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FINAL REPORT OF NAGA EXPEDITION

Sponsored by  
South Viet Nam, Thailand  
and the United States of America

Contract No. ICAC-1085 between the United States of America  
and the Regents of the University of California

SIO Reference 63-11  
March 20, 1963

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## Foreword

Because of the length and detail of the various proposals and agreements leading up to the contract, and of the contract itself, the attention of the reader with a specific interest in these aspects is directed to the respective documents, to the appropriate sections of this report and to the attachments thereto. However, and to orient the more casual reader with what follows, it seems desirable to preface the introductory section with a brief description.

### "1. Description of Project

The purpose of this project is:

- (1) To conduct a study of the marine life resources of the South China Sea and the Gulf of Thailand.
- (2) To train as marine scientists the nationals of the participating countries, which are initially Viet Nam and Thailand."

### 1. General Background

The "Naga Expedition" of 1959-61 was one of the more recent of a series of efforts on the part of the Government of the United States of America to cooperate in the development of the aquatic and other resources in Southeast Asia and in the training of participating nationals. Under its general agreements of economic accord with the Governments of Thailand and of Viet Nam, a supplementary tripartite agreement was reached early in 1958 for conducting an exploratory survey of the marine resources potentially available for development in the Gulf of Thailand and in that portion of the South China Sea adjacent to (South) Viet Nam and for the training of marine scientists and technicians.

To implement its part of the agreement the Government of the U. S. A. invited the Scripps Institution of Oceanography (SIO) of the University of California to submit a proposal for carrying out such an investigation including providing technical direction, a research staff and a suitable oceanographic research vessel. In response to this invitation the Director SIO submitted a proposal through the Regents of the University of California to the International Cooperation Administration (ICA). This proposal resulted in a Letter-of-Agreement which became effective on 7 May 1959. On 26 August 1960, a contract embodying and implementing the terms of the original agreement was negotiated.

Amendments No. 1 and No. 2 to this contract extended its effective period without additional cost and the contract as extended terminated on 6 May 1962, after a total period of three years. A sub-contract entered into on 6 November 1959, between the Regents of the University of California and the Goerge Vanderbilt Foundation (GVF) was funded from the prime contract and terminated therewith.

Financial support for the project by the United States was in the amount of five hundred and sixty thousand dollars (\$560,000) supplied through the contract. Sixty thousand dollars of this went into the sub-contract (SIO-GVF). Local country participation and facilities were funded by the respective governments. Additional U. S. support has been supplied from University of California general funds, Office of Naval Research, U. S. Public Health Service, the George Vanderbilt Foundation and, more recently, by the National Science Foundation(NSF)

Two independent advisory bodies were established to assist in the planning, the coordination and the prosecution of the program. The first of these was established by the terms of the program agreement (Pro/Ag) between the three cooperating countries and was composed of representatives of the cooperating countries (Viet Nam and Thailand) and of the respective USOM's. This group was known as the "Coordination Committee." The second group, known as the "Southeast Asia Panel" was a campus committee established by the Director SIO and was composed of members of the staff of the Scripps Institution and campus associated agencies including the Inter-American Tropical Tuna Commission, the U. S. Bureau of Commercial Fisheries, and California Marine Life Research Program. The Project Officer worked closely with these two groups and directed the operations in the field.

The principal field investigations were conducted from the R/V Stranger, a 25 ton research vessel from the Scripps Institution. Supplementing the work from the "Stranger" was that conducted from ships and small craft supplied through the courtesy of the Department of Fisheries of Thailand, the Royal Thai Navy and the Oceanographic Institute of Nhatrang Viet Nam. Additional collections were made at fish markets and fish landings both in Thailand and in Viet Nam.

The field work of the project commenced with the departure of the expedition vessel R/V Stranger from San Diego on 15 June 1959 and terminated with the return of the vessel to San Diego on 24 June 1961.

Following a short indoctrination course for participating nationals and an orientation cruise conducted in the Gulf of Thailand in September of 1959, a series of ten survey cruises was completed in the area. Laboratory analyses commenced in 1959 are continuing, as is the work on field collections of animals including the fish and planktonic forms, which are still under study. It is from these collections that reference collections will be selected and from which one or more illustrated handbooks on commercially important species will be prepared.

Progress of the field program was documented by written reports submitted routinely following completion of each survey cruise. A final "Field Report" was submitted (May 1961) prior to the Project Officer's return to the United States. Semi-annual reports were submitted by the sub-contractor, the George Vanderbilt Foundation.

Special reports by visiting and participating investigators were included in the routine cruise and field reports.

## 2. The Program Plan

### 2.1 Considerations

In addition to the problems of equipping, manning and providing logistic support for a marine project in distant waters for an extended period of time there were conditions unique to the participating countries which needed investigation.

Thailand and Viet Nam, together with other countries in Southeast Asia, share in the worldwide shortage of trained marine scientists and technicians. If the shortage there appears more acute than on the European and North American continents, there are recognizable contributing factors. Among these are factors of time, of utilization of potential manpower, and of biogeographical complexity.

As elsewhere, the number of people in Southeast Asia receiving training in the marine sciences has been on the increase. Up to the present time, however, most of these have been plowed back into the colleges and universities as instructors nearly as fast as they have become available. Even so, with the rapidly expanding student population, the ratio of students to instructors, already too large, is still on the increase. Complicating this picture still further is the traditional system of instruction which usually provides little time and a minimum of facilities for research and field investigations. This fact is widely recognized by most senior scientists and by a widening circle of administrators.

It is generally agreed that marine investigations in the Southeast Asia area are still in the early exploratory stage. Advancement beyond this stage is complicated by its geographical complexity, by its relatively high rate of productivity, number of species and by environmental complexities introduced through periodic monsoon reversals of oceanic circulation patterns.

To provide a comparison, intensive marine investigations have been proceeding in the temperate North Atlantic regions for periods of one to three hundred years and the training of marine scientists



there has more or less paced the extension of these investigations to other areas. Also, in the temperate North Atlantic, most animal species had been described by the beginning of this century; to find a non-described species today is, if not rare, at least not a common event, and especially all commercially important species are rather well known.

In the Asian seas the situation is in striking contrast. It is easy in any of the fish markets to find species, the systematic name of which is very doubtful if known at all. Proceeding to such important species as those found in the stomach contents of the fishes makes the case still worse because many invertebrates have been very little studied.

In some ways then, the explanation of why these studies remain so far behind is quite simple, e. g., because the number of species is so immense. Had the temperate North Atlantic had hundreds of species where it now counts tens, one would still have had many more species to describe.

One of the major considerations in determining the course of the Scripps - George Vanderbilt Foundation program was the effect that local country programs in-being and planned would have on the availability of trained associates to implement and assist the scientific staff. A secondary consideration was the probable results of these programs as they might implement the work planned by the Scripps team or might duplicate it. Because of this, the background of participating national agencies was investigated. The following brief history of the Department of Fisheries of Thailand will serve as an example though the background of other agencies both in Thailand and in Viet Nam could serve as well.

The Thai Department of Fisheries was officially established in the year 1926 under the Ministry of Agriculture. The present organization is thus the result of some 37 years of gradual development. The department has four main divisions, each with a number of sections.

The principal training in fisheries is carried out at the College of Fisheries which is an important part of the Agriculture (Kasetsart) University. The faculty of the college is drawn mainly from the technical officers of the Department of Fisheries. Additional (vocational) training, is being extended to other agriculture schools, and special in-service training for the officers of the Department is provided. Qualified fisheries officers are selected from time to time by competitive examination for award of fellowships for advanced studies in suitable institutions abroad.

Fisheries legislation in Thailand is of much longer standing than the Department of Fisheries itself. Historically, all fishing rights belonged to the King. In 1901, the first fisheries act was passed and all fishing waters of the country classified. This act was amended six times between 1901 and 1947. In 1921 the first "Fisheries Service" was established under the Ministry of Agriculture. Following the 1947 amendment to the 1901 Fisheries Act, the responsibilities of both fisheries administration and fisheries development were transferred to the Department of Fisheries, Ministry of Agriculture. To provide greater benefits to both the producers and the consumers, and to serve as the necessary basis for improving the socio-economic standard of the fishermen, the Fish Marketing Act was passed in the year 1953.

The Department of Fisheries is thoroughly cognizant of the problems it faces in attempting to improve the existing fishery industry and to expand it to meet the present and future demands of a rapidly expanding population. To this end it has many active programs in the areas of the inland, brackish water and marine fisheries. The lack of availability of sufficient numbers of trained personnel and of sufficient funds for long range programs in basic research is still a problem however, and one which has prevented as rapid implementation of these comprehensive plans as would be desirable.

As in other countries throughout the world, the informed public officials recognize the danger of indiscriminate expansion of the marine fisheries in advance of the results of the basic research which is a necessary prerequisite to intelligent administration and control. Here as elsewhere, support for basic studies is difficult to obtain and is reflected in large measure in the deliberateness with which implementation of many needed programs is approached.

When the marine resources survey (Naga Expedition) was initiated, several allied programs were underway or planned. Those included programs in (1) the handling and transportation of fresh fish, (2) processing, (3) packaging and storage, (4) chemical analysis, (5) canning, (6) fish meal for human consumption, (7) aid to fishermen through loan funds, (8) radio communications and (9) the Rastrelliger Investigation.

