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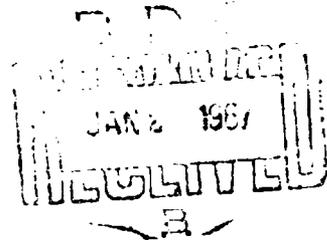
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MARINE AND LIFE SCIENCES IN INDIA

By JOHN D. COSTLOW, Jr. and AUBREY W. PRYCE

12 December 1967

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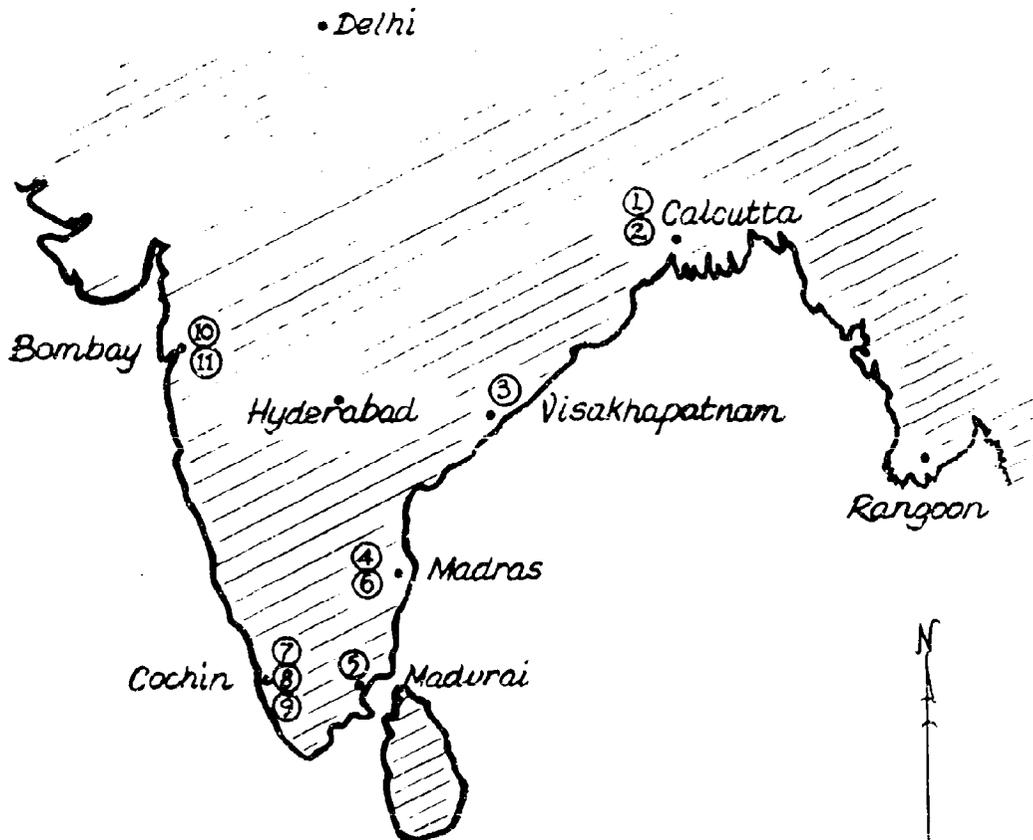
MARINE AND LIFE SCIENCES IN INDIA

The review, understanding, and appraisal of the marine and life sciences in India from visits to eleven institutions during a two-week period is comparable to an appreciation of oceanic plankton based on an examination of a 10-cc aliquot obtained from a tide pool. However, realizing that visits to even a limited number of facilities in this tremendous country are not an everyday occurrence for most US marine scientists, this report will attempt to describe the staff of these institutions, their research interests, the facilities which are available for research, and certain general trends which appear to be valid observations. Beginning in New Delhi, both for the sake of convenience and because most of the central government offices are there, the internal air line, India Air Lines, provides excellent service to most of the locations of major institutions involved in research and training in the marine sciences (see Fig. 1) or sufficiently close to permit ground transportation the remainder of the way. These included:

1. Zoological Survey of India, Calcutta
2. India Statistical Institute, Calcutta
3. Andhra University, Waltair
4. University of Madras, Madras
5. University of Madurai, Madurai
6. Porto Novo
7. Indian Ocean Biological Center, Ernakulam
8. National Institute of Oceanography, Ernakulam-Cochin
9. University of Kerala, Department of Oceanography and Marine Biology
10. Bhabha Atomic Research Center, Trombay, Bombay
11. Haffkine Institute, Bombay

One of the major marine laboratories on the East Coast, Porto Novo, was not visited because of the limited time, but a short resume is included here from published sources.

Figure 1



This report presents much detail on research, scientists, facilities and, to a certain extent, programs in the marine biology and life sciences area in India. Perhaps fortuitously consistent with the Indian scene, however, the report itself presents no general picture or conclusion except perhaps one of confusion. Some more general impressions of this scientific community, its efforts and attitudes are therefore in order.

Science in India has developed in line with British scientific policies which prevailed there for over 100 years. Indeed, "Indian science" is only some 20 years old. British influence is reflected in science as in so much of the government structure by similarities in organization and function. Undoubtedly, since Independence, much increased planning has been directed towards organization, long-term research programs and the problems of providing competent scientific personnel from the younger scientists who are completing their education. Despite this, however, and the fact that almost all government support is based on 5-year plans, fragmentation appears to be the order of the day at the working level. One feels that discussion and plan have become all-important, perhaps even to the detriment of science itself. One cannot help but feel that perhaps too much responsibility has been accepted by too few, resulting in weakened leadership.

Typical, perhaps of the problems experienced in this type of planning is the treatment of the following figures: one university's request to the University Grants Commission for 16 crore* for a five year period. 1.4 crore was approved, of which approximately 0.15 crore would be provided by the state government. Of the 1.3 crore to be allocated by the UGC, they were only able to make available 0.9 crore, and on the basis of previous experience it was generally expected that this would be the operative level.

At a crucial time when the universities have been given the responsibility of educating large numbers of students, conflict has developed between teaching and research. In many places the concern for developing research facilities and positions appears to have overshadowed the basic role of teaching students at the undergraduate level. Despite central planning, there is a high degree of "in-breeding" within individual state universities, and exchange of professional staff between universities in different states is rare. In the future, this may be further aggravated by the potential emphasis on regional languages rather than English as a central language.

* 1 crore = 10^7 rupees = 10^2 lakh = \$1.4 million.

India is well recognized as a land of contrasts. In the scientific arena there are both incredible contrasts on the one hand and surprising efforts at obtaining uniformity on the other. In some instances, interest in the major goal appears to be obscured and indeed, in conflict with the detailed aspects on which the ultimate achievement must depend. For example, the Indian Statistical Institute, which has an avowed objective of contributing toward the understanding, appreciation and use of statistical methods in Indian science generally, has developed a sophisticated research program covering many aspects of statistics. Despite its efforts to feed this knowledge out through research units established to cover specific scientific fields, the vast majority of publications from other scientific institutions continues to be devoid of even the simplest form of statistical analysis in terms of experimental design, the analysis of results, or in the expression of their conclusions.

In certain institutions one has the feeling, in spite of an apparent enthusiasm and professional pride in facilities and research effort, that the atmosphere is largely a carefully cultivated front which accepts the presence of elaborate equipment as justification of the scientists' ability and existence, without regard to the fact that it may never have worked properly or have provided any scientific results. This same front is manifest in the case of some individuals who contend that they should not be required to spell out research plans and needs in order to qualify for financial support; but that this should be automatic on a basis of the esteem and reputation which they believe they individually merit. On the other hand, there are research centers where, with a minimum of foreign currency support, equipment has been built up on the scene, works effectively, and, indeed, reflects a high degree of experimental ingenuity, comparable with anything to be seen elsewhere.

Many of these younger scientists are keenly aware of their responsibilities and are trying desperately to improve the situation. At Madurai the attitude of the professor encourages the students to question, criticize, and attempt to see the problems in the light of the many aspects of Indian life which they inevitably touch upon. At the Haffkine Institute in Bombay, one has the feeling that there is real competence and good research, in spite of the tremendous obstacles which face the Institute. On the other hand, in some research institutions one got the impression that many individuals were caught up in the methodical execution of a prescribed pattern of behavior, going through the well-worn motions of surveys and analyses without any real concept of why or to what use the information might be put.

Despite the myriad problems, the long-term scientific potential in India is impressive, and every effort should be made to assist in its development. It is undoubtedly basic to the nation's economy and future. However, it must be recognized that the Indian scene and problems are very, very different from those with which we are familiar in the US and Western Europe. That science and technology have a major part to play in the

development of India is a (if not the) focal point of Indian government economic policy. In consequence, scientific training has been promoted on a broad scale. Clearly, however, major problems can develop if this training cannot be utilized, and India appears to be in this position at the present time.

