



BIOS
BERMUDA
INSTITUTE
OF OCEAN
SCIENCES

Report for Training Programme for Developing Countries

Phytoplankton Community Structure: From the Molecular to the Global Scale

Under the Auspices of
Nippon Foundation – Partnership for Observation of the Global Oceans (NF – POGO)
As a Component of
The NF-POGO Centre of Excellence in Observational Oceanography
Bermuda Institute of Ocean Sciences (BIOS), Bermuda

In Association with
The National Institute for Space Research (INPE), Brazil

In Collaboration with
Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM), Brazil

This Training Program/Workshop is also a contribution to ANTARES, an integrated network of in situ and remote-sensing stations focused on detecting long-term changes in marine waters around Latin America.

Conducted by
Dr. Robert Frouin, Scripps Institution of Oceanography (SIO), La Jolla, USA
and
Dr. Milton Kampel, National Institute for Space Research (INPE), Brazil

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Venue: Arraial do Cabo, Rio de Janeiro, Brazil

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1. Introduction

The topic of the 2009 Training Programme in Brazil was the application of remote sensing data for determination of phytoplankton functional types for biogeochemistry applications. The rationale for this approach is that partitioning the autotrophic plankton community into functional types is expected to improve the modeling of primary production and increase our understanding of the role of phytoplankton in the global carbon cycle.

Satellite ocean-color sensors are providing data to study various biological and ecological issues related to phytoplankton and their role in global biogeochemistry. As new data streams become available, it is important that young scientists are trained in the theories and applications required for proper utilization and interpretation of such complex information.

The 2009 Training Programme in Brazil builds on the successful Training Programme in 2006 conducted by Dr. Robert Frouin in collaboration with Dr. Milton Kampel through the NF-POGO Visiting Professorship Programme. The 2006 programme

Evaluation of Satellite Ocean-colour Algorithms and Products in Coastal Regions of Central and South America

was conducted in association with the National Institute for Space Research, Brazil and the Oceanographic Institute of the University of São Paulo, Brazil. The training included two major group activities, with formal lectures, theoretical work, laboratory measurements, field experiment, and data analysis. The major aspects of ocean color remote sensing were covered, from fundamental principles to modeling, inversion, instrumentation, and measurements. The 2009 training programme covered many of the same topics, but emphasized aspects of algal taxonomy, biology, ecology, and physiology (as described in detail below).

The 2009 Training Programme in Brazil represents the first “Training Programme in a Developing Country” implemented as part of the NF-POGO Centre of Excellence. This Training Programme builds on the highly successful NF-POGO Visiting Professorship Programme, which allowed short visits by scientists from advanced oceanographic institutes to institutes in developing countries and economies in transition. The goals of the Visiting Professorship Programme have been retained in the Training Programme, which are, broadly speaking, to provide training and mentoring, to develop collaborations and enhance networking. This Training Programme is seen as a complement to the POGO-SCOR Visiting Fellowship Programme.

The 2009 Training Program was also a contribution to ANTARES, an integrated network of in situ and remote-sensing stations focused on detecting long-term changes in marine waters around Latin America. A major goal of ANTARES is to detect and understand the impact of climate change and human activities on coastal ecosystems of Central and South America and to provide the scientific basis for ecosystem definition and management.

2. Training Objectives

The Training Programme represented an intensive, graduate-level workshop in ocean biology and biogeochemistry as related to the optical properties of ocean waters, remote sensing technologies and satellite oceanography. The workshop content focused on developing skills required to use remote sensing technologies to determine phytoplankton functional types within the water column.

The Training Programme represented the continuation of a long-term, sustained effort at capacity building in the region. It is anticipated that the workshop will lead to other opportunities for advanced training and scientific exchange for many of the trainees.

Specific Training Objectives Included:

- capacity building in the host institution, leading to enhanced sustained ocean observations that address societal issues of the day.
- development of highly-trained scientific professionals
- promoting contacts, collaborations and networking among institutions of developing and developing countries

Another goal of the Training Programme is to recruit students into the 10 month Centre of Excellence Programme in Bermuda.