This latter program was most directly connected with the investigation of the SIO-GVF Project and, at the request of the Director-General of Fisheries, the Director SIO was requested to analyze and provide expert advice on this program. The importance of the program can be visualized from the generally accepted fact that the Rastrelliger accounts for about two-thirds of the total catch of marine food fish.

The Rastrelliger program included work on:

- (a) Collection of catch statistics
- (b) Scale studies
- (c) Egg studies
- (d) Larval collections
- (e) Tagging experiments
- (f) Plankton collections
- (g) Fish schooling habits and detection

Following a thorough study of the program by the Scripps Advisory Committee the results of the study were transmitted to the Department of Fisheries at Bangkok. The general concensus of the Scripps Committee was that the program was well conceived, comprehensive and remarkably sophisticated; that its very thoroughness emphasized the urgent need for additional personnel with advanced training and the need, for the immediate future, of concentrating available trained manpower on a few limited objectives within the framework of the overall program.

Of the marine fisheries programs planned to run concurrently with the Naga program the two most directly related were (a) the Thai-Japanese trawling experiments and (b) the Thai-German program directed at developing fishing gear, experimental trawling and the training of fishermen in the methods of using the gear, especially single ship otter trawls. Experiments were also directed toward the use of marine radios for ship-to-ship and ship-to-shore communications and the use of sonar gear for the detection of fish schools.

## 2.2 Development of Operational Plan

The general outline of an operation plan was developed during early meetings of SIO Staff and associates on the Scripps campus but it was considered unrealistic to attempt to fill in details without a more intimate knowledge of the current thinking of people in Southeast Asia. For this reason it was decided that both the Project Officer and the Chief Scientist should visit Viet Nam and Thailand. The visit was timed to coincide with the UNESCO sponsored, Marine Science Meeting held in Saigon in January of 1959. Because the Saigon meeting was attended by delegations of scientists from the principal maritime nations of Southeast Asia, and because the discussions there were concerned with the existing status and future plans for the marine sciences, this meeting afforded an unparalleled opportunity to obtain quickly and at first hand, information which would be invaluable to the program.

Following participation in the above meeting (14-17 January 1959) the Scripps representatives visited the Oceanographic Institute at Nhatrang and the University of Hue, returning to attend a sub-committee meeting of the Vietnamese Coordinating Committee held in Saigon on 20 January (enclosure No. 1) at the Rectory of the University of Saigon. On the following day both attended a similar meeting of the Thai sub-committee held at the Department of Fisheries in Bangkok (enclosure No. 2). A later meeting in Bangkok on 24 January 1959 was held in the Office of the Director USOM (enclosure No. 3).

With the background of these meetings as a basis, a more detailed proposal was prepared at SIO and forwarded to ICA Washington (20 February 1959) for integration in the expected contract. Excerpts from this proposal are quoted below:

### 2.3 Objectives

"The general objectives of the program are: to foster science in Southeast Asia in an acceptable form including:

"To demonstrate the importance of oceanography and marine biology in relation to fisheries.

"In cooperation with the governments concerned, to train oceanographic and fisheries scientists and technicians, to develop scientific understanding and appreciation, and to accelerate the progress of science in the Gulf of Thailand and adjacent portions of the South China Sea.

"To lay scientific and administrative groundwork for early and continued development of marine resources in the Gulf of Thailand and adjacent portions of the South China Sea.

### 2.4 Scope

"Major effort will be placed on carrying out the kind of basic studies which will be of value to the Southeast Asians over the next several decades. These studies will lead to an understanding of the oceanography of the region, including the circulation, methods of enrichment, primary productivity and to the nature, distribution and abundance of the important marine resources.

"A lesser, but equally important, effort will be placed on recognizing and acting on a specific problem or problems, in the solution of which it is possible to demonstrate the practical applications of scientific findings.

"To the extent possible, shipboard facilities will be provided for local scientific personnel to work as an integral part of the research

group. Also, to the extent possible, resident staff members and visiting specialists will cooperate with local institutions, such as Chulalongkorn University and the University of Saigon (for example), in giving a series of lectures or short-term courses in their specialties

"Scientific results arising from this project will be published in local and other suitable journals when feasible. In any case, summaries will be published locally.

"In cooperation with and by sub-contract with the George Vanderbilt Foundation at Stanford University, a program directed toward a marine faunal survey of the Gulf of Thailand and adjacent regions as can be covered, and ecological studies on the marine life of this region, will be undertaken. This program will include the preparation of a well documented collection of fishes, invertebrates and plant life for the monographic, systematic and ecological studies, for the preparation of handbooks and for the identification of commercially important species. The collection will be deposited eventually in United States and local repositories where they will be available to biologists for study and loan.

#### 2.5 General Work Plan

"The Gulf of Thailand and adjacent portions of the South China Sea (extent of area to be determined by scientifically significant rather than geographical boundaries) will be covered by descriptive type surveys during the first year, possibly during the NE monsoon season, during the SW monsoon and during the two transitional periods between the monsoon seasons. Monitoring cruises will be planned for the second year as necessary to establish how typical the conditions were during the first year. Additional cruises will be designed to attack specific problems raised by the descriptive studies and for training purposes.

#### Staff Specialists

"In order to provide the maximum benefit of its knowledge and experience the Contractor may from time to time substitute or provide additional investigators to look at specific problems."

#### 2.6 Cruise Plans - General

The general plan of operation called for the expedition vessel to work alternately in the Gulf of Thailand and in the South China Sea on a seasonal basis predicated on the major climatic phenomena, the northeast and the southwest monsoons. These climatic systems largely

control the environmental factors including the ocean currents, the temperature, precipitation and run-off. While these phenomena follow a roughly uniform pattern of change from year to year there are significant variations in their initiation, intensity and duration. There is even greater variation in the periods intervening between reversals of the system. Because of this and other factors mentioned below, the final details of cruise schedules were not attempted in advance of the vessel's arrival in the area.

The additional factors involved included the ironing out of certain philosophical differences of opinion on the best geographical layout of sectional lines, station patterns and of their extent. These in turn needed to be integrated in a practical way which considered also the limitations of available time, of logistic support and the probable capabilities of the ship, the personnel and the equipment to perform effectively for long periods of time on a rigorous schedule in all kinds of weather. In respect to the latter and to its effect on sea conditions, there is little doubt but that by the time the vessel arrived in Bangkok all optimism about smooth sailing under tropical moons or sunlit skies was wholly confined to the uninitiated and to those too distant to be personally affected. The most charitable thing that can be said for full-blown monsoons and for unscheduled depressions travelling across the China Seas is that they serve effectively to temper both the enthusiasm of the overly romantic and the criticism of the overly dogmatic

A result of discussions held in Saigon and in Bangkok with the Coordinating Committees, plans were firmed up for the preliminary instruction on shore of selected participants and for an orientation cruise on the research vessel Stranger. On completion of this ten-day cruise, the Stranger returned to Bangkok on 17 September 1959, at which time another meeting was held to discuss the outcome of this preliminary training and to lay plans for the regular survey cruises to follow.

Because of the success of the orientation cruise it was decided that all but three of the Stranger's regular crew would be returned to the United States and that the billets thus released would be filled by participants who could act in the dual role of crewmen and scientific trainees. In some ways this was the most critical decision to be made in the following two years. The Stranger represented the most expensive, the most essential and the only irreplaceable piece of equipment we had

and on her continued and safe operation depended the entire program as well as the lives of the people who would ride her.

The successful operation of the vessel on cruise after cruise repeatedly justified the confidence with which the above mentioned decision was made and the resulting benefits were immediate and lasting. Over night the Stranger ceased to be a stranger and the ship and the expedition became and remained a local country project. No better model for international cooperation at the "grass-roots" level could have been devised.

Cruise track and station position plans were drawn up and approved both for the Gulf of Thailand and for the South China Sea. It was agreed that the Stranger would return to Bangkok following each cruise and, to facilitate handling Vietnamese trainees, she would stop both at Nhatrang and at Saigon on each cruise to the South China Sea.

The work day at sea was on a twenty-four hour basis. Because of this the scientific staff including trainees was divided into sections or watches. Each watch ran from the beginning of one station to the beginning of the next, a matter of five to eight hours. On early cruises the people were divided into two watches. Later on, some of the more permanent trainees were able to take personal charge of the station work and a third watch was added.

Each watch was called thirty minutes before the vessel was due to arrive on station. Following a short briefing on any special conditions expected on the station they were left in charge and the off-going watch turned in. Routinely, all work from the previous station was completed prior to arrival at the next station.

## 2.7 Gulf of Thailand - Cruise Plan

On Gulf of Thailand cruises, the plan provided for making five sections across the Gulf oriented roughly perpendicular to the coastlines in a generally northeast-southwest direction. The southernmost line in the Gulf ran from the Thai-Malaya border near Kota Baru on the west to the southern tip of the Indo-China Peninsula at Poulo Obi on the east. The remaining lines in the Gulf ran parallel to this line and at selected intervals (not equidistant) to the north. Positions spaced at thirty to forty mile intervals along each section were designated for complete hydro-biological sampling. Between succeeding stations two additional positions were designated for BT(bathythermograph) lowerings and weather observations. The distance the vessel would travel on each Gulf cruise was approximately 2,000 miles and it would take fourteen to seventeen days.

