

**GRADUATE EDUCATION IN OCEANOGRAPHY IN DEVELOPING COUNTRIES AS A MEANS TO
UNDERSTAND GLOBAL ENVIRONMENTAL PROBLEMS:
The Results of a Team Residency at the Rockefeller Foundation Bellagio Study Center
August 26 - September 1 1998.**

EXECUTIVE SUMMARY

1. A Team Residency at the Bellagio Study Center of the Rockefeller Foundation took place from August 26 to September 1 to carry out a workshop with the following general objective:

To develop a format for international graduate programs in the field of Ocean and Marine Environmental Sciences for a number of regions of developing countries and prepare proposals to appropriate aid agencies and foundations with the goal of implementing such programs, as an urgent requisite to support the international studies and research on global environment.

2. Eleven highly reputed specialists took part in the workshop. Nine came from Australia (2), Argentina, Chile, Germany, India, Malaysia, South Africa and Thailand; two belonged to the following international scientific organizations: the Scientific Committee on Oceanic Research (SCOR), and the Intergovernmental Oceanographic Commission (IOC), respectively.
3. The five days of residence were largely devoted to the analysis of the information available on the subject. More than ten original documents and first hand oral contributions were presented and discussed. An attached list of the papers presented is included.
4. It was concluded that to reduce the gap between developing and industrialized countries regarding the ocean and marine environmental sciences, a proposal should be made to develop regionally graduate education programs in different parts of the world.
5. Building on the capacities of already existing institutions, the following four regions were selected to develop, enhance and upgrade graduate training programs on ocean and marine environmental sciences: Central and South America, Africa (south of the Sahara); South Asia (combining India, Bangladesh, Mauritius, Pakistan and Sri Lanka), and South East Asia (including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam).
6. The program on graduate education in Oceanography established at the University of Concepcion, Chile has already set the pace for national and regional higher training in Central and South America, and it is recommended to follow at least some of its successful characteristics. Two of them are: a) the establishment of an International Faculty to support the program; and b) an annual input of fellowships for students of the region conveying funds from the international and bilateral assistance (UNESCO/IOC; SCOR; Germany's DAAD; ad hoc governmental agencies and universities from South Africa, Japan, France, Canada, USA and Australia), plus local support from Foundations and the National Research Council.
7. According to the model envisaged, the proposed Regional Graduate Schools should be organized aiming to international standards, using English as language of instruction and emphasizing ship experience. They should also be supported with resources directed to organize manpower (including fellowships), ship time, library facilities and research funding. Although differences exist between the selected centers, it was considered that an annual total of US\$300,000 – 500,000 requested from various international funding agencies was necessary to launch each program, not including funds for research.
8. It was recommended that the Team Leader applies to the Innovation Fund in order to finance a study of the funding agencies and grants available to start the new Regional Graduate Schools and help to consolidate the network existing in Latin America coordinated by the University of Concepción. A study of the regional usefulness and adaptability of text-books in Oceanography and other teaching materials it is also necessary.

9. An open rigorous procedure for periodic assessment should be established by an International Advisory Panel of five to six scientists of the highest possible standing in each discipline of oceanography and the marine environmental sciences. The members of the Panel should be nominated by the Regional School and proposed to SCOR and IOC for suggestions and approval before they are formally appointed. In some cases it may be appropriate to include a representative of the interests of the major financial supporting organizations. The initial reviews may be biennial and later at some years interval. The process should not take more than six months for the submission of the final report.
10. A complementary Team Residency involving participants of the four Regional Graduate Programs here presented plus representatives of the developing countries of the Mediterranean and the Red Sea (Arab sub-region) and Central America and the Caribbean sub-region should be proposed to take place during 1999 or the year 2000.

INTRODUCTION: SETTING THE SCENE

With a few exceptions of certain institutions, the general status of the ocean sciences in developing countries lags behind that of the advanced countries. Yet the well-known stresses on the global marine environment are being exacerbated all the time. These include the impacts of natural climatic variability, or potential global warming, and, of even more immediacy for the many developing countries which are coastal states, the rapidly increasing effects of population pressures on the coastal zones and shelf seas. Already more than sixty percent of the world's population lives in the coastal zone, much of it in megacities, which are expanding in an uncontrolled manner.

It is in precisely these developing coastal and island states where expertise in ocean sciences must be harnessed and enhanced to identify, study and resolve these serious environmental problems. For example, of the ten most commercially important fish species, eight of them are small, pelagic fish found in the coastal and continental shelf seas; they comprise about ninety percent of the total world fish catch. Not only do they provide an important economic resource for many developing countries; they are also a very significant source of protein in the human diet - eighty percent in Bangladesh, for example. Fish stocks respond in complex ways to natural changes in climate regimes, but a growing understanding of this climatic variability is resulting in better predictive capabilities and assessments of its impacts.

It is impossible to generalize about the nature of coastal seas. Some are dominated by very large river inputs, such as the Amazon, Ganges or Yangtze outflows. Eastern coasts of some continents tend to have wide, shallow shelf seas ("passive margins") while some western coasts have very narrow shelves with upwelling of deep, cold, nutrient rich water. Climatic regimes, such as the monsoons of the Indian Ocean and east Asian regions or the El-Niño / La Niña phenomena of the eastern Pacific Ocean have strong effects all over the world bringing increased precipitation and storminess to some areas and unusual droughts to others. Sea levels change for various reasons including local subsidence as well as global warming. Whatever their causes, these higher sea levels when coupled with increasing storminess in the Bay of Bengal, for example, will cause even more severe flooding when storm surges reach the heavily populated Ganges River delta.

