STUDIES IN TROPICAL OCEANOGRAPHY • No. 4 (Part 1)

The R/V *Pillsbury* Deep-Sea Biological Expedition to the Gulf of Guinea, 1964-1965

UNIVERSITY OF MIAMI
INSTITUTE OF MARINE SCIENCE
October • 1966

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This paper may be referred to as:
Stud. trop. Oceanogr. Miami *4* (Part 1):
viii + 239 pp., October 20, 1966

Price — $5.00

R/V PILLSBURY moored in Lagos Harbor, Nigeria.

The
R/V *Pillsbury*
Deep-Sea Biological Expedition
to the
Gulf of Guinea, 1964-1965

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Published by the University of Miami

INSTITUTE OF MARINE SCIENCE

EDITORIAL COMMITTEE
for this Number

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Printed in the United States of America
PARKER PRINTING, CORAL GABLES, FLORIDA

Preface

We are pleased to present in this volume a general account of the biological operations conducted aboard R/V John Elliott Pillsbury in West African waters in 1964 and 1965, and the first group of scientific papers resulting from the field work accomplished in those years.

In presenting a narrative account of the cruises, we hope to provide a more realistic impression of day-to-day operations on a sea-going research vessel, and of the problems connected with mounting a biological expedition several thousands of miles distant from our usual base of operations. We also are providing an account of our experiences in using the various types of equipment necessary for obtaining samples of the fauna from the diverse habitats encountered. Our own ventures in this field, although based upon considerable background gained from work aboard our smaller vessel Gerda, would have been greatly simplified had we been able to benefit from the successes and failures of others who have struggled with the same problems. Unfortunately, very little has been published about the procedures and the difficulties of dredging and trawling from sea-going vessels, as it has not been fashionable in recent years to report upon the more subjective and practical aspects of scientific exploration. We have learned the hard way, by experience, often bitter and frustrating, sometimes unexpectedly rewarding, but always interesting. We hope, therefore, that others will find useful information in the account of our daily work at sea.

The stations conducted over a period of only a few weeks at sea now produce, by virtue of large, sturdy and modern equipment, enough material to occupy many investigators for many years, and it will be a long time before the results of all of our work can be made known to the scientific community. Some of our colleagues and collaborators have been able to study and report upon some of the material entrusted to them for investigation, and we are gratified to present now the results of their efforts. Several other reports are now in various stages of preparation, and we hope that the second volume of papers will be ready for publication in the near future.

The Editors.

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GILBERT L. VOSS
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INTRODUCTION

The deep-sea biological investigations carried out by the Institute of Marine Science of the University of Miami aboard the R/V JOHN ELLIOTT PILLSBURY in the Gulf of Guinea during the two years 1964 and 1965 were part of a long range study of the biology of the tropical Atlantic conceived by the writer and his colleagues, especially Drs. Frederick M. Bayer and C. Richard Robins.

Previous studies carried out at the institute had been concentrated in the waters of south Florida and the Bahamas, supplemented by a three-year study of the fauna of St. John, Virgin Islands, and various localities in the Antilles and the northern coast of South America. While most of these dealt with shore fishes and invertebrates, incidental investigations were made in deeper waters. In 1959, Robins and the writer participated in the Caribbean cruise of the R/V GERDA from St. Thomas, Virgin Islands, to Jamaica and Curaçao, making collections of bathypelagic animals with an Isaacs-Kidd mid-water trawl and night-lighting. From then until 1963 numerous short trips on R/V GERDA were made in Bahamian, Antillian and Florida waters. In May 1962, deep-water investigations aboard the R/V GERDA were undertaken on a systematic basis in the Straits of Florida partially supported by a ship support grant from the National Science Foundation and an additional grant from the National Science Foundation for study of Straits of Florida fishes. In 1964 this program was made fully operational by a research grant from the National Geographic Society for the study of deep sea biology and a ship support grant from the National Science Foundation permitting full and adequate scheduling of the R/V GERDA for biological studies.

As these studies developed it became evident that for a thorough understanding of the geographical distribution of the fauna of the shelf, slope, and deepsea it would be necessary to extend our investigation throughout the West Indies, the east coast of northern South America, and the west coast of Africa. Only such a broad program of investigations, utilizing many different types of collecting gear and methods and working from

[1] Contribution No. 729 from the Institute of Marine Science, University of Miami. This constitutes a scientific report of results from the National Geographic Society—University of Miami Deep-sea Biological Program, and National Science Foundation grants GB-3808 and GB-2204 in support of ship time.

the shore outwards into the greatest depths, could reveal the origins and relationships of the faunas in a meaningful manner.

It was therefore with particular interest that the writer attended the International Oceanographic Commission Working Group meeting on the International Cooperative Investigations of the Tropical Atlantic (ICITA) held in Washington, D. C. June 20-23, 1962 as an observer on the United States delegation.

The result of these meetings was the series of cooperative investigations in the tropical Atlantic from Brazil to West Africa now known as the Equalant Expeditions. The underlying purpose of these expeditions was a cooperative study of the physical, chemical, and biological characteristics of the tropical Atlantic proposed by the Bureau of Commercial Fisheries to aid in its study of the occurrence and abundance of tunas. In the proposed investigations, biological studies were restricted to plankton tows and microbial sampling. Investigations of the larger organisms inhabiting these waters were omitted due to lack of ship time, berthing facilities, and winches and cables adequate for such work. However, the writer committed the Institute of Marine Science to the study of the macrofauna as shiptime and equipment became available.

In 1963, the Bureau of Commercial Fisheries R/V OREGON conducted a six-week trawling survey along the coasts of the Guianas and Brazil, coinciding with Equalant I. In order to begin the macrobiological studies, the Institute of Marine Science participated in this cruise by assigning four biologists, William N. Eschmeyer, William P. Davis (ichthyologists), Robert C. Work and Donald R. Moore (invertebrate zoologists), to make representative collections of the fishes and invertebrates for study at Miami. The scope of the collections was somewhat limited, however, due to the exclusive use of commercial gear of large size, which failed to sample large sections of the fauna.

The Institute of Marine Science's research vessel PILLSBURY was not put into service until the summer of 1963, when it participated in Equalant II along the west African coast. No macrobiological program was undertaken on this cruise. The PILLSBURY next returned to Africa in 1964 for Equalant III. At the end of the scheduled program, a special cruise for microbiological investigations was made in the Gulf of Guinea, at the termination of which the ship was turned over in Lagos, Nigeria, to the macrobiology program.

The senior scientists participating in the first Deep Sea Biological Expedition in the Gulf of Guinea were: Gilbert L. Voss, Chief Scientist (IMS), Frederick M. Bayer (IMS), Lipke B. Holthuis (RMNH, Leiden), Raymond B. Manning (USNM), A. J. Provenzano (IMS) and C. Richard Robins (IMS). The junior staff, all of the IMS were: Richard Chesher, William P. Davis, William N. Eschmeyer, Clyde F. E. Roper, Richard E. Young and John T. Reynolds.

FIGURE 1. Scientific party, 1964. Left to right: Bayer, Robins, Voss, Davis Chesher, Manning, Provenzano, Eschmeyer, Roper, Holthuis, Young.

The scientists on the second expedition were: Gilbert L. Voss, (Chief Scientist), Frederick M. Bayer, Lipke B. Holthuis, Raymond B. Manning, C. Richard Robins, Robert F. Sisson (National Geographic Society photographer), Thomas Devany, N. Kenneth Ebbs, William N. Eschmeyer, Gary Hendrix, Clyde F. E. Roper, Jon C. Staiger, John Walsh and Richard E. Young.

The first cruise originated at Lagos on May 24, 1964, and ended at Monrovia, Liberia, on June 6. The second cruise departed Lagos on May 11, 1965, and returned to Lagos on May 28, 1965, after stops at the islands of Fernando Póo and Annobón. The cruise tracks are shown in Figure 2.

During the two cruises, 177 stations were occupied. These are shown in the Station List on page 82 where the depths and types of gear used are also indicated. They ranged from shore poison stations at Lagos, Fernando Póo and Annobón, to surface night-lighting and neuston collecting, to mid-water trawling and bottom trawling down to 4200 meters. A general account of the equipment, trawling methods, and problems of deep trawling will be given later in a separate section.

The material from the cruises was in the main returned to the Institute of Marine Science, although parts of the collection are at the Rijksmuseum van Natuurlijke Historie in Leiden and the U. S. National Museum in Washington where they are being studied. The reports on the collections are being presented in a series of papers in the Studies in Tropical Oceanography, designed to make the records immediately available for zoogeographical and other studies. Further papers in monographic or revisionary form may be published by the individuals cooperating with the IMS program. The complete station data, identification, and other information pertinent to the specimens collected are being entered into a computer program at the Institute of Marine Science for further utilization in studies of community structure, benthic and midwater ecology, and other investigations. The final summaries must await not only the completion of the studies of the West African fauna but also the completion of comparative studies off Brazil and in the Caribbean.

The success of the cruises and the publication of their results is due to the cooperation of many persons and institutions. Particular thanks must be extended to the officials of the U. S. National Museum and the Rijksmuseum van Natuurlijke Historie, Leiden, the Netherlands, for permission for scientists from those institutions to participate in the cruises. Frank Williams of the Guinean Trawling Survey gave generously of his time and advice in helping to plan the cruise track for cruise 1 and provided general assistance and comfort while we were in Lagos, for all of which special thanks are extended.

Shipboard work can succeed only through close cooperation between the scientists and the ship's crew. Work in the tropics is often unpleasant due to the weather but, despite many problems with gear and ship, the crew of the R/V PILLSBURY gave unstintingly of their time and effort, without complaint and with a cheerfulness that is unsurpassed. It is with pleasure and a great sense of appreciation that the scientific staff extends its thanks to the officers and men of the R/V PILLSBURY.

The work aboard the ship and in the laboratory was made possible by a series of grants from a number of institutions and agencies. Individual grants are acknowledged separately in the various scientific contributions. Particular thanks must be given to the National Science Foundation for its grants NSF GB-3808 and GB-2204 which provided funds for the necessary ship time which made the cruises possible.

The National Geographic Society is due a special word of thanks for

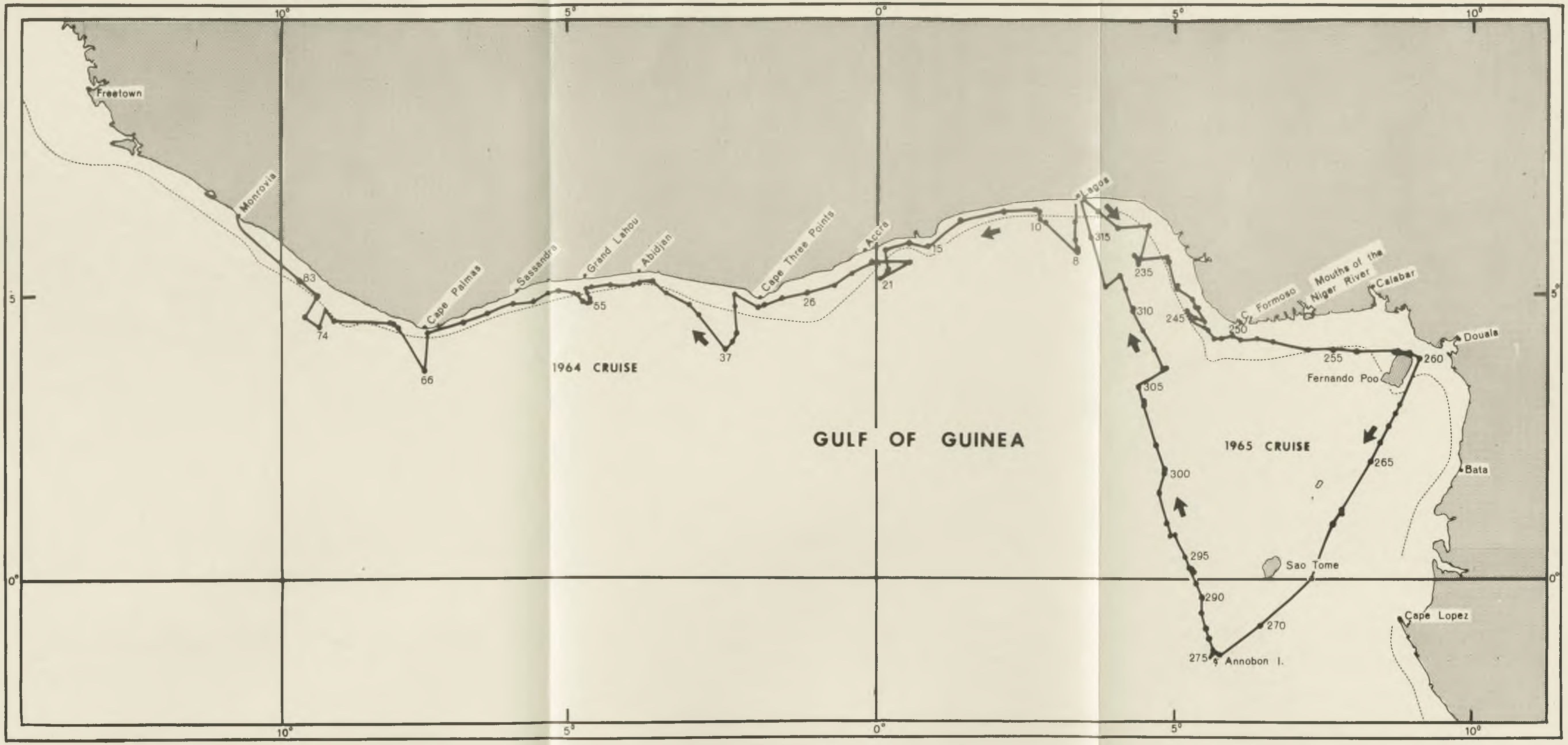

FIGURE 2. Cruise tracks of R/V PILLSBURY, 1964 and 1965.

its generous support of the field and laboratory program which forms the backbone of the Institute of Marine Science's investigations of the biology of the deep sea. Its grant has provided research time for scientists, sorters, and laboratory assistants, purchased deepsea sampling equipment, furnished funds for travel of the scientists to and from the ship, and assisted in the work of collaborating scientists. The Society also sent Mr. Robert Sisson on the second cruise to photograph shipboard activities and marine specimens. I have never sailed with a better shipmate.

The scientists who participated in the cruises have been listed above. To all of these persons grateful thanks are extended. A special word of thanks is due to my colleagues, Frederick M. Bayer and C. Richard Robins, who have given so generously of their time in the planning and the execution of the cruises and who have critically read this report. The following narrative was written aboard the R/V PILLSBURY, as time permitted and interrupted by many emergencies. I wish to thank them for their assistance in reading and smoothing out the narrative and for many useful suggestions. The omissions and errors are my own.

FIRST GULF OF GUINEA CRUISE
MAY-JUNE, 1966

We met Tony Provenzano and Ted Bayer at the airport at noon, Tuesday, May 19. We were given a big send-off by the press with numerous photographs and a trip to the plane by cart. When we were safely settled and buckled into our seats for take-off the pilot announced that we had a loose wing plate on the starboard wing and that take-off would be delayed thirty minutes. The plane actually left the ground an hour and thirty minutes later so that, with a stack up over Idlewild, we landed in New York only an hour before flight time.

The rest of the gang was there and we had a hectic time checking in and then found that our equipment was not on the plane. The rest of the group was already aboard, but I stayed in the terminal to try to get a definite commitment from the manager as to when the gear would be delivered in Lagos. He finally ended the argument by having the plane closed and pulled away from the ramp. He finally had it run back after agreeing to send the equipment on the next flight. It was several hours and several Martinis later before I finally cooled down. It was especially frustrating as this special equipment had been shipped air freight to New York 36 hours earlier and had been lying in the freight room of the connecting airline ever since.

The flight across was uneventful and we landed just after daybreak Wednesday, May 20, at Dakar. It was hard to believe that we were actually in Africa. But there were the natives in brightly figured flowing robes, wearing fezzes or turbans and sandals, many of them kneeling on their prayer rugs saying their morning prayers while facing Mecca. We took off in about 35 minutes, having taken aboard some Lebanese and a number of Africans, and ran down to Monrovia, Liberia, landing at Roberts Field, an old fighter strip cleared out of the jungle about thirty miles from the city. We were delighted with the large number of red or yellow-headed agamid lizards running over the ground and walls at the terminal.

Our next brief stop was at Accra, Ghana, after which we touched down at Lagos at about 2:40. Getting through formalities was rather hectic and in the process Dick Robins's bag was taken by someone else. Capt. Barkley met us with three cabs hired by our agent, UMARCO (Union Maritime et Commerciale), and took us down to the ship which was moored at the marina on Marina Drive. We found Dick Bader from the National Science Foundation, Ferguson Wood, Father McCarthy from Fordham University, and a few others still aboard. The ship had been plagued with difficulties on the preceeding cruise and I had several sessions with all concerned trying to iron out some of the problems.

Ted Bayer, Dick Robins and I went up town to PanAm to enquire about the IKMT depressor. The agent called UMARCO, our agent, and told us that the depressor plate had arrived. I then asked for a message to be sent to New York demanding that our freight be put aboard the next plane. When we got back to the ship four of our group went up to the Olympia Hotel for the night and Ted Bayer and I cleared out the Chief Scientist's cabin and turned in.

After breakfast, May 21, I had a seaman take me in the ship's launch to UMARCO in Apapa across the harbor. Here I located Mr. Mundine, the manager, and explained about the Smith-McIntyre grab, the depressor, and the delayed shipment in New York. He was dubious about locating the grab since it came by ship, we had no invoice for it, and about 125 ships a month enter the port. I then sent a message to Bob White, Assistant to the Director at Miami, explaining the situation and asking for emergency action. Mr. Mundine promised to do all that he could, and I returned to the PILLSBURY. While we were away Dr. Frank Williams, director of the CCTA Guinean Trawling Authority, came aboard and later we went up to his office in the Port Authority Building to discuss his program and get charts of his survey transects. He invited the senior members of our group to his home for drinks after dinner Friday.

About 1630 I went downtown to the Bristol Hotel and called Bob White on the Transatlantic radio-telephone. The operator said that he could not schedule the call for about a day or two but I told him I wanted to get through within an hour. While we were sitting at the bar drinking Carlsberg to support oceanographic research, the call came through! I explained the problem to Bob, asking him to raise hell with PanAm in New York. That telephone call cost us $32.00. Inquiry at PanAm revealed that the depressor was supposed to be in Lagos, but UMARCO said it was not. After dinner we retired to a small bar at the Domo Hotel a few blocks from the ship, again to help support oceanographic research. It was refreshing after a harried, humid day. The one bright spot of the day was the return of Dick Robins's errant suitcase.

Mr. Abib Aofiyebi from UMARCO came to the ship early this morning, May 22, and said that they had found the Smith-McIntyre grab and were working on the clearance papers, but that the depressor was not in Lagos. He also said that PanAm flight 150 was coming in at 1420 and that the "clark" would be there to meet it. Capt. Barkley and I agreed that we would be there too, to make sure that the shipment actually arrived.

In the late morning Ted Bayer, Dick Robins and I walked the few blocks to the Museum of African Art to see the wood carvings and bronzes for which Nigeria is famous. The museum is new and very modern. The bronzes are exquisite, rivaling many of those made elsewhere, and as castings are unexcelled. We took numerous photographs and I tried to persuade a Nigerian couple, especially a young woman dressed in one of the most beautiful costumes I had seen, to pose along with her little girl, but she refused.

The museum and the government buildings of Nigeria are built around a large common which also holds the race track. The buildings are very modern in a Neo-African design and quite colorful. Lagos runs the gamut from very modern to very primitive and from cleanliness to the typical tropical filth.

In the afternoon, Capt. Barkley and I headed for the airport in a taxi to meet the plane. We were through downtown Lagos and almost to Yaba City when we heard strange music ahead. In a moment we came upon a street procession consisting of an old patriarch with turban and flowing beard dressed richly in robes and carrying a brightly colored parasol. He was surrounded by an admiring group of natives and followed by a four-piece band: a drummer, a three stringed instrument, some kind of a flute and a cymbalist. These were followed by about 15-20 richly dressed young women who were swaying and dancing. All the cars had to stop. No sooner had we started up again when another group came along. We passed six in all. Our driver told us that they were hadjis who had just returned from a pilgrimage to the Sudan.

The drive to the airport was hectic as our driver seemed to think that he was on a race track. He took great delight in the near misses of pedestrians, who also entered into the game, and in cutting in front of other cars. When we finally arrived at the airport we found that PanAm flight 150 did not arrive until the next day! Taking the opportunity I checked with the freight clerk, a very bright young fellow by the name of Mr. Omoluoa, who took me down to the freight yard where I found the depressor sitting out in the middle of the lot!

Today we also had a visit from about 18 students and three professors from the University of Ibadan about 90 miles from Lagos. The students

FIGURE 3. The senior scientist lecturing to students from Ibadan University aboard R/V PILLSBURY in Lagos.

were very interested in our work, asked many intelligent questions, examined our gear and were very pleasant indeed.

Several of us also got a number of the brightly colored lizards, *Agama agama,* and several specimens of the true African chameleons in native wire cages to take back to the States.

After dinner we were met by Frank Williams who took us out to his home on a neighboring island. His wife is a very charming woman who has lived for a number of years in the tropics and seems to love it. Their house is cement and stucco, high-ceilinged, with great unscreened open windows and no insects! There were numerous geckos in the house, one behind each framed picture. After a very enjoyable evening we went back to the ship, where I bargained for a few pieces of native craft from the ubiquitous dockside hawkers.

I went uptown in the morning, May 23, to get some supplies needed for our work. On the way back I visited one of the wood carving establishments where most of the black or king ebony heads and masks sold in town are turned out by production-line methods. At 1320, Capt. Barkley and I went to call on the American Vice-consul, Mr. Carl Pearl. Afterward we made another wild ride to the airport with Mr. Abib to meet the plane, found our gear aboard, and left Mr. Abib to clear it and bring it to the ship. We sweated out a long evening before there was a hail from the road and Mr. Abib, now resplendent in colorful robes rather than his immaculate whites, arrived with all our gear. The last of the equipment was aboard two hours later. In celebration the entire scientific party proceeded to the Domo Hotel for the usual purpose of supporting oceanography, and closed it late that night by drinking to the success of the trip.

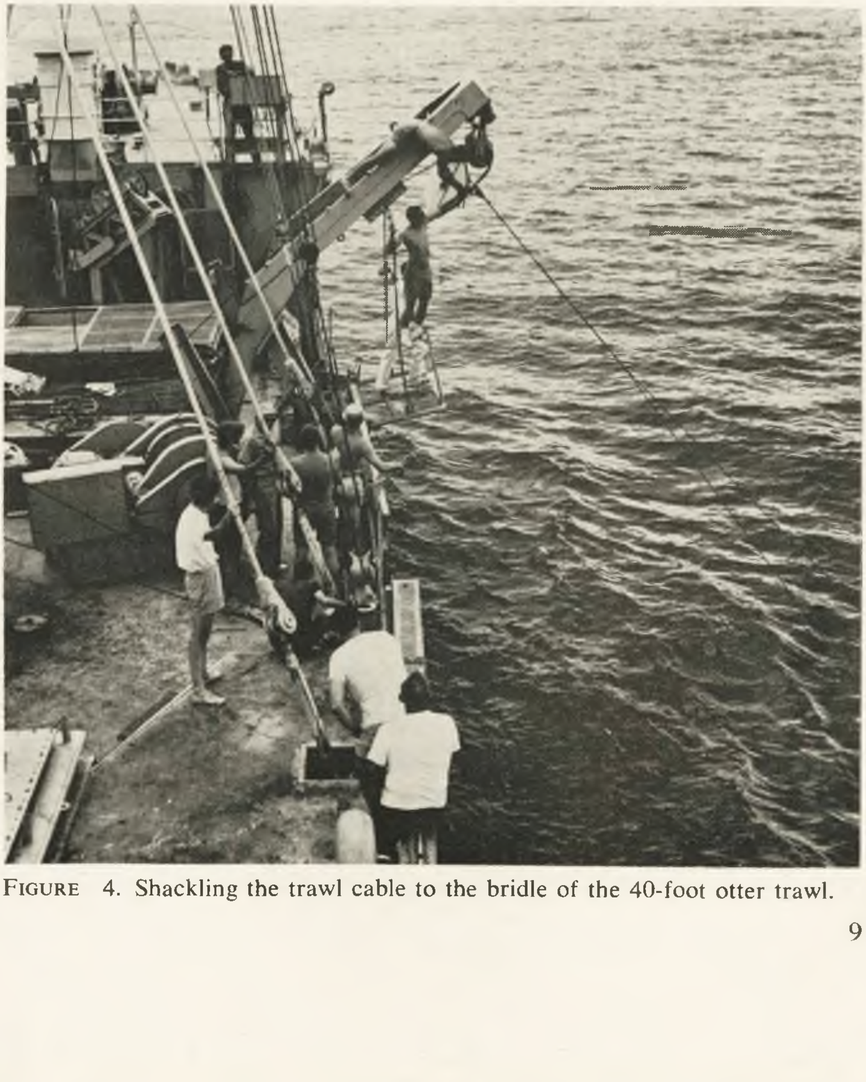

FIGURE 4. Shackling the trawl cable to the bridle of the 40-foot otter trawl.

May 24th, Sunday

All up at 0700 waiting for the harbor pilot. The natives all shook hands and wished us a good voyage. At 0800 the pilot, a big Englishman in white shorts, came aboard and took us down the river, a rather hazardous job because of the strong currents for which the river is noted. There was a heavy swell at the bar, which we cleared at 0930. At 1015 we had fire- and abandon-ship drill and at 1030 we set the 40-foot otter trawl in about 35 fathoms.

The operation was complicated but successful. The bridles are led through a Hathaway block alongside the running block at the head of the A-frame, across the ship to a leader and onto the deck cargo winch. The net is heaved out and shot with the engines slow ahead, the leader is run out clear of the Hathaway block, the main trawling cable shackled to the bridle and the leader unshackled and the net run on out. We used a 3:1 ratio of wire to depth and trawled for half an hour. Everything was going well, the tension increasing by sharp leaps indicating fish catch. We started hauling in and while I was at lunch Clyde Roper suddenly came in and reported that the cable had parted. We had been using the cable on the forward drum, and inspection showed that it was completely rusted and worthless. We rerigged with the new wire on the after drum, 42,000 feet. So ended our first trawling station, P-3.

We then switched over to the Blake trawl, a 10-foot model with a funnel in the mouth. We shot it at 1350 hours when we reached a depth of 1025 fathoms. The net streamed perfectly, and the tensiometer reading was about 1500 pounds with 5400 meters of wire out (ratio 3:1). We trawled for half an hour when the net began jerking, and, fearing that we were on rough bottom, I started hauling in at 1200. When we got it on deck at 1642 we found that it had been working well on black mud bottom. Station P-4 contained the aspidodiadematid *Plesiodiadema antillarum* and the spatangoid *Hemiaster expergitus*; mollusks were represented by numerous large *Dentalium* and bivalves of the genus *Yoldia*; polychaetes of the genus *Hyalinoecia;* molpadid holothurians; and sea-pens of the genus *Anthoptilum*; many fishes, including *Sternoptyx diaphana,* a ceratioid *Cyclothone, Cetonurus,* and others. On the footrope, Ted Bayer found a large number of pogonophorans, which are the first reported from this area of the Atlantic.

The watch list was posted in the afternoon 8-12: Voss, Eschmeyer, Manning and Chesher; 12-4: Bayer, Holthuis, Young and Davis; 4-8: Robins, Roper, Provenzano and Reynolds. I also learned today that Reynolds is quite sick with an allergic reaction from penicillin shots taken before he left Miami.

Station P-5 was made with the Blake trawl at 1800 hours in 1240 fathoms with 6400 meters of wire. It was on the bottom at 1931 hours and towed with the starboard engine slow ahead and a tensiometer reading of

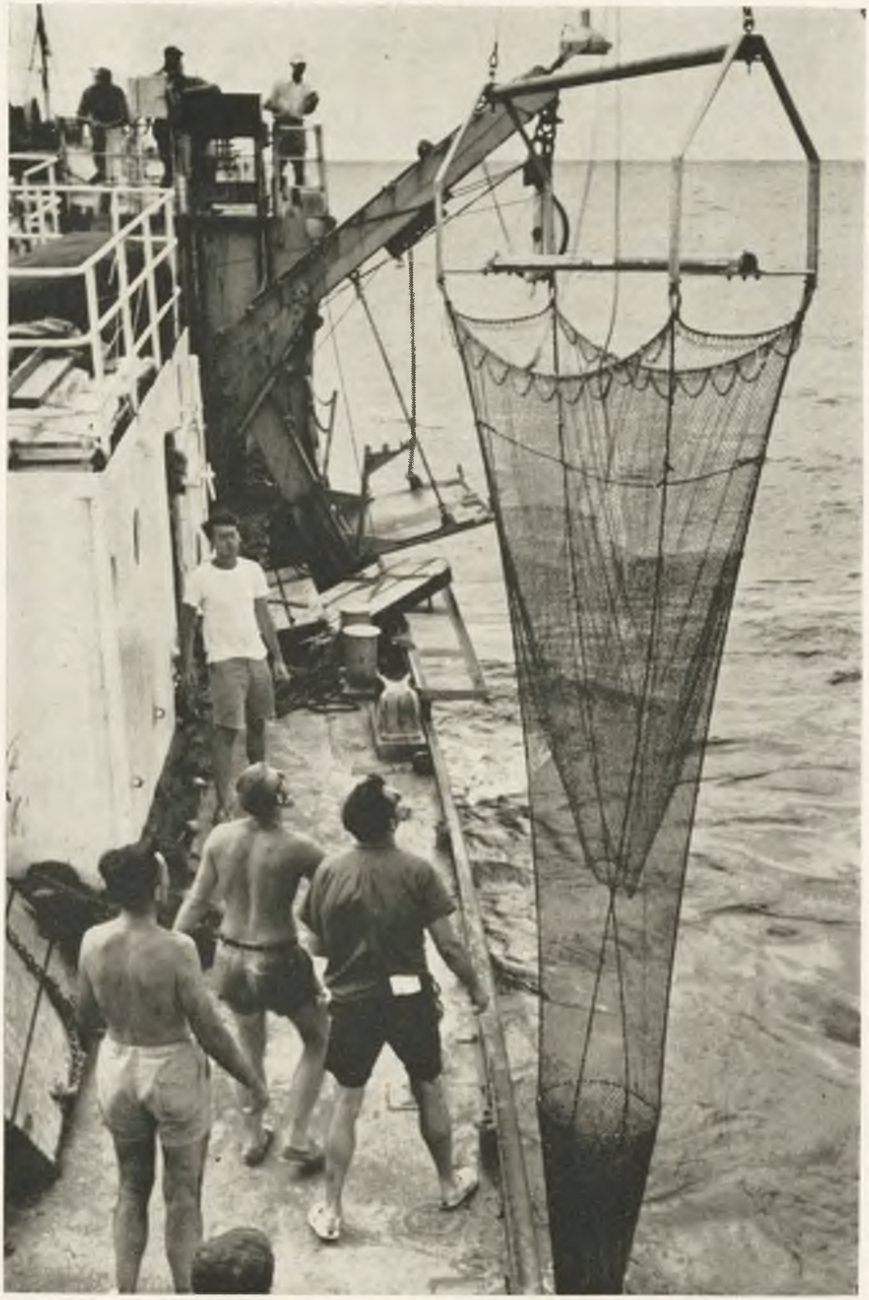

FIGURE 5. Lowering away the Blake trawl.

2200 pounds. At 2052 hours the reading suddenly increased to 5000 pounds at which time we stopped the ship and began hauling in. At 2230 when the net came in view we found the cod end tangled in about six loops of wire. Apparently it had dug in when the tension increased, for there were a few animals on the outside. Because of the danger of the wire we hooked on the leader from the cargo boom and lifted the whole mess on deck. We cut away the wire with a loss of only about 100 feet and I cleared away the tangle while the bos'n laid in a new eye splice. By midnight we were ready to run again.

May 25th, Monday

Station P-7 was also a haul with the Blake trawl, made at 0040 at 5°35'30"N, 3°10'E, in 1468 fathoms with 6500 meters of wire out and a tensiometer reading of 2100 pounds. The trawl was on deck at 0620 hours after three hours of fishing depth but must have been off the bottom the entire time, because the catch consisted of a flyingfish, a hatchet fish, three caridean shrimps and some barnacles scraped from the ship's side. During the hauling a dipnet station (Sta. P-8) produced flyingfish eggs in *Sargassum* weed, a *Porpita,* two *Coryphaena* larvae, a myctophid and one flyingfish.

At 0750 Dick Robins shot the IKMT for the first time at a depth of 230 meters with 700 meters of wire out (Sta. P-9) in order to sample a very large and concentrated scattering layer observed on the PDR at 5°42', 3°05'E. At 0905 an additional 300 meters were paid out since the layer had moved downward 30 fathoms. We brought the net on deck at 1025 to find a very poor catch, although the Benthos depth recorder attached to the net showed that it had been fishing in the middle of the scattering layer throughout the tow.

Eschmeyer drew to my attention the fact that the nylon sleeve in front of the bucket on the IKMT was wearing out, so I made a new sleeve of canvas, sewing a flat seam, and with the bos'n's help, put in grommets. It turned out rough but serviceable and fitted the net well.

Sta. P-10. At 1335 we shot the IKMT with 300 m.w.o. with the Benthos recorder attached and fished it from 1430 to 1630 hours. When brought on deck at 1710, the bucket was full of very good deepwater material including a number of very unusual fishes, squids, crustaceans, etc., which all hands crowded around to see. The Benthos showed that we had been fishing from 655 to 917 meters with a dip to 1065 meters when the ship was slowed before hauling in.

Sta. P-11. At 1810 Dick Robins shot the IKMT again at 6°00'N, 2°50'E, this time with 270 meters of wire out intending to fish at 90 meters. When it was brought back on deck at 2031 the Benthos showed that after a slight dip when the ship was slowed to one engine the net had held evenly at 90 meters for the whole tow. This time we did not cut down on our way until after commencing to haul. The catch was a good one, including several squids, *Onykia, Pyroteuthis,* several *Chiroteuthis* and cranchiids, etc. During the tow Bill Eschmeyer and Ray Manning made a plankton station (Sta. P-12) and got three decapod larvae and two mullets.

We secured the IKMT on deck and headed on a NW course for the shelf where we will make our next haul with a try net in about 30 fathoms. The PDR tracings along the supposed 100-fathom curve were some of the ruggedest contours that I have ever seen. At the change of watch at midnight, the sea was rising a little and the wind freshening from the SW.

May 26th, Tuesday

Station P-13. The try net was shot at 0055 in 35 fathoms at 6°08′N, 2°09′E. It was towed for 30 minutes with 250 meters of wire out and was back on deck at 0142. The catch was small but contained a *Sepia* and a *Sepiella, Pontophilus,* a pennatulid, a hermit crab, forams, *Stephanoscyphus,* several sparids, *Priacanthus,* a few triglids, several flatfishes, a myctophid and two unknown fishes. The tensiometer reading was less than 100 paying out, but held at 300 while towing and picking up.

Sta. P-14. 6°02′N, 1°29′E. Robins shot the try net again four hours later on smooth bottom but with patchy coral in 21 fathoms. It was shot at 0515, down at 0521 and lost at 0535. Because of time limitations we did not attempt to repeat the tow, but proceeded to the next station.

Sta. P-15. At 1032 we set the try net on muddy bottom in 70 feet of water with 125 meters of wire, and a tensiometer reading of 100 pounds. It was fishing at 1034 with a reading of 200 pounds, gradually increasing to 500 pounds when the depth increased to 150 feet and started abruptly downward. I shortened wire to 50 meters and changed course shoreward but decided to continue hauling in and brought the net on deck. It had a small but good catch of turrids, a blowfish, and other animals indicative of mud bottom. The PDR showed numerous 5-10 foot mounds in the trawling area but the tensiometer did not indicate that the net was digging in.

Sta. P-16. At 1313 we set the try net again in 25 fathoms with 275 meters of wire out. We towed for half an hour on mud bottom with the tensiometer increasing from 400 to 600 pounds and had the net on deck at 1355. The net contained a good catch with much foraminiferan material, some alcyonarians *(Filigorgia* and *Alcyonium),* many gastropods, about forty *Panaeus duorarum,* rays and various other fishes.

Sta. P-17. We now came onto the new transect area off Tantum and shot the 40-foot trawl in 23 fathoms with a wire ratio of about 4.5:1 with 180 meters of wire, and the tensiometer registering 2500 pounds. We towed for one hour on a bottom of fine sand and green mud. The net came on deck at 1638 and contained a good catch of herring, porgies, snappers, etc. Several boxes of *Brachydeuterus auritus,* several hundred mooonfish *(Vomer),* and about 10 porgies and *Lutjanus,* and a number of rays and clupeoids were discarded. All the others were saved. Among the gorgonids were a number of yellow-and-purple fans, a few *Paenaeus,* a number of large *Sepia,* an *Octopus* and about a dozen *Alloteuthis.* There were also a number of dark red starfish and a *Brissopsis.* We were surprised that we did not get any shrimp in commercial quantities, which the crew were hoping for, but the fish catch was impressive and we gave the steward, Mr. Knoop, enough for a meal.

Sta. P-18. We now headed offshore but could not find good bottom on the shelf so ran to 1200 fathoms and shot the Blake at 1935 hours. As our last deep hauls had either fouled the wire or not been on bottom, I was particularly careful about this haul and stood by at the winch through most of the operation. We tied a 75 pound lead pig to the cod end and began lowering away at 1935 at a rate of 90 m.p.m. with the ship slow ahead on both engines. After running about 3000 meters out Dick Robins came up to point out that the wire was running out at about the same speed as the ship. The pull was 1100 pounds. At this I cut the pay out speed to 50 meters and the pull increased to 1300 pounds. The tensiometer readings were recorded during pay out and at the stop intervals made to straighten the wire. They may be found in the Appendix.

I stayed with the tow during the two hours on bottom and until it was safely on its way back up. During lunch today the electrician and the bos'n were talking about the Deep Sea Bulletins which we are posting to keep the crew informed about our day to day work. They were very pleased that we have an interest in informing them about our operations and commented that none of the other scientific parties who came aboard could answer questions understandably. We not only answered them, but also showed them the animals down in the lab.

The entire haul took six hours. When Ted came off watch he said that it was successful, with a number of ophiurans, starfish, fish, etc. The depth increased during the tow from 1220 to 1760 fathoms, necessitating 8700 meters of wire out.

Sta. P-19. During this tow Eschmeyer, Davis and Young made a plankton tow of 6 hours duration, in which they caught a number of small *Psenes,* phyllosomas and other decapod larvae, worms, and a small *Ommastrephes.*

At the end of the Blake tow when changing to the IKMT, the wire suddenly kinked at the tension drum due to being stretched too far during the last tow. It required three hours to cut the cable and put in an end splice. During this time the ship drifted.

May 27th, Wednesday

Sta. 20. At 0715 the IKMT was shot over a bottom depth of 3490 meters to fish at 2000 meters. A 3:1 ratio (6000 m.w.o.) was used. The net was down at 0823 on my watch and was towed with only the starboard engine slow ahead for two hours. About 0900 a harmattan hit us with strong winds and rain. At 1025 we commenced hauling, with a tensiometer reading of

FIGURE 6. The Isaacs-Kidd midwater trawl ready for lowering.

4700 pounds. The pull during the haul varied from 3200 pounds at the beginning to 4200 pounds at the end. The net was back on deck at 1210. It is now brought aboard by hooking in the cable from the peaked-up starboard after cargo boom and lifting depressor, net and all onto the deck. The Benthos showed that we had towed from about 1900 to 2125 meters, very near the planned 2000 meters.

The catch was very good, including *Systellaspis, Acanthephyra,* and other crustaceans, a *Bathyteuthis, Mastigoteuthis, Abralia veranyi* and a few other small squid. A study of the fish caught in the IKMT showed that the haul was the best we have made: two gulpers, viper fishes, barrel eyes, a black swallower, a black cardinal fish and a *Benthosaurus.*

The cable again was filled with turns so that we steamed one hour on our way, stopped the ship and paid out 2500 meters with a 350 pound weight in order to take out the turns. The level wind also needed repairs. The sea is now moderating but the sky is still leaden and with drifting rain.

Sta. P-21. At 1600 Dick Robins shot the IKMT again in 3020 meters with 4500 meters of wire. It was on deck again at 2027 with a good catch. There were many crustaceans including a beautiful live *Notostomus;* a large squid, *Taningia danae,* a small *Bathyteuthis,* etc. The fishes consisted of a beautiful small angler, *Lynophryne,* and other very good deep sea fishes. The Benthos showed that the net had been fishing just below 1500 meters, our estimated depth.

We resumed our course to the NW for one hour, intending to make another IKMT haul in 500 meters, but when I went onto the bridge, Accra, Ghana, was only 16 miles north. The bottom was shoaling rapidly so that we turned westward and changed to the try net.

Sta. P-22. The try net was shot at 1148 hours in 57 meters with 275 meters of wire. The tow was intended to fish for half an hour, but the bottom proved to be rough and in 28 minutes the net gave several hard, sharp jerks and I brought it on deck. It had a good catch of alcyonarians, three cuttlefish, a number of small fishes, several red starfish and probably *Luidia senegalensis,* a number of cidaroids, numerous crustaceans including a beautiful maroon *Stenorynchus* and hermit crabs galore. A little for everyone!

May 28th, Thursday

Sta. P-23. Ted Bayer shot the try net at 0140 in 42 meters with 275 meters of wire. The bridle twisted during the tow and the doors were closed when the net came up. The bottom was covered with a foliate brown to orange bryozoan resembling large potato chips; there were a few red starfish, *Luidia* and *Astropecten;* many small crustaceans, to Lipke Holthuis's delight; not many mollusks, but those present included live *Xenophora,* small *Arca* and *Pecten;* not many fishes except for some rock hind.

Sta. P-24. At 0505 Dick Robins shot the net in 36 meters on a bottom of dark red bryozoans. The catch was heavy with bryozoans, but contained little else except cidaroids and some *Centrostephanus,* a few *Octopus defilippi* and *O. macropus,* some scorpionfishes, etc.

Sta. P-25. On the 4-8 watch a flyingfish, *Parexocoetus,* flew on deck and was preserved.

Sta. P-26. At 0900 I shot the try net in 27 meters with 164 meters of wire. We towed for 30 minutes and had the net back on deck at 0945, filled with dead *Pecten* shells, a *Squilla mantis, Sicyonia galeata,* turrids, etc. Among the fishes were sparids, bunkers, eels, goatfishes, large sea-horses and some elongate soles. There were also *Sepia* and very young *Lolliguncula mercatoris.*

Sta. P-27. At 1230 Ted Bayer shot the try net in 32 meters with 165 meters of wire. In about 15 minutes a heavy jerk on the cable indicated hitting an obstruction. The cable raised slightly which I thought indicated a door pulled loose but when the net came on deck we found that the footrope on the starboard door had parted. The haul was a good one, however, containing two small *Lolliguncula mercatoris,* a small *Apogon,* an electric ray, a drum *(Pteroscion peli), Trichiurus lepturus,* clupeids, and a number of species of alcyonarians.

The sea by now was running down and the day very pleasant, with short passing rain squalls. In the early afternoon we were circled by two Ghanian airforce planes, so the captain hoisted the American flag. There are some doubts about the territorial limits claimed by Ghana.

Sta. 28. Ted Bayer shot the try net again at 1445 in 49 meters with 275 meters of wire. The net was on deck again at 1530 with a good catch of mixed fish, of which all were saved except some percophidids and a few sparids. There were about 40 large shrimp in the net so I had the ship's course reversed and set the 40-foot trawl immediately at 1545 with 275 meters of wire; Sta. P-29. We had no lack of help on this haul, and the ship's crew lined the rail and practically threw the net into the water. We towed for half an hour and brought it on deck at 1637. It had a very good catch of about 3-4 count (heads on) shrimp, much to the delight of the crew who headed them then and there. Several large soles *(Cynoglossus canariensis)* were saved for the non-shrimp eaters. Other catches were soles, flounders, cuttlefish, porgies, sciaenids, triglids, *Brotula* and *Neanthias.*

Stas. 30 and 31. We then ran an hour and a half and made another haul with the 40-foot trawl in 58 meters. The net was shot at 2021 and hauled at 2102. Included in the catch were many fishes, *Squilla mantis,* two large *Stenorynchus,* a *Dardanus,* a few large *Penaeus duorarum, Solenocera,* and three *Sepia.*

Sta. 32. We then headed due south to the edge of the shelf in 110 meters where we set the 40-footer at 2228 with 540 meters of wire and a tensiometer reading of 2000-2400 pounds. The net was on deck at 2312 with a good catch of snappers and other reddish fish, four large *Centrostephanus,* five *Dardanus,* five *Illex illecebrosus coindeti,* a number of large *Sepia, Abralia* and an *Octopus macropus.* Many other things were obtained.

May 29th, Friday

Sta. P-33. Ted Bayer set the Blake at 0145 in 1170 meters. It was on bottom at 0302 with 4400 meters of wire. It was brought on deck again at 0614 but it had been mostly fishing in midwater and contained fishes, jellyfishes, a squid and a few *Dentalium* indicating that it had touched bottom at least once.

Sta. P-34. The Blake was shot again by Dick Robins at 0724 and run out at 74 m.p.m. I took over at 0800 at which time 2000 meters of wire were out. My procedure was to hold at every thousand meters for two minutes to straighten the wire out and pay out at about 60 meters per minute. I kept a very careful record of the tensiometer readings, about every 1-2 minutes for the entire operation. The net was on bottom at 0936 with 6000 meters of wire out, and towed for two hours, alternating with 10 minutes with both engines slow ahead and 5 minutes with one engine slow ahead. At 1130 we started hauling in and the net was off the bottom at 1208. We landed the net on deck at 1305 with a good catch of large red starfish, thousands of brittle stars, numerous small holothurians but some giants, a tremendous *Bathypterois* and some smaller fish, some glass sponges, a tunicate, and numerous other specimens including a large, white *Scaphander*. Unfortunately, due to lack of immediate attention, the large holothurians disintegrated before they could be preserved. This is a problem we must check more closely in the future.

We started to set the IKMT but when the trawl wire was raised it suddenly dropped off the hauling engine and slid out as though it had been cut. This necessitated suspension of operations while it was rewound and the cable payed out to remove the turns. While we were on the forecastle head this morning we noticed a number of small tunneys, possibly *Euthynnus alleteratus,* playing around the ship and feeding on flyingfishes. The weather has been beautiful, with only a few passing squalls.

Sta. P-36. At 1435 Ted Bayer set the IKMT in 1950 meters with 2400 meters of wire for an 800 meter tow. The net was down at 1510 and towed for two hours. On arrival on deck at 1803 we found a terrific catch: three *Vampyroteuthis,* two *Mastigoteuthis,* a gulper and a snipe-eel in perfect condition, several large leptocephali, *Malacosteus,* several kinds of black anglers, and hatchet fishes, melamphaids, bathylagids, and gonostomids.

Sta. P-37. We reset the IKMT at 1925 in 2215 meters with 1600 meters of wire out to sample the 500-meter level. It was at depth at 1944 and back on deck at 2230. It contained a large number of very good crustaceans and fishes but only one cephalopod, a small *Bathyteuthis.*

Sta. P-38. A tow with surface net was run simultaneously with the mid-water haul and yielded two flyingfishes, a crab, megalopas and stomatopod larvae.

May 30th, Saturday

Sta. P-39. At 0015 Ted Bayer shot the IKMT in 2985 meters at 300 meters with 900 meters of wire out. It was on deck again at 0250 with only a moderately good catch of which among the crustaceans were *Acanthephyra, Sergestes,* and euphausiids.

Sta. P-40. At 0425 Dick Robins again set the IKMT in 1100 meters for a depth of 200 meters with 600 meters of wire out. It was on deck again at 0631 with such fishes as *Cyclothone, Gonostoma* and *Argyropelecus,* also a tuna larva, *Ichthyococcus,* invertebrates including *Phronima, Systellaspis, Ancanthephyra, Procletes, Gennadus, Sergestes,* etc.

Sta. P-41. I came on deck at 0800 and decided to shoot the try net in somewhat deeper water. We set it in 715 meters at 0857 and towed it on the bottom for half an hour. It brought up a number of crustacea: *Nephropsis, Polycheles, Sergestes, Munida, Munidopsis, Brachycarpus,* stomatopod larvae, *Nematocarcinus, Pontophilus,* etc.

Sta. P-42. Before passing Abidjan we shot the try net again in 75 meters at 1412 hours. It was on deck again at 1455 with an excellent catch. The bottom was covered with brown, branched foraminiferans. In the net were numerous pagurids, *Parapenaeus longirostris, Pontocaris, Pontophilus, Sicyonia,* eucarids, parthenopids, *Scalpellum, Squilla,* etc. We did not get *Penaeus* in quantity, probably because we were too close to Abidjan, Ivory Coast, where the trawler fleet headquarters are. However, there were great quantities of *Nematocarcinus,* which alone would support a fishery. The plankton net was also over and caught two portunid crabs (Sta. P-43).

Sta. P-44. During Dick Robins's watch the try net was set in somewhat deeper water, varying from 585 to 402 meters, necessitating continual readjustments of the warp. It was shot at 1617 and was back on deck at 1812. This haul was in the Bottomless Pit, a deep, broad canyon leading into the port of Abidjan on the Ivory Coast. It ranges from about 366 to about 915 meters in depth but seems fairly level. The tow was successful and brought up a rich and varied fauna, probably due to the effluent from the river. In the tow was a striking red *Opisthoteuthis* of whose identity I am not certain, and a small sepiolid. Among the mollusks we also got *Calliostoma* and *Nassarius* and many others; crustaceans included *Parapenaeus, Nematocarcinus, Munida, Munidopsis, Geryon, Bathynectes, Pontophilus, Sergestes,* etc.

Sta. P-45. At 1852 we set the 40-foot trawl in 73 meters with 400 meters of wire out. It was on deck again at 1955 with a fairly good catch of pagurids, *Squilla, Parapenaeus, Solenocera,* etc.

Sta. P-46. The try net was set again at 2250 in 46 meters and came up with a net full of foliate foraminiferans, *Jullienella.* Here we got our first *Cymbium olla,* two live specimens of the bailer shells, *Squilla, Sicyonia galeata, Scyllarus caparti, Dorippe, Ethusa,* xanthid crabs, *Parthenope,* dromids, *Calappa,* etc.

May 31st, Sunday

Sta. P-47. Ted Bayer set the try net again at 0110 in 36 meters. It was up at 0150 again with a load of the foliate foraminiferan and about the same types of crustaceans as before.

Sta. P-48. When Dick Robins came on deck at 0400 he shot the try net in 22 meters and obtained a good haul. The fishes were toadfishes, *Brotula,* soleids, etc. Crustaceans included *Squilla,* hermit crabs, *Charybdis, Dorippe, Ethusa, Stenorynchus, Parapenaeus* and many others.

Sta. P-49. Dick Robins again set the net at 0522 in 69 meters, on deck at 0608. The catch was good, containing stargazers, gobies, *Brotula,* flatfishes, many hermit crabs, species of *Luidia* and other types of starfishes, etc.

Sta. P-50. At 0625 he again shot the net. We then were off Cape Lahu west of Abidjan and at the locality of our next offshore transect. Our idea was to sample the slope fauna as well as possible in closely spaced stations across the shelf and down to 1830 meters (1000 fathoms). The depth here on the edge of the shelf was 146 meters, and the wire scope was maintained at 5:1. The haul was successful but the PDR broke down during it, and to compound our difficulties the plastic sealer burned out. This latter was a real loss as it could not be repaired and it greatly increased the job of making plastic bags for storage of specimens. The PDR was put back in shape by Roper after he read through the manual.

Sta. P-51. I was on deck and we shot the try net again, this time in 383 meters on the upper part of the slope. The net was down at 0905 and up at 1012. Here we got *Lophius, Peristedion, Callionymus,* and a large number of other fishes. Robins commented that the fish fauna compared very closely with our Florida fauna at the same depth.

Sta. P-52. The next two tows were made between 400-520 meters in the bottom of a very rugged trough running 080° along the slope. The net went down at 1047 and by constant adjustment of the length of the wire, we made a good haul over very rugged bottom. The fishes included *Halosaurus, Bathypterois, Dibranchus* and several others.

Sta. P-53. Still off Cape Lahu, we went out to 1500 meters and set the Blake at 1350. We gave it a 3:1 ratio and towed alternately between one and two engines. The haul came up at 1843 with a very good catch of large *Dentalium* which seem to be everywhere, hundreds of small *Echinus,* a small *Sperosoma,* four *Phormosoma,* five whole and many broken *Brissopsis,* ophiuroids and asteroids. It was a beautiful haul made in very clear sunny weather with only a slight swell. It was our best deep haul yet. By the time I came off the forecastle head I was just about roasted.

Sta. P-54. We now secured the Blake but, as always after using it, the wire was charged and wound up dangerously. We therefore lay to, intending to stream the wire but didn't to our regret for we now set the IKMT with 2500 meters of wire out intending to spend the next 18 hours towing for squid. Just as the net was started up the heavily charged wire jumped the traction heads, shot out and snapped just ahead of the drum. Our IKMT was gone and we had no replacement.

We now lay to for several hours while the wire was run out, straightened, and a new eyesplice laid in. During this time we night-lighted and caught about 8-10 large *Ommastrephes pteropus.* The oval light organs on their backs glowed brightly in the water and in a bucket they flashed their ventral organs on and off emitting a bright glow. An exciting time was had by all, which somewhat compensated for the general dejection at losing our only midwater net (Sta. P-55).

Sta. P-56. While the wire was being rewound I lashed the pipe spreader bar to the footropes in the mouth of the Blake net in order to spread it out as wide as possible for an attempt at midwater trawling with an improvised rig. At 2230 I shot it with a 4:1 ratio (3200 m.w.o.), trawling with both engines slow ahead. I was hoping to hit 800 meters for squid. It was brought on deck at 0241 and the Benthos showed that it had been at depth at 800 meters. It had a rather poor catch in relation to the regular IKMT but there were two more *Vampyroteuthis,* and some gulper eels and snipe eels. It also contained *Acanthephyra*, *Gennadas* and *Sergestes*. The wire was again badly twisted and we had to cease using this net. The plankton net was also towed (Sta. P-57) but nothing much caught.

June 1st, Monday

When I came on deck we were making a long leg to the northwest. We had found that the current was setting us to the eastward and we were now east of the point from which we had started our outward transect. We finally reached the shelf about 1000, and at 1038 I shot the try net in 91 meters (Sta. P-58). The bottom was very rough according to the PDR and the cable gave several hard jerks, reaching as high as 5000 pounds tension. When we hauled in at 1132 we found the net and doors were gone. This is not critical as we have one more set of doors and if these are also lost we can bend the three remaining nets on a Blake frame and still trawl.

Sta. P-59. At 1140 in 64 meters I again shot the try net. It was on deck at 1240 during Ted Bayer's watch, about opposite the mouth of the Sassandra River. The bottom was mud with many dichotomously branched foraminiferans. The catch consisted of numerous venerid clams, tubicolous polychaetes, *Nucula,* and two live specimens of a large reddish *Marginella.* This is the second station at which we have obtained the latter. Ted thinks that they may be a new species, and certainly are one of the most gorgeous. The crustaceans obtained were *Parapenaeus,* leucosiids, parthenopids, and spider crabs; fishes were scorpaenids, stargazers, brotulids, flatfishes, gobies, etc.

Sta. P-60. He set the net again in 79 meters at 1445 and retrieved it at 1532. The bottom was rocky or coral and the bag was badly torn, with the liner ripped and the footrope broken. Most of the collection was lost but there were still two beautiful starfishes, one bright yellow and the other bright red; some crabs including leucosiids, parthenopids and dorippids; a small triglid and trachinids.

Sta. P-61. We now bent on the 40-foot trawl and shot it in 82 meters at 1825. At 1920 we brought it up and found that the net had fouled the doors, one foot rope was broken off at the inboard door, and the wire a hopeless mess. As the bo's'n said, it was a "bird cage with honors". It also seemed to have fouled the screws slightly as there is now a section of lines streaming astern. As it was by then dark, I told them to set the net aside and rig the new one in the morning. Opinions as to why the net fouled were numerous, although most blamed it on the chief mate who apparently did not keep enough way on the ship.

I came on deck at 2000 and after helping clear up the dry lab I went onto the bridge to talk with the captain, Dick Rogers. In going over the charts and sailing directories with him, I found that we were in an area of very strong currents, up to 3½ knots. The sailing directions stated that from Cape Palmas, which we were approaching, eastward to Cape Coast Castle the Guinea Current runs its swiftest during June. Cape Palmas is opposite the closest point of the interface with the South Equatorial Current so that the Guinea Current is here compressed and accelerated. This, of course, necessitated a revision in our towing since if we towed on one engine against such a current the net would tumble backward along the bottom and foul the warps. Since we were behind schedule, we decided to allow a longer time between tows.

Sta. P-62. I set the try net at 2250 and towed for half an hour on the bottom with both engines slow ahead. The net was on deck at 2326 with a good catch of scorpaenids, stargazers, brotulids, eels, flatfishes, gobies, triglids, serranids, and small crustaceans of the usual sort, from a bottom of brown, branching and leaflike foraminiferans.

June 2, Tuesday

Sta. P-63. Ted Bayer set the try net again at 0240 in 64 meters and brought it on deck at 0325. The bottom was sandy mud with dead shells *(Arca, Venus, Tellina, Nucula, Cardita),* live mollusks *(Natica, Marginella, Cymbium,* turrids, *Nucula)* and unbranched gorgonians, purple alcyonaceans, *Stenopus,* leucosiids, *Dromia, Macropodia, Pontocaris, Squilla, Parthenope,* brotulids, flatfishes, sparids, stargazers, gobies and a saber fish.

Sta. P-64. Dick Robins set the try net at 0635 in 68 meters and brought it in at 0724. The catch consisted of the puffer, *Sphaeroides spengleri* (an amphi-Atlantic species), scorpaenids, serranids, sparids, gobies, numerous solitary corals, etc.

When I came on deck for breakfast, the messman, Bob, told me that a pod of whales was astern at about a kilometer distance. I could see numerous spouts and flukes as they sounded. It was not possible to determine the species at that distance. The day was very cloudy, with rain squalls all around and a low but sullen sea. The gang turned to early to get the 40-foot trawl readied. A new bag was shackled on and chain seized to the footrope.

Sta. P-65. At 1042 directly off Cape Palmas we set the net in 44 meters, but due to the sea, wind and current, we laid off to seaward to keep all on our starboard or weather bow. We towed for one and a quarter hours and brought the net on deck at 1210. It had a good catch of fish including many *Priacanthus* with isopods on their sides, porgies with isopods in their

FIGURE 7. Isopod parasites on *Priacanthus arenatus.*

mouths, and numerous other small fishes many of which seemed like surface species. The shrimp were mainly pink striped *Parapandalus* and a few large *Penaeus,* some nice *Sepia,* etc. I gave all of the *Penaeus* to the cook along with four nice large soles.

We now secured the try nets and laid a course for 4200 meters in order to make a deep tow with the Blake trawl. Unfortunately, the weather began to get sour and as we ran southward a considerable head sea built up, and wind and rain increased so that the sea and sky became quite sullen. We reached 4200 meters at about 1800 and hove the ship to while the 300 pound lead was shackled on and 1500 meters of wire let out to clear the twists from the line.

Sta. P-66. We then shackled on the Blake trawl with 150 pounds of lead attached to the cod end swung it over the side. At 1855 the net went down beautifully, cod end first and we lowered away at a rate of about 30 meters per minute. The sea ran high with considerable swell, and drifting rain kept us in oilskins. After getting it started out I went below until my watch began. At 2000 when I again came on deck I found that the rain had ceased. I kept regular recordings of tensiometer and wire out for future reference. Despite the rising sea, the ship lay beam to the seas with hardly a roll.

Shortly after dark when the lights went on, a considerable number of squid came up to the lights to feed on flying fishes. All were *Ommastrephes pteropus* or "orange backs." Some of them were over four feet long, and the oval patch glowed clearly in the sea with occasional flashes of white from the ventral organs. I had always thought that squid caught fish in lightning-fast attacks but this is not so. Actually, they swim rather slowly tail first somewhat alongside and in front of their prey and then dart forward and grasp it with their tentacles.

At 2222 I had 8000 meters of wire out, and at 2300 the captain asked if another 1000 meters could be run out to realign the wire and get rid of several slack turns. This was done, accompanied by rather alarming snaps since the cable on the drum was not in line with the level wind. At 2350 the wire was out to 9000 meters. With this amount of wire out, the ship was brought head to the wind and pitching increased. I wanted to go ahead slow on one engine to tow the net but this was impossible due to the sea condition and we had to drift off at an estimated two knots. Bayer came on at midnight and I turned in.

June 3, Wednesday

At 0600 Dick Young called us out to see the net aboard. As soon as it broke water I could see that the tow was not a good one. Unfortunately, I had forgotten to secure the funnel in place for lowering away cod end first and it has apparently streamed out the mouth and then wrapped about the floats inside. This effectively prevented the capture of any fishes. However it was not a total loss as we had one nice holothurian, two white starfishes, two large *Plesiopenaeus,* probably caught on the way up, about five *Scalpellum,* a dozen small bivalves of one species and one or two others, some worm tubes and some manganese nodules. Dick and Ted both said that it had rained torrents during their watches and the sea and sky were still ugly.

Sta. P-67. Dipnetting had gone on most of the night and considerable collections of squid, flyingfishes and other small fishes were made, including numerous myctophids and some large salps.

We spent most of the day running in for our landfall and to obtain positions. When we raised land we were off Cape Palmas and could soon pick out the lighthouse, red-topped buildings, and a large two-spired church, and a ship lying in the anchorage at Harper, a town of about 6000 people in Maryland County, Liberia. We then changed course to the westward, trying to find a shoal of 10-20 meters shown on the chart, on which we wished to trawl, but it could not be located if, indeed, it existed.

At 1330 we called the scientific crew on deck in front of the bridge and Dick Robins presented Master of Science diplomas to Bill Eschmeyer and Will Davis who would have gotten their degrees today at the university. I drew up the wording and Ted did a magnificient job of lettering in Old English. Capt. Rogers, Dick Robins, Ted Bayer, and I signed the top line and Lipke Holthuis, Tony Provenzano and Ray Manning on the bottom. It made a distinctive scroll, and Ted took pictures of the occasion.

Sta. P-68. Shortly after, at 1357, we shot the otter trawl in 70 meters. It was on deck at 1441 with broken shell containing numerous small crustaceans, *Pecten jacobaeus* (our first live scallops), soles, gobies, stargazers, saurids, and a scorpion fish.

Sta. P-69. I then had the second mate bring the ship in to 27 meters just two or three kilometers off the beach, and we shot the try net again at 1550. The bottom was so rough that we only left it down 10 minutes for fear of loosing the doors and the net. The catch was small but indicated coral rock bottom with gorgonids and Antipatharia. A small blue-and-orange nudibranch was also taken.

Sta. P-70. There was some discussion about whether to continue trawling on such rough bottom and risk loosing our last set of try net doors. I decided, however, to go ahead and we shot it again at 1605. This time when it came aboard the net was full of branched foraminiferans among which were about six *Alloteuthis africanus,* two *Lolliguncula* possibly new, and a few crustaceans and sardines.

We then decided to run westward of the shelf for a trawl with the Blake on the slope a distance of about 64 kilometers. When I came on deck at 2000, the sky was clear and the stars were low and bright. I gave the captain our departure times from Monrovia, as requested, and learned that we probably would not shoot a net during our watch as we had a head current and were only making nine knots. I spent considerable time making a supply of plastic bags for preservation and had a good bull session with the watch below.

June 4th, Thursday

Sta. P-71. Ted finally set the Blake at 0155 in 997 meters of water with a 3:1 ratio. The ship was hove to and the net lowered away perpendicularly with 150 pounds of lead on the cod end as before. At 0255 it was down with 2800 meters of wire out and the ship was brought bow to the shelf and commenced towing with one engine slow ahead. As the slope shoaled, the warp was shortened to maintain the proper wire ratio as planned.

Dick commenced hauling at 0555 with 1760 meters of wire out. When the net was off the bottom they stopped the winch to talk over how best to bring it up. I had written down on the night orders that the ship was to be stopped and the wire brought in perpendicularly in order to prevent turning of the wire but Dick decided that if they did this they might loose some of the fish so he kept the ship ahead on one engine. The net broke water loaded but just as the frame came up the cable parted between the hauling engine and the storage drum due to a twist in the wire and the net sank slowly back into the depths! The net was close enough to be touched and its slow disappearance after so much effort was frustrating.

Sta. P-73. At 0845 we set the 40-foot trawl in 360 meters with 1800 meters of wire out. We towed for one hour and I set it on deck at 1100. The cod end was loaded and we had to give two hauls with the boom to get it aboard. Most of the catch consisted of *Nematocarcinus* and *Plesionika* but other crustaceans were *Heterocarpus, Metapenaeus, Bathynectes,* and two other species of *Plesionika.* Squids consisted of *Illex, Sepia,* and a *Sepiola,* and an octopod, *Benthoctopus.* Most of the fishes were green-eyes *(Chlorophthalmus)* but there were also numbers of the pelican flounder *(Chascanopsetta)* and assorted small fishes.

FIGURE 8. Drs. Holthuis and Robins sorting a large catch of *Nematocarcinus* and fishes, mostly chlorophthalmids and grenadiers.

Sta. P-74. We then headed west into 730 meters and shot the net again at 1242 with 3600 meters of wire out. While we were trawling the plankton net was put over and was soon filled with inch long salps which covered the ocean as far as we could see. About 1400 a school of blackfish passed at a little distance, setting off a great controversy as to what they were. The sky was still cloudy and threatening but the sun was out and the sea had run down considerably. In this haul we caught a good quantity of fishes: *Halosaurus, Synaphobranchus, Uroconger,* macrurids, searsiids, alepocephalids, *Torpedo, Raja, Bathypterois,* brotulids, *Argyropelecus, Gonostoma, Yarrella* and numerous crustaceans.

