Fill Space - Speech [Marine Science - Oceanography]

Congressman Joseph E. Karth
Luncheon Address
National Space Club
National Press Building
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POTENTIAL OF OCEANOGRAPHY

Perhaps I should begin with a personal note on why I am talking about oceanography at a Space Club luncheon.

Last summer I became a member of the Merchant Marine and Fisheries Committee - Later - in the fall - I went on the Oceanography subcommittee because I think it deals with an extremely important area ... and because oceanography is becoming increasingly related to space.

I should be quick to point out that I am no expert on oceanography. But I have been digging into it and want to outline some of my preliminary thinking - particularly because we're at a critical stage on deciding how to proceed with oceanography development.

One of the earliest Congressional oceanography experts is here in the audience today. From March to June 1959 Chairman Miller headed a special subcommittee which reviewed "Oceanography in the United States." He has consistently advocated a stronger national program and a more sensible organizational approach. Mr. Chairman, in addition to other things I think it only fair that I recognize you as the real congressional father of oceanography.

A moment ago I mentioned the relationship between oceanography and space activities. For a few minutes I intend to outline - what seems to me - some of the important points about this relationship.

One important contribution of aerospace technology has been general acceptance of the "total systems approach." A closely connected idea is the growing awareness that we need to view our world environment as a whole. And I have a hunch that in retrospect, historians will consider this concept as one of the truly significant ideas of our century.

As part of our environment, the sea is not "independent" - it is greatly affected by outside forces: the rotation of the earth and the movements of the sun and moon result in events we all can observe every time we go to the beach. Less apparent are the effects of the direct income and outgo of radiant solar energy - and the vital interchange between sea and atmosphere and land.

This suggests that, as in the broad field of space, hardly any aspect of the sea is capable of adequate analysis without coordination of all the fundamental natural sciences and engineering. In this sense, as with the study of space, oceanography is not a science in itself. Rather, it is a combination of various sciences and fields of engineering to study the sea in all its aspects - including the complex interrelationships with our total environment.

An approach of this kind leads directly to what a number of people are suggesting as specific correlation between space "know-how" and the problems being faced in oceanography. I'll just mention a few major areas:

(1) Reliability and efficiency requirements.

(2) Systems management experience.

(3) Structures and materials.

(4) Operating in a hostile environment outside the atmosphere.

(5) Instrumentation and sensors - especially in standardizing.

(6) Computer, guidance and power systems.

And finally

(7) Vehicle design and construction.

But - I'm just summarizing when I talk about specific areas such as these. Most certainly, I'm not telling you anything that is startling. Many aerospace firms have already grasped the point. For example:

(1) North American Aviation has a new Ocean Systems facility which will draw heavily on the firm's space effort. It's no accident that it is located in their Space and Information Systems Division.

(2) Lockheed has established a Marine Laboratory.

(3) Nortronics is working on the Navy's Deep Submergence Systems Project.

(4) The Underseas Division of Westinghouse is now building a new research and test facility.

AND

(5) General Dynamics' Electric Boat Division has been in the field for a long time.

Incidentally, I understand that some people have become somewhat disenchanted because certain corporate investments of the early 1960's haven't started to pay off yet. My advice is this: Stick around for a while; Small opportunities are often the beginning of great enterprises.

Just this month, there have been two solid indications that space and oceanography are more than "kissing cousins";

(1) The Naval Oceanographic Office has undertaken the coordination of all investigations about possible applications of manned earth orbital operations in the field of oceanography. I intend to suggest that their interest be expanded formally to include unmanned operations as well.

(2) A symposium was held here in Washington last week on "Man's Extension into the Sea." It was interesting to note that its co-sponsors included not only such expected organizations as the Marine Technology Society - but the AIAA as well.

Having, I believe, established why I'm not out in left field by talking oceanography to a space group, I'd now like to turn to why the subject is so important.

For most of human history we have considered the oceans as little more than hunting grounds for fishermen and highways for ships. Of course, the shores have always provided recreation - and recently there has been the added pleasure of "bikini watching."

But for the future I strongly believe that we can expect a greatly expanded "ocean-consciousness" as man turns to the sea with new eyes and new ideas. I see this as part of a broad scientific advance which may lead to profound changes in life as we now know it on this planet. In effect, we are taking the first, awkward steps to eventually controlling our environment - rather than letting it dominate us.

More specifically, as far as the sea is concerned, there is a growing consensus that:

(1) We will be able to obtain economically much of the world's fresh water needs from sea water within the next ten years or so.

(2) We will be able to harness tides as a source of power.

(3) Ways can be found to help control the world's climate by controlling or using ocean currents.

(4) The oceans and, of course, the seabed and subsoil of the ocean basins are a vast potential source of many metals which are rapidly becoming in short supply.

AND,

(5) We can look to the oceans to solve some of the world's food problems as we learn to "farm" instead of just hunt. While more than 70 percent of the earth's surface is covered by water, not more than one percent of its total food supplies are derived from it.

I would like to dwell on this point for a moment. Recently, Dr. Lawrence Gould, director of the U. S. Antarctic program during the latest IGY reported, "... these Antarctic waters are so protein rich that it is generally agreed among scientists that acre for acre they are potentially richer food sources than any other equivalent areas of our planet ..... clearly here is an enormous, potentially rich food supply for an increasingly hungry planet."

I don't think Dr. Gould's comment can be lightly dismissed. Our planet's food problem is acute, and despite the superb performance of the American farmer, he can't solve it all by himself. Even if all of our surplus food were somehow provided to the rest of the world, it wouldn't be nearly enough. In fact, some experts tell us that in ten years, U. S. citizens will consume every ounce the ingenious American farmer can produce.

Comments are being made widely "that there have always been hungry people and famine is part of the history of man." But what these people miss is a growing determination to attack and defeat one of mankind's most ancient enemies. The potential benefits of oceanography will clearly be powerful weapons in this attack.

While there seems to be relatively little controversy about the potential benefits of work in oceanography, how to go about realizing these benefits has been a cause of continuing debate for several years. The reasons for this debate are as complex as government itself, but I'll take a crack at them.

One reason seems to be that the focus of our attention in oceanography has undergone radical changes during the past decade. Yesterday, we were interested in it as a science. Today, we are thinking more about man working and living on and in the ocean. We are thinking about the engineering and technological problems connected with harvesting the resources of the sea. This kind of transition from science to use is never made easily -- but it must be made.

Another reason for the extensive debate is rooted in the fact that several Administrations and the Congress have had differing points of view on how the nation's effort in oceanography should be organized.

No small factor in this debate has been Congressional concern that 22 agencies (by one count) are involved with oceanography. I can't find any record of it, but I'd be willing to bet that even the Army and the Air Force have an "oceanography office" tucked away somewhere - just in case.

The activities of these 22 agencies are brought together by the Interagency Committee on Oceanography which is under the Federal Council for Science and Technology. Basically, Administration witnesses before the Congress have said this arrangement is satisfactory. The Congress has not agreed with them. Over the past several years it has considered these alternatives:

(1) Beefing up the present coordination set-up.

(2) Establishing a new independent agency - I might add it has been referred to as a "wet-NASA."

(3) Establishing a National Oceanographic Council headed by the Vice-President - it would be much like the present Space Council.

AND

(4) Establishing a national commission to study and recommend an overall plan for an adequate national program.

Of these various approaches, only the first - in the past - has been acceptable to Administration witnesses. However, during the 1st Session of this Congress, both the House and Senate passed a bill based on other approaches.

(1) The Senate Bill - S. 944 - proposed a Council at a higher level than the present Interagency Committee on Oceanography. The Council would be headed by the Vice President. A study commission also is provided for to recomment plans to the Council for implementation.

(2) The House version omits the National Oceanographic Council, and anticipates that the President would use existing mechanisms in the Office of Science and Technology and the Federal Council to implement these proposals. It also establishes a self-liquidating commission which would recommend plans for a program to the President.

Actually, I believe both bills agree on far more points than they differ.

Both broadly define "Oceanography" and "Marine Science". This is a major contribution to our understanding of the scope of the national effort.

Both set forth a declaration of national policy and purpose, so badly needed to give direction and stability.

Both provide for a representative, self-liquidating study Commission.

Both call for annual Executive reports and the development of long-range annual plans and budgets.

Both provide funds for independent, government wide central planning.

Importantly - both bills emphasize the need for political action - now. They differ only in the degree of required action and the level at which this action and leadership should be exercised. In proposing the Cabinet-level Council with its own staff, the Senate bill tends to go much farther than the House. The House prefers its version because we believe the legislation has a better chance of being approved by the Administration.

In any event, it is my opinion that recent discussion and action in the Congress has gone a long way toward focusing attention on two very important points:

(1) Oceanography is not getting satisfactory attention within the Administration under existing organizational arrangements. What seems to be needed as much as anything is to get oceanography out into the open in a more conspicuous position.

There is a distinct feeling within the Congress that the ICO - Interagency Committee on Oceanography - is buried too far down in the Government hierarchy. On this point, you don't need to be connected with space to know that Jim Webb heads NASA - but I would guess that relatively few would know who is the Chairman of the ICO.

The existing organization gives rise for concern on the part of the Congress as to whether there is a national program. I mean this in the sense of whether it is screened and adapted to fit a set of national priorities- in contrast to it being a simple addition of priorities arising from twenty-two different agencies.

(2) A second major concern on the part of the Congress is that oceanography is not receiving an adequate allocation of resources. Aside from the Navy Anti-Submarine Warfare effort in Fiscal Year 1966, our oceanographic budget totalled about $140 million. Perhaps it's not a valid comparison to make, but this past week, Sears Roebuck announced that it would spend $200 million on store expansion during 1966.

In a nutshell, an investment of $140 million for oceanography does not seem to be consistent with our present capability and the potential benefits. The present rate of growth of the composite budget is about 8 - 15 percent per year. I won't presume to say what it ought to be - because I think this is the kind of question that we in the Congress would like to have considered by either a Council or a Commission. I will say, however, that I do think such a rate of growth is not fast enough.

In making this judgement, I am not unaware that there is danger in building up too rapidly. Professional oceanographers have, in fact, expressed their fears of swift proliferation - beyond the capacity of the existing qualified and experienced scientists and engineers to train increasing numbers of recruits.

There is something to be said for this point of view - when it is considered that there are only about 3000 professionals working the field - and when it is considered that there are only 12 schools teaching 300 graduate students and turning out 20 PhD's a year. <u>But this view overlooks one vital point</u>.

An expanded oceanographic program will require the talents of many disciplines - not just those of professional oceanographers. In a sense, then, oceanographers will no longer have the isolation they have been accustomed to - but will be exposed to the rough and tumble world of teamwork on a large scale. Therefore, it seems to me that a shortage of oceanographers is not as critical as it might appear at first glance.

This is not to say our educational program is in good shape; it isn't. Twenty PhD's a year - of whom about half are replacements - won't be sufficient for the long pull. Energetic efforts should be taken to step up the pace - as has been done in the area of space. For example, we could well use the NASA - type facility grant for universities on an expanded scale in the field of oceanography - with emphasis on an interdisciplinary approach.

In concluding, I want to return to another facet of the space-oceanography relationship. As we move to considering more ambitious space programs - such as manned expeditions to Mars or the moons of Jupiter and Saturn - you all know what happens to the price tags. By comparison, Apollo may look cheap.

Frankly, I don't foresee general acceptance of the enormous outlays for such programs until we have solved the continually worsening home planet problems of hunger and poverty. This leads me to believe that in years to come there will be much greater emphasis on fields such as oceanography which have the potential for helping to solve them. By greater emphasis I mean far more than any of us might realize today; because true progress, it has been said, consists not so much in increasing our needs as in diminishing our wants.

I choose not to talk about this in terms of an "oceanography gap", even though I'm convinced we are not preeminent in the field. But I hope we don't wait for a sharp stimulus which forces us into a competition. Perhaps we should move more rapidly because we have the capability and it ought to be done for the benefits it can provide for us and the rest of mankind. How fast we move to meet the challenge of the ocean depends in large measure on the political action we take today.

ANNUAL REPORT

1964 - 1965

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OF
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Director's Review

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Among the more significant events of the year ending May 31, 1965, were the initiation of planning for a hyperbaric laboratory, to be developed in cooperation with the Medical School, the Institute of Molecular Evolution and other divisions of the University. Further EQUALANT expeditions were made to the mouth of the Amazon and to the Atlantic equatorial region in order to extend data from previous cruises. The end of this period was also marked by the organization of a 22,000-mile expedition to the Black Sea, Mediterranean and West Africa.

Land for a field station at Pigeon Key, in the Florida Keys, was acquired, but financial support from NSF was delayed. NSF financing, on a partial support basis, is gratefully acknowledged for the erection of a new wing for the Main Building and work was begun on the foundations. At the same time the U.S. Bureau of Commercial Fisheries broke ground for its new laboratory on a site adjacent to the Institute, thus enhancing the cooperative relationship already existing. A cooperative agreement with the oceanographic institutes of Woods Hole, Scripps (University of California), and Lamont (Columbia University) paved the way for the first of a number of pioneer major deepsea drilling operations which will enormously enhance our knowledge of the deepsea sedimentary structure.

The concept, and preliminary plans for financing, of a Marine Science Center were developed. This provides for a central building in which maximum opportunity will be provided for scientific communication and collaboration between the growing number of groups in the Miami area concerned with ocean science and engineering, including our staff, students and visiting investigators, scientists from other divisions of the University, the Bureau of Commercial Fisheries, and the industrial engineering organizations concerned with AUTEC and other major developments of naval and civilian nature in our general area.

The academic program, a part of the University of Miami Graduate School, has continued to attract a large number of well qualified students and the new curriculum in oceanographic engineering has been enthusiastically received.

PERSONNEL

The Institute's capabilities were extended by the following staff appointments:

Dr. Enrico Bonatti — marine geologist — from Scripps Institution of Oceanography

Dr. T. S. Cheung — crustacean physiologist — from the University of Hong Kong

Dr. Walter Drost-Hansen — chemical physicist — from Jersey Production Research Co.

Dr. Christopher Martin — microbiologist — from State College at North Adams, Mass.

Mr. John Michel — coastal engineer — from private engineering consultant

Dr. John L. Munro — fisheries biologist — from University College of Rhodesia and Nyasaland

Dr. Russell L. Snyder — physical oceanographer — from Scripps Institution of Oceanography

Dr. Norman L. Weinberg — electrical engineer — from Westinghouse Electric Corp., Baltimore (Aerospace Division).

A committee for the development of programs of visiting biological investigators was set up under the chairmanship of Dr. Morris Rockstein of the Medical School.

As of May 31, 1965, the total number of full-time employees at the Institute was 270. This included 82 staff engaged in teaching and research; 151 engaged in administration and technical services; and 37 employees in ship operation and maintenance. An additional 31 graduate assistants and 13 undergraduate assistants were employed on a part-time basis.

RESEARCH

Results of investigations carried out by the staff are reported in greater detail under the heading of each of the research divisions.

The radar meteorology laboratory developed improved instrumentation for its investigations of the sea breeze among other objectives and also established correlations between TIROS satellite cloud observations and radar data. Observations during hurricane Cleo were used for improving methods for locating the storm center. In cooperation with the U.S. Weather Bureau a historical study of Caribbean tropical cyclones was completed. The importance of air-sea relationships and hurricanes in oceanography was further recognized by an expansion of tritium research at the Institute to include studies of water exchange mechanisms between the sea, the troposphere and the stratosphere within hurricanes. Air-sea interaction studies were continued, among the objectives being the pressure/surface elevation relationship, acoustic triggering for white-cap photography and theories of wind generated waves.

Measurements of the Florida Current by means of freely dropped instruments gave a total flow ranging from 27 to 38 million tons/second, with variations as high as 25% over periods of a few days.

Further studies of the salinity core, the Undercurrent and foraminiferan species were carried out during EQUALANT V. Both fossil and living organisms were analysed for trace elements.

The 45-mile underwater sound range has been in almost continuous use during the year and has made possible a careful investigation of the effects of environmental changes upon the nature of transmission. The underwater acoustics group has also begun design studies for a modified video-acoustical system for the bio-acoustics group.

Geomorphological studies of the Florida Straits and neighboring areas indicate that large scale faulting or folding, previously thought to exist, are largely absent here. The Northeast and Northwest Providence channels, forming the largest submarine canyon in the world, were further investigated, together with certain Caribbean seafloor areas where exceptionally large manganese nodules were found.

Calcium carbonate precipitation on the Great Bahama Bank appears to involve, most probably, the formation of fine aragonite needles by inorganic precipitation. The Pleistocene Key Largo limestone was shown to be associated with extremely extensive areas of bryozoan limestone.

One of the longest known undisturbed cores of Globigerina ooze, in excess of 60 feet, was raised from the Venezuela Basin of the Caribbean. This dates back to over 500,000 years. It is believed to approach the limits of piston-coring. The JOIDES group undertook drilling on the Blake Plateau off the Atlantic coast of Florida and obtained a total of 1700 feet of core material from six holes reaching to the Paleocene.

Stratigraphic studies were continued on sediments from the mouth of the Amazon, off Antarctica, and in the Caribbean. Petrological examinations were made of material from five deepsea Pacific volcanoes.

The geochemistry of boron, manganese, cobalt and nickel in relation to the sediments continues to be investigated. Work was also continued on measuring radioactivity in the seawater and sediments, and radionuclide techniques for dating were extended to the Black Sea as well as the Atlantic and Caribbean. Studies were begun on the U234/U238 ratio. It was found that Pa231/Th230 is more reliable than Th230/Th232 in Caribbean cores.

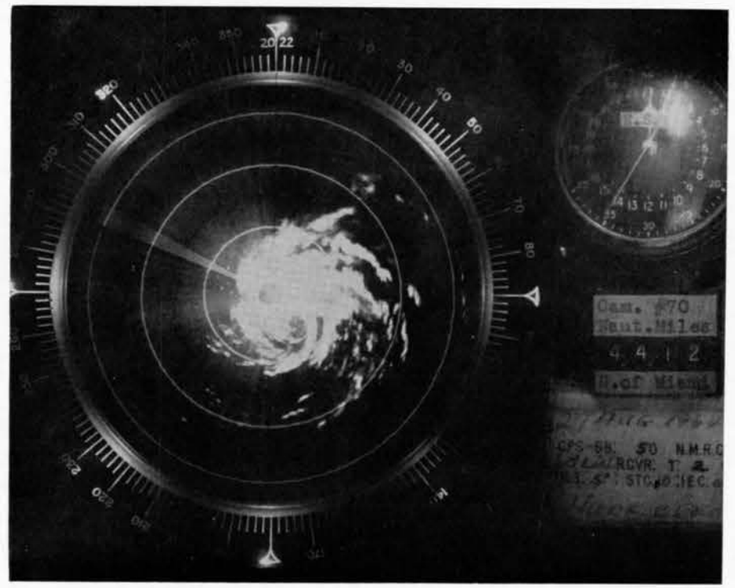
Investigations of the molecular structure of water were accelerated by the development of a rapid system for displaying conductivity as a function of temperature.

Phytoplankton production in relation to trace elements was studied in Florida waters, in the Gulf of Guinea and off the mouth of the Amazon River. During the EQUALANT cruises, the discovery of the larvae of shallow-water organisms in mid-ocean suggested that migration across the Atlantic is still active. The Straits of Florida plankton was shown to include a varying influx of organisms from the Atlantic. A study of the copepods of the Straits, totalling 216 species, nears completion. A rare giant copepod was taken from the Gulf of Guinea.

Investigations of anti-yeast strains of marine bacteria indicate a possible natural biological control of estuarine yeasts of terrestrial origin. Other investigations of the dominant mycota of grassbeds were concerned with their interaction with nematodes. Biometric studies were made of yeasts from the Black Sea, North Sea and Indian Ocean.

Calcification in green algae was shown to be influenced by the chelating action of low molecular weight organic compounds upon calcium and carbonate ions.

With completion of the Glassell Building, behavior and experimental ecology studies were intensified. A number of important investigations were made of the response of fishes and invertebrates to light and sound. Lemon sharks were found capable of detecting sound vibrations at frequencies as low as 7.5 c.p.s. and to discriminate between sounds differing by half an octave. In the field they responded to the vibrations caused by struggling fishes in distress. Visual acuity and discrimination was investigated in a number of fishes with important results. An ingenious group of experiments took advantage of the "weightless" condition of fishes deprived of their gravity receptors. The bioacoustics program undertook a survey of the bioacoustic behavior of fishes in areas surrounding



The eye of Hurricane Cleo is shown passing over Miami on August 27, 1964. This photograph of a radar scope was made at the IMS Radar Meteorological Laboratory.
(Homer Hiser)

the Bimini video-acoustic station. Ethological studies were also carried out upon fiddler crabs, hermit crabs and commercial shrimps.

The toxic properties of various marine invertebrates were investigated, using fiddler crabs and mice as indicators. Of especial interest was a study of the evolution of respiratory pigments and toxins in invertebrates. Research was also conducted upon osmoregulation and visual physiology in various invertebrate phyla. An important investigation was launched into the effects of pesticides on shallow-water fauna, using tarpon and other fishes as indicators. Of unusual interest was the beginning of physiological studies of the Pogonophora made possible by the discovery of considerable numbers of these "new" organisms in the vicinity of the laboratory.

Ecological studies of the shallow water grassbeds, including both fishes and invertebrates, and growth studies of gorgonians were continued. Studies of the reef fishes included feeding habits. Nocturnal behavior and distribution were shown to be drastically different from those of the daytime, by the use of diving techniques. Factors limiting the distribution of deep-sea fishes in the Florida Current were also investigated.

Descriptive studies of crustacean larval development, now in the fourth year, have reached a total of 110 species under investigation, ranging from Bermuda to West Africa and Panama. Attention has also been paid to physiological requirements of the developing stages. Similar studies have been carried out upon other invertebrates and fishes. The life history, distribution and biology of the larger game fishes, including marlins, sailfishes, tunas, barracudas, and tarpon were objectives of special investigations.

Research in deep-sea biology gained impetus with increased availability of ship time, design and purchase of new deep sea bottom and midwater trawling gear and organization of a special group of staff and students. Areas studied included the Caribbean, Sargasso Sea and West Africa. Data are IBM-carded for future analysis, reference and retrieval. A number of interesting zoogeographical relationships were reported. An entirely new family of deep-sea fishes was discovered.