The search for answers to global environmental problems requires an understanding of global ocean and climate processes as well as a detailed knowledge at the regional and local scale. This can only be achieved through an effective partnership between scientists in both developed and developing countries in the search for solutions to these problems.

Such a partnership does not exist now and can only be attained through an approach, which helps to increase the numbers of highly competent ocean scientists in developing countries. The enhancement of educational and research opportunities at home would help to raise the level of quality of their graduate degrees to internationally accepted standards. This will require a concerted effort at first, but the process of building research capabilities in developing countries may accelerate naturally as the numbers of good scientists in the regions increase.

As noted at the beginning, there are a few marine science institutions in developing countries, which have

been able to nurture relatively high quality teaching and research programs. These cases give us cause for optimism that the current situation can be improved and they provide a basis on which to build. It will take a concerted effort to take advantage of the existing strengths of established institutions in developing countries, to enhance them, and to build up expertise where it is weak or does not exist at all. In many areas there are specialized schools of fisheries science, but no expertise in the inextricably linked fields of physical oceanography and marine modelling.

Stimulated by the example of a successful regional graduate program in oceanography at the University of Concepción in Chile, which is taught by an innovative combination of local, national, regional and visiting international scholars, a successful proposal to the Rockefeller Foundation resulted in financial support for a small meeting (or “team residency”) at the Bellagio Study Center in August 1998. The objective of this meeting was:

To develop a format for international graduate programs in the field of Ocean and Marine Environmental Sciences for a number of regions of developing countries and prepare proposals to appropriate aid agencies and foundations with the goal of implementing such programs, as an urgent requisite to support the international studies and research on global environment.

The meeting was limited to 10 participants and so its geographic coverage was incomplete. For example, there was inadequate representation from Africa, Central America and from the Mediterranean region.

Discussions were designed to address the following broad objectives:

- a) To analyze the status of Oceanography and Marine Environmental Science in the three world regions embodying developing countries (Latin America, Asia, Africa) on the basis of their participation in international research programs and organizations (e.g. SCOR, SCAR, IGBP) and regional reviews.
- b) To analyze the status of existing undergraduate and graduate programs in Oceanography and Marine Environmental Science in such regions, with real or potential application to the search for solutions to global environmental problems.
- c) To review the contents and characteristics of existing graduate programs in developing countries to evaluate their potential for implementation at the regional or international level.
- d) To agree on a model for such international graduate programs to be applied in developing countries.

Although the general structure was laid out in the discussions at Bellagio, much more detailed inputs will be required from the various regions in order to define the specific approach to be followed in each of them as their scientific and cultural criteria may vary widely. Thus, a single approach to the problem cannot be defined, and, whether it may be successful in one or two regions, it could not be adequate to all of them. However, some scientific and teaching standards are universal and may be used as benchmarks against which to assess the success of any proposed program.

If more than one successful regional graduate program can be established, scientific co-operation both within and between the regions of developing countries will be enhanced. Communication between individual scientists and institutions would increase, and the overall impact would be an accumulation of the much-needed local and regional expertise about coastal and oceanic areas.

The team members developed a set of specific objectives for a program leading to the establishment of regional graduate schools of oceanography and marine environmental sciences:

1. To develop a high-quality, multidisciplinary graduate program in Ocean and Marine Environmental Sciences for implementation in various areas of the world which consist of developing countries

2. To devise and implement regional centers of excellence where both local, within-region and advanced countries specialists will provide high-level education and training to graduate students
3. To both reduce the loss of scientific expertise from developing countries through these centers which will attract students who might otherwise leave the region, and by encouraging young scientists who have studied abroad to return to their regions.
4. To encourage multi- and interdisciplinary research in both coastal and oceanic areas based on international teams with a strong leadership by developing country scientists.
5. To develop a network of intra-and inter-regional universities and research centers (e.g., south-south, north-south).
6. To bring about the required critical mass needed for quality graduate teaching in this multidisciplinary field.
7. To build within the regions the research capabilities required to address regional marine environmental problems

THE REGIONAL APPROACH TO GRADUATE EDUCATION IN OCEANOGRAPHY AND MARINE ENVIRONMENTAL SCIENCES IN DEVELOPING COUNTRIES

It is in the interest of all countries in a certain region that they pool their human and material resources to make the pursuit of knowledge in the region a common goal. Further, a joint approach will permit the better identification of local problems, specification of local and regional priorities, avoiding the duplication of work and ensuring that appropriate research is undertaken.

Ocean science as part of the environmental sciences is a multidisciplinary and interdisciplinary field. Therefore it needs the in-depth education of students in a specific discipline as well as the broad education which allows them to understand the interrelations between marine physics, chemistry, geosciences, and biology including fisheries oceanography. Because the subject cannot be separated along national borders and also because of the considerable cost of marine science, the exchange of information between countries and intensive international cooperation is required.

The fast changes in the field due to advances in knowledge, methodology and instrumentation require a close linkage between student education at higher graduate levels and ongoing research. In order to achieve high quality graduate education programs, a critical mass and a high standard of teachers and researchers is required at one location, requiring a pooling of expertise. The concentration of research facilities and ships available in developing countries, combined with an easy access to the sea, will provide the foundation for relating theoretical and experimental work in building a center of excellence.

