIO, plans to develop the regional laboratory as a centre for analysis of the marine ecosystem using remote sensing as the basis, that is to say in the subject area covered by the training. To this end, the investment in equipment will prove to be of great value, and the training should continue to bear fruit in the long term.

The participants from NIO-Goa are providing a series of lectures at NIO-Goa, to share their experience and new-found knowledge with the other scientists there.

Opportunities are being sought to provide the possibility for the group to meet in the future.

During the training, two trainees (Satya Prakash and Shovan Lal Roy) applied for, and subsequently were awarded, POGO Fellowships to study abroad for periods of three months. Another student (Sarat Tripaty) has received the Japanese Government Fellowship for doctoral study in Japan. These opportunities will help cement and extend the training begun at Kochi.

Furthermore, at the request of the Director of NIO, the participants also prepared two research proposals for future work in the subject area covered by the training, and in the same geographical area. These proposals are national in scope. They will be submitted to the Director, NIO, with the hope that, after suitable revision, they could be submitted to some national agency for funding. This would allow the group to continue working on the problems they have begun to study during the training.

The capacity building begun under the Nippon –POGO initiative continues.

## Appendix A1: Announcement



### **Announcement for Training programme in**

Calculation of Regional-Scale Primary Production for Indian Ocean Waters, and Applications to Ecosystem Dynamics

#### **Under the Auspices of**

**Nippon Foundation – Partnership for Observation of the Global Oceans  
(NF – POGO)**

**Visiting Professorship and Associated Training Opportunity**

#### **In Association with**

**National Institute of Oceanography, India**

**Conducted by :Professor (Dr.) Trevor Platt (FRS, FRSC), Bedford Institute of  
Oceanography,  
Canada**

**Venue: National Institute of Oceanography, Kochi, India**

**Dates: Part I: Dec 2004 (nominal, duration one month);  
Part II: February – March 2005 (nominal, duration two months)  
(exact dates will be announced later)**

**Background:** A joint initiative of the Nippon Foundation and the Partnership for Observation of the Global Oceans (POGO) has established a Visiting Professorship in Oceanography. Two such temporary Chairs will be named each year.

In this, the first, year of the Programme, NIO-Kochi has made a successful proposal to host an NF-POGO Visiting Professor for three months. Dr. Trevor Platt will be the Visiting Professor, and during his stay at NIO-Kochi he will offer training in the use of remotely-sensed data on ocean colour as a tool for the analysis of the marine ecosystem. Dr. Platt will be assisted by a small team of other experts. Initially, the course will cover the bio-optical bases of ocean colour, the retrieval of pigment biomass, the calculation of primary production and the interactions between physical and biological processes in the ocean. This material will be then used as the starting point for the quantitative analysis of marine ecosystems at all trophic levels, with particular reference to the Arabian Sea and the Bay of Bengal.

**Course content:** The syllabus will include:

- Theory and application of submarine optics, especially that part relevant to pigments of phytoplankton and the colour of the ocean
- Use of remotely-sensed data on ocean colour as a basis for the calculation of primary production at the regional scale
- Application of results of these calculations to analysis of the regional ocean ecosystem at all trophic levels
- Response of the biological system to climate change and potential feedbacks
- Interactions between mixed-layer dynamics and ecosystem processes
- Fundamentals of analysis and modelling of ecosystem variables
- Interpretation of results in context of larger questions of the day, including collapsing fisheries
- Preparation of results for publication in the open literature

**Format of the course:** Lectures on theoretical fundamentals will be complemented by practical demonstrations of analyses of satellite data on ocean colour, *in situ* field sampling and laboratory analyses of water properties important for the interpretation of remotely-sensed data on ocean colour (phytoplankton absorption, photosynthesis-irradiance parameters, pigment composition using HPLC). In addition, participants will work with the Professor on the design and execution of one or more small research projects, as well as on the analysis and interpretation of data, on presentation of results at seminars and on preparation of research papers. Application of relevant mathematical methods for the analysis of marine ecosystems will be encouraged. The goal is for the trainees and professor to work together as a team, and to develop strategies for establishing long-term successful observations and research in biological oceanography of the Indian Ocean region.