## 2.8 South China Sea - Cruise Plan

In the South China Sea, the plan provided for making six sections perpendicular, or nearly so, to the eastern coast of Viet Nam. The lines extended from near shore to a distance of about 250 miles offshore. The northernmost line ran due east-west at latitude fifteen degrees forty minutes north. Its location at the southern edge of the Gulf of Tonkin passed just south and clear of Triton Island in the southern Paracels. The remaining lines were spaced at approximately 100 mile intervals with the southernmost line approaching the southern tip of Viet Nam (at Poulo Obi) from the south. Hydro-biological stations were spaced at forty-mile intervals along the lines with two equally spaced BT stations between successive stations. The distance the vessel would travel on each South China Sea cruise was about 3,800 miles and it would take thirty to forty days including stops at Nhatrang and Saigon.

## 2.9 Work at Sea

With necessary modifications to accommodate the varying depths of water at station locations the routine sampling to be attempted at each was to be nearly the same. Exceptions included such things as making special stations in areas of observed current discontinuities, discolored water, concentrations of phytoplankton bloom and making special net tows shortly after sunset in the evenings and deep, mid-water, net hauls in the China Sea basin. Bottom sampling was limited to shallow and medium depths, usually less than three-hundred fathoms. With these exceptions the work plan was as noted below.

### 2.9.1 On Station Work

a. Nansen bottle casts: A serial hydrographic cast employing from three to thirteen Nansen bottles (depending on depth of water) was lowered on each oceanographic station for determination of in-situ water temperature and for collection of water samples at each level. Water temperature was determined by attaching paired "protected" reversing thermometers to each Nansen bottle. An "unprotected" reversing thermometer was used in conjunction with the paired "protecteds" at all depths greater than 100 meters for thermometric depth computation. Hydrographic casts were routinely made to 1,100 meters, depth of water permitting. Selected "deep" stations were made to 4,000 meters.



b. Bathythermograph (BT) observations were made on each hydrographic station, at two equally spaced locations between each two consecutive hydrographic stations, at each special biological station and at observed current discontinuities.

c. A routine weather observation was made in conjunction with each BT observation. Special six-hourly weather observations were made on request and whenever communications permitted their transmission to local weather centrals.

d. Plankton were collected at each oceanographic station using a silk net of one meter mouth diameter fitted with a flowmeter to permit subsequent quantitative analysis. Nets were towed obliquely and were lowered and retrieved at a predetermined rate in order to sample a uniform column of water. The net was lowered to an approximate depth of 140 meters in a routine tow and from 5 to 10 meters from the bottom in shallower waters. Vertical plankton tows were taken routinely at alternate and selected stations using a fine mesh silk net of 45 centimeter mouth diameter fitted with a flow-meter. The net was lowered to a similar depth as the one meter net at the same station.

e. Surface and mid-water trawls were made at night using a Stramin net of two meter mouth diameter.

f. Biological sampling on the bottom was carried out at selected stations using a six-foot and a ten-foot beam trawl, a two-foot and a 2.5-foot biological dredge, the Pederson and Van Veen samplers and the Otter Board trawl. This sampling was usually limited to depths of 300 fathoms or less.

g. Whenever possible, samples were collected by dip netting.

h. Bottom sediment samples were collected using a small (N.E.L.) snap-sampler, a small Phleger corer and a 150-pound gravity corer.

i. A determination of the surface water temperature was made in conjunction with each BT observation, using a "bucket" thermometer.

j. Whenever possible a station position was determined by star sights, sun lines or by the observation of terrestrial objects. If this was not possible then a tentative dead reckoning position backed up by soundings was used and this position was later subject to adjustment between earlier and later more definite fixes.

#### 2.9.2 Between Station Work

On completion of a station the bridge was notified and the vessel departed for the next station with the bridge giving the laboratory staff an estimated time of arrival (ETA). The routine work between stations

was essentially as given below.

- a. Make bathythermograph (BT) lowering at two equally spaced positions.
- b. Make weather observation at each BT lowering.
- c. Make thermometric determination of surface water temperature in conjunction with each BT observation.
- d. Make continuous thermograph recording of surface water temperature.
- e. Process data from last station, read and record thermometers, draw water samples, etc.
- f. Titrate water samples for contained oxygen.
- g. Preserve water samples for later determination of salinity and of inorganic phosphorus concentration.
- h. Preserve biological samples from net and trawl hauls.
- i. Preserve bottom sediment samples.
- j. Make continuous fathometer recording of bottom topography.
- k. Make observations for birds, fish, current discontinuities and other phenomena.
- l. Make special six-hourly weather reports.
- m. Make observations for ship position as conditions permitted.
- n. Trolling as conditions permitted.

### 2.9.3 Special Work

In addition to the "routine" work, additional sampling and observations were made either as the result of preplanning or because of special circumstances encountered. This additional work included:

- a. Anchor stations occupied over a lunar tidal day.
- b. Current and drift observations.
- c. Special observations predicated on the results of previous findings or analysis of previous cruise data.
- d. Mid-water trawling in the deeper waters of the South China Sea.
- e. Extra BT observations, water sampling and net hauls in areas of actual or suspected current discontinuities, in areas of upwelling and of phytoplankton concentrations.
- f. Surveys of topographical features encountered.
- g. Obtaining sediment and core samples from the surface of topographical features surveyed.
- h. Trawl hauls from the surface of topographical features plus deep net hauls, water samples and temperatures from either side.
- i. Bottom sampling for productivity studies in the Bay of Nhatrang, in the vicinity of Phu Quoc Island and in the upper part of the Gulf of Thailand as well as at selected isolated stations.
- j. Fish collecting at island and reef locations using emulsified "Rotenone," a paralyzing agent.
- k. Investigations and collecting using shallow water diving techniques and underwater photography
  - l. Photographic coverage as possible of observed surface phenomena.

### 3. Facilities and Cooperating Agencies

To implement the field work carried on from the expedition vessel, shore laboratory and administrative facilities were required. Facilities made available for these purposes included:

#### In Thailand

Chulalongkorn University, laboratory  
Department of Fisheries, office and laboratory  
Hydrographic Department Royal Thai Navy, laboratory  
George Vanderbilt Foundation, laboratory

#### In Viet Nam

Oceanographic Institute of Nhatrang, laboratory

#### In United States

Scripps Institution, administrative and laboratory  
George Vanderbilt Foundation (Stanford University), laboratory

#### 3.1 Department of Fisheries, Thailand

The administrative headquarters for the expedition in the field was in office space assigned in the Department of Fisheries, Ministry of Agriculture, in Bangkok. The Department of Fisheries also provided freezer type storage space at the Bangkok Fish Market and laboratory space at the Department of Fisheries Technical Laboratory. Fisheries Officers and technicians were assigned to assist in the work at the Technical Laboratory, in operating the expedition vessel (a diesel engineer) and to participate as trainees and technicians in the field. Instructors from the College of Fisheries at Kasetsart University participated in the field work on the expedition vessel and in the laboratory work at Chulalongkorn and at the George Vanderbilt Foundation (Bangkok) laboratories.

#### 3.2 Royal Thai Navy

Perhaps the most "unique" feature of the whole expedition was the assignment by the Royal Thai Navy of a group of trained hydrographic technicians, officers and petty officers, to act as crew, scientific assistants and trainees on board the expedition vessel under the command of an American civilian captain.

At its Bangkok headquarters, the Hydrographic Department provided both laboratory space and personnel to perform all of the routine

chemical determinations for salinity of the several thousand water samples obtained from the Gulf of Thailand and the South China Sea.

The Navy also provided medical and hospital facilities both at Bangkok and at Sattahip and berthing and repair facilities at both places. Additional berthing facilities for the vessel at Bangkok were arranged by the Navy through the courtesy of the Marine Division, Department of Police.

### 3.3 Chulalongkorn University, Bangkok

Through the courtesy of the Rector, Chulalongkorn University, laboratory, office and storage facilities were assigned in the Faculty of Science, Department of Biology. The Rector also assigned selected instructors to act as scientific assistants and trainees both in the laboratory and on the expedition vessel. Following his arrival in Bangkok in March of 1960, Dr. Edward Brinton directed the work in the laboratory on the biological field collections which were deposited there after each cruise of the Stranger. As a staff specialist he also attended seminars, accepted teaching assignments, and participated in the final special field cruises.

### 3.4 George Vanderbilt Foundation Laboratory, Bangkok

The sub-contractor, the George Vanderbilt Foundation, established field headquarters including laboratory space and staff housing facilities in the Bangkapi district at Bangkok. From this headquarters the scientific and technical personnel conducted sorties for collecting and field studies. The laboratory was equipped with special photographic facilities and provided with a staff of two photographers. Besides processing their own collections this group accepted for identification, classification and preservation the pelagic and demersal fishes collected from the expedition vessel. Dr. Ralph Bolin (Stanford) accompanied the Stranger on two field cruises while participating as part of the GVF team.

In addition to their work in Thailand and the Gulf area, Dr. Adair Fehlmann and Mr. Herbert Frey made one trip to Viet Nam at the request of the Project Officer who provided the necessary transportation. During this trip they investigated fish markets and landings both in the Nhatrang and in the Saigon areas. While at Nhatrang they accomplished field study and collecting trips using facilities provided by the Director of the Nhatrang Oceanographic Institute. Observations made in Viet Nam provided information from which useful comparisons could be made between the common market fishes in the two countries.