It is the intention of the present proposal to reduce the gap between developing and industrialized countries in ocean and marine environmental science education and in the standards and reputation of the degrees granted. At the same time, where possible, it should be attempted to reduce the "brain drain" from developing countries, which frequently occurs when students remain in industrialized countries after having graduated there. The tasks will be facilitated by forming a regional network of people and institutions, bringing together students from neighboring countries in regional centers of excellence, thus establishing the required critical mass. This will lead to the development of close international contacts and further the future cooperation inside the network, with groups in other regions and with the most advanced marine scientific and educational institutions in the field.

It will be helpful to look at existing activities in the development of regional oceanographic centers of excellence in developing countries. A particularly good example is the model of the University of Concepción. Chile is one of the few countries in Latin America, which in the last decades reached a rather advanced status in graduate education in ocean and marine environmental sciences, with regional prominence and international recognition. The

Concepción model is based on the gradual development of academic capacity in undergraduate and graduate educational programs and in advanced research. It started with an undergraduate professional program in Marine Biology in 1974, followed by a Master of Science program in 1986 and a doctoral program in Oceanography in 1992. It serves the interests of the network of those five universities which belonged to the initially five countries in temperate Latin America involved in the international COMAR Project of UNESCO. The success has arisen from:

- a long-term planning of the development of institutional academic capacities;
- the establishment of an initial regional network of interacting institutions;
- an advanced program for the graduate education of local students as well as students from the region (M.Sc. and Ph.D.);
- a regular annual provision of intensive international courses conducted over two to three weeks for graduates and young researchers from the region, given in the English language by outstanding foreign specialists (the “International Faculty”);
- an ad hoc local coordination of the program, with the regional academic components and the International Faculty;
- an annual budget for graduate fellowships offered to the region by international agencies (UNESCO), through bilateral assistance (German Academic Exchange Service/DAAD) and by academic exchange (Australia, Canada, France, FRD, South Africa, USA, and UNESCO/IOC), thus complementing the national and local budgetary commitment (University of Concepcion and Chilean Foundations).

In establishing regional graduate schools special attention needs to be given to the cultural and language problems which students from developing countries may encounter. Each country within a region will have its own quite distinct educational style, languages and culture. These are sensitive areas in human relations and cannot be ignored. Specially designed ‘transition courses’ provided to help students adapt to the expectations and style of international science and the prevailing cultural and educational considerations in the region would be most helpful.

Conducting courses in English as the international language of science provides its own problems. As proficiency in English is now required for postgraduate studies in ocean and marine environmental science, the majority of students will need courses designed to ensure their fluency in spoken English. Also their written English will need to be brought up to a standard that meets the requirement of international scientific exchange. However it is also important to foster the local language for the professional communication in the subject. This is particularly relevant in regions such as Latin America where Spanish is the dominant language and in which the majority of all undergraduate and graduate education is conducted in Spanish. It is also the language of interregional communication. In the Asian and African regions, English is more widely used but often only as a second language. Appropriate remedial help will still be needed particularly in relation to written scientific work.

As noted at the beginning, there are a few marine science institutions in developing countries, which have been able to nurture relatively high quality teaching and research programs. These cases give us cause for optimism that the current situation can be improved and they provide a basis on which to build. It will take a concerted effort to take advantage of the existing strengths of established institutions in developing countries, to enhance them, and to build up expertise where it is weak or does not exist at all. In many areas there are specialized schools of fisheries science, but no expertise in the inextricably linked fields of physical oceanography and marine modelling.

THE REGIONAL SCENARIOS

The analysis of information on the capacities and status of research and graduate training in Fisheries and Oceanography in developing countries considered during the meeting coincides with former international approaches to promote graduate training and research in developing countries through networking (e.g. START; ICSU, 1991) Such approaches divide the world in sub-regions roughly agreeing with the distribution of developing countries in three large sub-continental areas: Central and South America, Africa and Asia. (It was agreed that Sub-regions such as Central America and the Caribbean, or Arab countries around the Mediterranean and the Red Sea share similar needs and their participation will be sought for any future workshop.)

Four large sub-regions were defined as geographic areas involving groups of developing countries where special efforts should be directed to enhance and upgrade their present participation in graduate education and training on international research in fisheries, ocean research and marine environmental problems:

1. Central and South America. The Concepción Experience
2. Africa (south of the Sahara)
3. South Asia (India, Bangladesh, Mauritius, Pakistan and Sri Lanka).
4. South East Asia (ASEAN countries: Cambodia, Indonesia, Laos, Malaysia, Philippines, Thailand, Vietnam)

First hand information and documents were presented at the workshop on actual graduate education in Chile, South Africa, Malaysia, Thailand and India which represent the basis for the present proposal. This information is herewith briefly and separately discussed.