Sta. P-76. At 1945 we shot the net in 1460 meters with 7200 meters of wire. During towing the tensiometer reading increased from 3500 to 4800 pounds. We began hauling at 2335 and set the net on deck one hour and a half later. This was a very good tow with many specimens of the large solitary coral *Flabellum*, gelatinous holothurians, *Rhinochimaera, Antimora, Gonostoma, Diretmus, Synaphobranchus, Alepocephalus, Bathysaurus*, deepwater brotulids, *Plesiopenaeus, Glyphocrangon, Notostomus, Acanthephyra* and *Sergestes* among many others.

Stas. 77-81. We now had completed almost all of our trawl stations and at 0854 we heaved to in 1870 meters and dropped the 0.1 m^2 Smith-McIntyre grab, intending to make a transect inshore. However, although the grab hit bottom and there was a bird's cage in the cable just above it, the grab failed to trigger. We then went into 1790 meters and tried again, after closely examining the grab for any flaws. Again it failed to trigger. Again we worked on it and then set it in 1445 meters. Again it failed to work. Thinking that shallower water and less wire angle might be the answer, we took it in to 689 meters and lowered away. This time it failed to hit bottom and we dropped it again. This even bent the trigger plate without tripping the grab. I gave up the grab as a total loss and ran in to 149 meters for our last 40-foot hauls.

Sta. P-82. This haul, out at 1505 and in at 1635, was a surprise to all for in the bag were eight huge groupers, *Epinephelus aeneus*, weighing about 50-75 pounds each. There was also a large catch of *Ariomma ledanoisi, Synodus, Antigonia, Peristedion, Anthias, Scorpaena, Macropodia* and *Echinus*.

Sta. P-83. At 1800 we again set the trawl in 220 meters and had it on deck at 1940. It contained one large *Epinephelus aeneus, Solenocera*, pagurids, and *Macropipus*.

This ended our series of trawls. We ran into 55 meters, which we found at 2230, and heaved to for nightlighting. No fish or squid appeared, even under the 1000-watt light, so we secured at 2330 and headed for Monrovia. I now broke watches, turned everyone in for a good 0800 start at cleaning up the ship.

June 6th, Friday

At 0800 we opened number one hatch and stowed all our heavy gear, all nets, grab, Blake frames, etc. in the 'tween decks. We then cleaned out the wet lab of all our gear and started on the dry lab. In one hour and a half we had the dry lab clean, all our collections stowed for sea, and the place looking 100 per cent better than when it was turned over to us.

We rounded the cape at Monrovia at 1030 and had to lay in the anchorage to wait for the pilot, a Britisher, who took us in about 1130. Monrovia has a small port, protected by two curving breakwaters. It is dominated by the high hill or cape surmounted by the Ducal Palace Hotel, a modern hotel financed by money from Tel Aviv. The port is small and only about 10 minutes by taxi from downtown Monrovia.

Here the 1964 cruise ended. From Monrovia the expedition members dispersed over North Africa and Europe. The writer, Ted Bayer, Lipke Holthuis and Dick Robins with several of the graduate students went on to Dakar to visit the marine station at Gorée. From here all of the personnel went to Europe, some joining other members who had departed directly from Monrovia, and visited various research institutes in France and Great Britain. The writer and Ted Bayer returned directly to the Institute of Marine Science at Miami.

Second Gulf of Guinea Cruise
May 1965

May 7th, Friday

Nancy took me to the airport at 1300 to meet the rest of the Miami group: Ted Bayer, Dick Young, John Walsh, Gary Hendrix, Ken Ebbs, Jon Staiger, and Bill Eschmeyer. We checked in for Eastern flight 12 and all was going well when it was suddenly announced at 1355, five minutes before scheduled take off, that the flight had been cancelled. The Eastern agent quickly shifted us to another flight on National scheduled to leave at

Figure 9. Scientific party, 1965. Left to right: Eschmeyer, Voss, Robins, Walsh, Young, Devany, Staiger, Bayer, Holthuis, Roper, Hendrix, Ebbs, Sisson, Manning.

1415 but this flight did not take off for another ten minutes. When we were over Norfolk, Virginia, the pilot announced that the airport at New York was closed in and that we would be about half an hour late. Things began to look bad, since this would give us only 30 minutes between flights. However we landed a little earlier than expected, and were on the ground at 1815. A limousine was waiting for us to take us to PanAm, where efficiency came to the fore and we were all checked through the formalities in about 15 minutes.

The rest of the scientific party was waiting for us: Dick Robins, Tom Devany and Clyde Roper. Jim Böhlke had come down from MCZ with Robins, and Ingrid Roper with her mother and aunt had come to see Clyde off. The only member of our party missing was Lipke Holthuis who would join us in Lagos on Sunday, arriving direct from Leiden.

Just as we were to board PanAm flight 150 I asked one of the passenger agents if our baggage had been put aboard and was told that it had. Intuition and previous experience made me very doubtful, but there was no way to check so we boarded and were soon on our way. The flight was uneventful except for the gossiping which went on most of the night.

May 8th, Saturday

We landed at Dakar just at dawn and went into the lounge for complimentary refreshments and to stretch our legs. It was quite cold, about 62°F, and a topcoat would have been welcome. Those who had not made the previous trip were suitably impressed by the giant baobab trees around the airport which made them realize that they were really in Africa.

Most of the transatlantic passengers got off at Dakar and the trip on down to Lagos via Monrovia and Accra was without incident, except that due to the time changes and intermediate stops we were served about four breakfasts enroute. We touched down at Lagos exactly at 1415, the scheduled arrival time, a rather phenomenal feat considering the number of hours and miles flown.

We were met at the airport by Mr. Abib Aofiyebi of UMARCO, our agent, whom I knew from our previous visit and we went through immigration and customs quickly only to find that our baggage had not arrived except for that belonging to those who had joined us in New York. A cable from PanAm stated that it would be sent through for arrival on the Wednesday plane. I immediately sent a cable requesting that they be sent as quickly as possible by way of London since they contained all of our clothes, the ship's mail and considerable papers and necessary equipment.

The PILLSBURY, looking rusty and travel worn, was lying at the marina docks as before. The crew was disappointed that the mail which was in our baggage did not arrive with us. The ship was in considerable confusion. The 42,000-foot reel of new cable was still on the starboard deck as the wooden sides of the reel had collapsed, making it impossible to reel the wire onto the winch drum. Several natives, headed by a welder called "the Swede," were busily welding steel plates onto the sides of the reel and bolting them through to give the necessary support to the reel axle. One AC generator was out of commission and was being hoisted on deck, to be repaired in Lagos while we are at sea. To top it off, the ship's linen had not come back from the laundry and the bunks were all stripped down to the bare mattresses! After a short gam with the ship's crew we had dinner, which is never very substantial in port, and went up to the Domo Hotel to lift a few Carlsbergs. In a few minutes spirits were never better.

May 9th, Sunday

This morning I turned the scientific party to, breaking out the gear for our leg of the cruise. We set up the dry lab and got our large gear, trawls, dredges, etc. ready to be hoisted on deck as soon as the reel is cleared away. The spare parts for the main engine clutches, new field and interpole coils for the winch motor which I had brought with me, and refrigerator and stove parts were cleared out of the wet lab on deck, and then the scientific party was given the rest of the day off.

Collecting stations started immediately. Robins, Manning, Roper, Young and Staiger took the ship's launch to make a collecting trip at the harbor breakwaters, using Pronoxfish. Station P-223, the first of this trip, consisted largely of small fish, mainly *Blennius cristatus, Eucinostomus melanopterus, Sardinella* sp., *Lichia* and two flatfishes. Later, with Hendrix replacing Staiger and at the opposite side of the breakwater (Sta. P-224) a new species of Callionymidae was taken along with *Trachinotus, Lichia,* grapsoid crabs, *Hippa cubensis, Albunea pareti* and *Ocypode cursor, Olivella* and *Terebra.* Stations were also made with dip net and night light alongside the pier during the evening (Sta. P-225).

Frank Williams and his charming wife invited us to their home for the evening. Voss, Manning, Robins, Bayer, Holthuis and Sisson were in the party. Dr. Raitt and his most interesting wife were also present. I had met him before at the ICES meeting in Madrid where, according to him, our conversation consisted of my asking him "Where the hell can I get a bottle of cold beer?"

Frank had gotten Dick and me each a beautiful moonstone necklace for 30 shillings apiece. These are particularly good items in Lagos, supposedly coming from the Tchad. We had a very enjoyable evening accompanied by champagne (it was Frank's birthday) and gin-and-tonics, of which he had laid in a goodly supply remembering our last year's preferences. A very enjoyable time was had by all.

May 10th, Monday

The bos'n had worked all night running on the new reel of cable and the decks were reasonably clear when I came on deck so that the hatch was opened over the dry lab and we hoisted out the deck gear and stowed it against the wet lab. The day was rainy but hearts were gladdened when UMARCO's driver came and said that our baggage was at the airport and had already been cleared by Pan Am but that they needed our claim checks. I asked Eschmeyer and Staiger to go with the driver. It had been deuced awkward and sticky wearing our travel clothes and having to wash every stitch each night and go to bed hoping that they would be dry in the morning. I blessed drip-dries!

In the afternoon Dick, Ted and I went to town to make some last minute purchases and returned to send letters home. We sail tomorrow morning, only 24 hours late, which is very good for a stay in Lagos. This evening I purchased a few curios, always an interesting event because of the long and involved haggling and bargaining with the native hawkers who begin every sale by asking five times too much. I picked up an apparently old juju mask and another with a python carved on the forehead, which are quite different from the flat, highly polished ebony masks now made on a production-line basis for the tourist trade. The hawker wanted £4/-/- for the two but finally accepted £1/-/- and two packs of cigarettes. I also bought a small carved head of a woman for £1/-/- and a matched man and woman for which he was asking £4/10/- but took £1/-/- and 5 packs of cigarettes. Sisson bought two hand spears at the Ikoye Hotel, where I must visit when we return. Back to the Domo for more Carlsberg, helping to support oceanography. Sisson and Robins bargained all evening for two tanned python skins, which they finally purchased for £1/5.

May 11th, Tuesday

The pilot came aboard at 0845, and we dropped him at the bar at 0915. At 0940 we rolled the empty cable drum overboard and rigged our 40-foot trawl. We made our first station (Sta. 230) at 6°11′N, 3°36′E in 102 meters at 1137 with 450 m.w.o. and fished it on bottom for half an hour. The tensiometer showed only 900 pounds but when the net came on deck at 1235 the footrope was parted, the chain partly torn loose and the catch consisted, as a result, of only a small number of rock dwelling animals: *Eunicella, Ellisella, Muriceides, Dendrophyllia* (mostly white but a few branches pink); *Distorsio, Bursa, Pteria* on gorgonian, a squid *Illex;* eel leptocephali, the bigeye, *Priacanthus arenatus* and the porgy *Dentex* sp.; crabs *Pisa* and *Macropodia,* and a hermit crab.

I hung the net back on the spliced footrope with double hanging twine and Eschmeyer rehung the tickler chain.

I also set the watches today. They are:

8-12—Robins, Roper, Walsh, Holthuis.

12-4—Manning, Eschmeyer, Hendrix, Devany.

4-8—Bayer, Staiger, Ebbs, Young.

I spent most of the day in the cabin working up trawling data for the operation of the 40-foot otter trawl based on my last year's log, and the

10-foot Blake trawl. This gives us data on which to base our pay-out and pick-up rates and cable ratios. Data were posted in the scientific navigation room for the use of the scientific watch officers.

Shortly after this station was completed and while running to the next the PDR broke down. This caused some considerable consternation among the junior staff who thought that we couldn't sound without it. I reminded them that although we had no cannonballs we had lead weights and a high speed hydro winch.

As the charted depths along this coast are largely unreliable in deep-water, when we reached our calculated position I had the ship heaved to for a sounding. We put a 200-pound weight on the hydro cable and determined the depth to be about 1400 meters by watching for the change of tension on contact with bottom.

We then shackled on the 10-foot IKMT and set it (Sta. P-231) at 1705 for fishing at 750 meters with 2250 m.w.o. We trawled at depth for 1 hour and set it on deck again at 1921. It had actually been fishing, according to the Benthos, at slightly less than 600 meters, with 350 r.p.m. on both engines. This is rather startling after our usually exact 3:1 ratio experienced on the last cruise, but may have been due to the Benthos hanging in a crossed position. The catch consisted of the octopod *Japetella,* shrimps, *Gnathophausia, Systellaspis, Acanthephyra, Notostomus, Pseudoscopelus,* etc., a large number of lantern fishes, and a live *Chiasmodon* which bit Robins, probably a unique experience in ichthyological circles.

The condition of the material, badly damaged, caused some long discussions as to the design of the nets. Ours is based on the N.I.O. nets used by the DISCOVERY, which brings in material in excellent condition. Roper and Young contrasted our catch with the excellent condition of the material from the Scripps-designed nets used on the ELTANIN in the Antarctic and the VELERO off California. I doubted if this was due to the nets but rather to the sharp change in temperature in the tropics where, in this part of the Gulf of Guinea, the surface temperatures are about 28-31°C, above the thermocline lying at a depth of about 55 meters. The specimens came from a temperature of about 10°C, were pulled for some time through a layer about 100 meters thick at about 16-18°C, and then for 50 meters through water at about 25°C. These soft bodied animals break down quickly after death and Robins, Bayer and I believe that this rather than the net is the reason for their poor condition. No great changes are found between deep water and the surface off California, and in the Antarctic the temperature change is very slight.

We secured from this station, put on the 40-foot otter trawl and ran east to 101 meters, which we found with the ship's fathometer, and shot the trawl at 2145 (Sta. P-232) with 500-575 meters of wire out to adjust for a deepening bottom. While being shot the inboard door hit the starboard screw but caused no damage to the ship and minor damage to the door. On this haul we again noted a low tensiometer reading, only 1000-1500 pounds. On bringing the net aboard it contained a small but good catch of shrimps *(Parapenaeus, Solenocera, Processa, Alpheus),* crabs *(Pseudomyra),* two magnificent sea pens, a few gastropods, and the following fishes: lantern fishes, *Epinephelus, Brotula, Lepidotrigla cadmani, Chirolophius kempi, Trichiurus lepturus,* congrids, *Uranoscopus* (common), *Eucitharus linguatula, Pentheroscion mbizi, Bembrops, Gobius,* etc.

May 12, Wednesday

Station P-233. The Blake trawl was shot by Manning at 0206 in an estimated depth of 1100 meters. A 175-pound weight was shackled onto the cod end and the net was lowered vertically until 0305 when one engine was put ahead. At 0537 the net was estimated to be fishing with 7500 meters of wire out. At 0730 Bayer commenced hauling in. The tensiometer is not functioning and shows a steady 900 pounds, which is going to give us trouble on estimating time of contact with the bottom and build-up of the strain as the net fills. This time, the net was mudded and swung the ship around so that it probably did not fish for any distance. This is presumably due to much shoaler depth than was estimated. De Jony is still trying to repair the PDR.

During the hauling in, several very large schools of small tunas were visible as far as the eye could see. The species could not be determined but they appeared to run about 8-10 pounds and were continually breaking water. A few terns were seen at a considerable distance, working over the food remains. Robins has determined to keep record of all seabirds seen.

The net came on deck at 1055. The catch was small but good: crustaceans *(Polycheles typhlops, Stereomastus, Glyphocrangon),* tube worms, two giant *Dentalium, Phormosoma* the pancake sea urchin, a number of starfish, two large violet-colored holothurians, several fishes including a macrurid and other odd items. Just as the net came up De Jony got a blip from the PDR and found that the depth was actually 1,463 meters. With 7500 meters of wire it is no wonder that the net mudded. The wire was charged and spun somewhat when the strain was taken off the swivel. A 250-pound weight was put on, the wire streamed underway to 7500 meters and retrieved. This will be standard procedure for deep tows.

While this station was going on, dip net stations P-234 and 235 were made for squid, *Ommastrephes pteropus,* and Bob Sisson put them in his tank. He was able to watch mating. Both specimens died after copulation. Sexes were checked and loose spermatophores collected from the bottom of the tank. This is the first time, to my knowledge, that oceanic squids have been observed to copulate.

Because of the overcast, only one sun line had been taken. Navigation on this coast is always a problem because of the prevailing overcast in these latitudes, the low coast line that cannot be picked up on radar beyond about 18 kilometers, and the uncertainty of current velocity in the Guinea Current. The bridge reported that we were 121 kilometers from the edge of the shelf but by my calculations we were only 65 kilometers from the 183 meter curve. At 1815 we came onto soundings in 210 meters.

Sta. P-236. The 40-foot trawl was shot at 1828 in 155 meters with 750 meters of wire out. As the depth decreased continually to 101 meters the wire correspondingly was shortened to 590 meters. The net was on bottom for half an hour. When on deck at 1930 it had a good catch of mixed bottom animals but the net was torn from the foot rope to the lazy line rings. The mouth of the net was loaded with gorgonians, light yellow *Paramuricea*, large grey *Paramuricea*, pinkish brown *Eunicella*, white *Eunicella*, and yellow *Leptogorgia;* very many spiral Antipatharia, white *Dendrophyllia ramea*, a few small colonies of *Balanophyllia* with black flesh, small fragments of *Madracis*, and abundant basket stars of two or three species. Cephalopods were represented by *Illex coindetii, Todaropsis eblanae, Sepia berthelotii, Eledone carparti*, and *Sepia officinalis*. The fish were too numerous to mention but all were recorded by Robins in his notes and counts were made of those discarded. Since the bottom fishes from the first year's trip had been identified, most of those collected this year could be identified on sight.

As the 40-foot trawl was torn up and the PDR was still not working properly we decided to change to the 10-foot try net which is a real work horse despite its small size. The sea, which had been rising in the late afternoon, dropped down to a very low swell from the SSE and the wind lay entirely.

Sta. P-237. At 2105 Robins shot the try net in 101 meters with 590 m.w.o. which was maintained during the tow. Bob Sisson is now photographing the cuttlefish which adapted to tank life quickly. It is an amusing animal to watch as its head is so strongly reminiscent of an elephant. Bob was calling it Bertha until I noted her hectocotylized arm and told him that he should change her name to Bert as "she" was a "he." The *Eledone* was also in good condition and was photographed by Clyde, and then pickled. The try net came up at 2215. Fish were numerous: *Arnoglossus imperialis, Symphurus, Gobius koumansi, Scorpaena normani, Uranoscopus albesca, Chirolophius kempi, Lepidotrigla cadmani, Cynoglossus canariensis, Bembrops, Saurida brasiliensis;* and various invertebrates.

While the AC generator was out of service from 2340 to 2400, a night-light station was run (Sta. P-238). During this, a small school of about six *Alloteuthis africana*, a slender squid with a very long tail in the males, came by and a female was caught and put in the small aquarium.

May 13th, Thursday

Some days are just better skipped over than endured. This is one of them but it slipped up gradually so that we were deeply involved before we knew it. It started out well.

Sta. P-239 at 4°56′N, 5°00′E. Manning put over the try net at 0033 in 73 meters with 433 m.w.o., after the AC generator was put back into commission. The net was on deck at 0127. The set originally started at 2400 but was delayed by the generator breakdown. The catch consisted of cephalopods *(Sepia bertheloti)*; fishes *(Scorpaena normani, Dentex, Lepidotrigla cadmani* 2 species of blennies, a small eel, *Pentheroscion mbizi,* antherids, *Symphosus, Gobius koumansi, Bembrops),* and Crustacea (2 large *Penaeus, Pontocaris, Plesionika martia, Parapenaeus longirostris, Pseudomyra mbizi, Atlantotlos, Scyllarus posteli,* and *Sicyonia galeata).*

At 0305 Manning set the net again in 37 meters with 216 m.w.o. (Sta. P-240). The net was back on deck at 0345 with a good catch. Cephalopods were *Eledone caparti* and *Sepiella ornata;* Fishes included: scaenids, a brotulid, tongue soles and flatfishes, *Bembrops, Gempyla, Vomer, Raya,* polynimids, antennariids, blennies, and clupeids; among the Crustacea were: *Penaeus, Parapenaeus longirostris, Scyllarus* spp., and *Sicyonia galeata.*

Station P-241. Manning again set the try net at 0503 in 55 meters with 325 m.w.o. and trawled for half an hour. At 0542 the wire parted between the storage reel and the hauling engine. Luckily the wire did not run free but bound onto the traction sheaves. The bos'n stopped it off and put in a splice as it lay.

In the meantime, the AC generator failed again. This generator operates the metering device on the winch, and the lights and air conditioning in the dry lab below decks, the automatic steering and the water cooler! This was repaired about 0740 and the net was back on board at 0805 with an excellent catch. Two species of commercial shrimp were taken: 6 pounds of *Penaeus duorarum* (12 count, heads on) and 1½ pounds of *Parapenaeus longirostris* (104 count, heads on). This is well above try-net catches in the industry. Among cephalopods were *Alloteuthis africana* and *Sepia bertheloti;* numerous small crustaceans, gastropods, shrimp, etc. were also in the haul.

Night lighting was also carried out (Sta. P-242) while this haul was being made.

Station P-243. After securing from this station the 40-foot trawl was shot at 0940. I stayed on the wing of the bridge to advise Capt. Smith concerning the use of the large trawl, as we had already had the inner board hit once by the ship's screw. We shot it in 70 meters and ran 360 m.w.o. During the set the port door did not fish properly but finally dived and appeared to be working fairly well but not diving sufficiently. We towed with both engines at 350 r.p.m. When the net came up at 1035 it was empty and no indication that it had been on the bottom.

Station P-244. We immediately shot the net again having taken up one link on the forward lower chain in order to improve diving characteristics. As we were lowering away, the meter-counter went out due to the failure of the AC generator. The net was pulled in until the shackle broke water and held, but the automatic pilot failed and the steering engine would not cut back in for manual steering so two men at the wheel could not control the ship. At this I had the doors two-blocked and found that when we slowed down the port door had flipped over putting a twist in the wing of the net. We hauled the net aboard, unshackled the wings to straighten them out, changed the lazy line and took up one link on the forward lower chain of the port door.

We are now sitting in the middle of a slick sea in a strong tropical sun rolling under a long gentle swell waiting for a new shaft to be installed on the AC generator water pump. Jimmy Dunlap, the chief engineer, told me that it would be at least two hours. In the meantime the aerators are off in Bob Sisson's aquaria and water must be changed with a bucket. So goes life on the PILLSBURY.

Station P-245. At 1300 Jimmy got the AC generator back into operation and we immediately shot the 40-foot trawl in 64 meters of water with 315 m.w.o., which was increased to 540 meters as the depth increased to 119 meters. During the tow we finally received good news. Andy De Jony reported the PDR back in operation. The EDO is out but he rewired through the Thomas Gifft instrument and the whole equipment is now working beautifully on the starboard transducer.

Suddenly at 1551 both of the ship's main engines stopped. The net was immediately brought on deck. It contained a large haul of fishes and a few invertebrates. Numerous cephalopods: *Eledone caparti, Sepia berthelotii, Illex coindeti, Todaropsis eblanae, Alloteuthis africana;* Crustacea: *Parapenaeus, Pseudomyra, Pontocaris, Solenocera.* Fishes not recorded.

Things began to look up. The engines had been started, the ship forged ahead, the lights were on, and the PDR working.

Station P-246. Another 40-foot trawl station was made in 37 meters at 1946 with 180 meters of wire. When it came on deck at 2055 it had an excellent catch of fishes but few invertebrates, mostly squids: a dozen *Alloteuthis africana,* several *Sepiella ornata* and *Illex coindeti.* The fishes were mostly porgies. The 40-foot trawl makes clean catches but mostly fishes and needs to be readjusted in order to work bottom closer. We also obtained one pound of the shrimp *Penaeus kerathurus* which is beautifully cross-banded with maroon and is common in the Mediterranean. They were 12 count.

A night-light station (P-247) was made before getting underway but only a few flyingfishes were taken.

The evening turned out beautifully with a gentle swell, light breeze and bright skies. The Southern Cross was over our bows and the Big Dipper low over the stern.

Station P-248. At 2212 Robins shot the try net in 33 meters with a 6:1 wire ratio and towed it for one hour. It was on deck at 2310 with a small catch of fishes, a large number of crustacea, a *Sepiella ornata* and several *Alloteuthis.* I turned in at midnight after arranging for alternating try net tows and runs to the eastward.

May 14th, Friday

Sta. P-250. Manning shot the try net again at 0209 in 24 meters and brought it on deck at 0246. The net had a typically brackish water or estuarine fauna due to our proximity to the mouths of the Niger, or Kwara, which strongly influence this section of the coast. Our first squids of the genus *Lolliguncula* were taken in this tow.

Sta. P-251. Bayer set the net again at 0435 in 27 meters with 125 meters of wire and brought it back on deck at 0522. The catch was routine and nothing special was recorded. Porpoises were sighted alongside the ship for the second time on this cruise.

Sta. P-252. I came on deck at 0700 just as the try net was coming up from 31 meters. It had a good catch, a few ariid catfish, *Pseudotolithus, Larimus, Ilisha, Drepane, Galeoides, Alectis, Vomer setapinnis,* the squid *Lolliguncula* and 10 pounds of *Penaeus duorarum* and *P. kerathurus* (14 count heads on). The net was filled with jellyfish 2 inches in diameter which we had not seen before.

Sta. P-253. Robins set the net again at 0832 in 33 meters and brought it on deck at 0910. It had a poor catch of fishes, almost all of which were *Brachydeuterus auritus,* and a few *Neanthias accraensis* and *Upeneus prayensis; Lolliguncula mercatoris* and diverse mollusks including small *Xenophora, Cardium,* turrids, *Murex, Typhis tetrapterus* and *Marginella clerii.*

After this tow we decided to run out to 274-366 meters and tow all day with the 40-foot trawl after which we will use the try net at night in shallow water, planning our arrival at Fernando Póo for daybreak tomorrow. A number of squalls were on the horizon and about 1100 they hit, cutting the visibility to about 200 yards. Numerous leaks appeared in the former dry lab. These must be sealed when the ship returns to the States.

Sta. P-254. Manning shot the trawl at 1318 in 181 meters with 765 meters of wire. It was on deck again at 1451 with a good but clean catch. Cephalopods were represented by *Eledone caparti, Sepia elegans, Illex coindeti, Todaropsis eblanae.* Crustacea: *Parapenaeus longirostris, Heterosquilla* n.sp., *Dardanus arrosor.* Pennatulids were numerous: *Funiculina quadrangularis, Virgularia* sp., *Pennatula* sp., *Pteroeides.* Among the fishes were: *Synagrops,* sciaenids, *Bembrops, Scorpaena normani,* apparently another scorpionfish that is a new species according to Eschmeyer, *Antigonia, Pterothrissus,* soles, *Priacanthus, Heterenchylya, Peristedion,* brotulids, and *Dentex.*

We have been calling Santa Isabel all afternoon to get a pilot for early tomorrow morning but it seems to be off the air. A Polish and a Dutch freighter were also calling.

Sta. P-255. We were then coming deep down into the Bight of Biafra, but we decided to work along the deeper part of the slope, which here is rather gradual and smooth. Bayer set the net again at 1733 in 289 meters and 1440 meters of wire. The weather has cleared and a fine night is in prospect. I remained on the bridge trying to get all of the officers checked out in proper trawling operations.

The net was set on deck with the crane at 1941 with a fine catch. Cephalopods are *Illex* and *Sepia elegans.* With an hour tow we caught 62 pounds (heads-on) of *Parapenaeus longirostris* of about 24 count, heads on. They were all headed except a small sample and delivered to the cook. Fishes were numerous and different: *Callionymus phaeton,* flat fishes, elasmobranchs, *Zenion hololepis, Cyttopsis roseus, Parasudis truculatus, Chlorophthalmus* sp., *Pterothrissus, Malacocephalus laevis, Peristedion, Synogrops bella, S. microlepis, Epigonus.* Included in this haul was over a gallon of a large *Munida,* perhaps a new species. This is one of the squat lobsters and, as langostino, should well support a fishery combined with shrimp.

Sta. P-256. Robins set the 40-footer again at 2145 with 384 meters with 2000 meters of wire. It was fished for an hour and set on deck at 2403, having fished from 384 to 482 meters. The catch was very good with a fauna typical of similar depths in Florida and the Gulf of Mexico. One *Benthoctopus* was taken along with numerous starfishes, worms, brittle-stars, sea urchins, anemones, fishes, etc. I stayed on deck to see the haul, secured further scientific work for the night in preparation for field work at Fernando Póo and turned in. The ship is now four and a half running hours from Santa Isabel.

May 15th, Saturday

I came on deck at 0700 to see the low north coast of Fernando Póo about one mile abeam, shrouded in heavy rain clouds which completely obscured any view of 10,187 foot Pico de Santa Isabel. In the outer anchorage with us are the Dutch and Polish freighters, both at anchor awaiting the pilot. The town was clearly visible, yellow and glistening, set deeply into the verdant green of the island on a slight bluff above the harbor. Two freighters are already at the pier and two Spanish gunboats lie moored stern first to the lower quay.

As we circled, the pilot boat went alongside the Dutchman who got underway for the port. About two hours later the pilot took us in to the quay between the two gunboats, one of which is the PIZARRO. Our first approach was delayed because the winch was frozen up, but when this was cleared we came astern on the chain and were moored at 1010. The health officer came on board about half an hour later, checked the ship's health certificate and left, telling us we could now all go ashore. Immigration and customs officials never appeared!

Bob Sisson, the captain and I set out immediately to hire a car to see the island and shoot pictures if the weather permitted. I mailed some letters at the post office, having no trouble using American dollars. At the Hotel Bahia on the north point overlooking the harbor, we hired a car for $11.00

FIGURE 10. The harbor of Sta. Isabel, Fernando Póo. PILLSBURY is moored alongside the farther corvette.

for five hours and set out to drive around the island. Our driver, a rather sulky Nigerian, took us over the fairly well paved road at a furious pace, seldom dropping below 60 k.p.h. even on wet curves, and on the straight away hitting 85 and 90 k.p.h., and swerving toward every pedestrian regardless of which side of the road the person was on. Vigorous blowing of the horn seemed to help. With trucks the procedure was to head directly for it on a collision course and then at the last moment to swerve, missing it by inches. It's the old chicken game! Vigorous sign language and *"No tan de prisa, por favor"* brought little attention until I told him in Spanish not to exceed 70 k.p.h.

The highway was bordered by giant ceiba trees, coconuts of great height, bananas, red *Clerodendron* bushes and great plantings of cocoa trees which form the mainstay of the country. The land is divided into great *fincas*, well kept, with the trees all thoroughly sprayed, apparently against fungus. There were a few roadside houses, nearly all very dirty and poorly constructed shacks with corrugated iron roofs.

Our immediate destination was Moka, apparently the highest part of the island accessible by car. The road leading to it branched off to the left just before the town of San Carlos, situated in the middle of the broad sweeping Bahia de San Carlos bordered by coconut trees and a black volcanic sand beach very reminiscent of some Pacific islands. We indicated to the driver that we should turn here. He objected, we insisted, and we took the road to Moka.

This route turned into a mountain road leading through a semi-rain forest. The grades grew steeper, the curves sharper, the road narrower and the vegetation denser, cutting out all visibility. Along this road we tore at 70 k.p.h. Bob, beside the driver, told him to slow down. The driver pointed to the speedometer and said that he was not exceeding 70 k.p.h.! We broadsided around a sharp curve, nearly sideswiped an oncoming car travelling at the same pace. "I don't give a damn, slow down" Bob demanded. Shrugging his shoulders the driver dropped to a heart warming 30 and we leisurely made our way on.

The road here was bordered by frequent large farms of *melanga,* a great broad leaved plant growing 6-8 feet high and resembling taro. Its tubers are used as potatoes. As we climbed the weather became very chilly and damp. At the peak the panoramic view was completely obscured by clouds so we told the driver to go on to Concepcion on the other side of the island, about 10 kilometers distant. Now he told us that the bridge was out, that we had to go back the way we came to San Carlos and go on around the end of the island. This would have taken too long so we went back to Santa Isabel, stopping at a restaurant for a lunch of *pan, queso* and *vino rojo*. The ride back was made at an ever slower pace as the driver stretched it out to the full five hours.

In Santa Isabel, Bob and I walked about the town looking for souvenirs and picture possibilities. There is little color about the very clean, nicely laid out city. It stands on a bluff several hundred feet high overlooking the inner harbor. The double spired cathedral towers over the city square decorated with collonades, screens and monuments all covered with colorful but rather crudely done Spanish tiles. The cathedral had a few small stained glass windows and a pretty but not elaborate altar.

The native *mercado* opened at 1600, before which the whole town was drowsy in a siesta that began about 1100. We walked leisurely through the narrow lanes between the stalls. It was interesting but offered little color. The material for sale was nearly all of Spanish manufacture and there were no native goods of any type for sale. The only things of possible native origin were some heavy crude earthenware pots. The adjoining

FIGURE 11. Site of shore station P-258 in the harbor of Sta. Isabel, Fernando Póo. Photograph by Dr. L. B. Holthuis.

fish market was large, interesting and odorous. Most of the fish were so heavily smoked on slender wooden spits that the meat was black. Some appeared to be billfish, others small tunas and mackerels. A few simply sundried filets were stacked up, and some small fresh fish were slowly shrivelling in the sun.

When we got back to the ship it was too late for dinner. The two shore parties had returned from their collecting (Stas. P-257 and 258). The material obtained was terrific, a number of new species, many new records and interesting finds. Ted says that the mollusks in the intertidal zones look similar to, and some identical with, those from similar habitats in the West Indian region.

Bob and I went back to the Hotel Bahia for dinner, but there we met an English couple and a friend who invited us and Mike, the ship's cook, over to their hotel for dinner. The dinner started in true Spanish style at about 2230, went through four bottles of wine, black *café solo,* cigars and brandy. At about 0230 we returned to show them the ship and arranged to meet again in Lagos, their home. I excused myself from the party about 0300 and went to bed.

May 16th, Sunday

Up and on deck at 0615 to find the pilot aboard and singled up on the stern lines. It was another overcast day but I took several pictures as we cleared the harbor. The scientists and ship's crew are all a little shaky from attending the *gran baile* the night before and a number did not appear for breakfast.

Sta. P-259. Since the crew is not exactly vigorous this morning I switched to the try net, which Robins set at 0900 in 60 meters with 400 meters of wire out. The half-hour tow was on deck at 0936 with a good catch of fish and invertebrates from soft bottom of mud and broken shell. One large heart urchin was broken but the parts were saved, numerous small sea urchins, brittle stars, *Luidia senegalensis;* parthenopid crabs, *Penaeus duorarum* in commercial quantities; *Sepiella, Sepia berthelotii, Eledone caparti;* mollusks *Venus chevreuxi* very common, *Pecten jacobaeus,* a striped *Natica,* a few *Philene aperta,* one *Gastropteron,* and turrids such as *Genota mitraeformis.* Dominant fish were *Saurida brasiliensis,* of which hundreds were discarded, *Eucitharus, Arnoglossus, Gobius, Serranus,* etc.

Sta. P-260. The next set was in 46 meters with 270 meters of wire. This was a poor tow, few invertebrates, no cephalopods, fishes uninteresting, mostly *Serranus heterurus, Arnoglossus imperialis, Platycephalus gruveli* and *Saurida brasiliensis.*

Since the catches were so repetitive we held a conference and decided to run out southwest to about 1,829 meters between the line of the islands and the coast and put over the IKMT to fish at 1000 meters. I gave the course and time to the bridge and we secured the gear. At about 1300 I was told that a pod of small spotted dolphins was playing around the bows. They are exceptionally small animals, spotted on the sides and sometimes on the back and, according to Robins, may be *Stenella.* They left shortly to be replaced by another pod. They swim erratically, with much jumping, crisscrossing back and forth over their fellows and behaving not at all like the usual species.

Sta. P-261. We now changed our course to 90° to the right as we found our heading of 208° was too close to the mainland to give us the desired depths. After an hour on 310° we resumed our former heading and shortly came onto 1829 meters and holding. Bayer shot the IKMT at 1802 for fishing at 1000 meters but when 2750 meters of wire were out he called to me on the bridge that a strand had parted. Calling the bos'n we went forward and found one strand dangling free just inboard of the head block on the A-frame. Dockstader, the A.B., heaved in until the part was between the traction drums and the storage drum and the bos'n went down to put in a cut splice. After some loud hammering, he soon came up all grins and said to lower away. It seems that the wire rope company only butted the wires and did not lock and tuck them on this strand in the long splice. The strand simply fell out of the lay!

During this tow after sundown, large numbers of myctophids were at the surface. The floodlights showed their lights plainly from the starboard wing of the bridge. The large lights are the tail lights of the males, smaller presumably the side lights. They darted about in the foam like fireflies, though immeasurably brighter.

On this tow I decided to let out faster and the cable was paid out at 100 m.p.m. Haul in was at 80 m.p.m. and the whole job ran much more smoothly and quickly. We fished for two hours and hoisted the net on deck at 2113. The tow was a good one but about half the material was rather severely damaged. One *Vampyroteuthis infernalis* was taken by Dick Young to remove the brain and specially preserve it for histological examination. A tiny seahorse similar to an unique specimen described by Isaac Ginsburg was photographed by Bob Sisson in the tank. Crustaceans and fishes were normal although there were two *Eurypharynx* or gulper eels.

Sta. P-262. We lay to for an hour with the night lights on. Several large schools of squid, *Ommastrephes pteropus,* came under the lights but we were unlucky and caught only one. It died of shock in less than a minute after capture: shot out a lot of ink, curled its fins downward, trembled and died. We also caught a male flyingfish *(Parexocoetus)* in breeding coloration.

At the end of the night lighting I turned in, completely exhausted from a short night's sleep and a long day. The wind and sea have laid but the cloud cover is heavy. Good radar fixes have been obtained by Ken Ebbs. He is rapidly turning into the ship's navigator.

Sta. P-263. Robins shot the IKMT at 2325, fishing it at 80 meters, and set it on deck at 0021. Fishing into the wind which had now sprung up gave a somewhat lower wire ratio, 2.4:1. The catch consisted of various fishes and invertebrates including a squid, *Abralia veranyi,* and a small mesopelagic shark, *Isistius,* which bit several holes the size of a half dollar through the canvas sleeve of the net.

Sta. P-264. Manning has been sick the past 24 hours, apparently with the same virus that downed Andy Jones. Eschmeyer took his watch and set the net at 0222 to fish at 350 meters. Just before haul-in, the AC generator stopped but was quickly restarted and the net was on deck at 0440. It had a good catch of crustaceans and fishes including scyrelarchids, apogonids, gonostomids, bericids, etc.

Sta. P-265. I came on deck at 0650 to find the IKMT in operation at a depth of 450 meters with 1500 meters of out. The day is overcast, with a light wind and sea from the southeast and a short swell. A goat sucker is flying about the ship trying to rest. We tried to catch it for Bud Owre at the University but did not succeed and we never did succeed in identifying it. The net was hauled in at 0743 with a fair catch of the usual hatchet fishes, myctophids, and *Opisthoproctus* (the flatiron fish), a few shrimp, etc.

After considering our progress and studying the bottom contours shown on the charts, I gave the order to run at full speed on our former course for three hours. We will then set the 40-foot trawl in a little over 1829 meters.

The rest of the day was one of those that first drives one to drink but then suddenly changes and ends perfectly. The trouble began at 1120 when we shot the 40-foot trawl in 2,441 meters. I decided to fish it according to Kullenberg's graph —2 knots with a 40° wire angle and 5000 m.w.o. We payed out at a rate of 80 m.p.m. with both engines at 400 r.p.m.'s. All went well until we had run out 2690 meters of wire when Dave, who was operating the winch, reported a frayed strand and stopped the winch. I went below to the winch room and found that a strand had parted past the traction drums so that trawl and wire were hanging by only two strands. We reduced power to one engine to slow the ship and heaved in until the wire break was between the traction drums and the storage drum. Then we stopped off the wire with two come-alongs on deck, and pulled the bight of the wire on deck to the rigging bench where the bos'n and Bob, the ordinary seaman, cut it and put in a double short splice, laying each end past the other as in an eye splice. The line was then run back on the storage drum, the stops taken off and paid on out. The operation took only two hours in all. The break occurred in the long splice between the three-eights and half-inch parts of the cable. The bos'n maintains that the break was caused by the excessive difference in diameter of wire joined by the splice, and that steps in the wire should never be greater than 1/16 inch.

Sta. P-266. We then continued paying out but at 1435, with 3226 meters out, a bad straightened kink in the half-inch wire appeared. The same splicing procedure had to be repeated this time taking less than an hour and a half. Again we payed out. When 5000 meters was reached we held for half an hour to see if contact with the bottom was made by a change in the tensiometer. It held steady at 1500 pounds! We then let out another 500 meters and still no indication on contact. By then we decided that the tensiometer was not working properly and paid out to 6500 meters and commenced trawling.

At this point I left the forecastle head to do some typing in my cabin when I heard over the intercom the words "hung up" and "Voss". I made record time to the winch. The ship had been stopped and swung around by the wire. I immediately took all way off the ship and started hauling in. There was a heavy strain so I had the mate put the rudder hard down to starboard and come ahead on the port engine. This swung us around and got the wire leading forward. I then had him hold on that heading for a couple of minutes and then again took the way off of her. This did the trick and we hauled in with no difficulty. By now it was certain that the tensiometer was completely useless since it showed a steady 1500 pounds even with the ship stopped by the cable!

We got the shackle up at 2120, and had the net on deck at 2132. The cod end was filled with icy cold mud, medium to small size rocks, pebbles and debris, including a crumpled British newspaper.

The catch was very good but had a number of midwater animals because of the nearly four hours of holding during the splicing. Among the crustaceans were a *Willemoesia*, a new species of *Notostomus*, *Polycheles*, *Plesiopenaeus*, *Eryoneicus*, numerous bivalves, anemones, a *Vampyroteuthis*, and a number of white-bodied slender fishes of the family Scopelarchidae which Dick Robins says are new to our cruises. So all the work was not in vain!

We now set our course for São Thomé, hoping to make some try net and dredge hauls in the vicinity of the island, and I secured the scientific watches until daybreak. While we had been hauling in on the trawl, two dipnet and plankton stations were made (Stas. P-267 and 268). A large number of squids, *O. pteropus*, had been dashing about during the station. We caught 6 for Bob Sisson to put in his large tank, and he took a number of pictures until suddenly the squids went berserk, shot ink all over the room and brought photography to a halt.

May 18th, Tuesday

I came on deck at 0700 to find the rugged profile of São Thomé shrouded in rain clouds close aboard, and between us and it the small islet called the Isla de Capras. I found that the hydro-winch was being used to take a sounding, and was told that the PDR was broken down. Just then Andy De Jony came by and said that the only trouble was that some stupid fellow had not turned up the gain, and that we were in 320 meters. Ted was on the hydro-winch deck and said he was crazy, because they had just had a definite sounding with the deepsea lead at 2200 meters.

When I checked with Andy in the PDR room, we found that in two minutes at slow ahead, we had passed over a peak which rose almost perpendicularly to within 320 meters of the surface from a general bottom depth of 2195 meters. Obviously, the bottom was exceedingly rough and offered no possibility of dredging or trawling, so regrettfully I asked the bridge to run 135°T for three hours to reach 2926 meters, where we will make a IKMT tow at 2000 meters. The ocean ahead is heavily blanketed in rain but, hopefully, we should run through this shortly.

The weather cleared somewhat and on reaching our position (Sta. P-269) at 1140 we set the IKMT with 6000 meters of wire to fish at 2000 meters. The net was down at 1305 just as we passed over the equator. We fished it for two hours. During the tow we had a tremendous school of little tunnys about the ship, jumping and swerving after some small bait fish right up to the side of the ship.

We set the net on deck at 1635 and found a good catch, including a gulper eel, a snipe eel, and the usual assortment of midwater fishes. There was also a good catch of cephalopods: *Vampyroteuthis, Liocranchia, Pyroteuthis, Chiroteuthis, Histioteuthis hoylei, Japetella,* and an unknown oegopsid mantle.

We now laid a course for Annobón, our farthest point on this cruise. About the same time the ship received the following message:

NEPTUNOGRAM NO. 1. DEEPSIX, ATLANTIC BRANCH CK42, 18 2300GMT MAY 1965 MASTER JEPILLSBURY VIA RADIO STA.SEA
NEPTUNUS REX SENDS STOP YOUR SHIP UNDER SURVEILLANCE STOP BEARS ARE FERRETING OUT POLLYWOGS AND WILL WREAK VENGEANCE IF ANY FOUND YOUR RETRANSIT OF MY REPEAT MY EQUATORIAL LINE AND DOMAIN.

DAVY JONES FOR IMSUMKING

16000KC/CW/SEA (NEPTUNE COMMS CO)
2305Z/LK/TOR
5/18/65

This caused consternation and faint hearts among the pollywogs.

Sta. P-270. At 2216 we set the IKMT for a shallow tow with 1200 meters of wire, fishing in 400-450 meters. We towed for one hour and set it on deck at 2357. The catch must have been quite ordinary as it was not entered on the running log, and I had turned in before it came on deck.

May 19th, Wednesday

When I came on deck at 0640, Annobón lay about three miles distant, her peaks shrouded in clouds. We came in on the north end at Punta de San Antonio. The village of shacks lay just above the high tide mark, with only a single line of trees and a row of canoes pulled up on the beach. On a low bluff behind the town is the Mission de San Antonio, a small hospital, and the government house, all surrounded and contrasted by the dense green of the mountain side.

At 0800 the captain, El Segundo (the second mate whose name is Frank Williams), and I took the ship's launch and went ashore to see the officials. When we arrived off the landing beach we found a heavy surf running. Just offshore there was a big red can bouy with a mooring ring, so we made fast. Presently, a canoe was dragged down to the beach, shot out through the surf and was paddled over to us by two negroes. They came alongside and said they would take us ashore, two at a time. The captain and I went ashore first. It was exciting in the little, very tippy dugout canoe but the men were experts and shot us onto the beach where we stepped out in a few inches of water. We were met by a well dressed negro who enquired of us in good Spanish our business and escorted us to two nattily attired Spanish lieutenants dressed in shorts, and attended by several native Guardia Civil in their khaki uniforms. I explained who we were, what we wanted to do, and showed our papers from Fernando Póo. After a short discussion the senior officer told us we could go any-

FIGURE 12. The island of Annobón.

where we pleased, do whatever we wished and make ourselves at home. He then invited us up to his official quarters where we each had a bottle of beer, some canapés of squid, octopus, and anchovies, and chatted for a few minutes.

The shore collecting party was waiting to go to work, so we went back to the beach, engaged the official canoe, La Pachanga, a dugout about thirty feet long, and its five paddlers, and towed it out to the ship with the whaler. Dick Robins took the whaler over to the small Isleta la Tortuga, where he found that the shore dropped precipitously and could not be approached with safety. Instead, they found a very small sand beach on Annobón where they anchored and ran a poison station between Punta Yoyo and Punta Pedrinton near San Juan Chapel (Sta. P-271). They obtained an excellent collection of fishes and invertebrates, much resembling the fauna in the Florida Keys.

Our party took the canoe and landed on a cobble beach, which was steep-to, with large, flat cobbles which were thrown about by the surf with great rumbling. While beaching, the canoe almost swamped and had to pull back offshore to bail out before debarking the remaining passengers. We found it impossible to work the area, so we clambered over some rocks, crawled through a cave to a narrow but deep basin where the canoe was able to pick us up in relative safety.

After lunch, we all went ashore in several trips to visit Ambo, the main town, and spent the afternoon sightseeing, beach collecting and fishing. The surf rose greatly while we were ashore and we got some spectacular pictures of canoes landing through it. While we were on the

FIGURE 13. Shore party landing at the village of Ambo, Annobón.

island, part of the crew went hook-and-line fishing (Sta. P-272) just outside the anchorage, catching mainly blue runners. Someone who went diving brought up a bright blue *Linckia* from the bottom. Robins (Sta. P-273) ran another poison station on the shore opposite the rocky islet called La Piramide, again with good results. We strolled about the native village for some time and watched the little black boys playing in the surf on the beach, which they did for hours, scarcely coming out of the water the entire afternoon.

Annobón has no industry. We were the first ship that had visited the island in three months although a flying boat brings mail every 26 days. The people live in what looks like abject poverty, living off fish and cassava and growing limes and cocoa. The canoes are made of ceiba trees but because of the very soft wood last less than a year. Their paddles are very small and sharply pointed and seem by our standards somewhat ineffectual but apparently do the trick.

At 1630 we got back to the ship just in time to clean up before the senior lieutenant, the alcalde, and the government representative from Fernando Póo arrived for dinner. It was a poor dinner to set out and, of course, an atrocious hour for Spaniards who never eat before 9 or 10 o'clock. Afterwards we toured the ship, displayed some of our collections, and they departed. We gave each of the paddlers two cartons of cigarettes and $1.00, a very good day's salary.

In the evening all hands lined the rail, catching flyingfish by dipnets. Over a dozen were collected, and a medium-sized octopus was caught by hook and line.

May 20, Thursday

At 0700 Lipke Holthuis, Ted Bayer, Gary Hendrix and Dick Young went ashore in the launch to visit Crater Lake and collect fish and fresh water crayfish. At 0800 the Pillsbury got underway to make the first dredging station. I knew that this was going to be rough bottom but we began with a try net tow in 33 feet. It was set at 0825 (Sta. P-275 covers all shallow hauls in this area) and hauled at 0831, after we felt a number of sharp jerks on the cable. The net was completely torn up!

We then shackled on the dredge and flung it over in 42 meters. We towed it for 15 minutes, setting it on deck at 0902. It was completely filled with rubble, mainly concretions of *Lithothamnion* or a similar coralline alga, the hollow centers of which had a large population of various invertebrates and fishes hidden in them. With the diligent use of chipping hammers and looking like a bunch of rock hounds we got a very interesting and large collection. Some few larger animals were found loose among the rubble and sand. Species caught were *Scorpaenodes, Paranthias, Uropterygius, Serranus, Gobius,* etc. The invertebrates were numerous, including stomatopods, crabs, shrimp, brittlestars, starfish, cones, conchs, spiny oysters, and many others.

FIGURE 14. A large haul of spheroidal calcareous algae, Annobón.

We next went to 15 meters and towed for 10 minutes, bringing up about the same type of material. It was extremely difficult to hold to one depth, as the contours are irregular and change direction suddenly. Donguy's chart is useful but only as a general guide, but the H.O. chart is useless.

The dredge was then used about 7 minutes in 55-70 meters on very rough bottom of bare rock. It brought the ship up short at the last and when it came on deck it was badly bent and contained only a cone shell, two different alcyonarians and some raninids.

At noon two native canoes came alongside and traded their fish catch for cigarettes and loaves of bread. The fish consisted of conies, scorpaenids, *Balistes, Myripristis, Cephalopholis fulva,* and several others. They were also fishing by hanging bait over the side of the canoe several feet down and spearing larger fish as they rose to take it. The occupant of one boat looked like the old man of the sea and I took several pictures.

The last dredge tow was in 348-640 meters on a precipitous slope in which we got very little; a *Plesionika* and one galatheid; no fish. The dredge was filled with dead coral rubble and soft gray ooze.

The dredge was again set at 1359 in 64 meters on the rough bottom and lost at the first jerk of the cable.

Sta. P-278. The Crater Lake party returned at 1330 with a good collection of small fishes, *Macrobrachium* (the same species that Lipke Holthuis described from Fernando Póo) and several species of *Atya*. They reported the lake set in beautiful scenery but a hard climb! Two kinds of fishes were brought back from the lake one of which was *Gambusia affinis,* an introduction from the southern United States.

We tried without success to find trawlable bottom following the contours and then ran a transect due north of the Mission which showed a very steep but smooth drop-off. I then put over the Blake trawl, steamed slowly inshore to the top of the slope and hauled it in. We dragged it up from 439 meters to 120, where it hung up. After some jockeying we got it up to the surface and found the frame broken and hanging in pieces, the net torn to shreds and containing only four holothurians, a cone shell and several hermit crabs!

We quit for the day, returned to the anchorage and Dick Robins took a small party ashore to collect in a tide pool at the far end of the island

FIGURE 15. View of the crater lake. Annobón, near site of station P-278. Photograph by Dr. L. B. Holthuis.

beyond Ambo, between Punta del Palmor and Isleta Yebatulu (Punta de la Isleta). Fishes obtained were: *Awaous, Eleotrus, Mugil, Lutjanus griseus, Eucinostomus melanopterus,* the invertebrates *Macrobrachium, Atya, Ocypode* and a portunid crab among others. Dick got the field party back aboard rather quickly as he had the feeling that the natives were angry about the poisoning of the tide pool and killing the fishes which they needed for food.

No flyingfish were under the night light tonight. To bed early after writing up these notes for the last three days. Several of the ship's crew went ashore, but when the launch went to pick them up well after dark they said they had "beer and broads" and were not ready to leave. Where they found this combination at night in Ambo is beyond comprehension, even with sailors.

May 21st, Friday

The shore party apparently had quite a time last night. It seems there is a larger white population than we had been told: 8 soldiers, the doctor, their wives, and one missionary. The *teniente* supplied the party with beer and two bottles of Scotch, the native band played drums and can rattles, and the natives gathered around to watch the whites dance. Apparently a good time was had by all.

We were underway at 0800 and ran close in by Isla la Tortuga for Dick Robins to make observations on the sea birds. There are several species on the island heretofore unreported from the Gulf of Guinea. The captain took great pleasure in blowing the ship's whistle to see the birds fly and he did this the rest of the day whenever we neared the rocky islets around the shore.

The east side of the island is very precipitous with towering cliffs. We passed one small village in a tiny embayment but we were told it was inhabited only a short period of the year; the rest of the time the residents live in Ambo. This side of the island receives most of the rain and the slopes were covered with giant ceiba trees, great patches of bananas and plantains, etc.

The sloping south side of the island is covered with dense glades of grass. About 2 kilometers off shore to the eastward is the Isleta Adams, and to the westward three high precipitous rocky islets, nothing more than chimneys, named for the three Portuguese pilots who first discovered Annobón: Escobar, Santaren and Fernando Po.

Our system of dredging was quite simple but careful. I stayed on the bridge with the intercom connected three ways: bridge, main winch and PDR. Ted Bayer stayed on the forecastlehead at the winch, and Ebbs manned the PDR.

Station P-282. We made three hauls on this station, two inshore of the three islets in 18-22 meters on a west-east transect, and one offshore of Fernando Po in 38 meters in a little deeper water. The dredge worked well without heavy jerking in all three tows. The first and second tows brought up coralline nodules 6-8 inches in diameter, most of them hollow. The only animals found were within the concretions, and I suspect the reason is that the surge rolls the rocks about killing everything which is unprotected. The animals recovered were, in most cases, the same as those obtained the day before at the north end of the island.

It is interesting that the entire island seems to be surrounded by this broad band of *Lithothamnion*. The fauna is very similar to that of the West Indies and, according to Lipke Holthuis, also contains a number of crustaceans which are known only from the oceanic islands of the Eastern Atlantic.

In the hope of getting free-living material, a third tow was made in 38 meters south of the islet of Fernando Po. This brought up smaller concretions with, as hoped, free-living forms such as *Astropecten, Luidia, Eucidaris,* etc., and some interesting fishes new to our collections.

Sta. P-283. This station was made nearly due west of Fernando Po by radar bearings and distance, to coincide with the coral line on Dongouy's chart. Neither the depth nor the bottom were as given, and the material was much the same as in the previous dredge haul.

Sta. P-284. The next haul was due south of Fernando Po islet in 73 meters, exactly as indicated by Donguy. The bottom was very rough, judging by the action of the dredge, which was badly bent when we got it back. The catch consisted of several black basaltic rocks, two alcyonarians, an orange colored coral *(Dendrophyllia)* and a few crustaceans.

Sta. P-285. The dredge was next set in 750 meters due south of Isleta de Fernando Po on, according to the PDR, a smooth bottom. The tow seemed to go well until the pick-up when we hung up badly. We jockeyed the ship about continually, heaving in and then letting out when the tension grew too great, but the cable finally broke with about 800 meters out. Having lost our last dredge, we then secured operations and ran back to the anchorage.

Sta. P-286. After dinner, night lighting was started. A *Lagocephalus,* several needlefish, and small clupeids were caught.

About 2000 I suggested to Bob Sisson that he make his planned over-the-side picture from the crane. It took exactly two hours, as he said that it would, to rig the lights, get strapped in to the bos'n's chair and be swung out and over the side of the ship to get his pictures. The test pictures came out well and the color shots should be spectacular.

May 22nd, Saturday

I had left orders to get the ship underway at 0600 and when I came on deck at 0645, Annobón was well astern. We are now making a straight run back to Lagos, planning a series of IKMT tows from 50-3000 meters, four deep bottom tows, and night light stations.

Sta. P-287. The first of the IKMT series was shot at 0822 with 150 meters of wire and fished for one hour at 55 meters depth. The catch was rather poor as would be expected: a number of blue copepods, purplish *Phronima,* three cranchiids and a number of *Sternoptyx diaphana.*

Sta. P-288. We then ran for an hour and made another set at 1038 with 450 meters of wire at 190 meters. Again the catch was scanty, consisting of a *Doratopsis* larva and an octopod, upper mesopelagic fishes, etc.

Sta. P-289. The next set was at 1303 with 1500 meters of wire, fishing at 350 meters. The catch was fair but not unusual.

At 1500 King Neptune and Davy Jones came aboard to initiate the pollywogs into shellbacks. The pollywogs were Dick Robins, Ray Manning,

FIGURE 16. King Neptune, in the person of Bos'n Matheson, ready to initiate pollywogs in the line-crossing ceremony.

FIGURE 17. Dr. C. Richard Robins receiving his initiation rites upon crossing the equator.

John Walsh, Tom Devany, Gary Hendrix and Ken Ebbs. King Neptune was the bos'n dressed in a robe, with long rope yarn whiskers, and a fancy crown. Davy Jones was Bobby Marchetti, the O.S., well attired. The charges were read, all except Gary pleaded guilty and had eggs smashed on their heads and on the chair seat and ketchup liberally splashed over them. Gary was banished to repent his sinful ways, and when his punishment was meted out at the last, he got twice as much as everyone else and then had a jar of honey poured over his head. After the ceremony we had punch served on number two hatch, bringing our festivities to an end.

Sta. P-290. At 1600 the IKMT was set in 600 meters with 1500 meters of wire out, and towed for an hour. All tows are set, fished and hauled at

350 r.p.m. on one engine. The cephalopod catch was good, consisting of an *Onykia, Heteroteuthis* which was living, and two *Abraliopsis*. One of the *Abraliopsis* and the *Heteroteuthis* were put in the photographic tanks and photographed under UV but only the latter showed any glow at all. Adrenalin injection produced no response either.

Sta. P-291. This tow was set at 1905 and fished at 1230 meters for two hours with 3,000 meters of wire and 2200-3,300 pounds on the tensiometer. Only two cephalopod heads were obtained but Dick Robins said the fish were terrific, including a black leptocephalus of the snipe eel, *Avocettinops*.

Sta. P-292. We were now on station for the deep bottom tow in 1955 meters. The Blake was let over at 2350 and payed out in a vertical tow at 60 m.p.m., much too fast. It was stopped at intervals to straighten the wire.

May 23rd, Sunday

The Blake was considered down at 0400. At 0630 I came on deck to find Ted Bayer hauling in at a very slow rate (6-20 m.p.m.) and the winch straining at full power. About 0900 kinks began to appear in the wire. These must have been thrown in by coils of loose wire in the half inch cable. The net came on deck at 1045 and had only two holothurians, several starfish, a *Dentalium* and some stalked crinoids.

Sta. P-294. While hauling in, a number of sharks came about the ship, mostly white tips, and one blue shark. A white tip was caught by Mike, the wiper, and several *Remora* saved.

Sta. P-293. During the night when the Blake was going over, Sisson and Roper ran a night light station for close-ups of squid at the flash set up. A number of *O. pteropus* were photographed and caught.

Sta. P-295. At 1220 Manning shot the IKMT again. As the kinks from the previous tows were serious ones, the bos'n stood by the wire to inspect them as they came along. Several of them were found to have broken wires and two different overlap splices were made in the half inch wire. Since the stops were so long, the net was fished at 800-850 meters and was back on deck at 1800 with a good catch of cephalopods, crustaceans and fishes. Cephalopods were *Vampyroteuthis, Ctenopteryx, Abraliopsis, Pyroteuthis, Helicocranchia, Mastigoteuthis, Japetella, Bathyteuthis,* benthic octopods and fragments of other species.

Sta. P-296. At 1917 we set the net at the surface with the upper third out of water and towed it for half an hour. We had a good collection of surface fish, myctophids, dolphins, etc. and a small *Rynchoteuthis* larva of *O. pteropus* which Clyde photographed while still alive.

Sta. P-297. Immediately after seeing the net up we made an hour's nightlight station for Bob Sisson. Squid were fairly numerous, as were flyingfishes and dolphin. A number of sooty terns hung about the ship crying plaintively. Clyde got some good latex injections of *O. pteropus* and Bob and I made a number of shots with the UV of a large squid in the close-up tank.

Sta. P-298. The IKMT was set again at 2150 and was lowered away but with 3814 meters of wire out another strand was found parted and the winch was stopped while the bos'n put in another splice in the half inch cable. Since this took so long the net was held at this depth where it fished at 1000-1500 meters.

May 24th, Monday

The net was on deck at 0320 with a good catch of fishes and crustaceans and one large squid of unknown genus.

Sta. P-299. Ted Bayer set it again for a deep tow at 0450. When it was back on deck at 1202 the Benthos showed that it had been towing at 2000-2500 meters. There was a good catch of fish and crustaceans but little else. Today started off cloudy but by midday was clear and warm and much of the crew, both ship and scientific, was on deck reading and sunbathing.

Sta. P-300. Manning again set the IKMT at 1410 for our deepest tow, fishing it slightly below 3000 meters. It was down at 1720. During the afternoon we had both fire and abandon ship drills and the scientific crew mustered alongside the whaler. Secured at 1600. Jimmy Dunlap, the chief engineer, now thinks that all will go well with the winch if pay-out and haul-in do not exceed 30-40 m.p.m., so this is now the rule. The net was on deck at 2230 with a good catch of crustaceans, fishes and squid.

Sta. P-301. Night lighting began at 2245 and ran until 2345. The sea has kicked up pretty well and the water surface is roiled, making photography difficult. We caught several good squid and some flyingfishes. One large squid was netted and, as Clyde Roper had surmised, it turned out to be a female with bright magenta oviducal glands.

May 25th, Tuesday

Sta. P-302. As we were setting the IKMT for this station the meter indicator quit operating. Therefore we secured the net against the side of the ship, and made a surface tow from 0230 to 0340. Many myctophids, etc., were caught but no squids.

Sta. P-303. When I came on deck at 0645, there was a light rain and the sky was leaden in all directions. Ted Bayer had set the net again, this time estimating wire out by the number of splices! We now have three long splices and six short splices in the cable, at precisely known points. None of them seem to make any difference to our operation.

Sta. P-304. During breakfast Joe Kennedy caught a barracuda about three feet long. It was a beautiful, sleek oceanic specimen and Robins preserved it for de Sylva.

Sta. P-305. At 1240 Manning set the IKMT to fish at 1250 meters. We had to estimate the wire at 3800 meters, again by the number of splices, one advantage of having them! At 1505 the ship lost power due to air failure to the clutches and we began hauling in, but only a few minutes elapsed before way was regained and we let back out to the towing depth. The net was aboard at 1820 with a good catch of crustaceans, fishes and cephalopods. The latter consisted of *Abralia, Abraliopsis, Onykia, Galiteuthis, Histioteuthis, Helicocranchia, Japetella* (crown only), *Vampyroteuthis, Octopus* larva, cranchiids and *Bathyteuthis*.

Sta. P-307. As usual, just after dark at 1930, we stopped the ship for nightlighting. The entire day had been rainy and completely overcast but it was beginning to clear by 1900. Sisson took shots from the bridge, a better vantage point because of the wider field. Numerous flyingfish and squid were caught amidst the usual confusion and pole banging.

Sta. P-306. At 2120 Robins set the IKMT for 400 meters fishing depth and made an hour's tow. It was on deck at 2325 with a catch of *Isistius brasiliensis* (which again chopped holes in the sleeve), a large *Chiasmodon, Ichthyococcus, Gonostoma elongata,* all in very good shape. Cephalopods included *Japetella, Octopodoteuthopsis,* and *Pyroteuthis*.

May 26th, Wednesday

Sta. P-308. Manning set the IKMT again on his watch at 0145 to fish at 675-700 meters in about 1,207 meters depth. It was on deck at 0548 with a good catch of bathypelagic animals including five *Vampyroteuthis*.

Sta. P-309. We now decided to make one of our deep bottom tows with the 40-foot otter trawl. Robins began the set at 0800 while I was still at the desk trying to make up a cable for change of airplane reservations for myself, Ted Bayer, Ray Manning and Bob Sisson. I knew I should be on the bridge, but we had set the gear so often without trouble that I thought all would go well. Instead, Dick came in to tell me that the net was caught in the screw. The doors were just forward of the wing of the bridge and the cod end led sharply under the ship. By hanging over the stern, one of the seamen could see the net wrapped in the port screw.

As the sea was calm, Joe Kennedy went over with his SCUBA and found the net wrapped around the shaft and the hub of the screw. Normally reversing the screw did not help, so I had him cut the cod end off, and we got both parts back in good shape. A small white-tipped shark caused a brief flurry of excitement during the operation and the captain blazed away at it with a .22 revolver.

We then shackled on a new trawl and shot it again. Before the wraps were clear the net closed. We hauled in and reset the doors with good headway on, but the outer door turned under the closed against the inboard door shooting under the ship. I then had the doors brought aboard, cleared, and added 14 inches to the footrope with a series of shackles. Then we shot it again and it worked perfectly, so we resumed our course.

When the net was down at 1207 we cut to one engine slow ahead and trawled for two hours in about 1,240-1,317 meters. During the tow the tensiometer showed a gradual build-up to 3500 pounds. The net was on deck at 1640 with an excellent catch of brotulids, eels, etc., starfish, mollusk shells, *Polyodontes, Opisthoteuthis,* a large *Rossia,* and a small *Heteroteuthis.* It was an exciting catch.

The day was beautiful, clear and sunny and everyone was lying about the decks soaking up the sunshine and acquiring considerable sunburn. Numerous small tunnies were around the ship all day and several of the crew tried fishing for them without success. Their tackle was too large and the ship did not have enough way on. The nets were also spread out in the sun to dry, and in the cool of the evening after dinner I had the hatches opened up and we sent all of the gear below for storage, with the exception of the IKMT and the 40-foot trawl, which we would use again one last time.