Visiting investigators made use of the GVF laboratory, housing and transportation facilities when in the Bangkok area.

### 3.5 Gulf Stations - laboratories

The Chulalongkorn University, the Royal Thai Navy and the Department of Fisheries all maintain marine stations or laboratories on the Gulf of Thailand.

### 3.6 Oceanographic Institute, Nhatrang

The Oceanographic Institute at Nhatrang has been the center of oceanographic and marine biological study and activity in Viet Nam for many years. Among its facilities are included a large marine biological reference collection, a fine library and associated micro-filming service, a large aquarium, a physical-chemical oceanographic laboratory, a seismological center and (since 1959) dormitory accommodations for twenty students plus its villa-type housing for staff and visiting investigators. Not least among its other facilities was a small research vessel, the Mao Tien.

The research vessel Stranger invariably stopped at Nhatrang, anchoring just off the Institute, at the beginning of each survey cruise in the South China Sea and again after finishing the northernmost survey lines. This facilitated embarking and disembarking the scientists and trainees from Viet Nam. Usually one group would board the vessel on its first stop; then after participating on the northern run this group would disembark and another group would embark. The members of the second group usually disembarked at Saigon sometime later in the cruise.

The facilities of the Institute, including housing and transportation were made available to the expedition staff on request. The Institute staff assisted both in research activities and in the more mundane but essential areas of logistic support including arranging port clearances, deliveries of potable water, communications and locating sources of assistance for supplies and minor repairs.

At the Nhatrang Institute many of the young trainees who later participated in the survey cruises of the Stranger, attended a three month course of instruction in the marine sciences in the fall of 1959. This course was sponsored by UNESCO and included classes in marine biology, in physical-chemical oceanography and in marine geology. Instructors (Dr. D. L. Inman, Dr. Warren S. Wooster) for the latter two classes were supplied from the Scripps Institution.

During the spring and summer of 1960, the Institute made its facilities available for several weeks to a seven-man team of marine specialists supported by a U. S. Public Health grant and for a four-months bottom productivity study of the Bay of Nhatrang conducted by Mr. Ariel Gallardo (Chile) with support provided by the University of California.

4. Track Chart and Cruise Schedules

4.1 Cruise Schedules

SO	8 September 1959	GT	17 September 1959
S1	19 October 1959	GT	31 October 1959
S2	16 November 1959	SCS	16 December 1959
S3	19 January 1960	GT	31 January 1960
S4	15 February 1960	SCS	21 March 1960
S5	21 April 1960	GT	3 May 1960
S6	23 May 1960	SCS	28 June 1960
S7	2 August 1960	GT	15 August 1960
S8	6 September 1960	SCS	8 October 1960
S9	9 November 1960	GT	25 November 1960
S9A	8 December 1960	GT	14 December 1960
S10	11 January 1961	SCS	13 February 1961

GT - Gulf of Thailand  
SCS - South China Sea

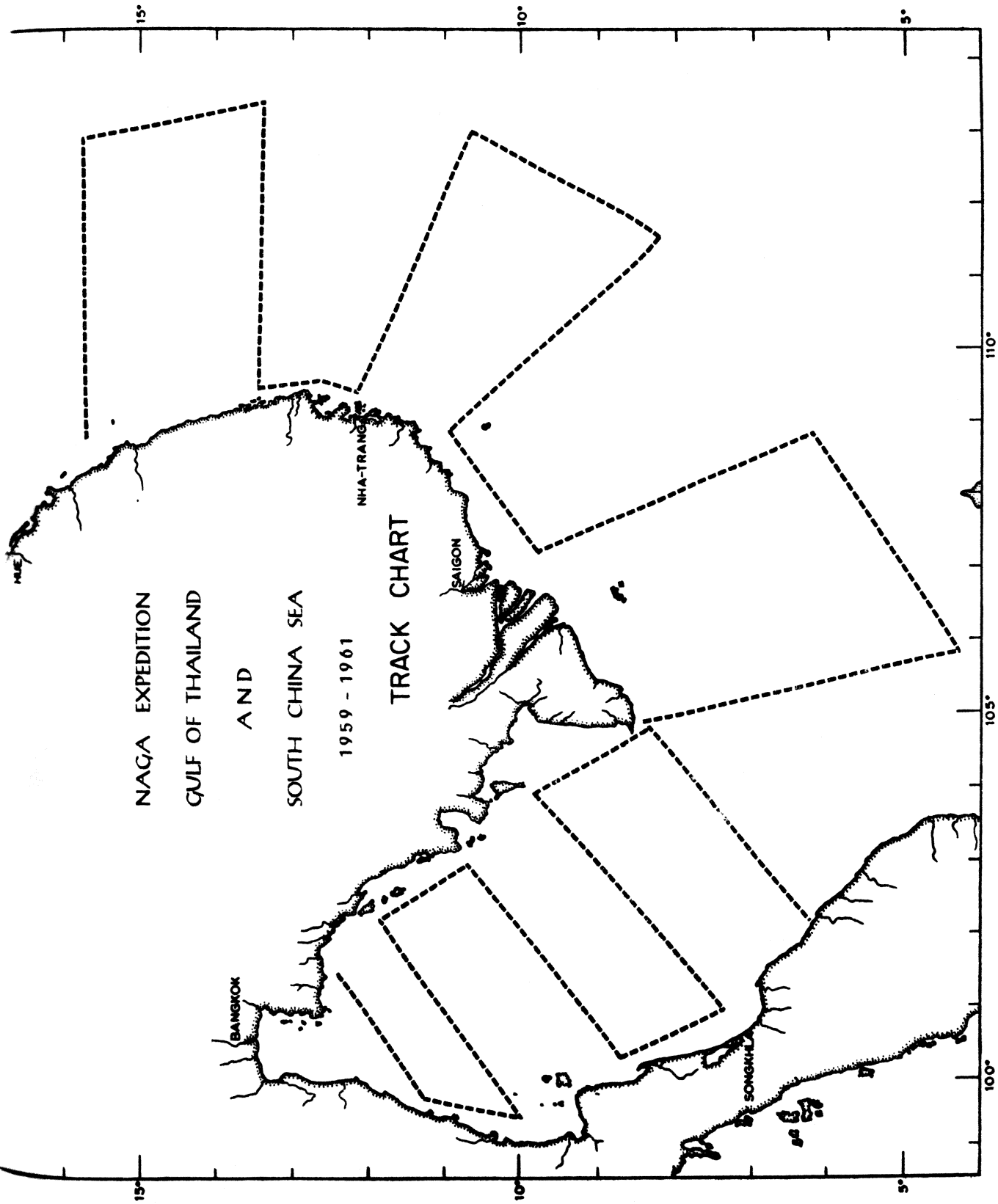


Figure 127



## 5. Accomplishments

### 5.1 Training

#### 5.1.1 General

The training program associated with the NAGA Expedition was an integral part of the overall project and was based on Scripps Institution general policy of "teaching through research." The program can only roughly be separated into training-ashore and training-at-sea. In the laboratories ashore it was convenient to segregate participants according to background and primary interests. The field work on board ship however is an integrated program requiring a large measure of inter-disciplinary understanding and mutual assistance. This latter is an important part of every marine scientist's training.

Lectures and demonstrations served to implement the practical training in specialized fields. Seminars by staff and visiting investigators served to keep people informed of current activities and to present an integrated picture of the overall program.

#### 5.1.2 Pre-operational

Soon after the arrival of the research vessel at Bangkok arrangements were made for the staff technicians to conduct a refresher course in physical and chemical oceanography and in the techniques of biological field collecting for a class of about twenty locally-selected trainees. Equipment from the vessel was supplied in order to provide practical demonstrations in its use and in the techniques employed.

The course was conducted at the Royal Thai Navy Hydrographic Office and lasted about three weeks.

In addition, a ten-day orientation cruise in the Gulf of Thailand was made on the expedition vessel. During this cruise the various operations which were to be employed later in the shipboard field investigations were repeatedly demonstrated. Trainees were first paired off with staff personnel and later worked complete stations by themselves.

The practical shipboard work included serial hydrographic casts for the determination of in situ water temperatures and for the collection of water samples at each of the selected levels; bathythermograph (BT) lowerings for determination of the temperature

micro-structure with depth; weather observations in conjunction with each BT lowering; surface water temperatures; chemical titrations for the determination of dissolved oxygen for each level of water sampling; preservation of water samples for later determinations of salinity and phosphate; collection of plankton using both vertical and oblique towing techniques; preservation of plankton and other biological samples; and bottom sediment sampling for ecological studies using grab samplers and corers.

Trainees as selected operated the ship equipment including winches, radio communication apparatus, depth recorders, signal lights, life saving equipment, main and auxiliary machinery, and refrigeration. They then stood regular deck and engine room watches underway, plotted the vessel's position using both celestial and terrestrial observations plus navigational radar and depth soundings.

Perhaps of equal if not greater practical importance, Chief Petty Officer Wong Potibutra of the Royal Thai Navy managed somehow to solve the intricacies of an American research vessel's most complicated apparatus, her commissary department, to the satisfaction and deep gratitude of his multi-national crew and shipmates.