Systematic biological research has resulted in a number of important publications covering pelagic fishes, reef and shore fishes, crustacea, echinoderms, polychaetes, barnacles, cephalopods and corals, both shallow and deep water. A new species of platyctean ctenophores, a group until fairly recently believed absent from the Atlantic, was described. The magnitude of the task of sorting material is indicated by the fact that over 1,500 specimens of Antarctic cephalopods were identified. Cephalopod studies included investigations on bioluminescence, larval development, locomotion and community structures.

For the first time, stone crabs were raised from the egg through five zooea stages to the megalopa, and environmental optima were established. Other objectives related to possibilities of economic culture included frequency of claw regeneration and growth rate.

The seventh year of a study of fish population dynamics in the Everglades National Park reveals rapid growth in fishing pressure. Also investigated was the influence of environmental factors upon the abundance of pink shrimp migrating from their nursery grounds in the Park and the relation of the latter to commercial catches on the Tortugas grounds. Conclusions based upon previous work give the population of larval shrimp as 500×10^{10} in a 1000 square mile area and indicate that spawning is heaviest at temperatures above 27° C. and at full moon. Evidence also indicates that the Florida Current plays a part in the transport of larvae to the nursery grounds.

Severe drought during the year made possible a study of the effects of hypersalinity upon the shallow-water biota of Florida Bay and the Park periphery.

The engineering division, the physical sciences division and the engineering school were responsible for the development of a number of new instruments for current measurement and water sampling. A platform and tower was erected in Bear Cut near the laboratory for the purpose of testing instruments and sensors and for biological observations.

ACADEMIC PROGRAM

A total of 118 students were enrolled for graduate study. Fifteen of these were in the oceanographic engineering program. Ten students completed requirements for the Ph.D. degree and ten for the M.S. Cooperation with other departments of the University by our faculty in offering advanced courses in their curricula was continued.

The oceanographic engineering curriculum completed its first year with marked success. A highlight was the participation of over 30 distinguished visiting lecturers.

BUILDINGS

The Institute is badly overcrowded, with stores and workshops located in old trailer truck bodies, and in areas designed for outdoor live specimen tanks. The beginning of construction of the new North Wing of the Main Building ensures that the Physical Sciences Division will soon move from the old "temporary" building into new well-furnished quarters and that there will be a partial relief for other divisions.

It is of great importance that the projected Marine Science Center be brought into being at an early date, in order to alleviate crowding that is increasingly serious and detrimental to efficiency. Negotiations for the land, adjacent to the Institute, are still progressing and architects' plans are well under way. The building will house the library, a new auditorium, the computer and future data retrieval systems, the biological reference collection and data files, and a dining facility. The latter will include smaller rooms for lunch conferences, available for lectures at other times. Here it will be possible to organize a focal point for the exchange and development of ideas and information between faculty, other university groups involved in research related to the sea, students, visiting investigators, and oceanographic engineering organizations. It will be open as an informal club to the scientists of the neighboring Bureau of Commercial Fisheries laboratory, the Weather Bureau, and similar groups in the vicinity. It will be a center for lectures, seminars, discussion groups and similar activities.

IMS Pigeon Key Field Laboratory lies beneath the Seven Mile Bridge in the Florida Keys.
(Florida State News Bureau)

PIGEON KEY

Negotiations for the lease of Pigeon Key from the Monroe County Commission were completed in August, 1964. The Key is located in an area inaccessible to the general public but superbly adapted to field studies of the geology, chemistry, physics and biology of calcium carbonate deposition, and mangrove and coral reef organisms. Though free from intruders by virtue of its distance from land, it can be reached by bridge and causeway and is thus within 1½ hours drive from Miami. It combines the advantages of island laboratories such as Bermuda, Bimini or Barbados with accessibility to modern laboratory and library facilities and the services of a large city. There are a number of buildings in various stages of repair, which can be replaced or put into good condition for use as living quarters and laboratories. It is proposed to maintain Pigeon Key as a field station for the use of visiting instructors and their classes as well as visiting investigators and our own staff and students. Fees charged would cover the cost of maintaining the modest facilities.

Preliminary discussions with the National Science Foundation were initiated and an application was submitted in March, 1965, for the funds required to make the buildings usable. So far no definite reply has been received.

In spite of inadequate laboratory space, and no living quarters, a number of groups have already used Pigeon Key. Because of the conditions it has not been possible to make realistic charges to cover our costs to date.

RESEARCH VESSELS

The vessels *Pillsbury, Gerda and Tursiops* are being fully utilized and it is apparent that any significant expansion in research involving deep-sea operations will call for additions to the fleet. In any case it will be necessary to plan for replacement of *Gerda* and *Pillsbury* within the next five or six years at the latest.

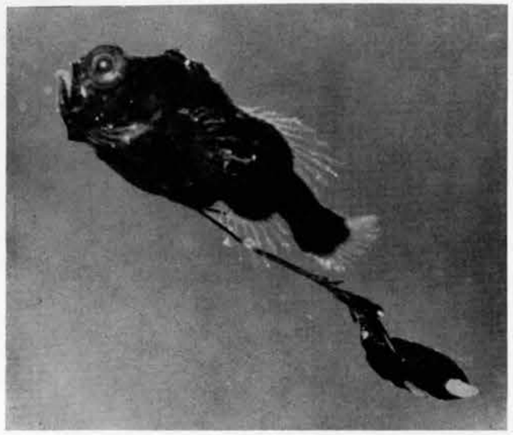
The need for a shallow draft vessel suitable for shallow water research and for carrying up to 25 students on field trips is now urgent.

OTHER ACTIVITIES

The Gulf and Caribbean Fisheries Institute, held in November at Runaway Bay, Jamaica, was, as usual, well attended by scientists and industry members from all parts of the U.S.A., as well as the Caribbean area. This marks the 17th annual session of the Institute.

In addition to contributing papers to the leading scientific journals, the Institute publishes its own quarterly journal, the Bulletin of Marine Science of the Gulf and Caribbean, of which volume 14, with 748 pages, was completed during 1964.

The new series, Studies in Tropical Oceanography, has gone to press with its second contribution, *Distri-*



Kasidoron edom, representing a new species, new genus and new family of fishes, was discovered south of Bermuda and photographed alive. *(W. M. Stephens)*

bution and Relative Abundance of Billfishes of the Pacific Ocean, by John K. Howard and Shoji Ueyanagi.

The library was expanded considerably during the fiscal year. During that time 23,727 pieces of library material were signed out. The library now has estimated holdings of 22,000 cataloged materials, filed in the card catalog under author, title and subject. Approximately 4,000 reprints have been added, making a total of 18,000 articles available in this form. These are filed separately under author and subject. A total of 144 new journal titles made a splendid addition to the already comprehensive holdings of journals covering the marine sciences. Many back-issues were also purchased, completing volumes that were lacking in its holdings. The Interlibrary Loan service was also used extensively during the past fiscal year, and the Institute reciprocated by lending material through the same medium. The library operates with the advice and counsel of a Library Committee, under the chairmanship of Dr. Robins.

FINANCIAL

The total costs of research and teaching amounted to approximately $4.19 million, of which about $3.8 million was subsidized by federal grants.

The greater part of the operating costs was supported during academic year 1964-5 by the National Science Foundation, the Office of Naval Research, the Atomic Energy Commission, and the National Institutes of Health. Additional significant support was obtained from the National Geographic Society, and from the Bureau of Commercial Fisheries, the U.S. Weather Bureau, the U.S. Department of Army, the National Park Service, and other federal sources. The total amount of government support, for operations, amounted to $3,316,654, toward the total operating cost of $3,609,168. Building costs exceeding $166,000 were met from federal grants as the new Physical Sciences addition was begun, and the Glassell Building was completed. The new addition was made possible through a $1,040,000 grant from the National Science Foundation.

Total expenditures for operations and capital acquisitions amounted to $4,190,411, of which $581,243 was spent on buildings, facilities and capital improvements of ships; $650,447 on ship operations, and $2,359,414 on the direct costs of research.

FINANCIAL SUMMARY

RESEARCH INCOME		
BUILDINGS AND FACILITIES		
State and Federal Grants	$ 475,675	
Other Sources	105,568	$ 581,243
RESEARCH AND GENERAL OPERATIONS		
State and Federal Grants	3,316,654	
Other Sources	292,514	3,609,168
TOTAL INCOME		$4,190,411
RESEARCH EXPENDITURES		
BUILDINGS AND FACILITIES	581,243	
RESEARCH	2,359,414	
SHIP OPERATIONS	650,447	
INDIRECT COSTS (b)	599,307	
TOTAL EXPENDITURES		$4,190,411

NOTE: (a) Summary is limited solely to funding of actual expenditures during Fiscal Year 1965.
(b) General and administrative costs not included.

Division of Biological Sciences

Dr. Gilbert L. Voss, *Chairman*

ECOLOGY

Ecological studies on the infaunal bottom communities of Biscayne Bay and neighboring regions were continued under Dr. Hilary B. Moore. These are concentrated at present in studies of growth and gonad production of the infauna of the sublittoral soft bottom. Work on *Moira atropos* and *Tagelus divisus* is nearly complete. *Chione cancellata, Codakia orbicularis* and species *of Tellina, Pitar* and *Anodontia* are still under study. There is a considerable year-to-year variation. For example, after the unusually warm winter of 1964-1965, the spawn output of *Chione* was less than half that of the previous year.

Studies of the feeding and respiration of the urchins *Lytechinus* and *Tripneustes* show that, in summer, the feeding is very sensitive to small fluctuations of temperature such as occur in shallow water. This may account for the slowed growth of both species in summer. The work is new being extended to the slower-growing *Eucidaris tribuloides*, and to several deep water urchins. Of the latter, two species of *Stylocidaris* and a *Coelopleura* are now being kept satisfactroily in aquaria.

Dr. Frederick M. Bayer continued investigations of the effects of environmental factors including water currents, light, temperature, sediment on the growth and form of gorgonians on the inshore reefs at Ragged Keys, Margot Fish Shoal, Virginia Key and Pigeon Key, where colonies of various species were transplanted on concrete tiles.

Dr. Moore's study of the interaction of temperature, light, and pressure, in determining the vertical distribution of oceanic copepods, is nearing completion and it is hoped the resulting constants may be employed to predict the distribution of the species in the North Atlantic. These predictions would then be compared with the known geographic distributions.

The ecological study of the *Thalassia,* or turtle grass, communities has been completed in its major detail concerning community structure, prey-predator relationships, etc., under the direction of Dr. Gilbert L. Voss. Before a final comprehensive report can be presented, it is necessary to investigate the primary production in the grass beds. This approach will now be handled by Dr. Leonard Greenfield and his associates.

The major effort in shore fish research in the past year has concerned the biology of reef species, especially as concerns the food and feeding habits and interspecific competition of these species. Work in this field is supported by a three-year grant by the National Science Foundation and is under the direction of Dr. C. Richard Robins.

Principal assistants on the project have been William P. Davis, Henry A. Feddern, and Dr. Walter A. Starck II. Early in 1965 Dr. Starck initiated work on his own program on the biology and spcies of Alligator Reef with suport from the National Science Foundation.

Mr. Feddern has recently been replaced on the project by Mr. Ray Birdsong. Mr. Henry A. Feddern submitted his report on the life history of the common wrasse, *Thalassoma bifasciatum,* for publication.

Alejandro Ciardelli is nearing completion of his study of the demoiselle, *Microspathodon chrysurus.* This fish is closely associated with shallow coral communities. Ciardelli's study pays particular attention to the unusual feeding habits of the species and to the mechanics of the feeding mechanism.

William C. Cummings is completing, in absentia, his work on the reproductive behavior of the sergeant major, *Abudefduf.*

Robins and Tabb published their work on the biology and systematics of the blue croaker, *Bairdiella batabana.* In this they showed that two very closely related species had different habitat preferences during periods of feeding and that their food items were substantially different. *B. batabana* prefers clear waters of grassy basins where there are good growths of red and brown algae; here it feeds on caridean shrimp. In contrast, *B. chrysura* seeks the more open and muddy, sandy bottoms where it feeds to a large extent on polychaetes.

Dr. Robins completed a general report on reef fishes which is scheduled for appearance in *Science.* This is an invited paper intended primarily for scientists in fields other than reef biology.

Walter A. Starck and William P. Davis prepared a report on the night ecology of reefs, which appeared in *Sea Frontiers.* The day and night distribution and behavior of reef fishes differ drastically. Davis continues to study comparative feeding patterns of grunts of the genus *Haemulon.*

Feddern continues his comparative study of food habits of angelfishes of the genera *Pomacanthus* and *Holocanthus.* An interesting side light of the latter study is the demonstration of hybridization between the blue and queen angelfish in the Florida Keys. Nine characters that show intermediacy were analysed according to procedures widely used in ornithology. Hybrids were found to constitute about four per cent of the natural population of these angelfishes in the study area in the Florida Keys.

Dr. William A. Gould completed a post-doctoral study under the direction of Dr. Robins on the life history of the emerald clingfish, *Acyrtops beryllinus.* This small fish is of special interest in that it spends its entire life history in the grass bed community. Isopods, amphipods, harpacticoids and ostracods are the major food items. These the clingfish scrapes from the *Thalassia* blades. The clingfish attaches its eggs to the *Thalassia* blades.

Some deep water fishes have now been taken in sufficient numbers and with sufficient regularity in the Florida Current that study of the factors limiting their distributions have been started. These studies include the synaphobranchid eels (under study by Miss M. C. Hale) and the benthic sharks (under study by J. Staiger).

Thomas Devany is studying the midwater fishes (particularly the Myctophidae) of the Florida Cur-

Plankton sampling aboard R/V Gerda in the Bahamas. (W. M. Stephens)

rent to determine their bathymetric seasonal and geographic distribution, again with the aim of determining ecological parameters.

PLANKTON

Studies of phytoplankton distribution in the Straits of Florida undertaken by Professor E. J. Ferguson Wood have shown that there is a varying influence of plant associations from the Bahama Banks and the Florida continental edge at different seasons of the year. In the northern Straits, phytoplankton from the Atlantic moves in through East and West Providence Channels.

A study of the Amazon delta made in February 1964 by Dr. E. F. Corcoran and Professor Wood showed a large phytoplankton population even in the heavily silted waters at the mouth of that river. Considerable differences were found in the phytoplankton associations northwest and east of the river canyon. This is ascribed to the trade winds forcing part of the Amazon waters to move northwest across the coast of French Guiana.

Dr. Harding B. Owre is completing her study of the oceanic copepods of the Straits of Florida. The manuscript, summarizing information on the 216 species found in the Florida Current samples, is nearly finished including extensive illustrations and publication is anticipated for the fall. Systematic lists of the pelagic copepods, mostly oceanic species, of the Miami area have been entered in the Biological Data Retrieval System.

Identification of copepods collected with the Isaacs-Kidd mid-water trawl in the Straits of Florida and the Gulf of Guinea (first expedition) has been completed. Preliminary examination of the richer material collected on the second expedition in the Gulf of Guinea revealed a nearly perfect specimen of the largest free-living copepod, *Bathycalanus sverdrupi* M. W. Johnson, 17.0 mm long. This is the first record of this species from the Atlantic Ocean and, probably, it is the third known specimen.

MICROBIOLOGY

Microbiological studies have received a new impetus during the year by the initiation of several new lines of study by the staff. An interesting aspect of these studies is the use now being made of the Pigeon Key facility for microbiological studies in the shallow waters of the middle and lower keys. A grant was received from the National Science Foundation, which has made it possible to hold a summer school in research problems in Marine Microbiology at Pigeon Key.

Morphological and physiological aspects of *Pseudomonas piscicida* and related marine pseudomonads have been studied by Drs. J. Buck and S. P. Meyers. Major emphasis has been placed on the physiological ecology of these widespread marine bacteria, especially the incidence of anti-yeast strains in estuarine environments. The general significance of antiyeast activity in marine microhabitats, such as intertidal crustacean fouling communities, has been evaluated in terms of yeast-bacteria associations. In one group of bacteria isolated, approximately 10 per cent of these organisms inhibited yeasts to some degree. Based on seasonal studies of these organisms, it has been postulated that the occurrence and activities of anti-yeast bacteria may serve as a natural biological control of pathogenic and non-pathogenic yeasts that enter estuaries from terrestrial sources.

Dr. Meyers is continuing his extensive studies of marine fungal physiology, with particular emphasis on physiological parameters of reproduction in various of the ascomycetous taxa. Comparative investigations of the Ascomycetes common on submerged wood and *Lindra thalassiae*, a fungus widespread on *Thalassia* leaves, show significant differences between the fungi in reproductive response to various nutrients and substrates. The dominant mycota present on *Thalassia* has been examined and patterns of seasonal infestation tabulated. Striking differences are seen between the foliicolous and lignicolous mycota of estuarine environments. Considerable attention is being given to characterization of the nematode population of the *Thalassia* community in connection with our overall study of interrelationships among the meiofauna and heterotrophic organisms in such locales.

Foliicolous nematodes show striking patterns of seasonal variation, differing widely among distinct turtle grass communities. Populations of these abundant metazoans are affected by such factors as type and concentration of associated algal epigrowth hydrographic conditions, and state of development of the total plant community. Senescence or death of the epigrowth often results in significant increases in numbers of nematodes present on the leaf surfaces. Omnipresent algal feeders, e.g., *Chromadora macrolamoides*, may serve as indicator species in certain grass beds. Furthermore, changes in bionomics of the foliicolous nematode population may possibly be used to characterize relative concentrations of organic deposition in the immediate locality. The foliicolous nematode population differs markedly from that found in the underlying sediment of the plant community. One omnivorous animal, *Metoncholaimus* sp., is an extremely abundant marine nematode and at times comprises the major meiofaunal representative of the biomass in the upper sedimentary layer. Tremendous variability occurs in colonization of the animal between sites within individual areas as well as at the same site at different sampling periods.

A newly-developed fungal disc method is an effective "tool" for the evaluation of marine nematode populations and especially for discerning ecologically significant shifts in animal concentrations and micro-site dissimilarities. Patterns of activity of *Metoncholaimus*, both in numbers and in ratio of sexes present, suggest that discrete loci of organic material (such as fungal infested leaves and decaying plant tissue) significantly affect biological activity of segments of the meiobenthos. Nematological studies in terrestrial and aquatic localities have suggested that various species may serve as indicators of levels of pollutants present and may occupy an important development niche in the biological build-up in contamination of water masses.

Mr. Charles A. Willingham has continued to evaluate the characteristics of corrosive enrichment cultures of marine anaerobic bacteria. Methods of testing microbial corrosion have been refined and simplified with statistically valid results. These methods have been for both mesophilic and thermophilic sulfate reduction, applied in both *in situ* and laboratory marine sediment aggressiveness tests. In screening of enrichment cultures, all but one culture exhibited mesophilic requirements. Bacterial and chemical corrosion of iron have been compared with results that show both types are galvanic but operative through different mechanisms. Uptake of molecular hydrogen by an extremely active corrosive sulfate reducer has revealed uptake rates indicating a pure hydrogen utilizing component of the mixed enrichment culture.

Turtle-grass beds are fertile fields for studies of ecology and productivity. (W. M. Stephens)

A critical review and re-evaluation of the taxonomy of asporogenous yeasts with major reliance on finite dissimilatory capacities and nutritional requirements continues under Drs. F. J. Roth, Jr., S. P. Meyers, D. G. Ahearn and J. W. Fell. The genus *Candida* and *Rhodotorula* have received special attention and will be the subject of an extensive work on the occurrence and distribution of these taxa in the marine environment. The recognized species of the form genus *Candida* have been assigned to seven major physiologic groups established on the basis of their dominant metabolic characteristics and phylogenetic origin; these categorizations will constitute the foundation for a comprehensive bionomic treatment of the genus. Cardinal growth temperature studies of marine-occurring yeasts have shown the existence of psychrotrophic strains. These deep-sea isolates exhibit good growth at 2°C. and have growth optima below 17°C and fail to grow at 30°C. These isolates demonstrate high oxygen consumption rates and glucose degradation maxima about their growth limiting temperatures.

Biometric studies of yeasts isolated from the North

Sea, Indian Ocean, and Black Sea are being continued. The finite identifications of the yeasts and fungi from collections made by Dr. J. W. Fell during our participation in the Indian Ocean Expedition are in their final stage. These data are now being analyzed as to distribution patterns, prevailing oceanographic conditions, and biological associations. Our study of the speciation and population densities of the indigenous yeasts of the Florida Everglades is largely completed. The taxonomy of isolates from virginal fresh, brackish, and true marine waters has been determined. Yeasts with marked fermentative capacity and certain ascosporogenous taxa were of greatest frequency in freshwater situations; however, the most ubiquitous forms in all aquatic environments were oxidative representatives of the genera *Cryptococcus, Rhodotorula,* and *Debaryomyces.* The role of salinity, water temperature, available organic material, and native vegetation on the bionomics of the yeasts is being determined and critically compared with data already obtained from the oceanic environment.

CALCIFICATION

Studies on the calcification of the calcarous green alga, *Penicillus,* were begun by Dr. L. J. Greenfield in the spring of 1964 and sponsored by the Petroleum Research Fund of the American Chemical Society. During the course of the year, growth, occurrence, and morphological characteristics of local species were investigated, resulting in a M. S. thesis.

Current studies on the internal environment (lumen fluid) of *Penicillus* have revealed a number of small molecular-weight organic compounds which are now being characterized. It is believed that these compounds directly influence calcium carbonate crystal formation by chelating large concentrations of calcium and carbonate ions.

In studying the influence of calcification of microorganisms contributing to the marine sediments, methods of direct enumerations of live and dead bacteria are being devised. These methods are to be used in assaying numbers in the sediments. A technique has already been developed for estimating calcified bacteria in the sediments.

Preliminary studies have been under way to determine the ability of various algae to concentrate sea salts. Both water soluble and insoluble fractions of algal cell walls are being analysed, and stress is now being placed on the ability of these fractions to complex with calcium. The latter will be carried out especially with calcareous algae.