AN EXISTING MODEL: AN ONGOING REGIONAL PROGRAMME WITH SOUTH-SOUTH AND NORTH-SOUTH COOPERATION BASED IN CONCEPCION, CHILE AND INVOLVING COUNTRIES IN LATIN AMERICA

As is the case for academic institutions in any developing country, graduate expertise in the marine sciences at the University of Concepción began in 1960 as a combination of national and international incentives, overseas training of staff and the sum of individual research interests directed to the need of developing marine biology and oceanography in Chile. Imitating the example followed by some institutions in some European and North American countries, the organization of marine science began with ad hoc planning for undergraduate training and careers dependent of a Department of Zoology, but also, as part of a major plan of UNESCO to develop research in basic sciences centered in four larger independent academic units called Central Institutes (Biology, Chemistry, Physics and Mathematics). A grant from the Ford Foundation was fundamental to the building of an important basic library in the natural and marine sciences and to facilitate graduate education among the staff members in some of the most important foreign universities (e.g. Harvard, Liverpool, British Columbia, and Southern California). At about the same time the University built (in 1962) a marine laboratory at Tumbes, Talcahuano, to serve the needs of student training and staff research. As a follow up, in 1972 the University created the Department of Marine Biology and Oceanography, which in the early 90's would become the Department of Oceanography. In 1974 an undergraduate program in Marine Biology was created to serve the needs of professional expertise in universities, governmental institutions and private industry. The success of this program ensured that other Chilean universities would soon offer similar courses. The gradual building of academic expertise, laboratories, specialized equipment, and a research vessel would allow the development of graduate studies only during the next decade.

The specific development of Oceanography at Concepción began in 1986, with a regional program for a Master of Science Program in Oceanography following the North American system of basic and specialized courses, aimed to train Latin American scientists thanks to a program of fellowships offered by the German Academic Exchange Service (DAAD). Its international and regional development and organization was accelerated by the creation of a UNESCO Chair in Coastal Oceanography under sponsorship of the COMAR Project of UNESCO. The appointment of a Coordinator responsible for the Chair and the international organization, which could act in close contact with the local administration of the graduate program, was fundamental. In the following years it quickly expanded from a sub-regional scope of only five countries related to COMAR, to practically all Latin American countries with the exception of Mexico and Brazil. Students ranging from Costa Rica and Nicaragua to Argentina and Chile have already obtained both M.Sc. and Ph.D. degrees in Oceanography. An M.Sc. program in Fisheries began in 1996.

The graduate program in Oceanography is successfully strengthening academic cooperation between some of the main Latin American universities, establishing a South-South regional network of academic expertise. In addition, a North-South collaboration is now in place with outstanding scientists from developed countries teaching short, intensive, specialized courses and forming a truly "International Faculty". Since 1993, about 25 Visiting Scientists have lectured in as many intensive international courses of two to three weeks duration covering all fields of Oceanography, particularly in topics which are poorly developed in the South American region. A set of six to seven courses planned for the spring (- summer) summer semester have resulted in an exponential increase in the

number of applications for travel grants unfortunately limited by the scarce funds available to the Chair. In general, the basis for its successful development has been the multiple sources of budgetary support; the need for such broadly based funding will be essential to the success other similar international undertakings. The main components are summarized below:

- The German Academic Exchange Service is granting five annual fellowships at the doctoral level, with a total of over 20 to date (non-Chilean) students of the region. The fellowships include university fees, monthly salary, health insurance and an allowance for books and specialized equipment amounting in total to several hundred thousand a year.
- Up to now, different programs of UNESCO but presently the IOC, have contributed a small annual grant for a Chair in Coastal Oceanography, to cover the costs of tickets of two Visiting Professors and 8-10 young scientists from neighboring countries to attend the annual international courses. Such courses are widely advertised in advance through posters and brochures containing the contents of each course.
- Bilateral assistance from Canada, France, Germany, Japan, South Africa, and the Chilean Foundation “Minera La Escondida” has provided annual grants to pay the tickets of the Visiting Scientists.
- Residence costs for the Visiting Professors are paid by the University of Concepcion.
- Local and national fellowships granted by the Chilean universities and the National Research Council (CONICYT) for Chilean students, plus the local costs of administration, infrastructure and salaries.

Without this complementarity of international academic and budgetary input, the successful regional development of this graduate program would not have been possible.

The budgetary support described above, largely because of its contribution to the development of Oceanography in Latin America, is expected to be available for the coming five to eight years. The graduates of the Concepción program who have returned to their home countries since its inception, and during the next few years, will gradually begin to reach the critical masses that will in turn impact the independent national development of scientific expertise in research and training. Undoubtedly, the role of the International Faculty will be fundamental to foster and evaluate the tempo and success of such developments.

It is foreseen that after this active period of Latin American involvement, the graduate program at the University of Concepción will continue its own development, more nationally oriented but strongly linked to its regional counterparts and the overall activities in oceanographic and marine environmental research.

AFRICA SOUTH OF THE SAHARA

This component of the Third World consists of coastal states stretching from Kenya on the East Coast of Africa, through South Africa at the southern tip, up to Senegal on the northwest coast. The majority of these countries have English as their official language, with Mozambique and Angola being Portuguese and some along the west coast Francophone. Extreme poverty, poor physical and educational infrastructures, unstable political systems and poorly developed tertiary education institutions characterize most of them. A substantial number have fishing industries and therefore also fledgling teaching programs in fisheries or marine biology. All are dramatically affected by climate variability, but few have graduate education in meteorology or physical oceanography to address these serious problems.

It is imperative to enhance the teaching of the marine sciences in these countries in order to enable their decision-makers to be properly informed on a range of environmental matters that affect their populations. We have recognized that a substantial potential advantage for education in this region is the fact that one world class university does exist here, the University of Cape Town (UCT). Not only does it have a well-developed research and teaching program in ocean and marine environmental sciences, it also has a strong mission of aiding educational development in the rest of Africa and of enhancing teaching to students from deprived backgrounds. We believe that any sensible program of capacity building in the field of ocean and marine sciences in Africa would have to have the existing strengths of UCT at its core. This university has the added advantages of using English as language of instruction, carrying out marine research appropriate to Africa, having direct access to the sea and to research vessels and, last, being relatively cheap compared to universities elsewhere.

