Intergovernmental Oceanographic Commission

Workshop Report No. 141

IOC/WESTPAC Workshop on Co-operative Study in the Gulf of Thailand: A Science Plan

Bangkok, Thailand
25-28 February 1997

UNESCO

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SUMMARY REPORT

ANNEXES

1. OPENING

The IOC/WESTPAC Workshop on Co-operative Study on the Gulf of Thailand was opened in the IOC Regional Secretariat for WESTPAC in Bangkok, Thailand, at 9:00 hours on 25 February 1997 by Prof. Manuwadi Hungspreugs, 1st Vice-Chairperson of IOC Sub-Commission for the Western Pacific (WESTPAC). On behalf of the Local Organizer, Ms. Kalayanee Thirarongnarong from the National Research Council of Thailand (NRCT) welcomed the participants and representatives from various international and regional organizations. She then invited Dr. Suvit Vibulsresth, the Secretary-General of NRCT to address the meeting.

Dr. Suvit welcomed all participants and emphasized that the Gulf of Thailand is an international water, which provides substantial resources to its coastal countries. Sustainable use of the resources and rational management of the coastal areas of the Gulf are the key issues facing the countries concerned. He expressed his satisfaction with the IOC initiative on this project, which has enabled the bordering countries to come together. He further pointed out that the international and regional co-operation will be the only way to study, and better understand the natural processes of the Gulf as a whole.

The Secretary-General informed the meeting that the Government of Thailand paid special attention to the research and monitoring of the Gulf of Thailand for the purpose of protecting marine and coastal environment in the Gulf and to sustainable use of the resources. Continued support will be provided by the Government to the relevant studies and monitoring.

The programme of the workshop is attached as Annex I. The list of participants is attached as Annex II.

2. SESSION 1: ASSESSMENT OF THE EXISTING KNOWLEDGE

Prof. Manuwadi Hungspreugs briefly introduced the development of the project, its rationale and objectives. She informed the meeting that this project was adopted by the Third Session of the IOC Sub-Commission for WESTPAC (Tokyo, Japan, March 1996) with a view to combining scientific efforts of the coastal countries for better understanding of the Gulf, and to addressing coastal needs of these countries. She recalled the relevant projects carried out in the region, including those implemented by SEAFDEC, SEAPOL and IOC/WESTPAC.

There were 5 presentations in this session, of which 2 dealt with management requirements for the scientific projects in the Gulf of Thailand.

Dr. Veerawat Hongskul's presentation, entitled *The ecology of the Gulf of Thailand and the Need for International Co-operation*, drew the attention of the meeting to the degradation of marine environment in the Gulf of Thailand. He briefly reviewed the history of scientific study in the Gulf, and particularly the NAGA expedition. However, the understanding of natural processes and human impact to the Gulf still need great amount of efforts in compiling the existing data and information on marine and coastal environment in the Gulf as a whole, and in setting up a regional network for the study, based on the close co-operation among bordering countries. He emphasized that the scientific project has to address certain management issues, in order to get

continued support for governments concerned.

Prof. Douglas Johnston, the representative of SEAPOL, provided information on the existing project of SEAPOL in the Gulf, with emphasis on the economic requirements and legal framework.

Dr. Anond Snidvongs, the Project Leader of the Gulf of Thailand studies, presented the general oceanographic conditions in the Gulf; Dr. Chris Garrett and Dr. Kate Stansfield provided their study results on *Salt and Heat Budget in the Gulf of Thailand*.

The workshop felt that in order to provide scientific knowledge and information to the various users and meet management requirements, further monitoring, observation and research work are fundamental. In particular the Gulf-wide circulation, water exchange of the gulf with South China Sea, etc. should be further studied.

3. SESSION 2: NATIONAL PRESENTATIONS

The Session Chairman, Prof. Dang Ngoc Thanh of Vietnam, introduced national representatives from Cambodia, Malaysia, Thailand and Vietnam.

The representative from Cambodia, Mr. Pich Sam Ang, informed the meeting that the main problems of marine and coastal environment in Cambodia are destruction of habitat, coastal erosion, over-fishing and discharge of wastes to the sea. Cambodia is interested in participating the WESTPAC project, but there are still a lot of constrains in the country, such as lack of experienced personnel, lack of data and information, shortage of funding, etc. However, with co-operation with other countries and organizations, some projects are going on, e.g. ADB project and DANIDA support in marine environment studies. He emphasized that the project should pay a special attention to training and capacity building and ensure wider participation and better scientific understanding.

Dr. Mohd Nasir Saadon from Malaysia provided information on *Physical Oceanographic Research in the East Coast of Peninsular Malaysia.* He indicated that the East coast of Peninsula Malaysia faces the Gulf of Thailand in the North and the South China Sea in the East. Therefore the variability of physical processes in the Gulf of Thailand will naturally affect the physical processes in the East coast of Malaysia, and vice versa. He expressed the interest in participating in the project.