BEHAVIOR

Dr. Warren J. Wisby's program of research on the behavior and sensory physiology of marine organisms has been facilitated by the completion and occupation of the new Controlled Environment Building (Glassell Laboratory). In addition, funds have been obtained for construction of new holding and research pens for sharks and other large marine animals. It is expected that the pens will facilitate research on large sharks and make possible experiments with species which do not survive well under laboratory conditions.

Graduate student prepares to spear a fish in order that the sounds it produces while struggling can be recorded through a submerged hydrophone.

(Samuel Gruber)

Experiments on hearing in sharks have been in progress at the Institute of Marine Science since 1960, and on vision since 1963. The implications of these investigations are many, and the avenues of research which have developed are numerous.

Hearing has been conclusively demonstrated over the range of 7½ c.p.s. to 640 c.p.s. in young lemon sharks. The most sensitive relative hearing occurred at 40 c.p.s., where the threshold value (-4 dBub) approximated filtered ambient noise.

It was found that these sharks could discriminate between frequencies which differed by less than one-half octave and that, in the laboratory, they could orient toward a sound with an average error of only 7.8 degrees. Airplane observations of the reactions of free-swimming sharks to various sounds have continued. It was found that they are able to orient directly toward certain low-frequency sounds including the sounds of a struggling fish, from a distance of 300 yards and to swim directly to the source. These experiments are being extended to other predatory, fishes. Hearing thresholds have been obtained for several species of bony fishes and indications are that they are able to detect higher frequencies than can sharks.

Experiments on vision have also progressed. Cone cells, which are ordinarily associated with color vision, have been found in the retinae of nine species of sharks. Dark-adaptation curves and spectral sensitivity curves have been obtained for young lemon sharks. Visual thresholds for these sharks are generally lower than those of man and indicate a maximum sensitivity in the green portion of the spectrum. Preliminary evidence indicates that they can discriminate between orange (6100A) and blue (4900A) even though the intensity of each color was varied at random.

The problem of weightlessness is of prime concern to our nation's space research, and the Institute currently is investigating how fishes respond to long periods of simulated weightlessness. Marine animals are more truly three-dimensional than terrestrial creatures, and their gravitational sense is not difficult to destroy. A fish with its gravitational sense removed swims in various positions and attitudes, and literally cannot distinguish "up" from "down". Reaction times and accuracy for various learned and innate responses are determined before and after each operation. This experiment should provide information useful to the space effort, as well as data fundamental to an understanding of fish behavior.

The ability of fiddler crabs, *Uca pugnax,* to remember environmental details is being studied. These animals live in holes, which they excavate, and seem able to find it again even after certain details of the surroundings have been changed. The fiddler crabs also exhibit the ability to solve detour problems in a surprisingly short time. *U. pugilator* is able to maintain compass directions through strange areas, and the probable mechanism is a sun-compass, incorporating a biological chronometer. During directionally-oriented movements, fiddlers are able to circumnavigate obstacles while maintaining the course of travel. Laboratory and field experiments indicate that *U. pugilator* exhibits the phenomenon of insight (awareness of spatial relationships).

The study of photo-orientation in shrimp was expanded to include the "shuttle-box" technique for measuring reactions to lights of various wavelengths. It was learned by use of the standard Columbia Obstruction Method that the activity of *Penaeus duorarum* varied according to lunar and tidal cycles, the drive being highest during the full-moon phase. This drive also was highest during the daylight hours and was found to be endogenous.

Avoidance conditioning to various wavelengths of light was also accomplished and, in an attempt to gain evidence from another source, the visual pigments were extracted and their absorption curves obtained.

The behavior program was recently expanded, with the addition to the staff of Dr. Arthur A. Myrberg, Jr., to include a study of the sonic activity and behavior of the fishes found in the vicinity of the Bimini video-acoustic installation. It is anticipated that Dr. Myrberg's efforts will result in a closer correlation between sound and organism at that facility, as well as a better understanding of the significance of the sounds produced by the resident fishes.

A behavioral study of the bi-color damsel fish *Eupomacentrus partitus* has commenced. Preliminary evidence indicates that the species possesses sonic activity, and efforts at determining the functions of the sounds are in progress. Observations and experiments are planned with the sounds and behavior patterns related to territoriality, courtship, spawning, parental care, feeding and aggression.

Dr. Anthony J. Provenzano, Jr. and Dr. Brian A. Hazlett completed studies of the comparative behavioral studies of adult and post-larval hermit crabs. The results of their findings are now in press.

PHYSIOLOGY

The investigation of *Physalia* toxin and a survey of toxic properties of marine invertebrates is continuing under the supervision of Dr. Charles E. Lane. During 1964-65 studies of *Physalia* toxin were directed to (1) describing its effects on the heart of various organisms, and (2) studying the stability of our toxin preparation. It was early noted that Lyophilized *Physalia* toxin dissolved in water or physiological salt solution rapidly lost activity at room temperature. Subsequently a similar loss of biological activity was observed when toxin solutions were maintained at refrigerator temperatures. In the early stages of this investigation it

was thought that concentrated frozen nematocysts retained their toxic characteristics for several years. More recently, however, we have found that the activity of toxin prepared from frozen nematocysts is significantly reduced after one year in deepfreeze storage. After two year's storage, toxin prepared from frozen nematocysts is 75% less active than toxin prepared from the same nematocysts preparation originally. Therefore it appears that some mechanism acting slowly in concentrated frozen nematocysts, and much more rapidly in solution, destroys the activity of the toxin. Recently, it has been found that crude toxin as it is presently prepared possesses considerable proteolytic activity, being nearly as effective in the digestion of casein as a crude trypsin preparation. This proteolytic activity is lost below pH 6.5.

Investigation of the toxic characteristics of a wide range of local marine invertebrates has shown that water extracts of *Millepora* sp., of *Haliclona viridis* and *Haliclona rubens*, and of *Tedania ignis*, are all lethal to *Uca pugilator* at dose levels in the milligram per kilo range. These substances are thermolabile and are destroyed by organic solvents such as ethanol and acetone. They are presently being further characterized. Mouse toxicity studies on these preparations have in general paralleled the results secured using the fiddler crab. A paper describing the effects of *Physalia* toxin on the heart of *Cardisoma guanhumi* has been accepted for publication in *Toxicon*. A further paper describing the effects of *Physalia* toxin on the electrocardiogram of the rat will form the substance of a Master of Science thesis by Mr. James Larsen. It is anticipated that this wil also be published in *Toxicon*.

Dr. Lane is also investigating the evolution of invertebrate respiratory pigments and of coelenterate toxins. Plasma proteins of 47 species of local invertebrates have been analyzed for total and combined amino acids. Of all the animals selected, *Physalia* is of considerable interest because it is the only coelenterate so far encountered that maintains an extra-cellular fluid compartment of approximately constant chemical composition under different physiological conditions. No early evolutionary forays into respiratory pigment synthesis have been detected among other coelenterates studied. When such chromoproteins appear in the phyletic series, it is in substantially their present form. Presumably the mutations resulting in the initial synthesis of metallo-proteins with primitive gas transport capabilities have been replaced in present-day animals by those determining the synthesis of the common respiratory pigments. Most marine invertebrates whose extracellular fluids differ from the medium in which they live show some capacity to concentrate various components of the medium. Hence the raw materials out of which respiratory pigments may be synthesized are generally available when the necessary gene mutations occur to direct the combination of metal and protein.

A manuscript comparing the amino acid composition of *Physalia* gastrovascular fluid with the mesogleal fluid of *Aurelia aurita* has been accepted for publication by *Comparative Biochemistry* and *Physiology*.

The Postdoctoral Training Program in Physiology and Biochemistry of Marine Organisms continued with a number of Postdoctoral Fellows who participated in the course in General Marine Biology, qualifying as SCUBA divers, and exploiting every opportunity to familiarize themselves with living animals in the field. They have either participated in ongoing research programs with other staff members or have initiated their own individual investigations.

Dr. Shiro Horiuchi has concerned himself with the digestive processes of the queen conch, *Strombus gigas*. He has elucidated the enzymatic components of the crystalline style, finding it to be a good source of several carbohydrases. The protein-splitting capacity of the crystalline style is limited, this function being assumed in *Strombus* by secretions from the hepatopancreas.

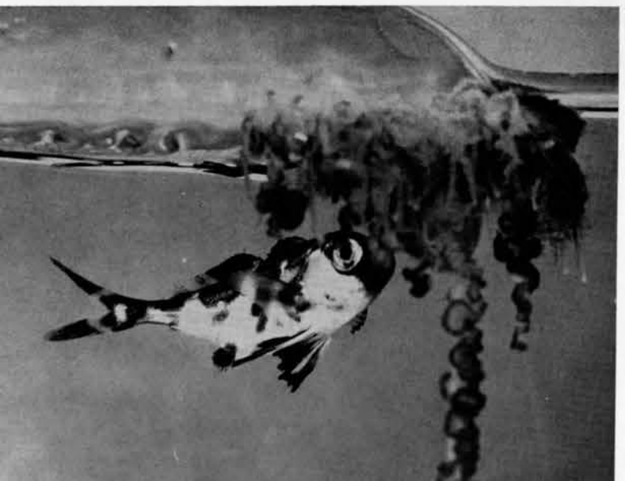
Dr. A. K. O'Gower has participated in several research programs, having investigated the electroretinogram of *Cardisoma guanhumi* exposed to light of different wave lengths and of different intensities, and has characterized the eye of this form in terms of its production of bioelectric potentialities. *Cardisoma guanhumi* gives a pronounced "off-response" and shows some differences in spectral sensitivity from the eyes of other Crustacea which have been examined.

Dr. J. W. Wacasey has investigated the metabolism of the polychaete *Onuphis* in relation to osmoregulation. In combination with Dr. O'Gower he has compared the in-fauna of several littoral areas near the laboratory, seeking to relate their abundance with ecological parameters.

Dr. J. N. Roth during this year has investigated a micro-sporidian infecting *Penaeus duorarum* and has become extremely interested in the nematode populations from various areas in Biscayne Bay and in its adjoining waters.

Dr. Conrad Hess has studied the conditions for successful culture of *Thalassia* in the laboratory, with a view to defining the metabolic requirements of this plant.

Studies are being made on the behavior, ecology and physiology of the man-o'-war fish, Nomeus, *and the Portuguese man-o'-war,* Physalia. *(W. M. Stephens)*



Dr. Christopher Martin, working with various members of the Microbiology Section, has continued his studies of the physiology of marine fungi.

Dr. Colin Little, a new staff member from Cambridge, England, has been studying osmoregulation and ionic exchange in the queen conch, *Strombus gigas*. Preliminary studies have involved the delineation of the anatomy of the conch and a paper on these studies is now in press. Work on the physiology of the conch is in progress.

Dr. Little has also become interested in the physiology of the Pogonophora. Large and apparently readily available communities of these interesting animals have been found in comparatively shallow water immediately out from the Institute of Marine Science. These were discovered in dredging operations by a visiting Nordic Fellow, Mr. Claus Nielsen, from Denmark. The availability of these, and the ease with which they may be maintained alive in aquaria, have at last made possible detailed studies on their biology. Preliminary investigations have been aimed at an elucidation of the problems of studying these animals, which live in extremely small but very long tubes entailing the development of microtechniques for their study.

A study on the esophageal pouch of the man-of-war fish, *Nomeus*, was completed by J. N. Baskin under the directions of Drs. Robins and Lane and is being readied for publication. This study principally concerned the gross anatomy of the pouch and its associated structures, its derivation and mechanical operation, with some comments on its possible function.

LARVAL DEVELOPMENT

Studies on the larval development of decapod crustacea under Dr. A. J. Provenzano, Jr., have continued into the fourth year with emphasis on descriptive morphology of certain groups and are extending into more refined phases of experimental work. Since initiation of this program, approximately 110 species have come under observation, including species from Panama, Bermuda and West Africa in addition to local species. Dr. Provenzano has recently been in Denmark to study the larvae of European hermit crabs.

Previously unstudied larval stages of more than 25 species of hermit crabs, scyllaridean lobsters, and brachyuran crabs have been reared in the laboratory during the past year. The phyllosoma larvae of a scyllarid lobster were recently reared from the egg to the first post-larval stage, this being the first time that phyllosomas have been successfully maintained from hatching to metamorphosis. Numerous species of hermit and brachyuran crabs, including several deep water forms, have been reared from the egg to advanced crab stages.

The larvae of a deep water species of hermit crab show a high percentage of consistent abnormality in the form of "interlarvae", which are intermediate between zoea and glaucothoe. The larvae of many deep-water brachyurans best develop to the megalopa stage at a warm surface temperature, but fail to metamorphose to the crab stage. There is need for experimentation to determine whether the larvae of such deep water forms do in fact survive best at surface temperatures and at what point they must return to lower temperatures for metamorphosis. A number of larvae collected from oceanic plankton have been kept alive until a moult to an identifiable juvenile stage, thus permitting identification of the larval forms.

Dr. Harding B. Owre is initiating a broad program of embryology and larval development of many of the marine invertebrates in the tropical western Atlantic other than the crustacea handled in the above program. Investigations are now being conducted on heteropod mollusks and certain other tropical marine gastropods, polyclad turbellarians, and various hydrozoan coelenterates.

Mr. Warren Burgess completed his comparative study of the larvae of four Western Atlantic species of surgeon fishes of the genus *Acanthurus*. Information on early development and a description of larvae were also provided for flying fishes in more comprehensive study by Mr. Jon C. Staiger and Dr. T. W. McKenney and on clingfishes by Dr. William Gould.

GAME FISH RESEARCH

Field work under the supervision of Dr. D. P. de Sylva has continued on marlins, sailfish, dolphin, barracuda, tunas, and other game fishes. Emphasis was placed on the identification and distribution of the larvae of these and other fishes. Field and laboratory work continued on the food habits, reproductive cycle, and age and growth of the larger game fishes; and, wherever possible, the relation of these fishes to their environment was studied. A paper is in preparation on the histology and spawning cycle of the billfishes.

Numerous cruises yielded a wide assortment of larval fishes, and larval blue and white marlin were collected between Bermuda and the Bahamas during a cruise of R/V *Pillsbury*. A highlight of this cruise was the capture and description of a new family of deep-sea fishes, the Kasidoroidae, which was described with Dr. C. R. Robins.

A pilot study was begun on the larger, deep-water predatory fishes (e.g., snappers, groupers, gempylids, istiophorids) using deep-fished trotlines and longlines on an electric reel at depths betwen 300 to 2,000 feet.

Research on the tarpon is being conducted by Mr. Richard A. Wade under the direction of Dr. C. Richard Robins. Monthly collections of young tarpon from marshes are being analysed in an evaluation of growth study of the natural population. It is also hoped to use the tarpon as a biological sentinel in studies of the effects of the pesticide dieldrin on freshwater and marsh communities which support a major sport fishery for young tarpon, snook, largemouth bass, numerous sunfishes and other species. The adjacent areas are important to agriculture. Apparatus has been prepared for analysis of the effects of dieldrin on tarpon and on the molly, an alga feeder important in the food chain of many of these fishes. The tarpon

is unusually insensitive to changes in oxygen levels and to the changes in water temperatures while retaining a high sensitivity to pesticides. This unusual combination of qualities makes it an ideal choice for study as a biological monitor of pesticides.

Colonel John K. Howard, who headed his own program of work on the distribution of billfishes on a world-wide basis and who provided many other scientists with information and logistic aid to further their own studies of these giant fishes, died in February, 1965. Most of his efforts of this year were devoted to compiling, with Dr. Shoji Ueyanagi, a report on the seasonal distribution of billfishes in the Pacific Ocean. This report has been prepared by Drs. Robins and Starck for publication in the *Studies in Tropical Oceanography* series. Colonel Howard's manuscripts on billfishes in the Indian and Atlantic oceans will be completed by Dr. Starck and his extensive files deposited with the Institute.

DEEP-SEA BIOLOGY

The deep-sea biology program has received considerable impetus in the past year and is now a large well organized program covering much of the research activities of the staff and students working in the areas of ichthyology and marine invertebrates. This has been made posible mainly through grants from the National Science Foundation and the National Geographic Society. National Science Foundation support has been primarily for research time for biological investigations aboard the ships R/V *Gerda* and R/V *Pillsbury,* and investigations in deep-sea ichthyology. Much of the oceanic gear purchased for ichthyological collections has been with the support of an National Science Foundation program. Support from the National Geographic Society has been in the form of funds for purchase of deep-sea trawling equipment such as 40′ Gulf of Mexico shrimp trawls, Isaacs-Kidd mid-water trawls, both 10′ and 5′ models, 10′ Gulf of Mexico shrimp try nets, 10′ Blake trawls, dredges, grabs, etc., the setting up of a computer system for data retrieval concerning the total deep-sea biological program, funds for the scientists to travel to and from the operations in West Africa, and direct support for research on marine invertebrates.

Electrode is implanted near the heart of a live shark to obtain the animal's electrocardiagram. (W. M. Stephens)

During the year 390 stations from mid-water down to about 1000 fathoms were made in the Straits of Florida aboard R/V *Gerda.* Research on deep-sea ichthyology is under the supervision of Dr. C. Richard Robins assisted by graduate students who are utilizing the material taken in this region for masters and doctoral dissertations and numerous individual studies. Investigations of the invertebrate fauna, both mid-water and benthic, is under the supervision of Drs. Frederick M. Bayer and Gilbert L. Voss, again assisted by graduate students. Dr. A. J. Provenzano, Jr., has also participated in the cruises in order to obtain larval crustaceans for his program.

During the year 1964 R/V *Pillsbury* made two extensive cruises in the deep-sea biology program in which 233 stations were made including dip neting mid-water and benthic trawls. Dr. Donald P. de Sylva was chief scientist for a cruise in July and August to the Bahamas and Bermuda, the expedition being primarily for the purpose of obtaining larval fishes and mid-water material. Among a number of interesting results from this cruise was the discovery of a new family of fishes, the Kasidoroidae, which was described by Drs. Robins and de Sylva and which was accompanied by numerous photographs of this specimen swimming in shipboard aquaria. The number of new species and the extension of ranges of others resulting from the work in the Florida current and adjacent areas points up only too clearly how little we know about the distribution of oceanic fishes. In two instances populations of species known previously only from Sicily have been discovered off Florida.

In May of 1965 R/V *Pillsbury* returned to West Africa and deep-sea biological investigations were again carried out in the waters from Lagos, Nigeria, to just north of the Congo River including the islands of Fernando Póo, and Annobon. Mid-water tows to 3500 meters were made with the mid-water trawl and bottom trawls were successfully accomplished with the 40′ Gulf of Mexico shrimp trawl in depth to 2000 fathoms. With this last cruise the planned work in the Gulf of Guinea is completed and the results are being worked up. The ichthyological collections from around the oceanic island of Annobon are probably unique and a preliminary examination of the material indicates a very close relationship with the high volcanic islands of the Lesser Antilles. Both the fish

and invertebrate collections from the shelf and deeper waters of the west coast of Africa are believed to be the richest in species taken from this region. Especially valuable comparisons will now be possible across the Atlantic for such groups as the benthic fishes. Preliminary study shows that the inshore fishes of the African Coast are quite different from those of the continental waters of the Americas as well as from those of Africa's offshore oceanic islands. In depths of 300-1000 fathoms the composition of the benthic fish faunas is strikingly similar for both sides of the Atlantic. An analysis of the status of the transatlantic populations collected in the two Gulf of Guinea cruises, but particularly the oceanic islands, will be the subject of a study by Dr. Robins.

All of the station data from the Gulf of Guinea cruises and the Straits of Florida have already been punched on IBM cards and many of the animal groups have been entered. The computer program has been completely developed and is now in operation. Fishes collected and processed are already being used in research studies at the Institute of Marine Science and elsewhere. Identification lists of the flatfishes collected were provided to the Guinean Trawling Survey Office for comparison with their results.

In ichthyology, present studies in deep-sea groups are those by M. C. Hale on the family Synaphobranchidae, of W. N. Eschmeyer on deep-water scorpionfishes, of T. J. Devany on the distribution of the lantern fishes, and of J. C. Staiger on benthic sharks. Dr. Robins and Miss Hale are preparing a report on Atlantic xenocongoid eels of the genera *Chlopsis* and *Xenoconger.* Among deep-sea invertebrates being studied are the crustaceans by Dr. Lipke Holthuis of the Leiden Museum, Netherlands; the stomatopods by Dr. Raymond B. Manning of the United States National Museum, the gorgonians by Dr. Frederick M. Bayer, and the cephalopods by Dr. Gilbert L. Voss and colleagues.

VERTEBRATE SYSTEMATICS

No specific program dealing with systematics of shore fishes has been in effect during the period 1964-1965. However, a considerable backlog of problems continues to receive attention and has formed the basis for several publications by students and visiting staff. Dr. Robins has continued his efforts on the world revision of ophidiid fishes and in this connection has received during the current year material of the genus *Genypterus* from New Zealand through the courtesy of Dr. J. A. F. Garrick and of the genus *Sirembo* from Japanese waters through the courtesy of Dr. T. Abe. In addition, Indian Ocean material has been received from the Smithsonian Oceanographic Sorting Center, Washington, D. C. Ophidiid fishes have proven to be of much interest to ichthyologist Dr. Courtenay of Boston University, who, as an outgrowth of work started under Dr. Robins at Miami, has taken over and expanded certain of the work, especially of the peculiar dimorphic gas bladders of this group. The affinities of the group to the cod-like fishes may now be taken as firm.

Numerous fishes of two poorly known mid-water groups, the Cetominoidei and the Chiasmodontidae, have been obtained in operations of R/V *Gerda* and R/V *Pillsbury.* Study of these groups is now in preliminary stages.

Jon Staiger's revision of Atlantic flyingfishes of the genus *Cypselurus* is in press. Additional information is already available on Eastern Atlantic species of this and other genera thanks to the Gulf of Guinea cruises, and this is being summarized. Among the early results is the description for the first time of bright, dimorphic breeding colors in one species. Revisionary studies of the barracuda have been continued by Dr. de Sylva. Dr. Walter R. Courtenay, Jr., completed his doctoral dissertation on the systematics of the soapfish genus *Rypticus.*

William N. Eschmeyer completed his study on Western Atlantic members of the scorpionfish genus *Scorpaena.* Two other systematic studies involving deep water scorpionfishes have been submitted for publication by Mr. Eschmeyer.