In considering the best way to use this strategic resource to the benefit of the ocean and marine environmental sciences in Africa, we have been lead by the example of the program of graduate teaching at the *Universidad de Concepción* that has been eminently successful in its objective of enhancing graduate teaching in South America. We are convinced that a regional center for the teaching of the ocean and marine environmental sciences at the University of Cape Town could be equally successful if initiated by the establishment of a dedicated, endowed chair. The incumbent would have as his/her main brief the scouting for students in Africa, the development of appropriate courses and curricula, the generation of travel funding and scholarships and, last, the establishment of a program of visiting lecturers and expatriates. A system of advisory boards consisting of representatives from the countries involved would guide and direct this regional program. Based on considerable experience in this regard in South America we believe it to be essential to have an individual with guaranteed income dedicated to this task.

We foresee a system in which students would come to UCT for their courses and to start their research work. They would then return to their native countries with a paid internship and be visited there on a regular basis by their UCT mentors to complete their degree research. To enable this system to function best, funds would have to be found for student scholarships; for travel for both students and supervisors; for subsistence and travel by visiting lecturers; and for subsistence for supervisors when visiting their charges abroad.

SOUTHEAST ASIA

For most countries in Southeast Asia, fisheries sciences have been fairly well -developed for a long time since people's livelihood has always been associated with the sea as source of food and for transportation.

In Thailand, the development of expertise in oceanography and the marine environmental sciences began in the 1960s. A Fisheries Degree was offered at Kasetsan University starting in 1943, although no interest was paid to the scientific aspects of the sea until much later on. The establishment of the Intergovernmental Oceanographic Commission (IOC) of UNESCO in 1960, the International Indian Ocean Expedition (1959-1965), the Scripps Institution of Oceanography survey in the Gulf of Thailand and South China Sea (1959-1961), the NAGA Expedition, in which Thailand and Vietnam took part, later stirred up much interest in the science of oceanography. The National Marine Science Committee was set up at the National Research Council of Thailand. A personnel development program was started preparatory to the establishment of university courses in marine science. In 1968, two Departments of Marine Science were opened; one in the Faculty of Science, Chulalongkorn University and one in the Faculty of Fisheries, Kasetsart University. In 1971, Masters Degree courses were added to the program.

In the Philippines, Malaysia and Indonesia, it was not until the 1970s that specialized degree programs in the marine sciences were offered. Marine Biology was offered in the Biology Department of the University of Philippines before the establishment of the Marine Science Institutes in 1974. Swift (1986) reported an upsurge in marine science as a separate subject in the 1960's. In Indonesia, at least 2 universities offered courses in marine science, but as elsewhere in the region, these courses were largely related to fisheries and marine biology. Personnel in other majors, namely- Physical Oceanography, Chemical Oceanography and Geological Oceanography were lacking, and still are, up to the present.

The university education programs in oceanography and marine environmental sciences in Southeast Asia were given more support following the establishment of the Intergovernmental Oceanographic Commission of UNESCO (IOC) in 1961 and several joint oceanographic cruises in the region with European and US institutions in the late 1950s and 1960s. In addition, the ASEAN Committee on Science and Technology, created about 30 years ago, includes a co-operative programme on marine science and several developed ASEAN member countries like the US, Canada, Australia, Japan, etc. have given some help in marine education. However, the strongest expertise in marine science in all these countries remains only the marine biology and fisheries fields. Very few students in the region would choose to specialize in physical, chemical or geological oceanography, which results in a serious lack of scientists of these important disciplines. A truly interdisciplinary effort will be needed in order to solve the many marine environmental problems that are shared by the Southeast Asian countries.

In addition to the countries mentioned above, there is a graduate program in marine science in Viet Nam,

but no information about it was available to this meeting.

INDIA AND NEIGHBORING SOUTH ASIAN COUNTRIES

Graduate and undergraduate programs in the fields of oceanography, atmospheric sciences and marine sciences exist in many universities and technological institutions in this region. There are two advanced centres for atmospheric sciences (one at the Indian Institute of Science, Bangalore and the other at the Indian Institute of Technology, Delhi) where oceanic research related to storm surges in the bay of Bengal, estuaries in the Hoogly River near Calcutta and the Rushikulya estuary in Andhra are undertaken. In addition, there is a new center for ocean Technology in Madras where ocean management projects are executed.

India, in particular, has a significant number of highly trained, well-qualified scientists in the field of oceanography. The Indian Institutes of Technology, The Indian Institute of science, The National Institute of Oceanography, Goa and many other Universities in the coastal areas have a formal collaboration with universities and organisations in the advanced countries like the ECMWF, Laboratoire de Meteorologie; Paris, North Carolina State University, USA and Reading University, UK among others.

The difficulty in enlarging the present level of activity, namely, starting new graduate programs in the ocean and marine environmental sciences is due principally to the lack of employment opportunities for postgraduates in those subjects. Also, good students do not opt for oceanographic studies since there are more lucrative avenues which are monetarily more attractive. Even those who are genuinely interested, aspire to pursue their studies in the USA.

Thus, there has not been much encouragement to enlarge the activities related to graduate programs in spite of the fact everyone understands the need and importance of oceanic studies. It is often said that important subjects like Atmospheric Physics or Physical Oceanography should be taught in the Physics Departments. At the moment, the Physics and Maths departments cater to the need for research scholars in atmospheric and oceanic sciences. One-year pre-Ph.D. courses in the relevant subjects are provided to equip them for research. Thus there is a big lacuna in graduate studies in oceanic studies and this needs to be looked into.