**Eligibility and prospects:** The course is open to a limited number of participants from the Indian sub-continent and surrounding regions, for whom travel and subsistence costs will be defrayed. The course will be aimed at doctoral students and young researchers with a leaning towards quantitative analyses of biological data from the marine environment, and an interest in physical-biological interactions. The course is seen as the beginning of a long-term, sustained effort at capacity building in the region. The activities of the participants will be monitored for some years after the end of the course. It is also anticipated that the strongest participants will have further opportunities for advanced training and scientific exchange with centres of excellence in India and abroad: it is expected that the legacy of the course will endure far into the future.

**Application and selection procedure:** Applications are invited from research institutes and universities in India and neighbouring countries. Those institutes interested in sending participants to the course are requested to forward the CV's of proposed candidates, along with a statement of their current activities and long-term goals.

In the selection of participants, preference will be given to young researchers near the outset of their careers. All participants will be expected to be present in Kochi for the entire duration of each period of the course. Where possible, participants will bring relevant data from the region, and will be encouraged to analyse and publish them. The intention is to help develop a core group of researchers who will continue to study the ecosystems of Indian waters into the future, and who will also help train the next generation of scientists in biological oceanography in the region.

**Recommended format for Application:**

- Name
- Designation
- Affiliation and mailing address
- Phone, Fax, Email
- Passport details (in case of foreign applicants)
- Qualifications (Degree, Subjects, Specialisation, Grade)
- Professional experience (Designation, From, To, Organisation)
- Summary of the work being carried out currently (100 words)
- Long-term goals (100 words)
- List of publications (including papers, reports, proceedings, dissertation, articles)
- Signature (with date)
- Recommendation of the Head of the Institute/Dept. (including any partial/complete financial support offered).
- Signature (with date) of the Head

The applications may be forwarded to:

Dr. Rahul Sharma, National Institute of Oceanography (NIO)  
Dona Paula - 403 004, Goa, India, e-mail: [rsharma@darya.nio.org](mailto:rsharma@darya.nio.org)

With electronic copies to

Dr. KKC Nair, National Institute of Oceanography, Kochi  
e-mail: [sic@niokochi.org](mailto:sic@niokochi.org); [kkcnaair2004@yahoo.com](mailto:kkcnaair2004@yahoo.com)

and

Ms. Shino Takahashi, POGO Secretariat, e-mail: [nipponproject@mar.dfo-mpo.gc.ca](mailto:nipponproject@mar.dfo-mpo.gc.ca)

**Deadline** for applications is 30 September, 2004.

Applicants will be notified if they have been selected or not, by mid October, 2004.

## Appendix A2

### Names and Affiliations of Participants at the Nippon Foundation – POGO Visiting Professorship at NIO-Kochi

No	Name	Country	Institution
1	Sarat Chandra Tripathy	India	NIO Regional Centre, Visakhapatnam
2	Phan Minh Thu	Vietnam	Institute of Oceanography
3	Shovonlal Roy	India	Indian Statistical Institute
4	Grinson George	India	NIO - Goa
5	Suriyan Saramul	Thailand	Chulalongkorn University
6	Kalluri Hanumantha Rao	India	National Remote Sensing Agency
7	R. Jyothibabu	India	NIO - Kochi
8	N. V. Madhu	India	NIO - Kochi
9	Habib Rehman. H	India	NIO - Kochi
10	Mini Raman	India	Space Applications Centre (ISRO)
11	Rabindra Kumar Nayak	India	NIO - Goa
12	Margareth Serapio Kyewalyanga	Tanzania	University of Dar es Salaam
13	Satya Prakash	India	Physical Research Laboratory
14	Sahana Hegde	India	NIO - Goa
15	Ravidas Naik	India	NIO - Goa
16	Sunita Kumari	India	Centre for Atmospheric Sciences
17	Srinivasa Kumar T.	India	Indian National Centre for Ocean Information Service
18	B. Meenakumari	India	Central Institute of Fisheries Technology
19	K. V. Jayalakshmy	India	NIO - Kochi
20	Siddhi R. PrabhuKonkar	India	NIO - Goa
21	Rajdeep Roy	India	NIO - Goa
22	Padmakumar K. B.	India	Cochin University of Science & Technology
23	Nimit D. Joshi	India	CIFT - Viraval
24	Shiju. C.K	India	NIO - Kochi
25	Maheshwari Nair	India	NIO - Kochi

### **Appendix A3**

#### **NF-POGO Project Equipment gifted to NIO-Kochi**

After evaluating the needs for equipment at NIO-Kochi essential for the success of the training programme, and for establishing a viable research and observational programme in the future, some specialised equipment was procured for the centre as part of the NF-POGO Visiting Professorship Programme. The participants were trained on the use and interpretation of the equipment, and most of the equipment was used in the research projects that the trainees executed. Discussions were held with the authorities at NIO on issues regarding the maintenance and operation of the equipment after the completion of the training programme.