ZOOLOGICAL SURVEY OF INDIA, Jabakusam House, 34 Chittaranjan Avenue,
Calcutta-12

The ZSI, directed by Dr. A.T. Kapur, an entomologist, is one of six scientific surveys of the Government of India, and traces its origin to the Asiatic Society of Bengal which was organized during the middle 1800's. There are a number of divisions within the Survey, following the traditional phylogenetic lines, and, although marine biology and oceanography received considerable attention during the period of earlier directors such as Lt. Col. R.B.S. Sewell, the Marine Survey Division is of relatively recent origin. Established in 1958, the Division was intended to provide new impetus to the survey work on marine fauna and to initiate ecological studies in Indian waters. Within the last six years the permanent staff has increased to four research officers and four scientific assistants, under the direction of Dr. Augustine Daniel, Superintending Zoologist.

Daniel, an experienced and active marine zoologist, has been involved in research on the taxonomy, life history, and biology of barnacles with special reference to problems of wood-boring and fouling. He has also been engaged in studies on zooplankton and on animal associations in collaboration with other members of the staff. At the Symposium in March on the Indian Ocean Expedition, Daniel presented a paper with his wife, R. Daniel, on the siphonophores collected during one of the cruises of the Russian Vessel VITYAZ.

Dr. A.K. Nagabhushanam, who has only recently joined the Division, has been involved with studies on the taxonomy and ecology of marine fish. More recently, he has become interested in pelagic tunicates of the Indian Ocean, and has described nine species belonging to two families which were collected during a cruise in the eastern portion of the Ocean by the R.V. VITYAZ.

Dr. G. Chandrasekhara Rao, formerly associated with Andhra University, Waltair, is interested in the interstitial fauna of the East Coast of India. Publications of some of his research report on the taxonomy, ecology, and physiology of kinorhynchs and polychaets found in the sandy beaches of the Waltair area.

The fourth member of this Division, Mr. Rama Rao, is working on the taxonomy of two groups of poisonous fishes, the Scorpaenidae and Plectognaths, which are available in the collections of the Survey.

Of the Senior Zoological Assistants, one, Mr. Premkumar, is working with Daniel on the taxonomy of Brachyuran crabs and the second, Mr. Surya Rao, has undertaken research on marine amphipods since his recent appointment to the Division.

Although the Marine Survey Division is the only one devoted exclusively to studies on marine animals, there are members of the staff of several other divisions who are engaged in research along similar lines. Dr. Datta, in charge of the General Non-Chordate Section of the Lower Invertebrate Division, has been trained as an ichthyologist, and after a lapse of several years, is beginning some work on the taxonomy of marine sponges. Mr. Sudarshau, who prior to his association with the ZSI was involved in studies on fish eggs and larvae, is now making a taxonomic survey of the Chaetognaths. Among the assistants, Mr. B.P. Haldar is working up the taxonomy and morphology of the Sipunculida and Echiurida within the Survey collections. Mr. Ch. S. Roy is beginning a survey of the anemones and Mr. S. Mukhopadhyay is planning to take up work on marine hydroid colonies.

Within the Crustacea and Mollusca Sections there are several staff with interests in the marine fauna. Dr. U. Kutty has been involved in studies on taxonomy, morphology, and distribution of marine copepods. Dr. H.C. Ray, the Superintending Zoologist of the Division, is a specialist on the Gastropoda and Mr. Rajagopal, head of the Mollusca Section, has previously occupied most of his research efforts with the woodborers, the Teredinidae. Lately, he has also begun some work on the nudibranchs. Mr. Murthi, previously associated with Andhra University, is continuing his work on the taxonomy, life history, and physiology of the Polyplacophora. It is understood that he expects to take a leave from the Survey in the near future to work in the US.

Within the Lower Chordata Division, Dr. A.G.K. Menon has had considerable experience in the taxonomy of several groups of marine and freshwater fishes. Menon, Superintending Zoologist of the Division, has recently left the ZSI to work at the US National Museum for one year. Dr. Talwar, head of the Marine Fish Section and a recent addition to the Division, is especially interested in the fishes of the family Sciaenidae. Two additional ichthyologists, although not actually associated with the Marine Fish Section, are engaged in research on marine fishes. Dr. K.S. Misra, who retired some years ago, is preparing a revision of the Fishes of India with Dr. M.A.S. Menon, a member of the freshwater fish section, which will be published in the Memoirs of the Indian Museum. Dr. Menon is also independently engaged in research on the taxonomy and zoogeography of marine fishes.

Although the Division of Ecology and Wildlife is not directly concerned with the marine environment, the Superintending Zoologist, Dr. K.K. Tiwari, is considered to be an authority on Crustacea, primarily the Decapoda. At the present time he is preparing a monograph on Indian Brachyura in collaboration with Dr. R. Serene, UNESCO Marine Animal Taxonomy Expert for Southeast Asia.

Two members of the ZSI staff associated with the Southern Regional Station at Madras are working on ecology and taxonomy of still other groups of marine animals. Dr. Reddian is interested in the ecology of molluscs, and is also involved in a study of semiparasitic copepods associated with other marine invertebrates. Mr. Sivaprakashnam is interested in the taxonomy and morphology of marine amphipods.

Last, but certainly not least in this predominately male society, is the one woman on the staff, Mrs. R. Daniel. She is a research fellow, interested primarily in Siphonophora, and is preparing a monograph on the Indian species of this group. She and her husband, Dr. A. Daniel, are collaborating on the Siphonophora material from the collections sorted out at the Indian Ocean Biological Centre at Cochin.

Inasmuch as the Zoological Survey does not have a marine laboratory, the field work has been restricted to survey tours to the coast or through the use of Indian Navy vessels when they might be available. Some regularity has been observed in the survey work since the establishment of the Marine Survey Division in 1956, but a number of occasional field surveys have been made by individuals in other divisions and sections, as well as mixed efforts.

Over the last few years a stock of basic equipment for marine biological field work has been acquired. This includes bottom grabs, dredges, plankton nets, a Clarke-Bumpus sampler, a beam trawl, a few Nansen bottles with reversing thermometers, a current meter, an underwater illumination meter, etc.

Within this same period 10 coastal surveys have been conducted by the Marine Survey Division, lasting from 10 days to three months, and groups from the other Divisions have organized five other surveys. Reports of these investigations, submitted to the Director, give a detailed account of the field work accomplished, descriptions of the areas and sampling stations, and data on the nature, size, and composition of collections. In some cases temperature, salinity, oxygen, and pH were recorded for the coastal waters.

A few ocean cruises have been made aboard the Indian Navy vessels KISTNA and JAMUNA, as well as the USSR, R.V. VITYAZ research vessel. During most of these, sampling was limited to plankton hauls; but on a few, sampling of bottom fauna could be successfully carried out.

In some of the sections of the ZSI, important collections of marine fauna are maintained. The main sources of these collections are donations from the original Asiatic Society of Bengal, as well as other institutions, and as a result of the survey work carried out over many years by the survey vessel INVESTIGATOR at the time of the Surgeon Naturalists. The total number of marine types is considerable. The most important groups represented in this type material are Mollusca (926), Crustacea (?), Pisces (198), Porifera (273), Coelenterata (207), Echinodermata (283), and Pycnogonidae (12). Marine material which has been identified is

estimated to approximate 10,000 species in the mollusc section, and 2,500 - 3,000 in the crustacean section. Most of the sections also retain unidentified material in the collections. The bulk of the collections is preserved in alcohol, but in the mollusc section about 50% of the material is in the form of dry shells.

The library of the ZSI, on a relative basis, is quite large, consisting of 35,000 bound volumes. Of the 700 journals which are received, approximately 80 deal with the marine sciences. Modern reference texts in this area, however, are not well represented.

The Survey has a number of publications, some of which have been available for many years and have international reputation. These are:

Records of the Indian Museum: a quarterly journal of zoology, now in its 60th volume.

Memoirs of the Indian Museum: a journal of zoology, primarily for monographic works. It is published irregularly and is now in its 14th volume.

Annual Reports of the Zoological Survey of India

Fauna of India. Monographs on Indian fauna (formerly the Fauna of British India).

Quarterly Bulletin of the Zoological Survey of India: now issued on a half-yearly basis, it is a cycle-styled bulletin containing accounts of the current activities of the Survey.

Bibliography of India Zoology: Annual bibliographies, beginning in 1958.

Miscellaneous publications

The Survey has recently received financial assistance from UNESCO for the establishment of a central card index for zoological specimens, and has been recognized as a center for South Asia for key zoological collections.

A number of scholarships are available within the ZSI, primarily designed as training programs in the field of taxonomy. According to the Third Five-Year Plan, the ZSI should provide ten, one-year scholarships. Eight, three-year scholarships are provided by the Government of India. These are available to MSc graduates, selected by a committee composed of the Director and two university professors. I understand, however, that normally only a small number of these are filled. The explanation given by one Indian scientist suggested that it reflected the general lack of interest in taxonomy, the relatively low financial scale associated with

the scholarships, and the difficulty in using them toward partial fulfillment for the requirements of the Ph.D. During the first year, the research scholars receive general training under the supervision of the section head, including basic principles of taxonomic work, conduct of field collections, taxidermy, and literature studies. During the second and third years, time is allotted for more specialized training in the different sections. One of the objectives of the program is to provide for the recruitment of new staff members, but unfortunately, it is apparently difficult to find support or vacant posts for them in the specialized areas of research when their training is completed. During the past four years, two one-year scholarships and ten three-year scholarships have been awarded, all in the non-marine sections.