I might add that the day was made perfect for two people, Bob Sisson and J.B., the messman, who both won pools on the Clay-Liston fight, Sisson $30.00 and J.B. $15.00.

Sta. P-310. We made another nightlight station from 1930-2100 and obtained numerous squid and fishes. Afterwards, Clyde and I injected the arterial system of a squid while Bob Sisson took a series of pictures for a National Geographic article. Robins dipnetted a young sailfish, the first of the cruise.

Sta. P-311. Dick Robins ran a surface tow with the IKMT from 2100-2255 and got a number of young tunas, *Exocoetus obtusirostris, Cypselurus, Balistes, Caranx,* eel leptocephali, two small *Nephropsis* and some larval flatfishes.

May 27th, Thursday

Sta. P-312. Between 0105 and 0403 Manning made a 550-meter tow with the IKMT which obtained a small catch.

Sta. P-313. Bayer set it again between 0500 and 0720 at about 600 meters. The usual catch of fishes were obtained, as well as two *Vampyroteuthis* and an adult *Abraliopsis,* the latter alive. It was placed in the tank and photographed under UV. Later I studied it under the microscope. The large light organs were contracted and closed, but the medium and small ones on the mantle and head shone with a beautiful clear ultramarine. As the animal died, the ultramarine changed to green, then to just a bright clear glow, and finally faded away completely.

Sta. P-314. At 0856 Robins shot the 40-foot trawl in 2175 meters. The weather was excellent and the haul was made without incident, the net starting up at 1415 and on deck about 1730. The catch was excellent and with it the ship board work of the cruise ended. By evening a heavy sea with drifting rain had set in and we secured and ran for Lagos.

May 28th, Friday

Sta. P-315. During the night, Robins, Manning, Roper and Walsh decided to do some night lighting as the weather had abated somewhat. The ship was hove to and one of the best night light stations of the cruise was made directly out from Lagos.

When I came on deck at 0630 the Pillsbury was laying to north of the breakwater with 8 ships in line ahead of us waiting for the pilot. We were informed by the blinker that we would get the pilot aboard about 1000 hours, but at 0730 the pilot boat came alongside and told us to proceed into the river and anchor off the signal station. Just outside the river mouth we passed a large Russian stern trawler, also waiting for the pilot.

We had the health officers aboard shortly and in about 15 minutes a pilot came aboard and took us on into the marine moorings where we made fast at about 1100.

Sta. P-316. There was much confusion and running about but at 1500 Dick Robins took the whaler and made another poison station which was a repeat of Sta. P-224 made at the beginning of this cruise. The catch was very good. This concluded all of our biological collecting.

This summer none of the party went on to Europe. We had a one day lay over for our plane, spent buying souvenirs and sight seeing, and flew directly into New York via Dakar.

During our two cruises we explored and collected over the heart of the tropical zone of West Africa, working both the shelf and the floor of the Gulf of Guinea and its oceanic islands.

THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

—2—

BIOLOGICAL COLLECTING GEAR AND ITS USE ABOARD R/V PILLSBURY[1]

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The R/V PILLSBURY is a converted 173-foot former Army FS designed and developed for troop supply during World War II. With the help of several grants from the National Science Foundation, the ship was progressively modified to her present condition. Her normal complement consists of 22 crew members and 14 scientists, all but two of the latter housed in quarters in a house over the fantail. Laboratory space is divided into a wet lab on deck forward of the wheel house, and a dry lab with various compartments below deck. General layout is shown in Figure 1.

There are five winches aboard the ship: a small BT winch mounted on the fantail; two hydrographic winches on the top of the wet lab; a Stroudsburg commercial shrimp-trawler winch on the top of the forward crew's quarters; and the main trawl and coring winch forward in number 1 hold. Hydrographic work is carried out from the hydro-winches working from a single A-frame about amidships on the port side. Heavy trawling and coring is done from an A-frame on the starboard side forward at the break of the forecastle head. The trawl winch is a large hydraulic model manufactured by Western Gear Corporation, Everett, Washington, known as Deep Sea Anchoring and Coring winch model number DBWH-150C.

The winch consists of three components apart from the motors: the hauling engine, composed of two sets of sheave wheels around which the cable is wound under tension, and two storage drums each with a capacity of about 45,400 feet of tapered wire (¾ to ⅜) or about 45,000 feet of ½ inch cable. The winch controls are on the after rail of the starboard side of the forecastle head, so that the operator faces aft in full view of and proximity to the fair lead wheels mounted on deck at the head of the A-frame.

In operation, the wire runs off the storage drum, with about 1100-1300 pounds tension, to the hauling or traction engine sheaves, up to the deck through a hawse pipe and over the fair lead wheels to the head or running block on the A-frame.

The running or head block is an Alpine Geophysical 3 in 1 sheave 24 inches in diameter with a sheave width of 8 inches. The center sheave is grooved to hold the cable. The object of the large block is to allow the passage of large shackles, etc. over the wheel.

[1]Contribution No. 730 from the Institute of Marine Science, University of Miami.

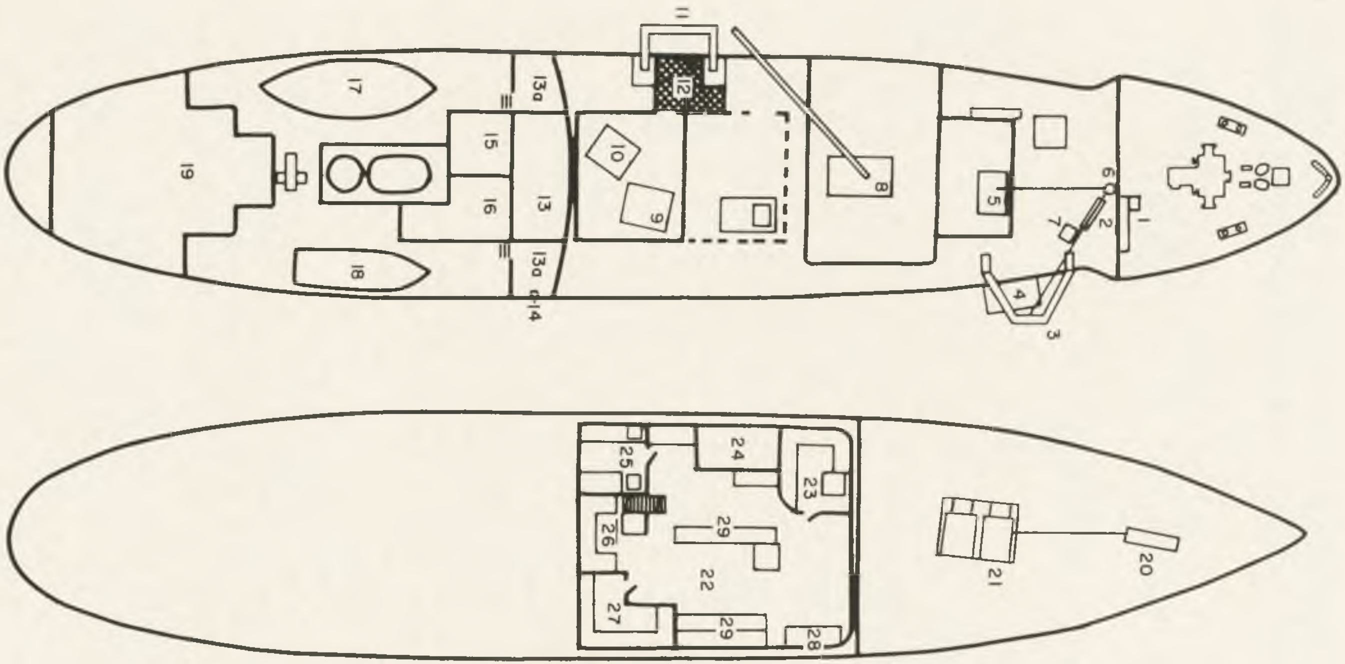

FIGURE 1. Top. Deck plan of R/V Pillsbury. Bottom. Laboratory plan and trawl winch arrangement. 1. Trawl winch control console; 2. Trawl wire fair leads; 3. Trawl A-frame; 5. Stroudsburg winch; 6. Stroudsburg winch deck block; 7. Wire change-over platform; 8. Austin-Weston hydraulic crane; 9-10. Hydrowinches; 11. Hydrowinch A-frame; 12. Hydro A-frame platform; 13. Bridge; 14. Wings of bridge; 15. Radio room; 16. Chart room; 17. Life boat; 18. Ship's launch; 19. Scientist's quarters; 20. Trawl winch traction unit; 21. Trawl winch storage reels; 22. Dry laboratory; 23. Hot lab; 24. Scientific store room; 25. Scientific navigation room; 26. Microscope room; 27. Data reduction room; 28. Freezer; 29. Work benches.

The Stroudsburg winch (Serial Number 13692, manufactured by Stroudsburg Work Manufacturing Company, Stroudsburg, Pennsylvania) is located on the forward edge of the crew's quarters on the starboard side and is aligned to lead forward. Cable for this winch leads to a Hathaway block fastened to a pad eye above the fair leads from the main wire. This winch is driven by a five horse power, 230-volt D.C. electric motor. The function and operation of this winch will be described later.

Collecting Gear

The biological survey work at the Institute of Marine Science is predicated on the use of many different kinds of gear in order to sample as many different kinds of habitats as possible. As a result, a much greater diversity of life is obtained than is possible when only one or two types of standardized gear are employed. As our major shipboard interest is in sampling communities and obtaining information for zoogeographical and broad systematic studies, we avoid standardization insofar as possible. Following is a list of the types of gear used aboard the R/V Pillsbury on the two Gulf of Guinea cruises, including modifications to date of writing. (This paper, incidentally, was written aboard the ship while the author was Chief Scientist on a cruise in the southwestern Caribbean, supervising and observing daily operations.)

Night Lighting

Samples of pelagic and planktonic fishes, larvae, juveniles and adults, and squids are often only obtained by use of night lights and dipnets at the ship's side. At night, whenever the ship is on station and stopped or moving slowly, the overhead deck lights are switched on and members of the scientific party employ dipnets to collect animals at the surface. These are of nylon netting on 18-inch diameter rings of tempered aluminum tubing mounted on 12- to 16-foot handles of bamboo or other suitable material. In West Africa, the poles were purchased in Lagos and consisted of the central rib of very long palm fronds. These worked very well but were somewhat heavier than bamboo. In addition to the ship's deck lights, a standard 1,000-watt watercooled Navy diver's light is usually suspended over the side about three feet or less below the surface.

Surface Netting

While underway at moderate speeds, collections of neuston are made by setting either the 6-foot or 10-foot IKMT with about half the mouth out of water and towing for several hours at a time. It works well and excellent collections have been made in this fashion.

Mid-water Trawling

All mid-water trawling is done with the 10-foot IKMT (Isaacs & Kidd, 1951, 1953). The net used at the Institute of Marine Science is identical with that employed by the National Institute of Oceanography aboard the

DISCOVERY II. It is used with a metal canister manufactured for us in Miami. When towed at the proper speed the trawl consistently fishes at a depth about ⅓ of the amount of wire out. However, to verify performance, a Benthos Time/Depth recorder is always shackled into the main bridle ring. Originally, the sleeve at the cod end was made of light nylon canvas but this quickly wore out. It was replaced by a heavy hand-sewn canvas sleeve improvised at sea. New nets now have medium-weight nylon canvas sleeves. On several occasions the sleeve has been damaged by the bathypelagic shark, *Isistius,* which bit as many as six holes through the sleeve as large as a fifty cent piece. The nets are manufactured for us by Marinovich Trawl Company, Biloxi, Mississippi. Another type of IKMT net, the USC model used aboard the ELTANIN on a recent cruise, is now being tested for operational efficiency. A report on comparative fishing efficiencies is being compiled by J. C. Staiger at the Institute of Marine Science. The depressor, bridles, spreader bar and all hardware are manufactured by Dale's General Repair Shop in Miami.

BOTTOM TRAWLS AND DREDGES

10-foot try net. One of the most useful trawls for work in shallow to moderate depths is the standard Gulf of Mexico 10-foot shrimp try net. Two types have been used: (1) a tarred cotton webbing net manufactured by Standard Marine Supply at Key West, complete with doors and heavy chain bridles; (2) a green-dipped nylon net manufactured by Marinovich Trawl Company, complete with doors and chain bridle. Some early nets from Standard were equipped with light chain bridles which broke too easily, resulting in considerable losses of both nets and doors. The heavier chain supplied on later models retains the doors even when the net is torn away completely, and is therefore more desirable. The try net is fished from 6 fathoms to over 400 with excellent results and minimum effort. These nets are immediately available in stock but liners are extra.

40-foot otter trawl. For work in shoal water and on the deep ocean floor down to 2,000 fathoms or more, a 40-foot otter trawl is employed. We have used two models, (1) a tarred net with multi-colored plastic chafing gear at the cod end, unlined, (Standard Marine); and (2) a green-dipped net with a cod end liner (Marinovich), without chafing gear but with a heavy mesh net around the cod end. Both nets performed about equally well and with about the same wear, but the crew usually prefers to set the Marinovich net because of its cleaner appearance. These nets measure 40 feet on the footrope and are supplied separately from the doors and bridles. The bridles are 20 fathoms long, of 7/16 inch wire cable with thimble spliced in ready for use. Footropes are equipped with chain and headropes with floats. The 40-foot net is readily available from stock.

Blake trawl. Considerable confusion exists as to what a Blake trawl is, and most so-called Blake trawls in use today are double-beam trawls. The trawls used on Pillsbury are 10 feet wide and are designed from the specifications given in the Blake reports. To simplify manufacture, the end runners are angled from flat stock rather than curved around the leading edge. This modification seems to have no adverse effect on performance. The Blake frames are manufactured by Dale's General Repair Shop in Miami, and galvanized after manufacture. Details of this net are shown in the narrative of the expedition (Voss, 1966, figure 5).

The nets were designed by William N. Eschmeyer of the Institute of Marine Science and manufactured by Marinovich Trawl Company. They are made of nylon webbing, are somewhat larger than the ones used by the Blake, and have a funnel in the leading third of the net. The funnel is lashed into place so as to prevent its turning inside out during trawling. Since the Blake is essentially a deep water net and is seldom towed at more than 2 knots across the bottom, the funnel is essential to prevent the escape of fishes. This net has been used principally in depths greater than 2,000 meters, but also has been very successfully employed for trawling up the continental slope in areas where this is too rough or precipitous to permit the use of other nets.

6-foot Chesapeake Bay oyster dredge. We used this net for the first time on the Caribbean cruise. It is a typical shallow water oyster dredge except that the chain bag is replaced with a nylon net manufactured by Marinovich. Its particular value lies in the row of steel teeth on the lower edge which digs burrowing forms out of the bottom. It is most useful in shallow water, but has been used with good results to several hundred fathoms by others.

Albatross box dredge. The box dredges used are modified from those employed aboard the U.S. Fish Commission steamer *Albatross.* Two sizes are used. They have been used with moderate success on very rocky bottom too rough for trawls, and with good success in broken rock, shell and rubble bottom.

Bottom grabs. The only grab used to date has been the 0.1m^2 Smith-McIntyre spring-loaded grab manufactured in Scotland by David Muir, blacksmith. It was intended to be used on the first cruise in the Gulf of Guinea and was shipped by the manufacturer directly to Lagos. When the grab was operated off Liberia, the trigger mechanism failed to function in repeated attempts. The difficulty was not corrected until the trigger was adjusted back at the Institute of Marine Science. This gear has not been used subsequently aboard the PILLSBURY.

TRAWL WIRE

While wire cable came into general use as a result of its employment by Alexander Agassiz, very little has been written concerning types of wire cable to be used in trawling and almost nothing concerning the nature of the problems encountered. We learned the hard way and it is hoped that some of the comments now recorded will be useful to those venturing into this field.

As mentioned above, the cable capacity of the storage drums is 45,460 feet in the following lengths and dimensions:

14,000 feet	⅜″ diameter
7,600 feet	7/16″ diameter
6,200 feet	½″ diameter
5,200 feet	9/16″ diameter
4,400 feet	⅝″ diameter
4,500 feet	11/16″ diameter
3,560 feet	¾″ diameter

The cable first used aboard PILLSBURY for trawling was an unfortunate selection. It was chosen by persons interested in coring alone, and wire for this purpose need not have the properties necessary for a good trawl wire. This wire, of which two full drums were furnished in late 1963, was aboard the ship when we arrived in Lagos on May 20, 1964. The first station made with the 40-foot trawl directly outside the harbor was a total loss as the wire parted as the net was being hauled in. Inspection showed that the cable was very badly rusted beneath the outermost layer or two on the drum, even though it had been in use for only 6 months. This rusted wire was later jettisoned and the new wire on the after drum, 42,000 feet, was run out and we were back in operation in a few minutes. Because of the placement of the winch and arrangement of sheaves leading the wire over the side, no satisfactory way has been devised to wash, wipe and oil the cable after each use.

Little difficulty with the wire occurred when used in moderate depths with the 40-foot trawl or the IKMT. However, as work progressed and hauls were made with the Blake in increasing depths, our troubles began. After Sta. P-18, the cable suddenly kinked between the storage drum and the hauling engine. It took three hours to cut the cable and put in a lapped short splice (for which seamen have a particularly appropriate name). On the next station, Sta. P-20, the wire came up "charged," and when the shackle was loosened the wire rotated several dozen turns. To alleviate this condition we payed out 2,500 meters with a 350-pound weight shackled to the end of the wire and rewound. We again had trouble on Sta. P-36. Upon starting to retrieve the IKMT on Sta. P-54, the wire, with many rotations in it, jumped the traction heads, snapped, and the net was lost. On its next set with an improvised mid-water net, the cable had rotated so badly that we gave up using the gear. At Sta. P-71, using the Blake, the wire kinked between the storage drum and the hauling engine and parted, again losing all of the gear.

Much discussion resulted from the fact that most of the difficulty with the wire occurred during the use of the Blake trawl, and the first thought was that it was the fault of the gear. This, however, was not the case as will be seen later, but rather was due to the stretching of the wire under the heavy strain of the long tows and resultant rotation of the wire.

On the second cruise, a new cable was reeled on in Lagos. This cable was of the same type used previously but was tapered from ⅜ to ¾ in increments of ⅛ inch, which is too great a difference for a satisfactory long splice in wire rope. On the third tow we overestimated the depth (the PDR was temporarily out of order) and mudded the net. When brought on deck the wire was badly damaged even though it had been used only three times. A weight was shackled on and 7,500 meters of wire streamed out to allow the twisting to unwind.

At Sta. P-241 with only 325 meters of wire out, the cable parted between the storage reel and the hauling engine. Luckily it jammed in the sheaves and did not go overboard. A come-along was applied to the wire to hold the trawl while the wire was led off and spliced. On Sta. P-261, one of the strands came free just inboard of the A-frame and it was found that the long splice between steps in the cable had been butted and not locked. The lay was put back in place and locked.

On Sta. P-266 with 2690 meters of wire out, a strand parted in the winch room outboard of the hauling engine, due to a kink in the wire. The way was taken off the ship, the wire slowly heaved in, stopped off and a short overlap splice put in in about 2 hours. At 3226 meters of wire out, another bad kink appeared and the same procedure applied, this time taking only 1½ hours.

At Sta. P-295 kinks again appeared in the wire and two more splices were put in and at Sta. P-298 another was necessary. By the end of the cruise the wire had six short splices in addition to the original three long splices!

In addition to this trouble, the wire jumped the traction heads innumerable times due to the "charging" brought about by tension, each time necessitating half an hour's work by the bos'n and the chief engineer.

All of these troubles can be attributed directly to the type of wire cable used. All ordinary wire rope rotates when under strain; it may rotate anywhere from 25° to 360° per foot, according to size and type. While it may be thought that this rotation developed when paying out and during the tow would reverse itself as the cable is brought back in, such is not the case as can be determined by close observation. Even though the end of the cable may spin several hundred times when the net is brought up and unshackled, a dangerous event, the rest of the wire remains unlaid as the result of strain applied during the trawling. At any time that slack occurs in wire which has been under heavy tension, either after it has been hauled in or during the actual tow, the tendency of the stretched cable to return to its normal lay will throw the wire into kinks. The kinks noted above were not due to free loops of cable due to excessive pay out rate or laying on the bottom but simply to any reduction in tension, as may result from the roll of the ship or the lessening of pull between the storage drum and the hauling engine.

The problem was brought to the attention of wire rope specialists from a major manufacturer, and several interesting but conflicting remedies were suggested. One engineer recommended the insertion of a 10-foot wire pennant with swivels between the trawl cable and the net, explaining that the problem was due to torque in the wire and that this would all be taken up in the pennant. This, needless to say, did not correct the situation. All stated that swivels were not the answer and would only aggravate the situation. Swivels were used on the first cruise but they were heavy galvanized ones that did not rotate under pressure when they were needed. They did, however, allow the cable to rotate before unshackling, an otherwise dangerous job. However, because of the rotation of the wire, the trawl warps often twisted badly. This was relieved by using a Miller Barrel Swivel which rotates freely even when under several tons of pull between the trawl cable and the bridle of the trawl.

Of course, as is known by all people experienced in deep sea trawling (these troubles do not occur in the depths worked by commercial trawlers), all of these troubles can be overcome by using a non-rotating cable. The usual non-rotating type is a woven or braided cable, rather than a laid cable, and its cost is excessively high. A newer type is a torque-balanced laid cable manufactured by U.S. Steel Corporation and designated as 3 × 19 seale Monitor AA-Amgal torque balanced-elevated elastic limit wire rope. The PILLSBURY now carries two drums of this cable, each holding 42,000 feet. It has very long lays of three strands and is stiff and difficult to splice and also must be used with an end fitting with which special care must be taken. Special training is required for splicing this cable and two members of the ship's crew were instructed in this operation by Florida Wire and Rigging Works Incorporated. Aside from the fact that this cable does not rotate, it has several other distinct advantages. It has a noncorrosive covering which prevents rusting. It has no core. According to our present experience, it does not require lubrication, a distinct advantage in both handling the wire and in preventing contamination of tows.

This cable, in over a hundred bottom tows in the southwestern Caribbean with up to 6,500 meters of wire out, has shown no sign of rotation and all parts of the cable when given slack, lie without charging. Because of this nature of the wire, no further difficulties have been encountered in kinking, bird caging, or twisting itself off the traction heads. In those cases when the wire has slipped off the traction heads because of incorrect adjustment of the winch, it lies in a free loop with no tendency whatever to twist, and can be replaced on the heads with no difficulty at all.

ACCUMULATORS

The history of accumulators and their various designs is an interesting one. Simply, an accumulator is a device used to reduce the sudden strain applied to the cable by the rise and fall of the ship in a seaway, or by the impact of the trawl or dredge upon submerged obstructions. From his experience on the PORCUPINE and LIGHTNING, Thomson was convinced of the efficacy of these mechanisms, and he devised an ingenious one for use upon the CHALLENGER. Various types were used later on board the BLAKE, ALBATROSS, DANA, and most other exploratory vessels.

On the other hand, experience during the cruise of the Swedish ALBATROSS demonstrated that wire rope and probably hemp as well, contained sufficient inherent elasticity to make the accumulator unnecessary. Indeed, it was suggested, I believe by Kullenberg, that the accumulator might even increase the effect of the surge on the cable by accentuating it. At the Institute of Marine Science, accumulators were used, both compression spring type and stretch shock cord types, on vessels prior to R/V PILLSBURY. In the last few years, we have abandoned the use of accumulators in favor of running the wire directly over the side. We have encountered no difficulties since eliminating the accumulator, and have one less piece of equipment that can give trouble at sea. Experience gained in repeated shallow water trawling indicates that an accumulator would be of benefit in that type of work because of the short length of wire employed with resulting reduction of stretch and catenary.

An additional useful feature of the accumulator is that it shows changes in tension of the wire by the variations in its movement, an important aid in determining bottom contact. This is determined aboard R/V PILLSBURY by an hydraulic tensiometer installed on the sheaves leading the cable to the A-frame. When this is functioning correctly, changes in tension indicate contact with and breakway from the bottom. However, the scale on the present instrument is too coarse, and an instrument with finer calibration is ready for installation.

WIRE KINKING

When wire rope supplemented hemp for sounding and trawling, a new major danger came into existence to haunt the mind of the oceanographer — kinking. Essentially, kinks are formed when the wire falls slack in a loop and then is pulled taut. This draws the loop smaller and smaller until it closes, throwing a sharp reverse turn, with a twist involved, into the wire. In all types of wire used in trawling the kink is usually sufficiently sharp to weaken the wire greatly, causing it to part when heavy pressure is applied. Therefore, kinking of the deep-sea trawl cable may, and usually does, mean the loss of the wire below the kink together with the attached gear. If the wire is recovered and the kink brought on deck, immediate repair is necessary. This requires cutting and splicing the wire, which demands expert knowledge and skills. It is a mistake to believe, however, that kinks are caused only by loops in the wire. In a heavily charged wire (rotated), a kink can be produced by the momentary lessening of strain, such as occurs during the downward roll of the ship in a heavy sea, or when improper adjustment of tension between the hauling engine and the storage reel occurs. Such kinks result when individual lays of the wire turn themselves and kink individually. This can be demonstrated by twisting the two ends of a piece of manila line against the lay; the strands kink separately. The result, however, is the same as the kink resulting from a tightened loop. One is due to negligence or miscalculation of the winch operator, the other to deficiences of wire rope construction.

A similar type of wire fouling is "bird caging," which occurs when several loops tangle together and produce a knot with several loose loops projecting from the snarl. This is invariably due to faulty winch operation, including lowering away the gear too rapidly, especially when hove to and running out the wire perpendicularly. If the trawl cable is let out too rapidly the cod end of the net may blacklash above the doors or frame, fouling the wire and looping when the payout is completed.

When the wire kinks with gear over board, the usual safest procedure is to bring the kink well on deck, stop off the wire with a large come-along attached to the deck by heavy chain, cut the wire rope and throw in a splice. Two kinds of splices may be used: a long splice if the blocks or fair leads require that wire diameter be the same throughout, or lapped end splices if irregularities in diameter are permissible. The long splice necessitates reeling in the kink onto the drum until over thirty feet of wire is aboard, stopping off the wire, and then running the kink back off the drum. Long splices are difficult to lay in. In usual shipboard conditions, the lapped end splice is faster, stronger, and will run through most blocks and fairleads. A good splicer can lay one in a 5/8 cable in less than 2 hours with only a vise and no rigger's bench. The U. S. Steel wire is very difficult to splice under the best of conditions and requires special training but fortunately, it has a minimum tendency to kink. The best preventive to kinking in any wire is to keep a taut cable at all times.

Trawling Methods

The methods of trawling given in this section refer mainly to trawling from the side of the ship well forward, but many aspects are the same for stern trawling as well. The only major differences in description might be when trawling over the bow using sternway. The methods described here are those we have used for three years aboard R/V Pillsbury to make over 400 stations, and for over four years on R/V Gerda to make over 1,500 stations. On the latter vessel, depths ranged mostly between 400 and 1,800 meters.

1. *Isaacs-Kidd mid-water trawl* (10-foot model). — The use of this net has been described in detail by several users (Aron et al., 1965, Aron et al., 1964, Clarke, 1963) and its towing characteristics will not be described here. However, through considerable experience with this net down to

3,000 meters, we consistently use a Benthos time/depth recorder on the bridle at each tow. This does not telemeter information to the surface to permit adjustment of the net to a desired depth during the tow, but records accurately the actual depth at which the net fished. Once the proper speed has been determined for towing at a 3 to 1 ratio, it is possible to control very accurately the depth at which the net fishes, as has been shown by the close correspondence of the Benthos time/depth record with the calculated depth of tow. It should be noted that when towing at great depths the ratio changes to 2½ to 1 or 2 to 1 because of the weight of the cable itself. As a result, we have not felt it necessary to employ pingers or other more elaborate devices for controlling depth, although these are desirable under adverse conditions of sea and current. On the first Guinean cruise at Sta. P-9 a remarkably distinct deep-scattering layer was observed on the PDR and the IKMT was set to fish in the middle of the layer. As the deep scattering layer moved downward as shown on the PDR, the cable was payed out to keep the net centered in it. On retrieving the net, the Benthos recording disc showed that it had been fishing within the layer over the entire period just as planned.

The value of closing IKMT's with multiple-chamber cods ends is debatable and I have discussed the matter elsewhere at some length (Voss, in press). The main difficulty is the large number of specimens caught in the webbing all along the net, and which subsequently drop off into the cod end when it is open, thus contaminating the catch with material from a different level. As this paper was being readied for press, John D. Isaacs and Daniel M. Brown published an account of the Isaacs-Brown opening-closing trawl (Isaacs & Brown, 1966). This is a modification of the IKMT net permitting sampling at discrete levels without the objectionable feature mentioned above.

On PILLSBURY the net is customarily set, towed and hauled in with the ship on course and moving ahead on one engine at 350 rpm's. The speed, however, is varied according to weather and sea state. On the last PILLSBURY cruise which was specifically for mid-water trawling, the net was set, towed, and hauled with two engines ahead at 340 to 350 rpm's (the rpm's given in this paper are those used aboard the R/V PILLSBURY. Actual speeds at these rpm's with the gear over the side are estimates only and therefore are not used in this paper). Customarily, the wind and any current are kept on the starboard bow to set the ship away from the cable when towing, and the port engine is used when the net is near the stern of the ship during setting and retrieval; the starboard engine is used when towing as it gives better steerage and requires less left rudder.

In towing near the bottom, it is essential that the ship not be slowed at the commencement of hauling in, since this will cause the depressor to dip steeply and perhaps make contact with the bottom. In fact, some interesting bottom specimens have been taken with the IKMT by various ships, either as the result of this practice or because the engines were shut down during towing for one reason or another.

In setting the IKMT, the depressor, spreader bars, and net are arranged on deck, the Benthos time/depth recorder is wound, secured, and shackled into the bridle of the net at the forward towing ring. The crane is then hooked into the ring, the trawl frame is lifted clear by the bridles and swung over the side, and the net put overboard. The trawl cable is heaved in bringing the head of the bridles to the running block, the crane hook is taken out and the net is lowered away. The reverse procedure is followed when bringing the whole gear on deck. During the first African cruise, the depressor was left hanging from the A-frame with one end secured to the ship to prevent damage in a seaway while running between stations. This is a dangerous practice, however, and has since been discontinued.

2. *10-foot try net.* — This net measures 10 feet on the footrope from door to door. The bridles are of chain and are 15 feet in length. In shooting this net the bridles are shackled to the trawl cable, the cod end tied off, and the doors and net put over the side. The ship is kept on course with wind, sea and current on the starboard side and with the port engine ahead at 350 rpm's for a calculated 2 to 3 knots. The net is then payed out at about 50 meters per minute until the desired amount of wire is out. The port engine is then stopped, the starboard engine ahead at 350 rpm's and towing commences.

This net usually is not set in depths greater than about 400 meters. On hard bottom a cable-to-depth ratio of about 3 to 1 is used. On smooth bottom about 5 or 6 to 1 is used for normal towing, but if it is desired for the net to dig into the bottom somewhat, a 9 to 1 ratio is used. Tows with this net are usually made for half an hour on bottom on the shelf, and for one hour in depths in excess of 180 meters.

The try net is one of the most productive nets that we use. It catches invertebrates somewhat better than fishes, but the fishes taken are those often missed by larger trawls. In addition, the gear is so inexpensive that it is economically feasible to tow it on very rough bottom where there is such a high probability of loss that one might not wish to risk the larger, more expensive nets.

Half-hour tows usually do not fill the bag beyond the capacity of one or two persons to pull aboard manually. However, when the net is filled, the hook from the crane is passed through the chains of both doors, the trawl cable is eased off, and the crane lifts boards and net onto the deck for dumping into the sorting frames.

3. *40-foot Otter trawl.* — This net measures 41 feet on the footrope. The wire rope bridles are 37 meters from the doors to the bridle shackle.

On board R/V PILLSBURY, due to her low freeboard, the distance from the water to the end of the A-frame and then to the fair leads of the winch is not sufficient to raise the doors out of the water when the shackle has been taken inboard to its full limit. The size of the shackles prevent their passing over the fairleads and down the hawse pipe to and over the traction drums. Therefore, it was necessary to devise a method of taking the long warps aboard. The first method employed the port deck winch (replaced by the Stroudsburg winch on the second Guinean cruise) and a Hathaway block hung from the A-frame alongside of the running block. The trawl warps, fastened to a short whip, were passed through the Hathaway block and wound on this winch. In setting this net, the warps were shackled onto the doors and the doors were then lowered away, the warp payed out until the shackle passed through the Hathaway block, and the net was pulling from the whip. A man then went out on the A-frame and shackled on the trawl wire passed through the towing block. By heaving in the towing cable the strain was taken off the whip, which was unshackled and the net was ready for shooting. This system was used on both Guinean cruises but it was slow, and dangerous for the man on the A-frame.

Since then the Stroudsburg winch has been relocated on top of the crew's quarters facing the bow and the Hathaway block is secured over the trawl winch fairleads. The running block now used is the Scripps Institute of Oceanography extra wide sheave block. The warps are now let out through the running block and payed out until the shackle is between the running block and the fairlead wheels within easy access of the end of the trawl wire. Here it is stopped, the trawl wire shackled on, the whip released, and the net is ready for shooting in a matter of a couple of minutes or less.

When the doors are in the water and the net ready for shooting, the ship is brought on a course opposite to the trawl course and is brought ahead on the port engine at about 350 rpm's in a wide turn to starboard to keep the net and doors clear of the ship and the active screw. Changing the bridle from the whip on the Stroudsburg winch to the towing cable is accomplished by the time the ship is nearly on course. The net is then lowered away, the ship is straightened up on her heading and both engines are put ahead slow at 350 rpm's for a speed of about 6 knots. (Figure 2).

The desired amount of cable is run out at this speed and when the wire is stopped off the port engine is stopped and the starboard engine put ahead at 350 to 400 rpm's, depending upon weather conditions and speed over the bottom. The wire ratio in depths less than 600 meters is essentially 5 to 1, between 500 meters and 1,500 meters about 2½ to 1. In depths below this, Kullenberg's ratios are taken from his graph (Kullenberg, 1956).

Running the net and towing at these speeds under normal weather conditions is a simple operation and involves almost no problems. The setting speed keeps the cable taut but allows the net to dive rapidly. It prevents the doors from closing and keeps the cod end away from the cable.

To determine the course on which to shoot the net, consideration must be given to the direction of the wind, the sea (these two are not always

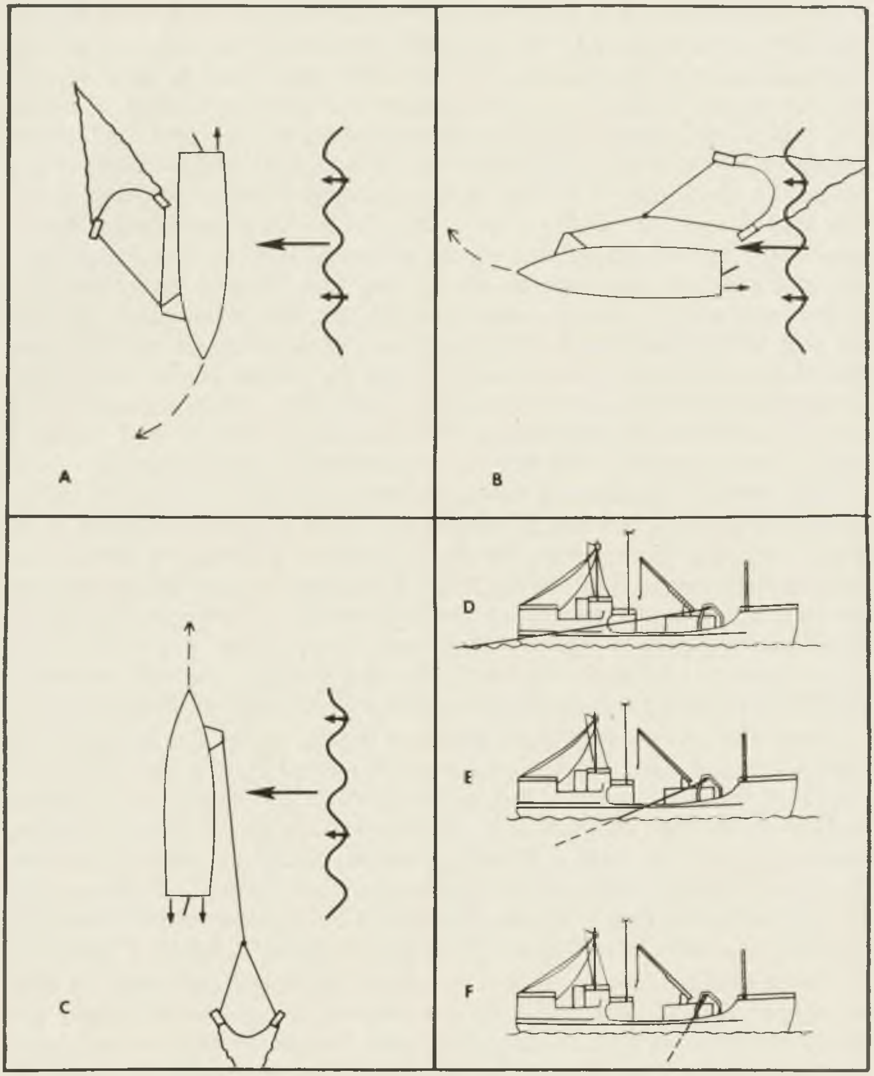

FIGURE 2. A-C. Shooting the 40 foot otter trawl. A. Doors alongside ship; right rudder, port engine ahead, ship turning to starboard on reverse course; B. Doors astern of ship with net towing from main trawl wire, engine and rudder as above, ship half way to final towing course; C. Ship on towing course with net astern and doors and warps clear of stern, both engines ahead, slight left rudder. D-F. Wire angles. D. Wire angle in shallow tows with 40 foot otter trawl. Wire leads well aft and ship's course cannot be changed to port. E. Wire angle with 10 foot Isaacs-Kidd midwater trawl. Ship can be turned over wire exercising caution. F. Wire angle with deep trawling below 2000 meters. Ship's course can be changed as necessary.

the same), and the current. The diagrams given in Figure 3 illustrate some of the possibilities. While wind and sea are obvious, and are kept on the

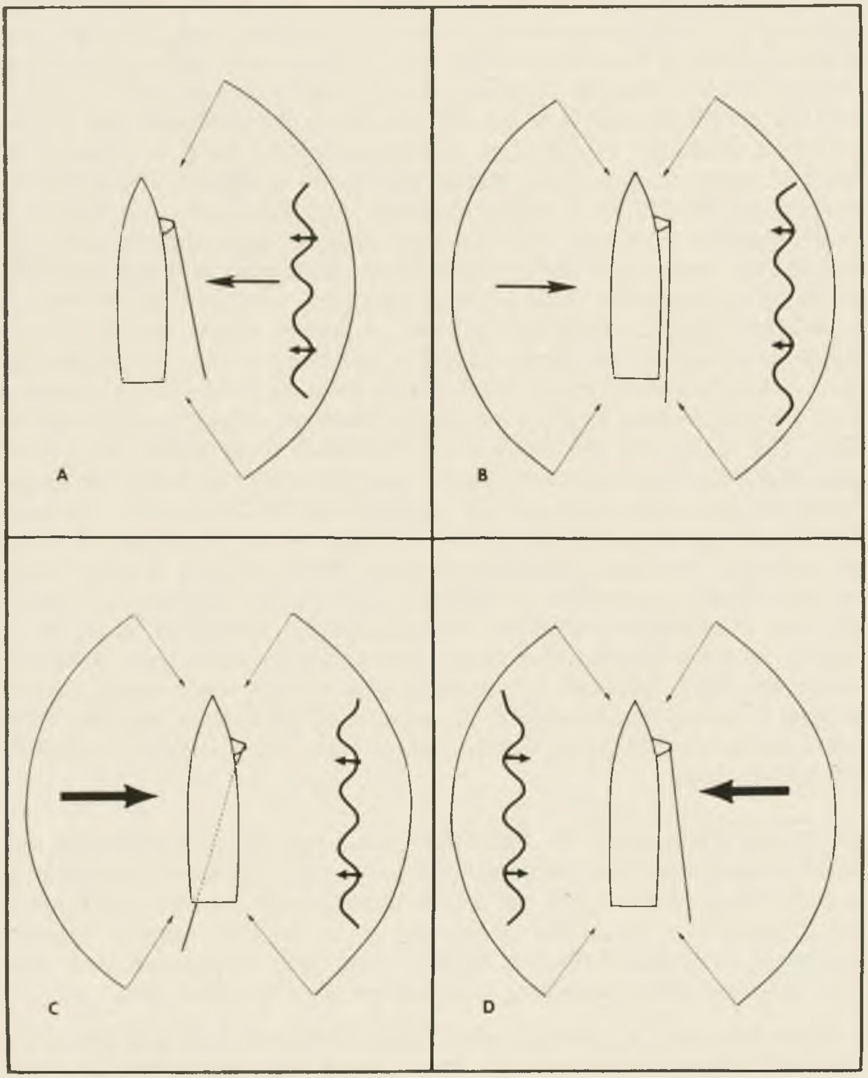

FIGURE 3. A-D. Effect of wind, sea and current on the position of ship and wire during trawling. (Wavy line indicates wind and sea, usually from the same direction, and arrow indicates current. Heavy arrow indicates strong current). A. Ideal situation with wind, sea, and current on starboard, or trawling side. B. Wind, sea and current counteracting each other. C. Current overriding wind and sea and setting ship down on wire. D. Current overriding wind and sea and setting ship away from wire.

starboard side of the ship in order to keep the ship off the wire while trawling, current direction is more difficult to determine and it often occurs that while the tow is perfect as far as wind and sea are concerned, the current may set from the opposite direction and be strong enough to move the ship to windward and down on the wire. If this occurs and not too much wire is out, it is possible to bring the ship slowly around until the wind and sea are on the port bow and the current on the starboard and the set can then continue. In areas of constantly shifting wind as during the tropical rainy seasons, the sudden change in direction accompanying passing squalls can be a vexing problem, and sometimes can force the discontinuance of a haul. For very deep tows the wire angle is such that the ship can turn "over" the wire permitting adjustments of course according to changing conditions. Thus in very deep tows wind and sea are less of a problem. With the wind and sea and/or current astern, the speed over the bottom may be too great, making it necessary to stop the engines to slow down the bottom speed. With a head wind, sea and current, progress over the bottom may be too slow, and an increase of rpm's may be necessary. The speed over the bottom is very difficult to determine in tropical regions due to cloud cover and lack of good loran lines. It is then necessary to depend upon wire angle and the reading from the tensiometer. We have successfully trawled along the continental slope where this is not too steep by carefully following the depth contours. When trawling in these areas we have found it preferable to adjust the ship's course off shore or in shore in order to maintain the proper depth of bottom instead of taking in or paying out cable. On the other hand, when towing on other types of bottom where the depth increases or decreases over a fairly wide range, bottom contact is maintained by careful observation of the bottom with the PDR and continuous changes in the amount of cable out in order to maintain the proper ratio.

4. *10-foot Blake trawl.* — The Blake trawl has certain advantages and disadvantages that must be considered in its use. Due to its similarity to a double beam trawl (it is not a true beam trawl since the foot rope is not secured to a beam but hangs free as in an otter trawl), its most important advantage is that the mouth is held open by the rigid frame and both sides are alike, permitting it to fish properly on either side.

Since this trawl is generally shot vertically its most obvious and often cited difficulty is the danger that the cod end may wrap about the wire, obstructing or damaging the net and kinking the wire. Menzies (1964) has solved this in use aboard the USNS Eltanin by enclosing the net in a rectangular metal frame within which the cod end is stretched out and secured. This is a cumbersome method and the large frame is dangerous to swing over the side in a seaway and disliked by the ship's crew. The Soviet scientists aboard the Vityaz have used a V-shaped metal frame, fixed rigidly to the trawl frame, which holds the bag in an extended position. This is less difficult to use.

We have not used such frames, but instead attach a 50 to 150-pound weight to the cod end. In shooting, the ship is brought into towing position, way is taken off and the net is lowered vertically until it has nearly reached the bottom. At this point, the winch is stopped, the ship is brought slowly ahead to an estimated 2 knots over the bottom and pay out continues until the desired amount of wire is out. In this fashion, prompt bottom contact is virtually certain and can be verified by changes in the tensiometer readings. In the PILLSBURY operations we have had only one case of the net fouling the wire and one case of failure to make bottom contact.

Obviously there are two major problems in both otter-trawl and Blake-trawl operations. First is putting the gear on the bottom and keeping it there; and second is moving it across the bottom. To accomplish these it

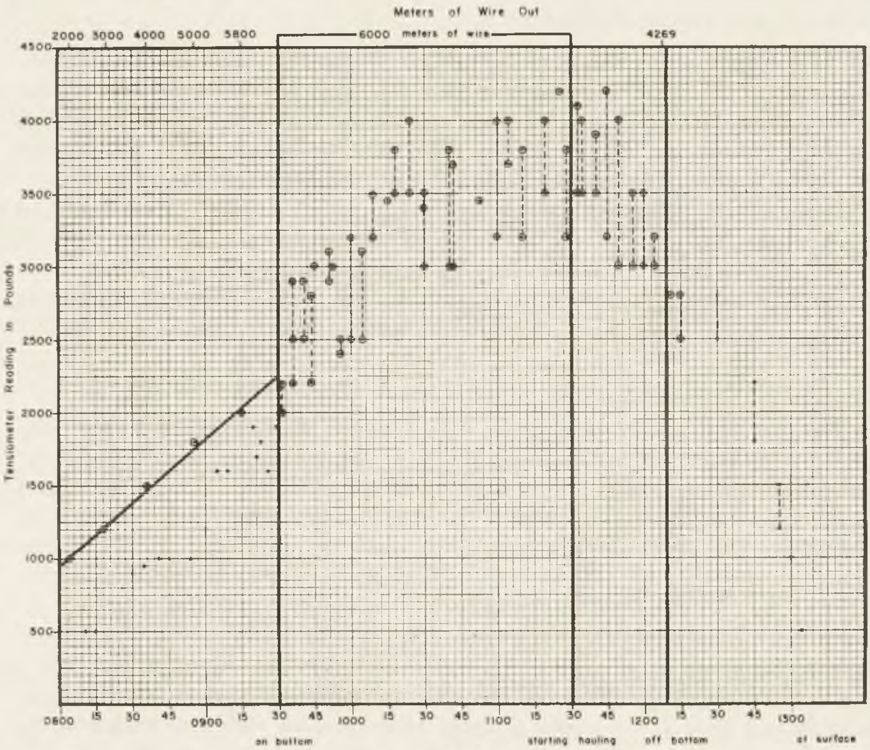

FIGURE 4. Graph showing tensiometer readings during Sta. P-34 with the Blake trawl. Dots are tensiometer readings while cable was being payed out or hauled in. Circles are tensiometer readings when winch was stopped. Dashed lines connect tensiometer readings over a one minute period. Bottom depth was about 2000 meters.

is absolutely necessary to know when bottom contact is made, how much wire is needed, and the speed of the ship over the bottom.

Careful observation of the tensiometer can determine when the net touches bottom. This has been discussed in detail by Menzies, using accumulator readings. The use of the tensiometer and a sample of tensiometer readings is given in Figure 4. Within sight of land and with good radar targets, speed over the bottom can be determined from continuous fixes. In mid-ocean, celestial navigation provides a less accurate means, but satellite navigation may eventually solve this. In the meantime, we have reverted to personal knowledge of the ship's towing characteristics and wire angle.

The amount of wire to be payed out for trawling with both otter trawl and Blake trawl in depths below 1,000 meters is taken directly from Kullenberg's graphs which are reproduced in Figure 5. Calculations derived from this graph have been shown to be accurate for our gear and are used faithfully aboard the PILLSBURY.

5. *The Albatross Box-dredge.* — The box dredge is used on hard bottom, but preferably not on rock bottom. When used properly, it obtains a good sample from ground that would tear the usual trawl net to pieces. If used improperly, it may take a single deep bite or gouge into the bottom obtaining a very poor sample of the life living on and beneath its surface. The box dredge is set with the vessel stopped and is lowered vertically to the bottom. Very slow way is then put on the vessel and the cable is paid out. The length of cable used for dredging is largely dependent upon the type of bottom, and the least scope possible to maintain bottom contact aids in getting a continuous surface cut rather than a single deep bite.

DISCUSSION AND ACKNOWLEDGMENTS

The descriptions of the gear used aboard the PILLSBURY and the methods and techniques of using it are based upon our own experiences and observations. This account is given in the hope that it will aid others in overcoming similar problems. It is a curious fact that despite the narratives and gear descriptions given for the major expeditions, few actual descriptions of methods and techniques have been included. Menzies (1964) has received the literature on this subject and has pointed out that even today methods and techniques are in the main passed on from person to person or gleaned from scanty observations. Menzies (loc. cit.) has the first detailed account of many of the problems of deep-sea trawling. It is hoped that the present account will in some ways supplement his paper as it deals more specifically with details of certain problems.

In writing this account I have been fortunate to have had the assistance of a number of people. In particular I wish to thank my colleagues C. Richard Robins and Frederick M. Bayer for their criticisms, advice, and assistance. Jon Staiger and William Eschmeyer pointed out discrepan-

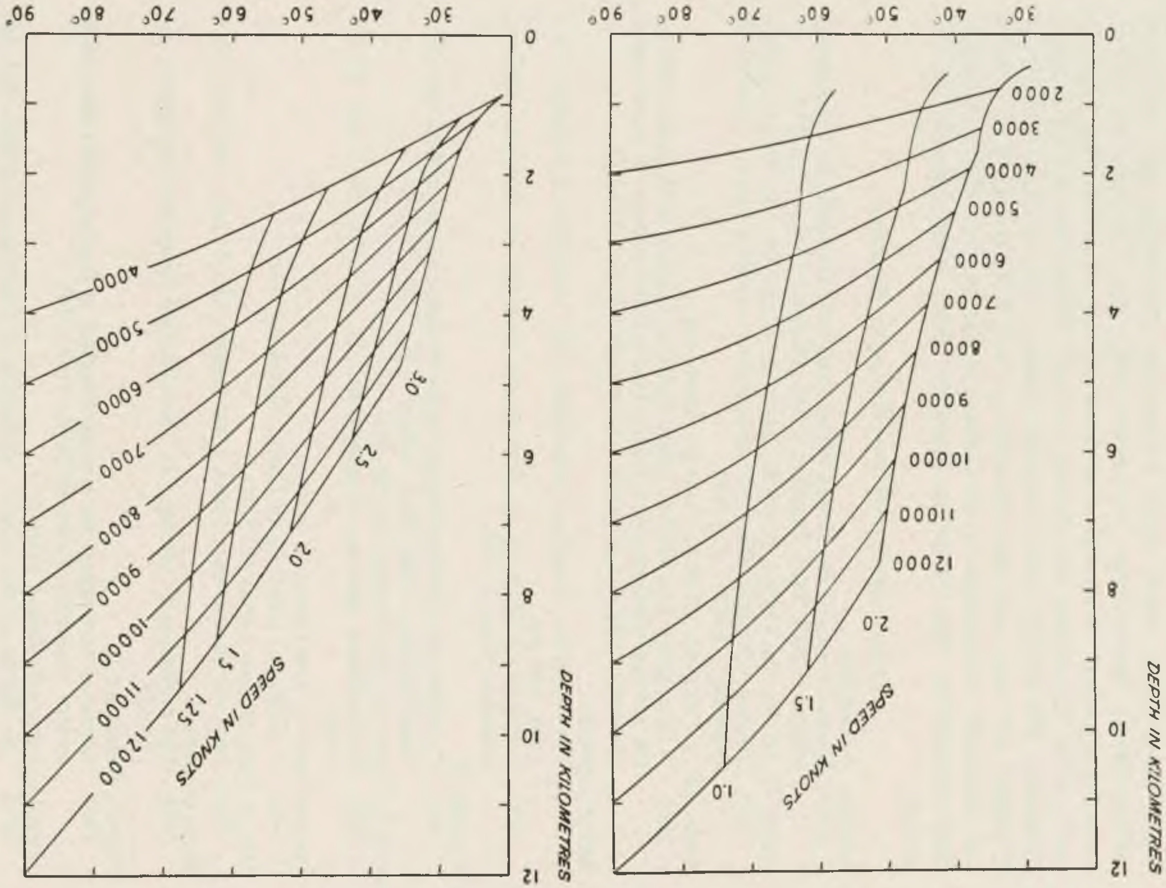

FIGURE 5. Kullenberg's diagram for calculating the length of wire to be payed out: *left,* otter trawl; *right,* beam or Blake trawl. The abscissa is the wire angle. (From Kullenberg, 1956, p. 113).

cies and added much useful information. Capt. Richard Gledhill assisted in obtaining gear data. In particular I wish to thank the master of the R/V PILLSBURY, Capt. Arthur Hollerich, and the chief engineer, Mr. James Dunlop, for much useful information concerning gear operation and machinery, respectively. The present bos'n, Mr. Roy Johnson, offered several suggestions. A special word of thanks is offered to the previous bos'n of the PILLSBURY who served on both African cruises, Mr. James Matheson. His willing hand, inventive genius, and profound knowledge of rigging and wire rope often brought us back from the edge of disaster and materially contributed to the success of the cruises. The illustrations were executed by Miss Constance Stolen to whom grateful thanks are extended.

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

—3—

DREDGING AND TRAWLING RECORDS OF R/V JOHN ELLIOTT PILLSBURY FOR 1964 AND 1965[1]

COMPILED ON SHIPBOARD BY MEMBERS OF THE SCIENTIFIC PARTIES
ASSEMBLED AND EDITED BY FREDERICK M. BAYER

The following table presents the records of dredging and trawling stations occupied by R/V JOHN ELLIOTT PILLSBURY during three biological cruises in 1964 and 1965. Two of these cruises, one in May-June 1964, the other in May 1965, were in the Gulf of Guinea. In order to make available all of the biological dredging records of R/V PILLSBURY, those of the Bermuda cruise, July-August 1964, are included here in numerical order.

The gear used and its method of operation have been essentially the same on all cruises and have been described in the foregoing pages by Voss (pp. 61-81). For the present purposes it is necessary only to list the types of gear noted in the tables and give such abbreviations as are used for them.

BLAKE TRAWL. — A 3-meter model with frame slightly modified from the original design. (See Voss, p. 64.)

DREDGE. — Metal dredges considerably modified after the design used aboard the BLAKE and the ALBATROSS. Two sizes are used, one 3 feet across the mouth, the other 4 feet. (See Voss, p. 65.)

GULF III-A HIGH SPEED PLANKTON SAMPLER (HSPS). — This device was not used in the Gulf of Guinea. It is described by Gehringer, 1952.

ISAACS-KIDD MID-WATER TRAWL (IKMT). — The 10-foot model is standard on all cruises. (See Voss, p. 63.)

NIGHT LIGHT. — Several types of lights were used over the side to attract animals within range of dip nets. A professional Navy diver's light, 1,000 watts, water cooled, was usually employed at formal night-light stations. A smaller unit, consisting of an ordinary 150-watt incandescent bulb in water-tight housing, was sometimes used when operation of the large light was inconvenient. Occasionally the deck-lights and flood-lights on the A-frame were used. All such stations are listed as "Night light and dip net" stations. (See Voss, p. 63.)

OTTER TRAWLS (OT). — The 10-foot model (try net) and the 40-foot shrimp trawl are standard on all cruises. (See Voss, p. 64.)

PLANKTON NETS. — Standard non-closing 1-meter and 2-meter nets equip-

[1]Contribution No. 731 from the Institute of Marine Science, University of Miami.

ped with 00 nylon mesh were used during the Bermuda cruise. These nets were manufactured by Ernest Case, R.D. 1, Andover, New Jersey.

A 12-inch net was occasionally used in the Gulf of Guinea.

PRONOXFISH. — An emulsifiable rotenone preparation used by shore-parties to collect organisms in littoral habitats.

SURFACE NET. — A conical net made of ¼-inch nylon netting mounted on a metal hoop 0.5 meters in diameter and towed like a plankton net immediately below the surface.

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Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
	Lagos, Nigeria												
P-1	23 May	1500	1600	—	—	—	—	—	tide pools	—	—	Shore collecting	Shore crabs and fishes.
P-2	23 May	2000	2400	—	—	—	—	—	surface	—	—	Night light, dip net	Crustaceans, fishes.
	Lagos to Cape St. Paul, Ghana (H.O. chart 2350)												
P-3	24 May	1120	1200	6°13′N	3°22′E	—	—	64-55	55-64	225	—	40′ OT	Gear lost.
P-4	24 May	1455	1523	[5°37′N	3°19′E	5°57′N	3°13′E]	1876-1263	1876-1263	4438	—	Blake Trawl	Black mud. Good catch of invertebrates; pogonophorans abundant.
P-5	24 May	1931	2052	[5°45′N	3°08′E	5°41′N	3°09′E]	2113-2306	2113-2306	6400	—	Blake Trawl	Net fouled on wire.
P-6	24 May	2100	2230	[5°41′N	3°09′E	—	—]	—	surface	—	—	dipnet	Myctophids and *Ommastrephes*.
P-7	25 May	0300	0502	5°35.5′N	3°10′E	—	—	2754-2837	2754-2837	6500	—	Blake Trawl	Net not on bottom.
P-8	25 May	0020	0115	[5°32′N	3°10′E	—	—]	—	surface	—	—	dipnet	Myctophids; flying fish; *Coryphaena*.
P-9	25 May	0805	1005	—	—	5°42′N	3°05′E	2837	295-423*	700-1000	65°	10′ IKMT	Poor catch in DSL.
P-10	25 May	1430	1630	[5°55′N	2°52′E	5°58′N	2°50′E]	1819-2268	655-1065	3000	—	10′ IKMT	Good catch; many large copepods.
P-11	25 May	1818	2025	[5°57′N	2°49′E	see navigational chart		1536-1353 1682-1609	92-114	270	65°-70°	10′ IKMT	Good catch; several squids included.
P-12	25 May	1830	1930	6°00′N	2°50′E	—	—	—	surface	—	—	0.5m surface net	Decapod larvae; Mullidae.
P-13	26 May	0103	0136	—	—	6°08′N	2°09′E	55	55	250	—	6′ OT	Fair catch; fish and invertebrates.
P-14	26 May	0521	—	6°02′N	1°29′E	—	—	38	38	200-250	—	6′ OT	Gear lost.
	Cape St. Paul to Cape Coast, Ghana (H.O. chart 2349)												
P-15	26 May	1034	1047	—	—	5°36′N	0°51′E	20-79	20-79	120	—	6′ OT	Many hermit crabs.

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-16	26 May	1318	1350	5°40′N	0°30′E	5°40′N	0°17′E	46
P-17	26 May	1536(?)	1633	5°35′N	0°10′E	5°36′N	0°11.5′E	48
P-18	26 May	2221	2324	[5°04′N	0°12′E]	5°01′N	0°12′E	3047-3129
P-19	26/May 27	1935	0135	[5°12′N	0°12′E	4°58′N	0°12′E]	—
P-20	27 May	0823	1025	—	—	4°56′N	0°13′E	3411-3246
P-21	27 May	1700	1905	5°07′N	0°05′E	5°10′N	0°04′E	2926-2450
P-22	27 May	2158	2225	5°25′N	0°01′W	5°22′N	0°02′W	51
P-23	28 May	0150	0220	5°10′N	0°25′W	5°08′N	0°28′W	42
P-24	28 May	0511	0541	4°56′N	0°47.5′W	4°56′N	0°50′W	37-35
P-25	27 May	1930	—	[5°11′N	0°30′E]	—	—	—
	Cape Coast, Ghana, to Grand Bassam, Ivory Coast (H.O. chart 2348)							
P-26	28 May	0906	0935	4°57′N	1°16′W	4°59′N	1°16.5′W	27
P-27	28 May	1232	1300	4°48′N	1°42′W	4°49′N	1°47′W	33
P-28	28 May	1452	1522	4°40′N	2°00′W	[4°39′N	2°02′W]	49-53
P-29	28 May	1555	1630	[4°38′N	2°02′W	4°36′N	2°00′W]	58-60

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
46	275	—	6′ OT	Good catch. Bottom covered with forams, mollusks abundant; *Penaeus.*
48	135-180	—	40′ OT	Large catch of fishes incl. *Boops, Vomer, Pagrus* etc.
3047-3129	8700	—	Blake Trawl	Polychaetes; echinoderms; *Oöcorys.*
surface	—	—	Dipnet	Crustacean larvae; fishes.
1650-2125	6000(?)	—	10′ IKMT	Crustaceans abundant.
1150-1450	4500	—	10′ IKMT	Abundant crustaceans; cephalopods; several fishes, incl. *Lynophryne.*
51	275	—	6′ OT	Mollusks and crustaceans abundant.
42	275	—	6′ OT	Catch small due to fouled bridle. Echinoderms, crustaceans common; mollusks rather sparse.
37-35	275	—	6′ OT	Very diverse catch.
—	—	—	—	*Parexocoetus brachypterus* flew on deck.
27	164	—	6′ OT	Shell bottom (scallops); echinoderms, numerous crustaceans.
33	165	—	6′ OT	Sparse catch of fishes; squids, alcyonarians.
49-53	275	—	6′ OT	Mediocre catch.
58-60	275	—	40′ OT	Very large catch of fishes, *Penaeus* abundant.

Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1964	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-30	28 May	2027	2055	4°46′N	2°30′W	4°45′N	2°33′W	60-64	61-64	270	—	40′ OT	Large catch of fishes; *Penaeus* less abundant; coral.
P-31	28 May	—	—	tow during stations P-30 and 32				—	—	—	—	Surface and dip net	Flying fishes; megalopa larvae.
P-32	28 May	2242	2312	4°37′N	2°32′W	4°38′N	2°35′W	110	110	540	—	40′ OT	Echinoderms, crustaceans.
P-33	29 May	0302	0351	4°21′N	2°34′W	—	—	1353-1445	1353-1445	4000-4400	—	Blake Trawl	Trawl on bottom only briefly; midwater fishes.
P-34	29 May	0936	1133	3°53′N	2°33′W	[3°47′N	2°33′W]	1984-1948	1984-1948	5600	—	Blake Trawl	Fair catch of fishes, echinoderms, crustaceans.
P-35	29 May	—	—	—	—	—	—	—	surface	—	—	Surface net	Medusae.
P-36	29 May	1510	1730	3°50′N	2°37′W	—	—	1975	750	2400	—	10′ IKMT	Good catch of fishes, crustaceans.
P-37	29 May	1944	2146	4°00′N	2°46′W	4°05′N	2°50′W	2232-1994	480-490	1600	—	10′ IKMT	Predominantly crustaceans.
P-38	29 May	—	—	—	—	—	—	—	surface	—	—	Surface net	Flying fishes; crustacean larvae.
P-39	30 May	0032	0230	4°24′N	3°00′W	[4°30′N	3°06′W]	2450-2195	300	900	—	10′ IKMT	Mostly crustaceans.
P-40	30 May	0435	0621	[4°39′N	3°10′W]	4°47′N	3°10′W	942-393	200	600	—	10′ IKMT	Fair catch of fishes: crustaceans, incl. many hyperiids.
P-41	30 May	0954	1054	4°47′N	3°33′W	4°47′N	3°35′W	641-842	641-842	3600	—	6′ OT	Good haul of crustaceans.
	Grand Bassam to San Pedro River, Ivory Coast (H.O. chart 2347)												
P-42	30 May	1420	1449	5°02.5′N	3°49.5′W	5°05′N	3°52′W	75-62	75-62	375	—	6′ OT	Excellent haul; mud with forams; crustaceans abundant.
P-43	30 May	—	—	—	tow during station P-42			—	surface	—	—	0.5m surface net	Portunid crabs.
P-44	30 May	1654	1738	5°05′N	4°00′W	5°04′N	4°02′W	586-403	586-403	2700-2520	—	6′ OT	Hard, dark grey mud. *Opisthoteuthis;* other mollusks, crustaceans.

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-45	30 May	1901	1945	5°05′N	4°04.5′W	5°06′N	4°06′W	73-97
P-46	30 May	2255	2329	5°07′N	4°32′W	5°07′N	4°36′W	42-38
P-47	31 May	0117	0145	5°04.5′N	4°51.5′W	(see Remarks)		37
P-48	31 May	0407	0437	[5°05′N	4°59.5′W	(see Remarks)]		22
P-49	31 May	0530	0600	5°00′N	5°00′W	4°59′N	5°00′W	73-77
P-50	31 May	0637	0700	4°58′N	5°00′W	4°57′N	5°01′W	128-192
P-51	31 May	0905	0930	4°56′N	5°01′W	4°56.6′N	5°03′W	494-329
P-52	31 May	1200	1229	4°54′N	4°58′W	4°54′N	4°56.5′W	952-915
P-53	31 May	1520	1740	4°50′N	4°55′W	4°51′N	5°00′W	1579-1519
P-54	31 May	2000	—	—	—	—	—	2305
P-55	31 May	2000	2230	4°43.5′N	5°07′W	4°43.5′N	5°04′W	—
P-56	31 May/ 1 June	2330	0140	4°40′N	5°04′W	4°33′N given as "gear down" posit. in log	5°04′W	2305-2725
P-57	31 May/ 1 June	—	—	—	tow during station P-56			—
P-58	1 June	1050	1121	4°56′N	5°15′W	4°56′N	5°17.5′W	988-823
P-59	1 June	1203	1234	4°57.5′N	5°22′W	4°57′N	5°30′W	64-55

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
73-97	360-400	—	40′ OT	Catch consists mostly of crustaceans.
42-38	250	—	6′ OT	Mud bottom with dense growth of *Jullienella;* abundant crustaceans, mollusks.
37	180	—	6′ OT	Haul similar to preceding.
22	300	—	6′ OT	Fishes relatively few; crustaceans.
73-77	360	—	6′ OT	Fishes few; crustaceans, echinoderms abundant.
128-192	720	—	6′ OT	Fishes include cardinal- and flatfishes; abundant pagurids.
494-329	2000-2440	—	6′ OT	Numerous fishes; shrimps abundant.
952-915	4650	—	6′ OT	Fishes sparse; pennatulid.
1579-1519	4860-5000	—	Blake Trawl	Good haul. Numerous scaphopods, echinoderms.
—	—	—	10′ IKMT	Gear lost.
surface	—	—	Night light	Myctophids, flyingfishes, young *Coryphaena.*
800	3200	—	Blake Trawl in midwater	Unsatisfactory procedure.
surface	—	—	0.5m net	—
988-824	46-40	—	6′ OT	Gear lost.
64-55	270	—	6′ OT	Mud bottom with dense foram population. Mollusks, crustaceans abundant.

Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1964	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-60	1 June	1455	1523	4°55′N	5°34.5′W	4°54′N	5°37′W	79-82	79-82	360	—	6′ OT	Most of catch lost due to net damage on coral.
P-61	1 June	1833	1903	4°46.5′N	5°47′W	4°46.5′N	5°49′W	82-79	82-79	405	—	40′ OT with liner	Net fouled, no catch.
P-62	1 June	2255	2326	4°45′N	6°13.5′W	4°44′N	6°16′W	46	46	300-325	—	6′ OT	Dense population of branching and foliate forams; crustaceans abundant.
	San Pedro River, Ivory Coast, to Sinu Bay, Liberia (H.O. chart 2346)												
P-63	2 June	0245	0316	4°35′N	6°40′W	4°35′N	6°41′W	64	64	400	—	6′ OT	Sandy mud and shells. Mollusks abundant. Brotulids, flatfishes numerous.
P-64	2 June	0643	0715	4°23′N	7°06.5′W	4°22′N	7°08.5′W	68	68	338	—	6′ OT	Small but good collection of fishes; solitary corals.
P-65	2 June	1047	1208	4°15′N	7°32′W	4°12′N	7°35.5′W	46-77	46-49	250	—	40′ OT	Good catch of fishes.
P-66	2/3 June	2225	0307	3°31′N	7°34.5′W	no DR pos. for ref.		4045-4008	4045-4008	8000-9000	—	Blake Trawl	Net fouled; poor catch.
P-67	2/3 June	2000	—	no reliable DR position for reference				—	surface	—	—	Night light, dip net	Squid, flyingfishes, myctophids; salps.
P-68	3 June	1406	1441	4°23′N	8°05.5′W	4°24′N	8°07.5′W	70	70	335	—	6′ OT	Fair catch of fishes.
P-69	3 June	1550	1555	4°29.5′N	8°06′W	4°29.5′N	8°07.5′W	29	29	130	—	6′ OT	Bad haul.
P-70	3 June	1610	1640	4°30′N	8°09′W	4°29.5′N	8°09′W	33	33	130-160	—	6′ OT	Serranids, anchovies and clingfishes.
	Sinu Bay to Cestos Bay, Liberia (H.O. chart 2200)												
P-71	4 June	0255	0555	4°23′N	9°27′W	4°30′N	9°18′W	997-558	997-558	2800-1760	—	Blake Trawl	Gear lost.
P-72	4 June	0155	0230	while letting out gear for P-71				—	surface	—	—	Night light	Flyingfishes.
P-73	4 June	0925	1029	4°38′N-?	9°20′W-?	4°40′N	9°20′W	366-311	366-311	1800	—	40′ OT	Good haul of crustaceans, cephalopods, fishes.
P-74	4 June	1242	1415	4°20′N	9°26′W	4°30′N	9°22′W	733-641	733-641	1000(?)	—	40′ OT	Good haul of crustaceans, fishes.

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-75	4/5 June	—	0530	during station P-76		—	—	—
P-76	4 June	2233	2335	4°32′N	9°42′W	4°40′N	9°49′W	1556-1464
P-77	5 June	0911	0929(?)	—	—	—	—	1830
P-78	5 June	1028(?)	1029	stations not plotted		—	—	1748
P-79	5 June	1130	1133	—	—	—	—	1446
P-80	5 June	1252	—	—	—	—	—	690
P-81	5 June	1309	—	—	—	—	—	699
	Off Baffu Bay, Liberia (H.O. chart 2345)							
P-82	5 June	1519	1620	4°57′N	9°30′W	4°58′N	9°32′W	150-146
P-83	5 June	1825	1925	4°59′N	9°37′W	4°57.5′N	9°33′W	220-156
	Miami, Florida, to Challenger Bank							
P-85	24 July	2155	2240	26°52′N	79°15′W	26°55′N	79°16′W	—
P-86	24/July 25	2240	0115	26°54′N	79°16′W	26°58′N	79°14′W	—
P-87	25 July	0439	0544	—	—	27°30′N	79°36′W	686
P-88	25 July	0855	0950	27°57′N	79°38′W	28°08′N	79°46′W	—
P-89	25 July	1202	1257	28°25′N	79°50′W	—	—	403
P-90	25 July	1634	1725	28°15′N	79°55′W	—	—	165-192
P-91	25 July	1822	1900	28°15′N	79°55′W	—	—	156-165

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
surface	—	—	Dipnet and surface tow	Dense swarm of salps.
1556-1464	7200	—	40′ OT	Huge catch of *Flabellum*. Fishes include chimaerid, brotulids, etc.
1830(?)	—	—	Smith-Mc-Intyre grab	Malfunction.
1748(?)	—	—	Smith-Mc-Intyre grab	Malfunction.
1446	—	—	Smith-Mc-Intyre grab	Malfunction.
—	—	—	Smith-Mc-Intyre grab	Malfunction.
699	—	—	Smith-Mc-Intyre grab	Malfunction.
150-146	775	—	40′ OT	Eight large seabasses. Crustacea, echinoderms.
220-156	1020	—	40′ OT	One large seabass. Crustacea.
surface	—	—	2 m. plankton net	Scattered *Sargassum* and detritus; stomatopod larvae.
surface	—	—	Night light	—
686	2800	—	20′ OT	—
surface	15	—	Gulf III-A HSPS	—
403	1700	—	10′ OT	Ovigerous *Glyphocrangon*; large galatheid.
165-192	700	—	10′ OT	Pogonophora; asteroids.
156-165	700	—	10′ OT	A few crustaceans, one asteroid; fish probably from near surface.

DREDGING AND TRAWLING RECORDS OF THE RESEARCH

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-92	25 July	1835	1915	28°15′N	79°55′W	—	—	155-165
P-93	25 July	2030	2055	28°27′N	79°54′W	28°25′N	79°50′W	512
P-94	25 July	2100	2255	28°25′N	79°50′W	28°42′N	79°42′W	—
P-95	26 July	0105	0230	28°46′N	79°38′W	28°51′N	79°37′W	732-713
P-96	26 July	0050	0230	28°46′N	79°38′W	28°51′N	79°37′W	732-713
P-97	26 July	0955	1133	29°45′N	78°52′W	29°53′N	78°43′W	732
P-98	26 July	1500	1521	29°53′N	78°43′W	—	—	736
P-99	26 July	1402	1602	29°53′N	78°43′W	—	—	736
P-100	26 July	2000	2100	30°06′N	78°42′W	—	—	732
P-101	26 July	2130	2200	30°09′N	78°48′W	30°12′N	78°55′W	—
P-102	26 July	2300	2400	30°12′N	78°55′W	—	—	747
P-103	26/July 27	2315	0045	30°12′N	78°55′W	—	—	—
P-104	27 July	1217	1315	31°00′N	79°50′W	—	—	247
P-105	27 July	1510	1610	30°58′N	79°42′W	—	—	388-402
P-106	27 July	1932	2237	31°10′N	79°19′W	—	—	539-475
P-107	27 July	2050	2145	30°08′N	79°23′W	—	—	494-486

VESSEL *John Elliott Pillsbury* FOR 1964 AND 1965

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
2	—	—	Gulf III-A HSPS	—
2	80	—	2 m. plankton net	—
surface	—	—	Night light	—
100(?)	300	—	10′ IKMT	Excellent haul of gonostomatids, carangids, larval fishes and crustaceans.
surface	—	—	Gulf III-A HSPS	—
—	3200	—	40′ OT	Net not on bottom.
—	4000	—	40′ OT	Cable parted, gear lost.
0-3	—	—	Gulf III-A HSPS	—
10*, 20*	20, 40	60°	1 m. plankton net	—
3	—	—	Gulf III-A HSPS	—
—	3200	—	10′ OT	—
surface	—	—	Night light	—
247	1040	—	40′ OT	Clay bottom. Crustaceans incl. many *Cancer;* Octopus; some fishes.
388-403	1700	—	40′ OT	Hydroids, alcyonarians, sponges; pycnogonid; echinoderms; few fishes.
40-60	180	—	10′ IKMT	Juvenile sailfish, kept alive in aquarium.
5, 15	95	—	1 m. plankton net	—

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-108	27/July 28	2310	0010	—	—	—	—	457
P-109	28 July	0130	0220	—	—	—	—	—
P-110	28 July	0657	1724	32°00′N	79°29′W	—	—	55-46
P-111	28 July	0739	0836	—	—	32°08′N	79°30′W	46
P-112	28 July	1028	1243	32°08′N	79°16′W	—	—	70-95
P-113	28 July	1835	1944	31°49′N	77°51′W	—	—	667-631
P-114	28 July	2016	2101	31°49′N	77°51′W	—	—	640-576
P-115	28 July	2145	2230	31°49′N	77°51′W	—	—	622-658
P-116	28 July	2255	2330	31°51′N	77°29′W	—	—	732-759
P-117	28/July 29	2340	0100	31°51′N	77°29′W	—	—	732
P-118	29 July	0400	0510	31°52′N	76°49′W	—	—	2195
P-119	29 July	0515	0600	31°52′N	76°49′W	—	—	2195
P-119A	29 July	0600	0645	31°52′N	76°49′W	—	—	2195
P-120	29 July	0847	1049	31°48′N	76°38′W	31°49′N	76°26′W	2196?-2379
P-121	29 July	1032	1233	31°49′N	76°26′W	—	—	2195
P-122	29 July	1945	2015	31°49′N	74°59′W	—	—	4023

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
—	—	—	2 m. plankton net	—
surface	—	—	Night light	Few fish about the light; juvenile exocoetid, larval angelfish.
55-46	170	—	10′ OT	—
46	200	—	10′ OT	Many scallops and other mollusks.
70-95	350	—	40′ OT	Fair catch of fishes, squid.
50	250	—	10′ IKMT	—
110-120	300	—	10′ IKMT	—
10	60	—	2 m. plankton net	—
5	40	—	1 m. plankton net	—
surface	—	—	Night light & 1 m. plankton net	Poor catch.
surface	—	—	Night light & 1 m. plankton net	—
surface	—	—	1 m. plankton net	Istiophorid, about 14 mm.
surface	—	—	1 m. plankton net	—
2196?-2379	5500	—	Blake Trawl	Ovigerous *Parapagurus; Ipnops*, macrourids, *Halosaurus*.
surface	—	—	1 m. plankton net	—
15-20*	80	—	1 m. plankton net	Good catch of plankton with many larval fishes.

Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1964	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-123	29 July	2030	2100	31°49′N	74°59′W	—	—	4023	5*	25	—	1 m. plankton net	—
P-124	29 July	2107	2118	31°49′N	74°59′W	—	—	4023	surface	10	—	1 m. plankton net	—
P-125	29 July	2130	2300	31°49′N	74°59′W	—	—	—	surface	—	—	Night light	—
P-126	29 July	2150	2300	31°49′N	74°59′W	—	—	—	surface	—	—	1 m. plankton net	—
P-127	30 July	1705	—	32°00′N	71°07′W	—	—	5194	surface	4	—	Gulf III-A HSPS	Much small zooplankton, few fish larvae; gempylid.
P-128	30 July	1910	1940	32°05′N	70°46′W	—	—	5194	10-12*	70	—	1 m. plankton net	Crustacean larvae; larval white marlin, about 14 mm; *Mola mola.*
P-129	30 July	2018	2045	32°00′N	70°37′W	—	—	5194	surface	10	—	1 m. plankton net	Much *Sargassum.*
P-130	30 July	2155	2205	32°00′N	70°35′W	—	—	5194	surface	—	—	Night light	Poor catch; much *Sargassum.*
P-131	30/July 31	—	—	—	—	—	—	—	3	—	—		Flying fish on deck.
			Vicinity of Challenger Bank										
P-132	31 July -1 Aug.	—	—	32°06′N	65°05′W	—	—	55	surface	—	—	Night light	—
P-133	1 Aug.	0045	0100	32°06′N	65°05′W	—	—	58	59	120	—	1 m² dredge	Rubble with algae, alcyonarians; ovigerous *Calcinus verrillii.*
P-134	1 Aug.	0125	0145	32°06′N	65°05′W	—	—	55	55	—	—	1 m² dredge	Rubble. *Calcinus verrillii, Dardanus venosus.*
P-135	1 Aug.	0215	0227	32°05′N	65°05′W	—	—	55	55	120	—	1 m² dredge	—
P-136	1 Aug.	0307	0328	32°05′N	65°03′W	—	—	51	51	120	—	1 m² dredge	Large coral rock with attached fauna.
P-137	1 Aug.	0430	0530	32°05′N	65°05′W	—	—	53	surface	—	—	Plankton nets	—
			Challenger Bank to Bermuda										
P-138	1 Aug.	0540	0635	32°05′N	65°02′W	—	—	55	10	50	—	1 m. plankton net	—

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Lat. Lat.	Long. Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-139	1 Aug.	0645	0730	32°09′N	64°58′W	—	—	878
P-140	1 Aug.	0750	0845	32°10′N	64°56′W	—	—	—
P-141	1 Aug.	0905	1300	32°10′N	64°55′W	—	—	878-2012
				St. George's Harbor, Bermuda				
P-142	2 Aug.	0030	0230	32°24′N	64°41′W	—	—	9
				East and North of Bermuda				
P-143	3 Aug.	1910	2018	32°42′N	64°33′W	32°46′N	64°33′W	1573-2926
P-144	3 Aug.	2025	2115	32°46′N	64°33′W	—	—	2743
P-145	3 Aug.	2135	2215	32°45′N	64°33′W	—	—	201
P-146	3 Aug.	2251	2325	32°40′N	64°33′W	—	—	—
P-147	4 Aug.	0040	0120	32°43′N	64°35′W	—	—	—
P-148	4 Aug.	0137	0220	32°43′N	64°35′W	32°46′N	64°32′W	1500-1939
P-149	4 Aug.	0224	0335	32°46′N	64°33′W	32°43′N	64°33′W	2195
P-150	4 Aug.	0550	0715	32°43′N	64°34′W	—	—	2743-1317
P-151	4 Aug.	0747	0945	32°43′N	64°34′W	32°40′N	64°38′W	1280-2012
P-152	4 Aug.	1139	1330	32°41′N	64°38′W	32°33′N	64°27′W	3109-2468
				Bermuda to Bahamas,				
P-153	5 Aug.	1828	2129	30°28′N	66°52′W	30°08′N	67°07′W	4865-4938
P-154	5 Aug.	1848	2200	30°21′N	66°58′W	30°08′N	67°07′W	4901

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
1-3	30	—	1 m. plankton net	—
surface	—	—	1 m. plankton net	—
surface	5	—	Gulf III-A HSPS	Zooplankton rich; copepods, gastropods, few fish larvae.
surface	—	—	Night light	Halfbeaks, clupeids, atherinids; squids seen but not caught.
surface	—	—	Gulf III-A HSPS	—
10	80	—	1 m. plankton net	Excellent plankton collection; many fish larvae.
surface	20	—	1 m. plankton net	—
—	200	—	1 m. plankton net	Rich haul.
surface	—	—	Night light	Flyingfish.
5	25	—	Gulf III-A HSPS	—
surface	10	—	Gulf III-A HSPS	—
40	180	—	10′ IKMT	—
300	900	—	10′ IKMT	Squids, good coll. fishes, incl. leptocephali, flounders.
900-1300	2500	—	10′ IKMT	—
1400	3500	—	10′ IKMT	—
10	15	—	Gulf III-A HSPS	—

Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1964	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-155	5/6 Aug.	2335	0012	30°11′N	67°07′W	30°11′N	67°08′W	4956	2, 20	65	—	1 m. plankton net	Surface tow filled with *Sargassum*, few fish larvae; deeper haul with fish larvae.
P-156	6 Aug.	0025	0115	30°11′N	67°08′W	—	—	4965	surface	—	—	Night light & 1 m. plankton net	Young *Remora*.
P-157	6 Aug.	1625	1925	29°40′N	69°55′W	29°30′N	69°58′W	6309	350	1200	—	10′ IKMT	—
P-158	6 Aug.	1627	1923	29°40′N	69°55′W	29°30′N	69°58′W	6309	15	37	40°	Gulf III-A HSPS	Poor results.
P-159	6 Aug.	2003	2045	29°28′N	70°03′W	29°24′N	70°03′W	6309	surface	3	—	Gulf III-A HSPS	—
P-160	6 Aug.	2105	2203	29°28′N	70°03′W	29°27′N	70°08′W	—	1, 31*	90	70°	1 m. plankton net	—
P-161	6 Aug.	2215	2330	29°27′N	70°08′W	29°25′N	70°09′W	—	surface	—	—	Night light & 1 m plankton net	—
P-162	7 Aug.	1634	1930	28°50′N	73°20′W	28°33′N	73°34′W	4444	550	2000	—	10′ IKMT	Excellent tow.
P-163	7 Aug.	1609	2100	28°50′N	73°20′W	28°30′N	73°39′W	4462	15-3	50-9	—	Gulf III-A HSPS	—
P-164	7 Aug.	2115	2215	28°30′N	73°39′W	28°27′N	73°42′W	4462	2	55	—	2 m. plankton net	—
P-165	7 Aug.	2235	2335	28°27′N	73°42′W	28°25′N	73°42′W	4462	60, 20*	150, 50	65°-70°	1 m. plankton net	Larval white marlin.
P-166	7/8 Aug.	2355	0110	28°25′N	73°42′W	—	—	—	surface	—	—	Night light & 1 m. plankton net	Larval white marlin.
P-167	8 Aug.	1451	1853	27°35′N	75°46′W	—	—	4755	1750	5000	—	10′ IKMT	—
P-168	8 Aug.	2017	2215	27°28′N	76°21′W	27°30′N	76°31′W	4846	1400	3000	—	10′ IKMT	—
P-169	8 Aug.	2115	2205	27°30′N	76°27′W	—	—	4938	surface	10	—	1 m. plankton net	—
P-170	8/9 Aug.	2329	0027	27°30′N	76°31′W	—	—	4755	20	60	—	10′ IKMT	—

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-171	8/9 Aug.	2333	0200	27°30′N	76°31′W	27°25′N	76°35′W	4755
P-172	9 Aug.	0055	0155	27°28′N	76°33′W	27°23′N	76°37′W	4755
P-173	9 Aug.	0245	0325	27°18′N	76°39′W	—	—	—
P-174	9 Aug.	0343	0452	27°18′N	76°39′W	—	—	2560-2103
P-175	9 Aug.	0500	0530	27°31′N	76°41′W	—	—	1646
P-176	9 Aug.	0635	0835	27°31′N	76°41′W	27°30′N	76°58′W	1280-1134
Vicinity of Little Bahama Bank								
P-177	9 Aug.	1203	—	27°46′N	77°08′W	27°58′N	77°05′W	1134
P-178	9 Aug.	1700	—	27°56′N	77°11′W	—	—	1189
P-179	9 Aug.	1943	2043	27°50′N	77°10′W	27°49′N	77°09′W	1280
P-180	9 Aug.	2053	2153	27°49′N	77°09′W	—	—	1170
P-181	9 Aug.	2203	2303	27°44′N	77°09′W	27°40′N	77°10′W	1061
P-182	9/Aug. 10	2315	0015	27°40′N	77°10′W	—	—	1134
P-183	10 Aug.	0030	0255	27°40′N	77°25′W	27°35′N	77°40′W	1152
P-184	10 Aug.	0310	0419	—	—	27°35′N	77°40′W	1152
P-185	10 Aug.	0425	0525	—	—	27°32′N	77°41′W	1170
P-186	10 Aug.	0535	0635	27°32′N	77°41′W	27°32′N	77°41′W	1280
P-187	10 Aug.	0826	0912	27°26′N	77°50′W	—	—	1373
P-188	10 Aug.	1330	1428	27°15′N	77°43′W	—	—	970

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
surface	10	—	1 m. plankton net	—
50	150	—	10′ IKMT	—
surface	—	—	Night light & 1 m. plankton net	—
20, 2*	50	—	1 m. plankton nets	Two small marlins.
20*	50	—	1 m. plankton net	—
400*	1200	—	10′ IKMT	—
—	4000	—	Blake Trawl	Gear lost.
—	3000	—	10′ OT	Gear lost.
21*	150	82°	1 m. plankton net	Gempylid, scorpaenids, pipefish, remora.
10*	60	80°	1 m. plankton net	Three marlins; otherwise poor catch.
17*	100	78°-82°	1 m. plankton net	One marlin.
10*	19	60°	Gulf III-A HSPS	—
7*	15	60°	2 m. plankton net	—
12*	60	—	1 m. plankton net	—
20*	100	—	1 m. plankton net	One marlin.
26*	150	80°	1 m. plankton net	—
1373	3500	—	10′ OT	Rocky bottom; gorgonians, echinoderms, shrimps, eel.
970	2500	—	10′ OT	Net lost.

Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1964	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-189	10 Aug.	1740	—	27°34′N	77°59′W	—	—	1134	—	3300	—	10′ OT	Net lost.
P-190	10 Aug.	2049	2225	27°25′N	78°08′W	—	—	1024	surface, 9*	30	72°	Night light & 2 m. plankton net	—
P-191	10 Aug.	2250	2345	27°26′N	78°16′W	—	—	1015	23*	55	65°	2 m. plankton net	—
P-192	11 Aug.	0001	0101	27°26′N	78°17′W	—	—	—	10*	60	80°	1 m. plankton net	Bottle smashed, no catch.
P-193	11 Aug.	0110	0210	27°28′N	78°14′W	27°30′N	78°17′W	1031	16*	90	80°	1 m. plankton net	—
P-194	11 Aug.	0236	0335	27°30′N	78°17′W	27°28′N	78°19′W	978	10*	60	80°	1 m. plankton net	—
P-195	11 Aug.	0345	0435	27°28′N	78°19′W	—	—	960-951	20*	120	80°	1 m. plankton net	—
P-196	11 Aug.	0450	0545	—	—	27°37′N	78°27′W	951-923	27*	160	80°	1 m. plankton net	—
P-197	11 Aug.	1148	1400	27°59′N	79°20′W	—	—	586-567	586-567	2000	—	40′ OT	—
P-198	11 Aug.	1740	1820	—	—	—	—	256-229	256-229	450	—	1 m² dredge	Good collection of mollusks, crustaceans, echinoids, fishes.
P-199	11 Aug.	1930	2023	—	—	—	—	311-329	311-329	600	—	1 m² dredge	Abundant solitary corals; mollusks, crustaceans.
P-200	11 Aug.	2103	2133	—	—	—	—	329-348	329-348	700	—	1 m² dredge	—
P-201	11 Aug.	2048	2150	27°30′N	79°10′W	—	—	329	3	—	—	1 m. plankton net	Plankton poor, a few tunas and gempylids.
P-202	11 Aug.	2030	2355	27°30′N	79°10′W	—	—	—	surface	—	—	Night light	—
P-202A	11/Aug. 12	2240	0005	27°30′N	79°10′W	—	—	—	17*	30	55°-60°	2 m. plankton net	—
P-203	12 Aug.	0015	0115	27°30′N	79°10′W	27°27′N	79°12′W	—	16*	60	75°	1 m. plankton net	—
P-204	12 Aug.	0128	0215	27°27′N	79°12′W	27°28′N	79°13′W	366	23*	90	75°	1 m. plankton net	—

Station No.	Date 1964	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-205	12 Aug.	2030	0315	27°28′N	79°13′W	27°27′N	79°14′W	384
P-206	12 Aug.	0330	0430	27°27′N	79°14′W	27°21′N	79°20′W	421
P-207	12 Aug.	0500	0530	27°21′N	79°20′W	—	—	421
P-208	12 Aug.	0758	0841	27°12′N	79°17′W	—	—	512
P-209	12 Aug.	1120	1210	26°59′N	79°16′W	—	—	—
P-210	12 Aug.	1533	1630	26°36′N	79°02′W	26°40′N	79°07′W	531-503
P-211	12 Aug.	1820	1900	—	—	26°41′N	79°05′W	403-384
P-212	12 Aug.	2039	2114	26°41′N	79°05′W	26°41′N	79°05′W	485
P-213	12 Aug.	2013	2210	26°41′N	79°05′W	26°41′N	79°05′W	475
P-214	12 Aug.	2020	2150	26°41′N	79°05′W	26°41′N	79°05′W	475-512
P-215	12 Aug.	2225	2320	26°41′N	79°05′W	26°38′N	79°04′W	521
P-216	12/Aug. 13	2332	0020	26°38′N	79°04′W	26°34′N	79°01′W	539
P-217	13 Aug.	0030	0130	26°34′N	79°02′W	26°31′N	78°56′W	567-610
P-218	13 Aug.	0147	0243	26°31′N	78°56′W	26°28′N	78°54′W	622-686
P-219	13 Aug.	0317	0420	26°28′N	78°54′W	—	—	692
P-220	13 Aug.	0431	0525	26°22′N	78°06′W	—	—	421
P-221	13 Aug.	0527	0600	26°20′N	79°10′W	—	—	421
P-222	13 Aug.	1245	—	25°48′N	80°00′W	—	—	293

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
31*	120	75°	1 m. plankton net	—
42-27*	160	75°-80°	1 m. plankton net	—
10*	60	80°	1 m. plankton net	—
512	—	—	1 m^2 dredge	—
—	1000	—	1 m^2 dredge	Sponges, crinoids.
531-503	1500	—	40′ OT	—
403-384	700	—	1 m^2 dredge	—
485	1000	—	1 m^2 dredge	—
surface	—	—	Night light	—
2*	12	80°	1 m. plankton net	—
10*	70	82°	2 m. plankton net	—
17*	100	80°	2 m. plankton net	—
29*	170	80°	2 m. plankton net	—
52*	300	80°	2 m. plankton net	—
surface	2	—	Gulf III-A HSPS	—
surface	4	—	Gulf III-A HSPS	—
2	7	—	Gulf III-A HSPS	—
—	—	—	1 m. plankton net	—

Dredging and Trawling Records of the Research Vessel *John Elliott Pillsbury* for 1964 and 1965

Station No.	Date 1965	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
	Lagos, Nigeria, to Niger Delta (H.O. chart 2201)												
P-223	9 May	—	—	6°28′N	3°23′E	—	—	0.9	0.1	—	—	1 gal. Pronoxfish	Sand, surf. *Blennius, Eucinostomus,* other fishes.
P-224	9 May	—	—	6°28′N	3°23′E	—	—	—	—	—	—	2½ qts. Pronoxfish	*Trachinotus, Callionymus; Hippa, Albunea, Ocypode.*
P-225	9 May	—	—	6°28′N	3°23′E	—	—	—	—	—	—	—	—
P-226	9 May	—	—	6°28′N	3°23′E	—	—	—	—	—	—	Night light	*Squilla calmani, Callinectes gladiator.*
P-227	10 May	—	—	6°28′N	3°23′E	—	—	1.8	surface	—	—	Hand	*Goniopsis, Pachygrapsus.*
P-228	10 May	—	—	6°28′N	3°23′E	—	—	—	—	—	—	—	*Callinectes;* misc. fishes purchased from Nigerian fisherman.
P-229	10 May	1930	2130	6°28′N	3°23′E	—	—	5	surface	—	—	Dip net	*Antennarius; Callinectes gladiator.*
P-230	11 May	1149	1219	6°11′N	3°36′E	6°10′N	3°38′E	82-97	82-97	450-400	—	40′ OT	Hard ground, with gorgonians and coral; mollusks, crustaceans; few fishes. Net damaged.
P-231	11 May	1743	1840	5°57′N	3°59′E	5°56′N	4°03′E	1372	590	2250	—	10′ IKMT	*Gnathophausia;* decapod crustaceans; *Japetella.*
P-232	11 May	2200	2230	5°56′N	4°27′E	5°54′N	4°27′E	101-132	101-132	575	—	40′ OT	Green mud. Good haul of fishes; some cephalopods; crustaceans abundant.
P-233	12 May	0537	0900	5°19′N	4°14′E	5°15′N	4°02′E	2013-1464	2013-1464	7500	—	Blake Trawl	Few fishes; some crustaceans, incl. *Munidopsis, Stereomastis, Glyphocrangon.*
P-234	12 May	0215	0305	5°26′N	4°10′E	—	—	2012	surface	—	—	Night light, dip net	Squid, myctophids.

Station No.	Date 1965	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
P-235	12 May	0430	0505	5°20′N	4°13′E	—	—	2012
P-236	12 May	1842	1910	5°20′N	4°45′E	5°19′N	4°48′E	128-101
P-237	12 May	2135	2205	5°19′N	4°48′E	5°07′N	4°55′E	101
P-238	12 May	2340	2400	4°56′N	5°00′E	—	—	82
P-239	13 May	0045	0115	4°56′N	5°00′E	4°54′N	5°05′E	73
P-240	13 May	0310	0340	4°44′N	5°17′E	4°41′N	5°19′E	37
P-241	13 May	0513	0800	4°35′N	5°18′E	4°34′N	5°19′E	59-63
P-242	13 May	0527	0555	4°34′N	5°19′E	—	—	55
P-243	13 May	0958	1027	4°19′N	5°27′E	4°22′N	5°23′E	86-95
P-244	13 May	1104	1130	4°26′N	5°15′E	4°27′N	5°14′E	91
P-245	13 May	1510	1551	4°32′N	5°07′E	4°31′N	5°13′E	64-119
P-246	13 May	1952	2040	4°13′N	5°30′E	4°10′N	5°33′E	37
P-247	13 May	2100	—	4°10′N	5°33′E	—	—	37?
P-248	13 May	2219	2303	4°03′N	5°41′E	4°07′N	5°40′E	33
P-249	14 May	0030	0120	4°03′N	5°46′E	—	—	37

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
surface	—	—	Night light, dip net	—
128-101	700-590	—	40′ OT	Net damaged on coral ground, with many gorgonians of several spp.; ophiuroids; crustaceans.
101	590	—	10′ OT	*Sepia, Eledone;* Crustacea; *Gobius koumansi, Symphurus, Scorpaena,* other fishes.
surface	—	—	Night light, dip net	One *Alloteuthis.*
73	433	—	10′ OT	*Sepia;* numerous crustaceans; fishes.
37	216	—	10′ OT	*Eledone, Sepiella;* several fishes; crustaceans.
59-63	325	—	10′ OT	Good catch of *Penaeus.*
surface	—	—	Night light, dip net	*Parexocoetus.*
—	315-360	—	40′ OT	No catch.
—	500	—	40′ OT	Generator failure; net not fished.
64-119	315-540	—	40′ OT	Large haul of fishes; few invertebrates, except cephalopods.
37	180	—	40′ OT	*Alloteuthis, Sepiella, Illex.*
surface	—	—	Dip net	Flyingfish.
33	210	—	10′ OT	Abundant crustaceans, some cephalopods, few fishes.
surface	—	—	Night light, dip net	—

DREDGING AND TRAWLING RECORDS OF THE RESEARCH VESSEL *John Elliott Pillsbury* FOR 1964 AND 1965

Station No.	Date 1965	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-250	14 May	0214	0246	4°06′N	5°58′E	4°02′N	6°04′E	24	24	125	—	10′ OT	Brackish-water fauna; *Penaeus*, 2 spp.; other crustaceans; catfishes, flatfishes, eels, etc.
P-251	14 May	0444	0515	4°03′N	6°03′E	4°04′N	6°04′E	27	27	125	—	10′ OT	—
P-252	14 May	0638	0708	4°04′N	6°18′E	4°05′N	6°22′E	30	30	150	—	10′ OT	Good catch of fishes and crustaceans; many medusae; 10 lbs. pink shrimp; *Lolliguncula*.
P-253	14 May	0838	0906	4°04′N	6°35′E	4°03′N	6°38′E	33-40	33-40	180	—	10′ OT	Poor catch of fishes; mollusks diverse.
P-254	14 May	1330	1436	3°50′N	7°08′E	3°51′N	7°12′E	174-148	174-148	765-845	—	40′ OT	Large haul of fishes; many invertebrates, especially cephalopods.
P-255	14 May	1802	1902	3°49′N	7°38′E	3°48′N	7°42′E	269-264	269-264	1440	—	40′ OT	Huge catch of fishes, incl. *Zenion, Cyttopsis, Parasudis, Chlorophthalmus*. etc.
P-256	14 May	2223	2322	3°45′N	8°03′E	3°45′N	8°02′E	409-485	409-485	2000	—	40′ OT	*Illex illecebrosus, Bathypolypus sponsalis.*
	Fernando Póo (H.O. chart 2381)												
P-257	15 May	—	—	3°45′N	8°48′E	—	—	—	—	—	—	6 qts. Pronoxfish	Good poison station.
P-258	15 May	—	—	3°45′N	8°48′E	—	—	—	—	—	—	2 gals. Pronoxfish	Good poison station. *Cypraea, Murex* other mollusks, crustaceans. No coral.
		Fernando Póo to Annobón											
P-259	16 May	0900	0928	3°53′N	8°53′E	3°51′N	8°54′E	59	59	400	—	10′ OT	Many fishes, *Saurida brasiliensis* dominant; several cephalopods, other mollusks.
P-260	16 May	1057	1130	3°45′N	9°05′E	3°43′N	9°10′E	46	46	270	—	10′ OT	Poor haul. Water thick with plankton.

Station No.	Date 1965	TIME		POSITION				Bottom Depth PDR(m)
		Gear Down	Start Up	Gear Down		Start Up		
				Lat.	Long.	Lat.	Long.	
P-261	16 May	1836	2036	2°45′N	8°46′E	2°49′N	8°43′E	1765-1871
P-262	16 May	2140	—	2°49′N	8°43′E	—	—	1871
P-263	16/May 17	2342	0012	2°37′N	8°36′E	2°34′N	8°38′E	1975
P-264	17 May	0245	0415	2°24′N	8°31′E	2°19′N	8°25′E	2129-2195
P-265	17 May	0622	0722	2°08′N	8°17′E	2°03′N	8°14′E	2305
P-266	17 May	1806	1910	1°13′N	7°46′E	1°05′N	7°43′E	2525
P-267	17 May	1700	—	1°12′N	7°46′E	—	—	2505
P-268	17 May	2030	—	0°57′N	7°36′E	—	—	2542
P-269	18 May	1305	1510	0°00′N	7°18′E	0°10′N	7°19′E	2765
P-270	18 May	2235	2335	0°46′S	6°23′E	0°42′S	6°41′E	3054
	Annobon (H.O. chart 2381)							
P-271	19 May	—	—	1°25′S	5°38′E	—	—	—
P-272	19 May	0800	2200	1°24′S	5°37′E	—	—	—
P-273	19 May	—	—	1°24′S	5°37′E	—	—	1.8
P-274	19 May	1830	2130	1°24′S	5°37′E	—	—	7-9
P-275	20 May	0825	0831	1°24′S	5°37′E	—	—	9
	20 May	0840	0855	1°24′S	5°37′E	1°24′S	5°38′E	9-47

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
740	2712	—	10′ IKMT	Fishes badly damaged. *Vampyroteuthis.*
surface	—	—	Night light, dip net	*Parexocoetus;* myctophids, anchovies; *Ommastrephes.*
80	200	—	10′ IKMT	*Isistius,* bit holes in net. *Abralia veranyi.*
350	1200	—	10′ IKMT	Good catch of Crustacea and fishes.
460	1500	—	10′ IKMT	—
2525	6000-6500	—	40′ OT	Mud with rocks & pebbles; sea anemones, mollusks, crustaceans, fishes.
surface	—	—	Dip net	—
surface	—	—	Night light, dip net	—
2020	6000	—	10′ IKMT	*Vampyroteuthis* and several other cephalopods.
450-410	1200	—	10′ IKMT	Catch not remarkable.
—	—	—	3 gals. Pronoxfish	Excellent coll. of fishes.
—	—	—	Hook & Line	Blue runners; *Linckia* dived from bottom.
0-2	—	—	Pronoxfish	Excellent coll. of fishes.
surface	—	—	Night light, dip net	Many *Cypselurus.*
9	50	—	10′ OT	Net mangled, no catch.
9-47	150	—	Dredge	*Scorpaenodes, Paranthias, Serranus heterurus,* gobiids.

DREDGING AND TRAWLING RECORDS OF THE RESEARCH

Station No.	Date 1965	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
	20 May	0955	1001	1°24′S	5°38′E	—	—	15-18
	20 May	1200	1207	1°24′S	5°37′E	—	—	55-69
P-276	20 May	—	—	1°24′S	5°38′E	—	—	—
P-277	20 May	1310	1325	1°23′S	5°37′E	1°24′S	5°38′E	567-238
P-278	20 May	—	—	1°25′S	5°36′E	—	—	—
P-279	20 May	1418	1442	1°23′S	5°37′E	—	—	55-73
P-280	20 May	1543	1606	1°22′S	5°37′E	1°23′S	5°37′E	476-156
P-281	20 May	—	—	1°24′S	5°37′E	—	—	—
P-282	21 May	0940	0945	1°28′S	5°36′E	—	—	23
	21 May	1014	1021	1°28′S	5°37′E	—	—	18
	21 May	1057	1111	1°29′S	5°36′E	—	—	37
P-283	21 May	1316	1324	1°29′S	5°35′E	—	—	51-55
P-284	21 May	1431	1436	1°30′S	5°36′E	—	—	73
P-285	21 May	1549	1611	1°31′S	5°37′E	—	—	750
P-286	21 May	—	—	1°24′S	5°37′E	—	—	—

VESSEL *John Elliott Pillsbury* FOR 1964 AND 1965

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
15-18	20	—	Dredge	*Chilomycterus, Uropterygius.*
55-69	210	—	Dredge	Dredge damaged. Alcyonarians; *Lyrideus.*
—	—	—	Fisherman	Several fishes purchased from fisherman.
567-238	900	—	Dredge	*Plesionika,* 2 galatheids, no other crustaceans.
—	—	—	Pronoxfish	Numerous shrimps at exit of crater lake and in stream.
—	100	—	Dredge	Dredge lost.
476-156	450	—	Blake Trawl	Trawl frame badly damaged; poor catch.
—	—	—	2 qts. Pronoxfish	Five spp. fishes; *Macrobrachium, Callinectes, Ocypode.*
23	50	—	Dredge	Nodular coralline algae, with animals living in hollow centers.
18	45	—	Dredge	Same.
37	110	—	Dredge	Same.
51-55	150-50	—	Dredge	Same.
73	150	—	Dredge	Black basaltic rocks; two gorgonians, fragments of *Dendrophyllia,* and a few crustaceans.
—	2271	—	Dredge	Dredge lost.
surface	—	—	Night light, dip net	One *Lagocephalus,* several needlefishes and clupeids.

Station No.	Date 1965	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)
	Annobón to Lagos							
P-287	22 May	0825	0925	1°03′S	5°31′E	0°58′S	5°31′E	3658
P-288	22 May	1045	1145	0°47′S	5°27′E	0°43′S	5°26′E	3658
P-289	22 May	1325	1425	0°36′S	5°22′E	0°29′S	5°23′E	2743
P-290	22 May	1623	1729	0°18′S	5°27′E	0°15′S	5°25′E	3502
P-291	22 May	1954	2200	0°01′S	5°20′E	0°05′N	5°16′E	3566
P-292	22 May	0305	0509	0°12′N	5°11′E	0°10′N	5°14′E	3587
P-293	23 May	0001	0130	0°07′N	5°16′E	—	—	3658
P-294	23 May	0955	—	0°12′N	5°11′E	—	—	3566
P-295	23 May	1313	1655	0°25′N	5°09′E	0°35′N	5°02′E	3731
P-296	23 May	1917	2022	0°47′N	4°55′E	0°52′N	4°53′E	4490
P-297	23 May	2040	2140	—	—	0°52′N	4°53′E	4480
P-298	23/May 24	2251	0115	0°54′N	4°53′E	1°05′N	4°51′E	4444
P-299	24 May	0700	0900	1°29′N	4°43′E	1°34′N	4°44′E	3713

Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
55	150	—	10′ IKMT	Siphonophores; blue copepods; hyperiids living in siphonophore bracts; 3 cranchiid squids.
190	450	—	10′ IKMT	*Doratopsis* larva; octopod.
350	900	—	10′ IKMT	—
600	1500	—	10′ IKMT	*Abraliopsis, Heteroteuthis, Onykia.*
1230	3000	—	10′ IKMT	—
3587	8500	—	Blake Trawl	Holothurians, starfish, crinoids, scaphopods. Poor catch.
surface	—	—	Camera	*Ommastrephes pteropus.*
1	—	—	Harpoon	Remora from a white-tip shark.
850	2464	—	10′ IKMT	Several cephalopods; crustaceans and fishes.
surface	0	—	10′ IKMT	Good catch of myctophids, dolphin and other surface fishes; *Rhynchoteuthis* larva.
surface	—	—	Night light, dip net	Squid, flying fishes, dolphin.
1000-1500	3839	—	10′ IKMT	Good catch of fishes, crustaceans, unidentified squid.
2500*	5600	—	10′ IKMT	Good catch of fishes and crustaceans; *Helicocranchia, Heteroteuthis, Japetella, Mastigoteuthis,* etc.

DREDGING AND TRAWLING RECORDS OF THE RESEARCH VESSEL *John Elliott Pillsbury* FOR 1964 AND 1965

Station No.	Date 1965	TIME Gear Down	Start Up	POSITION Gear Down Lat.	Long.	Start Up Lat.	Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
				H.O. 2201									
P-300	24 May	1720	1922	2°05′N	4°50′E	2°08′N	4°56′E	4334	3000*	6500	—	10′ IKMT	Good catch of fishes, crustaceans, cephalopods, incl. *Vampyroteuthis.*
P-301	24 May	2245	2345	2°08′N	4°55′E	—	—	4297	surface	—	—	Night light, dip net	Flying fishes; *Ommastrephes.*
P-302	25 May	0230	0335	2°26′N	4°51′E	2°30′N	4°49′E	4285	surface	0	—	10′ IKMT	Many myctophids.
P-303	25 May	0700	0855	2°53′N	4°43′E	2°55′N	4°48′E	3512	800-900	2600	—	10′ IKMT	Numerous cephalopods.
P-304	25 May	0850	—	2°54′N	4°47′E	—	—	3475	1	—	—	Hook & line	Barracuda.
P-305	25 May	1430	1626	3°14′N	4°45′E	3°17′N	4°50′E	3109	1230	3875	—	10′ IKMT	Good catch including many cephalopods.
P-306	25 May	2200	2300	3°30′N	4°51′E	3°30′N	4°52′E	3658	410	1300	—	10′ IKMT	Good catch of fishes in excellent condition; *Isistius* bit holes in net; many cephalopods.
P-307	25 May	2000	2100	3°30′N	4°47′E	—	—	3840	surface	—	—	Night light, dip net	Flying fishes, myctophids, squid.
P-308	26 May	0250	0454	3°55′N	4°47′E	4°01′N	4°44′E	2743-1280	675-700	1800	—	10′ IKMT	Good catch; five *Vampyroteuthis.*
P-309	26 May	1207	1430	4°15′N	4°27′E	4°12′N	4°28′E	1280-1318	1280-1318	4300	—	40′ OT	Excellent catch; mollusks, echinoderms, *Opisthoteuthis;* large brotulids, eels, etc.
P-310	26 May	1930	2100	4°34′N	4°14′E	—	—	1554	surface	—	—	Night light, dip net	Squid, flying fish, sailfish, dolphin, frigate mackerel, myctophids.
P-311	26 May	2120	2255	4°34′N	4°14′E	4°40′N	4°11′E	1582	surface	0	—	10′ IKMT	Young tunas, flying fishes, larval flatfishes; *Enoplometopus.*
P-312	27 May	0200	0300	4°58′N	4°05′E	5°01′N	4°07′E	1701-1582	550	1500	—	10′ IKMT	Small catch.

Station No.	Date 1965	TIME Gear Down	TIME Start Up	POSITION Gear Down Lat.	POSITION Gear Down Long.	POSITION Start Up Lat.	POSITION Start Up Long.	Bottom Depth PDR(m)	Gear Depth* m	Wire Out m	Wire Angle	Gear	Remarks
P-313	27 May	0555	0641	5°09′N	4°04′E	5°09′N	4°02′E	1664-1829	500-740	1800	—	10′ IKMT	Successful haul. *Vampyroteuthis; Abraliopsis.* Usual fishes.
P-314	27 May	1131	1415	4°58′N	3°48′E	4°52′N	3°48′E	2268-2332	2268-2332	6700	—	40′ OT	Excellent catch.
P-315	28 May	0030	0215	?5°43′N	?3°35′E	? ?	—	2058	surface	—	—	Night light, dip net	—
	Lagos, Nigeria												
P-316	28 May	1500	1715	6°28′N	3°23′E	—	—	0.9	0-1	—	—	1½ gal. Pronoxfish	Many fishes carried out by current, recovery impossible. Same location as P-224.

*Gear depth is actual except where indicated by asterisk, when it is calculated.

THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 4 —

POGONYMUS SHANGO, A NEW CALLIONYMID FISH FROM QUARTZ SAND BEACHES OF NIGERIA, WITH NOTES ON RELATED SPECIES[1]

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ABSTRACT

Pogonymus shango, a new species of the fish family Callionymidae, is described from the beaches near Lagos, Nigeria, where it burrows in the quartz sand in a region of heavy surf action. The species is illustrated and its internal anatomy, fecundity, habitat, and associated fauna are discussed. It is compared briefly with the genera *Charibarbitus* Smith, *Clathropus* Smith, *Draculo* Snyder, and *Eleutherochir* Bleeker. *P. shango* is the first species of *Pogonymus* to be recorded from the Atlantic and it represents another West African faunal element whose relations are with Indo-Pacific forms.

INTRODUCTION AND ACKNOWLEDGMENTS

On May 9, 1965 the junior author had opportunity to take a launch from our research vessel PILLSBURY and make some collections of shore fishes at the harbor entrance at Lagos, Nigeria. One such collection was in the heavy surf outside the breakwater. Among the fishes collected was the new dragonet described below. Since we had obtained only a small collection, we returned at the end of our cruise to the same spot and made a concerted effort over a quarter mile of beach to acquire additional material. In all, twenty specimens were obtained.

We wish to thank our colleagues who helped make the two collections: Gary Y. Hendrix, Raymond B. Manning, Clyde F. E. Roper, John J. Walsh, Jon C. Staiger, and Richard E. Young. We also acknowledge Dr. Gilbert L. Voss, chief scientist of the expedition, and Dr. Frederick M. Bayer both of the University of Miami. Dr. James I. Jones and Dr. Enrico Bonatti were very helpful in providing information on coastal sediments in Nigeria and in identifying sediments from the collection site.

The Guinean expeditions were financed from several sources, principally the National Science Foundation (Grants GB-1204 and GB-1350) and the National Geographic Society. The junior author is indebted to the Maytag Chair of Ichthyology.

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[1]Contribution No. 732 from the Institute of Marine Science, University of Miami. This paper is one of a series resulting from the National Geographic Society-University of Miami Deep-Sea Biology Program.

Pogonymus shango, new species

Figs. 1-4; Table 1

Diagnosis. — A small species, to about 25 mm standard length. Mouth terminal, gape wide, lower lip provided with 14-18 papillae. Preopercular spine without antrorse tooth on ventral edge, and usually with 3 teeth (including spine tip) dorsally. Isthmus with transverse fold connecting opercular flaps. Opercular flap extending to base of pectoral fin. Gill opening reduced to dorsal pore. Body naked, lateral line well developed and provided with commissural canal across dorsal surface of caudal peduncle. Spinous dorsal small in size, usually with 3 spines, the third barely discernible.

Description. — The various counts and measurements are listed for each specimen in Table 1. The dorsal fin consists of an isolated and reduced spinous portion with 3 diminutive spines and a posterior soft-ray portion usually provided with 9½ rays (two specimens had 10½). The third spine is small and may be absent in one small specimen in which the tiny spine may have been overlooked. The last dorsal soft ray (also true of the anal fin) is paired, sharing a common base, and considered to be one element as indicated by the ½ count. Except for this terminal element all dorsal soft rays are non-branched structures. The anal fin usually contains 10½ soft rays (1 specimen has 9½, another has 11½). All anal rays are branched except for some small specimens which have the first one or two rays simple or only with a tiny terminal branch. The caudal fin contains 9 or 10 striated elements on the two cleared specimens, 4 or 5 attached to the upper segment of the hypural plate and 5 to the lower. The uppermost and lowermost elements are small. In addition there are one or two procurrent elements above and one procurrent element below. In both specimens therefore the total caudal element count was 12.

The pelvic fins always contain 1 spine and 5 branched rays. The pectoral fin has 19-22 striated rays, most of them branched. The fin becomes elongate at about the 8th or 9th ray (counting from the dorsal side).

Both cleared specimens have 6 branchiostegal rays on each side, 2 small ones along the shaft of the ceratohyal, 1 larger one at the distal end of the ceratohyal near its junction point with the epihyal, and 3 on the epihyal. Thus they are clustered in 2 groups, 4 large ones laterally, 2 small ones near the midline of the throat. The epihyal branchiostegals are very elongate; their tips curve dorsally and add to the support of the opercular flap.

There are no gill rakers. Both the gill bar and the number and size of gill filaments are reduced. The gill filaments are short, few in number (about 10) and widely separated. This reduction presumably is correlated with life in the well oxygenated waters of the surf zone.

The lateralis system is well developed and all branches are pored, the

TABLE 1

COUNTS AND MEASUREMENTS OF THE TYPE SPECIMENS OF *Pogonymus shango* FROM NIGERIA[1]

Specimens	USNM 199728	ANSP 103411	USNM 199728	ANSP 103409	ANSP 103410	BM(NH)	USNM 199728	USNM 199728	ANSP 103410	ANSP 103410	USNM 199728	USNM 199728	USNM 199728	USNM 199728	ANSP 103411	USNM 199728	USNM 199728	USNM 199728	USNM 199728
Standard length	24.8	22.4	21.8	21.4*	21.2	20.6	20.0	19.7	18.8	18.7	18.5	17.4	14.4	13.6	13.1	12.7	12.6	12.0	10.9
Sex	♀	♀	♀	♂	♂?	♀	♂	♀	♂	♂	♀	♀	?	♂?	?	?	?	?	?
Counts:																			
Dorsal rays[2]	9	9	8	9	9	9	9	10	9	9	10	9	9	9[3]	—	9[3]	9	9	9[4]
Anal rays[5]	10	10	10	10	10	10	10	10	10	10	9	10	10	10	—	10	11	10	10
Pectoral rays	19-20	20-20	19-20	21-21	20-22	19-19	20-21	21-20	20-21	20-19	19-21	20-21	20-21	22-22	—	22-21	20-21	21-20	21-22
Labial papillae	16	—	17	15	16	16	15	17	17	18	16	15	17	16	—	15	14	16	14
Caudal rays[6]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	—	—	12	12
Preopercular points	3-3	3-3	3-3	3-3	3-3	3-3	3-3	3-3	3-3	3-3	3-3	—	—	3-3	2-2	3-3	3-3	3-3	3-3
Measurements:																			
Head length	35	38	37	34	33	39	37	36	35	36	34	36	38	37	37	37	35	38	40
Occipital length	24	24	25	24	22	23	22	23	21	22	23	24	24	24	22	24	25	28	27
Snout length	10	10	9.0	8.9	8.4	7.3	7.5	7.6	9.0	8.0	6.5	8.6	7.6	8.1	7.6	7.1	7.1	7.5	5.5
Eye diameter	8.7	9.8	9.0	8.4	8.4	7.8	8.0	8.6	8.5	8.6	8.1	9.2	9.0	8.8	9.2	10	9.5	10	9.2
Least depth caudal peduncle	7.9	7.6	8.1	7.9	7.0	6.8	8.0	7.1	8.0	7.5	7.0	8.0	8.3	8.8	—	8.7	8.7	8.3	10
Body width	24	22	24	21	19	22	20	25	20	21	21	21	20	21	—	24	19	22	24
Body depth	16	16	16	16	14	17	14	19	14	15	15	16	17	16	—	19	17	18	19
Dorsal-fin length	44	—	40	36	41	40	43	43	39	41	42	44	38	35	—	36	38	38	38
Anal-fin length	46	—	45	48	45	44	48	47	46	43	46	46	44	42	—	45	45	41	39
Caudal-fin length	28	—	30	27	27	28	29	27	29	28	26	25	27	24	—	26	25	28	28
Pectoral-fin length	26	—	26	24	25	24	22	23	24	23	25	28	26	23	—	24	25	27	18
Pelvic-fin length	28	—	21	22	21	21	22	18	22	21	22	22	22	21	—	20	21	22	21

* Holotype.
1 The twentieth specimen was damaged and therefore not studied in this regard.
2 Except as indicated, all specimens had three dorsal spines. The counts given indicate segmented rays only; the last element is divided to its base.
3 No spine count recorded.
4 Only two dorsal spines present.
5 The last element in each instance is divided to its base.
6 Unsegmented elements are included.

FIGURE 1. Frontal view of *Pogonymus shango* Davis & Robins to show labial fringe, based on several specimens in the type series from Lagos, Nigeria.

pores opening from small side canals in most instances (Fig. 2a). The supratemporal canal contains 3 pores, the second on the midline. The supraorbital canal contains 4 pores, 2 shared pores on the midline between the eyes, and one just behind and one in front of the single nostril. The infraorbital canal ends under the eye; it contains 3 pores. A small pore is present at the juncture of the infraorbital, supraorbital and lateral canals. The preopercular-mandibular canal contains 5 pores, one at the base of the preopercular spine on a ventrally projecting side canal, three on the mandibular ramus, the most anterior being under the tip of the maxilla, and the last on an anteriorly directed tube just below the junction of the lateral and preopercular canals. An unusual feature of *Pogonymus* and of callionymids generally is the presence of an opercular branch of the preopercular canals. The opercular canal contains one terminal pore, located beneath the preopercular process.

The lateral-line canal on the body is continuous from its junction with the head canal system to the tail tip. Lateral-line pore counts were noted on only a few specimens because of damage that resulted from blowing air on the specimens. There are 15 pores on the lateral-line canal anterior to the caudal commissural canal. The commissural canal joins the two lateral-line canals dorsally, just anterior to the caudal-fin base. It contains two pores on the dorsal midline, one pore posteriorly, one anteriorly. Their arrangement may be seen in Figure 2a.

Teeth are present only on the premaxillary and dentary bones and only in a single row on each. The hinged premaxillary teeth are short and conical whereas those in the dentary are fixed and more elongate (rod like). The lower lip has a fringe of 14-18 papillae. There are 7 to 9 on each side of the symphysis and their distribution usually is bilaterally symmetrical. The lower counts were from small specimens so that 18 is perhaps the best representative figure for the species.

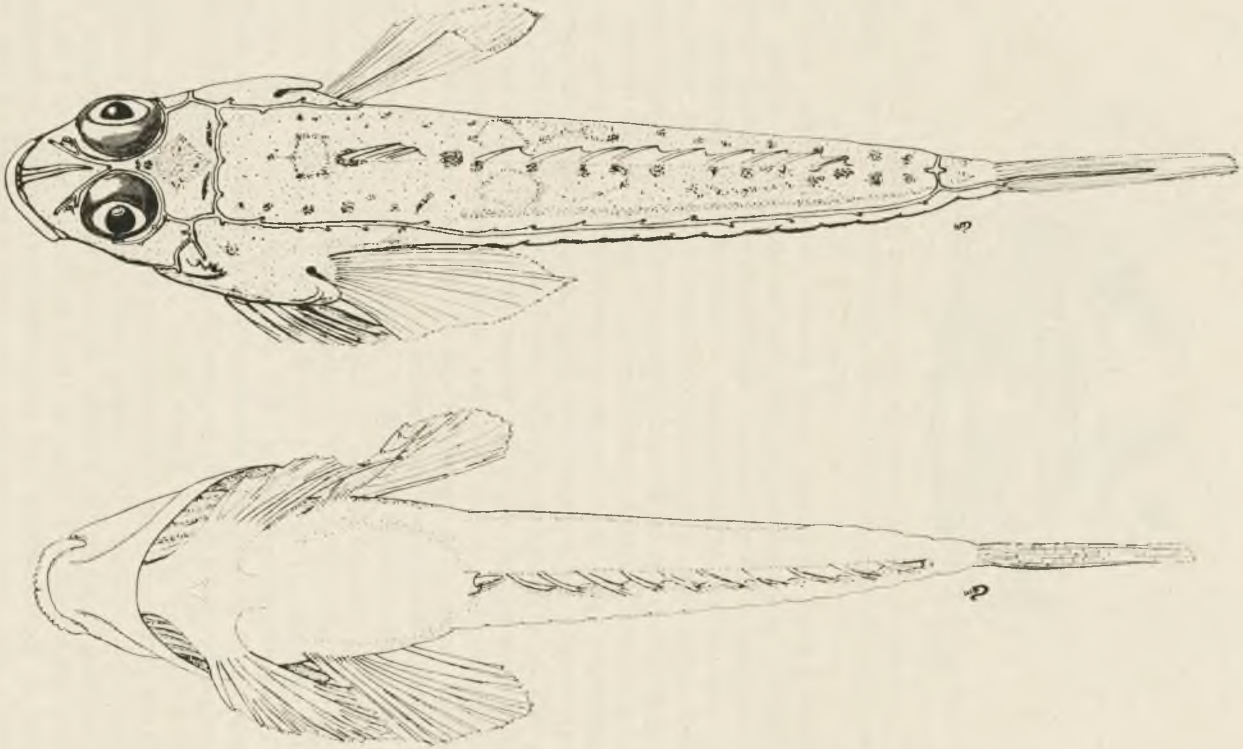

FIGURE 2. Quarter and ventral views of *Pogonymus shango* Davis & Robins. USNM 199728, paratype, an adult male, 20.0 mm standard length, from Lagos, Nigeria.

The opercular flap extends caudally to the base of the pectoral fin. Although there is a fold or depression behind this flap, there is no opening to the gill chamber apart from the dorsal pore. The opercular flap as noted above is supported by the opercle and the terminal part of the epihyal branchiostegals. This structure could enable *Pogonymus* to fill a considerable gill reservoir or form a bellows for taking in food particles but we can not support either point at this time. The preopercular spine is free and possesses 3 teeth dorsally including the terminal point. There is no antrorse ventral spine. One small specimen has only 2 dorsal teeth on the preopercular spine.

A transverse isthmial fold connects the opercular membranes from each side.

Both males and females possess a genital papilla, a simple elongate flap. That of the male appeared longer and more slender. We found no evidence of sexual dimorphism in other features. The spinous dorsal fin, which is often sexually dimorphic in callionymids, is much reduced in *Pogonymus* and is not dimorphic.

The general body form is best seen by reference to figures 1 and 2. Measures of body proportions are given in Table 1. The most striking aspect of the shape of *Pogonymus shango* is its depressed head and forebody. The head is very flattened and the mouth achieves a wide gape though it is almost entirely anterior in position. The caudal fin is truncate. The dorsal edge of the pectoral fin is sickle shaped, the elongation of the fin occurring at about the eight or ninth ray (counting from the dorsal edge). There is no membrane connecting the pelvic fin to the base of the pectoral fin. The last pelvic ray is free from the body.

Like all callionymids, *P. shango* has a very protrusible mouth. The premaxilla has an elongate nasal or ascending process that extends to the interorbit, and lacks an articulating process (Fig. 3). The maxillae combine to form a groove anteriorly through which the ascending process of the premaxilla slides.

There were no bright life colors. Generally *P. shango* is sand-colored. The pigment pattern is best seen by reference to Figure 2. Two small black spots are present consistently on the occipital line behind the eye (just anterior to the supratemporal canal). The fins and belly are unpigmented. The peritoneum and oral and gill cavities are unpigmented.

Several unusual osteological features were noted on the cleared and stained specimens. The first anal pterygiophore is anchor-shaped (Fig. 3). The caudal rays have a small hook that projects ventrally near their bases. The lachrymal or preorbital bone (Fig. 3) is quite large but the remaining suborbital bones are absent.

Name. — Shango, a mythological figure, whose statue decorates the Lagos waterfront. According to Forde (1951: 30) Shango is "a reputed early king of Oyo, the god of thunder and lightning."

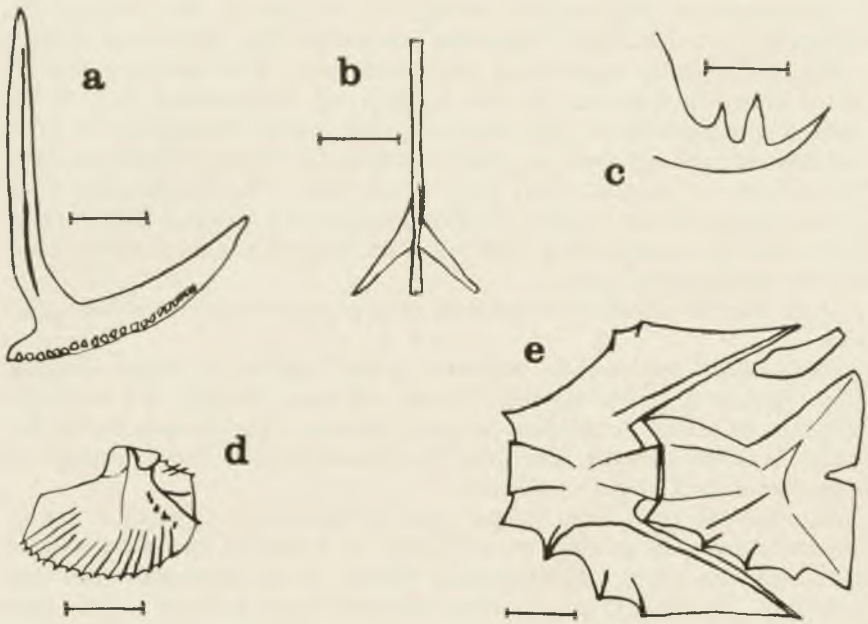

FIGURE 3. Skeletal features of *Pogonymus shango* Davis & Robins based on a cleared and stained specimen 22.4 mm in standard length, ANSP 103411: a, Left premaxilla viewed from the dorsal surface. Tooth bases showing through the cleared bone indicated by row of open markings.—b, First anal pterygiophore viewed from behind (ventral or distal part is bent toward viewer).—c, Left preopercular spine showing two dorsal teeth.—d, Left lachrymal (preorbital) viewed from outer surface.—e, Last two vertebrae. In each instance the horizontal bar = 0.5 mm.

Material examined. — HOLOTYPE: ANSP 13409, an adult male, 21.4 mm, standard length, collected at the beach at the west side of the west jetty at the entrance to the harbor of Lagos, Nigeria, PILLSBURY station 224, May 9, 1965.

PARATYPES: ANSP 103410, 4 specimens, 17.3 - 21.2 mm standard length, collected with the holotype. ANSP 103411, 2 specimens 13.1 and 22.4 mm, cleared and stained, USNM 199728 (14 specimens, 10.9 - 24.8 mm) and BM(NH) 1966.2.15.1 (1 specimen, 20.6 mm) collected at the same place, but PILLSBURY station 316, May 28, 1965.

Biology. — An effort was made to determine size at maturity in *Pogonymus shango.* The type series range from 12 to 25 mm, standard length. Because of the absence of secondary sex differences, other than the small difference in the genital papilla, sex could not be determined in specimens shorter than 15 mm. In western Atlantic species of *Callionymus,* differences between the sexes are evident at about the same size (12 mm). No females

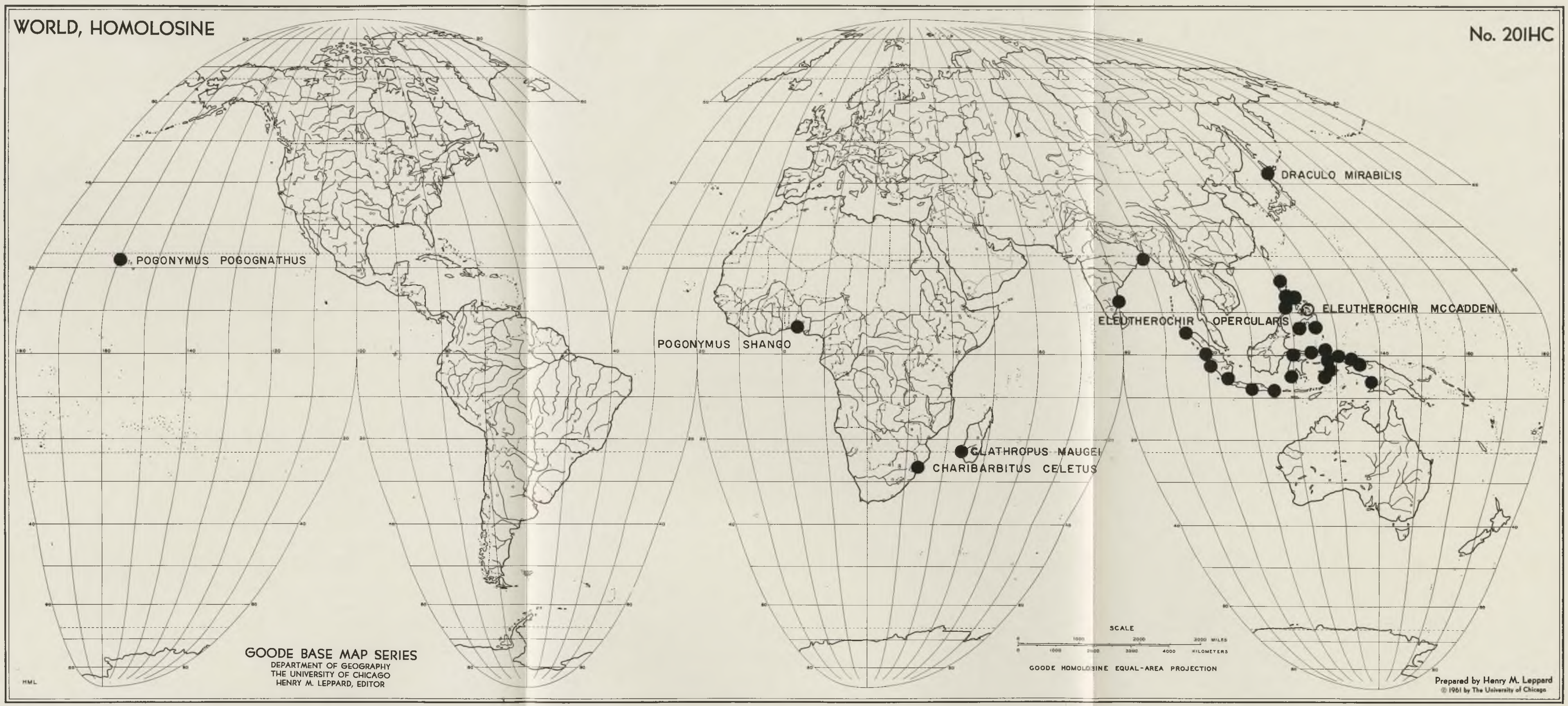

FIGURE 4. Distribution of *Pogonymus* and its generic allies. All known localities are marked except for *Eleutherochir opercularis* for which there are additional Indonesian and Philippine stations close to those already plotted and one questionable record from the Red Sea. *E. mccaddeni* is known only from the one station depicted by the open circle. Goode Base map copyrighted by The University of Chicago Press and reproduced with permission of the publisher, The Department of Geography, University of Chicago.

were identified from the collection of May 9 but of the 7 females taken in the collection of May 28 all were swollen with eggs and presumably ready to spawn. Either all of the eight specimens shorter than 15 mm were males or the females do not mature before attaining this size. The smallest gravid female was 17 mm, standard length.