### 5.1.3 Field Training

The training provided on board the Stranger during regular field cruises was both rigorous and eminently practical. At the meeting of the Coordinating Committee which was held prior to each cruise the selection of trainees was a regular and important item of business. The local-country members presented lists of potential participants. The Project Officer advised on the maximum number for whom space would be available and on any special requirements that might exist as to the minimum number needed to facilitate the planned work.

The selection of trainees was invariably viewed with the requirements of the project always uppermost. However, attempts were made to maintain a reasonable balance between the desirability of maximum training for a selected few and some lesser amount of field experience for as many as possible.

Because of the difficulties involved in providing transportation for trainees from Viet Nam when the vessel was operating in the Gulf of Thailand none of these people participated in Gulf cruises. To compensate for this it was mutually agreed that at least three

billets for Vietnamese trainees would be made available on board for each cruise in the South China Sea. To facilitate these arrangements the Stranger always made two stops at Nhatrang as well as one stop at Saigon when operating off the Vietnamese coast. In this way one group of trainees could embark at Nhatrang on the first stop and be replaced by another group at the second stop. The latter group then disembarked at Saigon.

In order to provide training in all aspects of the field work each student was immediately assigned to a particular staff member and later rotated to other assignments. As quickly as possible each trainee was made personally responsible for some particular operation together with a more general responsibility to assist the other members of his watch with the common work. There is little doubt but that this practice of integrating each participant into the team was a most significant factor in encouraging him to make his best effort.

The presence on board of visiting investigators and other specialists provided additional opportunities for the student to broaden the basis of his instruction as did visits to various institutions and attendance at seminars when the vessel was in "foreign" ports.

On the whole, the majority of trainees took the field work seriously and made significant progress in spite of occasional periods of seasickness, unaccustomed manual labor and other unfamiliar conditions inherent to shipboard life. One of the most heartening aspects of the mutual labor and close association on board the Stranger was the remarkable ease with which friendships developed among the young Vietnamese, Filipino, Japanese, Indonesian, Korean, Thai and Hong Kong students, and the rather effortless manner in which all accepted instruction from a staff consisting at times of nationals from the United States, France and Denmark.

Altogether, some 108 individuals participated in the NAGA Expedition on board the research vessel Stranger, of whom 12 were drawn from the Scripps Institution scientific staff. Of this number 83 participated in one or more of the regular survey cruises. The total number of trainees amounted to 69 of whom 58 were from Thailand and Viet Nam. Of the latter group 57 per cent made two or more cruises and 28 per cent made four or more cruises. Nearly all of the trainees who participated in four or more survey cruises were selected for four additional months of "post graduate" training. For three months of this time they filled staff billets on board the Stranger during her return voyage

to the United States. Following this, they spent two to four weeks at the Scripps Institution before returning to their respective homes. Thus sixteen trainees or 28 per cent of the total number from the two participating countries were under instruction in the marine sciences for periods of twelve to twenty-four months.

#### 5. 1. 4 Laboratory

Field investigations involving the collection and recording of environmental data and the sampling of organisms in their natural habitat are but a first step in the process leading to an understanding of the ecology of marine communities.

During regular cruises of the research vessel most samples and collections were routinely preserved on board and off loaded on return of the vessel to Bangkok. Water samples to be used for salinity determinations were taken to the Hydrographic Department laboratory; water samples to be used for the determination of inorganic phosphorus concentrations were transferred to frozen storage lockers at the Fisheries technical Laboratory and biological collections were taken to the biological laboratory at Chulalongkorn University.

Immediately following curise S-1 in the Gulf of Thailand and continuing thereafter until the end of the project, the titration of all water samples for salinity determinations was completed by personnel of the Hydrographic Office of the Royal Thai Navy. Following the preliminary instruction of laboratory personnel in the techniques to be employed, the staff chemist spent some time at the laboratory during each in-port period to check on results and to consult with the chemists. This routine was arranged for at the beginning of the project as a means of providing practical instruction for the personnel who would be engaged at a later date in the programs to follow. Periodically the tabulated data resulting from the laboratory analyses were transmitted to the data reduction center at the Scripps Institution where they were integrated with the corrected thermometric values to provide the density information required for determination of currents and seasonal variations in the circulation pattern.

Following cruise S-4 in the South China Sea a staff biologist was assigned to supervise the work on the plankton collections at Chulalongkorn University and the instruction of trainees assigned by the Coordinating Committee. The people selected for this training were drawn from the College of Fisheries of Kasetsart University, from the Hydrographic Department of the Royal Thai Navy and from the Department of Biology of Chulalongkorn University. Additional

trainees were assigned to the group for short periods of time from Viet Nam and from Indonesia. From time to time senior students from the University were added to the program. To permit interested trainees the opportunity to commence and follow through on individual projects and to provide continuity to the routine task of sorting and counting, two part-time salaried assistants were provided.

Concrete examples of results of the instruction provided to trainees, and of their serious interest, are provided in the "Field Report" which contains completed papers from two and abstracts of papers from three others. Several of the "Progress Reports" contain additional contributions from Viet Nam. Cruise S-8 report contains a contribution prepared by two trainees from Indonesia in cooperation with Dr. Roule Serene.

As a result of the work on the biological collections a preliminary picture of the abundance and distribution with time of selected indicator animals began to materialize. This information was used as a basis for much of the special work conducted in the field from the research vessel.

At the request of the Director of the Hydrographic Department at Bangkok a specialist (Theodore Chamberlain) was provided by the Scripps Institution for a period of two months to conduct a short course in marine geology for personnel of that Department plus additional trainees selected by the Coordinating Committee.

A second specialist (Eugene LaFond) was provided for a period of two months to provide instruction in the reduction and analysis of oceanographic data and to demonstrate its application to practical problems in fisheries investigations. More recently (October 1962 to March 1963) an additional specialist (Margaret Robinson) has been provided from the Scripps Institution for this latter purpose under sponsorship of UNESCO.

## 5.2 Basic Oceanographic and Ecological Studies

The observations made during the NAGA Expedition, the reasons for making them, and the techniques employed have been briefly described in the foregoing sections. A summary list is presented below. The details of the work accomplished and of the results of that work as we know them at this early stage are presented in the accompanying report, Ecology of the Gulf of Thailand and the South China Sea.

In the report last mentioned numerous charts and graphs are presented to assist the reader in visualizing the quantitative and

spatial distributions and the seasonal variations in zooplankton and other biota together with the temporal and geographic variations in physical processes. The relationship of these features one with another and with the fisheries is discussed in some detail. For instance, the identification of the larval and juvenile forms of the important food fish Rastrelliger from material collected by the expedition and the study of the larval catches in plankton hauls has made possible the determination of spawning areas and seasons in the Gulf of Thailand. Charts of the bottom topography in the Gulf and in the South China Sea prepared by combining soundings obtained by the expedition vessel with existing information, present new detail of the geological features of the marine basins. The nature of the bottom sediments, their probable sources and their areal distributions are discussed (K. O. Emery and Hiroshi Nūno, 1962). The gross average standing crops of benthic organisms on various types of bottom are compared for selected areas. The seasonal variations in abundance of total fish larvae are presented and the possible adverse effect of seasonally high concentrations of some organisms on a fishery is discussed.

#### SUMMARY OF WORK ACCOMPLISHED

Oceanographic Stations (regular)	364
Hydrographic Stations (special)	66
Bathythermograph Observations	1571
Stramin net hauls (2 meter)	107
Plankton net hauls (1 meter)	515
Plankton net hauls (1/2 net)	115
Plankton net hauls (20 cms.)	35
Beam trawl hauls (6 ft. beam)	30
Beam trawl hauls (7 ft. beam)	6
Beam trawl hauls (10 ft. beam)	9
Dredge hauls (2.5 ft. dredge)	6
Dredge hauls (2 ft. dredge)	5
Otter trawl hauls (16 ft. trawl)	16
Otter trawl hauls (40 ft. trawl)	5
Rotenone stations	6
Bottom sediment (Petersen) grab samples	164
Bottom sediment (Van Veen) grab sampler	22
Bottom sediment (NEL) grab sampler	59
Gravity cores (Phleger)	48

Summary of work accomplished (con't)

Water samples for salinity determination	2813
Water samples for phosphate determination	2696
Water samples for oxygen determination	2762
Anchor stations	4
Weather observations	1571
Drift bottles released	186
Thermograph recordings	continuous underway
Recordings of bottom topography	continuous underway
Trolling	continuous underway
Dip net sampling	on station
Hand line fishing	every opportunity

5.3 Follow-up Work (SIO)

During survey cruises in the South China Sea off the coast of Viet Nam, large flocks of birds and schools of surface feeding fish were occasionally observed along the eastern reaches of the area in the vicinity ( $8^{\circ}$  to  $11^{\circ}$  north latitude) of the Flora Temple, Northwest Investigator, London and Ladd Reefs and of Spratly Island. Mid-water concentrations of fish were also observed on the echo sounder recordings. This led to speculations that the large unsurveyed area to the eastward (toward Palawan and North Borneo) might prove to be a potential fishing area and perhaps a significant source of seasonally migrating fish found elsewhere off the Vietnamese coast and in the Gulf of Thailand (as well as off Borneo and the southwestern Philippines). Analysis of the charts prepared from results of the NAGA Expedition of seasonal distribution of planktonic forms in the South China Sea shows intrusions of heavier concentrations emanating from this area, suggesting a possible region of high productivity.