Dr. Kashane Chalermwat informed the workshop of the relevant studies of the Gulf, carried out by Thailand and provided information on general morphology, geological setting and existing understanding of the Gulf. He emphasized that the existing problems in the Gulf are over-exploitation of living resources and land-based pollution. National efforts have been made to mitigate problems in restoring living resources, controlling pollution and pollutant dispersion and coastal land use planing and zoning. However, further efforts are needed for the scientific understanding of oceanographic processes (physical, chemical and biological), and on how oceanographic processes will respond to large scale perturbation in the future, such as the alteration of major river run-off changes in the Asian-monsoon system.

The representatives for Vietnam provided information on national projects in the Gulf. Dr. Phan Van Hoc presented a paper entitled *Some Comments on the Situation of Studies in the Gulf of Thailand*. He emphasized the importance of the study of the Gulf and provided information on national activities. Reviewing existing knowledge of studies in the Gulf, he indicated that the Gulf of Thailand is one of the two biggest gulfs in the South China Sea, where limited studies have been conducted. A good knowledge of the Gulf provides as a basis for further research activities. Dr. Nguyen Tac An informed the workshop of biological studies and understanding in the Gulf by presenting a paper on *Primary Production and Some Factors of Environmental Capacity of the Waters around the Islands in the Eastern Gulf of Thailand.* In was concluded that in the waters around these islands the production is high, and planktons are abundant in species composition and quantity. The heterotrophic organism communities is favorable for the development of biological resources.

4. SESSION 3: DATA AND INFORMATION MANAGEMENT

The Session was chaired by First Admiral Mohd. Rasip Bin Hassan from Malaysia. There were four presentations in this session. They were:

- *Existing data and information on the Gulf of Thailand, by Dr. Anond Snidvongs*
- *IODE System and data management, by Mr. John Withrow*
- *Information management and global directory on marine science institutions and scientists, by Mr. Peter Pissierssens*
- *Data exchange and management in NEAR-GOOS and SEACAMP, by Mr. Yihang Jiang*

In co-operation with the Southeast Asia START Regional Centre (SEA START RCA), a preliminary database has been set up for the project, together with its homepage. Oceanographic data and information are available and accessible for the scientists from participating countries. However, necessary training on the database management and data exchange are urgently needed to provide timely services to all users and to allow users to obtain data and information from database via internet, disk and hardcopy.

With these requirements in mind, the concept and system of IOC International Oceanographic Data and Information Exchange (IODE) were introduced and discussed. The workshop expressed appreciation for the valuable information provided. It was recognized that to collect and review the existing data and information it will be essential to define a data exchange system. The workshop recommended that a training workshop on data/information exchange and management for the project be organized by IOC as soon as possible.

NEAR-GOOS and the proposed project on the South East Asia Centre for Atmospheric and Marine Predictions (SEACAMP) were introduced as examples of real time and delayed mode data exchange. In view of the technical capabilities in the area, the workshop felt that it would allow wider participation in the project if a suitable data collection and distribution system is designed.

5. SESSION 4: DISCUSSION ON THE DRAFT SCIENTIFIC PLAN

Dr. Chris Garrett chaired the session and invited the Project Leader, Dr. Anond Snidvongs to introduce the draft scientific plan for the project, which was distributed to the participants before the workshop. The workshop expressed its appreciation to Dr. Anond for his hard work to prepare the draft plan.

Ensuing discussion was focused on how the scientific study could better address various issues and requirements of the countries concerned. The following issues/requirements were identified as priority areas of further studies for the coastal countries of the Gulf:

- Pollution
- Fisheries/aquaculture
- Mineral resources
- Coastal degradation/habitat destruction
- Tourism

To provide necessary scientific information to address these issues/requirements, the following studies were identified:

- Exchange at the mouth of the Gulf
- Comparative water column studies
- Near-shore processes
- Biodiversity
- Circulation and dispersion
- Productivity (biological)
- Larval transport
- River Inputs

The workshop then divided into 3 working groups to discuss the draft scientific plan. Based on the outcomes of each group, the workshop agreed on the Science Plan for the project, which is attached as Annex III.

6. SESSION 5: DISCUSSION ON THE IMPLEMENTATION OF THE PROJECT

Extensive discussions were held on the implementation of the project, both in working groups and the plenary meeting. The workshop agreed three sub-projects should be implemented in the Gulf of Thailand. They are:

- Comparative water column studies
- Water circulation and dynamical processes
- Biological oceanography

For each of these projects, the scientific questions, approaches, expected outputs, project implementation and estimated costs, and national contributions were identified. The details are provided in the Science Plan of the project.

The workshop emphasized that it should keep in mind during the implementation of the project that the outcomes of the scientific research should address the management concerns identified by the project.

6. CLOSURE

Prof. Manuwadi, First Vice-Chairperson of IOC/WESTPAC, thanked all participants for their hard and productive work during the workshop, which ensured the success of the meeting. She expressed appreciation to all participants to join the meeting, especially those from Cambodia, and hope that the project will keep its momentum in the implementation phase. She closed the workshop at 12:30 p.m., on 28 February 1997.