The eggs of two specimens were studied with regard to number and size composition. Ovarian eggs were of two distinct size classes, the difference being entirely due to the presence or absence of the egg membranes and shell in the one group. Both types seemed equally distributed throughout the ovary. Counts for the right ovary of the two specimens (standard lengths 24.8 and 22.1 mm, respectively) were 396 large and 395 small (total 791) and 238 large and 276 small (total 507). The left ovary was about the same size. In each instance the large eggs represent eggs presumably ready to be shed and the small eggs represent fully developed ova needing membranes. Lack of available space may be the most important factor preventing the laying down of membranes on all eggs at the same time. This of course also means that not all eggs can be shed at one spawning.

Stomachs were removed from two specimens and their contents checked. Dr. Harding Owre, Institute of Marine Science, determined that the carapaces of calanoid copepods (more precise identification was not possible) composed the most abundant and only recognizable food item. Fine sand grains, smaller than the copepods, were the only other identifiable items. Copepod remains can also be seen in the stomachs of the cleared and stained specimens.

Habitat.—*Pogonymus shango* is known only from the type locality on the outer beach near the breakwater on the western side of the harbor entrance to Lagos, Nigeria. This is an area of heavy surf and dangerous currents. The waves are so frequent that several waves normally pass before a fish that has broken water due to the effects of the poison can be netted. Recovery of fishes in both collections was very low. The flocks of Damara terns *(Sterna balaenarum)* that were diving outside the surf zone attested to our inefficiency.

Compaction of beach sand was not uniform; one could locate soft spots at infrequent intervals along the beach. Four soft areas were located in about ¼ mile of beach at station 316 and it was at these spots that almost all specimens of *Pogonymus* were collected.

Such a habitat is seldom collected by the ichthyologists. It would be difficult, indeed impossible, to seine in such heavy surf and the apparent scarcity of fishes is discouraging. The use of ichthyocides in such areas should show a widespread Guinean distribution for *Pogonymus shango* and may reveal additional species of *Pogonymus* at Indian Ocean and Pacific stations.

It is increasingly apparent that burrowing fishes are very selective with regard to habitat. Type of sediment, particle size and shape, surge, interstitial oxygen and interstitial water movement probably combine to describe uniquely the habitat of such species. The sand collected at the outer beach station at Lagos was analyzed by our colleagues Drs. Jones and Bonatti who report that it is essentially a quartz sand (more than 70%) with the following accessory minerals in order of decreasing abundance: opaque mineral (probably magnetite), plagioclase feldspar (in the oligoclase-andesine range), amphibole (green hornblende), zircon, and calcite fragments. The probable source of this sand is an area of acidic igneous rocks, probably a granite or rhyolite and such a rock type is abundant inland from the Nigerian Coast.

Associated fauna.—Pogonymus shango shares the surf-sand habitat with a number of burrowing invertebrates. Particularly common are the gastropod *Terebra* sp. and the anomuran *Hippa cubensis* (de Saussure). Less numerous but still common are the gastropod *Olivella* sp. and the nereid worm *Glycera convoluta* Keferstein. There was one specimen of the burrowing anomuran *Albunea paretii* Guérin.

Identifications of these associates are by Frederick M. Bayer (gastropods), Lipke B. Holthuis (crustaceans) and N. Kenneth Ebbs (nereid).

Comparisons and relationships. — Discovery of *Pogonymus shango* on Nigerian shores far distant from Kauai (in the Hawaiian Islands) home of *Pogonymus pogonathus* Gosline, the only other species of *Pogonymus,* poses interesting systematic and zoogeographic problems. The two species differ in meristic characteristics, *P. shango* having 20-22 (rarely 19) pectoral rays instead of about 19, and 12 caudal rays instead of 10 (these counts include the unsegmented elements) and possibly in having 3 points on the preopercular spine (the drawing of *P. pogognathus* shows 2). More striking are the numerous similarities, and the two are surely close relatives.

Other relatives are secluded in a proliferation of generic names that has afflicted callionymid taxonomy. Here we can mention *Charibarbitus celetus* Smith (1963: 562), *Clathropus maugei* Smith (1966: 321-324), *Draculo mirabilis* Snyder (1911: 545-546), *Eleutherochir opercularis* (Valenciennes) in Cuvier and Valenciennes (1837: 305-307) and *Eleutherochir mccaddeni* Fowler (1941: 27-29, fig. 16). Figure 4 depicts the distribution of *Pogonymus* and its allies.

Charibarbitus is apparently represented by a single specimen from Inhaca Island off Mozambique. According to Smith (1963: 562) it has a single elongate spine in the first dorsal fin and lacks an interradial membrane in the dorsal and anal fins. In other respects it is immediately recognizable as a close relative of *Pogonymus* and Smith placed the two genera in the subfamily Pogonyminae.

Clauthropus maugei Smith is known from a single collection of five specimens collected on a hard sandy bottom along a beach near Tulear, Madagascar. It differs from *Pogonymus* in having four dorsal spines and three spinous points on the preopercular process. Like its relatives it has an elongate opercular flap and a fringed lower lip.

Draculo mirabilis is represented by larger specimens than have been recorded for *Pogonymus* or *Charibarbitus*. The holotype, USNM 68243, was examined by the senior author prior to the collection of *P. shango*. *Draculo mirabilis* possessed 13½ dorsal rays, 13½ anal rays and four dorsal teeth on the preopercular process. The most vital difference separating *Draculo* from *Pogonymus* is the absence of any vestige of a spinous dorsal fin in *Draculo* and this absence is confirmed by study of radiographs of the holotype. In view of the reduction in height and number of elements in the spinous dorsal fins of *Pogonymus* and *Charibarbitus*, loss of this fin in another form is not surprising. Interestingly, *Draculo* was captured with a seine on a sandy beach near Tomakomai in Hokkaido, Japan. The reduction of the first dorsal, a signal character in many callionymids, is a logical adaptation for existence in a turbid, surfy habitat. The labial papillae are reminiscent of the papillae in certain dactyloscopid stargazers and other fishes living in similar habitats in other regions.

As noted by Gosline (1959: 72), *Pogonymus* seems also to be related to *Eleutherochir* Bleeker (1879: 102-194). Perhaps, if one needs such a thing, *Eleutherochir* represents the best link with more typical callionymids. Although *Eleutherochir* lacks labial papillae and has a normal four-spine count in the first dorsal fin, it resembles *Pogonymus, Charibarbitus, Clauthropus,* and *Draculo* in its elongate opercular flap, the configuration of the lateral-line system, body shape, and its preopercular process. The unique larval form (described as *Brachycallionymus*) of *Eleutherochir* is not known in the other genera discussed here but does not seem to exist in *Pogonymus* at least.

Zoogeographically, *Pogonymus shango* represents another Indo-Pacific element in the fish fauna of the African Atlantic.

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 5 —

XENOCONGER OLOKUN, A NEW XENOCONGRID EEL FROM THE GULF OF GUINEA[1]

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ABSTRACT

The first Atlantic species of the xenocongrid eel genus *Xenoconger* is described from waters off the Ivory Coast, Gulf of Guinea in 25 fathoms. *X. olokun*, the new species, is compared to *X. fryeri* from the Indian Ocean and to other xenocongrid genera. The type of *Myroconger compressus* Günther is redescribed and placed in the monotypic family Myrocongridae.

INTRODUCTION AND ACKNOWLEDGMENTS

A single specimen belonging to the eel family Xenocongridae was obtained at PILLSBURY station 62, off Enframa Point, Ivory Coast, during the University of Miami's first expedition (1964) to the Gulf of Guinea. No additional material was obtained on this or the second (1965) expedition nor, apparently, was any obtained during operations of the Guinean Trawling Survey. The specimen represents a new species, the second known in the genus *Xenoconger* and the first from Atlantic waters. This species is described below.

We are indebted to Dr. Gilbert L. Voss, chief scientist of the expedition. The expedition itself was supported from several sources, principally the National Science Foundation (Grants NSF-GB-1204 and NSF-GB-1350) and the National Geographic Society. Travel by the senior author to the Gulf of Guinea and to the British Museum (Natural History) was supported by the Maytag Chair of Ichthyology. Dr. James E. Böhlke, Academy of Natural Sciences of Philadelphia, has advised us frequently on this and other eel problems, and David G. Smith of the Institute of Marine Science, University of Miami, has advised us about larval eels collected in the Gulf of Guinea.

Xenoconger olokun, new species

Figs. 1-3; Table 1

Diagnosis.—Pectoral fins absent. Dorsal-fin origin over anterior part of gill opening. Single pore on side above branchial region. Maxillary teeth in

[1]Contribution No. 733 from the Institute of Marine Science, University of Miami. This paper is one of a series resulting from the National Geographic Society-University of Miami Deep-Sea Biology Program.

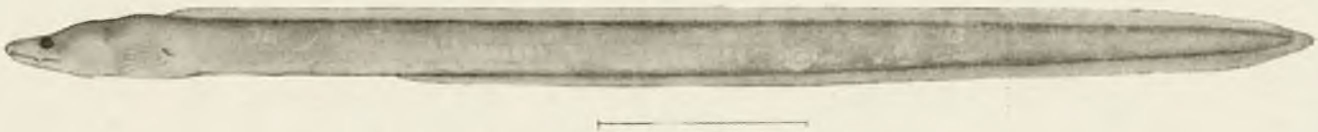

FIGURE 1. *Xenoconger olokun*. Lateral view of holotype, ANSP 103608, a female, 302 mm total length, from PILLSBURY sta. 62 off the Ivory Coast. Scale represents 50 mm.

two rows; dentary teeth in two rows posteriorly; vomerine teeth in two rows, the outer row shorter and less developed. Anterior nostril tubular; posterior nostril labial, covered by a broad flap. Vertebrae 130.

Description.—The general body form and positions of the fins may be seen in Figure 1. Body proportions are given in Table 1. There is no trace of a pectoral fin though there is a slight flap developed from the dorsal edge of the gill opening. The gill opening, round when expanded, is diagonal in position, sloping at about 45° downward and caudally. The origin of the dorsal fin is directly above the anterior edge of the gill opening. The trunk is proportionally short, the distance from the snout to the anus entering the total length about 3.4 times.

TABLE 1
MEASUREMENTS OF THE HOLOTYPES OF *Xenoconger olokun* AND *X. fryeri*

Character	*X. olokun*	*X. fryeri*[3]
Total length (mm)	302	436
Depth body at gill opening[1]	2.8	4.4
Depth body at anus[1]	2.8	3.6
Snout tip to dorsal-fin origin[1]	17	12
Snout tip to anus[1]	35	29
Anus to caudal tip[1]	65	71
Head length[1]	9.6	12
Eye diameter[2]	7.1	11
Fleshy interorbital width[2]	20	17
Snout depth[2]	25	24
Snout tip to mouth angle[2]	45	44

[1]Expressed in per cent of total length.
[2]Expressed in per cent of head length.
[3]Calculations based on data provided by Böhlke (1956: 75, Table II).

Xenoconger olokun is plainly colored. The body generally is tan, blotched with white ventrally. The chin, throat and belly are white, as is a narrow area along each side of the anterior part of the anal fin. The fins are pale tan, being clearest distally.

Head pores are well developed and the positions of most of them may be seen in Figure 2. In addition to the single pore in the lateral canal above the branchial region there are five pores along the upper jaw: two beneath approximately the anterior and posterior margins of the eye, two between the anterior and posterior nostrils (these four are in the suborbital canal), and one in front of the anterior nostril. Two other pores are on the side of the snout in positions approximately dorsal to the anterior and posterior margin of the anterior nostril. These two pores and the one anterior to the anterior nostril are on the supra-orbital canal. There are five pores on the mandibular ramus of the preoperculo-mandibular canal. Although the lateral line is unpored on the body its course is marked by a series of pale dashes.

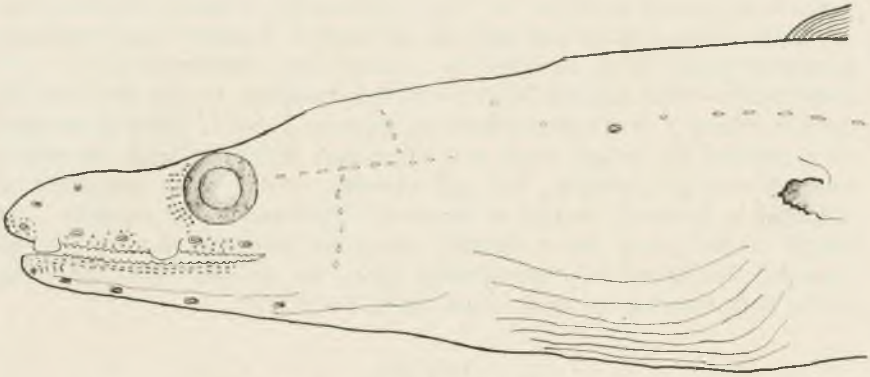

FIGURE 2. *Xenoconger olokun*. Lateral view of the head of the holotype, a female, 302 mm total length, from PILLSBURY sta. 62 off the Ivory Coast. Scale represents 10 mm.

In addition to the head pore system, *Xenoconger olokun* has many sensory papillae on the head, especially on the snout and along the upper surface of the lower jaw. The better developed papillar tracts are shown in Figure 2.

The anterior nostril opens through a long tube (in length about 1/3 the horizontal diameter of the eye) that is slightly flared distally. The posterior nostril is slit-like, opening along the outside of the edge of the upper jaw just anterior to the level of the anterior margin of the eye. The posterior nostril is covered by a flap that clearly projects below the border of the upper jaw.

In describing the dentition we follow the nomenclature employed by Böhlke (1956: 67-69). The dental pattern may best be seen by reference to Figure 3. The maxillary teeth are in two nearly equal and regular rows. All are conical and sharply pointed, a few with the tips slightly recurved. Those of the inner row are higher and more numerous (about 24) than those of the outer row (about 22). The intermaxillary patch is roughly circular and is composed of about fifteen blunt, conical teeth, the centrally located ones largest. This patch connects posteriorly to the elongate vomerine patch which bears two long central rows of large and blunt conical teeth which become smaller and closer together posteriorly. An outer row of smaller conical teeth occurs along each side of the anterior half of the vomerine patch.

The dentary teeth are essentially in two rows which diverge anteriorly to enclose an irregular and short third row of teeth. All are short and conical but those of the inner row are higher than those of the outer row. There is no tongue.

Numbers of vertebrae and fin rays were determined from a radiograph. There are 130 vertebrae but the transition from precaudal to caudal

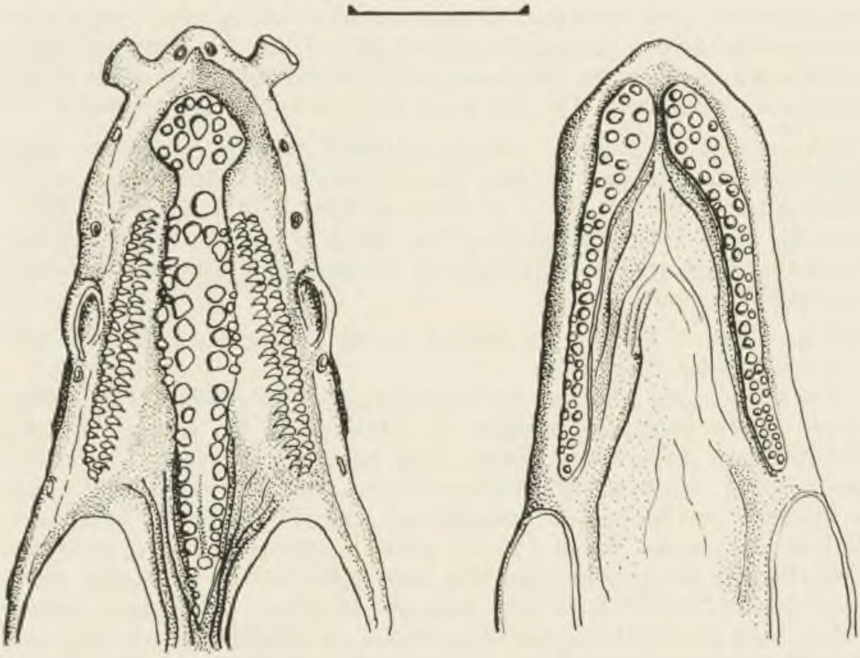

FIGURE 3. *Xenoconger olokun.* Dentition in upper (left) and lower (right) jaws of the holotype, a female. 302 mm total length, from PILLSBURY sta. 62 off the Ivory Coast. Scale represents 5 mm.

vertebrae is gradual and thus their numbers are difficult to determine. There are about 90 caudal and hence about 40 trunk vertebrae. The coelom extends well behind the anus and a considerable number of anterior anal rays receive no support from the vertebral column. There are 405 dorsal rays and 433 anal rays, this despite the fact that the dorsal-fin base is much the longer of the two fins. The absence of numerical relations of vertical-fin rays to vertebrae or to each other is a primitive feature.

Other skeletal features were noted from the radiograph. There is no trace of a pectoral girdle. The bones of the upper and lower jaws are about equal so that the inferior position of the mouth is due to the protruding fleshy snout. The supraoccipital bone has a short high crest above.

The holotype was slit so that the internal organs could be examined. The esophagus is short and muscular. The stomach is a very long blind sac that ends near the posterior part of the body cavity well behind the anus. It passes to the left side of the anus. The intestine is shorter than the stomach and is a simple bulky tube with many villi. The ovaries are long, equal in size and development, and extend from a point a short distance in front of the anus to the posterior end of the body cavity. A long, loose, sac-like oviduct runs the length of each ovary. These unite below and are seen as a long loose mesenteric structure but internally the two sides run quite separately. About two-thirds along their length they dip ventrally to open through the genital pore. There is a cluster of fairly well developed ova at the caudal end of the ovary. Elsewhere in the ovary the ova are quite small. The fish is not in or near spawning condition.

Holotype.—ANSP 103608 (formerly UMML 15299) a female, total length 302 mm, collected at night, June 1, 1964, at PILLSBURY Station 62, between Lat. 4°45′N, Long. 6°13.5′W, and Lat. 4°44′N, Long. 16°16′W (off the Ivory Coast just west of the offing of the St. Andrew River [Sassandra Bagnida]) in 25 fathoms on a bottom rich in brown branching and leaf-like foraminiferans.

Name.—Olokun, the god or goddess of the sea in the culture of the Yoruba-speaking peoples.

The xenocongrid eels were last treated in detail by Böhlke (1956) who placed in the family, in addition to *Xenoconger*, the genera *Chlopsis* (Rafinesque), *Chilorhinus* Lütken, and *Kaupichthys* Schultz. Recently, Smith (1965) returned *Chilorhinus* to its own family, an action with which we disagree, and announced the additional genus *Powellichthys*. In a paper of later appearance, Smith (1966) placed *Chilorhinus* in the subfamily Chilorhininae of the Xenocongridae and *Powellichthys ventriosus*, from Cook Island, Pacific Ocean, was formally described. *Xenoconger olokun* differs from *Powellichthys* and *Kaupichthys* in lacking pectoral fins, and from *Kaupichthys, Chlopsis,* and *Chilorhinus* in having the anterior vomerine teeth in two rows on each side. *Chilorhinus* differs in many other features (see Böhlke, 1956: 81), including having the posterior nasal opening inside the mouth. *Kaupichthys* also has more than two rows of maxillary and dentary teeth and it has two pores on either side of the branchial region instead of one. In all these features *olokun* shows relations to *Xenoconger*, known only from the type-species *X. fryeri* Regan, described from Assumption Island in the Indian Ocean. It is known only from its type. Comparisons of counts and measurements are given in Table 1. The two species differ most in placement of the dorsal fin (farther forward in *olokun*), diameter of the eye (larger in *olokun*), length of trunk (shorter in *olokun*) and in length of head (longer in *olokun*). According to Regan (1912: 301), *fryeri* has the jaws equal anteriorly (lower jaw definitely shorter in *olokun*) and the dentary teeth in broad bands (biserial except anteriorly in *olokun*). Norman (1922) illustrated the teeth of *Xenoconger fryeri* and indicated three rows of dentary teeth (four anteriorly) and a third row of maxillary teeth posteriorly. Comparisons of Norman's Figure A with Figure 3 suggest other dental differences, but Norman's drawing is rather schematic and perhaps should not be relied on for details.

One other Atlantic eel merits discussion. Günther (1870: 93) described, very briefly, *Myroconger compressus* from St. Helena and this he assigned to the group Muraenina which comprises the nucleus of what is today called the Muraenidae. This species has not been collected again. Recent collections from St. Helena (Cadenat & Marchal, 1963) failed to obtain additional material. The senior author examined the holotype of *M. compressus* (BM[NH] 1867.10.8.49) at the British Museum (Natural History) through the courtesies extended by Dr. P. H. Greenwood and Mr. G. Palmer. Although it can be dismissed quickly from the Xenocongridae on the basis of the high placement of the posterior nostril and its dental pattern, it seems worthwhile to add the following descriptive data on the unique type of *M. compressus* (measurements other than standard length and total length expressed in per cent of total length): total length 538 mm, standard length 528 mm, head length (to anterior point on gill opening) 15, eye diameter 2.0, snout to origin of dorsal fin 11, snout to origin of anal fin 46, pectoral-fin length 2.7, caudal-fin length 1.9, depth at anal-fin origin 8.4, width at anal-fin origin 4.0. The anterior nostril opens in a short tube (2.8 mm) which projets ventrally to a point just beyond the level of the upper jaw; the posterior nostril is a simple opening in front of the eye at the level of the upper border of the eye. There are two prominent pores over the pectoral fin and five additional small pores in a broad area posteriorly to a point over the gut about one-half head length behind the pectoral fin. Posterior to the last pore the lateral line becomes obsolescent but a few pin-hole like points may be seen about to the level of the anal-fin origin. The head is quite flattened above and the skull, which is exposed, lacks crests above. No trace of pigment remains. The tongue area is destroyed and the small tongue which can be seen may not have been exposed and free. There are five pores along the upper jaw, one in front of and slightly dorsal to the anterior nostril and four along the jaw in front behind the anterior nostril to a point under the posterior part of the eye. The dentary tooth patches are without real rows but are about 4-5 teeth wide at any point; the inner teeth are largest. The teeth in the upper jaw unite into a large three-pronged patch with the strongest teeth on the sections corresponding to the anterior part of the vomer, the posterior part of the intermaxillary and the inner part of the maxilla. Generally the maxillary teeth are crudely arranged in three rows.

Myroconger compressus is a puzzle, bearing some resemblance to the morays (2 branchial pores, position of posterior nostril) and some to the xenocongrids (pectoral fin, flattened head and snout) and possessing some features unique to itself. Provisionally it seems best to continue treating *Myroconger* as belonging to the monotypic family Myrocongridae.

The discovery of a species of *Xenoconger* in the Gulf of Guinea adds another Indo-Pacific element to the eastern Atlantic fauna and in this it parallels the discovery of a new species of *Pogonymus* in Nigerian shore waters (see Davis & Robins, 1966).

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 6 —

MICRODESMUS AETHIOPICUS AT FERNANDO POO[1]

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Introduction and Acknowledgments

The only microdesmid fish collected by the University of Miami's Gulf of Guinea operations was at Pillsbury station 257 at Fernando Póo. Since it represents the third known specimen of *Microdesmus aethiopicus* (Chabanaud) and since this poorly known species was recently and incorrectly synonymized by Blache (1962: 66) a redescription is in order.

I am indebted to Dr. Gilbert Voss, cruise leader. Charles E. Dawson of the Gulf Research Laboratory provided helpful comments on the manuscript. Pillsbury operations for the periods in question were conducted under grants from the National Science Foundation (NSF-GB-1204; NSF-GB-1350) and the National Geographic Society. I wish also to acknowledge the Maytag Chair of Ichthyology for travel funds and other support.

Microdesmus aethiopicus (Chabanaud)

Leptocerdale aethiopicum Chabanaud, 1927: 230-234 (description, type locality Cameroun, Malimba Bay, Kwele-Kwele Island in the Bay of Douala). *In* Monod, 1927: 730-736, figs. 34-35 (additional information on the type specimen). 1928: 280-285, figs. 1-4 (description of second specimen from Kwele-Kwele; general nature of color pattern shows well in fig. 1).

Microdesmus aethiopicus: Reid, 1936, 62-63, fig. 9d (placed in *Microdesmus;* characters compiled). Fowler, 1936: 1329 (name and type locality). Cadenat, 1950: 190-191 (comparisons). Robins and Manning, 1958: 301 (briefly mentioned). Dawson, 1962: 335 (in key).

Leptocerdale longipinnis: Blache, 1962: 66 (in part; *M. aethiopicus* incorrectly synonymized with *L. longipinnis* [=*M. longipinnis*]).

A single specimen, UMML 21308, 49.8 mm in standard length, was collected at Pillsbury station 257 in Santa Isabel harbor, Fernando Póo, on May 15, 1965, by C. Richard Robins, William N. Eschmeyer, and Clyde F. E. Roper. This rotenone collection made from the Pillsbury's launch was in the eastern end of the harbor between Pta. Pilon and Rio Carboneras along the shore and over a muddy sand and boulder bottom.

[1]Contribution No. 734 from the Institute of Marine Science, University of Miami. This paper is one of a series resulting from the National Geographic Society-University of Miami Deep-Sea Biology Program.

The water was mud-laden but cleared somewhat on the flooding tide. This station is within sight of Cameroun, the type locality.

Counts are: Dorsal rays XIV+34=48, striated caudal rays 17, branched caudal rays 15, anal rays 31 (all striated), pectoral rays 12-12, vertebra 52. The X-rays do not permit exact separation of the precaudal and caudal vertebrae. There are about 26 precaudal vertebrae. The anal fin originates under the space between dorsal soft-rays 5 and 6. Measurements (expressed in per cent of standard length) are: standard length—49.8 mm, snout tip to dorsal-fin origin—54, snout tip to anal-fin origin—45, head length—10 (from tip of upper jaw; 11 from tip of lower jaw), greatest depth of body—7.6, depth of body at anal-fin origin—7.0, eye diameter—1.6, anal-fin origin to caudal-fin base—45, caudal-fin length—10.

The gill opening is restricted, beginning anterior to the level of the second pectoral ray and extending obliquely ventrad and cephalad to a point anterior to the origin of the most ventral pectoral ray. The vertical fins are united caudally.

Microdesmus aethiopicus is a boldly patterned species with dark brown bars on a tan background. The bars or chevrons follow the myomeric pattern and thus the pattern may be termed herringbone. There are 26 dark bars between the pectoral-fin base and the level of the origin of the anal fin. Of them the anterior four or five do not connect dorsally and in their place there are 2 pairs of short longitudinal dorsal stripes, one in front of the other. Above the anal fin the barred pattern becomes more diffuse and finally disappears into a darker background color about half way along the anal fin. The head is splotched dorsally and posteriorly and elsewhere is sprinkled with small melanophores.

The body is covered with regular rows of small, dark edged (posteriorly) cycloid scales with the naked interspaces equaling the scaled area. Only the chin, throat, the anterior part of the chest and the snout are free of scales however.

Like *Microdesmus longipinnis* and *M. floridanus, M. aethiopicus* may be expected in mud-laden, salt-water, shore environments. Such areas are poorly sampled. It should have a broad coastal distribution in the Gulf of Guinea.

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 7 —

OBSERVATIONS ON THE SEABIRDS OF ANNOBON AND OTHER PARTS OF THE GULF OF GUINEA[1]

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ABSTRACT

Observations of seabirds are summarized for the two cruises of the research vessel PILLSBURY in the Gulf of Guinea, May 20-June 7, 1964 and May 7-29, 1965. The area treated extends from about Cape Lopez, Gabon, to Monrovia, Liberia, and includes the islands of the Guinea Rise from Fernando Póo to Annobón. New records of the masked booby, *Sula dactylatra,* at Annobón and of the wandering albatross, *Diomedea exulans,* off Nigeria are noted.

Particular attention is paid to the concentrations of seabirds on the islets around Annobón.

The University of Miami's Institute of Marine Science conducted biological studies aboard its ship R/V PILLSBURY in the Gulf of Guinea from May 20-June 27, 1964 and from May 7-29, 1965. The 1964 cruise followed a zig-zag course between the 20- and 2000-fathom curves from Lagos, Nigeria, to Monrovia, Liberia. The 1965 cruise went east from Lagos following approximately the continental margin to Fernando Póo, in the Bight of Biafra, thence southward to the oceanic island of Annobón and finally across the open ocean from Annobón to Lagos. In accord with divisions recognized by Guinean Trawling Survey personnel, these two cruises of PILLSBURY covered the western tropical region, the central upwelling region, and the eastern tropical region.

The author participated in the Guinean operations and recorded observations on oceanic and coastal birds. Watson (1965: 101) has noted that the seabird fauna of the Gulf of Guinea is poorly known and that reports from the area should be made available. In response to this request the present paper was prepared.

Except at Annobón, seabirds were scarce during the periods of the two PILLSBURY trips. For this reason the text below is divided into two sections, the first dealing with the observations near Annobón, the second summarizing the general records for each of the two trips. Although land birds were seen at the various islands, the author is not sufficiently familiar with the

[1]Contribution No. 735 from the Institute of Marine Science, University of Miami. This paper is one of a series resulting from the National Geographic Society-University of Miami Deep-Sea Biology Program.

African avifauna to attempt any documentation of them. Nomenclature follows that by Watson (1965). I am indebted to my colleagues on board Pillsbury, Dr. Gilbert L. Voss, cruise leader, for calling to my attention on many occasions the presence of seabirds, thus making possible a fuller record. Dr. Oscar T. Owre, Department of Zoology, University of Miami, and Dr. William B. Robertson, Jr., U.S. National Park Service, have reviewed the manuscript. Their suggestions have been much appreciated. Pillsbury operations for the periods in question were under grants from the National Science Foundation (NSF-GB-1204, NSF-GB-1350) and the National Geographic Society. I wish also to acknowledge the Maytag Chair of Ichthyology.

Annobón

The general topographic features of Annobón have been discussed by Fry (1961: 267-268) who seems to have been concerned chiefly with the main island. Bannerman (1915) summarized Alexander's account of the island and included information on some specimens of seabirds taken from the islets. More detail of the coast is provided in the sailing directions published by the U.S. Navy Hydrographic Office (1952: 153-156). The main seabird concentrations are associated with the southern high islets Escobar, Santaren, Fernando Po and Adams (Yecayi) and with the eastern islet, Tortuga. Other small islands are too completely awash and too close to the main island to attract seabirds. The heavy seas, steep-to profiles, and steep cliffs make access to the islets very hazardous. During her stay at Annobón from May 19-22, 1965, Pillsbury anchored to the north of Tortuga and passed close by this islet on its daily operations. The author also circled Tortuga at close range in the launch. It is a crescent shaped isle with the cut side precipitous. Dredging operations on May 21 permitted close observation of the southern islets and we sailed by them again on May 22 as we departed from Annobón. The southern islets appear snowy from the distance due to their heavy investment of guano (Figure 1). No observations were made along the western shore of Annobón. It was impossible because of sea conditions, to get sufficiently close to the islets to determine if any species were nesting.

Phaethon lepturus. White-tailed tropic-birds were present along the steep cliffs of Pico Fogo and along the equally steep but lower cliffs near San Juan Chapel. A few pairs were seen along the cliffs north of the village of San Antonio.

Sula dactylatra. One masked booby in adult plumage was seen on Santaren. This large booby is previously unrecorded from Annobón and the Gulf of Guinea.

Sula leucogaster. Brown boobies were on each of the five islets mentioned above. Ten to twelve were on Tortuga with others flying nearby, and each of the southern islets had colonies numbering in the hundreds.

FIGURE 1. Adams (Yecayi), a guano covered high islet off southern coast of Annobón. The black basal portion of the islet depicts the part washed by wave action. Photograph by Jon C. Staiger.

Sterna fuscata. Sooty terns were not seen by Fry (1961) who in fact made special note of their absence. Their presence at Annobón presumably is seasonal. They were, at the time of our visit, the common seabird on Tortuga, being especially numerous on the cut side. Hundreds were present in this colony. At the southern islets, where noddies dominated, there were probably between 100-200 sooty terns.

Anous stolidus and *Anous tenuirostris.* Both brown and black noddies were common at Annobón. The biggest flocks are on the southern islands where several thousand were seen. It was impossible to get reliable estimates of the two species but spot sampling supported the general impression that the black noddy was much the more common species. At Tortuga there were about 100 black noddies on the steep cliffs along with a few (about 10) brown noddies. They did not rest on the landward face of Tortuga. The ratio of 10 to 1 on Tortuga agrees with estimates made by Fry (1961: 270).

A breeding colony of the bridled tern, *Sterna anaethetus,* was recorded for Tortuga by Fry (1961: 270). None was present at the time of our visit.

Of these species only the brown booby and the tropic-bird were recorded by Snow (1950: 584-588), from Principe and São Tomé respectively, but he apparently was concerned primarily with land birds so that the absence of the other species from the recorded lists of these next islands along the Guinea Rise may not be meaningful.

Gulf of Guinea

A noteworthy feature of both Pillsbury cruises was the near absence of coastal and oceanic birds observed, except for the region of Annobón, this despite the numerous transects that were run from within sight of land across the shelf to the deep water. A detailed track of these cruises is provided by Voss (1966: Fig. 2).

At nearly all coastal areas during both cruises, from Fernando Póo to Monrovia, we encountered considerable numbers of the small Damara tern, *Sterna balaenarum.* Clearly this is the characteristic and common coastal bird along the Gulf of Guinea in May and June. It was absent at Annobón. Four roseate terns, *Sterna dougallii,* followed and circled Pillsbury from 0700-1030 on May 27, Lat. 4°50′N, Long. 3°48′E. An unidentified tern, *Sterna sp.,* was seen on May 12, at Lat. 5°19′N, Long. 4°14′E. Through the evening and night of May 23-24, a flock of sooty terns, *Sterna fuscata,* circled the boat. One sooty tern was captured for a time. Several brown noddies, *Anous stolidus,* joined the group in the late evening. During this period the Pillsbury steamed from about Lat. 0°35′N, Long. 5°02′E to about Lat. 1°29′N, Long. 4°43′E. One white-tailed tropic-bird was seen on May 23 at about Lat. 0°25′N, Long. 5°09′E. On May 9, several Sandwich terns, *Thalasseus sandvicensis,* were seen about the buoys near the entrance to Lagos Harbor. Two lesser blackback gulls, *Larus fuscus,* were seen on May 28 at the entrance to Lagos Harbor.

Except for the common Damara tern, all the records above are for 1965. None of these species was seen in 1964. The earlier date of the second trip may account for the presence of these other species.

On May 24, 1964, one immature wandering albatross, *Diomedea exulans,* was seen off Nigeria at about Lat. 5°57′N, Long. 3°13′E. Bannerman (1930: 12) notes that the wandering albatross has been recorded [from the West Africa region] on doubtful evidence from the Gabon Coast. Watson (1965: 4) states that vagrants have been noted near the Equator.

Aside from these sparse records all observations on oceanic birds during the two cruises concerned storm petrels, Hydrobatidae. Storm petrels were almost always in view of the ship except at inshore portions of the transects, all the way between Lagos, Nigeria, and Monrovia, Liberia, in 1964. They ignored the ship and were seldom close enough to permit identification. Only the British storm petrel, *Hydrobatis pelagicus,* was identified in 1964 and there was no suggestion that a second species was present. This was the only seabird reported by the Atlantide Expedition (Wolff, 1950: 132). In 1965, storm petrels again were seen on an hourly basis and two species clearly were involved. The British storm petrel seemed most widespread but the Madeiran storm petrel, *Oceanodroma castro,* was frequent especially in the Bight of Biafra and along the Guinea Rise. Neither species followed the ship, neither did they shy away from it.

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 8 —

THE FORE-GUT OF SOME MARGINELLID AND CANCELLARIID PROSOBRANCHS[1]

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ABSTRACT

The anatomy of the fore-gut is described for *Marginella marginata* (Linn.) and *M. desjardini* Marche-Machad, and for *Cancellaria cancellata* (Linn.) and *C. lyrata* (Brocchi), all from West Africa, the last supplemented by material of the western Atlantic *Cancellaria reticulata* (Linn.). Comparisons are made, the homologies of structures are discussed and their bearing upon the evolution of the Stenoglossa is indicated.

INTRODUCTION

The most advanced group of the prosobranch gastropods is the Stenoglossa or Neogastropoda, divided by Thiele (1929) into four stirpes: Muricacea, Buccinacea, Volutacea and Toxoglossa. Stenoglossans are usually easily recognizable on the basis of their shell and radula, though the characteristics of the sub-groups are not especially clear and the soft parts are often poorly known. This is particularly true of volutaceans which, as Marcus & Marcus (1959) have noted, have remained uninvestigated because they are largely confined to parts of the world where few malacologists have worked. As a result the inter-relationships of the stenoglossan groups and the way in which, for example, the aberrant anatomy of the toxoglossans may have arisen are still obscure. Some observations made on the anatomy of cancellariid and marginellid stenoglossans which seem to help in this connexion are recorded in the following pages. They mainly concern the alimentary system and were made on the animals sent to me by Dr. F. M. Bayer of the Institute of Marine Science, University of Miami, to whose great kindness I owe the opportunity of examining them. They were sent from Miami by air after freezing and were kept frozen until dissected. They gave excellent results with this treatment though they were of no use for histological examination. The animals were all collected in the Gulf of Guinea on a cruise by R/V JOHN ELLIOTT PILLSBURY of the Institute of Marine Science and comprised the following:

Marginella marginata (Linn.): stations 46 (25 fms.), 62 (25 fms.), 63 35 fms.)

[1]Contribution No. 736 from the Institute of Marine Science, University of Miami.

M. desjardini Marche-Machad: station 59 (35 fms.)

Cancellaria cancellata (Linn.): stations 46 (25 fms.), 59 (35 fms.), 62 (25 fms.)

C. lyrata (Brocchi): station 73 (170-200 fms.)

The two genera therefore occur in the same kind of habitat—a muddy bottom with a thick layer of large foraminiferans and an associated fauna of other molluscs, crustaceans and worms (Bayer, *in litt.*). All stations lie off the coast of West Africa between Greenville, Liberia, and Abidjan, Ivory Coast. Exact locations may be found in the station list, which appears elsewhere in this volume. Shells of the four species are illustrated in Figure 7 at the end of this paper.

In addition to these, some specimens of *Cancellaria reticulata* (L.) from Florida which had been fixed in Bouin's fluid were used for histological investigation. These were collected for me at Dr. Bayer's request by Mrs. Ellen Crovo and Lt. Col. Corinne Edwards, and were fixed for histological study by Mr. Robert C. Work of the Institute of Marine Science.

Marginella marginata

The external appearance of this animal presents no unusual features beyond the usual marginellid lack of an operculum and great development of delicate mantle skirt allowing it to cover much of the shell. The siphon is fused to the mid-dorsal line of the animal's head, which is much depressed. The penis is prominent in males.

There is a large and muscular proboscis (*p*, Fig. 1) with the mouth at its tip, lodged in a proboscis sac (*ps*). It is rich in circular muscle and there are also longitudinal retractor bundles. Some of these insert on the lateral walls of the proboscis sac about the middle of its length; others (*pr*, Fig. 3) reach along the whole length of the proboscis to a point near the mouth. The first group originate on the body wall of the head-foot; the second join the columellar muscle and so originate on the shell.

The course of the gut after leaving the proboscis is shown in Fig. 1. It runs through the nerve ring (*cg, pg*) and then opens to a capacious, thin-walled, crop-like expansion of the oesophagus, the walls of which exhibit a large number of low folds and are drawn out on the right side into a narrow caecal appendage (*oc*). The oesophagus emerges on the left (*po*) and continues back under the visceral ganglia (*vg*) to the stomach, which is a simple, sac-like structure.

Paired salivary glands (*sg*) lie over the point where the oesophagus emerges from the caecum. They are rounded, acinous structures, the right larger than the left. Both salivary ducts (*sd*) run dorsal to the oesophageal caecum towards the base of the proboscis where they diverge, one passing right, the other left of the gut. They continue along the proboscis, attached to its wall near the mid-ventral line (*sd*, Fig. 3) one on either side of the main proboscis artery (*pa*). Near the extreme tip of the proboscis they rise

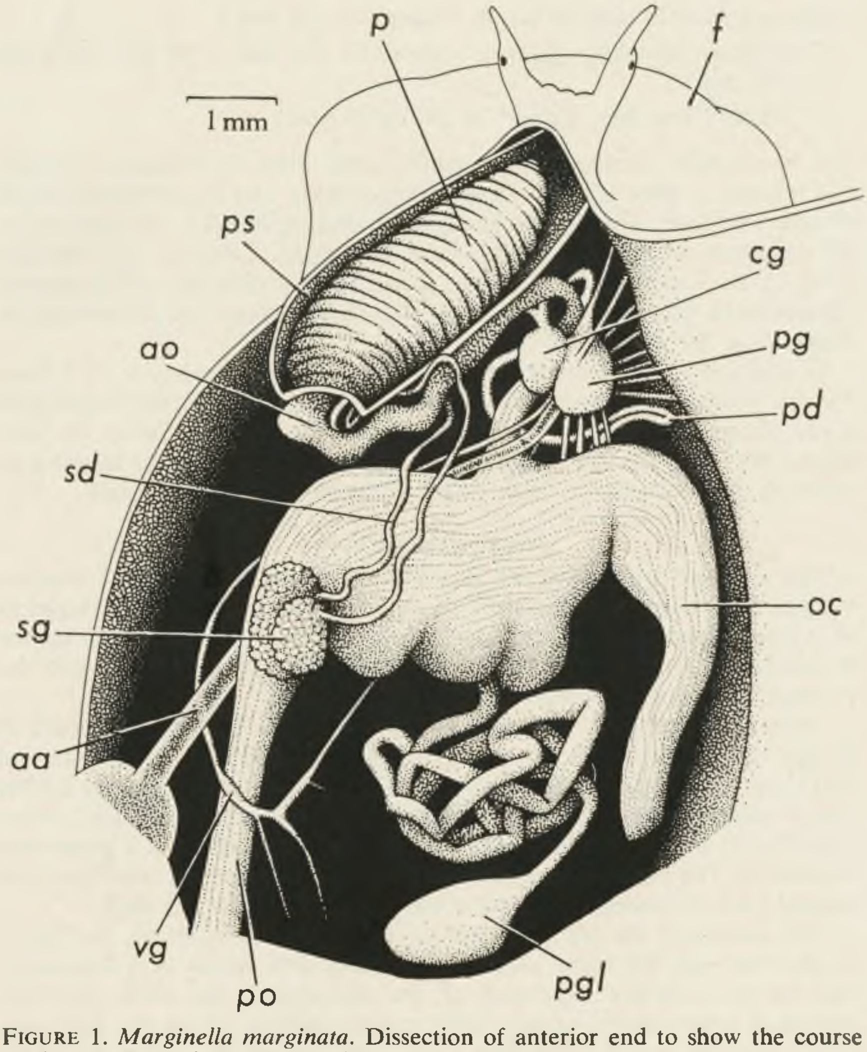

FIGURE 1. *Marginella marginata.* Dissection of anterior end to show the course of the gut. Lettering: *aa,* anterior aorta; *ao,* anterior oesophagus; *cg,* cerebral ganglion; *f,* foot; *oc,* oesophageal caecum; *p,* proboscis in proboscis sheath; *pd,* duct of poison gland; *pg,* pedal ganglion; *pgl,* poison gland; *po,* posterior oesophagus; *ps,* proboscis sheath, opened; *sd,* salivary duct; *sg,* salivary gland; *vg,* visceral ganglion.

dorsally, passing lateral to the local muscles and enter the buccal cavity in a dorso-lateral position (*sb*, Figs. 2, 3). In addition to the salivary glands the mollusc possesses a median gland which, for want of better information regarding its function, may be called a poison gland because of its resemblance to the poison gland of toxoglossans. Like that structure, this (*pgl*, Fig. 1) consists of a swollen terminal sac with extremely muscular walls and very narrow central lumen and a long, convoluted duct (*pd*). The duct runs forward (Fig. 1) ventral to the oesophageal caecum, passes through the nerve ring ventral to the oesophagus and then follows the ventral side of that structure (Fig. 3) until it reaches the posterior end of the buccal cavity, where it rather abruptly turns dorsally on the right side and opens on the lateral wall a little behind and below the opening of the right salivary duct (*opg*, Fig. 2).

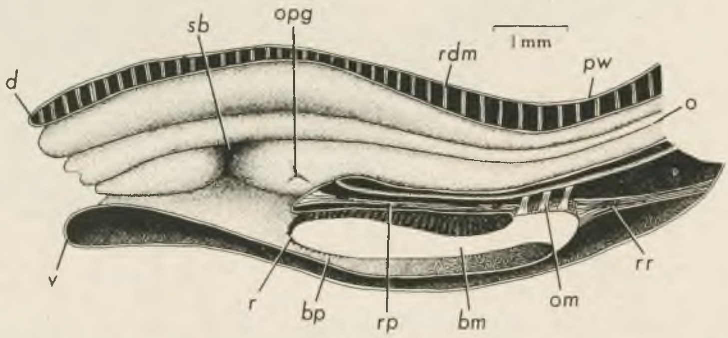

FIGURE 2. *Marginella marginata.* Sagittal half of anterior part of proboscis. Lettering: *bm,* buccal mass; *bp,* buccal pouch; *d,* dorsal lip; *o,* oesophagus; *om,* muscles to oesophageal wall; *opg,* opening of poison gland; *pw,* proboscis wall; *r,* radula; *rdm,* radial muscles; *rp,* protractor muscle of buccal mass; *rr,* retractor muscle of buccal mass; *sb,* opening of salivary duct; *v,* ventral lip.
v, ventral lip.

The anatomy of the buccal area of the gut is highly modified; it is shown in Figs. 2 and 3. The mouth is a small aperture and leads into the buccal cavity. This has a few longitudinal folds running along its roof and lateral walls, broken, right and left, for the openings of the salivary ducts (*sb*) and on the right for that of the poison gland (*opg*) as well. At the inner end of the buccal cavity there are two openings lying one above the other; the dorsal leads into the oesophagus (*o*), the lower, however, not as might be expected into a radular sac, but into a blind buccal pouch (*bp*) in which lies a complete (though rather reduced) buccal mass with supporting cartilages, muscles and radula (*r*). The buccal pouch is slung from the more dorsal oesophagus by a series of muscular slips (*om*) and is connected to the wall of the proboscis by moderately powerful muscles (*rr*) set along each lateral edge and sending a succession of branches across the cephalic haemocoel to origins on the body wall. In addition a number of muscular bundles (*rp*), which are inserted on the innermost part of the pouch, run anteriorly over its upper wall to an origin on the tissue lying between the

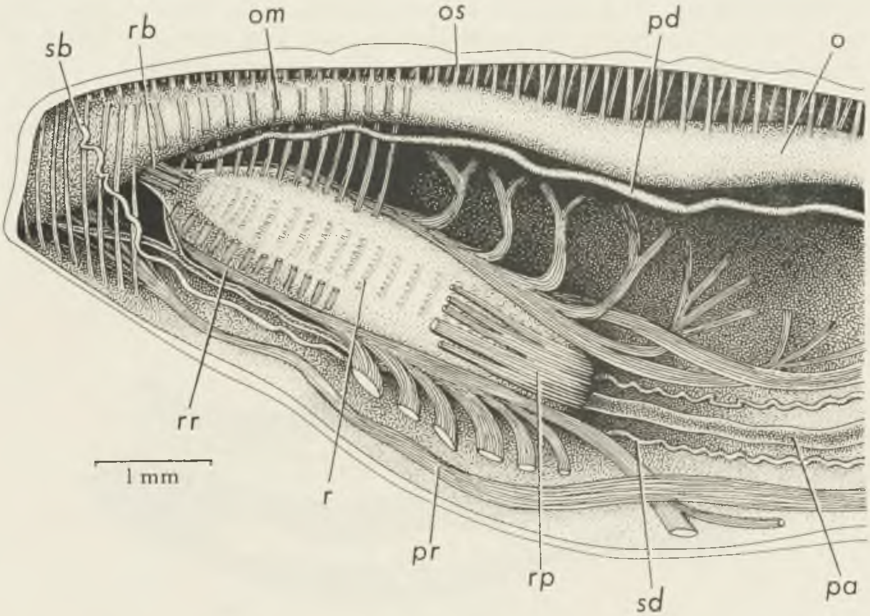

FIGURE 3. *Marginella marginata*. Dissection of anterior part of proboscis. Lettering: *o*, oesophagus; *os*, suspensory muscle of oesophagus; *pa*, proboscis artery; *pd*, duct of poison gland; *pr*, retractor muscle of proboscis; *r*, radular tooth; *rb*, opening of radular sac to buccal cavity; *rp*, radular protractor muscle; *rr*, radular retractor muscle; *sb*, opening of salivary duct to buccal cavity; *sd*, salivary duct.

mouth of the buccal pouch below and that of the oesophagus over it. Those running to the proboscis wall are clearly retractors of the pouch and buccal mass, the others their protractors.

Within the pouch lies the buccal mass (*bm*, Fig. 2) carrying the radula on its dorsal surface and anterior tip. The radula is composed of a single series of broad, comb-like teeth, each with numerous cusps. They arise at the innermost end of the pouch, which therefore corresponds to the radular sac of more normal gastropods, though no clear demarcation of this area is visible.

Marginella desjardini

Externally, animals of this species show a few differences from *M. marginata:* they are much larger but possess the same deep mantle edge. The foot has no operculum, folds longitudinally on retraction and, in females, has a ventral pedal gland placed about one-quarter of its length behind the anterior edge. The siphon is not fused to the dorsal surface of the head. In males the penis is relatively smaller than that of *marginata* and is much less pointed.

There is a large proboscis lodged in a proboscis pouch and carrying the mouth at its tip. It is very muscular, with intrinsic circular and radial strands and longitudinal bundles running back to an origin on the posterior body wall. The mouth leads into an apparently single tube with thick walls thrown into a small number of longitudinal folds. The diameter of this tube is so great that the haemocoel between it and the body wall is reduced to a very small space. On leaving the proboscis the gut passes through the nerve ring and then runs backwards to the stomach without any expansion along its course. From just in front of the nerve ring as far as the stomach its walls are marked by many small longitudinal folds.

A number of glands is associated with this section of the gut. Paired salivary glands lie dorsally near the nerve ring. They send ducts towards the oesophagus, both of which pass to its left and then curve to either side of the mid-ventral line, where they run forwards, each alongside a prominent buccal nerve, until they reach the extreme anterior end of the proboscis, where they discharge, still rather ventrally, into the buccal cavity. A poison gland lies in the haemocoel behind the nerve ring with a long, convoluted duct passing forwards from it. The duct comes to lie on the left of the oesophagus and passes through the nerve ring in this position; once through the nerve ring, however, it crosses to the right, dorsal to the oesophagus, curves to the mid-ventral line and there opens to the gut at almost the same level as that at which the salivary ducts reach the same position. This twisting of the poison duct repeats the twisting of supra-oesophageal connective and anterior aorta, but whereas these cross from one side to the other behind the nerve ring the duct of the poison gland does so anterior to it. The poison gland has the usual thick muscular wall with small central lumen. In addition to salivary and poison glands there is one further structure to be referred to here which, at first sight, looks like an unpaired accessory salivary gland opening to the gut medially just within the ventral lip. It has the form of a long, thin, slightly flattened and blind tube lying underneath the initial part of the gut; it is slightly thickened at the innermost end. Though there is nothing within this caecum to represent buccal mass or radula it seems inevitable to conclude, by comparison with *M. marginata,* that this structure is a vestigial buccal pouch homologous with the well developed one found in that species.

The stomach is a small globular structure embedded in the substance of the digestive gland with the oesophagus and intestine connected to it at opposite ends. Two ducts from the digestive gland open alongside the oesophageal aperture and a few large folds run along the gastric wall. The intestine arises directly from the gastric cavity and there is nothing comparable to the style sac area of the normal prosobranch stomach. The intestine is short and runs along the right wall of the kidney, which is invaginated into the cavity of the kidney as a consequence, before reaching the mantle skirt.

The reproductive system is built on the normal stenoglossan pattern. In the female (Fig. 6C) there is the unusual arrangement of a connexion (*rgc*) between genital duct and kidney, and two glandular structures (*rs, ig*) lie proximal to the albumen-capsule gland (*ag*). These might be receptacular and ingesting in function as in other stenoglossans (Fretter, 1941). No bursa copulatrix could be found.

Cancellaria cancellata and *C. lyrata*

The external features of these animals show nothing of special interest and are such as would be expected in a stenoglossan. There is no operculum, and the foot has a ventral pedal gland in females. There are no points in which the two species seem to be significantly different from one another.

There is a long proboscis held within a proboscis sac with well developed musculature. Some of the retractor muscles (*pr*, Fig. 4) originate from the body wall of the head; others, including some from the tip of the proboscis, are extensions of the columellar muscle (*cm*). The proboscis is protracted by a variety of means: the process is probably initiated by the contraction of muscles which run from the base of the proboscis sac into the anterior part of the foot (*pp*), and is continued by contraction of the powerful array of circular muscles in the sac wall (*cp*); it is certain that blood pressure will be involved as well. When extended (a state in which I have not seen it) it must be extremely long if its entire length can be protruded. At its apex lies the mouth, leading into the oral tube, a shallow cavity with a papilla projecting from its base carrying the entrance to the buccal cavity at its tip. This is very elongated and contains in its inner half a long, narrow buccal mass (*bm*, Fig. 5). From the innermost end of the buccal cavity arise the oesophagus *(o)* and the radular sac *(rs)*, the latter a short, narrow, finger-shaped structure.

The oesophagus *(o)* is very long and narrow, indicative, presumably, of extensibility of the proboscis. Just posterior to its origin from the buccal cavity it expands in diameter and exhibits some irregular swelling of the ventral wall *(vl)* but apart from this it is of even diameter throughout its entire length. When the proboscis is not extended the oesophagus is thrown into a long S-shaped loop in the cephalic haemocoel (*o*, Fig. 4); it penetrates the nerve ring *(nr)*, passes under the supra-oesophageal connective and anterior aorta *(aa)* and runs back to the stomach. This, as in marginellids, is a rather featureless sac with oesophageal and intestinal openings at opposite ends, the latter without anything reminiscent of a style sac. There are two wide digestive gland ducts connected to the stomach by a common vestibule placed near the opening of the oesophagus. There is a small rectal gland in *C. cancellata,* absent in *C. reticulata.*

With the elongation of the proboscis the salivary glands have been pulled forwards through the nerve ring and out of the main haemocoel and now lie entirely within the proboscis (Fig. 5). As an adaptation for lodgement in this site they have become tubular and lie parallel to buccal

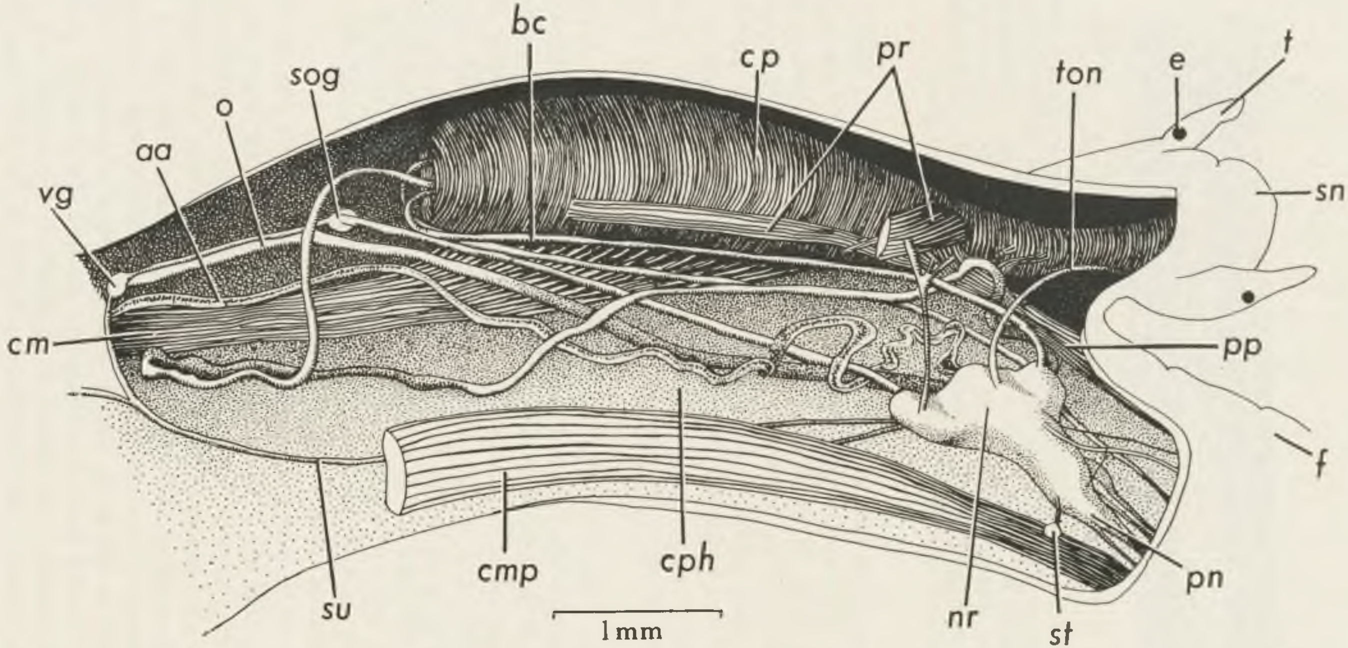

FIGURE 4. *Cancellaria cancellata.* Dissection of anterior end to show the course of the gut. Lettering: *aa,* anterior aorta; *bc,* cerebrobuccal connective; *cm,* cephalic branch of columellar muscle; *cmp,* pedal branch of columellar muscle; *cp,* circular muscle of proboscis sheath; *cph,* cephalic haemocoel; *e,* eye; *f,* foot; *nr,* nerve ring; *o,* oesophagus; *pn,* pedal nerves; *pp,* protractor muscle of proboscis sheath; *pr,* retractor muscle of proboscis sheath; *sn,* snout; *sog,* supraoesophageal ganglion; *st* statocyst; *su,* suboesophageal connective; *t,* tentacle; *ton,* tentacular and optic nerve; *vg,* visceral ganglion.

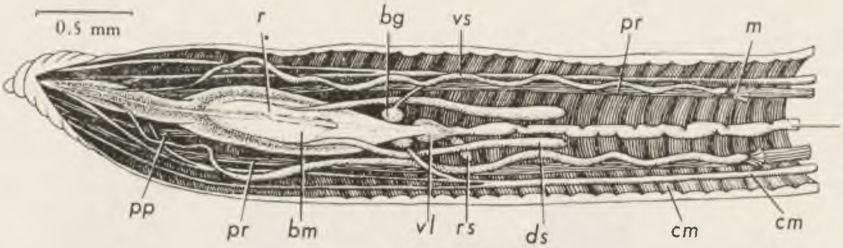

FIGURE 5. *Cancellaria cancellata.* Dissection of proboscis. Lettering: *bg*, buccal ganglion; *bm*, buccal mass; *cb*, cerebrobuccal connective and proboscis nerves; *cm*, circular muscle; *ds*, dorsal salivary gland; *m*, muscular tie; *o*, oesophagus; *ot*, oral tube; *pp*, protractor muscle of buccal region; *pr*, proboscis retractor muscle; *r*, point at which the radular teeth are parted into anterior and posterior series; *rs*, radular sac; *vl*, valve of Leiblein; *vs*, ventral salivary gland.

cavity and the anterior part of the oesophagus. There are two pairs, one shorter than the other and more dorsally placed *(ds)*. The dorsal pair opens into the buccal cavity at the level of the anterior tip of the buccal mass by a fine dorsolateral aperture on each side: they therefore seem to correspond to the normal salivary glands of other prosobranchs. The glands of the second pair *(vs)* which are longer and tied at their inner ends to the proboscis wall by small muscular slips *(m)* narrow anteriorly to exceedingly fine ducts which run forward to open to the buccal cavity close to the mouth.

The oral tube, buccal cavity, oesophagus, the ducts and neigbouring parts of the ventral salivary glands are very muscular. Many bundles which lie in the walls of the oral tube are longitudinal in direction and must act as protractor and retractor muscles by means of which the buccal mass and buccal papilla are moved backwards and forwards, though this is mainly effected by muscles in the proboscis wall. Some of the muscle in this part is circular and in the oesophagus and salivary glands and ducts there is a thick layer of circular muscles with which some radial fibres are intermingled (save in the case of the salivary ducts). In the salivary ducts these fibres are striated but they are plain elsewhere.

On the floor of the buccal cavity lies the long and narrow buccal mass, covered with a cuticle. It is supported by a pair of cartilages and is equipped with an elaborate set of muscles, all the fibres of which show striations. They are innervated from the two buccal ganglia *(bg)* which lie in their normal position and are linked to the cerebral ganglia in the nerve ring by connectives *(cb)* extending the whole length of the proboscis. These are bound in the same sheath with proboscis nerves of cerebral origin; they are double in *C. cancellata* but are tied into a single median bundle in *C. reticulata*. The radula is secreted in the radular sac and extends over the dorsal surface of the buccal mass in the usual way, lying in a narrow groove. The teeth, as is known, form a single series of long, flattened blades, like grass leaves. Each has two strengthening ribs running along its length with central and marginal strips of thinner, more flexible material. Whilst within the radular sac each tooth is attached to the subradular membrane, which lines its floor and side walls, by its base and lateral edges; as it migrates forwards out of the radular sac so the lateral attachments break, leaving only the basal connexion when the entire length of the blade has emerged. Whilst this is happening the teeth involved form a pile one over the other, the youngest at the base, the oldest most superficially, partly lying over the posterior half of the buccal mass but with their tips all pointing backwards and running into the radular sac within which they are anchored by their lateral attachments.

By the time the attachment of the sides of a tooth are broken it appears that it must rotate forwards through approximately 180°, because the anterior half of the buccal mass is covered by a second pile of radular teeth, free except for their basal connexion to the subradular membrane and all pointing forwards, with the youngset on top of the pile and the oldest at its base, the two sets presenting an arrangement like the pages of a book which has been opened in the middle. At the point where the two sets meet there is a parting *(r)* and at this point there is a marked change in the thickness of the subradular membrane to which the teeth are attached — under the posteriorly directed pile it is thin, whereas under the anteriorly directed group it is twice as thick. Since it has been shown by Ankel (1937) that the position which a radular tooth adopts is largely a function of tension in the subradular membrane it is likely that this change in thickness is responsible for the changed orientation of the teeth.

The teeth of the anterior bundle curve forwards far beyond the tip of the buccal mass; indeed, even when that is deeply withdrawn they may reach forwards and their tips project into the oral tube through the aperture at the tip of the buccal papilla. They reach a length of about 1.5 mm in *C. cancellata.* The teeth are clearly delicate parts of a specialized feeding apparatus. The animal protects them — and perhaps to some extent protects its own tissues from them — by secreting a cuticular covering over almost the entire buccal area. The only parts which are not so protected are (1) the mid-dorsal area of the buccal cavity where lie ciliated dorsal folds in relation to which the dorsal salivary ducts open; and (2) lateroventral areas on the sides of the buccal mass which must be left flexible if substantial movement of that organ is going to be possible. At a posterior level in the buccal cavity the cuticular armour therefore forms sheets over the lateral buccal walls; further forward these expand both dorsally and ventrally until, anterior to the buccal mass, the cuticle forms a complete tubular structure within which the projecting radular teeth are enclosed. This reaches right to the opening at the tip of the buccal papilla.

From the roof of the buccal cavity the dorsal folds run backwards into the oesophagus along which they may be traced, with subsidiary folds alongside and between, almost to the stomach. In the swollen area behind the buccal ganglia the folds expand and project deeply into the lumen of the oesophagus. They are fringed with long cilia at this point and form an apparatus similar to the valve of Leiblein of other stenoglossans. The wall of the oesophagus opposite that on which run the dorsal folds is composed of a glandular epithelium, though the state of preservation of the specimens prevents any more definite description of its histology. There is no visible rotation of the parts which can be ascribed to torsion, but this is not perhaps surprising in view of the way in which the length of oesophagus is coiled.

In the nervous system all the ganglia except buccals, supraoesophageal and visceral are fused into one large mass which lies in the cephalic haemocoel and through which the oesophagus and cephalic aorta pass. The ganglia not involved in this nerve ring lie in their normal situations.

The reproductive system is built on the usual stenoglossan pattern (Fig. 6A, B). In the male the testicular duct *(t)* runs down the visceral mass, its basal part being convoluted and used as a seminal vesicle. The vas deferens *(vd)* is extremely long and elaborately coiled and has many gland cells in its walls so that it also acts as prostate gland. There is an opening to the inner end of the mantle cavity *(ao)* similar to that described in other stenoglossans (Fretter, 1941). The female duct is largely as in *Marginella* except that there is a large bursa copulatrix *(bc),* and a gono-pericardial duct *(gpd).*

Discussion

The organization of the animals described above is typically stenoglossan. The alimentary canal is of special interest in both, though for rather different reasons. How does *Cancellaria* feed? Does the anatomy of *Marginella* help towards an understanding of that of the still more elaborate cones? In addition it is of interest to try to homologize both conditions with what is met with in Muricacea and Buccinacea, the anatomy of which may be easily compared with that of lower prosobranchs.