William P. Davis has completed and submitted for publication a study of the Western Atlantic species of the family Callionymidae. While participating in work on board R/V *Te Vega* in the South Pacific, Mr. Davis had opportunity to expand his studies on this group. A new species obtained from the Gulf of Guinea work is being described by Robins and Davis.

In cooperation with members of other institutions several papers involving systematics of shore fishes have been completed. These include one on the status of the goby genus *Ctenogobius* (with Dr. Ernest A. Lachner of the U.S. National Museum), Western Atlantic pike blennies and the description of a new tongue sole of the genus *Symphurus* (the last two with Dr. John Randall of the University of Puerto Rico). The pike blennies demonstrate again the need to take systematics into the field since four of the species differ most in their ecology, behavior, and breeding colors.

Walter R. Courtenay, Jr. completed a report on the systematics status of *Haemulon boschmae,* a pomadasyid fish from northeastern South America.

The various fish programs conducted in the Florida Keys by Dr. Robins and his students have yielded some 100-150 new records of fish species from continental waters of the United States. Some have been reported in connection with descriptions of new species. Dr. Starck is preparing a summary of these collections as they pertain to the Alligator Reef area.

INVERTEBRATE SYSTEMATICS

The Institute's Invertebrate Museum houses a comprehensive collection of West Indian invertebrates which is one of the best in the world. During the year, a large amount of new material was added to the collections. Much of this material was taken in the Straits of Florida by R/V *Gerda* and in the Gulf of Guinea by R/V *Pillsbury.* These excellent deep sea collections are presently being studied by invertebrate specialists both at IMS and at other leading institutions. Dr. Lipjke Holthuis, the well known

carcinologist from the Leiden Museum, spent six weeks at the Institute examining deep sea crustaceans. The material he studied was divided into three lots, of which one was sent to Leiden, one to the U.S. National Museum, and one was retained in Miami. Such a division of material insures that it will be available to wide range of specialists and typifies the philosophy of the systematics section which makes every effort to provide competent systematists with material for study.

Stomatopods collected by R/V *Pillsbury* are being studied by Dr. Raymond B. Manning of the U.S. National Museum. Dr. Manning will spend three months at IMS during the summer of 1965 in order to complete the final draft of his monograph on the stomatopods of the western Atlantic.

Dr. Lowell P. Thomas is presently undertaking a detailed study of the deep sea euryalous and ophiurous brittlestars in the IMS colection. He has just completed a monographic study of the amphiurid brittlestars of the Western Atlantic which resulted in extensive revisions of several general. In addition to the deep sea ophiuroids he is presently studying the ophiuroids of the continental shelf of eastern America.

Mr. N. Kenneth Ebbs has completed a study of the polychaete worms of the Florida patch and barrier reefs and is presently engaged in a comprehensive study of the deep sea polychaetes of the North Atlantic.

Miss Leona Vnuczenski has completed a study of the deep sea barnacles of the Straits of Florida. Her study entailed critical examination of type specimens from the Philadelphia Academy of Sciences and the U. S. National Museum.

Miss Lourdes Alvina recently completed a morphometric study of *Octopus hummelincki* which has elucidated the systematic characters of this interesting species. Miss Alvina is now engaged in a study of the systematics of the myopsid squid of the Indian Ocean which were collected aboard R/V *Anton Bruun* in 1963.

The systematic studies of hermit crabs by Dr. Anthony J. Provenzano are closely related to the larval development program which provides larval and post-larvel characters for systematic evaluation, including comparative behavior patterns of different species. Drawings of about 30 species of Caribbean pagurid and diogenid hermit crabs have been prepared and will illustrate keys for determination of the Caribbean fauna. Two joint papers have been published and five manuscripts have been sent to press. A number of undescribed hermit crabs from both shallow and deep water of the West Indian region have been discovered and the larvae of several of these forms have been reared.

Systematic studies upon the octocorals of the deep-water collections of R/V *Gerda* and R/V *Pillsbury* have been continued by Dr. Frederick M. Bayer, revealing many broad extensions of ranges of known species, as well as several new species. Significant among the latter are a second new species of the genus *Paragorgia*, and two species of *Calyptrophora*, one of which is closely allied to species from Japan. Taxonomic investigations of gorgonians collected through deep diving by W. A. Starck in Florida and the Bahamas and by T. F. Goreau in Jamaica are proving to be of great importance to the systematics of the octorals in general and to Dr. Bayer's study on ecological variations.

During the year, octocorals from Jamaica, the Red Sea, and West Africa were received for identification and specimens from the Red Sea, Brazil, California, Japan, Australia, and Oceania were identified for outside investigators.

Dr. Bayer completed and submitted for publication manuscripts on a new species of platyctenean ctenophore and the gorgonians of Los Roques Island in the southern Caribbean.

A study of the systematics, morphology, and ecology of spatangoid sea urchins by Mr. Richard Chesher has made considerable progress during the year under Dr. Bayer's supervision.

Dr. Ernest Marcus of Sao Paulo, Brazil, completed a large monograph on tropical American opisthobranch mollusks from the laboratory's invertebrate collections. This paper wil constitute a landmark in the systematics of nudibranches and tectibranchs of the western Atlantic.

Dr. Harding B. Owre and Maria Foyo are continuing their studies of the systematics of the copepods of the Straits of Florida and the Gulf of Guinea. Taken in the Isaacs-Kidd mid-water trawl, these copepods represent quite a different community than those taken in the conventional plankton nets. Many new records for both genera and species from the tropical western Atlantic have been compiled.

Dr. Gilbert L. Voss and his co-workers, Nancy A. Voss, Clyde Roper and Richard Young, are continuing their studies of the cephalopods of the tropical Atlantic, the Antarctic Ocean, and certain areas of the Pacific and Indian oceans. The second Gulf of Guinea cruise by R/V *Pillsbury* in 1965 added a considerable number of new species to this very rich faunal area. A complete report upon the collections made during the two cruises with field notes and ecological observations is being prepared and should be ready for publication in the fall of 1965. Added field work aboard the USNS *Eltanin* in the Antarctic Ocean between Chile and New Zealand has contributed much new information on the cephalopods of this region. Dr. Voss is reporting upon the benthic octopods of the Antarctic while Mr. Young is investigating the finned octopods and the vampire squid while Mr. Roper is concentrating upon the squid, *Bathyteuthis abyssicola*. Over 1500 specimens representing about 45 species have so far been identified from the Antarctic Ocean. Material is now being worked up from the International Indian Ocean Expedition collection aboard R/V *Anton Bruun* and extensive collections are being studied collected by mid-water trawls off the South African coast. Present investigations of these cephalopods include various studies in life history, bioluminescence, larval development, locomotion, community structure, and others.

Division of Fishery Sciences

Dr. Clarence P. Idyll, *Chairman*

BIOLOGY OF STONE CRABS

This work was begun in March, 1965, under Dr. T. S. Cheung. The aim is to study the development of the stone crab in the laboratory with a view to finding a method for its economic culture.

Preliminary results are encouraging. The crab exhibits a very high fecundity; one female in the laboratory laid eggs five times within three months, April - July. The hatched larvae have been successfully reared to the megalopa stage. Judging from other species of crabs, it is possible that there is only one stage of megalopa in the stone crab. If this is true, we have secured a complete series of larvae (5 zoea + 1 megalopa). Certain variability in larval stages as well as structures have been noted, especially the occasional appearance of a prezoea and a sixth zoea. Some of the fifth zoea were found to be abnormal in possessing megalop characters, notably the enlargement of claws with a reduction of the dorsal spine. The degree of the enlargement (as well as reduction) is not uniform. So far no megalopa has been derived from these abnormal larvae.

Rearing of larvae is being performed under different salinity and temperature conditions. It appears that 32-36 o/oo is the optimum salinity range at temperatures around 30° C.

Many fishermen believe that after the claws of the stone crab have been removed new claws will be regenerated and ultimately grow to full size. Experiments are being performed in the hope of finding an economic application of this phenomenon.

SPORT FISH POPULATION

The study of the dynamics of fish stocks in Everglades National Park is now in its seventh year. Results of this study, conducted by James B. Higman, provide information which permits Institute of Marine Science biologists to make recommendations to the Everglades National Park for the management of this fishery.

During the past six years fishing pressure on game fish stocks has almost doubled. The 1964 catch rates for spotted seatrout have declined from a peak in 1962 to their lowest level yet recorded. The catch rates for redfish have likewise declined from a 1962 peak, but they still remain well above the pre-1962 norm. Catch rates for mangrove snapper reached an all time high in 1965 following a steady increase since hurricane Donna in 1960. In general it may be stated that sport fishes are standing up well to fishing pressures so far applied. It is certain that these pressures will increase, and continued observation of the reaction of the populations will be necessary if depletion is to be avoided.

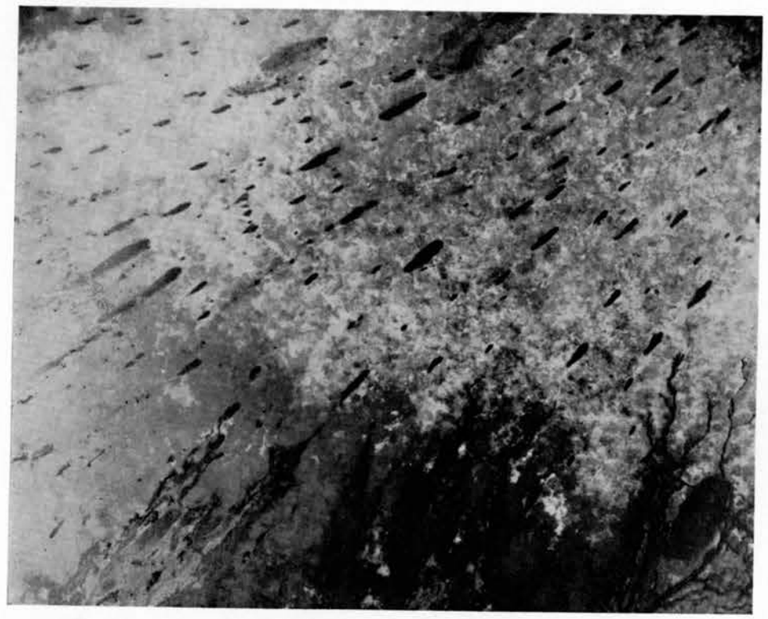
A report summarizing the past six years of catch and effort data on the fish stocks of Everglades National Park is being prepared for publication.

LARVAL SHRIMP

This report covers the final phase of the studies on the larvae of *Penaeus duorarum* on the Tortugas shelf. Principal investigator is Dr. John Munro. All data have now been analyzed and a detailed description of the results is in preparation.

During the past year, six cruises to the Tortugas Shelf were undertaken and 154 plankton samples were obtained. Field sampling ceased in October, 1964, and efforts were subsequently directed towards the analysis of a backlog of samples, computor conversion of data, and subsequent analysis of results.

Larval shrimp are separated from a plankton sample in a study of the life history of pink shrimp.
(W. M. Stephens)



Left:
This aerial view of the Everglades shows tree islands oriented in the direction that surface water flows. (U. S. Coast and Geodetic Survey)

Right:
Transitional zone of the Everglades. Fresh water (right) meets the mangrove salt marsh region (left). (U. S. Coast and Geodetic Survey)

Some of the highlights of the results are as follows:

The production of pink shrimp first protozoeal stages within a sampling area of 1000 square nautical miles during 1963 was estimated at 500×10^{10} individuals. However, considerable variations in production of larvae were apparent. The sampling area yielded an estimate of 210×10^{10} first protozoea in January to July, 1963, but numbers increased threefold to an estimated 645×10^{10} in January to July, 1964. For a variety of reasons, it is believed that these estimates may be low.

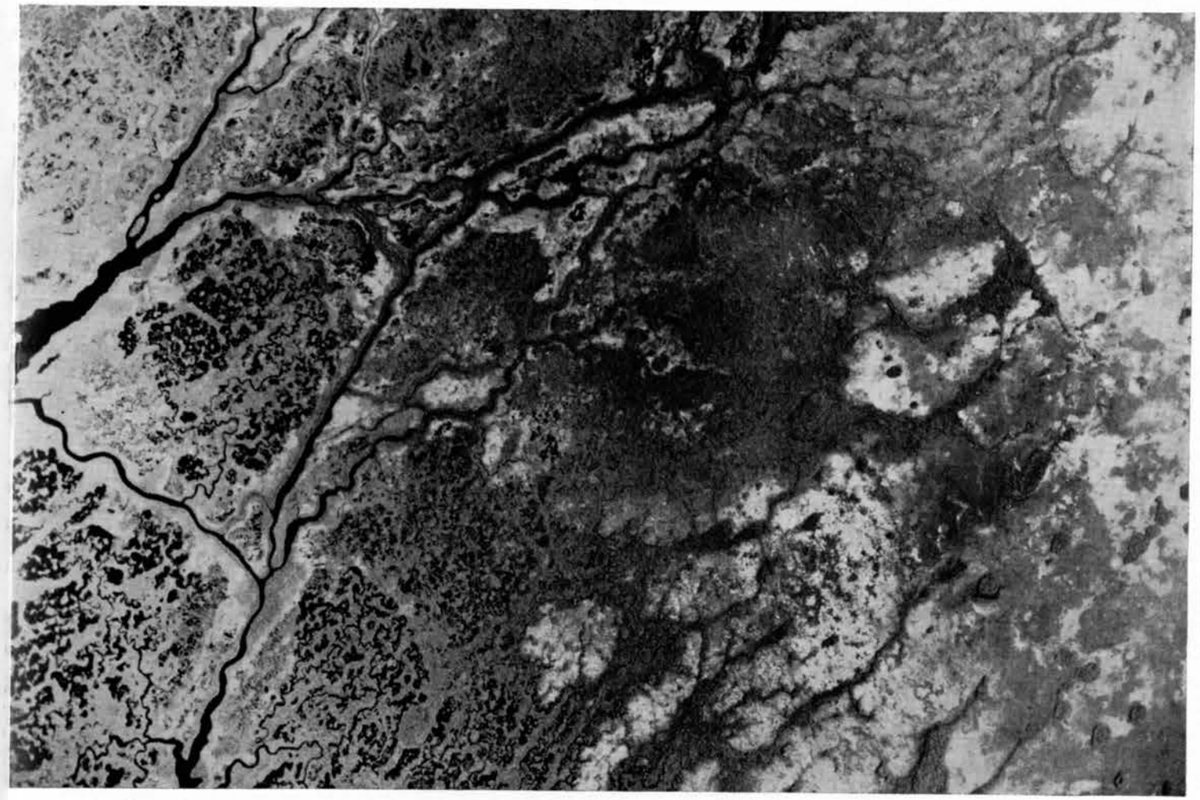
It was found that a direct relationship existed between spawing intensity and bottom temperatures, and the greatest amount of spawning over the past six years has occurred when temperatures exceeded 27°C. Usually less than 10% of each year's spawning occurred when temperatures were below 24°C.

The studies showed that there was a progressive movement of the center of spawning from shallow (24 meters) into deeper water as the spawning season proceeded, and by October the last spawning occurred in water as deep as 36 meters.

It has been clearly demonstrated that spawning intensity is related to moon age, and that most spawning occurs around the full moon period, and is least at new moon.

It has proved possible to estimate the apparent mortality rates of the larvae as they proceed through successive larval stages. Significantly, the mortality rates for various stages varied in a consistent fashion between stations, indicating that some stations were consistently losing younger stages, while other sampling stations (possibly located along the migration routes) were consistently receiving older stages. Thus, because spawning occurred at all stations, the apparent survival rates of the larvae varied according to station, and the survival rates could be used to indicate migration patterns. The survival rate throughout the larval life appears to be relativly constant and has an average value of 80.4% per day. It is therefore estimated that only 0.14% of the first protozoea produced survive to the postlarval stages, and they enter the nursery grounds at an average age of 35 days.

A single semi-synoptic survey cruise (42 stations) undertaken in October, 1964, showed the presence of concentration of larvae along the margin of the Gulf Stream south of the Florida Keys. It is possible that migration between the spawning grounds of the Tortugas and the nursery grounds on the Florida mainland may take place via Rebecca Channel and the Gulf



Stream. In this manner the larvae would arrive at a point within 20-30 miles of the nursery grounds only 6 days after leaving the spawning area.

Releases of sea-bed drifters have provided further evidence that the resultant currents in the Tortugas-Florida Bay area are of a low order of magnitude — approximately 1 mile per day, and that the movement is primarily towards the southwest. This might prevent movement of larvae in a direct line between the spawning grounds and the Everglades nursery areas, and this adds weight to the possibility that the Gulf Stream is the main mode of transportation.

JUVENILE SHRIMP

The primary objectives of this project, under the direction of Dr. E. S. Iversen, assisted by Mr. Bernard Yokel, are to describe the relative abundance of pink shrimp migrating out of the Whitewater-Coot Bay estuary (via Buttonwood Canal) in Everglades National Park and to determine the environmental and biological factors which influence this abundance.

Estimates of relative abundance are based on the catches of emigrating shrimp made in a large channel net fished in this tidal canal. Regular monthly samples have been taken since January, 1963. In most months ebb tides were sampled on adjacent nights and the abundance estimate was made up from combined samples of two nights. These data show that if weather conditions remain reasonably constant the abundance from night to night varies only moderately. Variation is least around the time of the full moon. In 1963 there were three peaks of abundance. These occurred in January, April and September, the latter two being the most important. In 1964 peaks of abundance occurred in March and June. These were substantially higher than any 1963 peaks. The relative abundance from May through August, 1964, was the highest for any four month period since the study began. Abundance for the spring of 1965 was lower than in any similar period in 1963 and 1964. A very small peak of relative abundance occurred in April, 1965. Thus it appears that periods of high relative abundance occur in spring, summer and early fall, with considerable inter-year variation.

Periods of low relative abundance occur during the late fall or winter, and in the spring. In 1963 and 1964 the spring low followed immediately after the spring peak of relative abundance.

During two years of sampling the monthly mean size of the shrimp (sexes combined) ranged from 9.9 to 18.0 mm carapace length with an overall average of about 14 mm carapace length. In general the

Roads at Flamingo, Everglades National Park, show four inches of new soil after a hurricane. Such increases in elevation can change the character of the coastal vegetation. (Walter B. Courtenay)

smallest shrimp are associated with peaks of high relative abundance. On an annual basis sex ratios were very close to 1:1 in both 1963 and 1964.

Secondary objectives of the study are to examine the relationship between the abundance of shrimp migrating out of the nursery area and subsequent commercial catches on the Tortugas fishing grounds, and to develop gear and techniques which can be used to monitor shrimp migrations from an estuary.

The relationship of relative abundance of juvenile shrimp in Buttonwood Canal catches to commercial landings of the smallest size category of pink shrimp (68 count and over) shows wide variation. The relationship is best described by using a two month lag for migrating shrimp of less than 12 mm (carapace length), and by a one month lag for shrimp of 12 mm carapace length or larger.

These findings suggest that the small shrimp moving through Buttonwood Canal may be a reasonably reliable index to predict numbers of shrimp which will subsequently appear on the fishing grounds. Since Kutkuhn (1962) has traced modes of Tortugas pink shrimp on the grounds, it seems likely that an estimate of what can eventually be harvested from the grounds can be made on the basis of shrimp leaving the Everglades National Park estuary.

One year of sampling, using 13 small nets placed from top to bottom across the canal, has provided information on the distribution of migrating pink shrimp in Buttonwood Canal. This study has produced some useful results based on samples taken during all moon phases, which show that more consistent numbers of shrimp are on the surface during the time of the full moon. During the new moon period the percentage of shrimp in the surface nets averaged 76% (ranging from 47% to 98%) and during the full moon period the numbers averaged 92% (ranging from 79% to 99%). The considerable variation found in earlier wing net samples (top meter of water) was probably due to sampling without regard to moon phase. Recent wing net samples collected during the time of the full moon in February, March and April have shown a consistent relationship with the channel net fished simultaneously, and these tend to confirm that variation in abundance estimates from wing nets can be reduced by fishing on full moons when the shrimp are close to the surface.

ESTUARINE ECOLOGY

The severe drought of the past year has provided an opportunity to study the effects of hypersalinity on numbers and species of shallow-water animals.

In the Florida Bay area salinity values have been above 40 ppt. generally for the entire year, with only localized salinity depressions due to rainfall. Several stations have exhibited salinity extremes of 50 to 70 ppt. One station near the mainland shore underwent a 40 ppt. fluctuation in a single month following heavy localized rainfall. This fluctuation caused apparent total mortality of animals, and killed *Thalassia* and *Diplanthera* to the mudline.

During the year Mr. Durbin Tabb and his colleagues made twenty-four quantitative sampling trips, 12 into Florida Bay and 12 into the Ten Thousand Islands. Salinity and temperature profiles across Coot and Whitewater bays were also made. A 36-hour series of observations were made at two Florida Bay stations, one with strong lunar tides and one with minimal tide effect. Salinity, temperature, dissolved oxygen, tide height, wind and water condition observations were made.

Animal abundance by species, and associated hydrographic and meteorological data are being put on IBM cards. The use of computer facilities will permit rapid calculation of the various statistical parameters on the more than 200 species of fish and invertebrates now described from offshore sampling stations. In addition, the rapid print-out of the data permits us to make our data available to interested individuals or agencies who are doing similar work.

Division of Physical Sciences

Dr. Fritz F. Koczy, *Chairman*

TRITIUM PROGRAMS

The hydrology program in Everglades National Park has been hampered by flood control activity in the area. The importance of this study lies in the fact that the hydrological picture of the Biscayne Aquifier is being dramatically changed by the construction of levees and canals. Below-average precipitation for the past three years constitutes a serious threat to the sensitive Park area. Coupled with the virtually total cut-off of the surface-water supply by the levees, this caused a catastrophically low water table. Operation of a dense network of sampling stations in the Park was begun in April, 1965, with the hope that measurements of tritium, rainfall and ground water might shed some light on the question of the Park's survival as a unique swamp area. The first pilot study was aimed at establishing the representativeness of a ground water sample. The result was unexpected and, at least at that particular test point, showed that the Biscayne Aquifer was well mixed vertically from the surface water to the bottom, 50 feet below sea level.