How would a regional approach help? It is important to realise that oceanic phenomena in the Bay of Bengal, Arabian Sea and Indian Ocean concern the bordering countries India, Pakistan, Mauritius, Sri Lanka and Bangladesh equally and any local analysis should be of equal interest to all these countries.

It is with this intention that a regional Asian school for oceanography and the marine environmental sciences is proposed. Since resources are limited and creating new infrastructure is expensive, it is only natural that this regional school should be located where the faculty of the participating nations can meet, teach students selected from their countries, interact with their counterparts in the neighboring countries and plan future programs with the assistance and experience of scientists from the developed countries. The appropriate choices, keeping in mind the aforementioned requirements, are, the National Institute of Oceanography, Goa (due to its long experience in conducting advanced training and the expertise /infrastructure available) and the Indian Institute of Technology, Madras (a reputed teaching institute in a coastal area which runs an undergraduate program in marine sciences).

The regional school should focus its attention on the following:

- Identify the organisations in the member countries where the graduates may be employed. If possible, campus interviews can be arranged.
- Arrange the faculty not only from the academic institutions of the participating countries but also from the pool of practitioners in the field and users of marine science knowledge in the industry.
- Organise an initial orientation program since the students will be drawn from multi-disciplinary areas (Physics, Maths and Biology) and multi-cultural background.
- Structure the syllabus suitable to the needs keeping in mind the recent advances. For example, subjects like mathematical modelling and remote sensing should be introduced as core subjects.
- Accommodate in the curriculum, elementary level courses on law, economics and Geography.

A GENERAL MODEL

In spite large differences between regions, the team members identified certain elements necessary to the development of regional graduate schools, which are universal. In general, they belong to four categories:

i) Human Resources

The building of a regional critical mass of highly qualified post-graduate marine scientists and the associated high standards of research constitutes the main goal of this proposal. To attain this objective, human resources needed should comply with the following requirements:

- a) Feasibility study/project design phase:
 - High academic level
 - Very good knowledge of region concerned (including cultural aspects)
 - Good experience in project design
 - Good connections at decision making levels and negotiation skills
 - Well established international links (academic, funding institutions, policy decision bodies....)
- b) Implementation Phase:
 - Strong regional leadership
 - Recognition and assistance of best academic and research expertise in the region
 - Knowledge and contacts with extra regional scientific expertise interested and relevant to filling gaps detected at regional level
 - Good academic position of the "core" regional center
 - Good administrative and negotiation skills

ii) Institutional resources

The main regional institutional asset is the existence of a "core center" (faculty, institute) at a well-established multi-disciplinary academic institution. Specialized "nodes" from other universities in the region should be formally linked to the core center to pool the expertise in post-graduate education and research. Some arrangements might be negotiated with extra-regional centers of excellence (south-south and north-south). Graduate student candidates would be recruited from universities qualified to join the regional network with due consideration to academic standards, geographic and gender distribution and priority socio-economic regional/national problems. A board of directors of institutions belonging to the network would be the governing or executive body for each regional program. A small inter-regional "Advisory Board" would assure global compatibility in scientific standards (SCOR), policy trends (IOC) and funding (main donors).

iii) Funding resources

- a) Feasibility study, negotiation process, final project design, seed/core money could be sought from such sources as: TEMA budget (of IOC/UNESCO); Travel grant program of SCOR; Rockefeller Foundation Innovation Fund, ICSU science development fund, national councils of relevant countries; relevant industry/private sector funds, etc.
- b) Main project implementation: Resources should be negotiated with major multilateral funding agencies (e.g., European Union initiative for marine science and technology development in Latin America and the Caribbean. This approach could also be extended at least to the African initiative); regional banks; contribution of host country of the core center; contributions of institutions subscribing to the regional network; pool of bilateral contributions of countries interested in a given region

iv) Communication resources

There must be extensive use of electronic communication systems (e-mail, Internet etc) in both the design and implementation phases of each regional program. A well-established electronic communication network with Internet and access to the WWW will be essential for each regional project and for linkage to the global oceanographic community.

This general model is not intended to be rigid and many innovative ways may be found to encourage students to complete graduate programs. The cost of a graduate degree could be reduced, for example, by the design of a "sandwich" system in which a student would go to the core center for course work and then return to his or her home institute to conduct the dissertation research. To be successful, such a system must include the provision for frequent personal contact with a supervisor, whether from the core center or from an overseas institution. Such a system would also permit a student who is already employed at a scientific institution to lessen his or her absence from the place of employment while in the graduate degree program. Such students will also help to build up the expertise in their home institutions, and bring back with them up-to-date knowledge and skills.

HOW DO WE ASSESS THE SUCCESS OF A REGIONAL GRADUATE SCHOOL IN MEETING THE OVERALL OBJECTIVES OF ENHANCING MARINE SCIENCE IN DEVELOPING COUNTRIES? A MODEL FOR IMPLEMENTATION

As noted in earlier sections of this report, the underlying objective of the concept of regional graduate schools of ocean and marine environmental sciences is to begin at the "grass roots" level to improve the size and scope of expertise of the oceanographic communities in regions of developing countries and to ensure that they are fully integrated in international research efforts as well as having the capability of providing top quality scientific advice to environmental managers and policy makers.