Because of this, a proposal was prepared for investigation of this area which was accepted (in part) by the administration at SIO and the Geophysics Branch, ONR. As a first result, the research vessel R/V Argo was made available for a few days during her passage through the South China Sea enroute to Singapore from Manila (14-23 June 1962).

This initial investigation was limited to making an exploratory search for a clear east-west passage through the center of the area which, if found, would serve to open it up to later investigation and to making such observations for marine life as were possible.

A preliminary look at the results of this later investigation indicated that (1) a clear passage, free of navigational hazards and at least 20 miles wide does appear to run through the area, and (2) the observations of birds and of fish life on the surface and of fish at mid-water depths (heaviest concentrations at 80-130 fathoms) by their abundance add support to the desirability of extending exploratory fishing operations to this large area.

The continuously recorded soundings obtained have permitted preparation of new bathymetric charts of the area traversed. Analysis of a series of cores obtained will provide information on the character and distribution of the bottom sediments. Further analysis of the magnetometer and gravity surveys will add materially to our knowledge of the geological history of the region.

The work of systematically sorting the large collection of biological samples obtained on the NAGA Expedition for identification, cataloging and for further study has continued and is continuing. The analysis of the physical data has continued until the present. It is expected that work with the physical data will continue but at a rate determined largely by the support made available.



## 6. Disposition of Data and Collections

The bulk of the oceanographic data, the geological samples, topographical records and the collections of planktonic organisms are at the Scripps Institution. The bulk of the fish collections were transferred to the George Vanderbilt Foundation at Stanford. The organisms obtained as a result of bottom productivity studies in the Bay of Nhatrang were divided -- some being left at the Oceanographic Institute of Nhatrang and some in the possession of Mr. Ariel Gallardo at the University de Concepcion (Chile). Those samples obtained in the Gulf of Thailand on cruises S-9a and S-10 are at Scripps. Twenty-five species of preserved fish specimens were deposited at Ban Pae as a study collection for the Marine Fisheries Station (Thai) and about thirty-five species of preserved fishes were presented for display purposes to the Department of Fisheries at Bangkok. Small aliquots of some plankton samples were made available to the Department of Biology, Chulalongkorn University. Several specimens from the various collections have been made available to individual investigators for identification and study.

## 7. Recommendations

### 7.1 General

The internal policies for initiating, funding and coordinating research projects may vary widely among countries and from time to time within a country. Because of this such matters are not considered as properly lying within the scope of this report. However, the experience gained through close association with administrative and research personnel of the participating countries during prosecution of the contract has been carefully considered in evaluating the practicability of the recommendations contained in this section.

It is believed that the latent ability of the countries to carry on effectively with the research necessary to ensure eventual and orderly realization of the maximum potential of their apparently abundant marine resources has been significantly increased as a result of this cooperative effort and through its associated training program. Many sincere and capable individuals actively participated in the field and laboratory work. They have developed latent skills and have learned new ones.

Necessarily, most of the non-administrative participants were young people -- junior officers and technicians from the Departments of Fisheries and of the Navy and junior instructors from the colleges and universities. They represent a cross section of those who must be depended upon in the future development of the countries' marine resources and it is important that their new skills not be lost. Because of this dependence and because these young people do now occupy junior positions it is necessary that they continue to be motivated through encouragement, direction and support which is the unique privilege and responsibility of an informed and progressive administration.

Many agencies and institutions participated in the Marine Research program and the spirit of cooperation between them appeared exceptionally good. As elsewhere, statutory requirements define and normally limit the scope of each such agency's activities and permissible provisions in fiscal budgets are necessarily confined by the same boundaries within narrow limits. Because of this, most inter-agency cooperation in research programs must be coordinated at the higher administrative levels -- usually through the Ministries or the National Research bodies. Practical considerations of another sort frequently combine to impede efforts directed toward full utilization of the trained manpower which is available. In general, these include such diverse items as lack of equipment, reference libraries, suitable research vessels, small craft and docking facilities. The project was also hampered by physical isolation of some facilities and, perhaps, a certain understandable unwillingness on the part of many qualified people to be away from present centers of academic, cultural and social activities. To counteract this it would seem desirable to give some consideration to making research in the field and at isolated stations more attractive.

## 7.2 Basic Oceanography and Marine Ecology

### 7.2.1 Thailand

The contract field report of May 1961 contained two proposals for follow-up work by Thailand. The first of these was prepared for joint investigations to be carried out by the Naval Hydrographic Department in cooperation with the Department of Fisheries. The second was prepared for an expanded program in the Department of Biology at Chulalongkorn University. Some of the work outlined in the first proposal has been accomplished and is continuing at present on a more modest scale. Financial support to implement the second proposal is mainly lacking though a start has been made in providing advanced training for some of the young instructors in marine biology.

One of the aims of continued effort in the fields of oceanography and marine ecology is to arrive at a fuller understanding of the marine environment, its populations, the relationship of one to the other and to apply this knowledge to increasing the economic welfare of the country. To accomplish this as rapidly as desired it is necessary to increase the numbers of trained personnel, the level of training, the facilities, the support and the emphasis on field investigations. Because the number of people and the subsequent effort required to process and evaluate the data from field investigations may exceed the number required to accumulate them by a large factor, the two aspects must be considered together if we are to avoid excessively large accumulations of undigested material.

The background of the Naga Expedition provides a basis for planning continuing programs, both those designed for general coverage and these having more limited objectives. Some of the more basic objectives which should be included in continuing programs are listed below.

#### 7.2.1.1 Objectives

a) Determination of seasonal and annual variations in environmental factors by repeated monitoring of selected fixed stations.

b) Determination of seasonal and annual variations in the abundance and in the general distribution of zooplankton by repeated monitoring of selected fixed stations on as wide a grid as possible but at frequent (perhaps monthly) intervals.

- c) Determination of the extent and periods of upwelling and other related processes and their biological importance both in the Gulf and in the coastal area of the Andaman Sea.
- d) Determination of ecological factors of importance to the demersal fisheries by intensive bottom sampling and oceanographic observation and of the long term and season effects of silting and run off.
- e) Investigation of mineral, petroleum and like resources in the Gulf and on the continental shelf area of the Andaman Sea.
- f) Determination of diurnal and seasonal variations in the current and circulation patterns by direct measurements with drogues and drift bottles and from repeated observations at selected anchor stations using current meters.
- g) Improvement of navigational charts and the delineation of areas most suitable for bottom trawling from the standpoint of bottom topography by closely spaced and precisely positioned soundings using modern echo sounding equipment.
- h) Development of a comprehensive program of research on the ecology and dynamics of population of Rastrelliger and other important pelagic fishes.

#### 7.2.1.2 Additional Considerations

A few of the local factors which have bearing on the attainment of the above listed objectives and on the prosecution of other programs are included below.

##### a) Marine Stations

Royal Thai Navy Hydrographic Department Marine Station at Sattahip. The physical plant for this station was already completed in early 1959 except for utilities, furnishings and laboratory equipment. The location of the station directly on the waterfront of a protected bay with nearby docking space, the availability of the supporting facilities of a large naval base plus ready accessibility to the Gulf makes it potentially a most attractive center for a Naval Marine Physical Laboratory.

Its distance from the present center of Departmental activity in Bangkok, some four hours by car or eight hours by boat, is a minor disadvantage from the standpoint of administrative supervision. It could be manned by a permanent, locally based, staff. Early consideration should be given to providing the necessary funds and people to equip and man this station.

Royal Thai Navy Hydrographic Department Marine Station at Hua Hin

This station fronts directly on the Gulf on the western coast, opposite to the station at Sattahip, and about sixty-five miles distant by water. It is somewhat further from Bangkok by road than the Sattahip station. The adjacent town of Hua Hin is a well known summer resort and is easily reached from Bangkok by rail, bus or by car. There are no dock facilities either at the station or the town but a "long pier" built out over the gently inclined sandy beach to deeper water could provide needed dock space for both the Naval Station and the adjacent Marine Laboratory belonging to the Chulalongkorn University.

During the period of the Marine Survey (1959-1961) the station was kept in a "caretaker" status except during the hot season. It has adequate facilities for housing a reasonably large staff plus space for a laboratory. It might be necessary to increase the capacity of the electric power and water utilities if a full time research staff were added. This should be encouraged.

Chulalongkorn University Marine Station at Hua Hin. This station is located on the beach front on the property adjoining the Naval Station and just to the north of it. The physical plant including laboratory, apartments and cabana-type dwellings is of recent origin and in excellent shape. Like the Naval Station, this laboratory was kept in "caretaker" status most of the year.

There is no natural harbor or other protection to the waterfront at either of the two stations. They are open to the Northeast Monsoon but adequately protected from most Southwest Monsoon conditions. The construction of a pier would be a most useful addition to the inherent capabilities of the laboratories and should present no major engineering difficulty though the upkeep might require somewhat more attention than would one in a less exposed location.

Chulalongkorn University Marine Station at Ang Sila. This station is located on the eastern side of the upper Gulf, above Sattahip, and closer to Bangkok. The physical plant is of recent origin and is still being slowly expanded. The station is equipped with a seawater pumping system and twenty-four aquaria for research purposes and for public display. A small new laboratory building provides ample space for perhaps two senior investigators plus research assistants. Additional rooms in the laboratory building can be used to expand the research potential or to house single investigators. There are housing accommodations suitable for a family of about five persons plus the caretaker's cottage. Additional "dormitory-type" facilities and additional

messing facilities are in the plans for the future. As is the case with the stations at Hua Him, no docking facilities are provided and shoal water extends for some distance out from the beach. No permanent staff other than caretakers are assigned to the stations and no equipment other than usual utilities and the new aquaria has been provided.