ANNEX I

PROGRAMME OF THE WORKSHOP

1. OPENING

2. SESSION 1: ASSESSMENT OF THE EXISTING KNOWLEDGE

Keynote speeches

3. SESSION 2: NATIONAL PRESENTATIONS

- Cambodia
- Malaysia
- Thailand
- Vietnam
- Discussion on the assessment of existing knowledge

4. SESSION 3: DATA AND INFORMATION MANAGEMENT

5. SESSION 4: DISCUSSION ON THE DRAFT SCIENTIFIC PLAN

6. SESSION 5: DISCUSSION ON THE IMPLEMENTATION OF THE PROJECT

7. CLOSURE

ANNEX II

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ANNEX III

Science Plan

IOC-WESTPAC Co-operative Oceanographic Studies of the Shared Coastal Waters of Southeast Asia Phase 1: the Gulf of Thailand

1. Introduction

The Gulf of Thailand is a regional sea bordered by Cambodia, Malaysia, Thailand and Vietnam. The living and non-living resources of the gulf are of great value to the people of these countries, but sustainable exploitation of the resources and minimization of conflict between different user sectors will require a greater understanding of the Gulf as a marine system.

Various activities that need to be considered are:

- Fisheries
- Coastal aquaculture
- Mineral resources, particularly hydrocarbons
- Shipping
- Tourism
- Waste disposal

(i) The Gulf of Thailand is one of the most productive regions of the world and thus marine fisheries is an important industry in the gulf coastal countries. In 1993 the marine capture fisheries landing were 33,100 tons for Cambodia, 1,047,350 tons for Malaysia, 2,752,486 tons for Thailand and 824,800 tons for Vietnam. The landed value was US$ 1,429,000,000 for Thailand and US$ 926,000,000 for Malaysia. Marine fishery product has long been a significant percentage of the diet for people in this region.

The sustainability of this rich fishery is far from assured, however. The ecosystem of the gulf has already changed dramatically as a consequence of over-exploitation of demersal stocks. These were, fortunately, replaced by squid, but there is a fear that, without proper management, these will in turn be overexploited and possibly be replaced by a non-commercial species such as non-edible jellyfish. Moreover, overfishing in the coastal regions has forced fishing fleets further offshore, leading to conflicts between neighboring countries. Many offshore transboundary and migratory stocks are, in fact, shared by several countries, stressing the need for an increased understanding of offshore oceanography and marine ecology, with respect to primary and secondary production, identification and understanding of spawning grounds, egg and larval transport and species diversity.

(ii) Marine and brackish water aquaculture have increased immensely in the last 10 years, particularly in Cambodia, Thailand and Vietnam. The total marine and brackish water aquaculture production in Malaysia and Thailand was 385,410 tons and worth US$ 1,395,000,000 in 1993.

In some regions disease problems have led to the closing down of aquaculture projects. More seriously, the impact of the destruction of mangroves on offshore biological production is not well understood.

(iii) Petroleum hydrocarbon production, as reported for the first quarter of 1997 by Unocal Thailand the largest producer in the gulf, were 957 million cubic feet per day of natural gas and 33,425 barrels per day of condensate. Unocal has drilled over 1000 wells and has 74 platforms under operation. The total length of under sea pipeline is now over 1,200 kilometers. This natural gas from the gulf supplies about 30% of the energy needs of Thailand. Moreover, at least, 1,000 million cubic feet of natural gas per day more is expected from new fields in Cambodia, Thailand and Vietnam, and the Thai-Malaysian Joint Development Area. Beside these productions, a negotiation is going on to construct a pipeline from Indonesia Natuna Field, one of the largest natural gas field in southeast Asia. If this project is accomplished, the Gulf of Thailand will be the central hub for natural gas production and transport for southeast Asia. These further exploitations of oil and gas are inevitable but will routinely produce waste products and, potentially, accidental spills of oil and other chemicals, that can have a negative impact on other sectors such as fisheries, aquaculture and tourism.

In addition to petroleum, the Gulf of Thailand has also potential for placer deposit of heavy minerals and gem stones. However, these resources have not been well studied especially with respect to environmental impacts of dredging for theses mineral resources

(iv) The use of the Gulf of Thailand as a shipping route is of immense value to the littoral states. For example, the shipping volume is expected to be about 140 million tons of cargo and 2.4 million TEU's of container by over 5000 vessels called at Thai ports in 1997. These numbers are predicted to be increasing by about 12% annually. Shipping in the gulf is affected by wind, wave and current conditions and can, in the event of accidents, have a negative impact on other user sectors. Another transportation project that is proposed is the "land bridge" between the Gulf of Thailand and Andaman Sea. This project will comprise of deep sea ports and a 1 million barrel per day pipeline that will significantly shorten the travelling distance of crude from the Middle East to the Far East. Yet such a large project require precise knowledge of marine and coastal environment in order to minimize impacts to the environment.

(v) Tourism is presently worth US$7,664,000.000 per annum to Thailand in 1995 and has tremendous potential for Cambodia and Vietnam. It is, however, sensitive to accidental spills, as mentioned above, and to nearshore environmental degradation associated with aquaculture and other activities.

(vi) The oceans everywhere provide a resource through their capacity to assimilate waste of many kinds. This is of very great value but, if over-used, can have a serious negative impact on other uses. Beside sea based pollution, land based pollutants from domestic, agriculture and industry can enter the gulf through rivers and streams. Some of them can also be discharged directly into the sea, especially from numerous industrial estates located along the coastline. Some of these include oil refinery, petrochemical and metalurgical industries.