A major obstacle to this is that the graduate degrees offered by universities in many developing countries may not be highly rated by scientists and institutions in the developed world. In order to change these entrenched attitudes, there must be a very open, rigorous procedure for periodic assessment and review of the regional graduate programs and their institutional arrangements.

At the same time, there should not be a large bureaucracy to implement such a review system. The requirement for periodic review should be forcefully stated in the formal arrangements for the establishment of each regional school. At some defined interval (perhaps more frequently during the first few years of each schools existence), an International Advisory Panel of about five or six members should be established to review the content of the curriculum, the standards of student assessment, the quality and originality of the research being conducted by the graduate students and the faculty members, and the relevance of the teaching and research programs to the needs of the particular region.

The review should include a site visit to the regional school by most, if not all, of the panel members. Their report should be submitted to the head of the school itself, to the senior representatives of the participating countries and/or institutions in the region, to the major funding agencies supporting the regional school, and to the two international organizations, SCOR and IOC. Any negative comments should be accompanied by constructive suggestions for improvement. The management of the school should also be assessed.

The members of the panel should include the best possible scientists in each discipline of oceanography, and there should be a mix of members from advanced countries and from the region. They should be nominated by the regional school (in the same way that most institutions in the developed world invite external review committees to assess them periodically), and the membership of the advisory panel should be sent to SCOR (and IOC) for suggestions and/or approval before it is formally appointed. In some cases, it may be appropriate to include a representative (preferably a scientist) of the interests of the major financial supporting organizations.

When a regional school is first established, initial reviews could be biennial. After that they could be less

frequent, say at five-year intervals. The process itself should be expedient, not taking more than six months from the appointment of the panel to the submission of the final report.

At all times the review process should be related to the original objectives established for the regional graduate program.

RESOURCES REQUIRED

In accordance with the model envisaged for the Regional Graduate School in Oceanography and Marine Environmental Science, several additional resources are required to strengthen the existing institution (or “core center”) to upgrade it to a level necessary to produce world class graduates. These facilities can be divided into several categories of items. They include:

1. *Human Resources:* Experience gained with the Regional Graduate School of Oceanography, at the University of Concepcion in Chile, clearly dictated the need for a dynamic and capable director for the school. His or her major responsibilities will include; developing a high level multidisciplinary curriculum for the program, staff and student recruitment, management, promotional duties, funding procurement, and in general to ensure that the school meets its objectives as determined by the Board. One or two new professorial positions may be required in order to overcome identified deficiencies in expertise in specific fields. In addition to the above, two to three other visiting positions should be made available annually to come for prominent oceanographers on opportunistic or short term visiting appointments. The teaching positions will be supported by an information officer, up to two technicians, and secretarial support where required.
2. *Ship time:* The education of any oceanographer would be incomplete without the necessary training in the use of instrumentation required for ocean process measurements including currents, nutrients, sediments and the like. Innovative methods will be devised to use existing facilities (such as SEAFDEC or fisheries department vessels for the ASEAN region) for the training of the students. It is thought that the students will still require a minimum of 2 to 3 weeks of ship time to fully prepare them in the skills of instrumentation and oceanographic research. For this purpose about 40 days of ship time will be required by the institute per year divided into 20 days of blue water and 20 days of brown water, or coastal, ship time.
3. *Library and computing facilities:* One of the major deficiencies in present marine science establishments in developing countries is the lack of books, journals and other library materials such as charts, audio-visual aids and electronic bibliographical search facilities. A special arrangement of loan textbooks will be devised for the use of needy students of the institute. Computing facilities must be adequate for research purposes as well as for providing rapid Internet access.
4. *Research funding:* Funding in the form of grants will be required to ensure that the students will have the resources needed to conduct dissertation research projects. A thorough understanding of the scientific process by undertaking and submitting research proposals in a competitive basis will be encouraged. Funding support for conferences and travel funds for students to join research expeditions will be funded.

Among the expenditure items identified for the implementation of the Regional Graduate School in Oceanography and Marine Environmental Science are:

- Salaries
 - Director, professors, visiting professors, technician, and secretarial assistance.
- Research (including ship time)
- Communications, utilities and maintenance.
- Promotion and student affairs.
- Library, computing.
- Conference support
- Travel

- Contingencies.

Funding for the Regional Graduate School in Oceanography and Marine Environmental Science will be modest compared to developing a brand new Oceanographic School/Institute. The sources of funds might include:

- Fees (scholarships for students from charitable Foundations, UN support and other organizations)
- Research grants
- Endowment funds
- Consultancy and professional services.
- United Nations, industry and private sector funds
- Mentoring funds from funding agencies such as Rockefeller, DAAD, IOC, SCOR and the like.
- Host country contributions.

To determine the budget for actual running costs of the Regional Graduate School in Ocean and Marine Environmental Science is difficult recognizing the differences in existing facilities and stages of development of the four regions identified. However as a first order approximation and planning purposes, the figure of US\$300,000 - US\$500,000 per annum for each school is envisaged, not including funds for research by faculty members and students.

THE WAY AHEAD: RECOMMENDATIONS.

The information and conclusions presented along this report, attempt a concerted worldwide approach to create comprehensive graduate programs in Oceanography and Marine Environmental Sciences in developing countries as a mechanism envisaged to enhance competent regional partnership in research with scientists from developed countries. Such a complex task initiated with the first Team Residency, abreast of the highly motivated participating scientists and the involved scientific institutions, it requires a reasonably extended analysis and economic support not to end - as one member put it - in sound documents of one more academic exercise gathering dust in the shelves of the foster organizations. In keeping with this aim, the team members agreed on a series of recommendations for ensuing (post-team) activities.