A grant for the study of tritium in hurricanes was received by Dr. Gote Ostlund in May. This program is based on the fact that sea water, tropospheric water vapor and stratospheric water vapor represent three systems with different tritium characteristics. The sea surface has a low tritium content of approximately 20 TU; the tropospheric water vapor in late summer has about 100 TU; and the stratosphere contains minute quantities of water vapor which nevertheless have a very high tritium concentration, 10^4 to 10^6 TU. These facts will be utilized in a study of the following two problems concerning hurricanes. The first is related to the fact that the surrounding air is drawn into the hurricane and its water vapor is partly removed in the rain bands. Over the ocean the vapor content of the hurricane is replenished by evaporation from the sea surface, part of the new vapor is precipitated further inward in the rain bands, and wall clouds around the eye. As long as no tropopause penetration occurs, the tritium assay of the rain at different points reflects the mixing of the sea water vapor with ambient vapor, and will establish how fast and to what extent the sea water vapor replaces the ambient water in the system. Coupled with measurements on the inward flux of water vapor into the storm, the amount of rain formed per unit time can be determined. This is very important, for the released heat of condensation of water in the storm is, by and large, the energy input of the storm.

The other obvious problem is the much debated question whether the properties of a well developed eye are the result of the sinking of stratospheric air. If stratospheric subsidence occurs, the contaminant could be detected as a higher than "normal" tritium content of the air in the eye, and the mixing ratio of stratospheric to tropospheric air can be determined quantitatively at different altitudes in the eye.

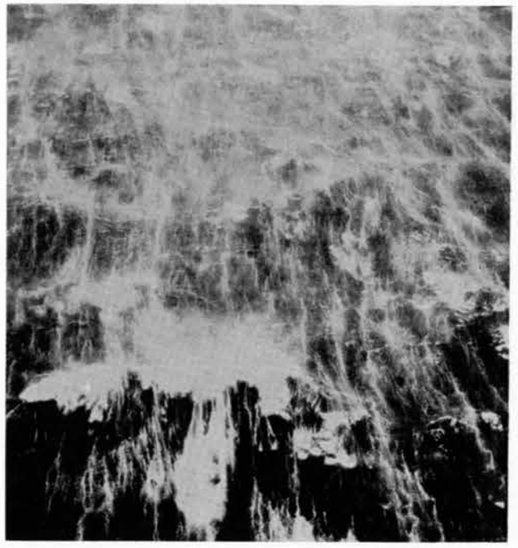
This work will be made possible through the cooperation of the USWB Research Flight Facility which maintains and flies the research airplanes, and through the courtesy of the USWB National Hurricane Research Laboratory. Samples of liquid water, i.e., rain in clouds and water vapor, will be collected by IMS personnel from airplanes flying through the hurricanes. Preliminary samples collected from the planes during last year's hurricane HILDA, showed the existence of the exchange of water between the hurricane air and the sea.

The tritium facility is being expanded to allow several hundred hurricane samples to be measured per year without interfering with the other tritium programs.

MARINE ACOUSTICS

Underwater sound studies under Dr. John Steinberg have continued. A fixed acoustic system is being used to observe continuously the relationships between variations in sound transmission across the Straits of Florida and variations in environmental effects. A large sound projector is located on the bottom off Fowey Rock Light, and receiving hydrophones are bottom-mounted off the west coast of Bimini, Bahamas. Signals are transmitted from the transducer to the hydrophones, and comparisons are made between the transmitted and received signals. Repeatability of the signals provided by a fixed system is of paramount importance in studies of the effects of the changing environmental conditions afforded by the Straits. In a recent four-day period of continuous transmission, an

The fury of hurricane winds at sea is shown in this aerial photograph made over the Atlantic. (U. S. Navy)



unexpected degree of phase stability was observed. The phase of a wave received at Bimini, referenced to the phase of the transmitted wave, varied little. The variations, which had a pronounced diurnal pattern, were perturbed by a passing cold front accompanied by a change of wind direction from SW to N, and an increase of wind speed from 5 to 12 mph.

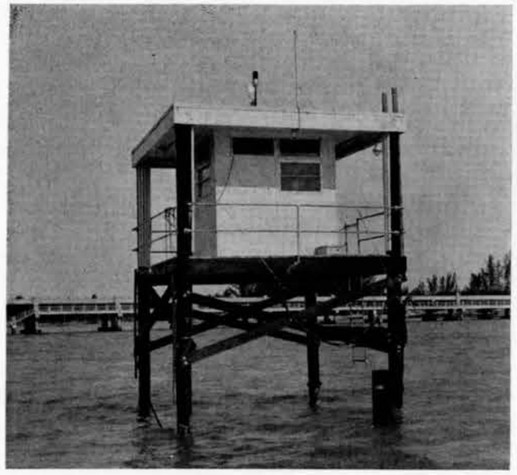
The redesigned system has continued to function satisfactorily since reinstallation with little evidence of corrosion, fouling or unstable motion in variable current and wind conditions. Calibration and evaluation studies involving environmental and noise measurements are being made preliminary to undertaking the noise measurement program.

The program on marine bio-acoustics, carried on cooperatively with members of the Division of Biological Sciences, is in the process of reorientation from a survey program to specific behavioral studies of particular marine species. Several changes in the underwater acoustic-video system are involved. To reduce artificial shelter effects, a camera housing for underground placement was designed so that only a 12-inch hemispherical dome of plexiglas projects above ground. Hydrophones, cable and accessory equipment will also be underground. Video-tape recorders are being incorporated into the system to provide for continuous observation of sound and scene. Means of increasing the light sensitivity of the camera are under study in order to extend viewing farther into the pre-dawn and postdusk hours during which there is normally considerable sonic activity.

BEAR CUT TOWER

An instrument tower, including a small laboratory, was installed in Bear Cut, approximately 700 feet from the end of the Institute's dock, in 16 feet of water. A group of environmental sensors are mounted on the tower and connected by means of armored submarine cable to a display panel to be installed in the main lobby of the new Physical Sciences Wing.

The Bear Cut Tower. *(Don Heuer)*



Wind speed and water currents are monitored by Savonius rotors coupled magnetically to reed switches. Wind direction is determined by a plastic vane magnetically coupled to a precision potentiometer. Current direction is obtained by a magnetic reed switch assembly actuated by a small plastic "sea anchor." Direct-current outputs indicated incoming, slack and outgoing tidal currents. Tide height is measured to 0.5" by means of a gauge utilizing a float and a counterweight. Both water and air temperatures are monitored by means of thermistor probes. Since completion, the tower has been used for the evaluation of such sensors and instruments as a single-axis doppler current meter, an enclosed float reed switch actuated wave staff and an inverted fathometer wave-height meter. In addition, the platform has been utilized by students for field studies in marine biology.

CALCIUM CARBONATE PRECIPITATION ON THE GREAT BAHAMA BANK

The action of calcium carbonate precipitation p, photosynthesis b and gas evasion to the atmosphere g produce relatively large losses of the total dissolved inorganic carbon dioxide from shallow tropical seas. These processes or their countertypes were related in the form of a dynamic equation for the Great Bahama Bank. The equation is only complete when the indirect increases by advection a and evaporation e, and losses by eddy diffusion d are also included. It may be written: $d\Sigma CO_2/dt = -p-g-b+a+d+e$. Dissolved species of the system $CaCO_3 - CO_2 - H_2O$, indices of photosynthetic activity and advection were examined for one year at a bimonthly interval which was assumed to be equivalent to the turnover rate for the water mass. Calcium analyses revealed a pronounced seasonal precipitation maximum from July through September, and a minimum from November through March. Direct measurements of the Ca/Cl ratio clearly showed that calcium losses increase with the chlorinity (or residence time) of the water mass. Measurements of the Mg/Cl ratio indicated a slight "enrichment" of this cation, which may play a role in the stabilization of aragonite.

The annual calcium carbonate precipitation rate was 9 moles/m^2/yr, which is in close agreement with reported sediment accumulation rates. However, the residence time or turnover rate ranged from 15-80 days depending on the wind. For this reason, and due to potential catastrophic rapid removal of the water mass by hurricanes, precipitation rates are to some degree uncertain.

From a knowledge of the equilibrium rate, chemical species of the CO_2 system were computed on the IBM 1601. By substituting the $d\Sigma CO_2/dCa$ ratio (1.87) and the degradation rate (120 mg C/m^3/day) into the general equation, inner bank gas evasion was calculated as 30 moles/m^2/yr. However, assuming a photosynthetic balance for the total area the b term drops from the equatation and the average CO_2 gas loss is reduced to 8 moles/m^2/yr. Hence, a total CO_2 loss of 17 moles results from the processes of precipitation and gas evasion.

Calcium and all sea salts are concentrated on the bank through evaporation. Contrary to previous ideas, it is theorized that the key to the initiation of the seasonal processes is the thermally induced evasion of $CO_2(g)$ folowed by the precipitation of $CaCO_3$. Finally, the correlation of seasonal calcium losses with the physicochemical parameters, chlorinity and temperature and the lack of correlation with biological parameters suggest the possible role of inorganic precipitation in the formation of fine aragonite needles found in the sediment.

Principal investigator on this project is Dr. E. D. Treganza.

FLORIDA CORAL REEF STUDIES

The study of the living reefs and the Pleistocene Key Largo coral reef limestone of the Florida Keys was continued by Drs. J. E. Hoffmeister and H. G. Multer. Investigations were made to determine the conditions which existed at the time of the formation of the Key Largo limestone in the back reef area which is now the Florida mainland. Where the surface formation is the Miami oolite of Pleistocene age, the Key Largo formation has a maximum thickness of about 35 feet; the upper 25 feet are crossbedded and contain well preserved ooliths. It was recently discovered that the lower 10-foot layer is massive and composed largely by bryozoans of which many zoaria are over a foot in diameter. Preliminary study indicated that this formation extended over at least 1200 square miles of southern Florida.

Now it is known to extend as a sheet across the entire peninsula from the Atlantic coast to the Gulf of Mexico including the southern Everglades. It covers an area of 1500 square miles and seems to be the most extensive bryozoan limestone in the country. This formation has an average thickness of about ten feet in the east and diminishes to a foot along the western border of the state. It immediately overlies various formations of the Pleistocene or Tertiary.

A study was undertaken to determine the stratigraphic relationship between the Miami oolite and the Key Largo limestone. Cores obtained from drill holes placed along the eastern side of the mainland have yielded considerable information. A tongue of the Key Largo extends westward from the Florida Keys, and penetrates the lower 10 feet of the Miami oolite dividing the latter into an upper and lower half. In other words, at the time the coral reefs were flourishing in the area of the Keys, bryozoans lived in large numbers in the shallow waters behind the reefs in the region which is now the Florida mainland. Somewhat later the coral environment extended farther westward and replaced the bryozoans. This was followed by a retreat of the corals and a replacement by bryozoans. Thus, it is now known that the upper part of the Key Largo is of the same age as the bryozoan member of the Miami oolite.

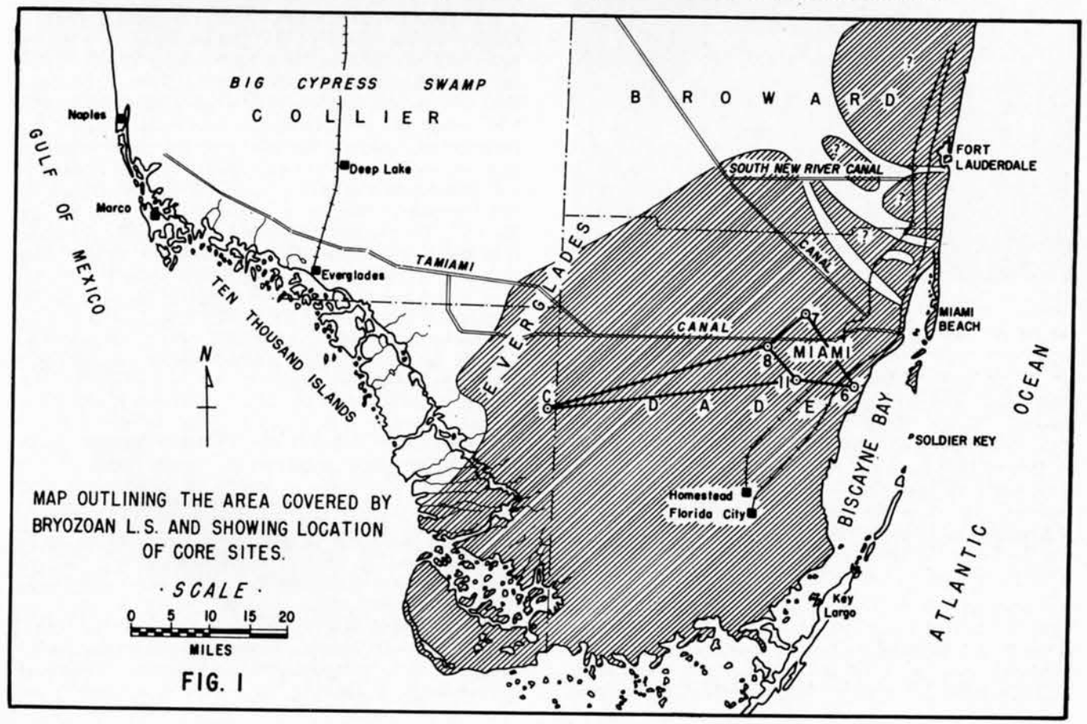
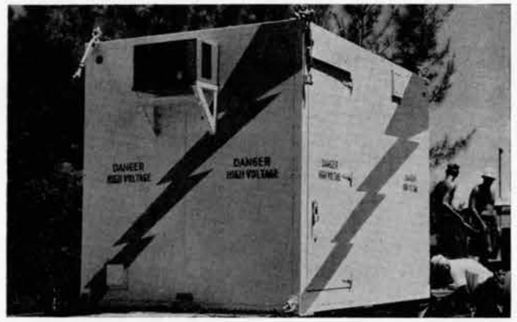


FIG. 1

GEOMORPHOLOGY

The study of the geological history and structural geology of southern Florida and the Bahamas, under Dr. Robert J. Hurley, has been a long range geomorphological program. Accurate charts of most of the deeper basins of the region as well as a large number of seismic reflection lines are now completed. An analysis of the existing data yields results that are at variance with the majority of the published descriptions of the region. Virtually all of these earlier works contain suggestions of large scale faulting, folding, or both. The information obtained indicates minor faulting or folding, if any, in most of the areas investigated. In several seismic reflection lines, nearly horizontal beds can be traced from Florida, under the Straits of Florida, and into the Bahama Banks. Perhaps equally surprising are the records obtained on the continental slope on the west side of Florida. This slope has often been described as a classic example of a fult-scarp continental slope, yet the information obtained indicates unequivocally that the slope is covered with sediments dipping at an inclination parallel to the surface slope.

A study of the bathymetry of Northeast and Northwest Providence Channel is in progress. This channel is occupied by a long, graded axial valley joined by a large tributary which drains the Tongue



Seismic profiler is used to trace the topography of the sea floor. *(W. M. Stephens)*

of the Ocean. Below the confluence, the channel continues north and eastward and empties into the Atlantic Basin. This channel has a considerably steeper longitudinal gradient than others investigated in this region; its walls are steep and deeply incised, with a narrow floor that is only locally flattened. This channel or, more accurately, submarine canyon is the longest and deepest known anywhere in the world and is also remarkable for being the only one having a suggestion of an undrained basin along its axis.

In an earlier analysis of the echo sounding data from the northern part of the Florida Straits, a fairly large area was noted as having a very small regional gradient, but being covered with small projections. Seismic reflection profiles indicated that these small surface irregularities apparently have no "roots" in the rocks beneath them. Attempts were made to photograph this region, and the resulting pictures indicate that these protuberances are apparently "reefs" of deep water corals. Whether these corals are only a surface layer or the entire hill consists of coral debris is not yet known. While such deep water corals forming reef-like masses have been found before, this is by far the greatest depth at which such features have been recognized, and the extent to which such masses have contributed to the older sediments is an interesting question.

An interesting observation was made of series of "cannon ball"- and "pancake"-shaped manganese nodules dredged in depths of only a few hundred fathoms on the Barbados Ridge south of Barbados Island. These nodules are partially embedded in a moderately well lithified sediment that resembles the Oceanic Series rocks exposed on Barbados. The nodules are remarkable both in their size and shape as well as their being embedded in the sediment at so shallow a depth. These circumstances, in conjunction with the exceptional nature of the Barbados rocks and the ridge on which the island rises, lead to the speculation that these nodules might be relics of a time when the Oceanic Series sediments were filling the then much deeper and more extensive West Indian Trench from the south. The question of these nodules and the possibility that they reflect an uplifted deep ocean floor will be the subject of further study.

On two recent cruises, many reflection profiles normal to the trend of the Lesser Antilles, between Saba and Martinique, have been made. In the region between Dominica and Saba, several geologic units that can be identified in each profile were recognized. The relationship between the two deeper units, the younger volcanics to the west and the older volcanics and sediments to the east, appears to be an onlap of the former on the latter according to hypotheses in the literature. Numerous relatively small faults are found in the western volcanic arc but, while the older arcs are badly contorted and complexly folded, there seems to be little evidence of recent tectonic activity. The distribution and the varying thicknesses of the younger sediments as well as the origin of the large, relatively flat-floored, sediment plain between the islands in the northern part of this region are still not understood.

PAELO-OCEANOGRAPHY AND MICROPALEONTOLOGY

Investigations have continued by Dr. James I. Jones, Dr. Donald R. Moore and Mr. Wayne Bock on the multiple role of shelled micro-organisms in the interpretation of ancient environments and in their contributions to sediments in modern oceans. Principal areas of investigation are the south Florida and Bahamas region, the Caribbean Sea and the Equatorial Atlantic Ocean. Taxa under study include pelagic and benthonic Foraminifera, pteropods, heteropods and microgastropods.

A relationship between foraminiferal species and the salinity-velocity maxima was clearly demonstrated on EQUALANT II. Further sampling of the Atlantic Equatorial Current system was accomplished during the EQUALANT V expedition. This sampling was conducted in April and May, 1965, and consisted of north-south transects crossing the equator at 8°W, with a 12-day anchored station near the equator at this longitude. Approximately 40 plankton samples from discrete depth intervals were collected. These samples will provide the basic information to test the relationships observed between planktonic foraminiferal species distribution and the physicochemical characteristics of the Equatorial Current system. These data will allow the definition of the relative importance of various measured environmental parameters to observed population distribution patterns. Analysis of ancient deep-sea sediments and their contained foraminiferal faunas will add a time element to the oceanographic studies now being made in this region.

To date, nineteen benthonic and eight planktonic foraminiferal species from south Florida, Bahamian, Caribbean and North Atlantic waters have been analyzed for trace quantities of silica, titanium, aluminum, iron, manganese, magnesium, boron, barium, copper and strontium. Both living and fossil specimens were studied. A higher MgO content for living specimens and a constant SrO content for both living and dead specimens has been observed. The remaining elements exhibit varying ranges of values from sample to sample, which probably is the effect of sample contamination by associated sedimentary material. The MgO content in benthonic foraminiferal species appears to vary between groups of families, those with porcellaneous tests having a higher value than those with perforated calcareous tests. All elements analyzed in the planktonic species show equal or higher concentrations in fossil material than in living material, with the exception of strontium, which has lower values. The ranges of concentration of each element in living and fossil populations from the same area exhibit varying degrees of overlap, with the exception of the Al_2O_3 values which are discrete. No significant regional differences in trace element composition have been observed.

Pteropod, heteropod and larval planktonic gastropod distribution in the tropical Atlantic is being investigated. A small number of shallow-water gastropods are found on the coasts of Africa and the tropical coasts of North and South America. The presence of the larvae of these forms in the central Atlantic would indicate the migration across the Atlantic is still taking place. Appropriate collections and observations will be made to determine if this is the case. Studies of benthonic micromolluscs of the western Atlantic are continuing. Three new species of Vitrinellidae have been described, and the description of a new family is in press.

GEOCHEMISTRY OF SEDIMENTS

A paper, "On the Geochemistry of Deep - Sea Sediments," has been published by Dr. Sture Landergren in "Reports of the Swedish Deep-Sea Expedition 1947-48". The pelagic sediments studied are mainly from the equatorial Pacific Ocean between the Society Islands in the south and the Hawaiian Islands in the north.

A general description of the chemical composition of the samples from the different cores is presented. Attention has been called to several significant features in the distribution patterns of some of the major constituents as well as to the transition elements which are called *ferrides*, i.e., titanium, vanadium, chromium, manganese, iron, cobalt and nickel.

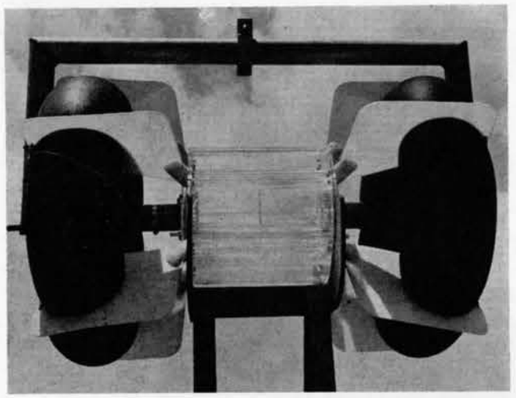
A review of the geochemistry of boron which from two viewpoints, may be regarded as a key element in marine sediments is given. Firstly, the concentration of boron bears a close relationship to the salinity of the depositional environment of the marine clay sediments, and, secondly, a study of the distribution pattern indicates the relationship between the grain size distribution and the boron concentration. Furthermore, there is no age effect in the concentration, so that the boron content gives an indication of the balance of more volatile elements in the sea.

The interrelationships of the elements have been studied partly by means of correlation coefficients of zero, first and second order, and partly by some significant element ratios. These data lead to a discussion of the sources of the elements in pelagic clay. Special attention is called to the relationship between manganese and the three *ferrides*, iron, cobalt and nickel. A discussion of the balance in the supply and removal of elements in the sea is included.

Tentative conclusions regarding the geochemistry of pelagic clay sediments follow. It is of interest to note, that iron and manganese seem to be well-balanced in the supply and removal in the sea. The concentration of boron in pelagic clay sediments is about the same as that of nearshore sediments. To attain balance in the boron economy in the Earth's crust, it is suggested that the deficiency in the supply of boron to the sea must be compensated by that from the endogenic phase in the orogenetic cycles. Boron that is removed from the sea during marine sedimentation must be returned to it and consequently, the pelagic clay sediments are involved in the orogenetic cycles.