Minimizing the conflict between the multiple uses of the ocean and maximising the total benefits obtained can only be achieved through wise management based on scientific knowledge and understanding. For examples, maximising the economic value of gulf fisheries will require an understanding of the oceanographic processes of the gulf ranging from basic circulation to primary and secondary production. Minimising the effects of routine chemical discharges and accidental spills require the ability to predict their movement, dispersion and interaction with the ecosystems.

In some situations enough is known so that reasonable scientific prediction of the impact of a proposed activity can be made, but in most situations we are hampered by the lack of a basic oceanographic framework. Developing this framework will take many years, but this proposal will attempt to seek ways and means to commence the task through scientific projects to be tackled collaboratively by the littoral states.

Because the Gulf of Thailand is a relatively small (about 400km x 800km) marginal sea any incidents which happen in the gulf or along its coast will more or less effect the rest of the Gulf. Physical as well as biological processes, such as water circulation and fish larval transport, are known to cross international boundaries in the gulf. Obviously the environmental and natural resources of the Gulf can not be effectively managed without an international cooperation to research, monitor the environment, exchange data and information, and set-up a regional management policy.

We stress, in fact, that the international scientific collaboration will lead not only to improved knowledge and predictive capability in the gulf, but will also serve to improve international relations generally, particularly through mutual assistance in the building of scientific and technical capability.

As an arm an international organization that has been very active in this region, IOC-WESTPAC has established an extensive regional network of oceanographic scientists, research institutions and science policy makers. Oceanographic and marine science related problems have also been identified and preliminary probed. By taking these advantages and past experiences, time and other resources will be minimized when the project is implemented under the umbrella of IOC-WESTPAC.

2. Background

To understand and predict the biological production of the Gulf of Thailand, to predict the fate and impact of contaminants, and to be able to assess future proposed uses of the gulf or the effect of changed patterns of river discharge, we need first to understand physical properties such as the stratification of the water, its circulation and vertical and horizontal mixing rates.

Much of the existing knowledge on the circulation and transport phenomena in the Gulf of Thailand is derived from data collected during the Joint Thailand-Vietnam-U.S. NAGA Expedition in 1959-1960. This expedition was the only opportunity that data of the entire Gulf were collected at comparable moment in time and therefore most useful for further analysis in term of water mass circulation. Since that expedition, even though parts of the gulf (mainly in the

EEZ of Thailand) were surveyed repeatedly, it is difficult to extrapolate the observed results for the area outside the survey area because the horizontal and vertical distribution patterns of oceanographic variables in the Gulf are not simple. And although there have been considerable efforts made to collect oceanographic data in the region, preliminary work through some of those data revealed that most of them are restricted to small geographical areas and the quality controls of some datasets are not compliant with international standards.

Circulation patterns and water mass characteristics variability in the Gulf of Thailand depend strongly on the monsoon season with significant effects from tide and freshwater run-off, among several other factors. A recent survey of the western part of the Gulf in 1995 sponsored by the Southeast Asian Fisheries Development Center (SEAFDEC) revealed that the water column in the central part of the gulf where water depth exceeded 40 meter is sharply stratified except for few small areas near the coast where vertical mixing is occasionally intense enough to disrupt such a prominent pycnocline.

From the vertical sections of salinity and temperature recently obtained it was possible to determine that the circulation in the surface and bottom layers might not be the same in terms of speed, direction and mechanisms that drive them. Chemical compositions of the surface and bottom water are apparently different indicating little exchange between the two water masses. Moreover, chemical and biological data suggest that most of the water column biogeochemical processes, including photosynthesis and biodegradation, were frequently peaked near the interface between surface and bottom water masses, not at the sea surface. These features all together clearly confirm that the circulation and biogeochemical processes in the Gulf can not be completely understood using only remote sensing tools and surface mooring buoys (such as those currently operated by SEAWATCH-THAILAND Program) but must include the complete vertical sections of oceanographic variables as well.

It was obvious from the recent surveys using high resolution CTD systems that salinity and temperature profiles of the water column can be sharply changed over the depth range of only a few meters. These fine scale salinity structures could be easily missed during the time of NAGA Expedition when only the discrete water samplers were available at that time although the thermocline at 40-60 meters could be detected by the mechanical bathythermographs. It is apparent that a better oceanographic data collected using a more up-to-date approach is required in order to better understand the oceanography of the Gulf.

The need for the study of circulation in the Gulf of Thailand is also arisen from some of the outcomes of the two projects under the IOC-WESTPAC that have been active in the Gulf. the River Inputs and the Harmful Algal Blooms. It was hypothesized that material Input into the Gulf, especially nutrient elements essential for phytoplankton primary production, might not be derived only from rivers and streams that drained directly into the Gulf but a substantial contribution could be from the Mekong River, possibly through the mouth of the Gulf and seasonal terrainial overflow in Cambodia. The magnitude and dynamics of this flux, which is yet to be determined, certainly effect the growth and biomass of phytoplankton, the net ecosystem production and even the ability of the gulf ecosystem to absorb or emit carbon dioxide and other greenhouse gases. In addition to the chemical aspects, distribution and occurrence of

phytoplankton blooms could be better explained and mitigated with the additional knowledge of watermass circulation and transportation through the controlling of nutrient budget of the gulf. Additionally, a scarcity of toxic strains of phytoplankton in the inner Gulf of Thailand even though the other environmental conditions appeared to be optimal for their growth might be attributed to the circulation pattern that did not favor the transport of those toxic strains into the inner sections of the gulf.