The Programme was made available to 25 participants from five Latin America countries, including four from Argentina, 15 from Brazil including two from INPE and four from IEAPM, one from Ecuador, three from Mexico and two from Venezuela. Student applications were evaluated based on academic credentials, prior work (e.g., motivation) and letters of recommendation. Travel and subsistence costs were defrayed for the trainees. The workshop was aimed at doctoral students and young researchers with interests in quantitative analyzes of biological data from the marine environment, remote sensing and physical-biological interactions. Trainee names and home institutions are provided in Appendix 1 (page 6).

3. Training Activities

The course format included lectures on theoretical fundamentals complemented by practical demonstrations, data collection, group work, and a sampling opportunity aboard the research vessel, *R/V Diadorim*. The specific topics for discussion and practicals included the rationale and methods for determination of phytoplankton community composition and structure and the relationship of phytoplankton to optical data derived from satellites. Data interpretation was stressed, both in terms of both regional and global issues. Selected photographs of the trainees during various stages of the programme are provided in Appendix 6 (page 17).

Laboratory practicals included identification (taxonomy) and characterization of well-known and characterized algal cultures as well as algae collected from waters adjacent to the lab using both light and epifluorescence microscopy. Pigments were qualitatively and quantitatively determined via HPLC for most of the same algal cultures. Spectral properties for algae cultures were determined with a spectrophotometer. Other projects/demonstrations for the trainees involved use of methods and protocols related to downloading and analyzing satellite ocean data. Software programs such as SeaDAS and WIM were emphasized. The schedule of activities is provided in Appendix 4 (page 12).

For independent research projects, the trainees were divided into three teams. Samples analyzed were collected aboard the *R/V Diadorim*. Briefly, two stations were sampled, one in the Bay and one further offshore. CTD data were collected from each station along with Secchi disk readings and net tows. Water was sampled from three depths at each station via Niskin bottles.

Once shipboard samples and data were returned to the lab, trainees were challenged to make determine algal taxonomy via light and epifluorescence microscopy. Pigments were quantitatively and qualitatively examined via HPLC. Quantitative aspects of phytoplankton abundance were analyzed via Utermohl chambers. Spectral properties of algae were determined via spectrophotometry. Trainees downloaded satellite images of the region and used the data to interpret the field data.

Each of the three teams had at least one trainee with expertise in phytoplankton taxonomy, one in HPLC analysis of pigments, and one in analysis of satellite images. Each team produced a written report and made an oral, group presentation of results. This format permitted trainees to learn and familiarize themselves with various aspects of ocean color remote sensing, methods for algal identification (including microscopy and pigments) and to apply and deal practically with the theoretical concepts introduced in the formal lectures. This format also allowed trainees to interact, develop strategies for their individual research projects in their home countries, and importantly, to build friendships that foster long-term networking on problems in each trainee home country.

4. Final Remarks

The list of trainees and instructors, including contact information, is given in Appendices 1, 2 and 3. The instructors' lectures and trainees' presentations are listed in Appendix 4 and Appendix 5, respectively. Team reports are provided online at:

<http://www.dsr.inpe.br/nfpogo2009/reports.php?idioma=EN>

A web page was developed for the course, i.e., <http://www.dsr.inpe.br/nfpogo2009/>. This page, written in English and Portuguese, includes information about course application, content, and format, a list of trainees and instructors, lectures, trainee presentations, and photographs. Links to the web pages of the main sponsors and organizations are also included.

The trainees were highly motivated and worked and studied diligently throughout the training programme. The student presentations were very strong, even for trainees who were just starting their research programmes. This sharing of information was viewed as one of the highlights of the programme, as students were able to see and hear first hand about research efforts conducted by their peers across Latin America. Trainees spent considerable time honing their presentations in an effort to accurately relay their work. This hard work paid off as trainees were required to present final presentations of their independent projects (i.e., analysis of samples collected from *R/V Diadorim* and interpretation of regional satellite images), as these presentations were remarkably professional given the short amount of time available for data analysis/interpretation. This speaks well to the strength of the training programme as well as the camaraderie developed between these young scientists in such a short period.