Through the tremendous effort expended on the Indian Ocean Expedition, interest in the marine sciences has increased considerably in India, but the long-term task of further extending the knowledge of the Indian Ocean must be carried out by Indian institutions. The portion of the responsibility which most logically falls on the Zoological Survey of India is the continued development of a sound faunistic background from which other specialized disciplines can evolve. Kapur obviously has the ability and interest, and the enthusiasm which was displayed by the staff of the Marine Survey would suggest that it will be a job well-done.

INDIAN STATISTICAL INSTITUTE, 209 Barrackpore Trunk Road, Calcutta-35

The Indian Statistical Institute, established in the '30's as a non-profit learned society, acquired the status of a university in 1959 giving courses in statistics leading to the B Stat and M Stat degrees. Doctorate degrees are also awarded. Since its inception, the Institute's program has centered on application of statistics to practical problems in the form of project work, solutions of which have resulted in significant contributions to statistical theory; and financial support of which has provided operating funds.

Two major types of project originated in the '50's. The first, the National Sample Survey, is probably the most comprehensive in existence, and of invaluable use to the Government. The second, Statistical Quality Control, has developed into a consulting service to industry on a national basis. Research at ISI is organized into research units, each pursuing a particular small scientific field. The units are purposely kept small, the formation of large units pursuing a multitude of subjects being strongly resisted. Individual units are expected to pursue a program of research which will yield problems of a statistical nature and which may stimulate new statistical methods. Further, they contribute to the teaching of degree courses in statistics, bringing to bear types of problems from their own particular field. They act as liaison between scientists in universities and the Government and the Institute's research statisticians and promote knowledge of statistical

methods. Dr. C.R. Rao, Director of the Research and Training School, a distinguished statistician, was recently elected to Fellowship of the Royal Society.

Dr. B.C. Das, Head of the Biometry Research Unit, primarily a hematologist, leads a staff of some dozen postgraduates undertaking comprehensive studies of blood chemistry in both man and carp. The aim of this work is to investigate correlation in and between many factors in Indian life, e.g., diet, the effects of movement from rural to city life, and various types of stress. Long period surveys of relatively large samples are of particular value and interest. The laboratory facilities directly available to the group are limited, indeed primitive by Western standards; however, they seem to be balanced by a degree of enthusiasm and careful experimental design around the limitations, which is encouraging and has led to considerable success.

Das, who received his training in the US at Cornell and Illinois in the early '50's, visited the US during 1960 and 1962 at Wayne State University and Case Institute. He has published widely, frequently with his wife Rhea S. Das, in the areas of blood chemistry in man and fish, particularly in terms of age-related trends.

The research unit concept at ISI is an admirable one. India, however, is a very large country, and we were impressed frequently on subsequent visits by the need for greater appreciation and use of statistical methods in terms of experimental design and the use of data and its interpretation.

ANDHRA UNIVERSITY, Waltair

This University, approximately one hour by taxi from Visakhapatnam (Vizak) and the major harbor there, has had an active program in the marine sciences for many years, and a number of the individuals associated with programs in other institutions have received their training here. Although there are three departments with interest in the marine environment, Geology, Meteorology and Oceanography, and Zoology, time permitted us to visit only with the few members of the Zoology Department that were available.

Dr. P.N. Ganapati has been professor and head of this Department for a number of years. Although, in typical European fashion, he publishes jointly with many of his staff, it is apparent that in recent years he has been totally absorbed in administration of the Department and the development of the marine laboratory adjacent to the University. Within the Department there are three Readers and nine Lecturers, although three of the latter are temporarily associated with other institutions. The Department accepts students only after completion of the BSc and at present has approximately 24 "post-graduates." Of these, 16 are listed as research fellows, receiving support from several sources which include the Council for Scientific and Industrial Research (CSIR), the Marine

Organisms Scheme of the Forest Research Institute, the University Grants Commission (UGC), and directly from the University.

Dr. S. Dutt, who received his PhD from Kiel, has been working for several years on marine fish, with emphasis on Sardinella. He has published on the reproductive cycles, biometry, and taxonomy of several species of this genus as well as on the taxonomy of several other genera. Dr. K. Hanumantha Rao is a parasitologist, working largely with Trematoda of freshwater and terrestrial animals. He has published on the morphology, histology and histochemistry, and taxonomy of a number of trematodes, as well as several studies on ecology and life histories. The third Reader in the Department, Dr. C.C. Narasimhamurti, is also a parasitologist, and is working on a description of some haplosporidians from the body cavity of marine copepods.

Dr. R. Nagabhusanam, who received his PhD from Tulane working on neurosecretion in Crassostrea virginica, has been continuing his interest in hormonal control of a number of processes in marine invertebrates. He has also worked at several other US laboratories, including a summer at Woods Hole where he investigated the color physiology of the crab Sesarma and a summer at the Virginia Institute of Marine Sciences studying the hormonal control of spawning in oysters. At present he is working on the neurosecretory control of crustacean pigmentary effectors, and has several graduate students engaged in research on related aspects. Although the catalogue of the University lists him as a Lecturer, recent correspondence suggests that he is presently affiliated with Marathwada University, Aurangabad, India.

Another Lecturer, Mr. M.V. Lakshmana Rao, has been working for some time with fouling organisms, although he has also published on the bottom fauna of the Indian continental shelf, the ecology of the intertidal sands, and the development of Scyphistoma larvae. For several years he has been involved in the "scheme" for protection of timber against attack by marine organisms, and many of his publications deal directly with this problem. He is currently completing a manual on teredinids as well as a paper on serpulids from Indian harbors. He visited the US several years ago and toured a number of laboratories on the East Coast.

Dr. D.V. Subba Rao, who has been involved in studies on primary production off the Waltair coast, has recently taken a leave from the University to work with Dr. R. Conover at the Bedford Institute of Oceanography in Nova Scotia.

Dr. Y. Radhakrishna, an ecologist, has been involved in a study of the Kakinada Bay. Situated on the east coast, the bay has a total area of approximately 132 km² and is bounded by the main land on the western side, by marshy mangroves on the southern side, and by a sand bar on the east side. On the north it opens into the Bay of Bengal. Radhakrishna's study involves the nature of the substratum, the fauna within each type of substratum, and the seasonal changes which occur.

Mr. D.V. Rama Sarma is studying the hydrographical conditions in this same Bay. Apparently the complexity is considerably increased because of a number of unusual conditions, including the different quantities of freshwater which enter during the southwest monsoon as opposed to the influx of high salinity waters from the north during most of the year.

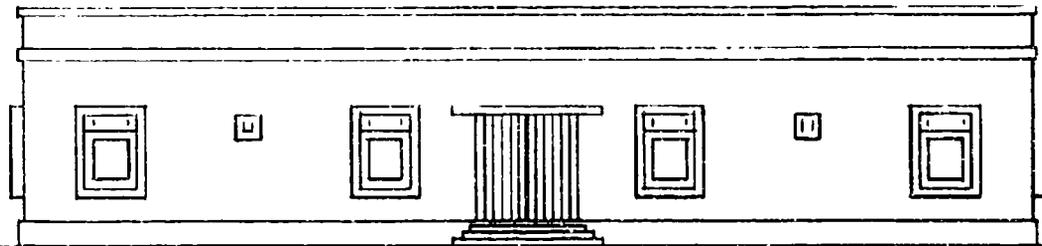
Dr. P. Chandra Mohan is completing a five-year study of the zooplankton of the Godavari estuary, the second largest in India. In spite of a highly fluctuating pattern of temperature and salinity, zooplanktonic organisms were found to follow a regular seasonal succession. The copepods, decapod larvae, and medusae were the major components of the zooplankton for most of the period of his study.

Many of the other lecturers, with whom we did not have any opportunity to talk, are working on the taxonomy, ecology, distribution, and life-histories of marine animals.