Besides its scientific significance, knowledge on the oceanographic processes of the Gulf of Thailand will enable policy makers of the coastal states to make decisions that benefit the most to the region. The management and restoration of fishery resources in the Gulf is now considered by the Thai government to be among the top priority national programs. However, such programs will not be effectively implemented without a cooperative study and scientific data and information exchange among all of its coastal countries especially when the shared fishery stocks are concerned. For example, there is a hypothesis that one population of chub mackerel in the Gulf of Thailand may have their spawning ground in Cambodia or Vietnam waters before larvae are transported by current into Thailand's EEZ where they grow and are harvested. The quality of seawater, especially with respect to dissolved toxic elements released from sediments either via natural diagenesis or by human perturbation, for example, is now also being concerned in Thailand. Even without many precise information on the subject at present, it is quite certain that a large scale deterioration of seawater quality, if it occurs, will affect the quality of life in all of its coastal countries. Physical characteristics of watermass, such as horizontal and vertical dispersions obviously control the rate and magnitude of dispersion of dissolved and particulate substances.

The exchange of water between the gulf and the South China Sea is also important. Stansfield and Garrett (1997) have recently examined this and its relationship to the freshwater content of the gulf. They reach two important conclusions which bear on the biological production potential of the gulf and on its ability to be flushed of any widespread contaminant:

(i) the overall flushing time of the gulf is only about 5 months, with the flushing being achieved by both Ekman fluxes across the mouth and by another mechanism which might well be a coastal current along the East coast of Malaysia.

(ii) a significant part of the freshwater discharge from the Mekong River finds its way into the gulf.

Confirming or disproving these hypotheses through measurements at the mouth would be a valuable first step in developing our understanding of the overall functioning of the gulf. Measurements at the mouth of the gulf could also be used to provide boundary condition for a numerical model of the circulation within the gulf.

While it is clear that the stratification and circulation of the gulf are intimately interconnected, it is possible to consider them separately to some extent. Thus the first topic of this proposal will be concerned with the examination, throughout the year and at many different locations, of the vertical column of water. This will be done from a chemical and biological as well as physical points of view.

The second part of the proposal will concern the circulation of the gulf. A particular aspect of this, of great importance to our overall understanding of the gulf as a system, is that of the exchange between the Gulf and the South China Sea.

The last aspect of this proposal will emphasize on the biological, environmental and fishery oceanographic processes. This part in compliment with the first two physical studies will formulate practical frameworks for environmental and natural resource management policy and implementation schemes for the region as well as for each individual coastal country.

3. Scientific Questions

To start to build up an oceanographic framework for the Gulf of Thailand, four key issues that are equally important need to be addressed:

- Exchange of water at the mouth of the gulf
- Sub-tidal circulation inside the gulf
- Stratification in the gulf
- Biological/fishery oceanographic processes in the gulf

For each of the above issues, spatial and temporal (seasonal, inter- and intra-annual) variability need to be addressed.

The key scientific question for each issue which comprises of a set of smaller questions are listed below:

(i) What drives the exchange of water between the Gulf of Thailand and the South China Sea?

- Do any of these possible processes: Ekman flux (wind driven), coastal currents along the Malaysian and Vietnamese coasts, mesoscale eddies, surface buoyancy forcing involve or are there any other processes?
- Which are the dominant processes?
- Are the important processes different between e.g. salt and pollutants?
- What are the temporal and spatial variability of the exchange and its driving functions?
- Does discharge from the Mekong River enter the Gulf? If so, what fraction is involved and what are the mechanisms by which it enters? Whether it involves a coastal jet along the southern coast of Vietnam, eddies or simply the Mekong discharge and terrainial overflow?

(ii) What drives the sub-tidal circulation in the Gulf of Thailand?

- Is the strength and direction of the sub-tidal circulation determined by local winds,
- coastal or surface buoyancy input, remote wind forcing or circulation in the South China Sea?

- How does the horizontal circulation affect the transport and dispersal of larvae, water column properties and pollutants?

(iii) What determines the local stratification inside the Gulf?

- What is the controlling factor between the competing influences of mixing by winds and tides, and stratification by surface heating, surface and coastal buoyancy input?
- What are the spatial and temporal (e.g. daily and seasonal) variations of the pycnocline?

(iv) What are the main biological oceanographic processes in the Gulf?

- What are the primary and secondary productions of the Gulf?
- How does the net ecosystem production related to the primary and secondary production?
- How are the production related to nutrient inputs, stratification, circulation and the sub-surface chlorophyll maxima?
- What are the species composition and distribution of the phytoplankton, zooplankton and higher trophic level organisms?
- How are biological components related to the temporal and spatial movement of water inside the gulf, the water exchange through the mouth, vertical stratification and sub-surface chlorophyll maxima?