In evaluating the training programme, it cannot be stressed more that access to the equipment was absolutely essential to the success of the training programme, and was rated very high by the participants among the benefits from the training programme.

The particulars of major equipment gifted, and recommendations for the future are given below:

#### **1. HPLC Machine and accessories for phytoplankton pigment analysis:**

The equipment that has been provided is the best available. No such facility exists in India or in the neighbouring countries. The participants were trained by Marie-Hélène Forget (Dalhousie/BIO Canada) on the use and maintenance of the instrument. The pigment data from the instrument has applications in a wide variety of fields in biological oceanography, including chemo-taxonomy, biodiversity of phytoplankton, remote sensing of ocean colour and phytoplankton physiology, primary production and underwater light transmission. It was used in two field projects during the training programme, and plans were developed for the use and maintenance of the equipment in the future. Recommendations:

- a. The need to maintain the instrument calibrated. Needs standards to be renewed, ideally on a yearly basis (related issue: the freezer has to be maintained at -20 C to prevent standards degrading in the freezer).
- b. Need to employ one scientist in charge of the instrument, ideally with one technical support person full time. Current nominee is Dr. Maheshwari, one of the participants at the training programme. Recommend hiring one scientist and two technicians specialised in the use and application of this instrument.
- c. Suggest NIO-Goa, SAC, NRSA and CIFT develop plans to use the instrument. There might be similar interest from other organisations and other countries in the region. Entering into collaborative projects with these partners, in which funds for the personnel, chemicals and standards are included in the operational costs, will help maintain the HPLC facility as a self-funded facility. Ideally the strategy will include a master plan for generating funds for replacing the equipment after a period of say 10 years.

#### **2. P-I meter:**

The P-I Incubator (or Photosynthesis – Irradiance incubator) consists of an incubation chamber (fabricated in Canada), a temperature-controlled bath (purchased in India), a light meter for measuring light in the incubation chamber (procured in Canada and transported to India), and a slide projector for light source (provided by NIO-Kochi).

Marie-Hélène Forget trained the participants on the use of the equipment for establishing the P-I parameters for use in primary production models. Recommendations:

- a. Please make it easy for non-NIO-Kochi participants of the training programme to borrow one P-I meter. Mr. HK Rao (NRSA, Hyderabad) would like to borrow one for east-coast studies. He would be prepared to buy a light meter and a slide projector to go with the box.
- b. Between NIO and SAC, please explore possibility of replicating the P-I box, and buy light meters and slide projectors to go with the boxes, so that the needs for such facilities at other institutes nation-wide can be met.

**3. Spectro-photometer:**

A spectrophotometer with integrating sphere was provided as part of the training programme. Marie-Hélène Forget and Vivian Lutz (Argentina) provided training on the use of the instrument for measurement of absorption spectra of phytoplankton, yellow substances (coloured dissolved organic matter) and particulate detrital matter. The instrument was used in two field programmes, and plans were developed for the future use of the instrument as part of scientific plans for the centre, as well as in national collaborative projects. Requirements for the future were discussed:

- a. Need dark curtains on windows (this is also needed for HPLC); the dark glass in the room is not sufficient to prevent degradation of pigments by light. This is being taken care of.
- b. Need storage room, which can be kept under lock and key for glass-ware and chemicals; acids need separate storage rooms. This is also being addressed.
- c. Similar to the HPLC, the spectro-photometer may be used as a revenue-generating, self-sustained facility.

**4. Liquid-Nitrogen containers:**

This was bought under contingency, as part of the student research programme, on realisation that such containers were required for field programmes for storage of pigment and absorption samples. This is a critical requirement. All too often, precious samples are lost through degradation in shipping and storage, so that every effort must be made to prevent such losses. Recommendation:

- a. Please let non-NIO Kochi trainees borrow it for cruises. For Indian cruises, it may be a good strategy to have one on all research vessels. Smaller containers (to be procured) can be used to transport the samples to the lab, where it can be stored in the larger containers. Ideally, NIO-Kochi will acquire a super freezer in due course, for storing samples at – 70 C in the laboratory.