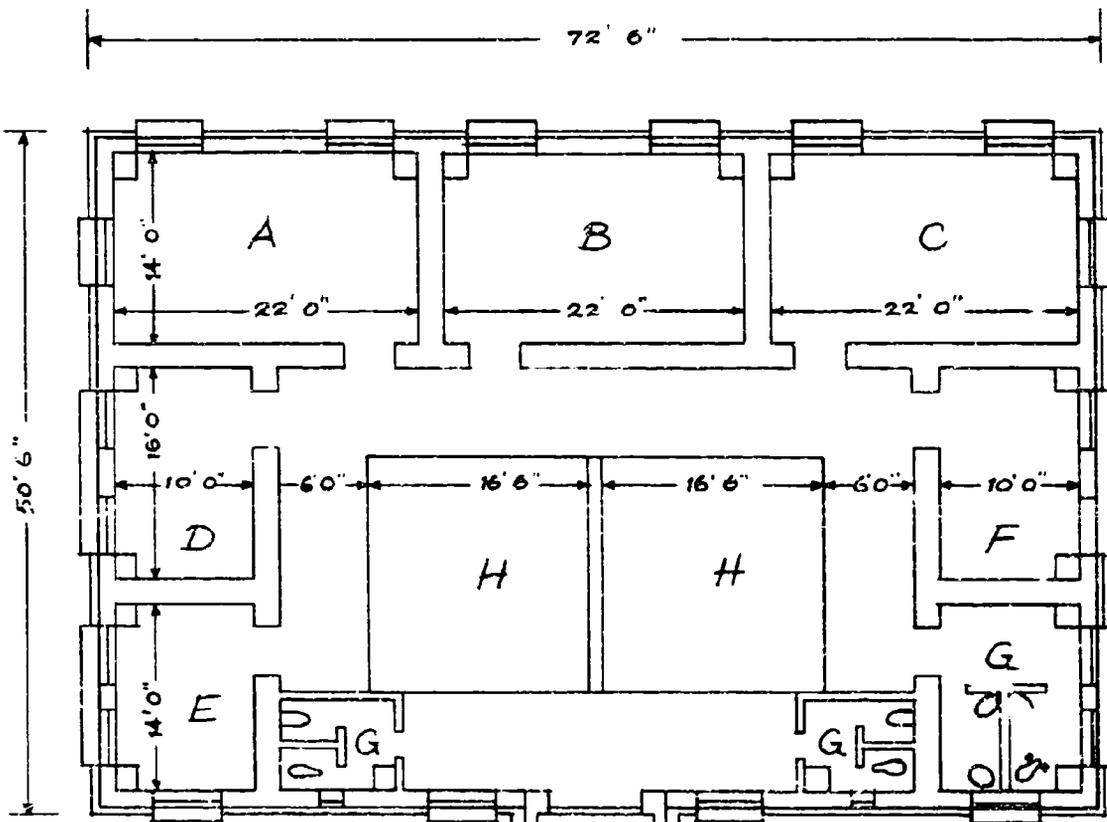
The Department of Meteorology and Oceanography, chaired by Prof. R. Ramenadham, has had an active program for a number of years. On two occasions this has received additional impetus from Prof. E.C. LaFond, U.S. Navy Electronics Laboratory, who was there as visiting professor of oceanography through the Fulbright Program. Two volumes have been published dealing with the physical, chemical, geological, and biological data collected during a number of oceanographic cruises in the 1950's, largely through the cooperation of the Indian Navy and the use of their vessel, I.N.S. ROHILKHAND.

The area around Waltair would appear to be especially well suited to a marine laboratory. The waters of the east coast are unusual in many respects: the currents are completely reversed when one monsoon is replaced by another; there is tremendous dilution from the large rivers in the north; the submarine canyon "Swatch of No Ground" is internationally known; the estuarine problems of the Ganges, Mahanadi, Godavari and Kistna rivers present separate and inter-related problems; and, both upwelling and sinking are present during different seasons. The marine flora and fauna, as well as the sediments and problems of sediment transport which are related to the unusual physical environment, offer an unusual combination of problems and opportunities for study.

Although there was little evidence of the more specialized equipment associated with some types of research, it was apparent that Ganapati has been making some effort to provide the basic equipment necessary for the type of research for which his department has now become well known. He expressed an interest in developing a program in microbiology as well as plans to expand considerably the present ecological studies. Both of these relate to the marine laboratory which is partially completed (Fig. 2).



FRONT ELEVATION



- A - Chemical Laboratory
- B - General "
- C - Plankton "
- D - Culture Room

- E - Equipment Room
- F - Constant Temp Room
- G - Urinals
- H - Aquarium

PLAN

This building, the shell of which is virtually finished, has obviously required a great deal of effort on Ganapati's part. A seawater system is planned which should greatly facilitate studies in a number of disciplines. The disconcerting aspect is that in a report based on visits to the University late in 1964, reference is made to the state of completion of this building, commenting that "sea-water aquaria will soon be available." Three years later the situation remains essentially unchanged.

UNIVERSITY OF MADRAS, Madras

Two Departments here, Botany and Zoology, were visited. They differ considerably in outlook and presumably in research facilities. The Botany Department has been designated a Center for Advanced Research by the University Grants Commission (UGC) and, as such, receives sizable support for specialized equipment which is rarely seen in other departments and centers that are not so designated.

Botany Department

Within this Department there are three professors, three readers, three lecturers, a number of post-doctoral research fellows, and 18 research students registered for the PhD. The Department, or Laboratory as they prefer to call it, is primarily a research institution. In 1958, however, a two-year MSc course was developed. Emphasis is placed on mycology and plant pathology, although the interest of a previous professor, M.O.P. Iyengar, in algae has also been continued, primarily in the areas of morphology and development.

Prof. T.S. Sadasivan, also the Director, received the PhD and DSc from the University of London. He is a member of many international botanical organizations and during the past few years has visited extensively in Europe, America, and the USSR. His research interests center around the physiology of fungi, with special emphasis on soil-borne diseases of plants and problems of plant virus diseases. During the next few years, he expects to continue studies on the physiology of diseased plants with special reference to nitrogen metabolism and changes in proteins and aminoacids. With Prof. C.V. Subramanian he is currently completing a volume Soilborne Diseases of Plants.

Subramanian, who in the absence of Sadasivan gave us the tour of their facilities, is interested in the physiology and ecology of fungi, largely those found in the soil, as well as plant diseases.

Dr. T.V. Desikachary, the third professor in the laboratory, received his PhD and DSc from Madras, continued his research at the University of California and subsequently worked in New Zealand and Australia. He is an algologist and expects to continue his research on morphology and reproduction of marine algae, as well as studies on diatoms. He also has an interest in the biology of soil algae, especially the blue-greens and is hoping to prepare for publication two monographs of the late Prof. Iyengar on "Volvocales" and "Siphonales."

Dr. L. Saraswathi Devi's research deals with zoospore soil fungi also, concentrating on the culture of a number of species. Dr. R. Kalyanasundaram, who received the PhD from Zurich, is interested in serological studies with fungi and plans to develop a program involving host specific toxins. Dr. D. Subramanian, the third Reader in the laboratory, is a biochemist, working on oxidases and their production in plants in response to a pathogen.

Dr. C.B. Sulochana, who recently returned from a one-year post-doctoral program in Moscow involving electron microscope techniques, is interested in the ultrastructure of microorganisms, ontogeny of spore formation in fungi, and rhizosphere microflora in diseased plants. Dr. S. Suryanarayanan, a biochemist, is attempting to solve a number of biochemical problems associated with fungi. These include radioisotope studies on changes in proteins in rusted tissues, fatty acid metabolism in uredospores, and the toxins of Piricularia. Dr. R. Narayana Swamy, the third Lecturer in the laboratory, is continuing studies on the respiratory metabolism of healthy and diseased plants and a study of actinomycetes and their metabolites.

Superficially the facilities and equipment within this Department leave very little to be desired. Apparently in the interest of uniformity, specialized equipment purchased for the Centers of Advanced Research from UNESCO funds is organized on a "national basis," i.e., centers are assigned to individual contributing countries and receive equipment manufactured in that country. At Madras much of it is from the USSR, and ranges from a mass spectrograph, which had recently arrived and was being installed, to the less complicated optical equipment. One exception was a RCA EMU-3 electron microscope. The depressing aspects of this impressive array of sophisticated equipment was whether it works and, when it doesn't the almost total absence of any provision for spare parts or repair by trained maintenance personnel. For example, the electron microscope, beautifully housed in an air-conditioned room with all of the ancillary equipment, at considerable cost in space and cash, has been at the University for three years. When I inquired about the quality of the pictures, magnifications, resolution, etc., and asked to see some examples, I was told that they did not exist.

Department of Zoology

The two-hour discussion with Dr. G. Krishnan, Professor of this Department, was in considerable contrast to our visit to the Botany Department. The entire period was spent in his office, and repeated suggestions that we would be interested in seeing the facilities and meeting other staff were to no avail. Since Krishnan refused to introduce the staff or show the facilities, the limited information on this Department has been derived largely from other sources. Krishnan, who received his PhD from the University of Manchester in 1951, has been professor since 1963. His earlier work dealt with the nature and composition of arthropod cuticle, and many of the staff and students

continue with these aspects plus problems relating to ecology of marine crustaceans. Some have also investigated problems on chemical composition of exoskeletal structures of polyzoa, molluscs, and hemichordates. He expressed an interest in further developing a program in the physiology of marine animals which would utilize radioisotope techniques. At present there are 15 students working toward the PhD, three of which were to submit their dissertations during this year. It is curious, and very possibly purely coincidental, that of the numerous papers presented at the March Symposium on the International Indian Ocean Expedition, not one was presented by a staff member or student from this Department nor are any included in the complete list of participants.

I understand that the running sea-water system and aquaria which have recently been completed are not functioning. The system ties into a well which is off shore, but at present, water carried in clay pots on the heads of fishermen is sufficient to meet the few demands for its use. The library is reputed to be one of the best in India insofar as marine zoology is concerned, but again this is second-hand information.