The main one was to round up a final report for the Workshop to be presented to the sponsoring organizations of the Team Residency (Rockefeller Foundation; Scientific Committee on Oceanic Research of ICSU; Intergovernmental Oceanographic Commission of UNESCO), one interested funding agency for academic activities (German Academic Exchange Service, DAAD) and the main regional institutions in developing countries represented by the participating members.

It was also recommended to apply to the Innovation Fund created by the Rockefeller Foundation, which offers the best opportunities for immediate continuity and accomplishment of the following post-team activities:

- To hire an expert to carry out a thorough and detailed study of the available international funding possibilities to sustain the launching of the regional programs and help to consolidate the already existing one at the University of Concepción, Chile with its Latin American coverage. The resulting report should be presented to the Rockefeller Foundation and to the institutions representing each one of the Team Members, in particular, those who accept the challenge and the compromise to organize a regional program and built up the network.
- To hire an expert (ideally an author) to carry out a study on the available text-books and specialized teaching materials in Oceanography and Marine Environmental Science, with perspectives of regional utilization and text expansion emphasizing the regional or sub-regional marine environmental problems. That report should also be presented to the Rockefeller, to the institutions responsible for the regional programs and those of the corresponding network.
- To carry out a three days gathering to study the status of research and graduate studies in Oceanography and Marine Environmental Science in the two major sub-regions not considered in the analysis made during the First Team Residency: a) northern Africa and Red Sea countries; b) Central American and Caribbean countries. This meeting should involve the two team leaders and at least one experienced scientist from each sub-region and may take place at the SCOR Secretariat, Baltimore, USA.

Finally, it was judged imperative to prepare the terms of reference to submit a proposal for a Second Team Residence to produce the detailed planning documents to develop each regional graduate program. The terms of reference should be based on all the documents prepared for this purpose, that is: a) the report on the first team residency; b) the reports on the two new sub-regions involved in the project; c) the report on possible funding agencies; and d) the report on text-books and specialized teaching materials.

**GRADUATE EDUCATION IN OCEANOGRAPHY IN DEVELOPING COUNTRIES AS A MEANS TO
UNDERSTAND GLOBAL ENVIRONMENTAL PROBLEMS**

**Rockefeller Foundation, Bellagio Study and Conference Center, Italy
26 August - 1 September 1998**

Day One - The General Issues

Introductions

1. What is the current status of graduate education in developing countries?
Participants from developing countries describe existing programs and institutions.
What are the objectives of the existing international activities and support mechanisms - e.g. UNESCO and IOC? Others?
2. How do we define post graduate education? Do we mean it in the narrowest sense of traditional degree programs leading to academic research careers? Do we include diploma training, continuing education, and professional development?
3. What are the needs in the regions for various levels/types of oceanography graduates? What opportunities exist for graduates in developing countries? Needs for graduates may exist in research (curiosity-driven and applied), resource management, coastal development, industry, government agencies, etc.
4. The Concepcion experience - a well-established regional program in graduate education in oceanography will be described by Jose Stuardo.

Discussion of the format for the rest of this meeting. What is our end product?

Major Topics for Discussion on Days 2, 3 and 4

1. What are the impediments to success of regional graduate education programs in oceanography?
 - Lessons to be learned from existing programs:

Malaysia	<i>Ibrahim</i>
Chile	<i>Stuardo</i>
Others	
 - Cultural problems to be overcome *Young*
 - Language problems and how to deal with them *Young*
 - Institutional problems *Jones, Gross, Robles et al.*
 - Funding issues
2. How would one assess the success of the regional approach?
3. In what areas is the regional approach likely to be really feasible?
4. Should there be a core program that could be tailored for regional priorities?
5. What are the strategies that might help ensure success?
 - The characteristics of very successful schools *Jones*
 - Individualized approaches such as internships, fellowships, and mentoring *Gross*
 - Partnership between research and teaching
 - Financial support for students

- Other financial issues
6. How to gather the resources for a successful program
- Minimal institutional requirements
 - Packages of curriculum and teaching resources
 - Building relationships between institutions (south-south and south-north)
 - Summing all possible resources

Others?

Formation of writing teams.

ANNEX 2**LIST OF POSITION PAPERS AND DOCUMENTS DISCUSSED**

Elizabeth Gross (SCOR)	Documentation on relevant ICSU and UN activities.
Manuwadi Hungspreugs (Thailand)	Oceanography in Southeast Asia.
Mohamed Ibrahim (Malaysia)	The Malaysian (regional) experience in implementing Oceanography/ Marine Science Programs: Challenges and solutions.
Ian Jones (Australia)	Internationally renowned graduate schools.
Girija Jayaraman (India)	The case of India and Modeling in marine ecology.
Johann Lutjeharms (South Africa)	Graduate education in Oceanography in Africa (South of the Sahara)
Gerardo Perillo (Argentina)	Joint International Program for oceanography in developing countries: a proposal.
Fernando Robles (IOC)	Documentation on TEMA/IOC program. Its present objectives.
Gerold Siedler (Germany)	Role of the DAAD in international scientific training.
Jose Stuardo (Chile)	Promoting mechanisms for graduate education in Oceanography in developing countries. The international graduate program in Oceanography at the University of Concepción. Organization and statistics (1993-1998)
Helen Young (Australia)	Cultural and language issues for regional graduate education.

ANNEX 3

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