The Cancellariidae are usually said to be vegetable feeders. If this is true of the species dealt with here, which live on sandy/muddy bottoms, then the only food available would be diatoms and other microscopic forms living on sand grains and the like. It may be that the unusual form and arrangement of the radular teeth, which form a brush which can be projected from the mouth, is a device for loosening or picking up such particles, which can then be sucked into the gut by contraction of the radial muscles of the gut wall, or pulled into it entangled on the radular teeth when the buccal mass is retracted. No trace of food was visible in the specimens dissected or sectioned; where the gut had contents these showed neither diatom frustules nor pieces of cell wall. In addition there are a

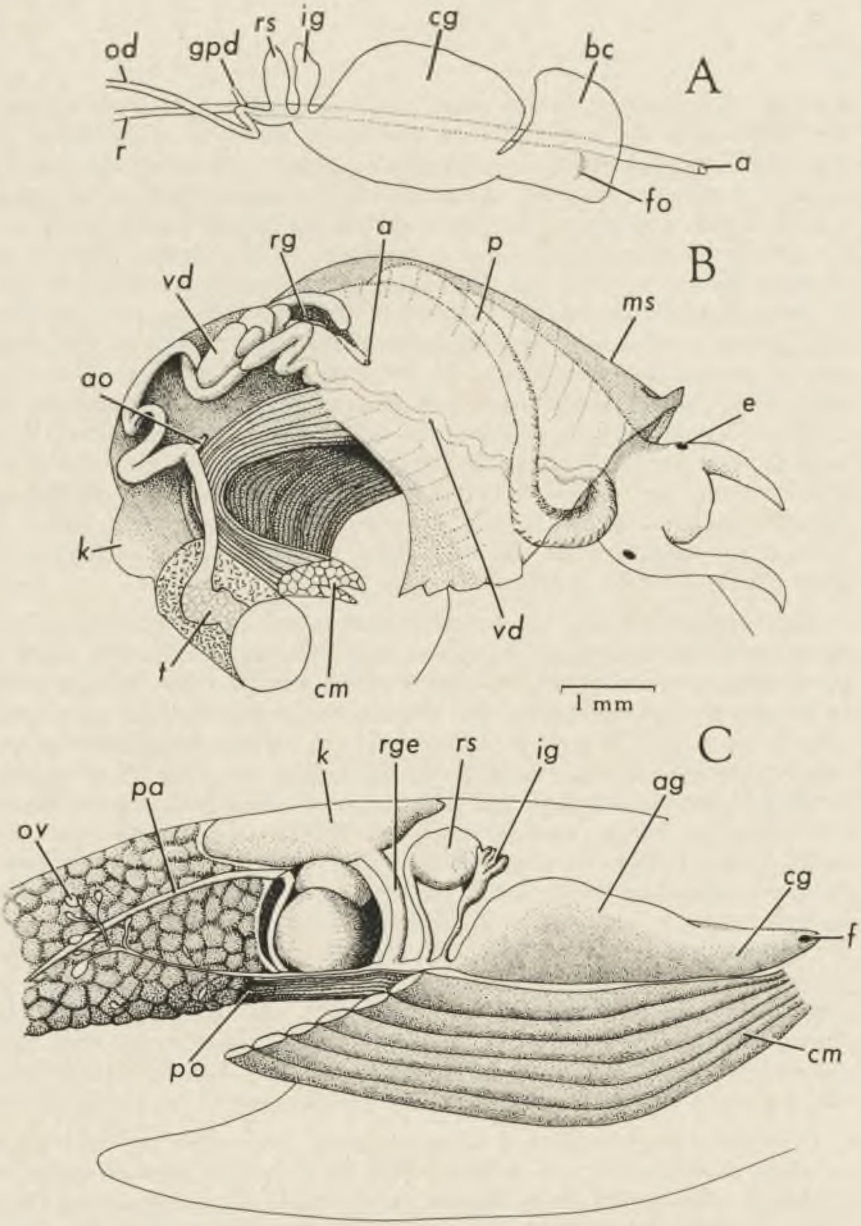

FIGURE 6. A. *Cancellaria cancellata*. Diagram of female reproductive system. —B. C. *cancellata*. Male reproductive system.—C. *Marginella desjardini*. Female reproductive system. Lettering: *a*, anus; *ag*, albumen gland; *as*, accessory opening to mantle cavity; *bc*. bursa copulatrix; *cg*, capsule gland; *cm*, columellar muscle; *e*, eye; *f*, female opening; *gpd*, gonopericaridal duct; *ig*, ingesting gland; *k*, kidney; *ms*, mantle skirt; *od*, ovarian duct, *ov*, ovary; *p*, penis; *pa*, posterior aorta; *po*, posterior oesophagus; *r*, rectum; *rg*, rectal gland; *rgc*, renogonadial canal; *rs*, receptaculum seminis; *t*, testis; *v*, ventricle; *vd*, vas deferens.

number of anatomical points which make it unlikely that these animals are vegetarians: the long proboscis (assuming that it is as extensible as the length of slack in the oesophagus suggests) and the extra pair of salivary glands are normally associated with a carnivorous, or, at least, a carrion diet, and often with rather specialized dietary habits. Even if it be agreed that *Cancellaria* is not a herbivore it still remains difficult to envisage the use to which this particular type of radular tooth can be put. It seems improbable that the muscles of the buccal mass can have any very precise control over the movement of the radular teeth or that these can be gripped and manipulated by the walls of the oral tube like a bit held in the jaws of a drill since they lie freely in a cavity maintained at constant diameter by its cuticular lining. However they are used, it is unlikely that the teeth are sufficiently rigid to exert any great force on whatever they are applied to. They might be appropriate for stirring up decaying material so that it could then be sucked into the gut, but it is not easy to imagine what else they might do: it would obviously be of great interest to have observations made on living specimens.

The suppositions that the buccal mass can be moved backwards and forwards within the buccal cavity and that the teeth are flexible allow a possible explanation of the movement of the radular teeth through 180° to be offered. Let us imagine that a tooth has grown forward out of the radular sac so that its base is situated near the parting of the teeth on the buccal mass and its tip is held within the radular sac only by a minimal length of lateral attachment, and that the animal then feeds. In the course of feeding the buccal mass is protruded, the lateral attachments of the radular tooth become broken and the tooth is freed except for the basal tie to the subradular membrane. If the tensions in the subradular membrane brought about by the change in thickness which it exhibits at this point are supposed to be such as to tend to erect the tooth and make its natural position of rest an anterior one, then it can be seen that a succession of protractions and retractions of the buccal mass will allow the tooth to be turned forwards through 180°. To keep the teeth forwards once they have reached that position it must be assumed that their tips slide easily over the surface of the cuticle which lines the anterior part of the buccal cavity.

Cancellaria has two pairs of salivary glands, one comparable with those of most prosobranchs, the second, from its extremely anterior point of discharge, with the accessory salivary glands of Muricacea (Bouvier, 1888; Graham, 1941; Franc, 1952), though their histology is simpler. The oesophageal swelling is clearly homologous with the valve of Leiblein of other stenoglossans (Amaudrut, 1898; Graham, 1941) and, as in these, has been pulled far forward of the nerve ring. The elongation of the oesophagus, indeed, which allows for the extension of the proboscis seems to have taken place posterior to the valve of Leiblein in *Cancellaria* and, therefore, to be mid-oesophageal, instead of anterior to it as in Muricacea and

Buccinacea where it affects the anterior oesophagus. The only remaining part of the full equipment of the stenoglossan oesophagus which has to be found in this genus is the glandular part of the mid-oesophagus which, as shown by Amaudrut (1898), is stripped off the mid-oesophagus in muricaceans and buccinaceans to form the gland of Leiblein, leaving a narrow thread of scar tissue (Graham, 1941) to mark the line along which separation took place. No separate gland occurs here, nor any line of scar tissue. There is, however, a glandular strip opposite the dorsal folds along the entire length of the oesophagus. It may well be that this represents the mid-oesophageal gland and so is the homologue of the gland of Leiblein of other stenoglossans. Reasons why this tissue has not been separated from the main oesophageal channel might be first that the whole glandular area had been pulled through the nerve ring before it had evolved to any size, and second, that with the extreme elongation of the mid-oesophagus which has occurred a sufficient concentration of glandular tissue is available even when it remains attached.

In some buccinaceans, however, such as *Semifusus* and *Galeodes* (Vanstone, 1894) the gland of Leiblein is much reduced or lost, and the same is true of some volutaceans such as *Volutocorbis* (Woodward, 1901) and *Olivella* (Marcus & Marcus, 1959). In other volutaceans such as *Oliva* and *Lintricula* (= *Olivancillaria*) the oesophagus is muricacean in its arrangement (Marcus & Marcus, 1959). It is, therefore, possible that loss of the gland of Leiblein has occurred in cancellariids and that the strip of glandular tissue which has been described is a new development of secretory tissue.

In marginellids the most interesting feature of the gut is the situation of the buccal mass, wholly withdrawn into a caecum from its typical place on the floor of the buccal cavity. In *M. marginata* it seems obvious that the buccal mass can be protracted and thrust through the mouth so that the teeth can operate on whatever they are brought in contact with, but it is likely that some of the uptake of food is by suction or ciliary action, and in *M. desjardini* where the buccal apparatus has been lost this must be the main or sole means by which food is ingested. From an organization such as is found in *M. marginata* (comparable with what is encountered in a typical prosobranch) it is easy to derive the arrangement seen in Toxoglossa. This has been well described by Bouvier (1887), Shaw (1915), Alpers (1931), Jaeckel (1952) and Robinson (1960). In all forms described, the gut forms a more or less straight tube from mouth to stomach. From its anterior parts there open what is usually described as the radular sac, the salivary gland or glands, and the poison gland. Sometimes these open separately, sometimes the salivary ducts discharge to the 'radular sac.' Sometimes there is a single salivary gland with a single duct, sometimes two, each with its own duct, sometimes a single glandular mass with two separate ducts. These arrangements are all derivable from what is seen in *M. marginata* where the two salivary glands, though united, are still easily separable and each has its own duct. So far as the connexion of these ducts to the so-called radular sac is concerned, it will be seen by reference to Fig. 2, that if the process of pinching off parts of the buccal cavity from the main channel of the gut were to be extended so as to include the opening of the salivary ducts then the arrangement found in toxoglossans would have been accurately reproduced. It is also evident that the 'radular sac' is the homologue of much of the buccal cavity as well as of the radular sac proper.

There still remains the question of homologies, in particular that of the poison gland. This was regarded by Alpers (1931) as the equivalent of the left salivary gland; in view of the simultaneous occurrence here and in many toxoglossans of a poison gland and two salivary glands with ducts, this interpretation does not seem tenable. Two other proposals have been put forward as to its homology: one, by Amaudrut (1898), that the poison gland, the gland of Leiblein and the mid-oesophageal gland of taenioglossans are all homologous, the other, by Graham (1941), that it corresponded to one or both of the accessory glands of Muricacea, also described here in cancellariids. No record has yet been made of the simultaneous occurrence in one animal of both accessory salivary glands and poison gland so that this remains a possibility. Nevertheless the arrangements described here in marginellids seem to me to make it less likely than Amaudrut's idea, however different in organization and function the toxoglossan poison gland and the mesogastropod oesophageal gland may be. The main point which seems important in this respect is the arrangement of the parts in *M. desjardini,* despite the fact that at least in its buccal anatomy this species is more advanced than *marginata.* Here it will be recalled, the duct of the poison gland opens from the mid-ventral line of the oesophagus just anterior to the nerve ring and as it runs back it twists dorsally round the right side of the gut, accompanied by the anterior aorta and by the supraoesophageal connective of the visceral loop. These are precisely the circumstances in which one looks for the oesophageal gland of prosobranchs.

If the homology of the poison gland of the higher stenoglossans and the gland of Leiblein be accepted then a number of consequences follow. The poison gland would appear to have been stripped off the oesophagus from behind forwards, as suggested by Amaudrut (1898). I have not been able to find any trace of this, but this is not surprising in such material and even in the lower stenoglossans, where the gland of Leiblein has been similarly stripped off (from in front backwards) the scar is not always visible. If the gland of Leiblein and the poison gland of toxoglossans have been produced by separation from the oesophagus in different directions the stenoglossans (neogastropods) are at least diphyletic, with those species containing a poison gland marking one evolutionary line, and those with muricacean type oesophageal structure belonging to another. A further consequence is that whilst the Muricacea, Buccinacea and Toxoglossa of Thiele's classification (1929) may well be natural groupings, his fourth neogastropod stirps, the Volutacea, cannot be, since it contains animals some of which have the type of oesophageal structure shown by muricaceans *(Oliva, Voluta),* others have a poison gland *(Marginella),* and still others have a gut which conforms to neither pattern *(Cancellaria).* The Volutacea therefore seem, as at present constituted, to be largely a dump for stenoglossans which fail to qualify clearly for inclusion in other, better defined, groups. This is not very different from the conclusions reached

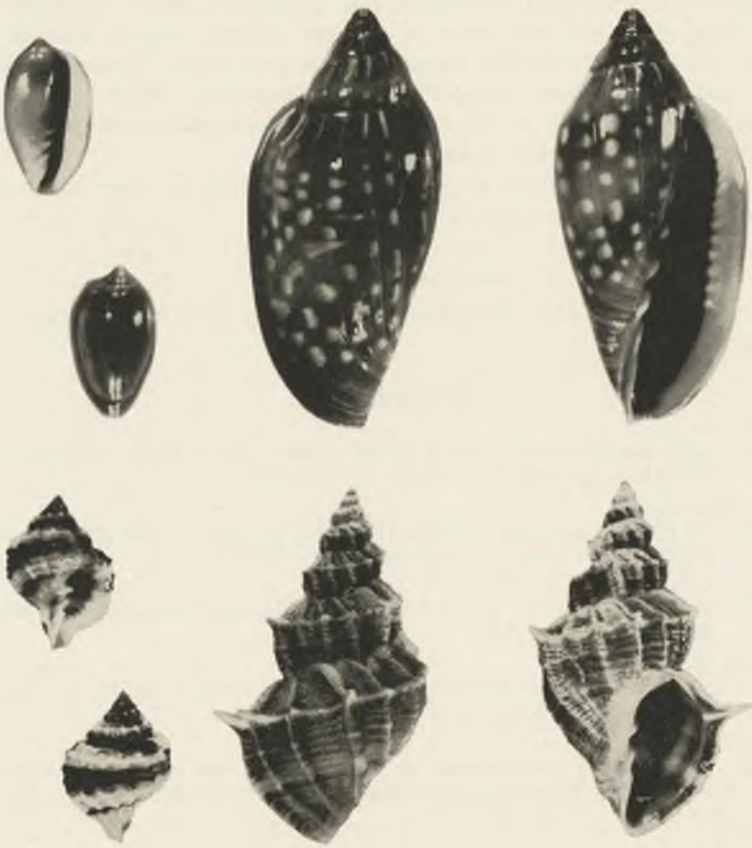

FIGURE 7. Shells of West African gastropods investigated in this paper: upper row left, apertural and dorsal views of *Maginella marginata;* upper row right, dorsal and apertural views of *Marginella desjardini;* lower row left, apertural and dorsal views of *Cancellaria cancellata;* lower row right, dorsal and apertural views of *Cancellaria lyrata.* All approximately natural size.

on other grounds by Olsson (1956) and Marcus & Marcus (1959). Their proper position can be explained only by further work.

Summary

Two species of the genus *Marginella* and three of the genus *Cancellaria* were investigated anatomically. They all show typical stenoglossan anatomy in respect of the nervous and reproductive system, though in *Marginella* the female duct connects with the kidney and lacks a bursa copulatrix. They differ in the gut. All have a proboscis. In *Marginella* there is a pair of salivary glands and a poison gland and the whole buccal mass is constricted from the buccal cavity into a ventral buccal pouch. This contains a well formed radula in *M. marginata* but is vestigial in *M. desjardini*. In *Cancellaria* there are two pairs of salivary glands, one opening at the mouth; the radular teeth are arranged in a posteriorly directed younger group and an anteriorly projecting older group and reach through an elongated buccal cavity to the mouth. The oesophagus shows a valve of Leiblein and has a ventral glandular tract.

The homologies of these structures are discussed and their bearing on the evolution of the Stenoglossa indicated.

Acknowledgement

I am grateful to Mrs. Margaret Shepherd for help with sections and drawings.

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 9 —

OPISTHOBRANCHS FROM TROPICAL WEST AFRICA[1]

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ABSTRACT

Between Monrovia and Lagos and southwards to Cape Lopez the Research Vessel JOHN ELLIOTT PILLSBURY collected 19 species of opisthobranchs, chiefly from the sublittoral. Of these, 18 were classified to specific level. New species and subspecies are: *Philine aperta guineensis, Gastropteron rubrum manx, Aglaja taila, A. pelsunca, Elysia slimora, Pleurobranchaea gela, Discodoris golaia, Marionia vanira, Armina bayeri, A. xandra,* and *A. joia.* In 44.5 per cent of the collection reationships with the fauna of the warm and warm temperate Atlantic Ocean including the Mediterranean Sea are recognizable; 27.8 per cent of these Atlantic forms occur in both the western and the eastern parts of this ocean, or those from the East Atlantic Ocean have morphological affinities to western elements. There are very few relationships with the Cape Province. The systematic principles for the classification of *Aglaja* and the Arminidae are discussed; all species of *Aglaja,* and the Atlantic ones of *Armina* are listed.

INTRODUCTION

The following report is based upon material submitted to us by Professor Dr. Frederick M. Bayer. It was collected by him and other members of the staff of the Institute of Marine Science, University of Miami, during the oceanographic cruises of the Research Vessel JOHN ELLIOTT PILLSBURY in the Gulf of Guinea, from Monrovia to Lagos, and southward to Cape Lopez and around Annobón Island. This area belongs to the center of the tropical region of the East Atlantic Ocean, a relatively small region of indistinct boundaries. Especially in the sublittoral, the tropical and warm-temperate elements mingle. Most of the present species were caught in depths beyond 30 m. These depths and the collecting area give a great importance to the material. Moreover the tropical East Atlantic opisthobranchs are very little known. The conchological material of the French Mission Gruvel comprises shells of cephalaspideans (Dautzenberg, 1913); two species, *Ringicula conformis* and *Glaucus atlanticus,* were reported from Port Alexandre, south of Mossamedes (Odhner, 1923: 9), and White (1955) united the results of voyages of the Belgian training-ship MERCATOR with those of the Belgian expedition to the South Atlantic (1948-49). She refers (p. 103) to all publications on the South African

[1]Contribution No. 737 from the Institute of Marine Science, University of Miami.

opisthobranch fauna; since 1954 Macnae's numerous studies must be added. In White's list of papers concerning the northern neighboring fauna of West Africa Eliot's record from the Cape Verde Islands (1906b) and Odhner's from the Canaries (1932) are wanting.

We thank Dr. F. M. Bayer for the opportunity to examine this interesting material, and for his kindness in editing the manuscript and reading the proofs.

Explanation of Lettering

a—ampulla
ao—genital aperture
ar—anus
b—spermatheca or bursa
ca—caruncle
ce—nerve ring
cs—lateral lamella
d—efferent duct
ei—hermaphrodite duct
es—penial sheath
f—insemination duct
g—female gland mass
i—intestine
io—opening of main hepatic duct
k—gill
l—digestive gland
m—mouth
ma—male aperture
mu—male atrium
ni—nidamental duct
no—notum
ns—accessory sac of penial sheath
oe—oesophagus
oi—oviduct
p—penis
q—prostate
r—retractor muscle
re—right anterior digestive gland
ro—upper border of veil
sa—salivary gland
so—stomach
ss—outer seminal furrow
su—inner seminal groove
uo—furrow of foot
uv—lower border of veil
v—vagina
vs—flap
wa—female aperture
wo—body wall
xo—insemination duct
y—spermatocyst

List of Species

Cephalaspidea

1. *Bulla mabillei* Locard, 1897 (P-273). Figs. 1-2.
2. *Scaphander mundus* Watson, 1883 (P-53). Figs. 3-7.
3. *Philine (Hermania) scabra* O. F. Müller, 1776 (P-59). Fig. 8.
4. *Philine (Philine) aperta guineensis,* subsp. nov. (P-23, 28, 30, 42, 45, 46, 47, 48, 62, 239). Figs. 9-18.
5. *Gastropteron rubrum manx,* subsp. nov. (P-241). Figs. 19-21.
6. *Aglaja taila,* spec. nov. (P-42). Figs. 22-27.
7. *Aglaja pelsunca,* spec. nov. (P-59, 62). Figs. 29-32.

Anaspidacea

8. *Aplysia (Varria) dactylomela* Rang, 1828 (P-273).

Ascoglossa

9. *Elysia slimora,* spec. nov. (P-283). Figs. 33-34.

Notaspidea

10. *Pleurobranchaea gela,* spec. nov. (P-26, 28, 46, 47, 48, 62, 241). Figs. 35-37.

Doridacea

11. *Hypselodoris* sp. (P-69). Figs. 38-39.
12. *Discodoris golaia,* spec. nov. (P-258). Figs. 40-42.
13. *Doriopsilla areolata* Bergh, 1880 (P-60). Figs. 43-44.

Dendronotacea

14. *Marionia vanira,* spec. nov. (P-28, 46, 60). Figs. 45-49.
15. *Fimbria fimbria* (Linné, 1767). (P-28, 46, 62, 232). Fig. 50.

Arminacea

16. *Armina bayeri,* spec. nov. (P-48). Figs. 51-55.
17. *Armina xandra,* spec. nov. (P-68). Figs. 56-60.
18. *Armina joia,* spec. nov. (P-254). Figs. 61-62.

Eolidacea

19. *Spurilla neapolitana* (Delle Chiaje, 1823). (P-258).

List of Localities with Species Obtained

Pillsbury Station	Date *1964*	Location	Depth	Species
23	5/28	5°10′N, 00°25′W to 5°08′N, 00°28′W	42 m	*Philine aperta guineensis*
26	5/28	4°57′N, 1°16′W to 4°59′N, 1°16.5′W	28 m	*Pleurobranchaea gela*
28	5/28	4°40′N, 2°00′W to 4°39′N, 2°02′W	48-53 m	*Philine aperta guineensis, Pleurobranchaea gela, Marionia vanira, Fimbria fimbria*
30	5/28	4°46′N, 2°30′W to 4°45′N, 2°33′W	61-64 m	*Philine aperta guineensis*
42	5/30	5°02.5′N, 3°49.5′W to 5°05′N, 3°52′W	75-62 m	*Philine aperta guineensis, Aglaja taila, Pleurobranchaea gela*
45	5/30	5°05′N, 4°04.5′W to 5°05′N, 4°06′W	73-98 m	*Philine aperta guineensis*
46	5/30	5°07′N, 4°32′W to 5°07′N, 4°36′W	42-38 m	*Philine aperta guineensis, Pleurobranchaea gela, Marionia vanira, Fimbria fimbria*
47	5/31	5°04.5′N, 4°51.5′W	37 m	*Philine aperta guineensis, Pleurobranchaea gela*
48	5/31	5°05′N, 4°59.5′W	22 m	*Philine aperta guineensis, Pleurobranchaea gela, Armina bayeri*
53	5/31	4°50′N, 4°55′W to 4°51′N, 5°00′W	1579-1519 m	*Scaphander mundus*

59	6/1	4°57.5′N, 5°22′W to 4°57′N, 5°30′W	64-55 m	*Philine scabra, Aglaja pelsunca*
60	6/1	4°55′N, 5°34.5′W to 4°54′N, 5°37′W	79-82 m	*Doriopsilla areolata, Marionia vanira*
62	6/1	4°45′N, 6°13.5′W to 4°44′N, 6°16′W	46 m	*Philine aperta guineensis, Aglaja pelsunca, Pleurobranchaea gela, Fimbria fimbria*
68	6/3	4°32′N, 8°05.5′W to 4°24′N, 8°07.5′W		*Armina xandra*
69	6/3	4°29.5′N, 8°06′W to 4°29.5′N, 8°07.5′W	29 m	*Hypselodoris* sp.
	1965			
232	5/11	5°56′N, 4°27′E to 5°54′N, 4°27′E	101-132 m	*Fimbria fimbria*
239	5/13	4°56′N, 5°00′E to 4°54′N, 5°05′E	73 m	*Philine aperta guineensis*
241	5/13	4°35′N, 5°18′E to 4°34′N, 5°19′E	59-63 m	*Gastropteron rubrum manx, Pleurobranchaea gela*
254	5/14	3°50′N, 7°08′E to 3°51′N, 7°12′E	174-148 m	*Armina joia*
258	5/15	3°45′N, 8°48′E		*Discodoris golaia, Spurilla neapolitana*
273	5/19	1°24′S, 5°37′E	0-2 m	*Bulla mabillei, Aplysia dactylomela*
283	5/21	1°29′S, 5°35′E	51-55 m	*Elysia slimora*

Systematic Section

1. *Bulla mabillei* Locard, 1897

Figures 1-2

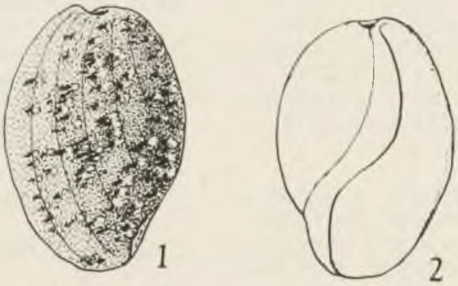
References. — Locard, 1897: 50; Odhner, 1932: 25.

Material. — Station 273 (Annobón), 0-2 m.

Further distribution. — Madeira; Canaries and Cape Verde Islands (typical locality). From the coast to 91 m (Dautzenberg and Fischer, 1908: 5).

Description. — Two empty shells, the larger 36 × 21 mm, the smaller 27.5 × 17.5 mm, both with damaged outer lip. Greatest breadth in middle of shell. Shell ovoid, rather solid, opaque, shining. Color purplish brown with transversely lengthened spots whose left part is white, the right one dark and twice as long as the light one. Axial growth lines distinct, evenly arched, not wavy (Locard). No spiral lines except for three (Odhner: four) on the inner side of the deep apical umbilicus. Outer lip overtops apex. Columella straight with strong, reflected base; a furrow between reflection and body whorl. Enamel layer of callus thin, rather broad, apically continued onto the inner side of the outer lip.

Remarks. — *B. perdicina* Menke, 1853 (Pilsbry, 1893-95: 335) from West Africa may be the same species, but it is not figured. It is smaller,



FIGURES 1-2.—*Bulla mabillei* Locard: 1, abapertural view of shell; 2, apertural view.

22 mm long, 14 mm broad, and the short description does not mention the spiral apical striae of *mabillei.*

2. *Scaphander mundus* Watson, 1883

Figures 3-7

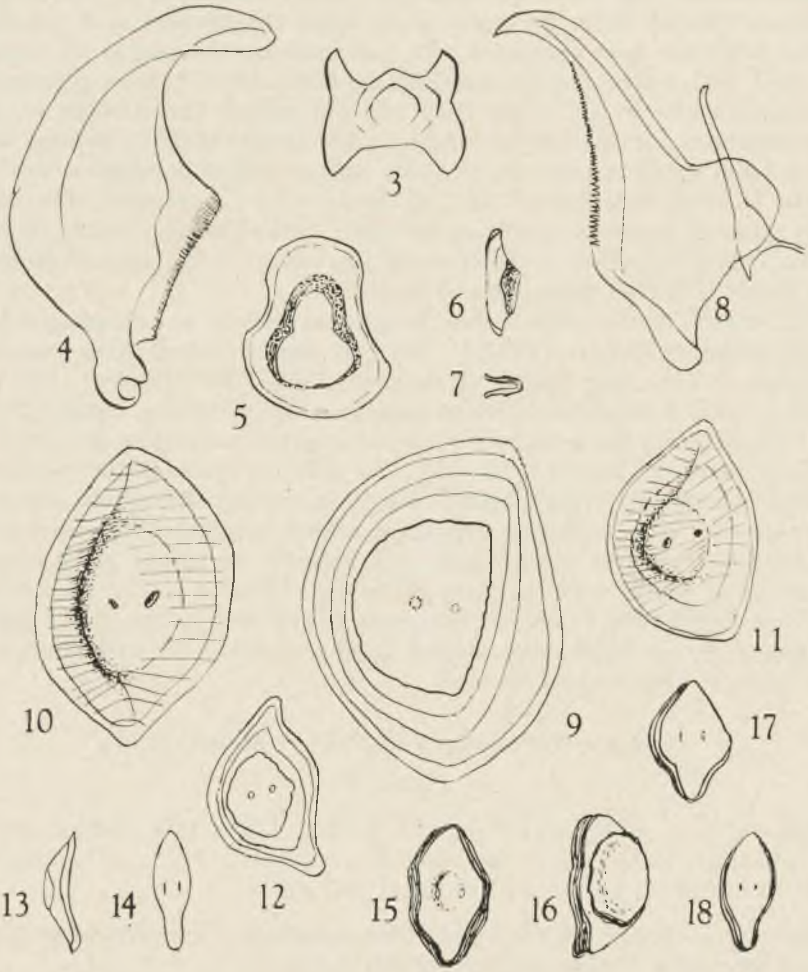
References. — Watson, 1883: 342; 1886: 643; Locard, 1897: 44, 46; E. A. Smith, 1906: 247; Clarke, 1962: 40.

Material. — Station 53, 1579-1519 m.

Further distribution. — Canaries and Cape Verde Basins, 1435-2334 m; east of Ceylon, 1840 m; Aru Islands, 1463 m (original locality).

Description. — The shells are rather solid, white; they have distinct growth lines and faint spiral lines. The spirally set dots are exactly as indicated by Watson, whose description and figures are repeated in Pilsbry (1893-95: 251-252). The measurements are: height 36, 34, and 32 mm; width 25, 24, and 22 mm; greatest breadth of aperture 14-15 mm. Watson's measurements are height 27, width 20, and breadth of aperture 15.5 mm. The callus is broader than in Watson's shell, but only in one of the present shells conspicuous along the whole parietal wall. Also in Locard's *S. mundus* var. *major,* whose height reaches 37 mm, the callus is more developed than in the original material. The thin periostracum of the present shells is generally light horny yellow, in the apical fifth darker yellow.

The skin of the head-foot is light brown, the intestinal gland is black. The pallial caecum is as in Perrier & Fischer's description and figure (1911: 76, Fig. L) of *S. punctostriatus* (Mighels, 1841). The radula comprises 25 rows. The rhachidian tooth (Fig. 3) is caducous, light yellow, and tricuspid. It is 0.18 mm broad, 0.13 mm high. The base of the flanking lateral teeth is striped. Some of these stripes project beyond the border as irregular hairs which cannot be called denticles (Bergh, 1901: 266). The gizzard plates have a yellow conchinous border around the grinding surface. The small plate (Figs. 6, 7) between the two bigger ones (Fig. 5) is compressed. The male copulatory organ is similar to that of *S. lignarius* (Linné, 1758) in Lloyd's figure (1952: Fig. 6), though shorter. The



FIGURES 3-18.—3-7, *Scaphander mundus* Watson: 3, rhachidian tooth; 4, lateral tooth of radula; 5, left gizzard plate, inner side; 6, unpaired gizzard plate, side view; 7, optical section of same.—8, *Philine scabra* (O.F. Müller): half-row of radula.—9-18, *Philine aperta guineensis*, subsp. nov., gizzard plates: 9, inner side of paired plate of 43-mm snail; 10, outer side of same, 46-mm snail; 11, outer side of same, 30-mm snail; 12, inner side of same, 17-mm snail; 13, lateral view of unpaired plate of 17-mm snail; 14, outer side of same; 15, outer side of same, 43-mm snail; 16, inner side of same; 17, outer side of unpaired plate of 46-mm snail; 18, outer side of same, 30-mm snail.

outermost part containing the penial papilla was macerated in the two examined snails of the present material.

Remarks. — According to Dautzenberg & Fisher (1896: 401-402) *S. punctostriatus* and *S. clavus* Dall, 1889, today considered as two distinct species (Bullis, 1956: 8), occur in the same abyssal area as *S. mundus.* The latter has been compared with *punctostriatus* thoroughly by Locard (1897: 46), whose exposition stresses the differences. *S. clavus* approaches *mundus major* by its strong shell and the callus. The strength of this thickening is not uniformly developed in the present shells of *mundus.* The maximum length of *clavus* is 25.3 mm against 37 mm in *mundus,* and the ratio of length to width is 1.53/1 in *clavus,* 1.44/1 in *mundus.* The outer lip of *clavus* is almost straight in the center, that of *mundus* evenly curved. The angled projection of the outer lip that occurs at the apex of *mundus* is absent in *clavus* whose apex is blunt.

S. nobilis Verrill, 1884, a thin, translucent shell of an exceedingly delicate texture (Pilsbry, 1893-95: 249), is farther distant from *mundus,* though it is the type species of *Bucconia* Dall, 1894 (Pilsbry, 1895-96: 235), today a subgenus, to which *mundus* is said to belong. Bullis (1956: 3) characterizes *Bucconia* by a pillar-like structure supporting an extension of the outer lip. Zilch (1959: 29) who does not quote Bullis, considers *nobilis* as the only living species of *Bucconia.* Correspondingly he indicates the absence of a thickened deposit of enamel concealing the spire as a subgeneric character of *Bucconia.* In *S. mundus* the apical "pit is almost completely coated with the glaze of the lip" (Watson). The same holds for the neighboring *S. sibogae* Schepman (1913: 465). The "sharp keel," Bullis' pillar, is much more distinct in *sibogae* than "the very slight and blunt keel" (Watson) of *mundus.*

3. *Philine (Hermania) scabra* (O. F. Müller, 1776)

Figure 8

References. — Pilsbry, 1895-96: 12; Kobelt, 1896: 148; Locard, 1897: 37; Odhner, 1907: 15, 57-58; 1939: 11; Vayssière, 1913: 173; Lemche, 1938: 10; 1948: 66, 91; Pruvot-Fol, 1954: 68.

Material. — Station 59, 64-55 m. In the oesophagus of an *Aglaja pelsunca* together with a *Philine aperta,* probably *guineensis.*

Further distribution. — The species ranges from the western and southern coast of Iceland and all the coast of Norway southward to the Atlantic coast of Europe, Madeira, and Africa. West African records are from the Los Islands (9° 28' N, 13° 50' W), the coast of Dahomey, Ouidah, and Cotonou, 20-25 m, and the entrance of the Port of Banana (5° 58' S, 12° 27' E) (Pilsbry, 1895-96: 12; Dautzenberg, 1913: 4). The older records from the Mediterranean Sea are no longer registered by Pruvot-Fol (1954), nor are there new ones in the local lists of Wirz-Mangold & Wyss (1958) and Haefelfinger (1960).

Remarks. — The two present radulae, two sets of gizzard plates, and one 9 mm-shell in the gut of *Aglaja pelsunca* confirm previous classifications of African material. Though Sars' figure (1878) of the radula, copied by Hoffmann (1938: Fig. 683 J) and by Pruvot-Fol (1954: Fig. 16 D), is recognizable, we give a new one (Fig. 8), chiefly in order to justify our determination.

The shape, size, sculpture, and anterior fringe of the shell as well as the three gizzard plates of nearly equal size define *Ph. scabra* unequivocally. The present find of two sets of radulae and gizzard plates but only a single shell is explained by Macnae's observation concerning *Aglaja cyanea.* The ingested shells are disgorged entire and completely cleaned out by digestion. Evidently this had happened with the shell belonging to one of the present conchiolin sets.

4. **Philine (Philine) aperta guineensis,** subspec. nov.

Figures 9-18

Material. — Stations 23, 28, 30, 42, 45-48, 62, 239, 37-98 m.; 77 of 150 collected specimens seen.

Distribution of Ph. aperta (without regard to subspecies). — Eastern Atlantic Ocean from western Norway to South Africa, including the Western Baltic Sea and the entire Mediterranean; Red Sea; Indian Ocean. From the tidal zone to about 100 m.

Descriptive notes. — Our biggest specimen is 63 mm long in preserved condition, the smallest 10 mm. Our maximum corresponds to the maxima of European *aperta,* alive about 10 cm from the English Channel (Guiart, 1901: 42), and 7 cm from the Gulf of Lions (Si, 1931: 75). The largest specimen of the present collection was dredged in 46 m (Station 62), the smallest in 75-62 m (Station 42). Our biggest dried shell is 33 mm long, 22 mm broad. Its shape agrees with Pilsbry's figures of Mediterranean shells (1895-96: Pl. 3, Figs. 47 and 51), and with that of *milne-edwardsi* Locard (1897: 35, Pl. 1, Figs. 7-9), 25 mm in length, 17 mm in width, from Cape St. Vincent, Portugal, 70 m. As the radula and the gizzard plates of *milne-edwardsi* are not known, we cannot use this name for our material. Also the form of the shell of the Australian *angasi* (Pilsbry: Fig. 59) is similar.

Our shells have a shining periostracum and distinct growth lines. Faint spiral lines are visible in the 33-mm shell, but not in one 25 mm long. The sculpture is variable in *aperta.* Pilsbry (1895-96: 10) said "irregular lines of growth and extremely slight and more irregular spiral lines." Kobelt (1896: 139) called the shells "smooth, only under a lens fine lines of growth." O'Donoghue (1929b: 8) noted faint lines of growth and still fainter spiral lines. Lemche (1948: 61) allotted *aperta* to his group "without sculpture except slight lines of growth," and also Barnard (1963: 326) indicated "shells showing growth lines only." Some of the present shells are broken. Evidently such happens also in living animals, as is shown by broad connections of conchiolin between calcareous areas of the shell.

The body has the same organization as the animals described by Guiart (1901: 111) and others; the parapodia are not produced behind as in snails from Siam (Thailand) (Bergh, 1902: 178). The radula has 25-32 rows. This corresponds to the data in the literature, only Brown's number, 15-16 (1934: 188), is exceptionally small. The shape of the radular teeth in the present material agrees with Brown's figures 15 and 16; their size, 0.9 mm, lies between that of the specimens from Naples, 0.8 mm (Bergh, 1901: 279) and those from South Africa, 1 mm (Bergh, 1907: 25). The bases of the teeth are striped as in the snails from Naples. The number of denticles in our specimens, 45-65, approximates that of Mediterranean material, 80. Nearly 100 denticles were reported from material from the Gulf of Siam (Bergh, 1902: 179). In the Guinean material the radula does not furnish any taxonomically evaluable characters.

The arms of the penial papilla are short, half as long as the diameter of the papilla. This agrees with the figures given by Lloyd (1952: Fig. 4) and Pruvot-Fol (1960: Fig. 2); in Bergh's (1902: 179; 1907: Pl. 5, Fig. 10), Brown's (1934: Fig. 25), and Förster's (1934: Fig. 13) specimens they are longer. These arms are evidently no systematic-geographic character.

The gizzard plates (Figs. 9-18) led us to the subspecific separation of our snails. The paired plates are strikingly broad. The ratio of length to breadth of the dry plates is 1.4/1-1.6/1. This differs widely from the proportions 2.2/1-2.7/1 in *aperta,* taken from the literature, viz. Bergh (1901; 1905; 1907), Brown (1934), Guiart (1901), Meyer & Möbius (1865: Pl. 6, Fig. 5, V), and O'Donoghue (1929a, *vaillanti;* 1929b). The cited publications deal with material from the North Atlantic Ocean, the Mediterranean Sea, South Africa, the Red Sea (*vaillanti*), and the Indian Ocean. The ratio is little influenced by the shrinkage of the margin of the plates which is not calcified. Such shrinkage results in different absolute values according to the condition — fresh, preserved, or dry — of the measured plates.

The unpaired plate is highly variable and cannot be considered for systematic purposes. In the Guinean material its ratio varies from 1.4/1 (Fig. 17) to 3/1 (Fig. 14), and thus exceeds the minimum (1.8/1) and the maximum (2.9/1) which we calculated from the above-mentioned literature. Also the position of the plates varies; we found the unpaired one located on the dorsal or the ventral, on the right or on the left side. These findings explain the different indications by the authors.

Bergh (1907), Farran (1905), Förster (1934) found it ventral, Brown (1934) and G. O. Sars (1878, quoted from Pilsbry. 1895-96: Pl. 9, Fig. 7) dorsal, and Guiart (1901) to the left.

In our material the two foramina are sometimes perforated, sometimes not, or the two holes show different conditions. Also for this detail the published records differ. The biggest plates, 15.5 mm in length, were found in the 63-mm snail, but the size of the gizzard plates is not rigorously correlated with the body size. There are 14.5-mm long plates in a 43-mm snail, and 15.5 mm long ones in an animal 46 mm in length.

Discussion. — The original locality of *Ph. aperta* (Linné, 1767) is the area of the Cape of Good Hope (Bergh, 1901: 277, note 1); it is known from Saldanha Bay to southern Moçambique (Macnae, 1962: 192), passing from temperate to tropical waters. On the western coast of Africa *Ph. aperta* occurs, according to Pilsbry (1895-96: 11), Dautzenberg (1913: 4), and White (1955: 168-169), from the coast of Morocco, Rio de Oro, the Cape Verde Islands and Sierra Leone to Mossamedes, Angola. White had material from Cape Lopez, the locality nearest to ours, and said, that its "gastric plates are quite typical for *Ph. aperta.*" But as she gave no measurements, one cannot see whether her material is *Ph. a. aperta* or *a. guineensis.*

Extremes of a long and pointed apical angle of the aperture and a short rounded one led Philippi (1844: quoted from Lamy, 1941: 303) to separate shells from South Africa (Pilsbry, 1895-96: Pl. 3, Fig. 50; Kobelt, 1896: Pl. 3, Figs. 1-3, Pl. 19, Fig. 18) and Europe (Pilsbry, Figs. 47-48; Kobelt: Pl. 19, Fig. 17) specifically; Pruvot-Fol (1933: 101, 158) added a more rounded and a more angular anterior border of the aperture, respectively. Linné's collection contains one shell of the shape typical for the snails of the British seas (Lamy, 1941: 304).

Bergh, who knew the variability of internal shells (1901: 285; 1905: 29) from his studies of lamellariids and pleurobranchids, avoided the original name given to South African shells, as long as he had no occasion to examine the anatomy of South African animals. Therefore he applied the oldest name given to North Atlantic snails, *Philine quadripartita* Ascanius, 1772, to his material from Naples (1901: 276) as well as to anatomically indistinguishable ones from the Indian Ocean (1902: 178; 1905: 28). Schepman (1913: 476) followed Bergh. After his study of specimens from False Bay, in the original area of *aperta,* Bergh (1907: 24) synonymized *quadripartita* with *aperta.*

Working with series of shells in the British Museum, Smith (1910: 184) stated that those of British and South African *aperta* are not distinguishable. Recently Swennen (1961: 45) arrived at the same result comparing the shells of the Leiden Museum from the Red Sea, the Cape, the Mediterranean Sea, and western Europe.

Anatomical characters, peculiar or predominant in a local fauna, may lead to the separation of geographic subspecies, as the present one from the coast of the Gulf of Guinea. Farran (1905: 348) admitted the existence of such "local races." Also Lemche who considers *aperta* as a widely distributed species (1948: 61-62), in the same sense as Pilsbry (1895-96: 10-11) and Odhner did (1907: 55-56), adds "(Variety *quadripartita*)" to *aperta* from the Northern Atlantic Ocean (1948: 90).

Ph. vaillanti Issel, 1869, from the Red Sea may be one of these subspecies. It was considered as a separate species (O'Donoghue, 1929a: 785). Pruvot-Fol (1933: 101, 157-158; 1954: 64-65) takes it to be identical with South African *aperta,* in spite of Bergh's above-quoted decision (1907). We do not discuss her arguments concerning the shell, because Smith's conchological uniting of British (*quadripartita*) and South African (*aperta*) ones is decisive in our opinion. Pruvot-Fol calls the "smaller" European snails *quadripartita,* but nearly 10-cm and 7 cm-snails from European seas were mentioned above. The color, light salmon in *vaillanti,* does not differ from the orange yellow in the snails from Toulon (Si, 1931: 75). The pointed ends of the paired gizzard plates of *vaillanti* (O'Donoghue, 1929a: Fig. 214, d) agree with those of South African *aperta* (id., 1929b: Pl. 1, Figs. 2, 3). The weak serration of the radular teeth, which bear only 24-26 denticles (1929a: 787), possibly represents a subspecific character of *vaillanti,* hitherto known only from the Red Sea.

Among the species identified with her restricted *aperta,* Pruvot-Fol (1954: 65) mentions "la *Ph. capensis* (du Cap) de O'Donoghue." This must be *Bullaea capensis* Pfeiffer, 1840, a synonym of *aperta. Ph. capensis* Bergh (1907: 27) differs from *aperta* by its radula, and has been renamed *berghi* by Smith (1910: 184) and once more by O'Donoghue (1929b: 10). In a so much consulted book as Pruvot-Fol's (1954), her explanation of figure 14 should be emended. Figure 14b is a dorsal view (Vayssière, 1885: Fig. 18), 14d a ventral view of the fore end (Brown, 1934: Fig. 5), and 14m a gizzard plate of *Ph. catena* (Vayssière, 1885: Fig. 30).

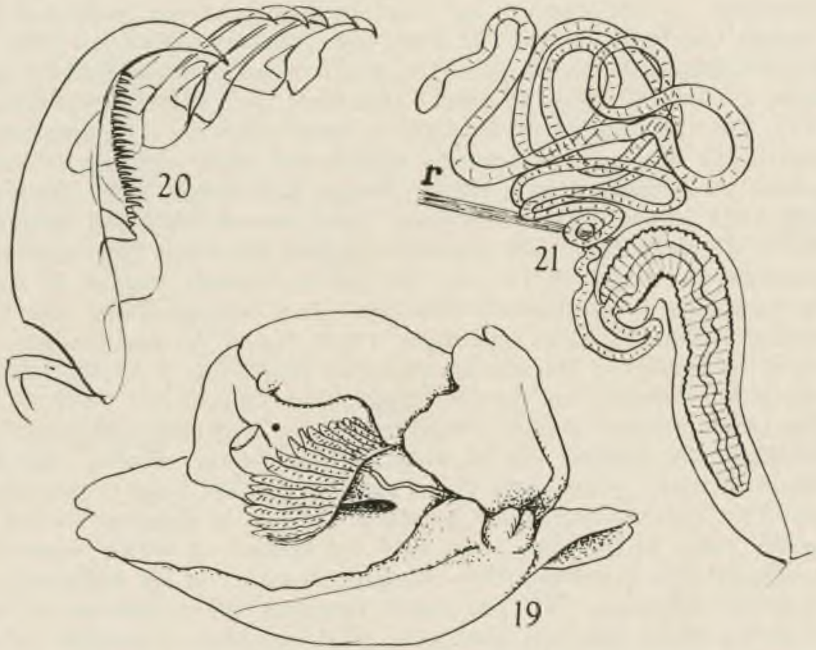
5. **Gastropteron rubrum manx,** subspec. nov.

Figures 19-21

Material. — Station 241, 59-63 m. One specimen.

Distribution of G. rubrum (Rafinesque, 1814). — West Atlantic, Florida, Antilles, southern middle Brazil; East Atlantic, coast of Morocco, Portugal, Gulf of Gascony; Mediterranean Sea including the Adriatic and Aegean Seas.

Description. — The living animal was reddish orange with minute white flecks, white marginal lines on the parapodia, and an incomplete marginal line on the head shield. The color is not preserved. The length is 10 mm, the width 16 mm with the parapodia expanded. The sole of the foot is



FIGURES 19-21.—*Gastropteron rubrum manx,* subsp. nov.: 19, side view of preserved specimen; 20, half-row of radula; 21, male copulatory organ.

rather distinctly set off from the parapodia; the pedal gland is a small slit.

On the right side of the visceral hump the mantle forms a narrow fold along the two anterior thirds. The posterior border of this mantle fold bears a knob (Fig. 19). The entire ctenidium lies bare; it has about 23 lamellae, those at the tip are very small. The branchial membrane reaches about the 20th lamella. The black renal pore lies behind the 5th leaf, farther behind and to the right the wide anus. The genital aperture is located under the fore end of the gill, whence the seminal groove runs to the furrow between the head shield and the right parapodium. The calcareous part of the shell is dissolved; the conchiolin was not found. At the position of the spire the mantle is somewhat protuberant.

The brown labial cuticle bears rodlets 40 μ in length and 5 μ in diameter. The radula (Fig. 20) comprises 23 rows with 5.1.0.1.5 teeth. The innermost lateral tooth is about 0.3 mm long; its edge has 18-26 denticles. The outer lateral teeth decrease in size outward; they have alate bases.

The male atrium (Fig. 21) is 2.7 mm deep and contains the 2-mm long penis, whose ental end receives a long, coiled prostate. The retractor (*r*) is a solid bundle which does not encase this gland.

Discussion. — The status of the Gastropteridae has been established by Tokioka and Baba (1964) and Baba and Tokioka (1965); we refer to the bibliography of these papers. The genus *Sagaminopteron* Tokioka and Baba, 1964: 218, differs by radular characters from *Gastropteron* Kosse, 1813. The classification of the latter is based upon the following characters: (1) The color, containing reddish and white elements in most species, but different ones in others (*sibogae nigra* Bergh, 1905; *cinereum* Dall, 1925; *viride* Tokioka and Baba, 1964; *fuscum* Baba and Tokioka, 1965). By quantitative and qualitative details the colors offer auxiliary characters for determination. (2) The sole is distinctly marked off from the parapodia, or continuous with them. In a species whose sole has distinct borders (Tokioka and Baba, 1964: Fig. 6 A) and another, in which the borders of the sole are indistinct (ibid., Fig. 8 A) the ventral aspects are different, but only by degree. The value of the distinctly or indistinctly bordered sole is diminished by the individual differences of shrinkage, the different loss of water in formalin and alcohol, and the shorter or longer permanence of the specimens in the liquid of preservation. (3) The number of the branchial lamellae is important within a certain range of variation, especially for species of which numerous specimens were examined. This character, however, is not applicable to immature individuals. (4). The mantle flagellum and its position, or one or several knobs and their place offer good taxonomic characters, as do frequently the structures without biological significance. (5) The denticles on the cusp of the innermost lateral tooth. Where the absence of denticles is stated for more than a single specimen, as in *G. sibogae* Bergh (1905: 33, "seem to be absent"), this is a good specific character, but in several species the numbers are about the same. Moreover, the variation seems to be considerable, at least in certain species. Vayssière's figure 13 (1879-1880) shows about 26 denticles of *G. rubrum;* Bergh (1893b: 297) indicated 4-18, and so Tokioka and Baba's text (1964: 204) "the first lateral being provided with a finely denticulated inner edge" becomes comprehensible. (6) The male copulatory organ seems to be a valuable systematic character, as in the Aglajidae, but it is only known of *rubrum* and the two species described by Bergh (1893b: 303; 1905: 32). As the organ of the present specimen agrees with that of *rubrum,* we give this first genuinely African *Gastropteron* only subspecific rank.

The shell consists of a minute and fragile calcareous spire and a big, membranous body whorl. It has no systematic value, as it was not found in most preserved specimens.

Systematic Characters in *Aglaia* Renier, 1804

Figure 28 A-D

The male copulatory organ should be described in the diagnoses of new species, and when an older one whose penis is not known is re-examined. Today we distinguish four types:

A. — Penial papilla without appendage, with an open seminal groove and a free prostate, generally paired, with a common duct of the two lobes. *A. cyanea, depicta, gardineri, pilsbryi,* and *tricolorata*. We ascribe *A. cyanea* to this type, because Macnae (1962: 194) found the reproductive system as in *depicta*. Exceptionally the prostate of *tricolorata* is unpaired (Vayssière, 1879-80: 96); the size and shape vary in *depicta* and *tricolorata* (Bergh, 1893a: 131). The two records concerning the prostate of *pilsbryi* refer to a single specimen each; in one case the organ was bicorn, the two horns of different size (Bergh, 1901: 306), in the other it was simple (White, 1945: Fig. 8). The remaining references to this species do not contain any descriptions or figures of the prostate (Eliot, 1900: 512; 1903c: 333; Marcus, 1960a; 892).

B. — Penial papilla as in the first type; prostate simple, coiled, coursing within the penial retractor. *A. taila,* spec. nov.

C. — Penial papilla with cuticularized tip and with closed ejaculatory duct. A narrow lobe at the base of the papilla. Prostate simple (Bergh, 1894: 212) or divided into a large and a quite small part (ibid.; Marcus, 1961: Fig. 12; read 67 for 91). *A. diomedea*.

D. — Penial papilla with open seminal groove, at rest coiled, distending the penial sac backwards. A conspicuous appendage, at rest in front of the papilla, in everted condition behind it. Prostate unpaired. *A. ceylonica, pelsunca,* and *pusa*.

The literature contains some more references to the male organ, but without opening or clearing the penial sac or sheath, a small basal appendage of the papilla cannot be seen.

The shell is taxonomically useful, but the differences are in most cases small. They must be settled by comparison with the figures. Those of Pilsbry's Manual are excellent, but the modern cheap reproductions of pen-and-ink drawings are less helpful. In certain species only the conchiolin part of the shell increases with age (Pilsbry, 1895-96: 46). Thus the posterior, calcareous part of the shell becomes proportionally smaller in older shells.

The color and its pattern vary widely in certain species, for example in *A. cyanea* (Macnae, 1962: 193). In others the color elements are only known from preserved specimens. In these blue or orange lines may appear as light or colorless, and of a possibly yellow ground color with melanophores only the latter remain. The brilliant emerald-green dots of *A. punctilucens* were preserved for 30 years in alcohol (Bergh, 1893a: 131).

The flagellum of the left posterior mantle lobe occurs in a small number of species. It is a specific character, but its absence cannot be decisive for the classification, if a single specimen is examined (Pruvot-Fol, 1954: 51; *tricolorata*).

The size of the buccal mass or pharynx is a specific character (Eliot, 1903c: 333). Of course it cannot be evaluated when it is everted, or when an animal just engulfing a prey is preserved. The number of dorsal branchial plumes should be indicated, though it is difficult to count them.

The ratio of the head shield to the mantle shield "can only be used on living specimens, and even then with caution" (Macnae, 1962: 194). The same certainly holds for the posterior mantle lobes and possibly also for the length of the parapodia.

6. **Aglaja taila,** spec. nov.

Figures 22-27

Material. — Station 42; 75-62 m. Two specimens.

Description. — The preserved animals are 15 mm in length, 10-11 mm in width and height. A flagellum, about 1.5 mm long, inserts on the left posterior mantle lobe (Fig. 22). The ventral border of the parapodia bears two triangular flaps in front (Fig. 24), possibly sensory organs.

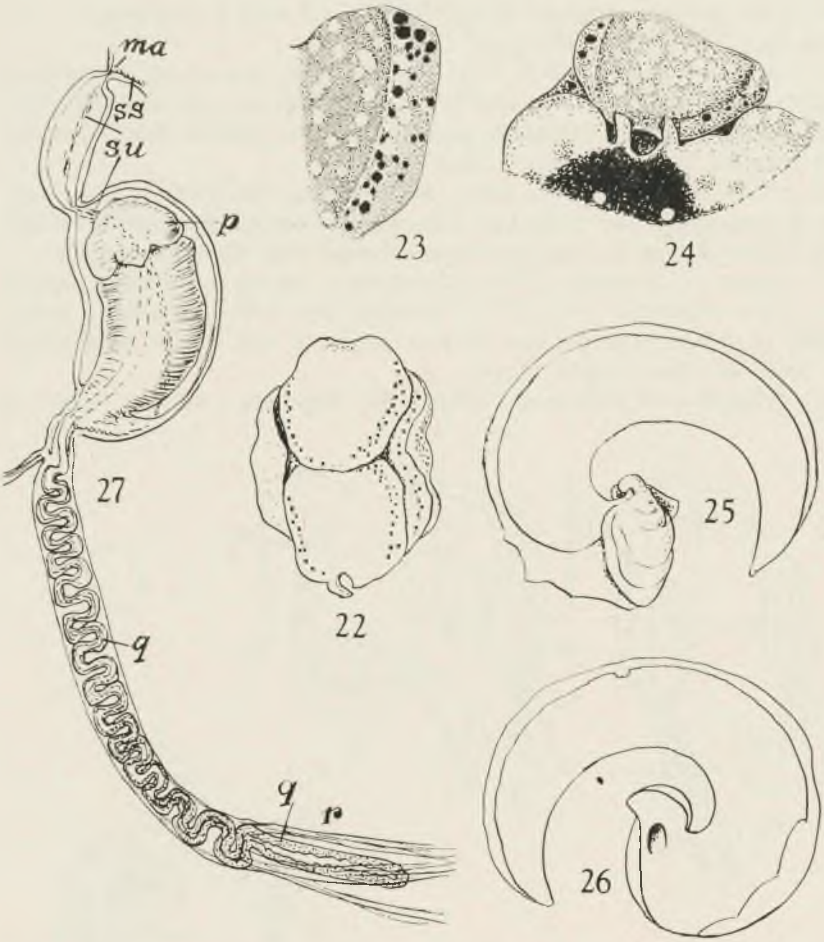
The sole is black with irregular light spots; head shield (Fig. 23), mantle shield and outer sides of the parapodia are less intensely pigmented and have more round pigment-free spots. Opaque white dots, drawn black in our figures, occur on the outer borders of the parapodia. Not all these spots are preserved. The dark ground color of the inner side of the parapodia is set off from the transparent, colorless zone, which is farther ventral, by an opaque limit. The region of the Hancock's organ is yellowish, the underside of the head shield and the parts covered by the shields are light.

The shell is a little shorter than broad, 3.4 mm in its greater diameter, and firmly calcified. The central area, comprising the apex and the spire, is set off from the body whorl on the outer face of the shell (Fig. 25). On the underside the broad columella juts out (Fig. 26).

The pharynx is very firm and thick-walled; it extends backwards under the mantle shield. The gill is colorless; it contains about 12 dorsal plumes.

The unpigmented male organ is a thick papilla. The seminal groove (*ss*) enters the male atrium (Fig. 27), continues (*su*) along the penial sac, and passes onto the papilla (*p*) at the fundus of the sac. Here it receives the secretion of the lo prostate (*q*) whose winding tube is incased in the fibres of the principal penial retractor (*r*).

Discussion. — In the following survey *Aglaja taila* is separated from the other species of the genus. As far as Pilsbry (1895-96: 45-56, 239) has cited the original descriptions, these are not repeated here.



FIGURES 22-27.—*Aglaja taila*, sp. nov.: 22, dorsal view of preserved specimen; 23, color pattern of head shield; 24, ventral view of fore end (in Figs. 22-24, the white dots are drawn black); 25, outside of shell; 26, inside of shell; 27, male copulatory organ, cleared.

A. adellae (Dall, 1894). No flagellum. Dark plum, mottled with fine vermiculate spots of golden yellow. Columella prominent, spur-like.

A. alboventralis (Bergh, 1897b: 119). No flagellum. Ground color white with large black markings on the parapodia and principally on the back.

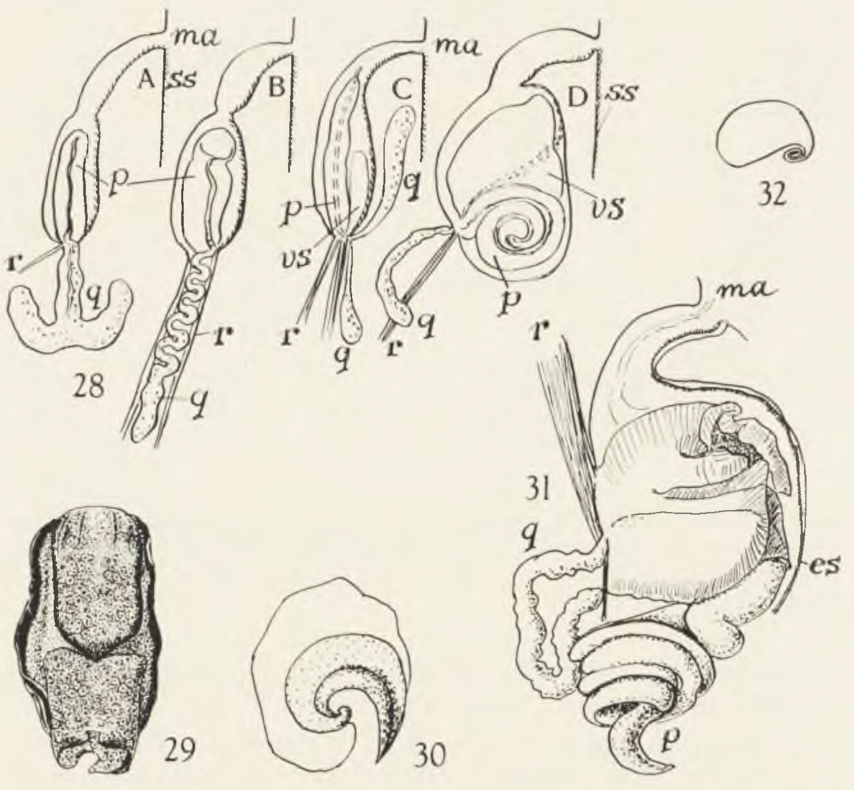
A. bakeri MacFarland (1924: 391). No flagellum. Yellowish white longitudinal lines on dark back and outer faces of the parapodia. The latter with a marginal series of light blue ocelli edged with black. Outer lip of shell long, falciform.

A. capensis (Bergh, 1907: 29). No flagellum. Preserved, 50 mm in length. Back light, evidently faded out, underside in part blackish. Gill large, projecting from branchial cavity. Only the nuclear whorls of the shell calcified. Penis yellowish, black in front.

A. ceylonica White (1946: 146). No flagellum. Head shield wide, prolonged posteriorly into a median lobe which overlaps the mantle shield. Male organ of type *D;* the appendage covered with hook-like papillae.

A. cyanea (v. Martens, 1879). Synonyms: *guttata, marmorata, nigra,* var. *vittata* (Macnae, 1962: 193). No flagellum. Most variable in color, similar to *depicta,* but the four or two stripes of buff on the head shield not recorded. Male organ of type *A*.

A. cylindrica (Cheeseman, 1881). No flagellum. Velvety black, if



FIGURES 28-32.—28A-D, Diagrams of four types of male organs in *Aglaja*.—29-32, *Aglaja pelsunca*, sp. nov.: 29, dorsal view of preserved specimen; 30, outside of shell; 31, male copulatory organ, penial sheath (*es*) opened; 32, transverse optical section of penial papilla.

Risbec's synonymy (1951: 124) is correct. Then his name *splendida* is unnecessary. Risbec's material has longitudinal stripes on the head shield, some irregular spots on the mantle shield, and the length of the shell is twice its breadth.

A. depicta Renier, 1807. Synonyms: *aplysiaeformis, carnosa.* No flagellum. Two (Vayssière, 1885: Pl. 2, Fig. 42) or four (Bergh, 1893a: 125) short stripes of buff on anterior part of head shield.

A. diomedea (Bergh, 1893a). No flagellum. Shell longer than broad. Male organ of type *C,* hence contrasting with the diagnoses of the family "penis with a superficial sulcus" (Pilsbry, 1895-96: 43) and "penis unarmed" (Pruvot-Fol, 1954: 48).

A. dubia O'Donoghue (1929b: 11). Flagellum present. White, without any traces of pigment. Shell distinctly longer than broad.

A. ezoensis Baba (1957: 10). No flagellum. Ground color of dorsum and sole ashy yellow.

A. gardineri (Eliot, 1903c: 332). In life 51 × 25 mm. Pharynx 31 × 3 mm, not conspicuously muscular. Both posterior mantle lobes prolonged, but no flagellum.

A. gemmata (Mörch, 1863). Yellow or dull fleshy with close longitudinal lines on head shield. The latter with green, shining, convex spots. Possibly identical with *punctilucens* from the same locality, St. Thomas.

A. giglionii Tapparone-Canefri, 1874; redescribed by Baba (1937a: 204). No flagellum. Length 50 mm. Back and sole dark yellowish brown with ashy yellow spots. Shell small, distinctly longer than broad.

A. iwasai Hirase, 1936 (description not seen). No flagellum. Baba (1937a: 206) and Engel and van Eeken (1962: 17) approach *iwasai* to *cyanea.*

A. laurentiana (Watson, 1897: 237). Only four shells known, 6 mm in length, 3.6 mm in width. "They are probably *Doridium.*"

A. lineolata H. & A. Adams, 1854; redescribed by Bergh (1902: 175), White (1945: 97) and Baba (1949: Pl. 1, Fig. 2). No flagellum. Light brown; back, sole, and outer side of parapodia with many darker transverse stripes. Penial papilla with 15 rounded warts near the tip.

A. maculata (d'Orbigny, 1837). No flagellum. Back greenish-brown with many spots of sulphur-yellow. Underside fleshy, plicate, striate and ridged transversely. Mörch (1863: 20) and others, e. g. Pilsbry (1895-96: Pl. 6, Fig. 40-43) gave the correct position of back and sole.

A. maderensis (Watson, 1897: 238). No flagellum. Alive opaque white with specks of crimson, preserved brownish black. Hind border of head shield indistinct. Shell abruptly truncated in front.

A. minor Si, 1934 (Tchung-Si, Contr. Inst. Zool. Peiping, v. 2, no. 2; not seen). Described as *A. depicta* var. *minor,* hence without flagellum. According to White (1945: 102; 1946: 167) a separate species.

A. minuta Pruvot-Fol (1953: 30). No flagellum. Preserved 5.2 mm in length. Underside brown with light spots. Shell longer than broad.

A. nana Steinberg & Jones (1960: 73). No flagellum. Preserved 9.8 mm in length. Translucent greyish white with irregular black flecks, small yellow brown dots, and opaque white larger spots. Shell without projecting process.

A. nuttalli Pilsbry, 1895. A short, flat flagellum. Length 40 mm, breadth 20 mm. Preserved black-brown above, sole the same color with faint light maculation. Shell not known.

A. obscura (Bergh, 1901: 307). Transferred to *Chelidonura* (Bergh, 1905: 43; Risbec, 1928: 43; 1951: 134).

A. ocelligera (Bergh, 1893). Flagellum present. Preserved similar to *taila;* alive black-purple with yellow spots. Central area of shell is not set off from body whorl (contrary to *taila*) and the columella is stronger than in *taila*. Gill yellowish; prostate forked. Though the differences between this species from Sitka and *taila* are small, their identity is highly improbable.