ZOOLOGY DEPARTMENT, UNIVERSITY OF MADURAI, Madurai

This University, until recently a part of the University of Madras, presented still another aspect of science in India. Located in southern India, quite far from the ocean, it would not normally have been chosen as a place to visit in connection with the marine sciences, but I had met the professor of zoology on several previous occasions and was particularly eager to see him again, as well as the department to which he had often referred. The professor, Dr. S. Krishnaswamy, received his PhD and DSc from the University of Southampton, and has returned on several occasions to do research with Prof. J.E.G. Raymont. Although he has an extremely wide range of interests, he has, in recent years, concentrated on the physiology and biochemistry of marine animals, primarily copepods. He has visited the US on several occasions, is a member of the UGC of India, and has recently completed a syllabus on zoology which is patterned after the A.I.B.S., B.S.C.S., of the US.

The department at Madurai was the only institution in India where we were introduced to the graduate students, who then outlined their own research problems, described the equipment and procedures, and answered specific questions about the research. Since Krishnaswamy was not there, it is highly unlikely that it was "staged," and the Reader, Dr. S.V. Job, showed us what facilities are available.

Dr. A. Abdul Rahaman, who recently received his PhD from the University of Madras, has been involved in a number of studies. These have included reproductive and nutritional cycles of crabs off the Madras coast, changes in the gonad and other tissues of the starfish, and fluctuations in nitrogen content of lamellibranchs.

Mr. P. Govindarajula, who was completing his thesis and expected to submit it in October 1967, has been working on the neuroendocrine control of reproduction in fish. He expects to expand this interest to include the endocrine systems in invertebrates, adults and larval stages.

Mr. S. Krishnan's research deals with reproductive physiology, with special emphasis on biosynthesis of proteins and nucleic acids. Mr. P. Navaneethakrishnan is working on a problem which has a number of basic and applied aspects. The work originated as a taxonomic study of one of the freshwater copepods, with physiology and ecology as secondary aspects. He has now found that the copepod serves as the host for the larval stages of the parasite which causes dracontiasis and he has become involved in studies on the development of the parasite and the host-parasite relationships. Miss R. Bernice Sara, one of three women graduate students in the Department, is working on the biology of Streptocephalus, a freshwater Branchiopod which is quite abundant in some of the adjacent lakes. This work includes general morphology, ecology, seasonal variations, and diurnal migratory patterns similar to the deep scattering layer of the oceans. Mrs. Mercy Gerald is working on several problems involving metabolism in fishes and Miss S. Vijayaraghavan is studying cyclic changes in the fauna of several nearby fresh-water ponds. Mr. M.R. Chandran's research deals with reproductive and nutritional cycles in several species of fish. Mr. A.M. Selvaraj is beginning a study of respiration and the effect of environmental factors in aquatic insects, and Mr. S.K. Dwarakanath, who has only recently joined the group, expects to begin a problem involving metabolism of millipedes.

The facilities at Madurai provided a true contrast with those available at Madras, as well as an example of what can be done with a minimum of hardware and a maximum of determination and hard work. Krishnaswamy had devised his own Warburg from glass and rubber tubing and the Indian equivalent of a Coke cooler, an approach which many of us followed in the US when the more sophisticated equipment was not generally available. What little equipment was available was home-made, but the interest, understanding of the principles involved, and enthusiasm on the part of the graduate students is a factor which is impossible to equate with equipment or dollars. Krishnaswamy, in several discussions over the past year, has stressed the importance of instilling "western objectivity" into the new generation of Indian scientists currently being trained: the capacity to reason out a problem, associate parameters of research, and generally question any hypothesis, regardless of who may have formulated it or presented it in lecture. From our tour of their limited facilities, explanation of research problems by the graduate students, and the informal discussion which occurred during the delightful afternoon tea, it is apparent that these are not idealistic theories which Krishnaswamy reserves for the purpose of impressing visiting scientists but rather a concept in which he firmly believes and is striving to put into practice in his own Department. The traditional "bottom-rung" in any Indian university is occupied by the man who patiently waits outside the professor's office,

ready to bring tea or run any errand for the master when summoned by the clapping of hands or ringing of bells. At Madurai, at least in the Zoology Department, this man has been retained but no longer waits patiently outside the professor's door. He is becoming familiar with what little scientific equipment is available, looks for ways in which the general atmosphere of the department can be improved, and has written over 30 pamphlets which are designed to familiarize the laymen of India with the fauna and flora which surround them. As a highly successful author, earning more from his publications than from his position at the University, he is an example of what can be done if those in positions of authority are willing to take the time and effort.

At present Krishnaswamy is considering the position of director at Porto Novo. If the conditions which he has stipulated are accepted by those in more official circles, one can certainly expect the same attitude which prevails at Madurai to develop at this largest marine laboratory on the East Coast of India.

MARINE BIOLOGICAL STATION, Annamalai University, Porto Novo

It was extremely unfortunate that our schedule did not permit us to visit this laboratory, the largest on the East Coast of India. Prof. R.V. Seshaiya, Director, was kind enough to provide some information through correspondence, and this brief description will be drawn from that and general observations provided by others who have actually visited the Laboratory.

Dr. Seshaiya, in his early 70's, is apparently an extremely capable and enthusiastic individual. Originally the Laboratory was developed as part of Annamalai University, and in recent years, following the general scheme of the UGC, it has been designated as an Advanced Marine Center. It is located some two miles from the sea in an area which is largely estuarine. Two laboratory buildings are available for research, one of which is relatively modern. There is also a guest house which provides accommodations for 40 students and some visiting scientists. For collecting there is a 30-ft boat which is berthed at the pier adjacent to the Laboratory. A new aquarium has been planned, but construction has not started as yet. The present sea water system depends upon an overhead tank which is filled manually with water brought in from the open sea. The library is reported to be moderately good, containing more references in the area of the marine sciences than are normally found in Indian institutions. As an Advanced Marine Center it has been supplied with equipment suitable for physiological and biochemical studies, largely obtained from the UK. Although Seshaiya did not include a list of research personnel at the laboratory at the present time, I did have an opportunity to chat with some of them during the Symposium on the Indian Ocean Expedition. These discussions, plus the list of current research interests supplied by Seshaiya, will serve to give a general impression of the wide

variety of research underway, admittedly without any indication of quality or equipment which is available and functional.

Drs. K. Balasubrahmanyam, F.S.P. Bhushana Rao and R.C. Subbaraju have been studying the distribution and seasonal variation of larvae and juveniles of two species of flying fish from the Bay of Bengal, Exocoetus volitans L. and Hirundichthys coromandelensis (Hornell). Dr. V.S. Ramamurthy and Dr. S. Krishnamurthy have been following seasonal variations in phytoplankton populations at the 10-fathom line in the Bay of Bengal. Forty-six species, representing 35 genera, have been recorded during the two-year period. Only three genera were present during the entire year, the remainder exhibiting seasonal variations. Ramamurthy is also interested in the distribution of yeasts in Porto Novo waters. Dr. P. Santha Kumari has been involved in a study of total phosphorus, inorganic phosphorus, and dissolved organic phosphorus in Porto Novo waters, as well as a comparative aspect in waters of the Bay of Bengal. Dr. K.K. Venugopalan is studying primary production in the estuarine and inshore waters at Porto Novo, using "light-dark bottle" methods as well as C^{14} .

In the list of work in progress a number of research programs are listed dealing with life histories, ecology, histological and biochemical changes in gonads and eggs, and salinity tolerances and osmoregulation in fish.

INDIAN OCEAN BIOLOGICAL CENTER, Ernakulam, Kerala

Early in the planning of the International Indian Ocean Expedition (IICE) it was realized that a large number of zooplankton samples would be collected during the expedition, and it was suggested that a sorting center be organized. It was recommended that the center be located in India, largely because a large number of young Indian biologists would be available for such a facility and also because of the existing tradition in taxonomy. The SCOR-UNESCO working group which met in India in 1961 endorsed the selection of Cochin, one of the three good harbors on the west coast of India. As a result the Indian Council of Scientific and Industrial Research (CSIR) was to provide buildings, staff and running expenses, with a total budget of one million rupees (approx. \$200,000) for a five-year period. There was to be a staff of 29 scientists, of whom 20 were to be sorters, and an administrative and technical staff of 24 was proposed. UNESCO was to supply equipment not available in India and, on the advice of SCOR, appointed a Consultative Committee for the IOBC as well as a Curator of the international collection.

Administration of the IOBC is, at first glance, slightly confusing. Dr. N.K. Panikkar, as Director of the Indian Programme of the IICE, is in over-all charge of the IOBC along with a similar center for Physical Oceanography and a new center for the International Biological Programme.

Dr. R.R. Prasad, the Deputy Director of the Central Marine Fisheries Research Institute, serves as part-time Chief Scientist-in-Charge and handles the administration of the Collection, assisted by Mr. L.R. Kasturirangan, Acting Assistant Curator. Dr. S.Z. Qasim, who wears several "hats" is Assistant Director of the International Biological Program, and head of the Office at the Center.