The instructors were very hard working, extremely supportive of trainee questions and concerns, and came well prepared to present lectures and labs on topics at the cutting edge of their respective fields. IEAPM administrators, scientists and staff were friendly, supportive, and helpful in all possible ways.

It will be important to monitor trainees for years to come in order to determine the success of Training Programme. Measures of success would include trainee ability to enter graduate programs, obtain employment and/or publish manuscripts in peer-reviewed journals related to topics covered during the Training Programme.

5. Acknowledgments

We would like to thank POGO and the Nippon Foundation and the Director and staff of IEAPM for giving us the opportunity to implement this training programme in Brazil. Our special thanks go to Drs. Heather Bouman, Vivian Lutz, Silvana Vianna Rodrigues, Silvia Mattos Nasimento, Roberto Millan and Rodolfo Paranhos as well as the Captain and crew of the *R/V Diadorim*.

6. *Appendix 1: Trainees*

Adriana Gisel Gonzalez Silvera
Facultad de Ciencias Marinas (FCM)
Universidad Autónoma de Baja California (UABC)

Amabile Ferreira
Instituto de Oceanografia Universidade Federal do Rio Grande

Ana Inés Dogliotti
Instituto de Astronomía y Física del Espacio (IAFE)
CONICET-UBA Ciudad Universitaria

Cassia Cristina de Azevedo Cubas Jonck
Universidade Federal Fluminense – UFF
Institute of Chemistry – Department of Analytical Chemistry

Eduardo Miranda de Souza
Departamento de Oceanografía Biológica, Universidade de São Paulo

Eduardo Santamaría del Angel
Facultad de Ciencias Marinas (FCM)
Universidad Autónoma de Baja California (UABC)

Eliliane Vasconcelos Corrêa
Universidade Estadual do Norte Fluminense Darcy Ribeiro.

Eline Simões Gonçalves
Federal Fluminense University – UFF
Institute of Chemistry – Department of Environmental Geochemistry

Gustavo Souto Fontes Moller
Instituto Nacional de Pesquisas Espaciais - INPE

Jaimie Cristina Rojas Márquez

Lohengrin Dias de Almeida Fernandes
UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO
DEPARTAMENTO DE BIOLOGIA

Luis Fabricio Guamán Guevara
University of Concepción. Chile

Mariana Elvira Callejas Jiménez
Universidad Autónoma de Baja California (UABC), Facultad de Ciencias Marinas (FCM)

Mayza Pompeu
Instituto Oceanográfico da Universidade de São Paulo
Departamento Oceanografia Biologica

Melissa Medeiros Ferreira Hatherly
Universidade Federal do Rio de Janeiro
Museu Nacional

Natália de Moraes Rudorff
Instituto Nacional de Pesquisas Espaciais – INPE

Rene Ayala-Campos
Valle de Sarteneja, Universidad Simon Bolivar,
Departamento de Estudios Ambientales,

Silvana Raquel Halac
Estación de Fotobiología Playa Unión
Instituto Nacional del Agua: Argentina

Simone de Castro Vianna
Universidade Federal do Rio de Janeiro (UFRJ)

Valeria Ana Guinder
Instituto Argentino de Oceanografía (IADO-CONICET),

Valeria Segura
Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) r

Wanderson F. de Carvalho
Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM)

Maria Helena C. Baeta Neves
Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM)

Mariana Dantas Alberto
Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM)

Bruna Pozzebon
Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM)

7. *Appendix 2: Instructors*

Heather Bouman
Department of Earth Sciences
University of Oxford

Dr. Robert Frouin, Lead
Climate Research Division
Scripps Institution of Oceanography
University of California

Vivian Lutz
Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP)

Milton Kampel
Instituto Nacional de Pesquisas Espaciais – INPE

Roberto Millan
Universidad Autónoma de Baja California (UABC)
Facultad de Ciencias Marinas (FCM)

Rodolfo Paranhos
Universidade Federal do Rio de Janeiro
Departamento de Biologia Marinha

F. Gerald Plumley
Bermuda Institute of Ocean Sciences (BIOS)

Silvana Vianna Rodrigues
Universidade Federal Fluminense
Centro de Estudos Gerais, Departamento de Química Analítica

Silvia Mattos Nascimento
Universidade Estadual do Norte Fluminense Darcy Ribeiro, Laboratório de Ciências Ambientais.