The geochemistry of manganese, cobalt and nickel has been the subject of a special study initiated due to the magnitude of the correlation coefficients. It is concluded that the principal source of these elements is the sea water, i.e., manganese is precipitated in the oxidizing environment above the ocean floor whereas cobalt and nickel are adsorbed on the surface of the fine-grained particles of manganese oxide (or hydroxide). The concentration of Co and Ni is a linear function of the concentration of manganese.

The relationship between manganese and nickel and their irregular distribution during Pleistocene-Recent time is discussed. It is suggested that the irregular distribution and decrease in the concentrations of the two elements, which have a tendency to periodicity, may be synchronized with the interglacial periods. The melting glaciers probably increases the rate of bottom currents, and this increase



A Surface Water Sampler, designed by Shale Niskin. (James Hitch)

may have partly removed the very fine-grained particles of MnO_2 with their adsorbed nickel content. The rate and direction of the bottom currents must be considered a factor responsible for the considerable variation in the concentrations of the *ferrides*, especially manganese, cobalt and nickel.

Spectrochemical analyses of major and minor constituents have been made on samples of the cores from the Congo area, a profile from Dakar to Miami, Swedish cores No. 73, 83 and 85 from the Pacific and several manganese nodules and crusts.

Preliminary laboratory experiments have been performed to study the leaching characteristics of the manganese phase of marine clays. When the samples were washed with water, a surprisingly large amount of molybdenum was leached along with the soluble salts. Apparently, in drying the sediments, the molybdenum had been oxidized and converted to a soluble form. The Mn, Ni and Co content of silicates which had been leached was found to be low; this was particularly true of Pacific clays. Yttrium and lanthanum were also leached but some of the phosphates were dissolved along with the manganese. Further research is required to devise a procedure for the separate leaching of the phosphate and manganese phases in order to obtain data on the distribution of yttrium and rare earth elements in these two phases.

PHYSICAL OCEANOGRAPHY

The techniques required to make integral transport measurements with freely dropped instruments have been considerably refined during the last year. Dr. W. S. Richardson has found it possible to make measurements of the total flow through the Straits of Florida, and values ranging from 27 to 38 million tons per second have been observed. It is not evident at this time whether there is any clear-cut seasonal pattern to this variation. A set of 24 cross-sections made during a one-month period has been completed and shows variations of 25% in the total transport through the Straits occurring over a period of a few days. This detailed set of sections should provide information on the total modulation of the flow and permit the evaluation of non-aliased derivatives of the velocity components with respect to geographical coordinates. These in turn should provide a check on the validity of the various hypotheses which have been proposed to explain the structure of the Florida Current.

R/V *Pillsbury*, under the direction of Murice O. Rinkel, spent 33 days during the past year in the Equatorial Atlantic regions continuing the Institute's studies of the Undercurrent. Previous data from EQUALANT II and III indicated the necessity for a finer scale study of the relationship of the salinity core and the temperature field, particularly in regard to the eastern termination of the Undercurrent. Therefore, Equalant V was undertaken to conduct in situ measurements of these variables. This cruise was undertaken in April with the cooperation of the Washington Biological Laboratory of the Bureau of Commercial Fisheries. At this time *Pillsbury* anchored a buoy to the bottom and made serial observations for a period of twelve days while R/V *Geronimo* made continuous oceanographic sections. The data from this extensive series of salinity profiles and current measurements are presently being reduced and studied.

INSTRUMENT DESIGN

During the year Mr. Shale Niskin has designed, fabricated and improved various instruments.

The prototype of the free bottom current intensity and direction recorder underwent a series of field tests to determine its repeatability, accuracy and reliability. A second improved model was then designed and fabricated. This model is substantially less expensive to manufacture, virtually unbreakable, and as reliable and accurate as its predecessor. Both models underwent calibration tests in the flow tank at Woods Hole Oceanographic Institution. This instrument, built to detect currents close to the ocean floor, was described in a paper presented at the annual meeting of I.S.A. held in Miami in April, 1965.

The construction of a non-metallic, continuous surface water sampler designed to collect the uppermost surface layer of the ocean was completed and sea tests were performed. The device is now being employed in various studies being carried out by investigators at the Institute.

A method and arrangement for recording the profile of a current structure from ocean surface to any depth short of the ocean floor was designed some time ago. In concept, the arrangement consists of a free-floating, neutrally buoyant line tending to orient vertically because of a lightweight plummet attached to one end and a buoy secured to the other. The vertical orientation of the line is affected by currents and shear patterns. By knowing the precise configuration of the line, current structure can be deduced provided the surface current is known. The slope and azimuth of the neutrally buoyant line is recorded by attaching directional inclinometers at points along its entire length. Final designs for this prototype array were completed in 1964 and it was recently fabricated. The array is currently undergoing a series of field tests.

RADIOACTIVITY MEASUREMENTS

A large-volume radiation detection instrument has been employed by Dr. J. M. Prospero in the Straits of Florida to measure the radioactive background in sea water. There are two distinct sources for this background, natural 40 K in sea water and cosmic rays. The effect of the former source should be relatively constant with water depth whereas the latter should decrease proportionately with the decrease in the mu meson flux. In experiments carried out aboard the R/V *Tursiops*, the general low-energy radiation spectra were recorded at various depth intervals down to 200 feet. The effects of the two sources of background could be clearly discerned. The decrease with depth of the portion of the spectrum attributed to the mu meson-derived component was found to agree extremely well with published values for mu meson absorption.

The possibility of using liquid scintillation counting for low specific activity beta emitters were investigated. Of particular interest was the problem of counting 26 Al extracted from sediments; it is expected that a core will yield 500 disintegrations per day of 26 Al containing about 100 grams of aluminum. In order to count such a sample with high efficiency, the sample must be dissolved or suspended in an organic scintillator liquid. Counting efficiency was determined for a number of scintillators to which silica gel had been added; this gel gave the liquid a thixotropic character which permitted large quantities of material to be suspended without too great a sacrifice in counting efficiency. The method was found to be satisfactory for such purposes and it may be of use in determining the gross activity of bulk sediments.

AIR-SEA INTERFACE

During the last year preliminary studies have been made by Dr. Russell Snyder on the experimental determination of the cross-spectra of fluctuations of atmospheric pressure immediately above the air-sea interface with variations of surface elevation. The design of the experiment and the selection of a data acquisition system have been of primary concern. The experiment will employ an array of four wave gauges to monitor the fluctuations of surface elevation and an array of four microbarographs to monitor the variations in atmospheric pressure. Data will be acquired with a digital system consisting of a low-level multiplexer, amplifier, analogue to digital converter, programmer, and computer-compatible incremental tape recorder. The experiment will be conducted on the Great Bahama Bank 20 miles northwest of Andros Island. In this area instruments can be easily mounted on staffs guyed to the bottom, yet the water depth is sufficient to permit the generation of a broad spectrum of ocean waves.

The close-up photography of whitecaps was also a major project. A preliminary experiment to investigate the feasibility of an acoustic trigger for photographing whitecaps showed that the acoustic signal from a whitecap monitored in air is well above the noise level. This signal contains frequencies in the range 1-10 kilocycles. It is planned to erect a support tower on the Great Bahama Bank, mounting the trigger and a motion picture camera on a boom 30 feet above the water surface. The photographs will be studied in relation to the spectrum of ocean waves. The investigation of this relationship is important to an understanding of wave-induced turbulence.

Theoretical investigations on wind-generated ocean waves were undertaken, and experiments indicate that the growth of 17-meter waves is more rapid than predicted by earlier investigators. Several implications of this study have been explored, resulting in the following conclusions: The principal transfer of energy and momentum across the air-sea interface derives from normal rather than tangential stress; the resonance mechanism is probably not important for the initial excitation of a wave component; the surface instability probably results from some sort of sheltering mechanism the precise nature of which is obscure.

231Pa/230Th GEOCHRONOLOGY

The validity of ages of pelagic sediments determined by the 231 Pa-230Th dating method has been further investigated by Dr. Paul Antal. Many Caribbean deep-sea sediment cores have been analyzed for 238U, 232Th, 230Th, and 231Pa; the yields of these nuclides were determined both for total dissolution of the sample and for partial extraction using HCl and $H\ NO_3$ in various concentrations. These cores were also dated by the C-14 technique to provide a reference time scale. The results indicate that the 231Pa/230Th dating method is more reliable than the 230Th/232Th method, even for the conditions under which these sediments were deposited. Partial extraction of sediments does not yield meaningful results because 230Th becomes chemically more resistant to dissolution with increasing age. This is attributed to a process similar to the well-known induration of hydrolytic thorium precipitates with aging. On the other hand, the extraction of 232Th is fairly constant with core sample age; it is believed that most of the 232Th extracted is detrital in origin. As a result of the disparity in chemical behavior of 230Th and 232Th, the ages obtained for sediments by this method will be older than the true ages; this error may be as great as a factor of three.

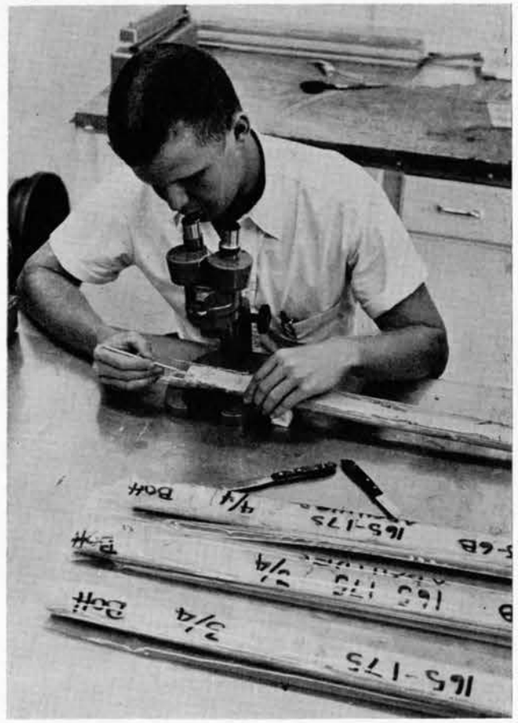
There is considerable interest in the ratio of 234U/238U in nature. For some time it was assumed that 234U, produced in the decay of 238U, was in secular equilibrium with 238U; that is, for every disintegration of a 238U atom, a 234U atom would decay. Recently, it has been discovered that 234U and 238U are not in equilibrium in rocks and minerals. Since uranium in the oceans is derived from land, it must be assumed that the value of the activity ratio 234U/238U in sea water would not be equal to one. Due to the importance of this ratio in the deter-

mination of sediment ages, an extensive study of uranium concentrations and isotope ratios was begun. In addition, the content of 230Th, 232Th and 227Th in sea water is being determined. For this purpose, over thirty 20-liter water samples have been collected from both deep and surface waters of the Caribbean Sea, the Tongue of the Ocean, the Florida Current and the Atlantic Ocean off the southeastern states. Uranium profiles are found to be in the range of 1.5 to 4 ppb. The 234U/238U ratios were found to be variable; the lowest value obtained was 1.09 and the highest 1.19. The cause of this variation with depth is of considerable interest; it may possibly be attributed to biological activity, to sorption on particulate matter or to diffusion from the sediments. These possibilities are presently under consideration.

SUBMARINE VULCANISM AND STRATIGRAPHY OF SEDIMENTS

Petrological and geochemical study of rocks recovered in the southeast Pacific from five deep-sea volcanoes and of sediments from areas adjacent to the volcanoes was carried out by Dr. Enrico Bonatti. This work included X-ray diffractometry, optical microscopy, wet chemistry, X-ray and optical spectroscopy of the samples. Among the findings of this study is the fact that deep-sea vulcanism takes place according to two distinct mechanisms: one "quiet," the other "explosive." In the latter case several secondary processes take place, and vulcanism of this type is found to influence the chemistry and petrology of wide areas of the ocean floor around the site of eruption.

Deep-sea sediments are examined in an IMS core laboratory. *(W. M. Stephens)*



DEEP-SEA SEDIMENTS

To establish the nature and extent of the solid input of the Amazon into the Atlantic, sediment cores were taken from a wide area off the mouth of the Amazon River. About 30 gravity cores were collected, and at two stations sediment suspended in water was also obtained. Preliminary X-ray diffraction work shows the latter material to consist mainly of muscovite, quartz, and chlorite-kaolinite. Size fractionation of the core samples has been carried out; determination of major solids and heavy mineral work will follow.

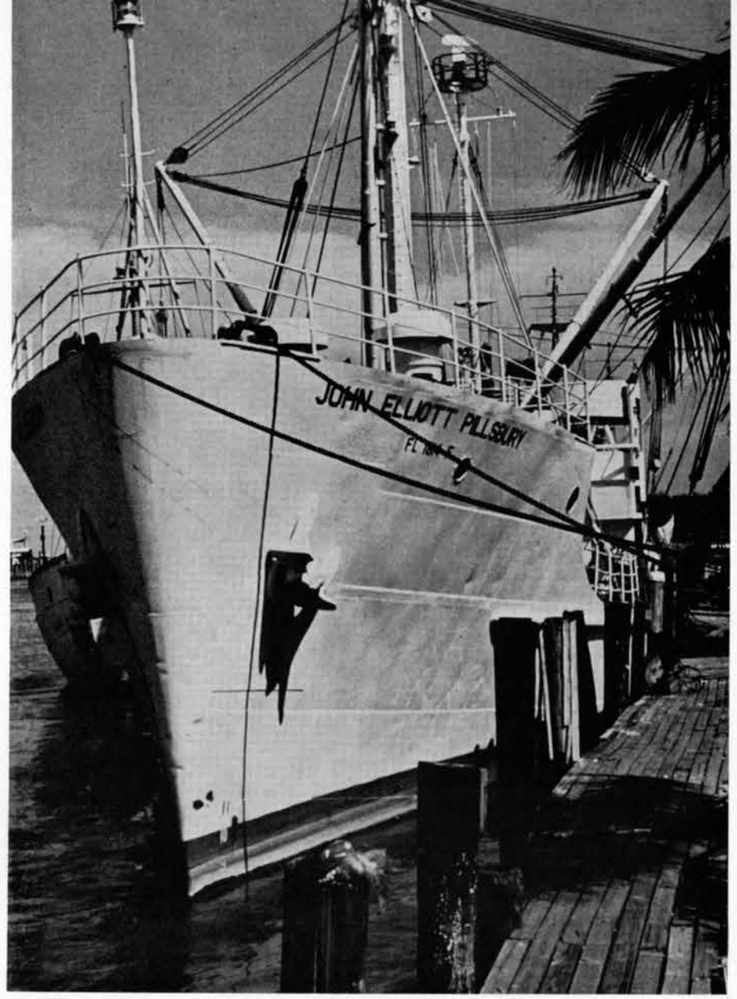
Study of the stratigraphy of deep-sea sediments from the Southwest Pacific, off Antarctica, has been initiated by Dr. Enrico Bonatti. Cores show alternating layers of diatomite and terrigenous clay with some levels of ice-rafted sands. Such stratification is probably connected with Pleistocene climatic fluctuations. Four cores have been size-fractionated and prepared for X-ray diffraction analyses which will be carried out when the new diffractometer is available. Such analyses will include quantitative determinations of opal, quartz, mica, feldspar, chlorite and smectite. The variations of these parameters with depth will be correlated with climatic events.

A 12-meter, undisturbed core from the deepest part of the Caribbean has been chosen for detailed petrological, geochemical and stratigraphic studies. Carbonate determination and size fractionation have been performed. The carbonate content of this core is very low; nevertheless, its variations can be correlated with those of cores with higher carbonate content taken from the same area. Quantitative determinations of major minerals and their variations with depth in the core will be carried out in order to establish stratigraphic criteria for deep-sea deposits where carbonate content is too low for paleontological or paleotemperature stratigraphy.

COMPUTER SECTION

The installation of the IBM 1401 computer at the Institute of Marine Science in December, 1964, has greatly enhanced our computer capabilities. We now have program compatibility between the IBM 1401 and the much larger and faster IBM 7040 located on the main campus of the University. IMS also has added an off-line plotting system which enables plotting of large amounts of data with a minimum of computer time. All oceanographic data processing programs and plotting programs previously developed for the IBM 1620 have been reprogrammed for the IBM 1401 and 7040. In addition, more than fifty new programs have been developed, some of which have received wide attention in the oceanographic community and are in use at other institutions.

Research Vessel John Elliott Pillsbury *is shown at Dakar during EQUALANT II.* *(James I. Jones)*



In addition to processing and graphically displaying oceanographic station data taken by IMS research vessels, the computing center is also processing station data taken by research vessels operated by the Bureau of Commercial Fisheries. The operational unit cost with the 1401-7040 combination is lower than that of the previous IBM 1620 data processing system. The computing center now processes data from the Geological, Biological, and Fisheries sections of IMS in addition to the oceanographic station data. An appreciable increase in program development is expected during the next academic year. The proposed facilities in the new Physical Sciences wing will aid in meeting this demand.

PRIMARY PRODUCTION AND TRACE ELEMENTS

During the past year the study of trace elements and primary production, under Dr. Eugene F. Corcoran, has been expanded to include two geographical areas in the equatorial Atlantic. The investigation of chlorophyll and trace elements in the Straits of Florida has also been continued. The equatorial areas added were the Gulf of Guinea off the west coast of Africa and the Amazon River area.

In the Gulf of Guinea, the study was carried out at 4 stations: one off the mouth of the Niger River, one off the mouth of the Congo River, and one on either side of the Cameroon mountain extension. At these stations, a comparison of the diurnal changes in vertical distribution of phytoplankton and chlorophyll *a* was made. The C-14 uptake, the distribution of the trace metals, such as copper, iron, and nickel, and the silicate and phosphate nutrients were determined. The C-14 measurements showed this area to be extremely productive. The diurnal fluctuations in plant productivity were due to chlorophyll-containing microorganisms in the photic zone although no constant ratio between chlorophyl *a* concentration and phytoplankton counts could be established. The nutrients (silicates and phosphates) as well as the trace metals (copper, iron and nickel) were in slightly higher concentrations than those found in the Straits

of Florida and showed river influence off the Niger and Congo rivers. The analyses for nickel have not been completed, nor have the sediments been examined for organic content. However, preliminary examinations show the cores to be extremely rich in chlorophyll derivatives and carotenoid pigments.

During March, 20 stations were occupied on the shelf and in the canyon off the mouth of the Amazon River. Complete oceanographic information as well as samples for nutrients, trace metals, chlorophyll and phytoplankton were collected on each station. In addition to these samples, two gravity cores were obtained at each station, and volatile organic samples were collected at two selected positions. Although all the analyses have not been completed, some interesting results have been obtained. The phytoplankton distribution was a direct function of temperature variation while the population itself was a function of nearness to shore and salinity. The phosphate and silicate concentrations of the Amazon River water were unusually high, but this was lost very quickly upon entrance to the sea. No measurable quantities of copper or iron in the ionic state were found in the river. However, complexed iron and copper in moderate concentrations (Cu 2.5 μg/L surface and 10 μg/L bottom; Fr 4.7 μg/L surface, 25 μg/L bottom) were found. The ionic concentrations of both iron and copper increased with the distance from the mouth of the river until, at the Amazon canyon station (the greatest distance from the mouth), the ionic was almost equal to the soluble organic complex.

WATER STRUCTURE STUDIES

The molecular structure of water and aqueous solutions is being investigated by Dr. Walter Drost-Hansen through a number of different experimental and theoretical approaches which will be applicable to many different aspects of oceanography. A comprehension of the properties of sea water must be based upon an understanding of the structure of both pure water and water in aqueous solutions. Such physical parameters as specific heat, compressibility, sound velocity, ultrasonic absorption, molecular light scattering, surface tension, viscosity, dielectric properties and solubility must eventally be related to molecular arrangements in solution.

High precision conductance studies are being performed, both as a function of temperature and of concentration of electrolytes and non-electrolytes in solution. A method has been worked out in which the conductivity changes are displayed directly on an XY recorder as a function of temperature. This automates the otherwise tedious procedure of obtaining individual conductivity data at different temperatures at various times. The results indicate the existence of marked anomalies in the structure of water, reflecting order-disorder phenomena such as higher-order phase transitions at a number of discrete temperatures. In order to study possible discreteness in the structure of water, experiments are being made to determine the effects of added non-electrolytes on the properties of aqueous electrolyte solutions. In particular, the conductivity of dilute electrolyte solutions as a function of the concentration of non-electrolytes present has been measured.

A large number of viscosity determinations have been made on a variety of dilute solutions. Using Cannon - Ubbelohde viscometers of the suspended meniscus type, high precision has been obtained (standard *deviations* + 0.02 to 0.04%) on relative viscosity determinations. Both solutions of electrolytes and non-electrolytes have been studied in order to attempt delineating the structure of such solutions.

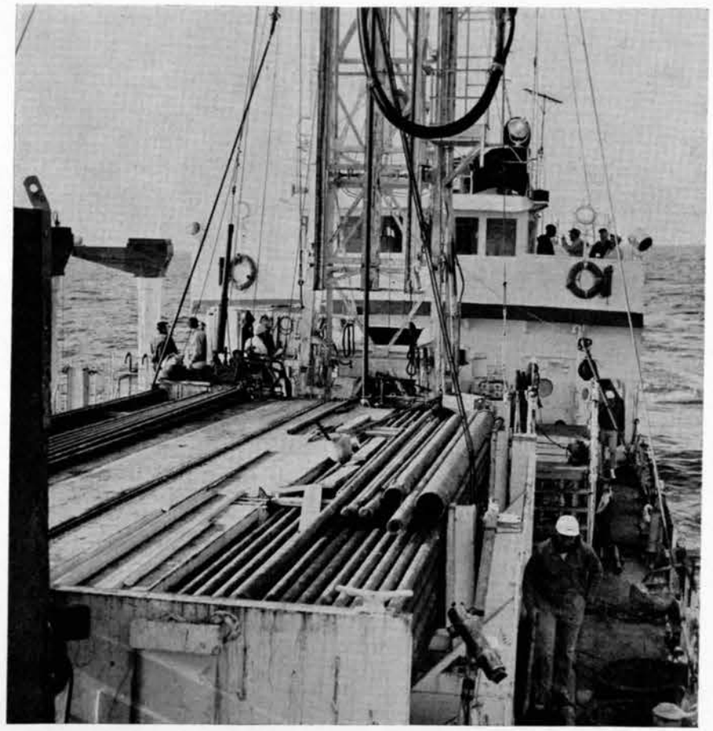
Information regarding the viscosity of aqueous solutions is of importance in connection with the problem of diffusion; in general, the higher the viscosity, the lower the diffusion rate. At the same time, an approximate relation also exists (Walden's rule) which connects the specific conductivity with the viscosity. Hence, all three transport phenomena (viscosity, diffusion and ionic conductivity) are intimately connected and the experimental program along these lines is designed to approach the problem of the structure of water through a detailed study of the nature of transport phenomena. Diffusion rates are of importance in connection with many processes of oceanographic interest such as gas equilibration at the sea-air interface and the distribution of the dissolved gases as a function of depth, salinity and temperature. The problem of diffusion also plays a dominant role in connection with biologic membranes.