UNESCO has appointed three International Curators since 1963. Mr. Vagn Kr. Hansen, normally associated with the Danish Institute for Fisheries and Marine Research, Charlottenlund, Denmark, was the first Curator and served during the first two years of the organization and planning. Dr. E. Brinton, Scripps Institution of Oceanography, La Jolla, California, was appointed as the second Curator in October 1965, serving until approximately May 1967. At the time of our visit Mr. D.J. Irwin, C.S.I.R.O. Marine Laboratory, Cornwall, Sydney, Australia, had been appointed as the third Curator. The international advisory body to the IOBC, the Consultative Committee, consists of up to six plankton experts nominated by UNESCO on the advice of SCOR. They normally serve for three years, but not more than six. In addition to assuming responsibility through the Curator for the treatment, loan, and further examination of the samples within the IOBC, the Committee is charged with working out procedures for maintaining the collection, advise on presentation of data resulting from the examination of the samples, and give lectures and seminars to the scientific and technical staff of Indian marine science institutions. The present Committee is composed of scientists from the United Kingdom, West Germany, the USA, India, Japan, and Australia. A general description of the sorting techniques, plus provisions for loan and study by specialists in countries other than India, is given in a publication by the first Curator, V. Hansen, "The Indian Ocean Biological Centre: the centre for sorting plankton samples of the International Indian Ocean Expedition," Deep Sea Research, 13, 229-234 (1966).

At the March Symposium on the IIOE in Delhi a number of papers were presented by scientists associated with the IOBC. These gave preliminary results of general abundance and distribution of euphausiids, phytoplankton, copepods, fish, etc., as determined by the studies at the IOBC. For a more complete account of these papers, as well as of the Symposium one is referred to the ONR Conference Report ONRL-C-4-67 dated 1 June 1967.

From our brief visit to the IOBC one got the impression that the sorting is going extremely well and the Center is certainly making a contribution to the Indian Ocean Expedition. While the more detailed studies of specific groups will undoubtedly go on for a number of years, the preliminary phases have contributed much, and the individual Indian sorters have a far better understanding of the groups and their interrelation than could have been obtained from lectures or assigned reading.

DEPARTMENT OF MARINE BIOLOGY AND OCEANOGRAPHY, UNIVERSITY OF KERALA,
Ernakulam

Adjacent to the IOBC is the Oceanographic Laboratory, the only one of four facilities associated with the Department of Marine Biology and Oceanography of the University of Kerala which time permitted us to visit. The Department was organized in 1938, by the erstwhile University of Travancore, and has in recent years been under the direction of Prof. C.V. Kurien.

The Oceanographic Laboratory was initially established at the Naval Base in Cochin in 1957 and moved to new quarters on their completion in 1962. The new facilities include laboratories for biological and chemical work, research rooms for scientists and students, a reference library, air-conditioned rooms for instruments, a photographic dark room, lecture hall, museum hall and prep room for biological specimens. Space is also available for two visiting scientists who would also be provided with furnished living accommodations in the hostel attached to the Laboratory. An aquarium for marine and freshwater forms is completed, but apparently there have been the usual difficulties in maintaining it in proper working order as well as difficulties associated with the polluted water supply of the harbor which is immediately in front of the Laboratory.

The R.V. CONCH, designed, built, and equipped for oceanographic research in India through financial assistance from the UGC and the Indo-Norwegian Foundation, was launched in 1956. The R.V. CONCH is 50 ft in length, draw 5 ft, is powered by two 44-hp Kelvin Diesel engines, which also provide power for the hydrographic and trawl winches, and has a cruising speed of 8 knots. The small laboratory in the deck-house has facilities for preliminary analysis and preservation of samples. Equipment available include Nansen reversing water bottles, bathythermographs, Ekman current meter, various types of plankton nets and dredges, beam trawl, Petersen grab, LaFond Dietz Bottom snapper, Phelgar corer, and transparency gauge. One Simrad Echo Sounder and one Radio Telephone are fitted in the wheel house. The ship takes the captain and a crew of five and will accommodate two scientists.

Results of studies carried out in the various laboratories associated with the Department are published in a variety of journals as well as the Department's own journal. Until 1963, eight volumes of this journal were published under the title "Bulletin of the Central Research Institute, Part C." Since then, however, the journal has been renamed "Bulletin of the Department of Marine Biology and Oceanography," the first number being issued in 1964. Through this volume an exchange is maintained with approximately 75 different marine science institutions throughout the world.

Prof. C.V. Kurien continues to maintain an interest in research, and find some time to expand on a long-term study of bottom fauna and bottom deposits at several points along the west coast of India. During the past eight years, he has made a detailed investigation of the benthos from 125 stations from Mangalore in the north to Puvar in the south, extending to a depth of 200 fathoms. Portions of this work were reported at the March Symposium on the Indian Ocean Expedition. During our visit Kurien was on leave from the University, spending three months visiting the Fisheries Laboratory in Aberdeen, the Oceanographic Laboratory in Southampton, and the NIO in Wormley. I had occasion to chat with him briefly; at a recent meeting of the Challenger Society and some of the information given here is from this conversation.

Dr. N. Balakrishnan Nair, Reader in oceanography, was also on leave, spending several months at the Marine Station, Millport, Isle of Cumbrae, Scotland. On a visit to that institution prior to our trip to India, I chatted with Nair about the marine sciences in India and, in particular, his own research interests. Nair has been working for a number of years on fouling organisms, with special interest in the woodboring pelecypod Bankia. He has published extensively, in Indian journals as well as in foreign journals, on a number of aspects of the biology of Bankia, including sexual changes, the physiology of digestion, breeding seasons and larval development, and rates of growth of several different species from tropical and temperate areas of the world. More recently he has also become interested in gastrotrichs and, with A.G. Govindankutty, also of this Department, presented a paper on interstitial fauna of the southwest coast of India at the March Symposium.

It was Dr. N.M. Shah, Lecturer in chemistry, who explained the workings of the Department in the absence of either the professor or the reader. Shah, who worked at Scripps several years ago, is an algologist and has been studying diurnal changes in phytoplankton pigments in the Arabian Sea as well as changes in temperature, salinity, dissolved oxygen, inorganic phosphorus, and nitrite. Samples for pigment studies were taken from surface waters and a depth of 8 m, whereas hydrographic samples were taken from the surface, 5, 10, and 15 m. He found little diurnal variation in phytoplankton pigments from 8 m, whereas samples from the surface exhibited a peak at noon. Nutrients, as well as the other factors, were virtually constant.

Dr. C.T. Samuel, lecturer in ichthyology, is interested in the biology of the oil sardine, Sardinella longiceps, and hopes to initiate a program which will investigate the taxonomy and distribution of this species in Indian waters. The work could also consider morphological changes associated with growth, chemical composition of the fish and variations in fat content with age, and an analysis of stomach contents in an effort to determine food and feeding habits. Samuel is also interested in the eggs and developmental stages and their distribution.

Mr. Y.L. Dora, lecturer in marine geology, has been involved in studies on sediments and sediment transport in the Vasishta Godavary River, initially concentrating on particle size and distribution of these particles in relation to position in the estuary.

Four remaining members of the Department were not available during our brief visit. These included Mr. K.P. Balakrishnan, Lecturer in planktonology, Dr. P. Dinamani, Lecturer in invertebrates, Mr. M.G.S. Rao, Lecturer in physical oceanography, and Mr. B. Rami Reddi, Lecturer in physical oceanography.

Within the Department two post-graduate programs are offered which lead to the MSc. One, for 10 students, who have completed the BSc, leads to a degree in Marine Biology and the other, for four students, to an MSc in Oceanography. Both are two-year programs, and limited support is available through "University of Kerala" merit scholarships for a "few" students each year.

Facilities for research leading to the PhD are also available for approximately 12 candidates. A number of scholarships for PhD students are available from "time to time" from a variety of sources, including the UGC, the CSIR, Kerala University, and the Government of India.

Within the Department there has been an obvious effort to build up equipment for the wide range of research which is of interest to the staff and necessary for a good graduate program in marine biology and oceanography. In many cases the equipment is available, but as was observed throughout institutions in India, there are no trained individuals to maintain it if breakdowns occur nor does the budget contain funds for maintenance. For example, we were shown a freezing unit which had been used to keep biological specimens until analyses could be made. The unit, resembling a typical kitchen freezer, was made in India and was only slightly over one year old. Six months ago the compressor coils developed a leak (with a loss of all the stored material) and the unit has not been used since. The cost of repairing the coils has been estimated at approximately 600 rupees (slightly less than \$100.00), but this sum is not available, and since the budget is made up for a five-year period, it is highly unlikely that repairs can be effected in time to make it worthwhile. The reversing thermometers had never been calibrated, largely because there was no one there equipped to undertake the job.

The three other divisions within the Department of Marine Biology and Oceanography are the Marine Biological Laboratory and Aquarium, the Estuarine Biology Laboratory, and the Fishery Technology Laboratory.