Wanderson F. de Carvalho (listed as both a trainee and an instructor)
Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM)

8. *Appendix 3. Other Instructors/Participants*

Danilo Vinicius Pierone
Thermo Scientific
Manager for GC & LC Products

Aline Quinaia
Thermo Scientific
GC & LC Product Support

9. *Appendix 4: Lectures, Laboratory Exercises, Group Work, and Field Work*

(T): Theory
(L): Laboratory demonstration
(G): Group work (Trainees' projects in groups)
(F): Field work
AM: 9:00 to 12:00 hours; PM: 14:00 to 18:00 hours
Lunch break: 12:00 to 14:00 hours

Monday, September 21

AM: -Welcome/Logistics. (Milton Kampel, Eliane Gonzalez, Robert Frouin, Gerry Plumley)
-(T) Importance of phytoplankton; Aspects of macro-ecology; Overview of ways to quantify and identify phytoplankton, to connect the subjects to be covered in the course: taxonomy, molecular biology, flow cytometry, pigments, bio-optics, remote sensing, 'Phytoplankton Functional Types'. (Heather Bouman)
Lunch break
PM: -(T) Cell structure; Phytoplankton taxonomic composition, morphology, and size; Microscopy (light, electron, and fluorescence types). (Silvia Nascimento)

Tuesday, September 22

AM:
-(T) Why Size and Taxa Matter: Patterns, and Global Biogeography; Global Biogeochemical Cycles and Ecosystem Dynamics. (Heather Bouman)
Lunch break
PM: -(L) Microscopy, demonstration; Looking at different types of phytoplankton under the microscope (cultures and fixed samples). (Silvia Nascimento)
-(G) Group work.

Wednesday, September 23

AM: -(T) Molecular biology; Phylogenetics; Importance and Applications. (Gerry Plumley)
- Trainee presentations. (Fabricio Guaman, Amabile Ferreira, Valeria Guinder)
Lunch break
PM: -(T) Pigment composition of phytoplankton; Different approaches to estimate phytoplankton groups from pigment data. (Roberto Millan)
-(G) Group Work.

Thursday, September 24

AM: -(T) Phytoplankton pigments; Chemical structure and properties; Methods, HPLC (Silvana Rodriguez)
-(T) Brief introduction to chromatography. (Silvana Rodriguez)
Lunch break
PM: -(L) HPLC, demonstration. (Silvana Rodriguez)
-(G) Group work.

Friday, September 25

AM: -(L) HPLC, demonstration, cont. (Silvana Rodriguez)

Lunch break

PM: -(T) Phytoplankton ecology. (Roberto Millan)

-Trainee presentations, cont. (Eduardo Miranda, Eduardo Santamaria, Eliliane Corrêa)

-(G) Group Work.

Saturday, September 26

AM: -(T) Nature of light. Properties defining the light field. (Robert Frouin)

Lunch Break

PM: -(T) Primary production modeling. (Heather Bouman)

-Trainee presentations, cont. (Eline Gonçalves, Gustavo Moller, Jaimie Marquez)

-(G) Group work.

Sunday, September 27

AM, PM: Free.

Monday, September 28

AM: -(T) Phytoplankton absorption; Implications of pigment composition; Photo-adaptation, photo-acclimation. (Vivian Lutz)

-Trainee presentations, cont. (Mariana Jiménez, Lohengrin Fernandes)

Lunch break

PM: -(L) Measurements of absorption, demonstration. (Vivian Lutz)

-(G) Group Work.

Tuesday, September 29

AM, PM: -(F) Collection of water samples at sea for microscopy and HPLC analysis.

Wednesday, September 30

AM: -(T) Ultra-phytoplankton; Flow cytometry. (Rodolfo Paranhos)

-Trainee presentations, cont. (Melissa Hatherly)

Lunch Break

PM: -(G) Group work.