**5. Plant-growth incubators:**

A plant growth incubator was seen as an essential addition to the field equipment. This will allow laboratory experiments on phytoplankton physiology to be carried out, complementing the field work, and enhancing our understanding of the functioning of the marine ecosystem. Recommendations:

- a. May be maintained by the aquaculture group, under the supervision of TV Ravindran, since that appears to be a natural home for this piece of equipment.
- b. However, it must be maintained as a common facility, with access to others, especially the NF-POGO trainees, for legitimate, good quality work.

**6. Computer facility:**

The computer facility that has been established is designed primarily for processing satellite data and for computation of primary production. Ms. Linda Payzent and Mr. Peter Payzant provided training to the participants on satellite data on ocean colour and their processing and manipulation of images. Recommendations:

- a. The facility is meant for the use of the trainees, and primarily for satellite-data processing. Please keep them in Room No. 40 along with all the other NF equipment.
- b. The Fedora installation appears to be fragile. Already only one of the two is functional, for SeaDAS. Need computer support staff to reinstall Fedora and SeaDAS.
- c. The satellite data acquisition will become prohibitively slow, without the high-speed internet connection which was established for the training period. However, the cost for high-speed internet is surprisingly high. Whenever possible, it would be good to address this problem.
- d. Research fellows in biological oceanography have limited access to personal computers. If this status can be modified for the better, it would be very beneficial.

## Appendix A4 Teaching Material

### Books distributed to POGO participants and to the NIO-Kochi Library

1. **Ecological Geography of the Seas** - Alan. R. Longhurst
2. **Remote sensing of ocean colour in coastal and other optically complex waters** (Edited by Shubha Sathyendranath) - Report No. 3, IOCCG.
3. **A guide to the creation and use of ocean colour level 3, binned data products** (Edited by David Antoine) - Report No. 4, IOCCG.
4. **Calculus** - 9<sup>th</sup> edition- Thomas & Finney.
5. **High school English grammar & composition** - Wren & Martin (S.Chand).
6. **A key to Wren & Martin's regular & multicolour edition of High school English composition** - S. Chand.
7. **Phytoplankton pigments in Oceanography** – S.W. Jeffrey, R.F.C. Mantoura & S. W. Wright - SCOR - UNESCO.
8. **Light and Photosynthesis in Aquatic Systems**- John T.O. Kirk, Cambridge University Press, 1983.
9. **Ocean Biogeochemistry** - The Role of the Ocean Carbon Cycle in Global Change - Series: Global Change - The IGBP Series - Fasham, Michael J.R. (Ed.).
10. **Master Math: Precalculus & Geometry** – Debra Anne Ross (Master mind books).
11. **Master Math: Calculus** - Debra Anne Ross (Master mind books)
12. **Modelling marine primary production** - Trevor Platt & Shubha Sathyendranath (Spiral bound photocopy, unpublished manuscript).
13. **Marine Ecological Processes** – Ivan Valiela 2<sup>nd</sup> Edition- Springer
14. **Dynamics of Marine Ecosystems** - Biological - Physical interactions in the ocean - K. H. Mann & J.R.N. Lazier (Blackwell science).
15. **Oceanography** - Special issue - Ocean observations – Vol. 16, No. 4.

### Computer Software

1. SeaDAS Satellite data processing software (prepared by NASA)
2. Software for modelling primary production (prepared by Trevor Platt, Shubha Sathyendranath and George White III, BIO)
3. Type-setting software for TeX, WinEdit (commercial package)

### Web-based Material

Mr. Phan Minh Thu, one of the trainees, took the leadership in designing and setting up a web-based resource for the use of the participants. This web page, which is password protected, is housed by NIO. It contains lecture notes, power point presentations of all lectures provided by the Visiting Professor, and guest lecturers, pdf versions of scientific papers, an exhaustive bibliography of relevant literature, links to related sites. It also provides links to sites that provide material on writing papers, reports, proposals and theses. The site also houses the project proposals and reports prepared the participants, and the power point presentations that they made. This protected web site is at <http://www.coastalhazards.info/pogo>. The sign-in is pogo, and password is pogo123.

The group also decided to form an e-mailing group for sharing information and experience in the future. This group has been very active since the conclusion of the training programme.

It is recommended that the name of the site be changed to something more appropriate for the programme.