MARINE GEOLOGY AND PALEONTOLOGY

A core 20.5 m long, one of the longest undisturbed Globigerina-ooze cores, (reaching sediments 500,000 years old) was raised from the central Venezuela Basin of the Caribbean by marine geologists working under Dr. Cesare Emiliani.

Several geochemical, sedimentological and paleontological techniques have been developed and are utilized to extract from these sediments information on the history of the Earth during the time of deposition. One of the more important parameters is temperature. Mass spectrometric analysis of the longer cores show that the surface temperature of the ocean in tropical and equatorial areas oscillated between 21.5 and 26.5°C during the past half million years with a periodicity of about 40,000 years. In addition, a straight-line correlation was observed between the thickness of the temperature stages of this and other deep-sea cores from the same area and the duration of the Milankovitch insolation cycles. From these observations it may be inferred that the pelagic rate of sedimentation, when averaged across time intervals of 40,000 years or more, remained essentially constant during the past half million years; and that the glacial and interglacial events in the high latitudes were triggered by insolation minima as postulated by Milankovitch and others.

With the collection of a 20-m long deep-sea core of Globigerina-ooze facies, the potentialities of the piston core appear exhausted as far as obtaining continuous Pleistocene stratigraphic records from the sea floor.



Working deck of Caldrill I, used in the JOIDES deep-drilling program.
(Franklin Young)

The collecting of longer stratigraphic sections will become a primary purpose of the Institute and other oceanographic institutions in the immediate future. A cooperative venture, involving the four major oceanographic institutions (Lamont, Miami, Scripps and Woods Hole), was recently completed on the Blake Plateau east of the Atlantic coast of Florida. This effort, which was coordinated by a committee including ex-officio the directors of the four institutions, was called JOIDES (Joint Oceanographic Institutions Deep Earth Sampling). Scientists from all four institutions actively participated in the month-long field work on the Blake Plateau. A total of 1700 feet of core material was recovered from 6 different holes. Preliminary investigations show that the oldest sediments reached are of Paleocene age, and that much valuable information for elucidating the structure and stratigraphy of this important continental borderland will be forthcoming. IMS has been designated as repository for the core material recovered from the Blake Plateau and has been assigned the task of routine analysis of the sediments for stratigraphic boundaries as well as for the main geochemical properties. For this purpose, a trailer-laboratory has been built and is in operation.

CORING

The previously-developed theoretical coring analysis has been refined by Professor Hans Frohlich. A new digital program has been compiled which incorporates these refinements and which will also permit evaluation of the forthcoming data from the dynamic simulator. Theory and preliminary tests clearly show that the resisting forces of deep-sea sediments depend on the velocity (or the vibratory parameters) of the penetrating object. Available information on shear strength and load bearing capacity of deep-sea sediments pertains to static conditions only. Since it is extremely difficult to measure in situ the pertinent velocity-dependent parameters, a dynamic simulator has been built for the purpose of measuring the resisting forces acting on a 40-inch probe while it penetrates core samples at constant, controlled speeds. The hydraulicaly-operated test rig works at speeds up to 15 ft/sec, and provisions have been made to increase its speed range. The instrumentation for recording probe displacement, probe speed and resisting force during penetration is being calibrated.

During the Pillsbury cruise P6408 many cores were taken in the Venezuelan Basin to define the relationship between corer weight and penetration. A specially instrumented core nose was prepared to measure the resisting forces during the coring process. The first coring with this instrumented nose aborted and damaged the probe beyond repair. Cruise P6408 produced a total of over 600 feet of sediment including a near-record core of 71.5 feet. A large portion of

this sediment has been reserved for the forthcoming tests on the dynamic simulator.

Along with the development of the self-contained vibrating deep-sea corer, the preliminary design of a new "two-stage corer" with a simple release mechanism has been completed. Analysis indicates that two or more successively released telescoping tubes will penetrate deeper than the present single tube corers.

RADAR METEOROLOGY

Modifications have been made in the two radar systems, located in the Merrick tower on main campus, to improve their data collection capabilities. Range-normalized logarithmic and linear receivers and stepped iso-echo contour circuits have been installed on both radars. A larger antenna is being sought for the 10-cm wavelength radar. Wind-indicating equipment has been acquired and installed. A recording station for radio noise generated by thunderstorms is now operated for the National Bureau of Standards Radio Propagation Laboratory.

Research studies of mesoscale instability patterns and winds in the tropics with emphasis on the Caribbean and south Florida region are continuing for the Army Electronics Laboratories. Special attention has been given to mesoscale rainfall patterns, the sea breeze and its effects on rainfall, climatology of rare weather events such as tornadoes and hailstorms in south Florida, and radar propagation in the tropics. Preliminary models of the low-level atmosphere during periods of rare weather events including unusually heavy rains have been developed. Detailed rainfall climatology maps of South Florida have been constructed which show the effects of the sea breeze and Lake Okeechobee on the rainfall patterns. Constant-altitude PPI photographs have been used to study motion of individual tropical showers and shear within them. Nomograms have been developed to relate theoretical radar reflectivities and rain fall rates with radar power received, and also for radar propagation in the mean summer tropical atmopshere. Future plans include the study of the life cycle and growth rates of cumulus clouds.

A U.S. Weather Bureau sponsored project for the correlation of Tiros satellite cloud observations with weather radar data has been completed and satellite research in the immediate future will be combined with hurricane studies. A technique was developed for rectifying and gridding portions of Tiros satelite photographs to permit accurate comparisons of the satellite observations with radar and other forms of meteorological data.

Data collection for the study of light propagation at night in the Everglades has been completed. Measurements were made in the red, blue, green and infra-red regions of the spectrum. Temperature, humidity and cloud conditions were also recorded. The data are now being processed and analyzed for the final report to the Army Electronics Laboratories.

Considerable information on winds and storm motions has been compiled from analyses of radar data obtained from many hurricanes. Hurricane Cleo 1964 has provided much new input data for the studies. Spiral overlays, based upon past radar observations have been constructed as an aid in locating the center of a hurricane at the edge of a radarscope when not all of the eye region is shown or when it is poorly defined. Studies have been made of precipitation echo motions versus wind speed and direction. These show that the echoes near the storm center move in a nearly circular path like the winds about the center. Thus the individual echoes move somewhat across the spiral bands rather than along them. They form on the upwind side and dissipate on the downwind side so as to preserve the spiral pattern. Dr. José C. Millas, former director of the Cuban Meteorological Service, has completed a study of the history and climatology of tropical cyclones in the Caribbean area as recorded during the eighteenth century.

DATA ACQUISITION AND PROCESSING

During the last year under Mr. Saul Broida, 710 oceanographic stations were reduced from raw data to final processed form. This reflects an increase of 8% compared with the number of stations processed the previous year.

The first step in processing these data is to check all entries on the scientific and ship's logs, winch sheets, bathythermograph logs, weather data sheets and station sheets. For example, bottom depth entries are checked against PDR traces; positions are checked against the ship's log and track charts; winch sheets are recomputed; thermometer numbers are entered beside each reading on every data sheet. After all errors and omissions have been checked, the thermometer readings are punched on computer cards. The computer produces corrected temperatures as well as thermometric depths and a plot of wire length vs. depth. From this graph, the correct sampling depths for each bottle of every cast are determined. Meanwhile, all samples are analyzed for salinity, dissolved oxygen, inorganic and total phosphates, alkalinity and specific alkalinity, pH, nitrate, nitrite, and ammonia. Many of the computations necessary for such analyses are performed by the computer. Upon completion of the chemical analyses, the data are entered on the proper forms and punched on computer cards. Computations are made for sigma-t, sound velocity, specific volume anomaly, and percent saturation of dissolved oxygen. These data are listed by station, and a graph of selected parameters (specifically, temperature vs. depth, salinity vs. temperature, oxygen vs. temperature, inorganic phosphate vs. temperature, and sigma-t vs. depth) is automatically plotted. The station list, graph and BT trace are then examined for errors, discrepancies, and any unusual values of the several parameters. More than 360 bathythermograph slides were processed this year. All have been adjusted for correct surface temperature and traced onto cards for easy reading and reference.

Division of Oceanographic Engineering

Dr. William C. Knopf, *Chairman*

The activities of the division during the initial 12-month period have been mainly devoted to the development of the teaching program. The division has now completed its first year of graduate training and expects to have about 20 students enrolled in the fall of 1965. This program emphasizes the various engineering aspects of problems relating to the ocean including actual engineering experience on research vessels at sea. This is the first time such a curriculum has been developed specifically and successfully to offer the M.S. degree in oceanographic engineering to qualified engineering graduates.

The need for qualified oceanographic engineers is urgent. This is shown by the fact that nearly every major corporation that has participated in the outer space effort now has groups or divisions actively engaged in problems of exploring and exploiting the oceans — the inner space program. This is further evidenced by the fact that many bills have been submitted to Congress during the past year, and more are still to come, to strengthen and develop our studies of the oceans, so important to the nation's welfare. Unfortunately, few well-qualified people are available for work in this area and none to date has been formally educated in oceanographic engineering to participate in this new, exciting and necessary endeavor.

The graduate curriculum leading to the M.S. degree consists of a minimum of 12 credit hours in Oceanography and Oceanographic Engineering, 12 credit hours in specific advanced areas of engineering, and 6 credit hours in an approved thesis covering an engineering problem related to the oceans. All students also are required to have at least 30 days' experience on a research vessel at sea before graduating.

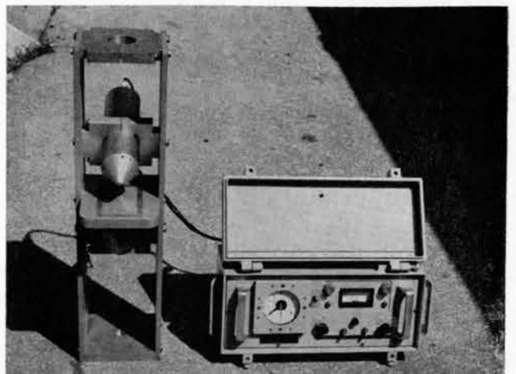
One of the unique undertakings of this new program was the development of the course entitled "Problems in Oceanographic Engineering". It is necessary in such an offering to acquaint graduate students with some 30 to 40 different engineering areas relating to the oceans, but no single organization, to our knowledge, is equipped with "experts" competent to teach in all of these selected and specialized fields. It was decided, therefore, to compile a list of about 40 qualified potential lecturers from industry, government agencies, universities and research laboratories. Each of these persons was invited to participate in this program by giving one or more lectures on specific topics in oceanographic engineering. It was felt that the graduate engineering students would gain invaluable knowledge from the lectures and discussions with these specialists, knowledge which could be obtained in no other way. The response to this course was extremely enthusiastic. On several occasions there were more members of the scientific staff attending the lectures as auditors than there were students. This, of course, attests to the high scientific caliber of the lecturers invited to participate. The following subjects were covered in some detail in the first offering of this unique course during the past year:

Buoy Technology
Nuclear Problems and Waste Disposal in Oceanographic Engineering
Design and Analysis of Experiments
Coastal Engineering and Beach Erosion Problems
Electrical Cables for Use in Underwater Environment
Problems in Engineering for the Environment, Instrumentation Data, Engineering Materials, Undersea Research Vehicles, Structures and Platforms
Anti-submarine Warfare
Underwater Vehicles
Deep Sea Moorings, Structures and Salvage Problems
Unmanned Submersibles — Telechirics
Marine Corrosion and Fouling
The Status of Underwater Acoustics
Underwater Sound and Structure
Simultaneous Measurement of Environmental Factors and Underwater Sound Propagation
Ambient Noise and Environmental Measurements Employing Sampling Techniques
Wave Formation and Propagation
Oceanographic Sensors and Expendable Instrumentation
Data Reduction, Processing and Analysis
Desalinization of Sea Water
Marine Positioning and Navigation Systems
A System for Underwater Sound Propagation Studies
An Underwater Acoustic Video System
Moored Buoys
Sensors for the Measurement of Oceanographic Parameters
Oceanographic Vessel Engineering Problems
Deep Sea Drilling and Servicing

Letters and appropriate certificates of appreciation were sent to each lecturer at the successful conclusion of this course. Compensation for travel and honoraria for participating lecturers were not available.

Engineering research has been carried out, in collaboration with the Division of Physical Sciences, in theoretical and experimental analysis of the penetration limits of piston corers and selected devices, sub-

Doppler Current Meter, designed by IMS personnel. (James Hitch)



marine acoustics and instrumentation for temperature, salinity and current measurements and for sterile water sampling.

FUTURE PLANS

The experience of planning, organizing, and conducting this program for more than a year gave evidence that much more can and must be done to develop an improved and coordinated program of oceanographic engineering courses designed carefully to satisfy the needs of this rapidly-growing field. Toward this end the Institute of Marine Science and the School of Engineering of the University of Miami propose jointly to study and develop an improved Oceanographic Engineering Program. This new curriculum, to be used in training our own graduate students, also can be put into practice by other schools and universities as a working model in establishing their own ocean engineering curriculum. The objectives would include development of new core courses, the compilation of suitable lecture notes to be modified later for textbook material, the collection of appropriate practical oceanographic engineering problems and laboratory experiments, and the procurement of equipment to aid in lecture demonstrations. In addition, experimental and basic research problems will be devised for use on oceanographic vessels at sea and in laboratories. The textbooks which emerge as a result of these studies will fill a serious void now existing in this new field.

It is estimated that three years will be needed to develop adequately a program of graduate education in Oceanographic Engineering. At the end of this period the program should be far enough along to offer the Ph.D. program.

In addition to work on the graduate level described above, there is a great need to develop an oceanographic engineering curriculum on the undergraduate level. Such a development would supply the Bachelor of Science candidate with a more suitable educational background to permit him to enter directly into the field of ocean engineering with government agencies or in developmental industries. If his scholarship level permits, this curriculum would adequately qualify the student to enter directly into an appropriate graduate program. As yet, however, no specific curriculum of undergraduate study has been offered or approved.

Another approach to this area of undergraduate education would be to modify certain of the traditional areas of engineering, such as civil, electrical, industrial and mechanical engineering, by the addition and/or substitution of certain suggested technical electives. This approach would not be as satisfactory as a well-developed and specific program for the undergraduate student in ocean engineering, but it could serve as an adequate intermediate stage in this long-range development. This undergraduate program is now under study in the School of Engineering at the University of Miami.

Funds to support the further development of these oceanographic programs will be sought from outside sources.

ADVISORY COMMITTEE ON OCEANOGRAPHIC ENGINEERING

During the year the Advisory Committee on Oceanographic Engineering was formed to serve as a guiding body to the new division. The committee consists of:

Capt Henry A. Arnold
United Aircraft
Dr. Winston E. Kock
National Aeronautics and
Space Administration
Dr. David S. Potter
General Motors Corporation
Professor James M. Snodgrass
Scripps Institution of Oceanography
Dr. Athelstan F. Spilhaus
University of Minnesota
Dr. James H. Wakelin
formerly Asst. Secretary of the Navy
for Research and Development
Dr. F. G. Walton Smith
Institute of Marine Science
Dr. F. F. Koczy
Institute of Marine Science
Dr. William C. Knopf
Institute of Marine Science

The Committee held two meetings during its first year. The first was held at the Institute of Marine Science in January and the second was held in June at the Cosmos Club in Washington. The role of the Committee and the activities of the Division of Oceanographic Engineering were discussed in considerable detail. The Committee was enthusiastic about the development and progress of the program in Oceanographic Engineering education and recommended that outside support should be sought for development in more detail.

SYMPOSIUM — MARINE SCIENCES DIVISION OF THE INSTRUMENT SOCIETY OF AMERICA AND THE UNIVERSITY OF MIAMI

The Symposium on "Oceanographic Sensors and Expendable Instrumentation," sponsored jointly by the Marine Sciences Division of the Instrument Society of America and the University of Miami, was successfully held April 21 through April 23 at the Dupont Plaza Hotel. Tours of the main campus and inspection of facilities of the Marine Laboratory were well attended. Eighteen organizations displayed exhibits. Dr. Knopf, Chairman of the Marine Sciences Division of I.S.A., served as general chairman for the Symposium.

Geo-Marine Technology in its April, 1965, issue, had this to say about the Symposium:

> "The Instrument Society of America's 3rd National Marine Sciences Symposium, held at the Dupont Plaza Hotel in Miami, April 21-23, was with little doubt the best symposium on oceanographic instrumentation ever held in this country."

Division of Graduate Studies

(Department of Marine Science)

DR. LEONARD J. GREENFIELD, *Chairman*
DR. EDWIN S. IVERSEN, *Assistant Chairman*

Senior Faculty

FREDERICK M. BAYER, Ph.D., *Professor,* Marine Invertebrates
ENRICO BONATTI, Ph.D., *Assistant Professor,* Sedimentation
EUGENE F. CORCORAN, Ph.D., *Assistant Professor,* Chemical Oceanography
WALTER DROST-HANSEN, Magister Sc., *Associate Professor,* Chemical Physics of Water
CESARE EMILIANA, Ph.D., *Professor,* Marine Geology
LEONARD J. GREENFIELD, Ph.D., *Associate Professor,* Biochemistry
HOMER W. HISER, *Professor,* Meteorology
ROBERT J. HURLEY, Ph.D., *Assistant Professor,* Submarine geomorphology, Geophysics
CLARENCE P. IDYLL, Ph.D., *Professor,* Fishery Biology
EDWIN S. IVERSEN, Ph.D., *Associate Professor,* Fishery Biology and Parasites
ALBERT C. JONES, Ph.D., *Assistant Professor,* Fishery Statistics
JAMES I. JONES, Ph.D., *Assistant Professor,* Marine Geology
WILLIAM C. KNOPF, JR., Ph.D., *Professor,* Oceanographic Engineering
FRITZ F. KOCZY, Ph.D., *Professor,* Oceanography
STURE LANDERGREN, Ph.D., *Visiting Research Associate,* Geochemistry
CHARLES E. LANE, Ph.D., *Professor,* Marine Biology and Physiology
SAMUEL P. MEYERS, Ph.D., *Associate Professor,* Marine Fungi
DONALD R. MOORE, Ph.D., *Assistant Professor,* Marine Invertebrates
HILARY B. MOORE, Ph.D., *Professor,* Marine Ecology and Plankton
ARTHUR A. MYRBERG, Ph.D., *Assistant Professor,* Acoustic Biology
HARDING B. OWRE, Ph.D., *Assistant Professor,* Marine Biology
JOSEPH PROSPERO, Ph.D., *Assistant Professor,* Physical Chemistry of Sea Water
ANTHONY J. PROVENZANO, Ph.D., *Assistant Professor,* Marine Invertebrates
WILLIAM S. RICHARDSON, Ph.D., *Associate Professor,* Physical Oceanography and Instrumentation
C. RICHARD ROBINS, Ph.D., *Professor,* Ichthyology
F. G. WALTON SMITH, Ph.D., *Professor,* Oceanography
RUSSELL SNYDER, Ph.D., *Assistant Professor,* Ocean Waves and Tides
JOHN C. STEINBERG, Ph.D., *Professor,* Underwater Acoustics
GILBERT L. VOSS, Ph.D., *Professor,* Marine Biology
ROBERT H. WILLIAMS, Ph.D., *Professor,* Marine Science and Botany
WARREN J. WISBY, Ph.D., *Associate Professor,* Psychophysics of Marine Organisms
E. J. FERGUSON WOOD, M. Sc., *Professor,* Marine Microbiology

GRADUATE STUDENTS

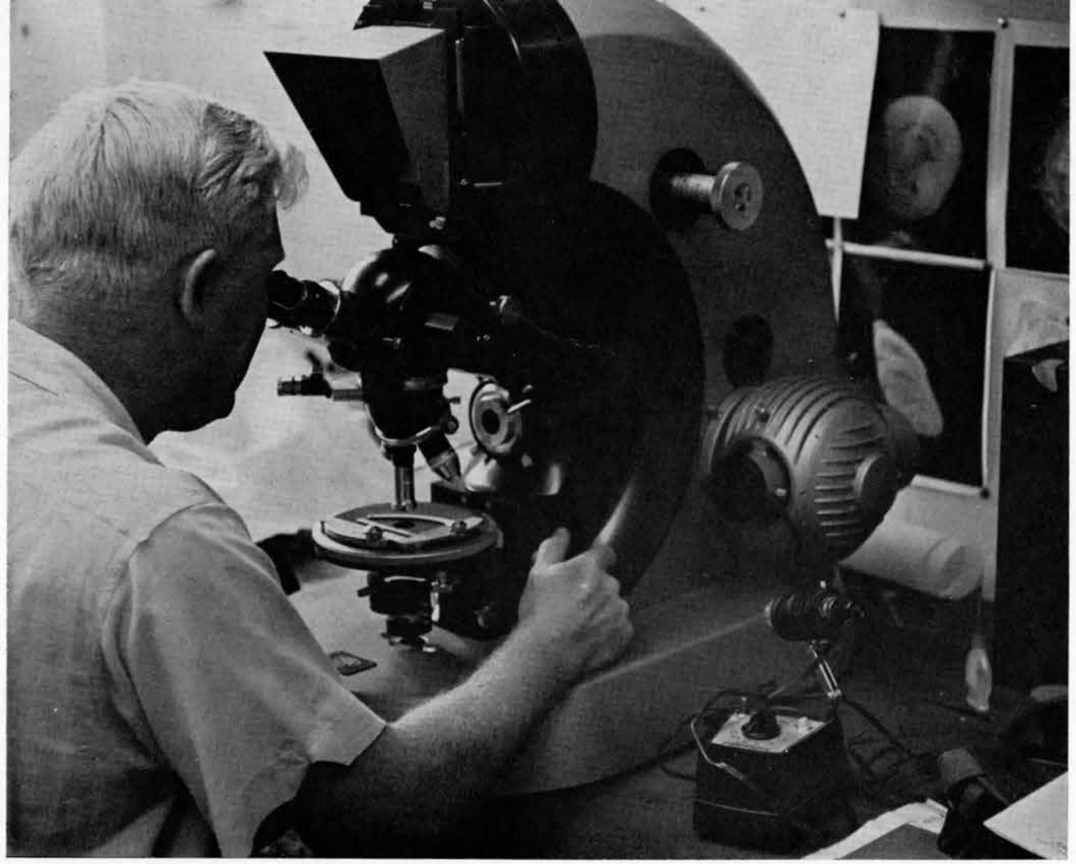
A total of 103 students was enrolled during the 1964-65 academic year. In January 1965, six students achieved the Doctor of Philosophy degree and two received the Master of Science. In June, 1965, four more Ph.D. and three Master's degrees will be given together with four additional Master's to be awarded in the summer graduation. For the year, a total of 10 Doctoral and 10 Master's degrees will have been awarded. Total enrollment for academic year 1965-66 is expected to be between 90 and 100 students.