4. Objectives

The ultimate objectives are to understand key oceanographic processes and set-up information service system necessary for making decisions related to the environmental and resource management for the Gulf of Thailand. These objectives will be fulfilled by enhancing the capability on the forecasting on marine environment phenomena, and to upgrade capability in the coastal countries in scientific research, marine environmental monitoring, and data and information management in the region to further provide necessary information on rational uses of marine resources and protection of marine environment. In order to achieve these goals, the project will aim:

(i) to upgrade the capability of the coastal states to understand the natural processes of the gulf via scientific observations, monitoring and research within the identified activities of the project;

(ii) to establish a regional network for marine environment study in the Gulf of Thailand, including observation, monitoring, modelling and interpretation of the scientific results; and

(iii) to provide high quality data and information on oceanography and sustainability of coastal and marine resources and environment to the resource management, policy makers and communities concerned for various uses through the project in cooperation and coordination with other organizations and programs in the region.

5. Project Plan and evelopment

Project 1: Comparative Water Column Studies

(i) Scientific Questions

- Why water column is stratified?
- Why does chlorophyll maxima occur near bottom?
- What controls concentration and vertical distribution of chemical and biological constituents?
- How and how much do stratification and subsurface plankton maxima influence elemental cycling and fishery resources of the gulf?

(ii) Approaches

- Compilation of existing data/information by national data centers and regional data center for the Gulf of Thailand project;
- A network of "volunteer" observers/data collects to construct gulf-wide oceanographic profiles in time and space;
- Setting up distributed data and information archives, data/information exchange system, exchange protocols and data policies;
- Analyze data for time and space variability of water properties using robust approaches and models;
- Promote the development and using of models and other tools to predict, manage and answers some specific questions of managers and policy makers on the gulf environment and resources.

(iii) Expected Output

- Database of existing data and information;

- Baseline of capacity in oceanography in participating countries;
- Some oceanographic modelling tools to be used by different researchers and decision makers in government and non-government sectors;
- Detailed implementation plan for oceanography of the Gulf of Thailand;
- Regional network of skilled data managers and scientists capable to handle and analyze oceanographic data.

(iv) Project Implementation

a. Capacity Building

- Training courses on:

- Compilation of existing information related to the Gulf of Thailand for national coordinators for data/information;
  - Preliminary analysis of oceanographic data/information for young and committed scientists in the region;
  - Using of oceanographic data and information for policy makers, managers and officers from participating governments.

- In-country training:

  - Data manager of the regional center and/or an expert will travel to participating countries to help local data centers and researchers solve problems and demonstrate new technology.

- Provide scholarships to active scientists in the region to attend training courses/scientific conferences abroad;
- Provide software updating and supports, problem solving, and technical recommendations for national and sub-national data centers concerning oceanographic database and data analysis;
- Equipment loan to volunteer observers to cover the entire gulf:

  - Basic conductivity-temperature-depth (CTD) systems with data downloading unit and global positioning system (GPS) receivers.

b. Meetings

- One workshop among national coordinators and experts for technical planning and design for data/information compilation and analysis;

- One scientific seminar on:

    - existing knowledge/understanding on the variability and controlling mechanism of the water properties, missing gaps, logistic problems and specific scientific problems needed to be addressed by national and regional organizations;
    - master implementation planning for future data collection/observation, capacity building and personnel requirement, and a permanent regional data/information archive, network and services.

c. Data/Information Plans

- Establish a distributed data/information archive system among coastal states, the regional data center, other regional organization, and organization and countries outside of the region;
- Set up oceanographic database and information.
- Set up bibliography data bank;
- Set up directory of experts and regional scientists;
- Set up a regional clearing house for oceanographic models and other tools/software for data analysis, interpretation and prediction that are applicable to the Gulf of Thailand.

(v) Cooperation With Other Regional/National Programs

- Exchange data and provide links with near real-time projects, such as SEAWATCH, SEACAMP, national meteorological agencies, GTS data system, remote sensing receiving facilities;
- Exchange data/information with delayed mode database, such as START, LOICZ, oceanographic data centers, government agencies, universities within and outside WESTPAC region;
- Promote the uses of oceanographic data/information and supply information to government departments, universities, non-government organizations and international/regional programs dealing with resource and environmental management, ocean law and policy, and development of economic and quality of life.

(iv)Estimated Costs and National Contributions

Items	Cost (USD x1000)	Possible Sources	Possibility for National Contribution				In USD x1000
			CM	MY	TH	VN	
Three training courses	50	Donors, IOC	?	y	y	y	5
In-country training	10	Donors, IOC	y	y	y	y	5
Training/conference scholarships (10 person x week)	30	Donors, IOC					
One planing workshop	15	Donors, IOC	?	y	y	y	5
One scientific seminar	25	Donors, IOC	?	y	y	y	5
Computer, software and office hardwares at the regional center	50	Donors, IOC			y		10
Operation cost at the regional center	20	Donors, IOC			y		10
Computer, softwares and office hardwares at about 12 national/subnational data centers	180	Donors, IOC	?	y	y	y	50
Operation costs at the national/ subnational data centers	240	Donors, IOC	y	y	y	y	100
Twenty basic CTD units	200	Donors, Manufacturers	?	2?	3?	1?	50?
Expert (12 person x month)	42	Donors, IOC					
Data managers/researchers (800 person x month)	800		y	y	y	y	800
Publication	50	Donors, IOC, Private Sectors	?	y	y	?	10
TOTAL	1,712	Total contribution from countries					1,050
Estimated direct cost to outside donors/IOC	662						