In summary then, there are four marine stations (not counting Fisheries stations) in the upper gulf. Combined, they offer a great potential for additional marine research if and when they can be properly staffed and equipped. Every reasonable encouragement should be provided to see that this is accomplished.

b) Reference material

With the possible exception of the Oceanographic Institute at Nhatrang Vietnam, there is an urgent need for adequate reference material - - libraries and collections. It is expected that a reference collection of marine animals will become available from the results of the contractor's work. There is still the unanswered question of a suitable place in which to house and care for such collections. The availability of reference books and similar material in most disciplines is woefully inadequate for present needs and can only get worse as the numbers of students and research workers increase unless funds can be made available for purchase and adequate space provided for storage.

c) Staffing of isolated laboratories

If the research and field investigations in the marine sciences are to catch up with the present need and to keep pace with the future needs for the economic development of the marine resources then the underlying reasons why the existing marine stations and laboratories remain understaffed or without any staff at all, must be thoroughly investigated and whatever steps are necessary to alleviate the problem must be taken.

d) Research Craft

Research craft may be classified for purposes of discussion in this report as small-craft, medium-range and long-range.

Small-craft. To encourage work close offshore, and around nearby islands, off-lying reefs and shoals when research workers are at the marine stations, one or more suitably powered small craft should be made available. At least one sixteen-foot skiff with outboard motor plus

one thirty-five to forty foot inboard launch should be provided for this purpose at each station. Equipment suitable for use from small boats should be furnished.

Medium-range craft. Both the Navy and the Fisheries Department have suitable craft in the range fifty to ninety feet for operations of three to six days extent and, with logistic support, for longer periods. However, neither the universities in Thailand nor in Viet Nam have vessels in this range nor does the Oceanographic Institute at Nhatrang. It is possible that cooperative ventures could be arranged between the universities and the Departments of the Navy and Fisheries but because any such arrangements would necessarily be at the convenience of these latter Departments it would seem desirable to consider as well the development of some other or additional means for providing such services. Until such time as the separate institutions are prepared to operate their own vessels it is possible that one such vessel in each country could be operated by or under the direction of the respective National Research body.

Long-range craft. Because both Thailand and Vietnam are principally concerned with development of those marine resources in and adjacent to their respective or mutual waters it seems reasonable to define a long-range craft as one of about 300 gross tons (the approximate size of the Scripps vessel Stranger which could carry a scientific staff of eight or ten and which could be expected to remain at sea for periods of three or four weeks at a time and 150 to 180 days per year. One such vessel in each country dedicated to research, both basic and applied and so funded as to provide the necessary flexibility of operation would probably suffice for the immediate future. The flexibility spoken of is taken to mean, for example, that the vessel not be committed wholly to specific areas of applied research such as purely fisheries or purely military. It should be possible for it to spend some time on projects of this nature but it should also have significant time allocated for university type projects of any nature designed to increase understanding of the marine environment and of the communities that dwell therein.

Because of conditions existing in Viet Nam it might be necessary for such a vessel to operate under Naval control for the present or in cooperation with some international agency. If the latter, then consideration might be given to operation on a regional basis.

### 7.2.2 Viet Nam

A program for expanding marine research investigations in Viet Nam was presented at the marine science meeting held in Saigon in 1959. This was presented as a joint program of the Faculty of Science University of Saigon and the Oceanographic Institute of Nhatrang. Definite plans of more recent origin are not available at the Scripps Institution but personal communications indicate that activity at Nhatrang will continue at about its present level for the foreseeable future with a possibility of some increase if the plans for a new regional project get going.

As of January 1963, the Oceanographic Institute at Nhatrang did not have a research vessel in commission and it has been many years since a sea-going vessel has been assigned there. The small vessel (Mao Tien) previously used by the Institute for work in the bay and around the nearby islands in the bay was to be replaced by two small craft supplied by FAO and these were awaiting repairs before being put to use. A proposal that a larger vessel be supplied by the U. S. Government has been lying dormant for some time. Considering the existing military situation and other factors it is not clear by whom or on what basis a sea-going research vessel, if made available, would be operated. Nevertheless it seems clear that without such a vessel needed investigations in the offshore regions are not possible.

In Viet Nam research in physical-chemical oceanography is carried out by the Physics-Chemistry Laboratory of the Oceanography Institute of Nhatrang, the Departments of Physics and Geology of the faculty of Science University of Saigon and in consultation with the Navy, the Hydrographic Service and the Meteorological Service. Research in marine biology is conducted in the laboratories for Botany and Plankton at Nhatrang and is directed by the Heads of the Departments of Botany and Zoology of the Faculty of Science at the University of Saigon. Fisheries biology is studied by collaboration between the Fisheries Direction and the Fisheries Research Bureau of the Oceanographic Institute.

Each of the Departments and Agencies mentioned above has indicated a need for additional assistance for continuing and expanding investigations in the fields with which they are concerned. Assistance needed includes additional training of personnel, provisions for sea-going facilities, additional laboratory and field equipment, periodic assistance of specialists and financial support.

During the past twenty years, preliminary studies have been conducted on hydrology and ocean currents, on the geology of off-shore



islands and on the topography of the continental shelf area. Particular attention has been paid to the topography of the sub-marine prolongation of the Mekong valley. Measurements of sea water temperature and salinity at fixed locations in the Bay of Nhatrang have been made routinely. More recently has been added research on seismology and a systematic study of ocean waves. The Hydrographic Service is in charge of tide recordings and the Meteorological Service of the routine checking at coastal stations.

It is planned to extend the routine oceanographic investigations to offshore oceanic areas and by organizing a more systematic analysis of temperature, salinities, dissolved oxygen content and of phosphate to gain a better insight into the oceanic circulation in Vietnamese water. This plan envisions also the direct observation of currents by current meters and the use of drift bottles. A study of seasonal upwelling in the area of Cape Varella is included.

It is hoped that further analysis of the short and long-period seismograph records together with analysis of wave recordings, will open up a new field of research on the morphology of sea movements.

There is a strong interest in expanding mineralogical studies of recently submerged continental formations, variations in the submarine topography and in exploration of nearby submarine volcanism. The Navy is particularly interested in coastal waves, wave predicting and in precise surveys of the coastal area. The Hydrographic Service is interested in precise determinations of mean sea levels.

In marine biology one of the principal efforts has been directed towards a systematic inventory of all available species (Taxonomy) but the effort is now being gradually oriented toward bionomy and ecology. In planktology it is hoped to systematize and extend the sampling program and to identify and catalog the samples. Quantitative and qualitative studies of the collections will be made and correlated to physical parameters. The reference collections of marine fauna reflect the results of the past twelve years activities. Of 5,000 recognized species living in Vietnamese waters some 3,500 are represented in the present collection of 42,000 specimens. Taxonomic studies at the Institute have led to the description of nearly 500 species, new to science, since its foundation. It is expected that this work will continue until the reference collection includes at least the 5,000 known species.

In the field of botany, the original inventory of marine plants by DAWSON consisting of some 200 species has been increased until there is now some 350 species represented by about 2,000 herbarium specimens. This work will be extended by further exploration of the coastal area and in connection with planned expanded studies of coastal ecology.

### 7.3 Fisheries Research and Development

The general background of the Department of Fisheries of Thailand has been described in some detail in foregoing sections of this report. In the preceding section it was stated that fisheries biology in Viet Nam is a cooperative effort of the Fisheries Direction (Department of Fisheries of Vietnam) and the Fisheries Research Bureau of the Nhatrang Institute.

The work of the Fisheries Direction is, at least for the present, especially oriented toward the immediate increase in production dictated by the growing demand for more food. Its principal research effort has been directed toward the breeding of fish in fresh and brackish waters. A smaller effort has been directed towards marine fisheries biology. Some research has been conducted on the tunas and the shrimp and it is planned that these studies will be extended to other species of commercial interest.

During the period of Naga Expedition the Director of Research (trawling) expressed considerable interest in the possibilities of increasing the catch of bottom fish in the near shore areas, and of extending trawling operations farther offshore and to new areas. To permit evaluation of such possibilities it is required that a careful survey be made of the bottom topography in depths of water where commercial trawl gear can be used, that intensive sampling for productivity studies be made and that experimental trawling in the proposed areas be conducted. Three promising areas along the Vietnamese coasts where such studies might be initiated are:

- 1) The continental shelf area east of Tourane and south to about latitude 15 degrees north.
- 2) The shelf area east of Cap St. Jaques at the mouth of the Saigon River and southward to Camau Point including the area surrounding the Poulo Condores.
- 3) The area in the Gulf of Thailand extending westward from Camau Point and northward to include Phu Quoc Island.

Extensive bottom productivity studies made in the Bay of Nhatrang during 1960 provided a great deal of experience in this type of investigation for the people at the Oceanographic Institute. Experimental trawling activities conducted by the Thai-German team in the upper Gulf of Thailand during the same period could serve as an example for investigation of the Vietnamese waters.