A. orbignyana (Rochebrune, 1881). No flagellum. Head shield surprisingly short. Mantle shield with longitudinal stripes.

A. orientalis Baba (1949: 21, 123). No flagellum. Body slender. Parapodia longer than mantle shield. Transverse bands in front and middle of back.

A. perparva (Risbec, 1928: 42). Transferred to *Chelidonura* (Risbec, 1951: 134).

A. pilsbryi (Eliot, 1900: 512). White (1945: 91). No flagellum. Whitish or greyish with black blotches and bands. As White indicated a "vas deferens" in her figure 8, it appears possible that the efferent duct is closed in *pilsbryi.*

A. punctilucens (Bergh, 1893a: 131). No flagellum. Head shield with emerald-green dots preserved in alcohol. Outer face of parapodia and sole with longitudinal lines.

A. purpurea (Bergh, 1894). No flagellum. Preserved 38 mm long. Outer and inner face of penial sac black; the papilla yellow.

A. pusa E. & E. Marcus (in press). No flagellum. Length preserved 45 mm, width 19 mm, height 18 mm. Shell longer (15 mm) than broad (13 mm), completely calcified; three spines on inner margin. Male organ of type *D*.

A. queritor Burn (1957b: 117). No flagellum. Head shield 1/3 of total length. Shell minute, entirely calcified. Gill with 4 or 5 plumes.

A. reticulata (Eliot, 1903c: 335). Back reticulate, the borders edged with black. Left posterior mantle lobe longer than right one, but no flagellum.

A. sanguinea Allan (1933: 445). Transferred to *Chelidonura* (Allan, 1950: 218).

A. seurati Vayssière (1926: 125). No flagellum. Preserved 8-10 mm in length, 3-3.5 mm in width. Wax-white. Shell 3-3.2 × 2-2.3 mm. Columella strong, curved.

A. splendida Risbec (1951: 124). According to Risbec identical with *cylindrica* (Cheeseman, 1881). Bergh (1894: 209) considers the latter as possibly identical with his *purpurea.*

A. taronga Allan (1933: 444). No flagellum. Length alive 65 mm, breadth 26 mm; another specimen was preserved 22.5 × 9 mm (Burn, 1957a: 13). Shell of original specimen 10 × 9 mm.

A. tricolorata Renier, 1807. Synonyms: *meckelii, membranacea.* Flagellum present. Preserved 30 mm in length. Shell without distinct limit between spire and body whorl. Male organ type *A.*

A. troubridgensis Verco (1909: 276). Only shell known: 21 mm long, 15 mm in diameter, hence belonging to an animal of at least 60 mm in length.

A. velutina (Bergh, 1908: 154). No flagellum. Buccal mass not set off from oesophagus. Gill with 20 plumes.

7. **Aglaja pelsunca,** spec. nov.

Figures 29-32

Material. — Stations 59 and 62, 46-62 m. Three specimens.

Description. — The preserved animal from Station 59 is 28 mm long and 18 mm broad and high. The measurements of the specimens from Station 62 are: length 26 and 22 mm, breadth 14 and 14 mm, height 13 and 9 mm. The ground color is greyish brown above and on the outer side of the parapodia, black below. The greyish brown parts are slightly mottled by rings whose yellowish center is darker and whose margin is lighter than the ground color. This annulation is especially dense on the posterior mantle lobes. The lips are white. A black border surrounds the head shield and the mantle shield; it is separated from the rings by a yellowish line. Four yellowish brown stripes extend from the front of the head shield over its anterior fourth. A black band runs near the border of the parapodia and is accompanied by a more dorsal bluish and a more ventral yellow line, both in part faded out and only light. A broad black band occurs on the inner face of the parapodia.

There is no flagellum (Fig. 29).

The shell (Fig. 30) is longer than broad, 8.5 mm in its greater diameter. It is delicate, calcified only in the nucleus, the spire, and a small part of the outer lip.

In the examined animal from Station 59 the muscular pharynx is soft, thin-walled. The wide portion of the oesophagus was distended by remains of *Philine scabra* (Fig. 8) and a 10-mm shell of *Ph. aperta,* probably *Ph. a. guineensis.* There are 13 dorsal plumes of the ctenidium.

The male aperture (Fig. 31, *ma*) leads into a spacious penis sac (*es*).

In its fundus lies the spirally coiled penis papilla (*p*). Its seminal groove is open (Fig. 32). Farther ectally the sac lodges a bulky cushion. This penial appendage is a lobed, cavernous organ with a smooth surface. The seminal groove descends along the ventral wall of the penial sac and then passes to the dorsal side, where the simple tubular prostate (*q*) opens into the groove at the root of the papilla. The retractor (*r*) inserts in the middle of the dorsal wall of the sac.

Discussion. — The two or four stripes in buff of *A. depicta* (see above) and its shell (Bergh, 1894: Pl. 12, Fig. 3) are similar to the present species. The ringed dorsal pattern of *pelsunca* is not known of *depicta.* The male organ of the latter belongs to type *A,* hence differs clearly from that of *pelsunca.* The above-mentioned *A. pusa* and *A. ceylonica,* whose male organs belong to the same type as the new species, differ by the shell (*pusa*) and by the hook-like papillae of the penial appendage (*aceylonica*). Also the shape of the head shield of *ceylonica,* examined in preserved condition like *pelsunca,* is peculiar.

8. *Aplysia (Varria) dactylomela* Rang, 1828

Reference. — Eales, 1960: 307-310, and frontispiece.

Material. — Station 273 (Annobón), 0-2 m; one specimen.

Further distribution. — Worldwide in warm seas; type locality: Cape Verde Islands (Rang, 1828: 56).

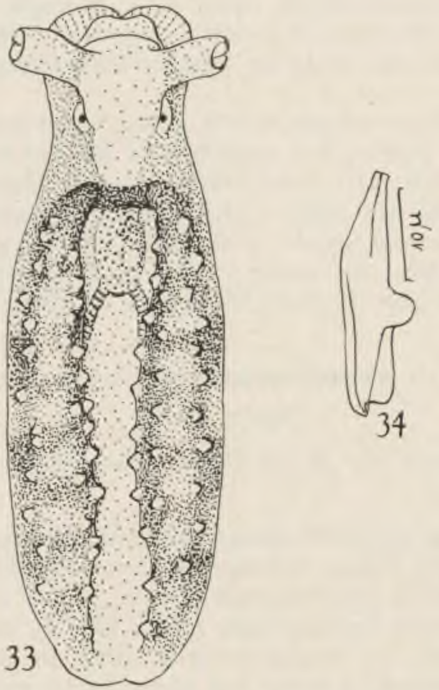
9. **Elysia slimora,** spec. nov.

Figures 33-34

Material. — Station 283 (Annobón), 51-55 m. One specimen.

Description. — The living and extended animal was 7 mm in length (Fig. 33); preserved it is 4.5 mm long, 4 mm broad with expanded parapodia. Alive the ground color is pale green, granular in appearance. Between the parapodia the dorsum is very pale green, almost white. Dark coloration, consisting of deep green flecks, occurs as a border of the parapodia, whence this color merges into that of the parapodia. These are darker near the borders and in the zones of insertion; the free edges themselves are paler. About seven darker bands traverse the lighter middle region of the parapodia, uniting the mentioned darker zones with one another. Deep green flecks occur on the pale green, longish reno-pericardial eminence. Two oblique afferent vessels (branchial veins) behind this elevation stand out as transparent tubes encircled by irregular dark green rings. The eyes are surrounded by light halos.

The parapodia, which leave the head and neck free, are very thick and fleshy, their faintly lobed free edges are papillate. Also the outer surface



FIGURES 33-34.—*Elysia slimora*, sp. nov.: 33, living animal, after drawing by F. M. Bayer; 34, radular tooth.

of the parapodia bears papillae whose tips are pale. The head is rounded, not carinate on the sides. The small rhinophores are smooth without papillae. The anterior foot corners are rounded, not prominent. A transverse groove in the anterior half of the sole unites the insertions of the parapodia.

The radula comprises a total of 24 teeth, eight in the upper, ten in the lower limb, and six discarded ones. The edge of the teeth is smooth, also when examined with immersion. The maximum length of the teeth is 29 μ, but the difference between the largest and smallest teeth is slight. The oesophagus bears a dorsal crop.

Discussion. — Thanks to a detailed drawing and description of the living slug by Professor Bayer the specimen can be named, though it is quite immature, and the species evidently reaches a rather great size, when the reproductive organs are developed. However, the relatively uniform size of the teeth indicates that this will not increase considerably in adult animals. The great number and the smallness of the teeth are important characters of the new species. In *E. livida* Baba (1955: 12, 43) the teeth are comparably small, about 40 μ in length, according to his text-figure 13 B. The color of *livida* is deep blue with an orange band between two black ones along the edge of the parapodia. It is smooth, without papillae.

The species of *Elysia* whose body is always, or at least in larger specimens, beset with papillae are contained in the following publications: Marcus, 1957a: 408, 410; Baba, 1957: 71, 73; Marcus, 1960b: 153; 1963: 20-22; 1966 (in press). The absence of melanophores around the outlets of cutaneous glands or along the edge of the parapodia; the general color pattern; the shape of the head, rhinophores, and foot corners; the crop; and the teeth distinguish *E. slimora* from the other papillose species.

10. **Pleurobranchaea gela,** spec. nov.

Figures 35-37

Material. — Stations 26, 28, 46-48, 62, 241, 22-75 m. A total of 55 specimens.

Description. — The preserved animals are quite differently contracted and 15-47 mm in length. Those with the buccal mass in normal position are high and broad, those with the pharynx more or less extruded are lower and thinner. Generally the specimens of less than 20 mm in length have no genital apertures, but among the larger slugs the size is not strictly correlated with maturity. A dorsal flap on the border of the genital orifices indicates the full development of the reproductive organs.

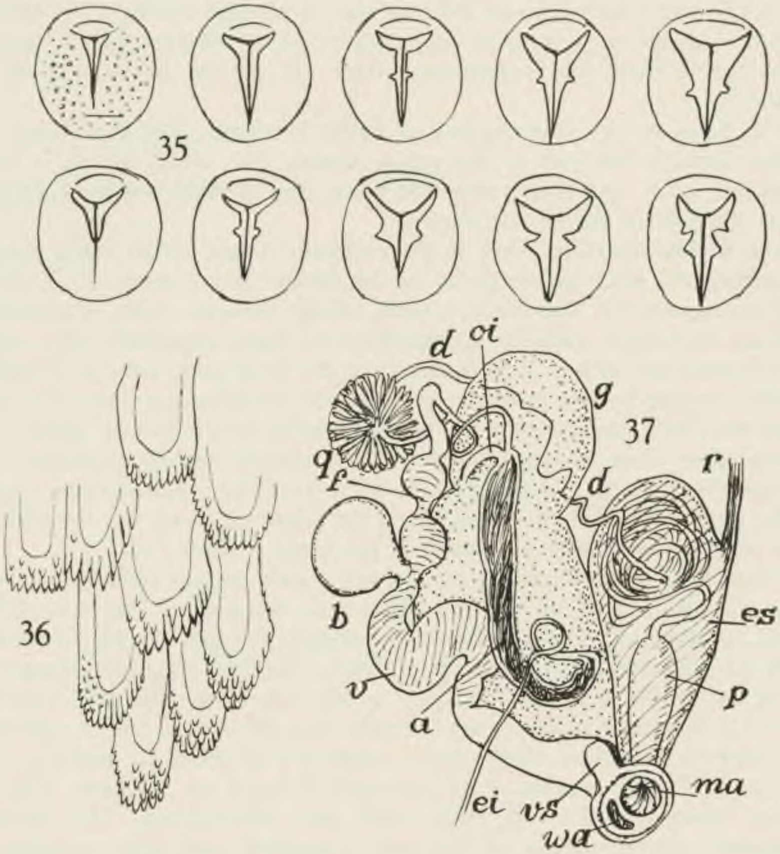
As far as the color marks are preserved, they consist of a dark brown net with light spots on the notum, melanophores on the dorsal part of the ctenidium, a slight pigmentation of the upper surface of the foot, a blackish spur, a black sole with light border, and black tentacles and rhinophores with light tips. Some specimens have a purplish notum and a black sole.

The veil between the tentacles generally has a single row of warts. The notum is smooth or slightly bossed. The spur is small, 1.5 mm in height. The anterior border of the foot is bilabiate. The pedal gland is distinct.

There are 24-27 branchial pinnules on either side of the rhachis; sometimes there is ventrally one more pinnule. The branchial membrane extends over 3/4 of the length of the gill. The anus, whose location is difficult to define, lies on the level of the 4th to 7th pinnule, the renal pore under the 2nd. The opening of the prebranchial or Bourne's gland is situated in front of the gill as in other species. The above-mentioned flap (vs) points upwards.

The cerebro-pleural ganglia are farther apart from one another than in *Pl. hedgpethi hamva* and *Pl. inconspicua.*

The mouth is open in all specimens, at least the anterior surface of



FIGURES 35-37.—*Pleurobranchaea gela,* sp. nov.: 35, aspect of the mouth of ten specimens; 36, mandibular elements; 37, diagram of reproductive organs.

the buccal mass set with dark warts shows. Frequently also the anterior borders of the yellowish mandibles appear turned outwards; they are indented in different ways (Fig. 35). The pharynx is up to 18 mm long. The jaws of a 40 mm slug are 14×5 mm. The anterior border of the mandibular elements bears 16 denticles or more, frequently disposed in several rows (Fig. 36). The radula of this slug is 15×14 mm and comprises 40 rows with 70 teeth per half-row. The innermost tooth is 60 μ long; the teeth in the middle reach 0.6 mm; the outermost tooth is 0.15 mm long. Sometimes the innermost and the outermost tooth have no secondary cusps.

The hermaphrodite duct (Fig. 37, *ei*) forms a tubular ampulla (*a*). Its outlet divides into the inner oviduct (*oi*) which enters the female gland mass (*g*) and a duct with an efferent and an afferent function. As efferent duct it leads its own sperm to the prostate (*q*), as afferent duct it conveys alien sperm from the insemination duct (*f*) to the bifurcation of the ampulla.

The prostate (*q*) is composed of loose filaments. The male duct (*d*) passes through the wall of the penial sheath (*es*) inside which it forms numerous coils, and then enters the penis (*p*). Behind the male opening (*ma*) lies that of the female organs.

The female aperture (*wa*) is the common orifice of the outer oviduct or nidamental duct, as the outlet of the female gland mass (*g*) is called, and the vagina (*v*). The latter, a wide, entally muscular tube, is connected with an unstalked, globular spermatheca or bursa copulatrix (*b*), where alien sperms are stored. For insemination the male germ cells are impelled farther inwards by two muscular bulbs of the insemination duct (*f*). These bulbs may be called a spermatocyst constricted in the middle. Entally the insemination duct becomes thinner. Its innermost section coincides with the pre-prostatic part of the efferent duct. The alien spermatozoa, arrived at the post-ampullar bifurcation, reach the albumen gland, the folded inner part of the gland mass, by means of the inner oviduct (*oi*).

From Station 26, depth 28 m, a single specimen was obtained, 12 mm long, 8.5 mm broad. Its foot is smaller than the notum. The ventral foot gland and the black dorsal spur are developed. The gill has 20 pinnules on each side; the anus lies over the 5th pinnule. The branchial membrane fixes about ¾ of the gill. The pharynx is 3.5 mm long. The jaws are flat, 2.8×1.1 mm, their elements are tile-like, very different in length (29-40μ) and breadth (23-26μ); they have a single row of about 10 denticles. The radula, 3×2 mm, consists of 37 rows and 53 teeth per half-row. The first lateral tooth and the 4-5 outer teeth are unicuspidate. The stomach contained several species of hydroids, caprellids and other amphipods. The flap on the border of the genital aperture is directed upwards; the inner reproductive organs are complete; the ampulla is filled with sperm. The short insemination duct agrees with that of the larger animals, whose specimens with less than 20 mm are immature.

A 15-mm long slug from Station 42 has a 6.5 mm long pharynx, jaws of 5×2 mm, and a radula of 6×4 mm. Its mandibular elements are 40-65 μ long, 23-40 μ broad, and all have more than 10 denticles. The radula has 37 rows of 62 teeth per half-row, and all teeth have a secondary denticle. In spite of these differences in the armature of the buccal mass between the 12-mm slug from Station 26 and the smallest, 15 mm long, immature animal classified as *Pl. gela,* we ascribe the former to the same species, because we consider the reproductive organs as decisive.

Discussion.—Since we published the list of the species of *Pleurobranchaea* (Marcus, 1957b: 25-27), we have seen the descriptions of *Pl. algoensis* Thiele (1925: 282) and *Pl. japonica* Thiele (p. 283). Both species are unrecognizable. The caudal spur of *algoensis* does not distinguish it from *Pl. capensis* Vayssière, 1900 and *Pl. melanopus* Bergh, 1907, as Thiele thought, because it was later found in both species (O'Donoghue, 1929b: 49, 51-52). The aspect of the mouth which Thiele considered as a specific character, principally of *Pl. japonica,* is of no use, as our Figure 35 shows. A further addition to our list is, that *Pl. novaezealandiae* Cheeseman, 1878 (Baba, 1937a: 229) and *Pl. dorsalis* Allan, 1933, were synonymized (Burn, 1958: 6) with *Pl. maculata* (Quoy and Gaymard, 1832). Finally *Pl. gemini* Macnae (1962: 178) was described, "whose female genital aperture is provided with two leaf-like flaps above and below." *Pl. capensis* and *Pl. melanopus* recorded from West Africa by White (1955: 171, 173) have genital apertures without flaps.

Pl. gela is near to a group of West Atlantic species with the same extension of the branchial membrane, the position of the anus over the anterior part of the gill, and a flap on the border of the genital aperture. Within this group *Pl. inconspicua* Bergh (1897a: 49) and *Pl. hedgpethi hamva* Marcus (1957b: 21) have a flap which points upward. The single mature specimen *Pl. inconspicua* from the coast of Sergipe, northeastern Brazil, is 19 mm long, has the caudal spur tipped with red, and mandibular elements with 6-10 quite delicate denticles. The cerebro-pleural ganglia of *inconspicua* are more concentrated than in *gela.* The same holds for *hedgpethi hamva,* whose mandibular elements bear less denticles than those of *gela.* The insemination duct of *hedgpethi hamva* differs widely from that of *gela.* As we recently found (in press, Fig. 56) in *hedgpethi* this duct is much coiled in the part leaving the spermatheca, so that the muscular bulbs or constricted spermatocyst lie farther inward.

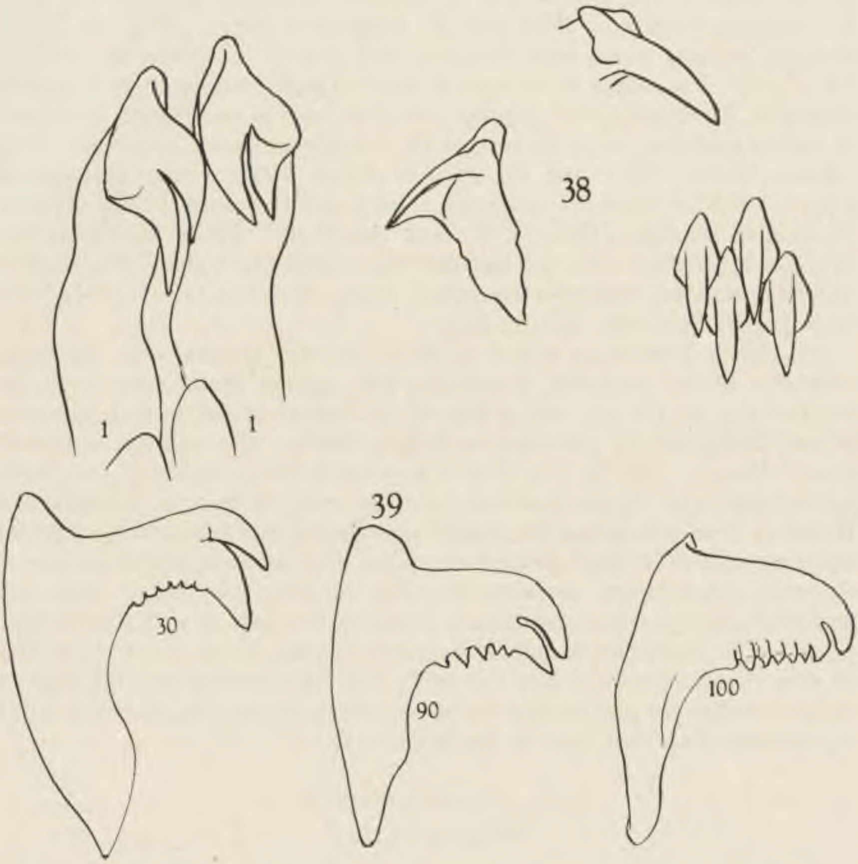
11. *Hypselodoris* spec.

Figures 38-39

Material.—Station 69, 29 m. One specimen.

Description.—The preserved, rather contracted, slug is 8 mm long, 5 mm high, and 5 mm broad. The notum is smooth, translucent; its border shows vestiges of green color. The color of this streak may have been different in life. According to a note by Prof. Voss, the slug was blue and orange in life. The tentacles are thick and grooved on their ventral side. There are nine unipinnate gills.

The labial armature is divided into a narrow median and two broader lateral fields. It consists of pointed hooks with secondary prominences (Fig. 38). *Chromodoris nyalya* Marcus (in press) has a similar structure of the labial cuticle. The radula comprises about 50 rows with 100 bicuspid teeth per half-row. The rhachis is naked, without thickening. The two first lateral teeth have no denticles (Fig. 39). Such begin on the following teeth and are up to six. Outwards they increase in size. Even the outermost tooth is denticulated.



FIGURES 38-39.—*Hypselodoris* sp.: 38, jaw elements; 39, radular teeth.

Discussion.—Though it is impossible to classify a chromodoridine, whose color pattern is not known, we compared the present specimen with the species of *Hypselodoris* from the eastern Atlantic Ocean, the Mediterranean Sea, and the area of the Cape of Good Hope recorded by Barnard (1927), Bergh (1899; 1907), Eliot (1906b), Odhner (1932), and Pruvot-Fol (1951b; 1953; 1954). If the synonymy of Pruvot-Fol (1951a) is adopted, the species of *Hypselodoris* in the mentioned region are: *bilineata* (Pruvot-Fol, 1953), *capensis* (Barnard, 1927), *coelestis* (Deshayes, 1866), *euelpis* (Bergh, 1907), *fontandraui* (Pruvot-Fol, 1951b), *gracilis* (Rapp, 1827), and *valenciennesi* (Cantraine, 1835). *Polycera webbii* d'Orbigny, 1844, whose radula is not known (Pruvot-Fol, 1951a: 157), is undefinable.

When the available characters of the present slug, the smooth notum, the nine unipinnate gills, the labial armature, and the radula are considered, *H. bilineata* (Pruvot-Fol, 1953: 72) from the Atlantic coast of Morocco seems to differ least. Its denticles are 2-3, rarely 4, and the labial armature is evidently different.

12. **Discodoris golaia,** spec. nov.

Figures 40-42

Material.—Station 258 (Fernando Póo). One specimen.

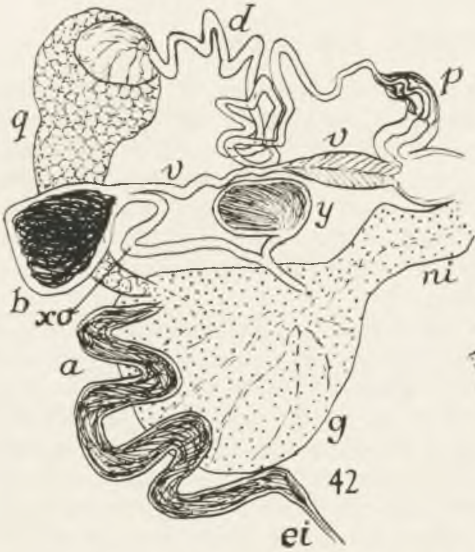
Description.—The preserved slug is 38 mm in length, 25 mm in width, and about 10 mm in height. The margin of the notum is up to 8 mm broad. The slug had autotomized its notum, but this was kept. It is very hard, brownish, with irregular brown spots, whose size decreases to the sides. The gills are dark brown. The hyponotum is light with brown, in part coalescent, spots, not as dark as those on the notum. On the borders of the hyponotum the spots are scarce. The upper surface of the foot is dark, the border light, and the sole white.

The white tentacles (Fig. 40) are 2 mm long and pointed, without a groove or fold. The rhinophores are light with minute dots of pigment, the perfoliation of their clubs consists of about 25 leaflets on either side. The notal papillae (Fig. 41), densely set in the middle of the back, are broader (0.17 mm) than high (0.12 mm), flat above, and light in the center, pigmented all around, and stiffened by monaxonous, not projecting spicules. The rhinophores stand 7 mm apart from one another and 7 mm from the lateral border; the rim of their pockets is smooth. There are 6-8 at least tripinnate gills; some of them are in regeneration. The anterior border of the foot is grooved, the upper lip deeply notched.

The two blood glands are dark. The labial cuticle forms two quadrangular areae, 1.4 mm from right to left, and 0.6 mm in antero-posterior direction, beset with thin rodlets, 80 μ in length and 5 μ in diameter. There are 23-24 rows of radular teeth and 47-50 teeth per half-row. The rhachis is naked. All teeth are hook-shaped. In the middle of the half-row they have an about 0.3 mm high base and a 0.18-mm long cusp. The 16 innermost and 6 outermost teeth decrease in size. The stomach lies completely free over the remaining viscera; it is a sac with longitudinal folds.

The hermaphrodite duct (Fig. 42, *ei*) dilates into a long, winding ampulla (*a*). Its outlet merges into the gland mass (*g*), where it divides. The glandular male duct leaves the ental part of the gland mass and thickens outwards, forming a massy prostate (*q*). The structure of the ectal end of the prostate differs from that of the main part, as described of *D. tristis* Bergh (1899: 14). The coiled efferent duct is sheathed (*p*) before it opens into the male atrium.

Behind the male atrium are the entrance of the vagina (*v*) and the exit of the nidamental duct (*ni*), all situated in the same depression of the skin, whose outer opening is inconspicuous. The shorter ectal section of the vagina is glandular, the longer ental part thin-walled. The vaginal entrance into the spermatheca (*b*) and the beginning of the insemination duct (*xo*) are in common. The spermatocyst (*y*) communicates with the insemination duct by a short canal. The insemination duct enters the ectal region of the gland mass.



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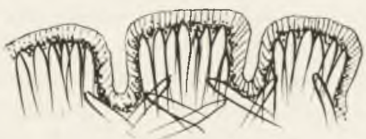

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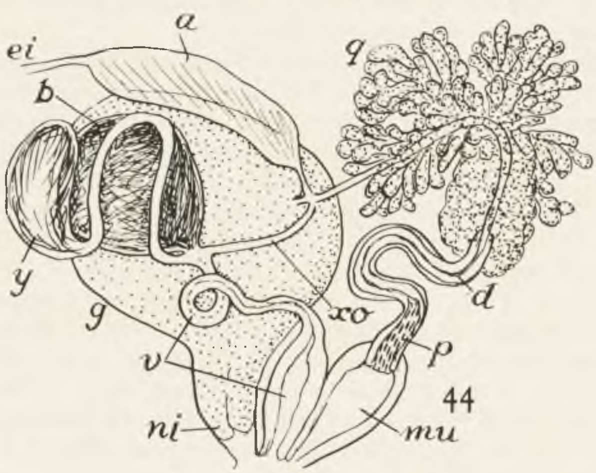

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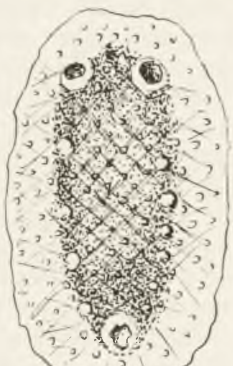

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FIGURES 40-44.—40-42, *Discodoris golaia,* sp. nov.: 40, ventral view of fore end; 41, sculpture of notum; 42, diagram of reproductive organs.—43-44, *Doriopsilla areolata* Bergh: 43, dorsal view of preserved specimen; 44, diagram of reproductive organs.

Discussion.—Though autotomy of parts of the notum is especially frequent in the species of *Discodoris,* it occurs also in *Peltodoris* and *Platydoris* (Bergh, 1892: 1087; Risbec, 1953: 32).

Of the 19 species of *Discodoris* recorded from the lower latitudes of the Atlantic Ocean and the Mediterranean Sea, five have an armed penis: *branneri* MacFarland, 1909; *evelinae* Marcus, 1955; *hedgpethi* Marcus, 1959; *mortenseni* Marcus, 1963; and *spetteda,* Marcus, 1966. Lamellar outer radular teeth occur in *rubens* Vayssière, 1919, and *pusae* Marcus, 1955. Narrow radulae with a maximum of 20 teeth per half-row characterize *indecora* Bergh, 1881, and *cavernae* Starmühlner, 1955.

For the ten remaining species we mention one or more characters which distinguish them from *golaia. D. notha* Bergh, 1877, has a muscular cone covered by a cuticle beside the male aperture. In the minutely granular *D. muta* Bergh, 1877, the basal plate of the innermost radular tooth is split (Bergh, 1877: 533), or these teeth are very irregularly arranged (Eliot, 1906b: 138). *D. maculosa* Bergh, 1884, originally from Naples, and recently from the south coast of Turkey (Swennen, 1961: 62), is lighter than *golaia,* but its sole is spotted. Its labial cuticle has very narrow fields with rodlets; the rhachis of the radula bears peculiar thickenings, and the number of rows is 37-40. *D. erubescens* Bergh, 1884, not with certainty a *Discodoris,* as no prostate was mentioned, has a rather small stomach enclosed in the liver, and 12 bipinnate gills. In *D. tristis* Bergh, 1899, the tentacles are somewhat flattened and grooved on their outer side; in *D. edwardsi* Vayssière, 1902, two or three innermost teeth are rudimentary. The six gills of *D. voniheringi* MacFarland, 1909, are bipinnate; the labial cuticle consists of a median and two lateral fields, and there is a row of round blotches, up to 2 mm in diameter, on the hyponotum.

D. alba White, 1952, is white alive, cream in preservation; it has an aberrant, bluntly hamate innermost tooth. The notal sculpture which furnishes useful systematic characters in the Dorididae (Odhner, 1932: 37), consists of caryophyllidia in *D. phoca* Marcus, 1966. The radula of *D. purcina* Marcus, 1966, is broader (3.3 mm) than long (2.5 mm).

The geographically nearest species to *D. golaia* are: an unnamed *Discodoris* from Dakar (Pruvot-Fol, 1953: 76) with three fields of labial rodlets, and three species from the Cape Verde Islands (Eliot, 1906b: 136, 137, 139). The two named species, *D. indecora* and *D. muta,* were separated from *golaia* in the preceding; the unnamed one (l. c., Pl. 14, Fig. 3) has a labial armature consisting of peculiar, scale-like elements.

13. *Doriopsilla areolata* Bergh, 1880

Figures 43-44

References.—Bergh, 1880: 316; Marcus, 1962: 472 (further references).

Material.—Station 60, 79-82 m. One specimen.

Further distribution.—Adriatic Sea (original locality); French Mediterranean coast; East Atlantic coast from southernmost France; Portugal; Morocco; off the Mauretanian coast, 140 m (Vayssière, 1902: 235); Sénégal, Dakar (White, 1955: 184), and the Cape Verde Islands. West Atlantic Ocean, Virgin Islands.

Descriptive notes.—The animal is 22 mm long, 12 mm broad, and 5 mm high. The border of the notum is a little rolled in, so that the expanded notum must be broader. The width of the hyponotum is 3 mm, that of the sole 8 mm. The color is light brown with darker brown pigment in a middle zone whose center is lighter again. The hyponotum is transparent, not pigmented; also the peritoneum is colorless.

Along each side of the darker area of the notum there is a row of bigger bosses (Fig. 43). Smaller tubercles are scattered all over the notum. Especially in the middle these knobs stand on the crossing-points of the tracts of spicules. The spicules look silky. They are smooth and cross diagonally at right angles. The tubercles are stiffened by upright spicules. On the underside the spicules supporting the notal border appear as a regular rectangular network.

The rims of the rhinophorial pockets are smooth, that of the branchial pit is ragged. The rhinophore clubs have 27 leaves. There are five gills; the anus lies to the left of their center. The oral vestibule is inconspicuous, not set off from the pharynx which in the present specimen is relaxed and forms a loop.

The ampulla (Fig. 44, *a*) is fusiform; its outlet divides into a short inner oviduct immediately merging into the female gland mass (*g*), and the male duct. The prostate (*q*) consists of an inner part composed of long, ramified lobes, and an outer, compact part. The prostate is wrapped around the sperm-storing vesicles as a layer of white spherules (Bergh, 1880: 325). The male duct leaving the prostate forms a loop (*d*) and is sheathed till to the terminal section which opens into the male atrium (*mu*). The wall of this section, an acrembolic penis (*p*), 0.3 mm in length, is beset with around 12 rows of quincuncially arranged cuticular hooks.

Between the male atrium and the nidamental duct (*ni*) the wide entrance of the vagina (*v*) is located. The vagina runs winding to the bag-shaped spermatheca (*b*) inserted on the vagina without stalk. Immediately behind the spermatheca the canal of the pyriform spermatocyst (*y*) and the insemination duct (*xo*) separate. This duct is long and thin; it enters the inner oviduct.

Discussion.—For the description of the normally present, snow-white epidermal, and the silky, subepidermal spicule net we refer to Vayssière (1901: 50-51) and Pruvot-Fol (1952: 412). Also in the original description (Bergh, 1880) both nets are described, but on widely separate pages (318, 321). The superficial opaque net conceals that of the spicules in the conjunctive tissue which shines through the transparent hyponotum. Both nets may be affected by the liquids of preservation. In the present slug, in the specimen from the Virgin Islands (Marcus, 1962), and in the material from the Cape Verde Islands (Eliot, 1906b: 148) the epidermal net is absent, evidently also in Vayssière's variety of *areolata* (1919: 84). Eliot was in doubt whether his specimens should be classified as *areolata* or as *pelseneeri* Oliveira, 1895 (Nobre, 1938-40: 47). *D. pelseneeri* (in Marcus, 1962: 475, erroneously called *paulinoi*), perhaps a local form of *areolata,* has up to 2 mm high dorsal bosses which bear secondary tubercles. Its further characters, a highly convex notum, darker in the center, and without white lines, are hardly sufficient for a specific separation. In any case, neither Eliot's nor our present or previously described slugs have tuberculate bosses, and we consider them as *areolata.*

The hook-bearing section of the male duct is 0.7, 0.8, and 0.6 mm long in Bergh's (1880: 325; 1896: 458) and Vayssière's specimens (1901: Pl. 7, Fig. 9). This difference of the present slug deserves attention, but may depend on a more relaxed or more contracted condition of the muscular tube.

Such a regular arrangement of the bigger bosses as in our slug has not yet been described for *areolata.* However it is better to mention this detail than to fix it by a new name. Moreover a denomination would involve a specimen from the French Mediterranean coast, published as *Doriopsilla* (or *Dendrodoris*) *pusilla* Pruvot-Fol (1951b: 41; 1954: 339). It measures 3×2.5 mm, has five to six rhinophore leaves, is probably young, and certainly undefinable.

The oral vestibule of *areolata* has been qualified as "gros, long et contourné" (Pruvot-Fol, 1953: 90) and as "très petit" (ead., 1954: 337). In fact, sometimes the vestibule lodges the protruded anterior part of the pharynx and is distended by it, while it is inconspicuous when the pharynx relaxes. A specific separation of *D. fedalae* Pruvot-Fol (1953: 90) from *areolata* cannot be based upon the smaller vestibule of the former.

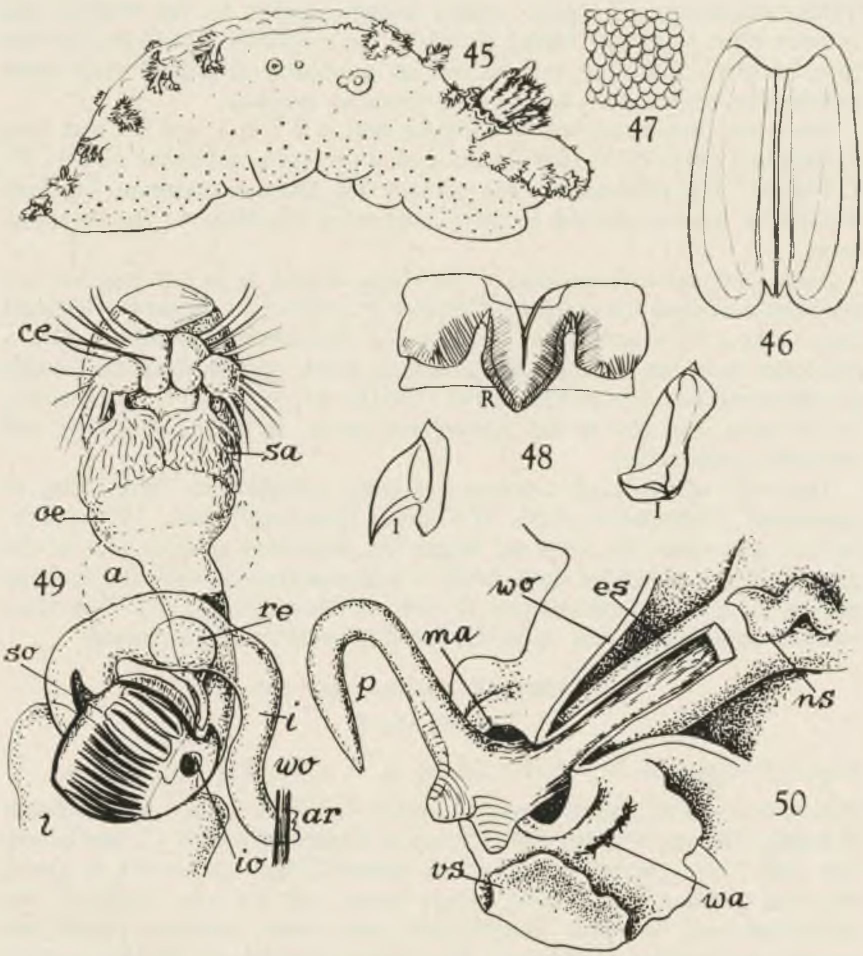
14. **Marionia vanira,** spec. nov.

Figures 45-49

Material.—Stations 28, 46, 60, 38-82 m. A total of five specimens.

Description.—The biggest specimen, one of two from Station 46, is 52 mm in length, 18 mm in width, and 13 mm in height. Its sole is 12 mm broad. The color, best preserved in the two animals from Station 60, is green, the velar papillae and gills are darker green, and the sole is lighter. The rhinophores are brownish. Minute dark green warts, evidently glands, are located on the sides of the foot. The anterior border of the foot bears a shallow transverse furrow, whose yellowish color pales backwards. Also the genital aperture and the anus are bordered with yellow.

The back is indistinctly reticulated and gibbous; the highest spots are dark green and diminish in size towards both sides. There are about 14 pairs of branchial tufts. These insert on short projections of the notal border without a stalk. They are about tripinnate, but are often bitten off and in different stages of regeneration (Fig. 45). Also the tails show signs of damage. The genital aperture lies under the third right gill tuft, the anus under the fifth. The nephropore is situated in front of the anus, the space between them corresponds to the breadth of the anus.



FIGURES 45-50.—45-49, *Marionia vanira,* sp. nov.: 45, view of right side of 41-mm specimen from sta. P-60; 46, jaws; 47, tubercles of masticatory border; 48, rhachidian (R), intermediate (I), and first lateral (1) teeth of radula; 49, diagram of alimentary tract.—50, *Fimbria fimbria* (Linn.): male copulatory organ; penial sheath (*es*) opened.

The veil is entire, not emarginate, only the two or three innermost appendages are shorter than the others. There are eight to ten appendages on either side; they have up to eight tips. The outermost velar appendages are the quite short, spoon-shaped tentacles. The border of the rhinophorial sheath is crenulate. These sheaths and the upper surface of the veil bear glandular warts, such occur also on the underside of the veil.

The dark yellow jaws (Fig. 46) are very strong, 20 mm in length, hence 38 per cent of the body length of our biggest slug. The hindmost part of the masticatory border bears about six rows of minute tubercles (Fig. 47). The radula consists of 55 rows with 104 lateral teeth per half-row. All cusps are smooth, not denticulate. The cusp of the rhachidian tooth (Fig. 48, *R*) is tripartite and striate on its border; that of the intermediate tooth (*I*) is blunt, and that of the lateral teeth pointed and hook-shaped. The rhachidian tooth is 492 μ broad, 257 μ high; its median projection is about triangular and flanked by nearly rectangular cusps. The intermediate tooth is 250 μ high, contorted, and concave in its inner side as in most species of the genus. The first lateral tooth (*l*) is also 250 μ high; the following teeth increase in size to about 400 μ; while the 30 outer teeth decrease again to 300 μ, the height of the outermost tooth.

The short salivary glands (Fig. 49, *sa*) are broad and flat. The gut contains red and white polyps of gorgonians and up to 10 mm long pieces of their corneous axes. There is a girdle of about 50 low cuticular ridges in the stomach (*so*); two bigger ones lie behind the main hepatic duct (*io*). The right liver (*re*), located under the intestine, forms a separate, round organ, and opens by its own duct in front of the main or left hepatic aperture. The liver leaves the stomach free.

The reproductive organs correspond to those of other species of *Marionia*, e.g. *M. cucullata* (see Odhner, 1934: Fig. 69). The mature specimen of our dissected animals was in the male phase with a longish ampulla distended by sperm and overlying the dilated part of the oesophagus. The flat spermatheca or bursa copulatrix was empty. The penial papilla is conical but slightly flattened, thicker than in *cucullata*.

Discussion.—Odhner's paper on the Tritoniidae (1963) establishes the limits of the genus *Marionia* Vayssière, 1877. Since his survey of the species (1936: 1087-88) few modifications and additions were published. *M. blainvillea* (Risso, 1818) and *M. tethydea* (Delle Chiaje, 1828) which Odhner united, were separated again by Pruvot-Fol (1937: 71-72; 1954: 352), followed by Haefelfinger (1960: 338). Baba (1937; redescription 1949: 86, 166) described *M. olivacea* and a new subspecies of *M. pustulosa* (1937b: 313); White (1955: 180) found a new species, *M. cabindae*, off the mouth of the Congo River.

In 1963 Odhner (p. 50) transferred *Marionia olivacea* to *Marionopsis* Odhner, 1936, because he found the liver fused into a single mass, though a right duct is developed. The pluriserial denticulation of the mandibular border and the position of the genital aperture beneath the third gill of *olivacea* agree with *Marionia,* not with *Marionopsis* (Odhner, 1936: 1085-86). *M. olivacea* differs from *vanira* by a smaller number (71) of lateral teeth, higher plates of the stomach, and a shorter jaw. The latter is 14 mm in length in the figure (Baba, 1949: Fig. 108 A); the body of *olivacea* is 50-80 mm. Hence the length of the jaw is at most 28 per cent of the body length. *M. olivacea* was found in middle Japan (34-35°N).

M. pustulosa pustulosa Odhner, 1936, from Queensland, and *M. p. odhneri* Baba, 1937, from middle Japan (34°25'N) have 113 and 125-130 radular teeth per half-row, respectively, hence numbers comparable with the 105 teeth of *vanira.* Both forms of *pustulosa* have a straight, not contorted, innermost lateral tooth. The length of the jaw of *p. pustulosa* is 13.6 per cent of the body length. Assuming that the figure of the jaw (Baba, 1937: Fig. 11 A) was drawn from the biggest *p. odhneri,* the length of its jaw is 25 per cent of the body length.

The number of the radular teeth is not known for *M. tessellata* Bergh (1905: 207) from the Savu Sea, W of Timor. Its dorsal reticulation is strong, the masticatory border of the jaw bears only three rows of denticles, and the length of the pharynx (that of the jaw is not given) is 18 per cent of the body length. In this species the dorsal polygons are evident (Pl. 19, Fig. 3). However, they are not always recognizable in all specimens (Vayssière, 1902: 244) of species belonging to Odhner's group with distinct polygons. The length of the "branchial stems" does not furnish a reliable character, because it depends on contraction.

The West african *M. cabindae* White, from about 10° farther south than our material, needs a special comparison. The color is cream with a few brown streaks, preserved. The back is finely papillose with a few larger papillae. The velar processes are simply branched. The wall of the stomach has no cuticular structures. The radular formula is similar, but the teeth are not described in detail.

15. *Fimbria fimbria* (Linné, 1767)
Figure 50

References.—Bergh, 1875: 348; 1883: 67; Vayssière, 1901: 82; Si, 1931: 108; Odhner, 1936: 1112-1115; Nobre, 1938-40: Pl. 12; Pruvot-Fol, 1954: 356.

Material.—Stations 28 (two specimens), 46 (two specimens), 62 (three cerata), 232 (one ceras), 38-132 m.

Further distribution.—Mediterranean Sea, from Turkey to Morocco. Atlantic Ocean, coast of Portugal and Morocco (Risbec, 1931: 88); Canary Islands (Bergh, 1890: 160); off Banana, 25 and 30 m (White, 1955: 179).

Remarks.—The body of the biggest specimen (Station 46) is 10 cm in length, 8 cm in width with the veil, 5 cm without it, and 2 cm in height.

The sole is 7 cm long, and in the big specimens of Station 46 3.5 and 4.5 cm broad. In these animals the veil is complete and forms a funnel with a fringed border around the mouth. The fringes of the bulged under lip are longer and stand more densely than those of the anterior velar border. The latter is accompanied by big black spots. There is a black streak along the inner border of the rhinophores, whose approximately 10 leaves are dark. As usual in preserved specimens of *F. fimbria,* all cerata have fallen off; their length attains 30 mm, and some black spots are preserved. Contrary to the caducous cerata the branched gills are fast; they also contain some black pigment.

The oral tube is lined with tubercular papillae, as described by Bergh (1875: 351). The salivary glands are minute as in Odhner's figure (1936: Fig. 5, *l, r*); Vayssière's "glandes salivaires" (1901: Pl. 7, Fig. 14, *s*) are the left and right anterior livers. These leave the stomach free. We found an accessory sac (Fig. 50, *ns*) opening into the penial sheath (*es*) in one of the small specimens of Station 28. It is short and does not deserve Bergh's designation "flagelliform sac" (1875: 361), but otherwise corresponds to the organ drawn by Bergh (Pl. 26, Fig. 14, b; Fig. 15, *c*) and Vayssière (1901: Pl. 7, Fig. 15, *pp*). The everted penis is 18 mm in length. There is a 7-mm long, 2.5-mm broad flap of skin (*vs*) behind the genital openings.

The color marks of the veil, the short salivary glands, the anterior livers not extended over the stomach, and the accessory sac evidence that the present material belongs to *F. fimbria,* not to Bergh's variety (1890: 156), today known as *F. occidentalis* Odhner (1936: 1114), from near the Windward Island Dominica, in 252 m depth. Odhner's name has precedence to var. *dominiquensis* Pruvot-Fol (1954: 359). Probably White's material from Dry Tortugas, 73 m (1952: 113) belongs to *occidentalis.*

Since O'Donoghue (1926: 226) and Engel (1934: 532-533) advocated Fimbriidae and *Fimbria,* these names are used currently (Odhner, 1936; Pruvot-Fol, 1954; Taylor & Sohl, 1962, and others), though Bohadsch, the author of *Fimbria,* was not strictly speaking a binominalist. Risbec (1931) and White (1952) write *Tethys leporina* Linné.

Notes on the Classification of the Arminінae

These animals were described as sluggish and voracious (Bergh, 1892: 1062). They live on sandy and muddy bottoms of the sublittoral, at least below the low water line, occurring chiefly in tropical and warm temperate seas. At day-time they lie burrowed into the superficial layer of the substratum (Bergh, 1866: 53; Eliot, 1903a: 565); at night they move about feeding upon sea pansies (MacGinitie, 1949: 373; Hedgpeth, 1953: 159), dead fishes (*Histiomena marginata* Bergh, 1866: 70), and other animals (Marcus, 1960b: 173). Due to their hidden way of life they are seldom captured in considerable numbers. Six specimens examined by

Lance (1962: 51) were from an exceptional locality "a rocky association at the lower edge of the intertidal area during minus tide." From certain frequently explored coastal localities numerous species are recorded. O'Donoghue (1929b: 75) and Lance (1962: 54) consider this as an artificial result of the nearly always insufficient number of specimens examined. It may as well be the effect of ecological isolation, because sandy and soft bottoms are inhabited by widely different associations.

The species of the Atlantic Ocean, the Mediterranean Sea, and the area of South Africa can all be distinguished by their radulae, whose intraspecific variability seems to be small in the arminines (Bergh, 1881: 172). When we glanced at the literature on the species from the Indian and Pacific Oceans, we met with some difficulties for the separation within two groups of species. One of these is the group with a single lateral lamella (Bergh, 1905: 214, note 1), the other is that of species with dorsal tubercles. Also Baba (1955: 50) found it hard to separate *Armina (Linguella) punctilucens* (Bergh, 1874: 268) and *A. (L.) variolosa* (Bergh, 1904: 21), both originally recorded from the China Sea. These two species are separable, thanks to Bergh's exhaustive descriptions. The differences concern the number of the lateral lamellae, the shape of the glandular lamella, the number of radular rows, and the details of the teeth.

Bergh (1866) distinguished three genera, *Armina* Rafinesque, 1814 (*Pleurophyllidia* Meckel, 1816), *Linguella* Blainville, 1825 (*Sancara* Bergh, 1861), and *Camarga* Bergh, 1866, which must be *Histiomena* Mörch, 1859. Their internal organs are similar (Bergh, 1876: 5). Fischer (1887: 531), Thiele (1931: 442) and others consider these taxa as subgenera. As Baba's key shows (1937b: 317-318) the outer morphology is clearly different. *Histiomena* is farther distant from the two other taxa than these from one another. We prefer to consider them as genera, because criteria for a subgeneric division of *Armina* are turning up (Pruvot-Fol, 1955: 467).

The range of *Armina* extends over all warm and temperate seas. *Linguella* occurs in the Indo-Westpacific Ocean. *Histiomena* is recorded only from the tropical Pacific coast of America.

In *Armina* the head is separated from the notum (mantle). The anterior border of the notum is continuous or nearly so; as a rule it is notched in the middle. In *Linguella* the head and the notum are coalesced due to a broad interruption of the anterior mantle border. The rhinophores stand close together in *Armina* and are farther apart in *Linguella*. As older and newer figures which show these differences we mention for *Armina*: Bergh, 1866: Pl. 4, Fig. 5, and Marcus, 1961: Fig. 153; and for *Linguella*: Bergh, 1863: Pl. 13, Figs. 1, 5, and Baba, 1955: Pl. 12, Fig. 33.

A folded anterior border of the notum may produce the impression of an interruption also in *Armina*, e.g. in Baba's colored figure (1955: Pl. 11, Fig. 29), but the careful drawing Fig. 30 in the text (p. 22) shows the notal border continuous around the central notch. In well stretched animals the position of the genital aperture, in front of or below the gills *(Linguella)* or behind them *(Armina)* may furnish an additional character (Bergh, 1881: 176-177), but the difference is rather slight. The caruncle, Bergh's "caruncula tentacularis," does not occur in all species of *Armina,* as we mention in the discussion of *A. bayeri.* On the other hand, a larger nodule may represent a caruncle in a species of *Linguella,* whose nuchal area bears white nodules (Bergh, 1904: 21). The sculpture of the notum is not disjunctive, though species with straight ridges or stripes are not known in *Linguella.* However, two verrucose species of *Armina* are discussed together with a third, *A. xandra,* in the following.

Bergh's name *Camarga* ("in Schedulis 1855") must be replaced by *Histiomena* Mörch, 1859, in spite of Bergh's protest (1866: 69). The three animals of the type-species, *H. marginata* (Bergh, 1866: 70; 1863: 490, name only) had been baited with dead fish by Örsted in a depth of 38 m (20 fm., probably Danish fathoms) at Realejo on the Pacific coast of Nicaragua (12°32'N, 87°09'W). *Armina convolvula* Lance (1962: 51) from the Gulf of California (30°48'N, 114°42'W) is the second species of the genus. The most important characters of *Histiomena* are: rhinophores separated; notum and veil continuous; lateral lamellae (side lamellae, posterior gills) flabelliform (Bergh, 1866: Pl. 9, Figs. 4; Lance, 1962: Fig. 4 b); and a single large glandular lamella, Bergh's "enkelt kolossal Sidelamel", on either side. The sculpture of the notum is different in *marginata* and *convolvula.* Also some details of the radulae can be distinguished. The smaller number of the gills and lateral lamellae in *convolvula* is possibly correlated with its smaller size.

Pleurophyllidiella Eliot (1903b: 251) has no gills, only lateral lamellae. Bergh (1907: 100, note) doubted this genus, but *Pl. paucidentata* O'Donoghue (1932: 149) confirms it. *Pleurophyllidiella* connects *Linguella* with *Dermatobranchus,* hence the Armininae with the Dermatobranchinae.

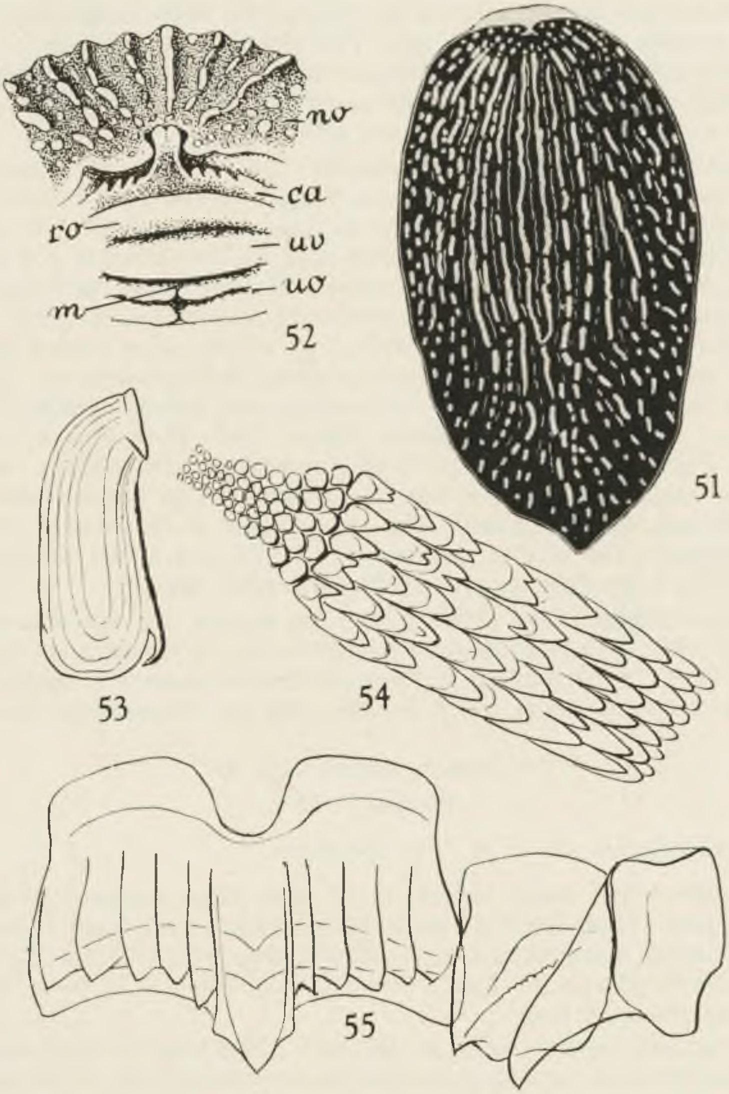
16. **Armina bayeri,** spec. nov.

Figures 51-55

Material.—Station 48, 22 m. Two specimens.

Description.—The bigger animal is 55 mm long, measured over the curved back (linear length 26 mm), 30 mm broad, and 14 mm high. The corresponding measurements of the smaller slug are 25 (15), 19, and 8 mm. The breadth of the foot of the bigger specimen is 18 mm, that of the hyponotum 10 mm.

The animals are transparent reddish with a thin layer of black pigment preserved between the ridges, especially in the anterior part of the notum. The light ridges are interrupted in the posterior part of the notum and on the lateral thirds (Fig. 51). In the middle of the back of the smaller animal (Fig. 52) three thick ridges and two thinner ones between them are rather complete. The bigger specimen has four thick ridges and three thin ones, so that the ridge in the middle may be a thick or a thin one. The ridges run parallel in the anterior part and diverge towards the sides behind.



FIGURES 51-55.—*Armina bayeri*, sp. nov.: 51, dorsal view; 52, ventral view of head; 53, jaw; 54, masticatory border; 55, center of radula.

Intercalary ridges, streaks, and knobs appear as quite thin marks between the stronger ridges. Probably the number of these sculptures increases with age.

The orifices of the marginal glandular sacs (Hoffman, 1939: 1202 ff.) are numerous. The gills lie far in front, under the border of the veil; there are about 20 complete and a number of quite short ones. Six to eight of the branchiae continue backwards as lateral lamellae, all of nearly the same size and parallel with one another. They run obliquely towards the border and leave the caudal end free. On the right side there are about 30 side lamellae, on the left side 26, but they are interrupted and irregular.

The upper border of the cephalic veil (Fig. 52, *ro*) is smooth; its corners are rounded. It is as broad as the foot, has a transverse fold on its anterior side, and a grooved inferior border. The dorsal caruncle *(ca)* is upwards directed, pigmented, and forms a spur fitting into the median notch of the notum. About three colorless papillae lie on either side of the caruncle. The rhinophores are completely retracted.

The foot is slightly notched in front, its corners are recognizable, but not projected beyond the veil. The posterior foot gland is weakly marked. The genital aperture lies immediately behind the right gills, the anus in the middle of the right side.

The jaws (Fig. 53) are 6.3 mm long, each is 2.5 mm broad. The masticatory border bears about ten rows of pegs (Fig. 54). Generally the pegs end with a single point, but many are bicuspid. The radula is 4.5 mm in length, 3.7 mm in width. Its formula is $44 \times 52.1.1.1.52$. The rhachidian tooth (Fig. 55) is 180 μ broad and 125 μ high; it has a broad and pointed middle cusp and five lateral denticles on either side. The innermost denticle is apposed to the median cusp. Sometimes the tip of the second denticle is carved. The short cusp of the intermediate tooth is serrate on the outer side. From the 135 μ long cusp of the first lateral tooth the cusps increase to 250 μ in the 44th tooth and then decrease to the outermost 50-100 μ long one. All cusps are smooth.

The species is named for Professor Dr. Frederick M. Bayer.

Discussion. — No other species of the Armininae has a notal sculpture as *A. bayeri.* According to the description, that of *Histiomena convolvula* (Lance, 1962), though it is different, might be similar in effect. Apart from the sculpture, all species from the Atlantic Ocean and neighboring seas have one or more characters to distinguish them from *bayeri.*

1. *A. tigrina* Rafinesque, 1814. The type-species of *Armina;* for description and figures see Pruvot-Fol, 1954: 344, Fig. 135a, P1. 1, Fig. 1. Mediterranean Sea; coast of Portugal (Nobre, 1938-40: 62); Sénégal, Casamance, 12° 47′ N, 17° 07′ W (White, 1955: 184); Sargasso Sea (Bergh, 1866: 28); Gulf of Mexico (Hedgpeth, 1953: 159; Moore, 1961: 35). Rhachidian tooth high and narrow; its cusp serrated by 15-30 denticles on either side; lateral teeth dentate on both sides, with exception

of the two or three outermost ones (Vayssière, 1901: P1. 6, Figs. 18, 19).

2. *A. maculata*, Rafinesque, 1814. For synonyms see Pruvot-Fol, 1927: 46; 1937: 64. Mediterranean Sea, Sicily; Bay of Biscay; southern France, Arcachon; Portugal; Morocco; Rio de Oro; Angola, off Lobito, 12° 12′ S, 13° 27′ E (White, 1955:185). Caruncle reduced, not flanked by nuchal papillae. Rhachidian cusp with 6-12 denticles on either side *(maculata maculata). A. maculata denticulata* White (1955: 186) from Rio de Oro is very slightly papillose on the dorsum and has 4-5 denticulations on either side of the median cusp of the rhachidian tooth.

3. *A. neapolitana* (Delle Chiaje, 1824). Re-established by Pruvot-Fol (1937: 59-63, P1. 1, Figs. 2, 3). Mediterranean Sea; Bay of Biscay; southern France, Arcachon. Rhachidian tooth low and broad; its cusp flanked by six denticles. Cusps of lateral teeth pectinate, due to secondary denticles which are as long as the principal prong.

4. *A. lovéni* (Bergh, 1860; 1866: 29). Odhner, 1907: 35, 90, P1. 2, Figs. 20, 21; Eliot 1910: 111, P1. 8, Figs. 8-10. From middle Norway Trondheimdistrict (Odhner, 1939: 49), to the North coast of Denmark, the West coast of Sweden, the Shetland Islands, and the British coasts. Rhachidian tooth with seven to nine denticles on either side of the cusp; of the 27 lateral teeth per half-row 10-12 have denticulated cusps.

5. *A. natalensis* (Bergh, 1866: 34). Barnard, 1927: 217. Southwest Africa, coast of Natal. Caruncle bilobed, with strong transverse folds. Rhachidian tooth uncommonly broad.

6. *A. mülleri* v. Ihering, 1886: 223. Marcus, 1960b: 170. Probably Nijssen-Meyer, 1965: 147 (called *semperi* Bgh.). Brazil, from Sta. Catharina to Cabo Frio; probably Surinam, 37 m. Two caruncles, flanking a median boss, smaller than in *bayeri*. No nuchal tubercles. Rhachidian tooth with 3-4 denticles on either side.

7. *A. capensis* (Bergh, 1907: 99). Barnard, 1927: 212; O'Donoghue, 1929b: 67. South Africa, Sebastian Bay (Odhner, 1923: 4); off East London; southern Moçambique, Inhaca. No nuchal caruncle. Eight to ten denticles on either side of the rhachidian cusp. Lateral teeth with 4-7 denticles, except those on the outer side of the row.

8. *A. gilchristi* (Bergh, 1907: 101); not White, 1955: 187. Barnard 1927: 212. South Africa, Cape Point; Agulhas Bank; Sebastian Bay and Cap Barracouta (Odhner, 1923: 5). No caruncle. Up to 41 lateral teeth per half-row, in part denticulate.

9. *A. euchroa* (Bergh, 1907: 102). Barnard, 1927: 212. South Africa, False Bay. Caruncle small, not certain. Tip of rhachidian cusp with a denticle on either side.

10. *A. microdonta* (Bergh, 1907: 103). Barnard, 1927: 213; White, 1955: 188. South Africa, off Saldanha Bay and Dassen Island. No caruncle. Cusp of rhachidian tooth flanked by 8-10 denticles. Inner and middle lateral teeth with pointed denticles.

11. *A. henneguyi* (Labbé, 1922: 51). South coast of Britanny, Le Croisic. Differs from *loveni* by black, not brick red color.

12. *A. serrata* O'Donoghue, 1929b: 70. South Africa, 66 m. Veil with papilliform projections. Most of the lateral teeth with two to five inconspicuous denticles.

13. *A. grisea* O'Donoghue, 1929b: 72. South Africa, 440 m. Caruncle small. Up to 28 radular rows. Cusp of median tooth with 9-10 denticles on each side. Lateral teeth with 6-9 long, narrow denticles.

14. *A. liouvillei* Pruvot-Fol, 1953: 63. Morocco, Fedala, 33° 45′ N, 7° 22′ W. Notum tuberculated. More than 50 gills.

15. *A. gilchristi* White, 1955: 187 (not Bergh, 1907). Cabinda, off Landana, 5° 10′ S, 12° E. Studded with small papillae which tend to be arranged longitudinally, but no lines. As *A. gilchristi* was described with folds, White's specimen cannot be this species, nor is the sculpture that of *bayeri*. White's slug is 18 mm in length, has four rows of cones on the border of the jaw, and the six inner teeth are denticulate.

16. *A. adami* White, 1955: 188. Rio de Oro. Length 14 mm; notum with 20 stripes. Gills grouped together to form a globular mass. Radula compared with Farran's figure 10 (1905: Pl. 1), hence all but the two outermost teeth are denticulate.

17. **Armina xandra,** spec. nov.

Figures 56-60

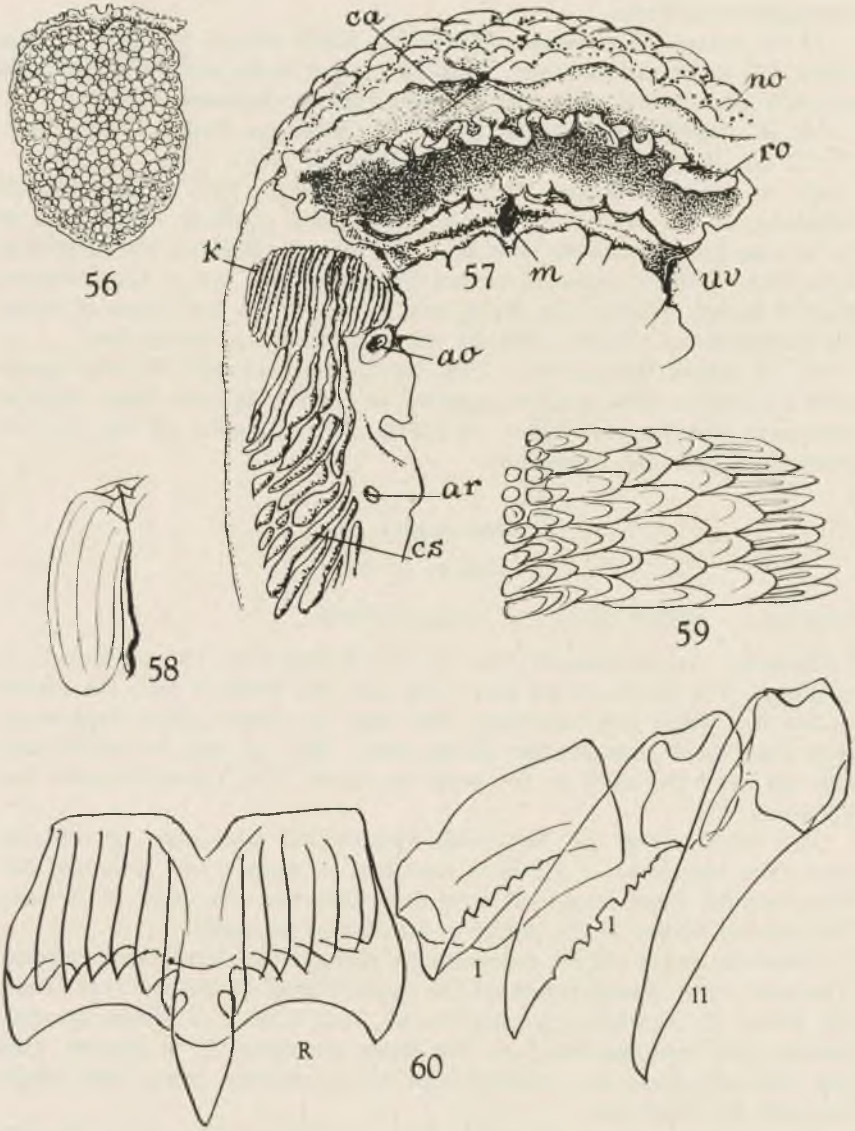
Material. — Station 68, 29 m. One specimen.