Thursday, October 1

AM: -(T) Radiative processes within the water, at the surface, and across the interface; Link between particle properties (size, composition, shape, and internal structure) and inherent optical properties. (Robert Frouin)

Lunch break

PM: -(G) Group Work.

Friday, October 2

AM: -(T) Modeling the diffuse reflectance of natural waters. (Robert Frouin)
-(T) The measurement of marine reflectance. (Robert Frouin)
Lunch Break
PM: -Trainee presentations, cont. (Adriana Gonzalez, Mayza Pompeu, Cassia Jonck)
-(G) Group Work.

Saturday, October 3

AM: -(T) Atmospheric correction of satellite ocean-color imagery. (Robert Frouin)
-(T) Structure and function of the photosynthetic apparatus. (Vivian Lutz)
Lunch break
PM: -Trainee presentations, cont. (Simone Vianna, Ana Dogliotti, Valeria Segura)
-(T) Satellite ocean-color data processing software. (Ana Dogliotti, Eduardo Santamaria)

Sunday, October 4

AM, PM: Free.

Monday, October 5

AM: -(T) Principles of satellite ocean color remote sensing. (Milton Kampel)
-(T) Estimation of phytoplankton biomass and inherent optical properties. (Milton Kampel)
Lunch break
PM: -Trainee presentations, cont. (Rene Ayala, Natalia Rudorff, Silvana Halac)
-(G) Group work.

Tuesday, October 6

AM: -(T) Discrimination of phytoplankton functional types from space. (Robert Frouin)
-(T) Mixotrophy. (Wanderson Carvalho)
-(T) The Antares network. (Vivian Lutz)
-(T) NF-POGO Center of Excellence. (Gerry Plumley)
Lunch break
PM: -(G) Group work.

Wednesday, October 7

AM: Group Presentations.
Lunch Break
PM: -Presentation of certificates.
-Closing remarks.

10. *Appendix 5: Trainee Presentations*

- **ANTARES: Baja California Station** (Adriana Gonzalez)
- **Optical characterization of the phytoplankton blooms at the Patagonian Shelf-Break** (Amabile Ferreira)
- **Satellite-based estimates of primary production in the Patagonian Continental Shelf** (Ana Inés Dogliotti)
- **Phytoplankton of Campos Basin: Measuring Composition and Abundance by Chemotaxonomy** (Cassia Cristina de Azevedo Cubas Jonck)
- **Chlorophyll and phytoplankton size-structure on Abrolhos Coral Reefs, Brasil** (Eduardo Miranda de Souza)
- **Relationship between Chl a "in situ" and Chl a derivative from remote sensing observations: Statistical consideration to the matchup approach** (Eduardo Santamaria-Angel)
- **Physiology and Toxicology of *Ostreopsis ovata*, a bloom forming epi-benthic dinoflagellate on the east coast of Rio de Janeiro.** (Eliliane Vasconcelos Corrêa)
- **Determination of phytoplankton pigments in sediments by HPLC** (Eline Simões Gonçalves)
- **Space-time variability of the Amazon River plume based on satellite remote sensing images from 2000-2004** (Gustavo Souto Fontes Molleri)
- **Optical Measurements at the CARIACO Time-series Station** (Jaimie Cristina Rojas Marquez)
- **How does suspended sediment affect microplankton grazing?** (Lohengrin Dias de Almeida Fernandes)
- **Seasonal influence of the near-inertial frequency on currents and temperature over continental shelf off Conception, Chile** (Luis Fabricio Guaman Guevara)
- **Dynamic regionalization of Gulf of Mexico Based on Water-leaving Radiances, nLw** (Mariana Elvira Callejas Jiménez)
- **Ubatuba long-term plankton and bio-optics time series – UPBITS** (Mayza Pompeu)
- **Campos Basin Microplankton: Taxonomy, Composition and Abundance** (Melissa Medeiros Ferreira Hatherly)
- **Multi-scale temporal analysis of Chl and SST obtained by satellite derived products from MODIS, MERIS, SeaWiFS and AVHRR, at the Ubatuba ANTARES station, South Atlantic** (Natália de Moraes Rudorff)