The Marine Biology Laboratory at Trivandrum has a resident staff of three, with Dr. N. Krishna Pillai as the senior research officer. Facilities for research leading to the PhD are available for approximately six candidates at one time, and purportedly the present interests include

studies on the biology of certain littoral animals of the Kerala Coast, digestive and nervous systems in Crustacea, and studies on the taxonomy of Amphipoda. The Trivandrum Aquarium, associated with the Marine Biology building, has a closed system of sea-water circulation to which sea water is added three or four times a year. The building was renovated in 1964 and there is currently a proposal to add a number of freshwater tanks for maintaining a greater range of fauna.

The Estuarine Biology Laboratory, Ayirmthengu, was established in 1945 to develop freshwater and estuarine fisheries of the area. Interest has centered around the experimental breeding of lake fishes, studies on artificial fertilization of culture ponds, and, more recently, efforts to culture Tilapia on a commercial scale. At present studies on the migration and growth of prawns and mullets, investigations on bottom fauna, and chemical analysis of brackish water and fresh water molluscs are the major problems being investigated.

The Fishery Technology Laboratory, Trivandrum, originally established under the Fishery Development Scheme for studies on the utilization of waste products from fish and the exploitation of other marine products, is at present concerned with the chemistry and technology of marine oils and fats, the production of odorless fish flour and preservation of fresh fish by antibiotics and hypochlorite ice.

NATIONAL INSTITUTE OF OCEANOGRAPHY

The NIO is a recent organization in India, having been formally set up in January 1966 on recommendation from the Indian National Committee on Oceanic Research, the body largely responsible for Indian planning and participation in the Indian Ocean Expedition. The National Committee on Oceanic Research, chaired by Dr. D.N. Wadia, F.R.S., serves as the planning committee for the Institute, and has recommended that the main Institute be located at Goa with regional centers at Cochin, Waltair, and Calcutta. During our visit it was not possible to visit Goa, where construction of the new facilities is still in the planning stages, but we were able to discuss the general plans with Dr. N.K. Panikkar, Director, in New Delhi and visit with the existing staff of the Biological and Physical Oceanographic divisions at Cochin, Ernakulam. At present there are five divisions within the NIO: the Headquarters and Planning and Data Division in Delhi; the Indian Ocean Biological Center, Ernakulam; the Physical-Oceanography Division, Ernakulam; and, the Biological Oceanography Division, Ernakulam; and the Bombay Office. All of these are directed by Panikkar.

The Planning and Data Division is located in New Delhi and Panikkar maintains his office here, presumably until the new facilities are available in Goa. This Division, headed by Mr. R. Jayaraman, maintains a staff of approximately seven scientists and research fellows. The

Division is primarily concerned with processing data and maintaining an exchange of data with world data centers and other oceanographic data centers. It also functions as a central point from which to exchange and disseminate information pertaining specifically to the Indian Ocean and the seas around India.

Some of the staff are apparently involved also in research, judging by some of the papers presented at the March Symposium. R. Jayaraman co-authored four papers dealing with various aspects of distribution of temperature and oxygen in the Arabian Sea and Bay of Bengal. Dr. S.N. Dwivedi has been involved in an electrophoretic study of hemoglobin components of clupeoid, scombroid, and other pelagic fishes of the Indian Ocean in an effort to differentiate fish populations. Dr. U.K. Gopalan has also been working on fish but with an interest in determining cycles of maturation and spawning of the silver pomfret; Pampus argenteus.

The Physical Oceanography Division, located in Ernakulam, is handling most of the scientific problems relating to the physics of the sea around India. It is also engaged in studies on bottom topography, geology, beach erosion, accretion, sand movement, coastal currents, storm surges and sea level variations, wave refraction, and statistical studies on the chemical and physical characteristics of sea water. Many of the studies would appear to be based on cruises made during the IIOE and on data collected by the INS KRISTNA.

The Division is headed by Dr. V.V.R. Varadachari and has a staff of approximately seven scientists. Varadachari, collaborating with several of the staff, has been involved in a number of studies in the Bay of Bengal. At the March Symposium in New Delhi he presented papers dealing with internal waves, the level of least motion and circulation in the upper layers of the Bay of Bengal, and some features of the thermocline. He has also been involved in a bathymetric survey off the Pondicherry coast, and reported on the existence of three sets of distinctly separate canyons, giving a brief description. Dr. C.S. Murty, and Mr. P. Udaya Varma Thirupad have also been involved in most of these studies. Murty has also been interested in sediments and their transport in the areas around Cochin. Drs. Ch. Madhusudhan Rao and P.S.N. Murty have been studying shelf sediments off the Madras coast, and Murty has been particularly interested in the distribution of phosphorus in marine sediments in relation to upwelling, biological productivity, and the influence of river systems. R.R. Nair and A. Pylee have been making a study of size distribution and carbonate content of the sediments of the Western Shelf of India, using samples collected during the 25th cruise of INS KRISTNA during the IIOE. Pylee has also been involved in a study of alkalinity in the Indian Ocean and the way in which this is affected by the Southwest monsoon.

Studies within the Biological Oceanography Division fall within four general categories: hydrography and primary productivity of Cochin backwaters; hydrography of inshore waters; studies on the physiology of crabs; studies on interstitial fauna.

Factors which are being considered within the general category of hydrography include temperature, salinity, light penetration, seston, alkalinity, dissolved oxygen, nutrients, and tidal influences. Under primary production, studies are being made on rates of photosynthesis, zooplankton, benthos, meiofauna, and marine bacteria. The physiological studies on crabs have included observations on osmoregulation of two species of swimming crabs, Scylla serrata and Charybdis lucifera, calcium regulation, oxygen consumption, and the effect of ligaturing the eyestalk on the level of blood calcium. Studies on interstitial fauna have concentrated on abundance and distribution of Nematoda, Ostracoda, Foraminifera, Copepoda, Polychaeta, and Kinorhyncha in the Cochin backwater.

This Division is headed by Dr. S.Z. Qasim who worked with Prof. Knight-Jones at Swansea on effects of pressure on zooplankton, receiving his PhD there several years ago. He is now head of the Indian International Biological Program. Qasim attended the XVth International Congress of Zoology in Washington, D.C., 1963, and made contacts with a number of American and European scientists at that time. He has been working with M. Frishnan Kutty on population dynamics of the common sole of the Arabian Sea, Cynoglossus macrolepidotus, as well as on biometrics, and a paper of portions of this work was given at the March Symposium in Delhi. He has also been involved in studies on ratios of chlorophylls a, b, and c and plant carotenoids in phytoplankton found in the estuarine waters of the Cochin backwaters, a joint project with C.V. Gangadhara Reddy.

B.N. Desai, also working with M. Krishnan Kutty, has been making a study of the marine and estuarine benthos in the nearshore region off Cochin, attempting to determine which environmental factors in a number of areas contribute to the abundance and distribution of benthic fauna. Kutty was particularly interested in developing a program to study the abundance of major fishes, the distribution of fish eggs and larvae, and statistical methods which might be useful in predicting abundance and yield.

Two other members of the staff, C.V. Gangadhara Reddy and V.N. Sankaranarayanan, are involved in a study of distribution of phosphates, silicates, nitrates, and its relationship to prevailing patterns of temperature, salinity, oxygen, and zooplankton.

M. Krishna Menon is doing most of the physiological studies on crabs and expressed an interest in decapod larvae, reproductive cycles and spawning, and distribution as well.

The function of the fourth Division, the Bombay Office, is not clear. It is staffed by two scientists, Dr. T.S.S. Rao, the Director of the NIU training program, and Dr. A.B. Wagh.

The NIO has organized a number of symposia dealing with various aspects of the IIOE, marine sciences in India and the Indo-Pacific area, and is developing a training program in oceanography sponsored by UNESCO. In November 1966 a symposium was held in Ernakulam on "Coastal and Nearshore Oceanography." Abstracts of the 53 papers presented, primarily by Indian scientists, appeared in the IIOE Newsletter 14, 2, September 1966. The three-day Symposium on the Indian Ocean, March 1967, was also sponsored by the NIO (see ESN-21-6, 20 June 1967).

Early in 1966 the NIO initiated a training program intended to promote the growth of the marine sciences in India and neighboring countries. There was a four-week course in general oceanography, after which the 20 candidates from various institutions and universities in India and five from Ceylon, Malaysia, Singapore and Thailand were divided into two groups for a two-week specialized training in physical, chemical, biological and geological oceanography. The geological group received this portion of their training at Andhra University, Waltair; the biological group at Cochin, and the physical and chemical groups continued their training at Bombay. A team of 30 scientists from India and 11 from various countries gave a total of 90 lectures covering most aspects of oceanography.

In addition to publications in Indian and foreign scientific journals, the NIO published "International Indian Ocean Expedition-Newsletter, India" which is now in its fourth volume. A brochure on the Indian Ocean Biological Center was published in 1965 and the article by Vagn Kr. Hansen (Deep Sea Research 13 229-234 (1966)) provides more current information.