In addition to the two students enrolled in the Oceanographic Engineering program for this year, approximately 13 new students have been admitted to the program for the 1965-66 year. In accordance with this program a course entitled Problems in Oceanographic Engineering was instituted during the spring semester.

Another new course, Marine Parasitology, was also given, as well as special study courses in Phytoplanktology, Chemical Physics, Molluscan Phylogeny, and Topography of Ocean Basins. As in past years, IMS students have participated in course programs of other schools in the University and students from other schools have reciprocated.

University assistantships numbered eleven this year including one at the Master's level. Beginning with the coming year, the University will assign the division a lump sum to be used in assistantships in accordance with its own devised allotment system. Other student support is from National Defense Education Act, Na-

During the U. S. Navy's Sealab I experiment, IMS behavior students made underwater observations of marine life. (U. S. Navy)



Student photographs microscopic protozoans through a microscope. *(W. M. Stephens)*

tional Science Foundation, Bureau of Commercial Fisheries, International Oceanographic Foundation, Shrimp Association of the Americas, Maytag Foundation, Petroleum Research Fund of the American Chemical Society, Agency for International Development, Organization of American States, and support funds for individual students from other governments. A substantial number of students are also supportedby research assistships financed by research grants and contracts.

POST-DOCTORAL FELLOWS

The National Institutes of Health Post-Doctoral Fellowship Program, initiated in 1961 was designed to make available to trained biologists opportunities for experimental use of marine organisms. The current year's **participants have been working on electro-retinography** of *Cardisoma guanhumi,* digestive enzymes of *Strombus gigas,* physiological studies on littoral polychaetes, microsporidial infection of *Penaeus duorarum,* skeletal pigments of needlefish, cultural characteristics of *Thalassia,* **and physiology of marine occuring fungi.**

UNDERGRADUATE RESEARCH PARTICIPATION

Since 1960, the Institute has had a grant (renewable each year) from the National Science Foundation for the participation of four undergraduates in research at IMS during the summer months. In the past these students, selected from applicants locally and elsewhere in the United States, have assisted in research projects and have been encouraged to pursue independent research. Last summer, the four participants worked on problems in microbiology, algology, and marine biochemistry. The program has been successful in that students in sophomore or later standing obtain contact in research at a critical time for them. Frequently, they become oriented toward graduate school research. Three who have obtained bachelor's degrees since the inception of the program have entered graduate school. Another participant in this program is sponsored by the Petroleum Research Fund of the American Chemical Society. Much of the research will be done at the field station on Pigeon Key.

SUMMER PROGRAMS

The Institute's formal summer school offerings included two undergraduate courses: Introduction to Oceanography and Introduction to Marine Biology.

The NSF-sponsored summer microbiology institute is now being run at the graduate level only. Much of this course will be carried out at the field station on Pigeon Key.

Research Cruises

The Institute's largest research vessel, R/V *John Elliott Pillsbury,* steamed about 30,000 miles during the academic year 1964-65. The 176-foot oceanographic research ship was away from her home port for 284 days, conducting scientific investigations throughout the Caribbean and tropical Atlantic, and along the east coast of South America and the west coast of Africa. In March she departed on a 23,000-mile expedition that will include geological, geophysical and geochemical studies of the Mediterranean and Black seas. She will return in November for the Dedication of the Virginia Key Campus of the Institute.

R/V *Pillsbury* carries 15 scientists and a crew of 21. The ship has both wet and dry laboratories, a deep-sea trawling winch with a capacity of 46,000 feet of wire, deep-sea coring apparatus, hydrographic winches, and is completely equipped to do analyses at sea. She carries a Precision Depth Recorder, loran and radar.

Research Vessel *Gerda* is 75 feet long and has berths for 7 scientists and a crew of 5. Equipped with wet and dry laboratories, a Precision Depth Recorder, trawling and hydrographic winches and precision navigational instruments, R/V *Gerda* has averaged more than 200 days a year at sea for the past ten years. During the past year she steamed about 17,000 miles on investigations in the Straits of Florida and the Bahamas.

The Institute's numerous smaller vessels, including R/V *Tursiops,* a 65-foot T-Boat, have made many short cruises to the Straits of Florida, the western Bahamas, the Florida Keys and the Gulf of Mexico.

R/V PILLSBURY CRUISES

1964

21 May to 18 June
Lagos to Monrovia: biological survey of the Gulf of Guinea; trawling and dredging.

24 July to 13 August
Miami to Bermuda: plankton tows, night-lighting, midwater and bottom trawling.

21 August to 3 October
Miami to Guadaloupe to Barbados to Miami: seismic profiling, abysal hill studies, bottom sampling, geophysics.

13 October to 11 November
Miami to Kingston to San Juan to Miami: marine geology, chemical and radio-chemical sampling; coring technology.

3 to 15 December
Miami to Antigua to Virgin Islands to Miami: stratigraphy of Bahamian slopes and Barracuda Scarp; piston and gravity coring; dredging.

1965

22 to 24 February
Jacksonville to Miami: Test cruise of Western Gear and Markey winches, PDR recorders and EDO tranducers; recording of echo sounding and bathymetry.

2 to 5 March
Miami to Northeast Providence Channel to Miami: testing equipment and procedures; geostrophic calculations of transport in Straits of Florida.

11 to 31 March
Miami to Recife: geochemical and biochemical examinations; oceanographic investigations; productivity studies.

4 April to 6 May
Recife to Lagos: study of the Equartorial Atlantic Undercurrent; bathymetry; plankton studies.

7 to 30 May
Lagos to Fernando Póo to Annobón to Lagos: biological observations in the Gulf of Guinea; survey of deep sea, continental slope, and shelf of West African Coast; bottom trawling, dredging, and shore collecting.

R/V GERDA CRUISES

1964

1 to 10 June
Bahama Islands: bathymetric survey of outer Bahama slopes, testing instruments.

25 to 27 June
Florida Straits: biological observations; plankton tows, trawling.

27 to 29 June
Florida Straits: collection and identification of phytoplankton, water salinity and temperature studies.

9 to 13 July
Bahama Banks: calcium carbonate, carbon dioxide and chlorophyll studies.

14 to 17 July
Northern Straits of Florida: collection of oceanographic data for seasonal and yearly variations.

22 - 26 July
Eastern Straits of Florida: biological observations, plankton tows, trawling.

26 to 28 July
Florida Straits: collection and identification of phytoplankton; water salinity and temperature studies.

1 to 15 August
Hogsty Reef, Bahamas: bathymetric survey, oceanographic and meteorologic observations.

R/V Pillsbury *(Don Heuer)*

17 to 19 August
Florida Straits: Water samples and particulate matter samples; trace elements.

23 to 26 August
Eastern Florida Straits: biological observations, plankton tows, trawling.

30 August to 1 September
Florida Straits: collection and identification of phytoplankton; water sampling.

4 September
Florida Straits: calibrating and testing instruments.

10 to 13 September
Bahama Banks: calcium carbonate, carbon dioxide and chlorophyll studies; training marine technicians.

18 to 23 September
Florida Straits: biological observations; plankton tows, bottom trawling and dredging.

24 to 28 September
Florida Straits: biological observations; plankton tows, dredging, collecting by nightlights.

28 to 30 September
Florida Straits: biological observations; plankton tows, dredging, nightlighting.

7 to 10 October
Bahama Islands: collection, identification, and culture of phytoplankton; productivity studies.

19 to 21 October
Northern Straits of Florida: water transport and chemical studies.

30 October to 1 November
Florida Straits: collection and identification of phytoplankton; water salinity and temperature studies.

9 to 14 November
Bahama Banks: calcium carbonate, carbon dioxide and chlorophyll studies.

23 to 25 November
Florida Straits: collection and identification of phytoplankton; water salinity and temperature studies.

13 to 15 December
Florida Straits: collection and identification of phytoplankton; water salinity, temperature and chlorophyll studies.

1965

4 to 7 January
Northeast Providence Channel: testing instruments.

8 January
Florida Straits: testing instruments and developing sampling procedures.

12 to 15 January
Bahama Banks: calcium carbonate, carbon dioxide and chlorophyll studies; training marine technicians.

17 to 20 January
Bahama Islands: collection, identification, and culture of phytoplankton; sampling protozoa, fungi and chlorophyll.

22 to 27 January
Florida Straits: biological observations; plankton tows, bottom trawls, and otter trawls.

28 to 30 January
Florida Straits: collection and identification of phytoplankton; water sampling; salinity, temperature, phytoplankton counts.

2 to 4 February
Florida Straits: plankton towing, nightlighting, and dredging; collecting larval and juvenile fishes and invertebrates.

9 February
Florida Straits: testing instruments and gear.

23 to 25 February
Florida Straits: collection and identification of phytoplankton; water sampling.

2 to 4 March
Western Bahamas: trawling, plankton towing, nightlighting, collection of living fishes and invertebrates.

9 to 13 March
Bahama Banks: calcium carbonate, carbon dioxide and chlorophyll studies; training marine technicians.

15 to 25 March
Northeast Providence Channel: submarine geology and bathymetric surveys; gravity cores, dredges, and bottom photography.

29 to 31 March
Florida Straits: collection and identification of phytoplankton; water sampling.

1 to 3 April
Western Bahamas: plankton towing, nightlighting, and midwater trawling; collection of fishes and invertebrates.

6 to 7 April
Northern Straits of Florida: water transport and chemical studies.

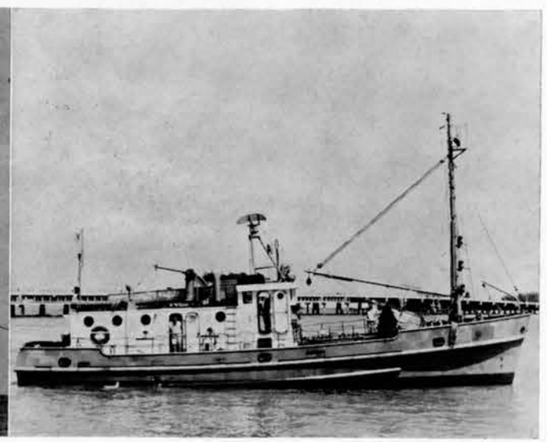
10 to 16 April
Florida Straits: dredging; bottom and midwater trawling.

24 to 28 April
Bahama Islands: collection and identification of phytoplankton; salinity, temperature, phytoplankton counts; trace element samples, oxygen and phosphate samples.

20 May
Florida Straits: testing gear; training marine technicians.

28 to 30 May
Florida Straits: collection and identification of phytoplankton; water sampling for salinity, temperature and phytoplankton counts.

R/V Gerda *(Don Heuer)* *R/V Tursiops* *(Don Heuer)*



Visiting Investigators and Lecturers

The following visitors attended the Institute as visiting lecturers, consultants, or for longer periods during which they carried out research and in many cases presented seminars and advised students.

1964

1 June - 1 December
Mr. J. A. Cabrera
Instituto de Biologia
Universidad Nacional
Autonoma de Mexico
Mexico City
Research on the rearing of decapod crustacean larvae.

22 June - 4 July
Dr. John McLaughlin
Haskins Laboratory
New York
Lectures on algal ecology and physiology for Summer Program in Microbiology

1 July - 22 August
Dr. Phyllis Cahn
The American Museum of Natural History. Research on the hearing of fishes.

3 - 8 July
Dr. Bassett Maguire
University of Texas
Lectures in protozoology for Summer Program in Microbiology.

20 - 21 July
Dr. A. J. Tickner
Guidance & Control Division
U.S. Naval Ordnance Test Station
Pasadena, California
Consultation on acoustics.

24 July - 8 August
Dr. Shoji Ueyanagi
Nankai Regional Fisheries Research Laboratory
Kochi, Japan
Research on the distribution and identification of billfishes.

1-15 August, 18 December - 31 May
Dr. Elisabeth Deichmann
Museum of Comparative Zoology, Harvard University
Research on life histories and classification of holothurians. Consultation.

15 - 17 September
Prof. W. E. Ankel
Giesen, Germany
Seminar.

16 - 17 September
Drs. William P. Jacobs & James Chen
Princeton University
Research.

November - May, 1965
Dr. Jean-Rene Donguy
Office de la Recherche Scientifique et Technique
Paris, France
Research on physical and chemical oceanography.

11 November
Dr. Robert Johannes
University of Miami
Seminar on "The ecological significance of animal excretions in the sea."

17 - 18 November
Dr. A. Conrad Neumann
Lehigh University
Seminar on carbonates in the sea.

22 November - 1 December
Dr. J. A. Jeletzky
Seminar on a geological survey of Ontario; research.

24 November
Prof. S. K. Runcorn
Newcastle-on-Tyne
Seminar on "Geophysical uses of corals."

25 November
Dr. Bruce Benson
Amherst College
Seminar on "Dissolved gases in the oceans."

1 December - 10 January, 1965
Dr. Lipke Bijdeley Holthuis
Curator of Crustacea
Rijksmuseum van Natuurlijke Historie
Leiden, The Netherlands
Research on decapod crustaceans.

29 December - 6 January, 1965
Mr. Basil Nafpaktitis
Museum of Comparative Zoology, Harvard University
Consultation.

31 December - 15 January, 1965
Dr. E. Batham
Porto Bello Marine Laboratory
Consultation on research vessels.

1965

January - March
Dr. Bruce Hopper
Entomolgy Research Institute
Canada Department of Agriculture
Research in nematology

1 January - 31 May
Dr. Albert Tester
University of Hawaii
Research on sharks.

21 - 22 January
Dr. Frederick Aldrich
Memorial University of Newfoundland
Consultation on laboratory construction.

22 - 23 January
Dr. Raymond Guschue
Vice Pres. and Rector
Memorial University of Newfoundland
Consultation on inter-university cooperation.

24 - 30 January
Dr. Kenneth Webb
University of Georgia
Sapelo Island
Seminar on "ecology & physiology of *Spartina.*"

3 February
Mr. William Rainnie
Woods Hole Oceanographic Institution
Seminar on "DSRV (Deep Submergence Research Vehicle) *Alvin* as an oceanographic tool."

10 - 14 February
Dr. A. C. Tarjan
Citrus Experiment Station
Lake Alfred, Florida
Consultation on marine nematological studies.

17 February
Dr. Albert Tester
University of Hawaii
Seminar on "Research on shark behavior"

24 February
Mr. William S. Harney
DuPont Company
Savannah River Laboratory
Seminar on "Biological indicators of radioactive pollution in streams."

1 - 5 March
Mr. Noble Roberts
University of Southern Mississippi
Consultation on shrimp biology.

8 March - 2 April
Miss Marisa C. Moreira
Brazil (Auspices Agency for International Development). Consultation.

15 - 18 March
Dr. Donald I. Mount
U. S. Public Health Service
Robert A. Taft Engineering Center
Consultation.

18 March
Dr. Eugene Agalides
General Dynamics Biophysical Communications Laboratory
Seminar on "Electrical activities of fresh-water fishes."

29 March - 11 May
Dr. A. Stefanon
Venice, Italy
Research on X-ray diffractometry.

6 April
Dr. Gustaf Arrhenius
Scripps Institution of Oceanography
Seminar on "Some news from the ocean floor."

28 April
Dr. Michael Garstang
Florida State University
Seminar on "Diurnal and synoptic variations in latent heat exchanges between tropical oceans and atmospheres."

29 April
Dr. A. M. Wilson
Emory University
Seminar on "Modern chemical methods in oceanography."

5 May
Dr. L. Tepley
Physics Research Group
Lockheed Missile & Space Co.
Seminar on "Underwater photography, California and Central Pacific."

9 - 12 May
Dr. R. N. Farvolden
University of Illinois
Consultation on cooperative program in hydrology.

19 May
Dr. A. Tester
University of Hawaii
Seminar on "Superficial neuoromasts in sharks."

25 May
Dr. Robert Dietz
U. S. Coast and Geodetic Survey
Seminar on "Oceanography in the Soviet Union."

26 May
Dr. Robert Dietz
Seminar on "The history of ocean basins."

Publications

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BAYER, F. M. 1965. Spanish language translations to Bulletin of Marine Science grant. ONR Contr. Nonr (G) 00060 - 63, 3 pp. FINAL REP.

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BONATTI, E. 1965. Palagonite, hyaloclastites and alteration of volcanic glass in the ocean. *Bull. Volcanologique:* in press. SCI. CON 611

BUCK, J. D. 1965. A comparative study of marine pseudomonads with special reference to antiyeast activity. University of Miami, 132 pp. PH.D. THESIS

BURGESS, W. E. 1965. A description of the larvae of the surgeonfish genus *Acanthurus* Forskal of the Western North Atlantic. M.S. THESIS

CORCORAN, E.F., and J. E. Alexander. 1964. The distribution of certain trace elements in tropical sea water and their biological significance. *Bull. Mar. Sci. Gulf & Carib., 14*(4):594-602. SCI. CON. 576

CORCORAN, E. F., J. F. Kimball, Jr. and J. E. Alexander. 1964. An improved method of filtration for chlorophyll analyses. *Bull. Mar. Sci. Gulf & Carib., 14*(4):545-548. SCI. CON. 564

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de SYLVA, D. P. 1965. Investigations on the distribution and ecology of marine organisms of Los Roques Islands, Venezuela. ONR Contr. Nonr (G) 00031-64, 7 pp. FINAL REP.

de SYLVA, D. P. 1964. Venezuelan adventure. *Sea Frontiers, 10*(3):180-187. ART.

de SYLVA, D. P. and W. M. Stephens. 1964. An investigation of the effects of an oil spill on the area at Fort Jefferson National Monument. I.M.S, 5 pp. SPECIAL REP.

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EMILIANI, Cesare. 1965. Precipitous continental slopes and considerations on the transitional crust. *Science, 147*(3654):145-148. SCI. CON. 568

ESCHMEYER, W. N. 1965. Western Atlantic scorpionfishes of the genus *Scorpaena;* including four new species. *Bull. Mar. Sci., 15*(1):84-164. SCI. CON. 587

EWALD, Joseph Jay. 1965. The laboratory rearing of pink shrimp, *Penaeus duorarum* Burkenroad. *Bull. Mar. Sci. 15*(2):436-449. SCI. CON. 615

FELL, J. W. 1965. Bionomics and physiological taxonomy of marine yeasts. University of Miami, 181 pp. PH.D. THESIS

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GOULD, W. R. 1965. The biology and morphology of *Acyrtops beryllinus,* the emerald clingfish. *Bull. Mar. Sci., 15*(1): 165-188. SCI. CON. 588

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KIMBALL, J. F., Jr. and E. J. Ferguson Wood. 1964. A simple centrifuge for phytoplankton studies. *Bull. Mar. Sci. Gulf & Carib. 14*(4):539-544. SCI. CON. 574

KOCZY, F. F. 1965. Remarks on age determination in deep-sea sediments. *Progress in Oceanography,* 3:155-171. SCI. CON. 562

KRONENGOLD, M. and J. Loewenstein. 1965. Cinematography from an underwater television camera. *Bull. Res. Film, Internl. Scient. Film Assn.* and ENCYCLOPAEDIA CINEMATOGRAPHICA, 5(3): in press. SCI. CON. 595

KRONENGOLD, M., J. Loewenstein and G. A. Berman. 1965. Sensors for the observation of wave height and wind direction. *Marine Sciences Instrumentation,* 3: in press. SCI. CON. 604

KRONENGOLD, M. and W. Vlasek. 1965. A doppler current meter for deep ocean research. *Marine Sciences Instrumentation,* 3: in press. SCI. CON. 603

LANDERGREN, S. 1964. Geochemistry of pelagic sediments. Part Two. *Swedish deep sea expeditions, X*(5):110-154. SCI. CON. 534

LANDERGREN, S. and O. Joensuu. 1965. Studies on trace element distribution in a sediment core from the Pacific Ocean. *Progress in Oceanography,* 3:179-189. SCI. CON. 561

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LANE, C. E. 1965. Evaluation of invertebrate respiratory pigments. NSF Contr. GB-1881, 2 pp. ANN. REP.

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LANE, C. E., S. Pringle and A. M. Bergere. 1965. Amino acids in extracellular fluids of *Physalia physalis* and *Aurelia aurita. Comp. Biochem. Physiol., 15*:259-262. SCI. CON. 593

McKENNEY, T. W. 1965. A study of young Western Atlantic flyingfishes (excluding *Cypselurus*) and some young stromateoid fishes, with comments on pelagic life. (Exocoetidae and Stromateoidea, Pisces). University of Miami, 336 pp. PH.D. THESIS

McPHERSON, B. F. 1965. Contributions to the biology of the sea urchin *Tripneustes ventricosus. Bull. Mar. Sci., 15*(1):228-244. SCI. CON. 590

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