- **Phytoplankton variability and photoacclimation state in the Cariaco Basin** (Rene Ayala-Campos)
- **Interactive effects of UV radiation and temperature on phytoplanktonic species and assemblages in Patagonia** (Silvana Raquel Halac)
- **Microphytoplankton taxonomy and ecology** (Simone de Castro Vianna)
- **Phytoplankton dynamics in the Bahía Blanca Estuary, Argentina** (Valeria Ana Guinder)
- **Variations in primary production in relationship to phytoplankton functional types in the Patagonian Sea, Argentina** (Valeria Segura)
- **The double life of Mixotrophic Organisms** (Wanderson F. de Carvalho)

11. Appendix 6: Selected Photographs During the Training Programme



Group picture during week 1.
Photo taken outside the lecture hall and labs.



Milton provides information on satellites.



A lecture from Robert on the properties of light.



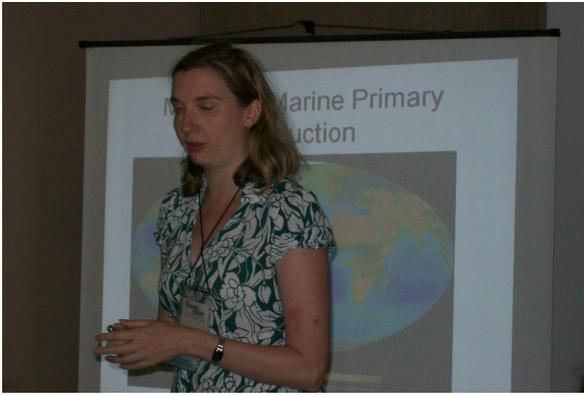
Students discuss an issue.



Robert & Milton consider a new approach to data.



Anna lectures on data analysis programs.



Heather (above) updates the class on global primary production.
Vivian (rights) discusses different types of algae.



Boarding the *Diadorim* for a day cruise.



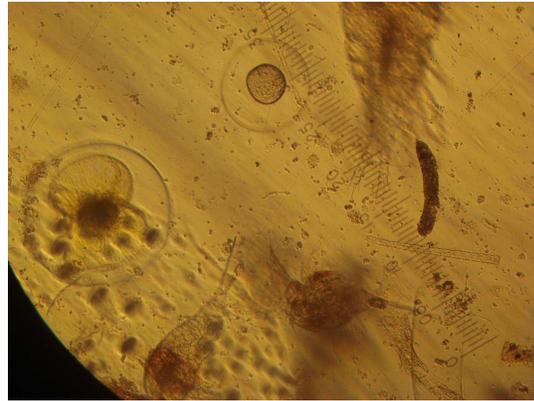
Trainees watch sample collection procedures.



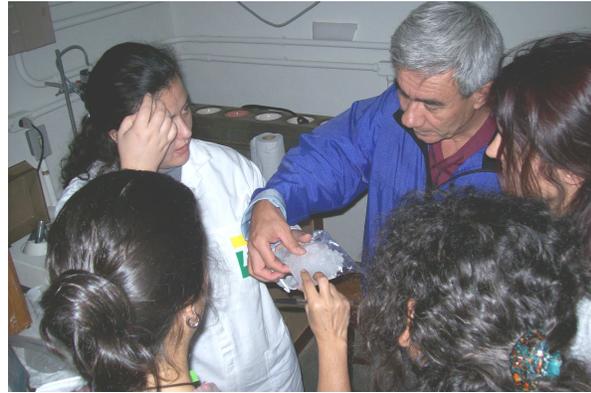
Trainees preparing the net for sampling.



Other trainees label samples from the net tow.



Back in the lab, students and instructors examine what they have collected under the microscope (left). View of local phytoplankton through the microscope (right).



Roberto (left) and Robert (right) discuss field results with trainees in the lab.



Interesting data?



Student presentation.



Students preparing their final group report.



Certificate presentation (closing ceremonies).