The facilities of the NIO, insofar as the Physical and Biological Divisions at Ernakulam are concerned, would appear to be similar to those previously described for other marine laboratories. The physical plant is located at Karikkamuri Cross Road, several blocks back from the waterfront, and it would be extremely difficult to install and successfully operate a sea-water system, even if the source of water were reasonably unpolluted. Although there are some modern pieces of laboratory equipment, one was given the impression that there are the same difficulties with maintenance and repair that had been found in previous institutions. It is to be hoped that in providing new facilities for the NIO at Goa it will be possible to provide some of the basic requirements for operation, maintenance, and repair.

At the present time the NIO does not have an oceanographic research vessel, although arrangements have been underway for some time to present the RV ANTON BRUUN to India.

BHARHA ATOMIC RESEARCH CENTRE, Trombay (Bombay)

This Centre, one of several operated by the Indian Atomic Energy Commission, must be seen to be appreciated in its fullest. It occupies several hundred acres approximately 20 miles from Bombay, and many of the scientists associated with the eight groups and divisions have recently moved into the three-story, 1/3 mile-long building which was still being finished during our visit, only one of many which have been built within the past few years. A township to house the officers and staff of the Centre has been planned, several hundred additional acres have been acquired, and some construction has begun. According to the most recent annual report which is available, the Trombay Establishment employed a total of 8,545 people in 1966, of which 5,318 were scientific and technical. The ratio of one administrator for every 3.1 scientists must represent an administrator's dream and would make an interesting figure for comparison with similar institutions in other countries.

Within the Biology Group, directed by Dr. A.R. Gopal-Ayengar, there are four major Divisions: Biochemistry and Food; National Botanical Gardens; Biology; and, Technical Division. Most of the studies involving marine organisms are in the Health Physics Group, but some of the further subdivisions of the Biological Division are also involved in marine studies. Approximately 100 scientists are employed in these various subdivisions which include Agriculture and Botany, Radioactive Transfer Studies, Physical Radiobiology, Organic Chemistry, Insect Sterilization and Birth Control, Plant Physiology, Biochemical Genetics, Plant Morphology, and Biophysics. Time did not permit us to talk with the scientists individually, but some idea of the types of research currently underway can be obtained from the papers which were presented at the March Symposium by members of these two major groups.

Dr. Y.M. Bhatt, Health Physics Division, has been making a study of vertical distribution of intertidal organisms on sandy and muddy shores in the area of Bombay. Three members of this group, Drs. V.K. Iya, A.C. Eapen, and N. Kirti have been employing radiotracer techniques in a study of movement of silt on the sea bed, expecting to use the information eventually to aid in the selection of a site for a canal which is to be built near Madras. Several other members of the staff have been involved in a study of current pattern to contribute information on dispersion of radioactivity in the sea. Dr. B. Patel, who received his Ph.D. 10 years ago with Prof. D.J. Crisp at Menai Bridge, UK, is now employed in the Health Physics Division and has been studying the uptake of a variety of trace elements in marine organisms from the West Coast of India.

From a brief discussion with Gopal-Ayengar, I got the impression that although the Centre has excellent facilities and a wide variety of modern equipment, they would welcome visiting scientists for the "expertise" which would hopefully be available to the younger Indian scientists. This Centre, which must certainly have received the major

funding from that portion of the national budget devoted to the sciences, also has problems with foreign currency and is not able to obtain many things which are manufactured outside India.

Considering the numbers of scientists which have been attracted here, largely because of the salaries and security which are afforded, and the tremendous financial effort which is represented, it can only be hoped that the Indian people will eventually realize a return which is at least partially commensurate with the investment. At a time when major institutions within the same discipline are being reduced in a number of European countries, it is difficult to understand why scientific advisors in India should choose to continue the development and expansion of such a facility.

HAFFKINE INSTITUTE, Bombay

This Institute, one of the largest research-production facilities of its kind in the East, has a technical staff of more than 200 scientists in ten departments and sections. These include: Bacteriology; Immunology; Virology; Pharmacology; Clinical Pathology and Diagnostic Reagents; Biochemistry; Entomology; Chemotherapy; Blood Bank; and, Nutrition. Despite the fact that we were told initially at central government levels in New Delhi that there was no research at the Haffkine Institute, we found it to have an active research unit. The numerous activities of the various departments are summarized in a special report prepared by the Haffkine Institute in connection with its Diamond Jubilee.

The Director, Dr. H.I. Jhala, who impressed us with his sincerity and dedication, emphasized the Institute's capability for research in biochemistry, but indicated that at the present time comparable capability does not exist in biophysics. The Institute is well equipped for biochemical studies, but has had difficulty in obtaining and retaining qualified senior research fellows. The Director commented on the competition for staff from other research institutions and industry and indicated that it makes it difficult to continue with existing programs and develop new areas of interest. Frequently scientists who are trained at the Haffkine Institute move on to other institutions where there is apparently greater security.

NATIONAL PROGRAM OF THE INTERNATIONAL BIOLOGICAL PROGRAM, MARINE PRODUCTIVITY

At the present time India's program is composed of two cooperative efforts with marine laboratories in the UK. Dr. S. Krishnaswamy is collaborating with Prof. J.E.G. Raymont, Oceanography Department, Southampton University, in a comparative study of productivity in temperate and tropical regions. The second program, a collaborative effort between Dr. Qasim of the NIO at Ernakulam and Dr. Steele, Marine

Laboratory, Aberdeen, UK, involves primary productivity and a study of food chains in inshore areas near Cochin.

GENERAL REMARKS

In a visit of this type, with a few days spent at a number of institutions, it is extremely difficult to arrive at any general impressions which can apply to all. The previous trip to New Delhi, however, had the advantage of permitting me to talk with any number of Indian scientists in marine biology and oceanography, discuss with them the status of the marine sciences in India, and then, on the second trip, attempt to determine how their comments and criticism fit in with the situation which I observed.

Enthusiasm is a common feature of many Indian scientists, especially among the younger group. Many of them have received advanced degrees in foreign universities and have now returned to India to put to use the knowledge which they acquired, usually at Government expense. On their return they are faced with a situation over which they as individuals have little control, and it is apparent why many of them candidly admit that they will plan to leave if reasonable efforts are not made to improve the facilities and opportunities. One facet of the situation is "bio-politics," on a scale which is difficult to imagine. Within the marine sciences, which have developed largely during the past ten years, two rival groups have emerged which attempt to dominate and control all aspects of the disciplines involved. The activities of these two groups are not limited to competition for quality, but rather competition for position and authority, normally referred to as "empire building," and duplicate schemes are far more common than the complementary ones. Younger scientists who do not wish to be involved with either camp are persona non grata, and find it virtually impossible to receive appointments to desirable positions, participate in research efforts, or receive financial assistance to carry on the studies which they initiated during their advanced training abroad. Some, on their return to India, find that during their five- or six-year absence from the scientific community their colleagues, who were not so fortunate to receive the necessary financial assistance to acquire degrees abroad, are now well advanced in the "bio-political" regime and in positions where they can stifle any advancement of their returning colleagues, regardless of ability or effort.

In addition to finding a "bio-political" situation with which they are unable to cope, they return to laboratories where both basic, everyday equipment and modern equipment is virtually non-existent or, if it is available, it frequently does not work, cannot be maintained, and funds are not available for repair or spare parts. It is difficult for this author to imagine the logic which motivates "senior" scientists to invest sizable amounts of foreign currency in such items as electron microscopes, and incidentally plan to purchase another in the near future, when the

existing staff cannot make use of such equipment. With this approach to science considerable assistance will be necessary to provide for the day-to-day running, maintenance, and repair of specialized equipment on the RV ANTON BRUUN.

One remaining impression, and one which is perhaps more disturbing than the others, is the lack of "objectivity" on the part of many of the scientists and students. If information is given in a lecture, it must be true; if results are presented in a journal, there can be no question concerning their authenticity; an individual, especially at the level of the graduate student or young post-doc, would never question the concepts set forth by a senior scientist. This attitude, coupled with an approach which stresses the memorization of facts without any comparable stress on associations and relationships between facts, cannot contribute to a scientific effort which is truly original and searching. There are individuals, and even groups, who are attempting to use the basic concepts of the scientific approach, but as in disciplines other than the sciences, it is a very unpopular approach and certainly would not win an individual a coveted place within one bio-political camp or the other.

Several of the younger scientists expressed sincere hope that current efforts to establish an Indian National Science Foundation, patterned after the American institution, would be successful before it was too late. They realize that only if proposals are considered on the basis of merit can they expect any financial support for research. They also realize that unless the individuals who compose the various committees within the proposed foundation make a concerted effort to adhere to the principle of merit, the scheme will do nothing but contribute to one or another of the empires which are presently stifling initiative and competition for quality.

Over-all, perhaps the most pressing need in India today, apart from leadership, is the building of a capability in the maintenance of modern equipment. Without this, the sophistication which is currently being sought will be doomed to failure.

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<p>The report considers the staff, facilities and research interests of institutions in India which have programs in the marine sciences and life sciences. Certain general aspects of the scientific community, the problems of development of research facilities, and the role of science in the development of India are also considered.</p>		

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