(vii) Time Frame

Year 1

	1	2	3	4	5	6	7	8	9	10	11	12
Regional data/information center	x	x	x	x	x	x	X	x	x	x	x	x
Planning workshop	x											
Training: data compilation		x										
Training: data analysis										x		
In-country training			x				X				x	
Voluntary observation		x	x	x	x	x	X	x	x	x	x	x

Year 2

	13	14	15	16	17	18	19	20	21	22	23	24
Regional data/information center	x	x	x	x	x	x	X	x	x	x	x	x
Training:data/information uses								x				
In-country training			x									
Voluntary observation	x	x	x	x	x	x	X					
Scientific seminar										x		

Project 2: Water Circulation and Dynamical Processes

(i) Scientific Questions

- What is the water circulation pattern in the Gulf of Thailand?
- How does water exchange between the Gulf of Thailand and South China Sea?

(ii) Approaches

- Regional network of research cruises;
- Deployment of mooring/drifting instruments;
- Data analysis, model synthesis.

(iii) Expected Output

- Circulation pattern in the Gulf of Thailand and their spatial/temporal variability necessary for natural resource management and environmental protection;
- Magnitude and dynamics of water and material exchanges between the Gulf of Thailand and South China Sea;
- Magnitude and dynamics of contribution by major rivers and small streams in the region
- Scientific/technical reports;
- Materials for general public education;
- Regional network of synoptic and dynamical physical oceanographers, one of the weakest disciplines in Southeast Asia.

a. Capacity Building

- One shipboard training course on equipment operation, maintenance and

deployment;
- One training workshop on physical oceanographic data analysis and modelling;
- Expert visits to conduct in-country training;
- Provide scholarships to active scientists in the region to attend training courses/scientific conferences abroad.

b. Data collection

- Four cruises conducted by each country to collect station data
- One year deployment of acoustic Doppler current profiler (ADCP) in each country
- Two deployments of drogues by each country
- One year deployment of mooring buoys (2 by each country)

c. Meetings

- One per year project steering committee meeting
- One per year scientific seminar

d. Data/Information Plans

- Database and data service (shared resources with Project 1)
- Publication of scientific results
- Publication of digested/synthesized results (e.g. books, newsletter, etc.)

(v)Estimated Costs and National Contributions

ItemsCost (USDPossible SourcesPossibility for National ContributionIn USD x1000x1000)CMMYTHVN							
Shipboard training: data collection	50	Donors, IOC, Instrument Manufacturers	?	y	y	y	5
Training: data analysis	30	Donors, IOC	?	y	y	y	5
In-country training	20	Donors, IOC	y	y	y	y	3
Two annual steering committee meetings	20	Donors, IOC	?	y	y	y	2
Two annual scientific seminars	50	Donors, IOC	?	y	y	y	5
Training/conference	30	Donors, IOC					

scholarships (10 person x week)							
Four research cruises in each countries	800	Donors	?	y	y	y	600
Deployment and maintenance of mooring/drifting instruments	600	Donors, Instrument Manufacturers	?	y	y	y	400
Computers:							
- Four workstations (1 for each country)	200	Donors		y	y	?	20
- Eight PC's (2 for each country)	40	Donors	?	y	y	y	30
- Software for data storage, processing, analysis and presentation	20	Donors	?	y	y	?	5
Twenty five tide gauges (~20 existing and 4 new ones)	450	Donors, Manufacturers	~1?	~5	~10	~3	360
Four ADCPs (1 for each country)	400	Donors, Manufacturers		1?	1?		?
Twelve Argos/Inmarsat tracked drifting drogues (3 for each country)	180	Donors, Manufacturers		1?			?
Four CTDs (1 for each country)	100	Donors, Manufacturers		1	1	1?	20
Twenty mooring buoys for wave, S, T measurement (~12 existing and 2 new for each country)	8,800	Donors, Manufacturers		2?	8+	2?	8,000
Expert (18 person x month)	63	Donors, IOC					
Project scientists (600 person x month)	600		y	y	y	y	600
Publication	100	Donors, IOC, Private Sectors	?	y	y	?	10
TOTAL	12,553	Total contribution from countries					10,065
Estimate directed cost to outside donors/IOC	2,488						

(vi) Cooperation With Other Regional/National Programs

- Exchange data with existing near real-time projects, such as SEAWATCH, SEACAMP, national meteorological agencies;
- Exchange data/information with existing delayed mode database, such as JODC, WDC, START, IGBP-DIS;
- Provide data for the validation and boundary condition of numerical circulation models.