The proximity of deep water off the east coast of Vietnam and the presence of numerous banks (both deep and shoal), islands and reefs suggest the desirability of orienting a reasonable amount of the fishing effort of Viet Nam in this direction. Thailand has a similar potential in the Andaman

Sea which should be investigated.

The program for Rastrelliger investigations by the Department of Fisheries of Thailand would be a useful model for similar investigations by Viet Nam and the continued cooperation of the two countries in developing the fisheries in their respective spheres of influence in the Gulf of Thailand would be of considerable mutual benefit.

There is a need, recognized by both Thailand and Vietnam, to increase the extent and accuracy of catch statistics.

In the field of fisheries research and development the problems facing all the countries bordering on the Southeast Asian seas parallel each other in so many areas that there is a decided need and advantage to continued and expanded cooperation.

#### 7.4 Coordination - General

In general, the coordination of marine research and associated activities is desirable and necessary both at the national and at the international levels. However, some agencies and institutions have developed both capabilities and requirements over a period of many years while others have only more recently entered the field in a serious way and their ultimate direction, capabilities and requirements are not yet well known. Because of this, whatever plan is eventually adopted must be subjected to critical review at reasonably frequent intervals. While the indiscriminate expansion of effort in all directions by individual agencies is to be avoided, coordination must not have as its prime objective the fixing within narrow limits of boundaries for different areas of investigation. It must provide as well the flexibility necessary to permit getting along with essential work in the absence or redirection of effort on the part of one or more members to the partnership who normally supply some service or provide the know-how in specific fields.

##### 7.4.1 National Agencies and Institutions

The Naga Expedition succeeded in training a fair number of nationals selected by local administrative officials to form a reservoir of talent capable of carrying on with needed field investigations. It drew the attention of the officials concerned to the potentialities of the marine resources available for development and excited the interest of many others whose cooperation is needed in support of continuing programs.

Of equal importance, the expedition provided a practical demonstration of the extent of the effort involved both in the field and in the laboratories in conducting long continued marine investigations. At the same time, by lifting the mystical veil which hangs between the classroom and the deep sea, it increased the confidence of the participants both in their ability and in the ability of relatively simple equipment to perform in an

acceptable manner.

By bringing members at all levels of the various agencies into close association - - many apparently for the first time, it broadened individual acquaintanceship and developed a better understanding of mutual or associated areas of interest. In doing this it provided senior administrators and investigators an opportunity to review their own programs and the potentials of their respective personnel and facilities and to consider more fully how these potentials might be increased through close inter-agency collaboration.

#### 7.4.2 International Cooperation

With the qualifications necessary for extension beyond the limits of national boundaries most of the foregoing discussion could be repeated here. Admittedly the complexities involved in extending cooperation from the field of national agencies to cooperation between governments are of a different order of magnitude, but there is a growing recognition of the fact that the marine environment, like the atmosphere, is highly mobile, that both are of international concern and that the solution of their many complexities can best be achieved by the cooperative effort of nations.

Deep-sea world-wide expeditions traversing the Southeast Asian Seas have contributed greatly to our knowledge of the biological and physical oceanography of the region. These efforts however, because of their transient nature, have only served to bring into relief the vastness and complexity of the scientific information remaining to be assembled before even a general assessment of the potential yield in marine resources or an understanding of the environmental factors affecting this yield could be made.

Long continued systematic investigation of the area is prerequisite to any plan for rational exploitation and management of the marine resources of this vast and populous region. The Naga Expedition has been a step in the required direction and as a pilot project the experience and impetus gained should now be capitalized upon without unnecessary delay.

The report of the "Regional Meeting of Specialists in Marine Sciences" held in Saigon in January of 1959 under the sponsorship of UNESCO contained a proposal for a five-year program to follow and expand the work of the Naga Expedition. This proposal recommended use of a single, internationally supported, vessel for continuous general survey with cooperating vessels contributed by participating countries implementing its work by operations in local waters and by repeated monitoring of

selected stations to provide synoptic coverage at intervals dictated by variations in important environmental factors.

Because of an expansion in the effort and funding for investigations in the Indian Ocean, the proposal for the program in Southeast Asian waters was sidetracked. However, new plans for a regional program are now being discussed in Thailand, and it is understood that government invited to consider participation include Viet Nam, Malaya, the Philippines, and Hong Kong. The government of the British territories in North Borneo have also expressed an interest in such a program. We wish these friends every possible encouragement and success.

8. Appendix

8.1 List of Progress Reports

- 8.1.1 Project Commentary on Marine Resources  
Survey and Preliminary Report of Cruise S-1 in Gulf of Thailand;  
Bangkok, Thailand, November 1959.
- 8.1.2 Project Notes and Preliminary Report Cruise S-2, South China Sea;  
Bangkok, Thailand, January 1960.
- 8.1.3 Naga Expedition. Progress Report and Preliminary Report of Cruise  
S-3, in Gulf of Thailand. Bangkok, Thailand, February 1960.
- 8.1.4 Naga Expedition. Preliminary Report Marine Research Cruise S-4 and  
Summary Status Report of First Year's Operation. Bangkok, Thailand,  
April 1960.
- 8.1.5 Naga Expedition. Progress Report and Preliminary Report of Cruise  
S-5, in Gulf of Thailand. Bangkok, Thailand, May 1960.
- 8.1.6 Naga Expedition. Progress Report and Preliminary Report of  
Cruise S-6 in South China Sea. Bangkok, Thailand, July 1960.
- 8.1.7 Naga Expedition. Progress Report and Preliminary Report of  
Cruise S-7 in Gulf of Thailand. Bangkok, Thailand, August 1960.
- 8.1.8 Naga Expedition. Progress Report and Preliminary Report of  
Cruise S-8, South China Sea. Bangkok, Thailand, October 1960.
- 8.1.9 Naga Expedition. Progress Report and Preliminary Report of  
Cruise S-9, Gulf of Thailand. Bangkok, Thailand, December 1960.
- 8.1.10 Naga Expedition. Progress Report and Preliminary Report of  
Cruise S-9A, Gulf of Thailand. Bangkok, Thailand, January 1961.
- 8.1.11 Naga Expedition. Progress Report and Preliminary Report of  
Cruise S-10, South China Sea. Bangkok, Thailand, March 1961.
- 8.1.12 Naga Expedition. Field Report. Bangkok, Thailand, May 1961.

- 8.1.13 Naga Expedition, Interim Report, 7 May 1959 to 6 March 1960, by the George Vanderbilt Foundation, Stanford, California.
- 8.1.14 Naga Expedition, Semi-Annual Report of the George Vanderbilt Foundation. 6 March 1960 (with additions to 6 September 1960).
- 8.1.15 Naga Expedition, Progress Report. April-May 1960. George Vanderbilt Foundation. Bangkok, Thailand.

8.2 Enclosures.

8.2.1 Enclosure No. 1

Coordinating Committee meeting (Viet Nam) held in  
Rectory of University of Saigon on 20 January 1959.

Attending:

Dr. Anton Bruun

Captain James L. Faughn

Dr. Nguyen Quant Trinh

Mr. Nguyen Dinh Hung

Mr. Pham Hoang Ho

Dr. Roule Serene

Mr. Nguyen Hai

Dr. R. Benoit

Lt. Le Phung (NVN)

Mr. Nguyen Minh Truyet

Dr. Le Von Thoi

Dr. Ngo Ba Thanh

Dr. Hoang Quoc Truong

Dr. E. M. Saurin

Mr. Do Donh Cuong

Mr. Nguyen Van Chi

Mr. Do Ba Khe



- 8.2.2 Enclosure No. II  
Coordinating Committee meeting (Thailand) held at Department  
Fisheries, Bangkok, on 21 January 1959.

Attending

Dr. Anton Bruun  
Captain James L. Faughn  
Mr. Boon Indrambarya  
Prof. Suprachai Vanitch Vadhana  
Dr. G. Moore  
Mr. Chinda Tiammeth  
Mr. Tuan Tai Bumrabarinpai  
Mr. Burlin Hamer  
Commander Jansen (U. S. Naval Attache)  
Commander Janzen (Jusmag)  
Dr. J. A. Tubb (FAO)  
Captain Amporn Penyapol  
Lt. Cdr. Sak Thalongasuk  
Mr. Samrong Savetserani  
Miss Saengdeun, recorder  
Representative of Public Relations Department

- 8.2.3 Enclosure No. III  
Meeting held in Office of the Director, USOM, Bangkok,  
24 January 1959.

Attending

Dr. Anton Bruun	SIO
Captain James L. Faughn	SIO
Captain Amporn Penyapol, RTN	RTN
Mr. Burlin Hamer	USOM
Mr. Holmes	USOM
Mr. Axford	USOM
Mr. Shabsin	USOM

8.2.4 Enclosure No. IV  
Southeast Asia Panel (SIO)

Dr. Milner B. Schaefer	Director, Inter-American Tropical Tuna Commission (Chairman)
Dr. Elbert H. Ahlstrom	Director, La Jolla Marine Laboratory, Bureau of Commercial Fisheries
Dr. Douglas L. Inman	Professor of Marine Geology, SIO
Prof. John D. Isaacs	Director, Marine Life Research Program, SIO
Dr. Warren S. Wooster	Professor of Oceanography (SIO) and Director Oceanographic Section, UNESCO (Paris)
Mr. Garth I. Murphy	Ex. Secretary of the California Marine Research Committee