(vii) Time Frame

Year 1

	1	2	3	4	5	6	7	8	9	10	11	12
Steering committee meeting	x											
Training:data collection		x										
In-country training			x					x				
Research cruises			x				x				x	
Instrument mooring			x	x	x	x	x	x	x	x	x	x
Drifter deployment			x								x	
Scientific seminar												x

Year 2

	13	14	15	16	17	18	19	20	21	22	23	24
Steering committee meeting	x											
Training:data analysis/modelling				x								
In-country training	x					x						
Research cruises			x									
Instrument mooring	x	x	x									
Drifter deployment												
Scientific seminar										x		

Project 3: Biological Oceanography

(i) Scientific Questions

- What are the spatial and temporal distribution of species diversity in the main body of the Gulf of Thailand especially relationship with coastal ecosystems such as coral reefs, mangroves and seagrasses?
- Human impacts on production and degradation processes in main water body of the Gulf of Thailand?
- What are the pattern of larval transport and recruitment of fisheries stock in the Gulf of Thailand?

(ii) Approaches

- Regional network of research cruises;
- Continuous monitoring;
- Data analysis and model development.

(iii) Expected Output

- Biological/ecological models necessary for environmental protection and fisheries resource management;
- Gulf-wide biological oceanographic data/information;
- Dynamics of the population and ecosystems;
- Scientific/technical reports;
- Materials for general public education;
- A regional network of synoptic biological oceanographers and ecological modellers.

(iv)**Implementations**

a. Capacity Building

- Two training courses on taxonomy/species diversity;
- Two training courses on biological and environmental sampling and sample analysis;
- Two training courses on biological oceanographic process modelling;
- Expert visits to conduct in-country training;
- Intercalibration programs for nutrient and pigment analyses;
- Provide scholarships to active scientists in the region to attend training courses/scientific conferences abroad.

b. Data Collection

- At least two cruises per year conducted by each country for biological oceanographic survey (share with Project 2);
- At least one monthly monitoring of some biological process and species composition/abundance at selected sites in each country.

c. Modelling and Data Analysis

- Model of primary production base on incubation results and field data;
- Migration and recruitment models for economically important fish/shellfish species.

d. Meetings/Workshops

- One per year steering committee meeting;
- One per year scientific seminar.

e. Data/Information Plans

- Database and data service (share resources with Project 1);
- Publication of scientific results;
- Publication and distribution of digested/synthesized information (e.g. books, newsletter, etc.) for resource managers, regulators and general public.

(v) Estimated Costs and National Contributions

Items	Cost (USD x1000)	Possible Sources	Possibility for National Contribution				In USD x1000
			CM	MY	TH	VN	
Six training courses	150	Donors, IOC	?	y	y	y	10
In-country training	20	Donors, IOC	y	y	y	y	3
Training/conference scholarships (10 person x week)	30	Donors, IOC					
Two annual steering committee meetings	20	Donors, IOC	?	y	y	y	2
Two annual scientific seminars	50	Donors, IOC	?	y	y	y	5
Monthly monitoring program in four countries	400	Donors	?	y	y	y	300
Equipment upgrade		Donors, Manufacturers					
-Water and biological samplers	160		?	y	y	y	60
-For primary production	120		?	y	y	y	20
-For nutrient analysis	120		?	y	y	y	20
Sample analyses	192	Donors, IOC	y	y	y	y	50
Expert (18 person x month)	63	Donors, IOC					
Project scientists (600 person x month)	600		y	y	y	y	600
Publication	100	Donors, IOC, Private Sector	?	y	y	?	10
TOTAL	2,025	Total contribution from countries					1,080
Estimated directed cost to donors/IOC	945						

(vi) Cooperation With Other Regional/National Programs

- Provide information to government, non-government and regional agencies responsible for marine environment and/or living resource management and protection;

- Provide information to education institutes to strengthen education and research in marine environment and living resources.

(vii) Time Frame

Year 1

	1	2	3	4	5	6	7	8	9	10	11	12
Steering committee meeting	x											
Training: taxonomy				x			x					
Training: sampling		x								x		
Training: modelling					x							
In-country training			x			x				x		
Research cruises			x				x				x	
Monitoring				x	x	x	x	x	x	x	x	x
Scientific seminar												x

Year 2

	13	14	15	16	17	18	19	20	21	22	23	24
Steering committee meeting	x											
In-country training		x										
Research cruises			x									
Monitoring	x	x	x	x								
Scientific seminar										x		

ANNEX IV

LIST OF ACRONYMS

ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
CTD	Conductivity-temperature-depth
DANIDA	Danish Agency for International Development
DIS	Data and Information Systems
EEZ	Exclusive Economic Zone
GOOS	Global Ocean Observing System
GPS	Global Positioning System
GTS	Global Telecommunication System
IGBP	International Geosphere-Biosphere Programme
IOC	International Oceanographic Commission
IODE	International Oceanographic Data and Information Exchange
JODC	Japan Oceanographic Data Centre
LOICZ	Land-Ocean Interaction in the Coastal Zone
NEAR-GOOS	North-East Asian Regional GOOS
NRCT	National Research Council of Thailand
PC	Personnel Computer
SEA START RC	Southeast Asia START Regional Centre
SEACAMP	Southeast Asian Centre for Atmospheric and Marine Predicitons
SEAFDEC	Southeast Asian Fisheries Development Center
SEAPOL	The Southeast Asian Programme in Ocean Law, Policy and Management
START	Global Change System for Analysis, Research and Training
WDC	World Data Centres
WESTPAC	IOC Sub-Commission for the Western Pacific