Description. — The animal (Fig. 56) is 24 mm long, 18 mm broad, 12 mm high. The length of the foot is 16 mm, the width 9 mm; the furrow of the foot gland is 4 mm long. The color is reddish grey, diaphanous, with some small pigment dots on the back. The veil and its nuchal part, the sole, and the sides of the body are black. The lateral lamellae are yellowish.

The notum (Fig. 57, *no*) bears densely set gibbosities of different sizes. The biggest are 1.5 mm in diameter. A median row is rather distinct, but the other knobs are irregularly disposed. As usual in *Armina,* the anterior border of the notum is notched in its middle.

Glandular pores are not recognizable; perhaps the glands were emptied. The gills *(k)* lie distinctly behind the upper border of the veil *(ro).* There are about 25 complete branchial leaves, four to five of which are continuous with side lamellae *(cs).* The latter are about 32 in number, they run obliquely from an anterior inner to a posterior outer level nearly reaching the hind end.

The cephalic veil *(ro),* blackish above and below, is broader than the foot. Its frilled, light border is directed upwards, and its sides are produced into pointed flaps. The surface of the veil is set off from the circum-oral area by a colorless bulge *(uv)* with a transverse furrow. The caruncle *(ca)* consists of two slight ridges which converge towards the notch of the notum. The rhinophores are withdrawn.



FIGURES 56-60.—*Armina xandra,* sp. nov.: 56, dorsal view; 57, combined frontal and ventral view of anterior end; 58, jaw; 59, masticatory pegs; 60, teeth of radula.

There is a slight notch and a groove in the anterior border of the foot, whose lateral corners are not salient. The pedal gland is marked by a pigment-free longitudinal groove. The genital aperture *(ao)* lies behind the posterior end of the gills, at some distance behind the level of the anterior pedal border. The anus *(ar)* is situated approximately in the middle of the right side.

The buccal mass is 4.5 mm long. The jaws (Fig. 58) are delicate, 3.5 mm long and 1.7 mm broad. The masticatory border bears about eight rows of unicuspidate pegs (Fig. 59). The length of the radula (Fig. 60) is 2.7 mm, its breadth 2.6 mm. The formula is $30 \times 30.1.1.1.30$. The rhachidian tooth, 0.16 mm in width, 0.13 mm in height, has a lanceolate middle cusp, and on either side eight denticles, the two innermost of which are apposed to the median cusp. The intermediate tooth is irregularly serrated; the cusp of the first lateral teeth is 135 μ long. The 25th tooth has the longest, 170 μ long cusp, those of the outermost teeth are smaller. The denticulation of the lateral teeth is irregular. In the younger rows, and forwards to the 15th the ten innermost of the lateral teeth bear up to nine denticles, the outer teeth none. In the older rows most of the lateral teeth have no denticles.

Discussion. — The three species of *Armina* with papillae or tubercles on the notum, *A. maculata, A. liouvillei,* and *A. gilchristi* White (not Bergh), were mentioned in the preceding discussion. A further species, *Diphyllidia marmorata* Kelaart (1859: 260) from Ceylon, figures in previous lists of verrucose species of *Armina.* It is only known by a rather vague diagnosis, and possibly corresponds (Eliot, 1906a: 677) to *Linguella cinerea* Farran (1905: 334).

In *A. maculata* the notum bears scarce tubercles (Bergh, 1866: Pl. 7, Fig. 1; Vayssière, 1913: Pl. 26, Fig. 6; Pruvot-Fol, 1954: Fig. 135 *e*). The lateral teeth are smooth (Bergh, 1866: 57) or sometimes irregular traces of two quite small denticles occur under the cusps of the two innermost lateral teeth (Pruvot-Fol, 1937: 64). *A. liouvillei* has more than 50 gills, pointed tubercles on the notum, and smooth lateral teeth with exception of traces of denticulation on the 2-3 innermost ones. White's *gilchristi* has small papillae, not gibbosities, up to 1.5 mm in diameter; the papillae tend to be arranged longitudinally. The process of the jaw bears four rows of cones. The median tooth has 3-4 strong denticles on either side and one small one on each side of the cusp.

18 **Armina joia,** spec. nov.

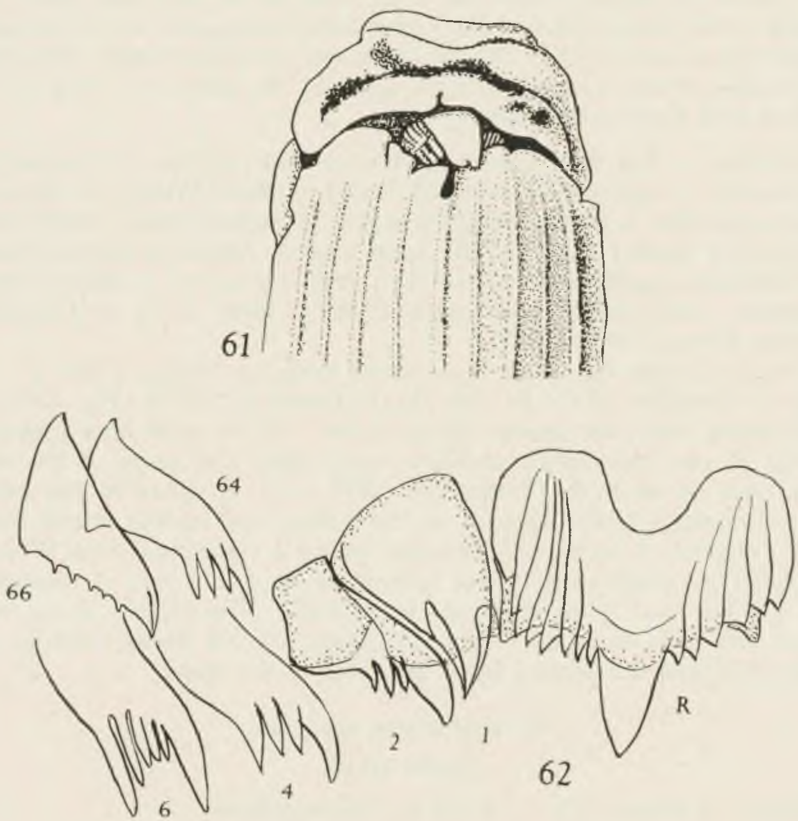
Figures 61-62

Material. — Station 254, 174-148 m. One specimen.

Description. — The preserved slug is 20 mm long, without the extruded buccal mass, 6 mm broad, and 4 mm high. The notum is somewhat bent downward and the sole upward; the latter is 19 mm in length and 7 mm in width.

The color of the living specimen, described by Prof. Bayer, is of a neutral flesh tint with lines of white pigment granules converging anteriorly. A black transverse stripe fading to grey marginally lies in a furrow of the cephalic veil. The sole is sprinkled with white granules, most densely at the anterior tip, where there is a narrow double marginal stripe of black flecks and a scattering of melanophores. In the preserved slug the black elements of the sole and the frontal veil are recognizable. The posterior pedal gland is white. The slight notal ridges are noticeable as light lines, but with carmine they stain darker than the ground.

The notum reaches the frontal veil but is not coalesced with it (Fig. 61). The anterior border of the notum is continuous around a deep median



FIGURES 61-62.—*Armina joia*, sp. nov.: 61, dorsal view of anterior end; 62, tooth of radula.

notch. Of the nine notal ridges visible in front two run out before they reach the hind end. A great number of ventral pores, Bergh's cnidosac pores, lie in the notal border. Further cutaneous glands occur on the sides of the notum and also nearer to the middle, even between the second and third ridges. The branchiae form antero-lateral elliptical fields with 25 or more lamellae of different sizes with scarce melanophores. From two or three gills start delicate lateral lamellae of irregular height that do not contain ramifications of the intestinal gland. In front the lateral lamellae are parallel to the notal border, behind they are more numerous and form an angle with it.

The frontal veil (Fig. 61) is smooth, trapezoid-shaped, and furrowed transversely in the middle; its postero-lateral corners are directed backwards. In front of the rhinophores a strong caruncle is situated which bends towards the rear separating the rhinophorial pockets. As far as the withdrawn rhinophores could be examined without damaging the specimen, their clubs bear about ten thick leaves.

The anal opening lies behind the middle on the right side, the genital aperture farther in front, under the right branchial field. The cylindrical, pointed penis projects from the genital opening which is surrounded by an annular fold. The renal pore is located between the anus and the genital pore, nearer to the latter.

The anterior border of the foot is furrowed and notched in the middle. The pedal gland is 2.5 mm long.

The extruded pharyngeal bulb is about 5 mm long, 3.5 mm broad, and 2 mm high. The jaws are yellow; their masticatory process bears ten or more rows of slender denticles. The radula (Fig. 62) consists of 55 rows with 66 teeth on either side of the rhachidian tooth. The latter is 0.1 mm in width. Its median cusp is flanked by 5-8 denticles. The cusp of the innermost lateral tooth is connected with the basal plate by a narrow support. The second lateral tooth has 2-3 outer denticles. In the following teeth 3-4 denticles occur, the outermost of which is nearly the size of the principal cusp. These denticles are directed forward like in a fork, not as in other species arranged like the teeth of a saw, one behind the other along the edge. Only the 2-3 outermost teeth have their denticles disposed in the common way. Frequently the penult is longer and narrower and has about five denticles. The last tooth is thin and broad, and its denticles are only suggested.

Discussion. — The denticulation of the lateral teeth in *A. joia* is a quite peculiar character which obviates a detailed comparison with the other species of the genus, except for the South African *A. microdonta* in White's figure (1955: Fig. 19). In that species, whose "caruncle could not be detected" (Bergh, 1907: 103), 50 (Bergh) or 34 (White) laterals occur on each side of the median tooth. The outermost denticle of the inner teeth is smallest, and the 10-15 (Bergh) or 14 (White) outer teeth have no denticles. In *A. microdonta* the ground color of the back "seemed to have been black" (Bergh).

A. rosea (Bergh, 1905: 213) from the coast of Halmahera is a small, pink species with faint, though densely set lines on the back. Its caruncle is short, conical; the jaws bear 3-4 rows of denticles, the half-rows of the radula have up to 20 teeth, whose shape differs from those of *joia*.

19. *Spurilla neapolitana* (Delle Chiaje, 1823)

References. — Pruvot-Fol, 1954: 433; Marcus, 1966 (in press).

Material. — Station 258, (Fernando Po). One specimen.

Further distribution. — Mediterranean Sea, from the southern coast of Turkey (Swennen, 1961: 71), the Adriatic Sea, and the western parts; Atlantic coasts of France, Morocco, and Sénégal; Canary and Cape Verde Islands; Sargasso Sea; Florida; Gulf of Mexico; Jamaica (Edmunds, 1964: 28); Brazil, southwards to São Paulo.

Descriptive notes. — The present specimen is 22 mm in length; the tail is blunt, possibly bitten off some time ago. The foot corners are produced. The cerata are flattened, the intestinal diverticula knobby. The cnidosacs are very small. The first right arch of about 16 cerata surrounds the genital aperture, the second arch of 20 cerata lies over the anus. There are 31 radular teeth, 0.5-0.63 mm in width, 0.37-0.4 mm in height. The short median denticle is flanked by 50-70 denticles on either side.

Remarks. — Pruvot-Fol's *Sp. mograbina* and *Sp. dakariensis* (1953: 55) are evidently synonyms of *Sp. neapolitana*. The bulbous bases of the cerata of *mograbina* are not constant, as Pruvot-Fol's two figures show. The mandible of *dakariensis* is said to be shorter and broader than that of *neapolitana*. But its breadth is 65 per cent of the length, and in *neapolitana* 63-66.7 per cent occur.

White (1955: 189) reported from Rio de Oro *"Eolidina glauca* (Alder and Hancock, 1855)," in fact, 1845. As she described the rhinophores as lamellate, it cannot be an *Eolidina*, better *Aeolidiella* (Odhner, 1939: 83). The smooth, only sometimes wrinkled or furrowed rhinophores (Eliot, 1910: 174) distinguish *Aeolidiella* from *Spurilla* (O'Donoghue and White, 1940: 94, 96; Pruvot-Fol, 1953: P1. 2, Figs. 22, 27). White's species, "orange dorsal, with green gills," is probably *Sp. neapolitana*. White's identification was based upon Vayssière's *A. glauca* (1888: 108), whose rhinophores have a spiral furrow (P1. 1, Figs. 8, 8a), but are not "perfoliés avec lamelles," as those of *Sp. neapolitana* (ibid., p. 111-113). The original figures of *A. glauca* (Alder and Hancock, 1848: Fam. 3, P1. 11) show smooth rhinophores. As Bergh mentioned (1886: 26), *Sp. neapolitana* and *A. glauca* have been confused in a zoological station of high standard.

Sp. neapolitana feeds upon sea-anemones. Dr. Jean Tardy, Poitiers

(France), kindly informed us that a single animal usually does not attack the actinian *Anthopleura ballii* (Cocks), but that when in a group, the slugs devour it without hesitation.

Zoogeographic Remarks

The following comments are restricted to the present collection, though the species also represented in White's material (1955) are considered too. But the totality of her material was not included here: it came from Rio de Oro to Sierra Leone and from Cape Lopez southward. In White's collection the South African elements are much more numerous than in the present one. This disagreement shows, that both collections contain only fortuitous samples of the West African opisthobranch fauna.

The 11 new species and subspecies in our material amount to 61 per cent of the total number. The *Hypselodoris* not classified specifically is left aside. The high number of new forms proves that the West African opisthobranchs are little known; when we began to study this group in the littoral of southern Middle Brazil, the percentage of novelties was even higher. In seven of the new forms, affinities with previously described ones were recognizable, so that they could be allotted to one of the following groups.

Doriopsilla areolata and *Spurilla neapolitana* are transatlantic warm-water species. Due to their relations with transatlantic or West Atlantic species, three of our new forms can be added: *Gastropteron rubrum manx* continues the range of the transatlantic *G. rubrum rubrum* southward, *Aglaja pelsunca* is allied to the Floridian *A. pusa,* and *Pleurobranchaea gela* is close to the West Atlantic *P. hedgpethi hamva.* Therewith we obtain 27.8 per cent transatlantic elements in the present collection.

Species of the warm temperate, or warm temperate and warm East Atlantic, are *Bulla mabillei* and *Fimbria fimbria.* The new *Discodoris golaia* can be united with them geographically, because its most approximate relative is the Mediterranean *D. maculosa.* Hence 16.7 per cent of the present collection are East Atlantic warm-water species.

Only allusions to the Cape fauna exist in our material. The shell of *Bulla mabillei* is more similar to that of *B. ampulla,* whose range extends from South Africa eastwards, than to that of the transatlantic *B. striata.* But as the radula and the male organ of *B. mabillei* are not known, the degree of conchological similarity has very little weight. A second species to be mentioned in this connection is our *Armina joia.* Its peculiar radula is comparable with White's material of *A. microdonta* from Dassen Island, north of Cape Town.

An East Atlantic species occurring from boreal waters to tropical West Africa is *Philine scabra.* The range of *Ph. aperta* extends still farther to the south and widely into the Indian Ocean. Only now geographic subspecies of *Ph. aperta* begin to be recognized, e. g. the present *guineensis* and probably *vaillanti* in the Red Sea.

Scaphander mundus is an abyssal species whose distribution is possibly due to the Tethys; its conchological relationships include the West Atlantic.

Of the remaining species *Marionia vanira* approximates *M. cabindae*, another West African species found 10° farther south. *Elysia slimora* is geographically isolated, because the other papillose species of the genus are West Atlantic and West Pacific. *Aplysia dactylomela* has a worldwide range in warm seas. No special geographical affinities are evident in *Aglaja taila*, *Armina bayeri*, and *A. xandra*.

Zusammenfassung

Zwischen Monrovia und Lagos und südwärts bis zum Kap Lopez hat Prof. Dr. Bayer mit dem Forschungsschiff "John Elliott Pillsbury" 19 Opisthobranchierarten, hauptsächlich aus dem Sublitoral gesammelt. Von diesen konnten 18 bis zur Art bestimmt werden. Neue Arten und Unterarten sind: *Philine aperta guineensis, Gastropteron rubrum manx, Aglaja taila, A. pelsunca, Elysia slimora, Pleurobranchaea gela, Discodoris golaia, Marionia vanira, Armina bayeri, A. xandra* und *A. joia*. Bei 44.5% der Sammlung sind Beziehungen zur atlantischen Warmwasserfauna oder zur gemässigt warmen (einschliesslich des Mittelmeers) erkennbar. Bei 27.8% dieser Formen handelt es sich entweder um solche, die im West- und Ostatlantik vorkommen, oder um ostatlantische, die morphologische Beziehungen zu westatlantischen Faunenelementen haben. Mit der Kapfauna hat die hier vorliegende Sammlung nur sehr geringe Beziehungen.

Die Grundlagen Für die Systematik der Gattung *Aglaja* und der Unterfamilie Armininae werden erörtert; alle Arten von *Aglaja* und die atlantischen von *Armina* sind aufgeführt.

Resumo

Entre Monrovia e Lagos e, mais para o Sul, até ao Cabo Lopez, Prof. Dr. Bayer colecionou, no navio de pesquisas "John Elliott Pillsbury" 19 espécies de opistobrânquios, provindos, principalmente, do sublitoral. Destas, 18 puderam ser classificadas especìficamente. Novas espécies e subespécies são: *Philine aperta guineensis, Gastropteron rubrum manx, Aglaja taila, A. pelsunca, Elysia slimora, Pleurobranchaea gela, Discodoris golaia, Marionia vanira, Armina bayeri, A. xandra,* e *A. joia*. Em 44.5% da coleção reconhecem-se relações com a fauna da água quente ou temperada quente (o mar Mediterrâneo incluido). Destas formas, 27.8% ou ocorrem nas partes ocidental e oriental do Atlântico ou, sendo atlântico-orientais, possuem afinidades morfológicas com atlântico-ocidentais. Há muito poucas relações com a fauna do Cabo da Boa Esperança na coleção presente.

Discutem-se os fundamentos da classificação de *Aglaja* e das Armininae. Todas as espécies de *Aglaja* e as atlânticas de *Armina* são relatadas.

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 10 —

REPORT ON THE ECHINOIDEA COLLECTED BY R/V PILLSBURY IN THE GULF OF GUINEA[1]

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ABSTRACT

Twenty species of echinoids were collected by the R/V PILLSBURY in the Gulf of Guinea. Four of these species are reported for the first time from the Gulf of Guinea area. Similarities in the echinoid fauna of the West Indian and Gulf of Guinea areas are discussed in relation to the possible role of the equatorial undercurrent as a route for transoceanic migration of echinoid larvae.

The echinoids collected by the R/V PILLSBURY in the Gulf of Guinea during biological cruises following participation in the Equalant III and IV expeditions illustrate the close similarity between the faunas of the West Indies and the Gulf of Guinea. This relationship recorded by Greeff (1881) and summarized by Mortensen (1951a) and Mayr (1954) is even more interesting when reviewed and correlated with recent investigations on the equatorial current systems (Metcalf et. al. 1962; Rinkel, et. al., 1966).

The echinoid species common to the Gulf of Guinea and the West Indies show little geographic variation (Koehler, 1914; Mortensen, 1928 - 1943). The transatlantic populations are more closely related to each other than to populations occurring at St. Helena or the Ascensions. In addition, populations of geminate species on either side of the Isthmus of Panama show greater differentiation than closely related species from the Gulf of Guinea and the West Indies. Thus, it is evident that a certain amount of gene-flow exists (or has existed in recent times) between the transatlantic populations. The direction of gene-flow, west to east or vice versa, seems to differ for different species. *Paracentrotus gaimardi,* for example, seems to have come to the Brazilian coasts from the Mediterranean area while *Eucidaris tribuloides, Arbacia lixula, Lytechinus variegatus, Echinometra lucunter,* and possibly *Tripneustes ventricosus* seem to have originated in the West Indian area. The origins of *Diadema antillarum, Lytechinus callipeplus,* and *Plesiodiadema antillarum,* which also occur in the Gulf of Guinea and the West Indies, are not indicated by available evidence. In general, the gene-flow appears to be from west to east. Most of the species common to the two areas are distributed more widely and

[1]Contribution No. 738 from the Institute of Marine Science, University of Miami.

more luxuriantly on the American coasts. In addition, fossil evidence tends to indicate that the West Indian area was the center of distribution for species of *Echinometra, Eucidaris,* and *Arbacia* (Mortensen, 1928 - 1943).

Zoogeographers have postulated that a transatlantic gene-flow between urchin populations could only occur if the pelagic echinoid larvae could endure the prolonged northern route from the western to the eastern Atlantic, a journey lasting over a year and taking the larvae through vast changes in ecological parameters (Scheltema, 1965). With the exception of *Diadema antillarum* and, perhaps, *Eucidaris tribuloides,* the species common to the West Indies and the Gulf of Guinea are not found north of the Cape Verde Islands. It would seem, therefore, that if the echinoid larvae of the majority of the species common to both areas were to survive the crossing via the North Atlantic Drift, they must by-pass the Azores and Canaries and remain in the plankton until they reach the Cape Verde shores.

The distribution of these echinoid species is more understandable if the rapidly flowing equatorial undercurrent is considered as a possible route for the pelagic larvae. This current, extending from the shallow coastal waters of Brazil to the Island of São Thomé off the African coast, is rapid enough that the journey would be a matter of two or three months rather than over a year. In addition, the current is so constructed as to maintain an ideal ocean transport system characterized by a high oxygen content, high primary productivity, and unchanging physical parameters (Jones, in press).

The precise origin and velocity of the equatorial undercurrent is unknown. Measurements of the velocity, taken at the core of the well defined current, vary from 2.9 knots (Metcalf et. al., 1962) to 1.8 knots (Rinkel et. al., 1966). The core of the current is situated at a depth of about 75 meters. An eastward flow is found as shallow as 15 meters and, during calm weather, even at the surface. The velocity varies considerably from time to time and from place to place, and it is impossible, with exisitng measurements, to determine the exact time that would be required for a larva to drift from Brazil to the Gulf of Guinea. If the current is flowing at 2.9 knots, the 3000 mile journey would only take 43 days! If the current averages 1.8 knots, 70 days would be required. Certainly, a tropical larva stands a better chance of survival in the unchanging environment of the equatorial undercurrent for 70 days than does a larva in the North Atlantic Drift for over a year.

It seems probable, therefore, that the equatorial undercurrent provides a route for direct gene-flow accross the Atlantic Ocean for such species as *Echinometra lucunter, Diadema antillarum, Tripneustes ventricosus, Lytechinus variegatus, Lytechinus callipeplus, Eucidaris tribuloides,* and *Plesiodiadema antillarum,* which occur in the littoral and sub-littoral area in both the West Indies and the Gulf of Guinea. In addition, larvae of

Paracentrotus gaimardi may also travel with this current; that species occurs from Rio de Janeiro to Desterro on the Brazilian coast, and from Eloby Island in the Gulf of Guinea to Angola on the African coast.

Several genera have closely allied species on both sides of the tropical Atlantic. In many cases, it seems that the African species were erected mainly on the basis of their supposed geographic isolation from the West Indian species. Lack of either African or American specimens has prevented settling the question of whether the species are really distinct as, for example, is the case with *Echinolampas depressus* (West Indies) and *Echinolampus blanchardi* (Gulf of Guinea). When material is available, the differences between the "species" are found to be slight and often within the range of variation of a single population. *Meoma cadenati* (Gulf of Guinea) differs from the West Indian *Meoma ventricosa* mainly in the retention of a complete subanal fasciole throughout life. I have, however, an adult (135 mm test length) *Meoma ventricosa* from the Bahamas with a complete subanal fasciole. *Brissopsis jarlii* (Gulf of Guinea) and *Brissopsis elongata* (West Indies) differ mainly in the position of the thorns of the globiferous pedicellaria. In about 50 per cent of the valves of *Brissopsis jarlii,* however, the thorns are lacking entirely. *Plagiobrissus africanus* (Gulf of Guinea) differs from *Plagiobrissus grandis* (West Indies) in having the posterior end of the test more vertically truncate, a character which shows considerable variation in the West Indian species. Other closely related pairs of species in the West Indies and the Gulf of Guinea are: *Schizaster edwardsi* (Gulf of Guinea) and *Schizaster orbignyanus* (West Indies), *Centrostephanus longispinus* (Gulf of Guinea), and *Centrostephanus rubricingulus* (West Indies), and *Clypeaster rangianus* (Gulf of Guinea) and *Clypeaster prostratus* (West Indies).

Some species occurring in the Gulf of Guinea and the West Indies have such a wide distribution in the Atlantic that their occurrence in the areas in question does not necessarily indicate a close zoogeographic relationship. Such species are *Genocidaris maculata, Brissus unicolor, Hemiaster expergitus, Brissopsis atlantica, Phormosoma placenta, Arbacia lixula,* and *Echinocyamus pusillus*. Still other species, such as *Echinus stenoporus* and *Brissopsis lyrifera capensis,* are endemic to the West African area, their affinities with other, related species offering little to the understanding of the faunal relationship of the West Indies and the Gulf of Guinea.

The PILLSBURY collection contains the following species:

Eucidaris tribuloides africana Mortensen, 1909
Phormosoma placenta Wyv. Thomson, 1872
Sperosoma grimaldii Koehler, 1897
Plesiodiadema antillarum (A. Agassiz, 1880)
Centrostephanus longispinus (Philippi, 1845)
Diadema antillarum Philippi, 1845

Arbacia lixula africana Mortensen, 1935.
Echinometra lucunter (Linnaeus, 1758)
Echinus acutus Lamarck, 1816
Echinus stenoporus Mortensen, 1942
Lytechinus callipeplus Clark, 1912
Tripneustes ventricosus (Lamarck, 1816)
Genocidaris maculata A. Agassiz, 1869
Genocidaris maculata splendens Mortensen, 1943.
Hemiaster expergitus Loven, 1874
Spatangus sp.
Brissopsis lyrifera capensis Mortensen, 1951
Brissopsis jarlii Mortensen, 1951
Brissopsis atlantica mediterranea Mortensen, 1913
Schizaster edwardsi Cotteau, 1889

Echinoids collected at each station:

STATION	
P-4	*Plesiodiadema antillarum, Hemiaster expergitus.*
P-15	*Schizaster edwardsi.*
P-16	*Centrostephanus longispinus.*
P-17	*Brissopsis jarlii.*
P-22	*Eucidaris tribuloides, Centrostephanus longispinus.*
P-23	*Centrostephanus longispinus.*
P-24	*Eucidaris tribuloides, Centrostephanus longispinus, Brissopsis jarlii.*
P-26	*Eucidaris tribuloides, Spatangus sp., Schizaster edwardsi.*
P-28	*Centrostephanus longispinus.*
P-30	*Eucidaris tribuloides.*
P-32	*Centrostephanus longispinus.*
P-34	*Phormosoma placenta, Sperosoma grimaldii, Brissopsis atlantica.*
P-41	*Phormosoma placenta.*
P-45	*Centrostephanus longispinus.*
P-46	*Centrostephanus longispinus.*
P-47	*Centrostephanus longispinus, Genocidaris maculata.*
P-48	*Schizaster edwardsi.*
P-52	*Phormosoma placenta.*
P-53	*Sperosoma grimaldii, Echinus stenoporus, Brissopsis atlantica.*
P-62	*Centrostephanus longispinus, Schizaster edwardsi.*
P-64	*Centrostephanus longispinus.*
P-65	*Centrostephanus longispinus, Genocidaris maculata.*
P-68	*Centrostephanus longispinus.*
P-74	*Phormosoma placenta.*
P-76	*Phormosoma placenta, Sperosoma grimaldii, Brissopsis atlantica.*
P-82	*Echinus acutus.*
P-232	*Centrostephanus longispinus.*
P-233	*Phormosoma placenta.*

P-237 *Centrostephanus longispinus.*
P-239 *Centrostephanus longispinus, Genocidaris maculata.*
P-240 *Schizaster edwardsi.*
P-241 *Centrostephanus longispinus, Schizaster edwardsi.*
P-245 *Centrostephanus longispinus.*
P-248 *Centrostephanus longispinus, Genocidaris maculata.*
P-250 *Schizaster edwardsi.*
P-251 *Schizaster edwardsi.*
P-256 *Phormosoma placenta, Brissopsis lyrifera capensis.*
P-258 *Arbacia lixula africana, Echinometra lucunter.*
P-259 *Centrostephanus longispinus, Brissopsis jarlii, Brissopsis atlantica.*
P-260 *Centrostephanus longispinus, Genocidaris maculata, Brissopsis atlantica.*
P-271 *Echinometra lucunter.*
P-273 *Eucidaris tribuloides, Echinometra lucunter, Tripneustes ventricosus.*
P-275 *Eucidaris tribuloides, Diadema antillarum, Centrostephanus longispinus.*
P-282 *Eucidaris tribuloides, Diadema antillarum.*
P-283 *Eucidaris tribuloides, Lytechinus callipeplus.*
P-309 *Phormosoma placenta, Sperosoma grimaldii, Plesiodiadema antillarum, Brissopsis atlantica.*

This collection does not, of course, represent all of the known echinoid fauna of the Gulf of Guinea area. Particularly disappointing is the lack of any specimens of *Meoma cadenati* Madsen, 1957, *Plagiobrissus africanus* (Verrill, 1871) and *Lytechinus variegatus* (Lamarck, 1816). Other noteworthy echinoids not collected by the PILLSBURY are: *Cidaris cidaris meridionalis* Mortensen, 1928; *Cidaris nuda* (Mortensen, 1903); *Arbaciella elegans* Mortensen, 1910; *Clypeaster rangianus* (Desmoulins, 1835); *Plagiobrissus jullieni* Cotteau, 1889; *Rotula deciesdigitata* Leske, 1778; *Rotula orbiculus* (Linne, 1758); *Echinocyamus pusillus* (Müller, 1776), *Echinolampas rangii* Desmoulins, 1837; *Paracentrotus gaimardi* (Blainville, 1825); and *Brissopsis caparti* Cherbonnier, 1959.

The following echinoids are new to the Gulf of Guinea area: *Sperosoma grimaldii* Koehler, 1897; *Plesiodiadema antillarum* (A. Agassiz, 1880); *Echinus stenoporus* Mortensen, 1942; and *Brissopsis lyrifera capensis* Mortensen, 1951.

I would like to express thanks to Dr. James I. Jones and Mrs. Michelle Davis for furnishing me with plankton from the equatorial undercurrent and for their assistance in obtaining information on the characteristics of that undercurrent. The manuscript was critically reviewed by Dr. Fredrick M. Bayer, to whom the author expresses his gratitude. This research was supported in part by the National Science Foundation, grant No. GB 2037, and in part by the National Geographic Society.

Eucidaris tribuloides (Lamarck) *africana* Mortensen, 1909

Eucidaris tribuloides var. *africana* Mortensen, 1909, p. 40, pl. 6, fig. 1, 3, 10, 13; pl. 10, fig. 1, 4; pl. 13, fig. 17; pl. 14, fig. 11, 12, 13, 19; pl. 15, fig. 1, 15, 18, 19; pl. 16, fig. 19.
Eucidaris tribuloides var. *africana.* Mortensen, 1928, p. 406.
Eucidaris tribuloides var. *africana.* Mortensen, 1951a, p. 295.
Eucidaris tribuloides var. *africana.* Cherbonnier, 1959, p. 41, pl. 2, fig. F-O; pl. 3, fig. A-F.

Material Examined. —
Sta. P - 22. Off Ghana, 5°25'N., 0°01'W., 28 fm: 9 specimens.
Sta. P - 24. Off Ghana, 4°56'N., 0°50'W., 20 fm: 23 specimens.
Sta. P - 26. Off Ghana, 4°57'N., 1°16'W., 15 fm: 1 specimen.
Sta. P - 30. Off Ghana, 4°46'N., 2°30'W., 33 fm: 1 specimen.
Sta. P-273. Off Annobón, N.E. Pta. YoYo. Littoral: 1 specimen.
Sta. P-275. Off Annobón, 1°24'S., 5°37' E., 6 to 40 fm: 18 specimens.
Sta. P-282. Off Annobón, 1°28.1'S., 5°36.2'E., 10 to 20 fm: 6 specimens.
Sta. P-283. Off Annobón, 1°28.6'S., 5°35'E., 28 fm: 10 specimens.
Smallest specimen: 2.9mm H.D. Sta. P-283; largest specimen: 42mm H.D. Sta. P-22.

Distribution. — From Cape Verde to the French Congo, including São Thomé and Annobón. *Eucidaris tribuloides* s.s. is distributed from North Carolina to Rio de Janeiro, Brazil, including all of the West Indian area.

Phormosoma placenta Wyv. Thomson, 1872

Phormosoma placenta Wyv. Thomson, 1872, p. 494, pl. 62-63.
Phormosoma placenta Mortensen, 1935, p. 125, pl. 1, fig. 1-5; pl. 2, fig. 1-6, 19.
Phormosoma placenta. Mortensen, 1951a, p. 295.

Material Examined. —
Sta. P-34. Off the Ivory Coast, 3°53'N., 2°33'W., 1080 fm: 6 specimens.
Sta. P-41. Off the Ivory Coast, 4°47'N., 3°33'W., 460 fm: 6 specimens.
Sta. P-52. Off the Ivory Coast, 4°54'N., 4°58'W., 500 fm: 2 specimens.
Sta. P-74. Off Liberia, 4°20'N., 9°26'W., 400 fm: 1 specimen.
Sta. P-76. Off Liberia, 4°32'N., 9°42'W., 800 fm: 9 specimens.
Sta. P-233. Off Nigeria, 5°19'N., 4°14'E., 1100 fm: 1 specimen.
Sta. P-256. Off Cameroon, 3°44.7'N., 8°01'E., 250 fm: 1 specimen.
Sta. P-309. Off Nigeria, 4°15'N., 4°27'E., 720 fm: 8 specimens.
Smallest specimen: 28 mm H.D. Sta. 76; largest specimen: 105 mm H.D. Sta. 52.

Distribution. — All over the North Atlantic from Iceland and Davis Strait to the West Indies and the Azores, the Gulf of Guinea, south to Cameroon.

Sperosoma grimaldii Koehler, 1897

Sperosma grimaldii Koehler, 1897, p. 302.
Sperosoma grimaldii. Mortensen, 1935, p. 184, pl. 8, figs. 1-2; text fig. 107, 108.

Material Examined. —
Sta. P-34. Off the Ivory Coast, 3°53'N., 2°33'W., 1080 fm: 1 specimen.
Sta. P-53. Off the Ivory Coast, 4°50'N., 4°55'W., 850 fm: 4 specimens.
Sta. P-76. Off Liberia, 4°32'N., 9°42'W., 800 fm: 1 specimen.
Sta. P-309. Off Nigeria, 4°15'N., 4°27'E., 720 fm: 1 specimen.
Smallest specimen: 32 mm H.D. Sta. P-53; largest specimen: 143 mm H.D., fragmentary. Sta. P-76.

Distribution. — The discovery of the specimens at Sta. P-309, off Nigeria, extends the known range of this species well into the Gulf of Guinea. Previously, it had been collected from south of Iceland to the Azores and Cape Verde in depths of 300 to 2300 meters.

Plesiodiadema antillarum (A. Agassiz, 1880)

Aspidodiadema antillarum A. Agassiz, 1880. p. 73.
Plesiodiadema antillarum. Mortensen, 1940. p. 27, text figs, 2a; 11a; 4c; 15.

Material Examined. —
Sta. P-4. Off Lagos, Nigeria, 5°57'N., 3°19'E., 700 fm: 2 specimens.
Sta. P-309. Off Nigeria, 4°15'N., 4°27'E., 720 fm: 3 specimens.
Smallest specimen: 7 mm H.D. Sta. P-309; largest specimen: 9 mm H.D. Sta. P-4.

Distribution. — Previously unrecorded from the Gulf of Guinea; it was known to occur near the Canaries and St. Helena.

Plesiodiadema antillarum is widely distributed in the tropical Atlantic from the Caribbean to Brazil and from the Canaries to St. Helena, including the Gulf of Guinea, in depths of 375 to 1500 fathoms.

Diadema antillarum Philippi, 1845

Cidaris (*Diadema*) *antillarum* Philippi, 1845. p. 355.
Diadema antillarum. Koehler, 1914, p. 218. pls. 11, figs. 12, 13, 15; pl. 15, figs. 64-72.
Diadema antillarum. Mortensen, 1940, p. 269, pls. 47, fig. 8; pl. 49, fig. 5; pl. 57, figs. 1-8; pl. 58, figs. 1-6; pl. 73, fig. 21; pl. 74, figs. 4-8.

Material Examined. —
Sta. P-275. Off Annobón, 1°24'S., 5°37'E., 5 to 40 fm: 16 specimens.
Sta. P-282. Off Annobón, 1°28.1'S., 5°36.2'E., 10-20 fm: 21 specimens.
Smallest specimen: 3.3 mm H.D. Sta. P-282; largest specimen: 31.5 mm H.D. Sta. P-282.

Comments. — The 22.4 mm H.D. specimen from station 275 has two parasitic molluscs (*Pelseneeria* sp.) on its oral side.

Distribution. — In the western Atlantic, from Bermuda to Surinam, including all of the West Indies. In the eastern Atlantic, from Maderia, the Azores, and the Canaries to Cape Verde and the Gulf of Guinea. Littoral to 200 fathoms.

Centrostephanus longispinus (Philippi, 1845)

Diadema longispina Philippi, 1845, p. 354.

Centrostephanus longispinus. Mortensen, 1940, p. 300, pl. 34; figs. 1-11; pl. 35, figs. 11-12; pl. 75, figs. 5-24.
Centrostephanus longispinus. Mortensen, 1951a, p. 296.
Centrostephanus longispinus. Cherbonnier, 1959, p. 44, pl. 4, fig. B-L; pl. 5, fig. A-B.

Material Examined. —
Sta. P-16. Off Ghana, 5°40'N., 0°17'E., 25fm: 2 specimens.
Sta. P-22. Off Ghana, 5°25'N., 0°01'W., 28fm: 2 specimens.
Sta. P-23. Off Ghana, 5°10'N., 0°25'W., 23fm: 2 specimens.
Sta. P-24. Off Ghana, 4°56'N., 0°48'W., 20fm: 34 specimens.
Sta. P-28. Off Ghana, 4°40'N., 2°00'W., 29fm: 6 specimens.
Sta. P-32. Off Ghana, 4°37'N., 2°32'W., 60fm: 2 specimens.
Sta. P-45. Off the Ivory Coast, 5°06'N., 4°06'W., 53fm: 1 specimen.
Sta. P-46. Off the Ivory Coast, 5°07'N., 4°36'W., 23fm: 9 specimens.
Sta. P-47. Off the Ivory Coast, 5°05'N., 4°52'W., 20fm: 1 specimen.
Sta. P-62. Off the Ivory Coast, 4°45'N., 6°14'W., 25fm: 2 specimens.
Sta. P-64. Off the Ivory Coast, 4°23'N., 7°05'W., 37 fm: 1 specimen.
Sta. P-65. Off the Ivory Coast, 4°15'N., 7°32'W., 42fm: 1 specimen.
Sta. P-68. Off Liberia, 4°29'N., 8°06'W., 38fm: 2 specimens.
Sta. P-232. Off Nigeria, 5°56'N., 4°27'E., 55-72fm: 1 specimen.
Sta. P-237. Off Nigeria, 5°19'N., 4°48'E., 55fm: 2 specimens.
Sta. P-239. Off Nigeria, 4°56'N., 5°00'E., 40fm: 22 specimens.
Sta. P-241. Off Niger River, 4°35'N., 5°18'E., 32fm: 7 specimens.
Sta. P-245. Off Niger River, 4°32'N., 5°18'E., 32 fm: 4 specimens.
Sta. P-248. Off Niger River, 4°03'N., 5°41'E., 18fm: 1 specimen.
Sta. P-259. Off Fernando Póo, 3°53'N., 8°55'E., 33fm: 68 specimens.
Sta. P-260. Off Cameroon, 3°45'N., 9°05'E., 25fm: 21 specimens.
Sta. P-275. Off Annobón, 1°24'S., 5°37'E., 5-40fm: 3 specimens.

Smallest specimen: 5.8 mm H.D. Sta. P-259; largest specimen: Sta. P-232, 38 mm H. D.

Distribution. — Western Mediterranean; Cape Verde to Angola. 18 to 104 fathoms.

Arbacia lixula (Linnaeus) *africana* Mortensen, 1935

Echinus lixula Linnaeus, 1758. p. 664.
Arbacia lixula var. *africana*. Mortensen, 1935, p. 570.
Arbacia lixula var. *africana*. Mortensen, 1951a, p. 296.
Arbacia lixula var. *africana*. Cherbonnier, 1959, p. 43, pl. 3, fig. G-P; pl. 4, fig. A.

Material Examined. —
Sta. P-258. Fernando Póo. Westernmost of the Islotes de Enrique. Littoral. 17 specimens.
Smallest specimen: 5.5 mm H.D.; largest specimen: 24.2 mm H.D.

Distribution — These specimens represent a slight northward extension of the range of this species, known previously from the Congo and Angola areas to Annobón and São Thomé. *Arbacia lixula* is common in the Mediterranean and along the Atlantic coast of Africa to Cape Verde and Guinea, including the Canaries, Madeira, and the Azores. In the western Atlantic, it is found along the coasts of Brazil.

Echinometra lucunter (Linnaeus, 1758)

Echinus lucunter Linnaeus, 1758, p. 665.
Echinometra lucunter. Mortensen, 1943b, p. 357, pl. 41, fig. 1-5; pl. 42, figs. 12-14; pl. 43, figs. 1-13; pl. 44, fig. 9; pl. 14, figs. 17, 20-24.

Material Examined. —
Sta. P-258. Fernando Póo. Westernmost of Islotes de Enrique, littoral. 2 specimens.
Sta. P-271. Annobón. Pta. YoYo and Pta. Pedrinha, littoral: 24 specimens.
Sta. P-273. Annobón. Islet a La Piramide, littoral: 5 specimens.
Smallest specimen: 10.5 mm H.D. Sta. P-271; largest specimen: 59 mm H.D. Sta. P-271.

Distribution. — From the Bermudas and Florida to Rio de Janeiro, Brazil, including all of the West Indian area. In the eastern Atlantic, it occurs from Dakar to Angola, and at Ascension and St. Helena. Littoral to 20 fathoms.

Echinus acutus Lamarck, 1816

Echinus acutus Lamarck, 1816, p. 45.
Echinus acutus. Mortensen, 1943b, p. 41, pl. 3, fig. 3; pl. 5, ág. 1-5; pl. 7, figs. 7-9; pl. 8, figs. 1-10; pl. 10, figs. 1-2; pl. 54, fig. 26, text figs. 15, 16.
Echinus acutus. Cherbonnier, 1959, p. 46, pl. 5, fig. C-J; pl. 6, fig. A-F.
Echinus acutus mediterraneus. Madsen, 1957, p. 481.

Material Examined. —
Sta. P-82. Off Liberia, 4°58'N., 9°32'W., 82 fm: 2 specimens.

Diagnosis. — Primary tubercle on every second or third ambulacral plate; no spines on buccal plates; valves of globiferous pedicellariae with prominent corners on the lateral edges of the base; secondary tubercles small, few. Color of test red, spines green, tubercles purple. Primary tubercle on every interambulacral plate; test not stout or rough.

Comments. — The coloration and tuberculation indicates that these specimens belong to the subspecies *norvegicus* (cf. Mortensen, 1943b, p. 43) but the spines are much shorter than in the forms from the northeastern Atlantic and Mediterranean. *Echinus acutus,* however, is so variable that the specimens from the Gulf of Guinea can be included in this widely distributed species. Cherbonnier (1959) records *E. acutus* from as far south as Angola.

Echinus stenoporus Mortensen, 1942

Echinus stenoporus. Mortensen, 1943b, p. 92, pl. 14, figs. 7-11; pl. 55, figs. 28-30; text figs. 35c; 37; 38.

Material Examined. —

Sta. P-53. Off the Ivory Coast, 4°50'N., 4°55'W., 850 fm: 140 specimens. Smallest specimen: 12 mm H.D.; largest specimen: 29 mm H.D.

Comments. — Mortensen indicates that the test is a cream color. In live specimens, the spines are light red and the test dark red. When preserved in formalin, the red color persists but when preserved in alcohol, the test and spines bleach to a cream color.

Distribution. — The distribution of this species has been somewhat in question. Mortensen's specimens were labeled only as from "South Africa." The PILLSBURY collection of *Echinus stenoporus* confirms Mortensen's hypothesis that it is a deep-sea inhabitant. In all probability, it is fairly common from the Gulf of Guinea to Angola in 850 to 900 fathoms. *Echinus stenoporus* is, as indicated by Mortensen, very closely related to *Echinus affinis,* which is widely distributed in the North Atlantic.

Lytechinus callipeplus Clark, 1912

Lytechinus callipeplus H. L. Clark, 1912, p. 251, pl. 96, figs. 4-6.

Lytechinus callipeplus. Mortensen, 1943a, p. 459, pls. 52, fig. 16; pl. 53, fig. 9, 10, 21.

Lytechinus callipeplus. Mortensen, 1951a, p. 297.

Material Examined. —

Sta. P-283. Off Annobón, 1°29'S., 5°35'E., 28 fm: 2 specimens.

The specimens are small, 8.2 mm and 8.0 mm H.D., as is usual for this species.

Distribution. — This collection extends the African range of this species considerably to the south. *Lytechinus callipeplus,* described from the West Indies, was collected in the Cape Verde area by the ATLANTIDE. Its southward extension to Annobón is of great zoogeographical interest, bringing the known eastern Atlantic distribution within range of a possible transoceanic route via the equatorial undercurrent.

Tripneustes ventricosus (Lamarck, 1816)

Echinus ventricosus Lamarck, 1816, p. 44.

Tripneustes ventricosus. Mortensen, 1943a, p. 490, pl. 33, fig. 4; pl. 36, fig. 1-4; pl. 37, fig. 3, 11, 12; pl. 38, fig. 5-8; pl. 56, fig. 3, 6, 7, 9, 15, 16, 17.

Material Examined. —

Sta. P-273. Annobón. Isleta La Piramide, near Ambo, littoral: 7 specimens.

Smallest specimen: 6:3 mm H.D. St. P-248; largest specimen: 8.6 mm

Distribution. — In the West Atlantic, from Bermuda and Florida to Brazil, including all of the West Indies. In the southeastern Atlantic, it is found from Ascension and the Gulf of Guinea south to Walfisch Bay (ca. 23°S.). Littoral to 15 fathoms.

Genocidaris maculata A. Agassiz, 1869

Genocidaris maculata A. Agassiz, 1869, p. 262.

Genocidaris maculata. Mortensen, 1943a. p. 358. Pl. 18, figs. 37-47.
Genocidaris maculata. Mortensen, 1951a. p. 297.

Material Examined. —
Sta. P-47. Off the Ivory Coast, 5°05'N., 4°52'W., 20 fm: 1 specimen.
Sta. P-65. Off the Ivory Coast, 4°15'N., 7°32'W., 42 fm: 1 specimen.
Sta. P-239. Off Nigeria, 4°56'N., 5°00'E., 40 fm: 4 specimens.
Sta. P-248. Off the Niger River, 4°03'N., 5°41'E., 18 fm: 2 specimens.
Sta. P-260. Off Cameroon, 3°45'N., 9°05'E., 25 fm: 1 specimen.
Smallest specimen: 6:3 mm H.D. Sta. P-248; largest specimen: 8.6 mm H.D. Sta. P-248.

Comments. — The specimens from Stas. P-239 and P-260 are infected by parasitic gastropods (*Pelseneeria minor* Koehler & Vaney) which are attached by the foot to the aboral side of the test.

The specimens from Stas. P-65 and P-248 are of the variety *splendens* Mortensen (1943a, p. 362).

Distribution. — In the West Atlantic, from Cape Hatteras through the West Indies. Distributed from Greece and Egypt, along the African coast south to the Congo. *G. maculata splendens,* probably only a color variation of the typical *G. maculata,* has been found at Las Palmas, Bocayne Straits, and the Niger River.

Hemiaster expergitus Loven 1874

Hemiaster expergitus Loven, 1874, p. 13, pl. 5. figs. 46, 47; pl. 11, fig. 93, 94; pl. 13, fig. 114-120; pl. 26.
Hemiaster expergitus. Mortensen, 1950, p. 387.
Hemiaster expergitus. Mortensen, 1951a, p. 300.

Material Examined. —
Sta. P-4. Off Lagos, Nigeria, 5°57'N., 3°19'E., 700 fm: 3 specimens.
Smallest specimen: 23 mm test length; largest specimen: 25 mm test length, genital pores not present.

Distribution. — Widely distributed in the North Atlantic from south of Iceland to the West Indies, the Azores, and the Gulf of Guinea to Cameroon.

Spatangus sp.

Material Examined. —
Sta. P-26. Off the Gold Coast, 4°57'N., 1°26'W., 25 fm: 1 specimen.

Comments. — This badly broken specimen, ca. 20 mm test length, could not be sufficiently reconstructed to determine if it is *S. capensis* or *S. purpureus.* None of the ventral or posterior portions remain. As pointed out by Mortensen (1951a) and by Cherbonnier (1959), the southern range of *S. purpureus* and the northern range of *S. capensis* are still uncertain. All of the specimens of *Spatangus* collected in the Gulf of Guinea and the Congo area are too badly damaged for positive identification.

Brissopsis lyrifera (Forbes) *capensis* Mortensen, 1951

Brissus lyrifera Forbes, 1841, p. 187.
Brissopsis lyrifera var. *capensis.* Mortensen, 1951b, p. 387, pl. 30, fig. 1, 13.

Material Examined. —
Sta. P-256. Off Cameroon, 3°45'N., 8°03'E., 250 fm: 5 specimens.

Comments. — The characters pointed out by Mortensen, *viz.* the longer posterior petals, the larger size (61-91 mm test length), and the location of the globiferous pedicellaria separate this subspecies clearly from the *Brissopsis lyrifera* of the N.E. Atlantic.

Distribution. — Previously, this subspecies was known only south of Cape St. Martin (32°30'S.). Finding it at 3°45'N indicates that it may be geographically connected with populations of the typical *Brissopsis lyrifera,* known to occur as far south as 8° N. (cf. Madsen, 1957).

Brissopsis jarlii Mortensen, 1951

Brissopsis Jarlii Mortensen, 1951a, p. 302, pl. 1, figs. 1-3.
Brissopsis jarlii. Cherbonnier, 1959, p. 54, pl. 10, figs. A-L.

Material Examined. —
Sta. P-17. Off Ghana, 5°35'N., 00°10'E., 26 fm: 1 specimen.
Sta. P-24. Off Ghana, 4°56'N., 0°50'W., 20 fm: 1 specimen.
Sta. P-259. Off Fernando Póo, 3°53'N., 8°55'E., 33 fm: 4 specimens.
Smallest specimen: Broken, ca. 17 mm test length. Sta. P-20(?). Largest specimen: 106 mm test length, Sta. P-259.

Distribution. — Gulf of Guinea, from the Gold Coast to Gabon. Very closely allied to the West Indian *Brissopsis elongata* Mortensen, 1907.

Brissopsis atlantica Mortensen *mediterranea* Mortensen, 1913

Brissopsis atlantica Mortensen, 1907, p. 160, pl. 3, figs. 6, 10, 17; pl. 18, figs. 5, 9, 10, 13, 19, 20, 24; pl. 19, figs. 1, 4, 5, 11, 25, 28, 32, 33.
Brissopsis atlantica var. *mediterranea.* Mortensen, 1951b, p. 415. text-fig. 199a.
Brissopsis atlantica var. *mediterranea.* Cherbonnier, 1959, p. 51, pl. 8, figs. M-O.

Material Examined. —
Sta. P-34. Off the Ivory Coast, 3°53'N., 2°33'W., 1080 fm: 3 specimens.
Sta. P-53. Off the Ivory Coast, 4°50'N., 4°58'W., 500 fm: 14 specimens.
Sta. P-76. Off Liberia, 4°32'N., 9°42'W., 800 fm: 1 specimen.
Sta. P-259. Off Fernando Póo, 3°53'N., 8°55'E., 33 fm: 1 specimen.
Sta. P-260. Off Cameroon, 3°45'N., 9°05'E., 25 fm: 1 specimen.
Sta. P-309. Off Nigeria, 4°15'N., 4°27'E., 700 fm. 1 specimen.
Smallest specimen: 22 mm test length. Sta. P-260; largest specimen: 85 mm test length, Sta. P-53.

Comments. — A complete analysis of this material will be presented in a publication now in preparation. I should mention here that the young specimens (Stas. P-259, 260) are positively identified despite their shallow habitat. In addition, anal branches from the subanal fasciole are present, although poorly developed, in the smaller specimens.

Cherbonnier (1959) figures a valve of a globiferous pedicellaria of this species (Pl. 8, fig. N). The figured valve is so atypical of a spatangoid that I must venture the opinion that the illustration is in error. Perhaps the illustrated valve became trapped in the mud or spines of the urchin during capture or handling. It is, with little doubt, the valve of a globiferous pedicellaria from *Eucidaris tribuloides africana* (compare Cherbonnier's Pl. 8, fig. N, with his Pl. 3, fig. B). Although several of the specimens collected by the RV PILLSBURY are in excellent condition, I was, like Mortensen, unable to find a single globiferous pedicellaria.

Distribution. — Mediterranean south to Cameroon and, perhaps, along the eastern coast of North America.

Schizaster edwardsi Cotteau, 1889

Schizaster Edwardsi. Mortensen, 1951b, p. 304, pl. 21, fig. 1-4, 11-13; pl. 54, figs. 4, 6, 10, 11, 13, 18.

Material Examined. —

Sta. P-15. Off Lagos, Nigeria, 5°36'N., 0°51'E., 20 fm: 1 specimen.
Sta. P-26. Off Ghana, 4°57'N., 1°16'W., 15 fm: 1 specimen.
Sta. P-48. Off the Ivory Coast, 5°05'N., 4°52'W., 12 fm: 10 specimens.
Sta. P-62. Off the Ivory Coast, 4°50'N., 6°14'W., 25 fm: 1 specimen.
Sta. P-240. Off the Niger River, 4°41'N., 5°14'E., 20 fm: 19 specimens.
Sta. P-241. Off the Niger River, 4°35'N., 5°18'E., 32 fm: 47 specimens.
Sta. P-250. Off the Niger River, 4°06'N., 5°58'E., 13 fm: 9 specimens.
Sta. P-251. Off the Niger River, 4°03'N., 6°03'E., 15 fm: 8 specimens.

Smallest specimen: Sta. P-48, 8 mm test length; largest specimen: Sta. P-240, 37.5 mm test length.

Distribution. — Cape Palmas to Angola. This species is closely related to the West Indian *Schizaster orbignyanus.*

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THE R/V PILLSBURY DEEP-SEA BIOLOGICAL EXPEDITION TO THE GULF OF GUINEA, 1964-65

— 11 —

THE FRESHWATER SHRIMPS OF THE ISLAND OF ANNOBON, WEST AFRICA[1]

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The literature on West African decapod Crustacea contains two records of the occurrence at Annobón of each of two species of freshwater Caridea: Osorio (1895) and Balss (1914) both mentioned *"Palaemon Olfersi"* (or *"olfersii"*) Wiegmann and *Atya scabra* (Leach) from the island. However, as has been pointed out earlier, the correctness of their identifications is by no means certain (Holthuis, 1951, pp. 24, 25, 149, 150).

The visit of R/V John Elliott Pillsbury of the University of Miami to the island of Annobón (19-21 May 1965) afforded an excellent opportunity to collect fresh water material and so to solve the problem of the identity of the species of shrimp inhabiting the island. On 20 May 1965 the crater lake of Annobón was visited by a group of participants of the Pillsbury cruise (Dr. Frederick M. Bayer, Messrs. Thomas Devany, Gary Hendrix, John Walsh, Richard Young, and the present author).

This crater lake lies at an altitude of about 300 m above sea level. It is approximately 700 m long and 500 m wide, being irregularly oval in outline, the long axis running north-south. It is surrounded by rather dense secondary forest. On the western shore a small effluent leaves the lake and flows rather rapidly down the slope of the mountain. The water of this rivulet is clear and flows in a shallow bed, which is about 2 m wide and less than 1 m deep at the deepest places; the bottom is rocky with many boulders. Near the origin of the effluent the shallow part of the lake shows a grassy vegetation, which penetrates a short distance into the rivulet. In the stream itself there is little vegetation, but at some places the bushy roots of trees afford shelter to smaller shrimps. A low concrete dam, which is interrupted in the middle, is built across the origin of the rivulet near the shore of the lake. The upper reaches of the rivulet were poisoned with "pronoxfish," poured into the water from this dam. A surprisingly great number of well developed and smaller shrimps were obtained, which, equally unexpectedly, proved to belong to four different species. These specimens form the subject of this note.

The material reported upon by Osorio (1895) was collected at Annobón between 19 November 1892 and the first days of January 1893 by the

[1]Contribution No. 739 from the Institute of Marine Science, University of Miami

Portuguese naturalist Francisco Newton, who seems to have been the first zoologist to visit the island. Newton collected freshwater shrimp in the Rio São João, the exact location of which is unknown to me.

Balss's (1914) material was obtained during the 1910-1911 German Central African Expedition under the leadership of Adolf Friedrich Duke of Mecklenburg. During this expedition Dr. Arnold Schultze, one of the two zoologists, and Dr. J. Mildbraed, the botanist of the expedition, visited Annobón from 2 September to 13 October 1911. An account of this visit is published by Mildbraed (1913, pp. 263-277, figs. 212-230). The German scientists collected freshwater shrimps only in the crater lake, the level of which at that time was at its lowest due to the dry season. Because of this low level the effluent did not function and the lake was without an outlet.

ACKNOWLEDGEMENTS

It is a great pleasure to thank the University of Miami for enabling me to participate in the 1965 PILLSBURY West African Expedition, and especially to Drs. Gilbert L. Voss, Frederick M. Bayer and C. Richard Robins, the leaders of the expedition, who allowed me to join their team. The authorities of Annobón were most cooperative in making our visit to the lake a success.

PALAEMONIDAE

Macrobrachium chevalieri (J. Roux, 1935)
(Figs. 1, 2a)

Material. — Annobón, upper reaches of the effluent of the crater lake, 20 May 1965; PILLSBURY Sta. 278: 9 specimens, including 3 ovigerous females.

Description. — The specimens are 39 to 72 mm long with a carapace length of 16 to 32 mm. The ovigerous females are 65 to 72 mm long (cl. 27-32 mm).

The species is characterized by the shape of the rostrum and that of the large chelipeds.

The rostrum (Fig. 1) is short and narrow; it reaches to or somewhat beyond the base of the third segment of the antennular peduncle but fails to reach the end of it. The dorsal margin is straight or slightly convex over the eyes; it bears 11 to 14 teeth, the first 4 to 7 of which are placed on the carapace proper behind the posterior orbital margin. The first 3 or 4 teeth are robust, erect and placed wider apart than the following. The lower margin bears 2 to 4, usually 3 teeth, which are separated from the tip of the rostrum by an unarmed space. The shape of the posterior dorsal teeth of the rostrum distinguishes the species immediately from the next.

The second pereiopods are usually unequal in size, especially in large specimens, but they are practically identical in shape. The fingers are somewhat shorter than the palm and do not gape. The cutting edge shows a number of well-separated small granule-like teeth in the proximal part, the distal part being smooth. The chela is spinulated, the spinules on the lower part being larger and placed wider apart than on the rest of the surface. The fingers show a pubescence near the cutting edges while a short woolly pubescence is found on the lower surfaces of propodus, carpus and merus. In the smaller specimens this pubescence is very indistinct. In these specimens furthermore the ischium, merus, carpus, and palm are of about the same length. In the larger the palm is longer than the carpus. No fully grown adult males are present in this collection, but I could examine such males from the Cape Verde Islands. They differ from the not fullgrown Annobón specimens in the shape of the second pereiopods, which are much stronger and much longer (Fig. 2a). The fingers are relatively much shorter in these adults, being often only a little more than half as long as the palm. The cutting edges are evenly denticulated over practically their entire length. The carpus is much shorter than the palm. The pubescence of the ventral surface of the chela, carpus and merus is much stronger than in the smaller specimens.

The eggs are numerous and small, measuring 0.5 to 0.8 mm in diameter.

Colour. — The chelae are of a greenish brown colour, which persists in the freshly preserved material. No colour description of the living specimen was made.

The species was described only as late as 1935 but may have been

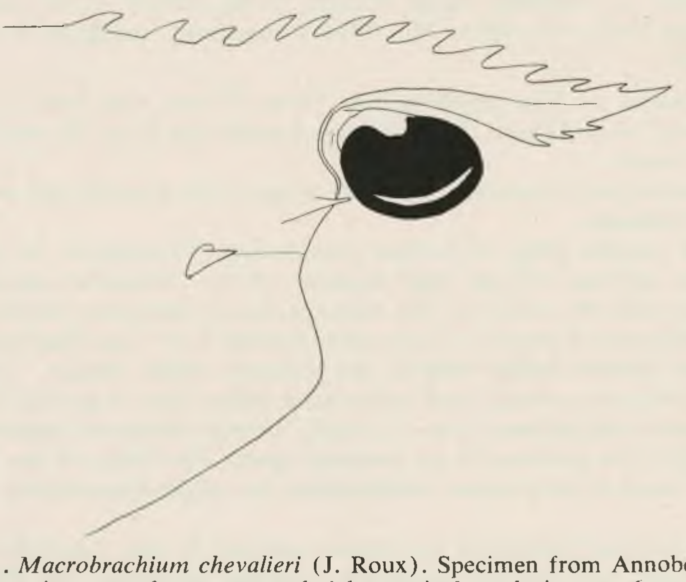

FIGURE 1. *Macrobrachium chevalieri* (J. Roux). Specimen from Annobón: anterior part of carapace and right eye in lateral view, × 6.

reported upon before that time under incorrect names. The type locality is: Paul River, São Antão, Cape Verde Islands (J. Roux, 1935). As pointed out by Holthuis (1951, p. 148) the material identified by Greeff as *Palaemon Olfersi* from São Thomé belongs at least partly to the present species. Furthermore, De Man (1904) and Holthuis (1949, 1951) reported the species from Katumbella near Benguella, Angola. Since 1951 I have seen material of *M. chevalieri* from the following localities: Ribeira de Paul, near Pombas, São Antão, Cape Verde Islands (altitude about 340 m, May 1950, J. Cadenat, coll. IFAN; 20 specimens, cl. 15-46 mm). — Ribeira Grande, near village, São Antão (May 1950, J. Cadenat, coll. IFAN; 63 specimens cl. 15-42 mm) — Ribeira Grande, São Antão (27-28 December 1953, H. Lindberg; 4 specimens, cl. 20-24 mm). — Ribeira Brava, São Antão (28 December 1953, H. Lindberg; 1 specimen cl. ±22 mm). — Sal Palha Verde, São Nicolau, Cape Verde Islands (20 January 1954, H. Lindberg; 1 ♂ cl. 45 mm). — Chão da Preguiça, São Nicolau (13-17 December 1953, H. Lindberg; 31 specimens cl. 6-14 mm). — Faja Agua, Brava, Cape Verde Islands (25 February 1954, H. Lindberg; 18 specimens, cl. 10-31 mm). — Praia, São Tiago, Cape Verde Islands (5-14 February 1954, H. Lindberg; 1 specimen cl. 11 mm). — Dikullu, just E. of Victoria, Cameroons (23 October 1925, coll. IFAN; 7 specimens). — Tiko, E. of Dikullu (22 October 1925, coll. IFAN; 2 specimens). — Kribi, Cameroons (in rapids, coll. IFAN; 2 specimens). — Kindambo, N'Goma, Chiloango River, Mayombe Province, Bas-Congo, Belgian Congo (E. Dartevelle, Museum Tervueren; 1 specimen). — Tshela, Mayombe Province (1954, leg. De Vriese, Museum Tervueren; 2 specimens). — Sungi, Zambi, Mayombe Province (27 May 1925, A. Collart, Museum Tervueren; 1 adult male).

It is possible that the material from Annobón reported upon by Osorio (1895) as *Palaemon Olfersi* and that by Balss (1914) as *Palaemon olfersii* contained material of this species, although it almost certainly contained *Macrobrachium zariquieyi* (see below).

Macrobrachium zariquieyi Holthuis, 1949
(Figs. 2b-c, 3)

Palaemon Olfersi Osorio, 1895, Jorn. Sci. math. phys. nat. Lisboa, ser. 2 vol. 3, p. 249.

Palaemon olfersii Balss, 1914, Ergebn. Zweiten Deutsch. Zentral-Afrika Exped., vol. 1, p. 98

Material. — Annobón, upper reaches of the effluent of the crater lake, 20 May 1965; Pillsbury Sta. 278. — 24 specimens, including many full grown males and 3 ovigerous females.

Description. — The specimens are 18 to 91 mm long, with a carapace length of 8 to 41 mm. The ovigerous females measure 54 to 74 mm (cl. 22-30 mm).

The rostrum (Fig. 3) is short and narrow and reaches as a rule to or

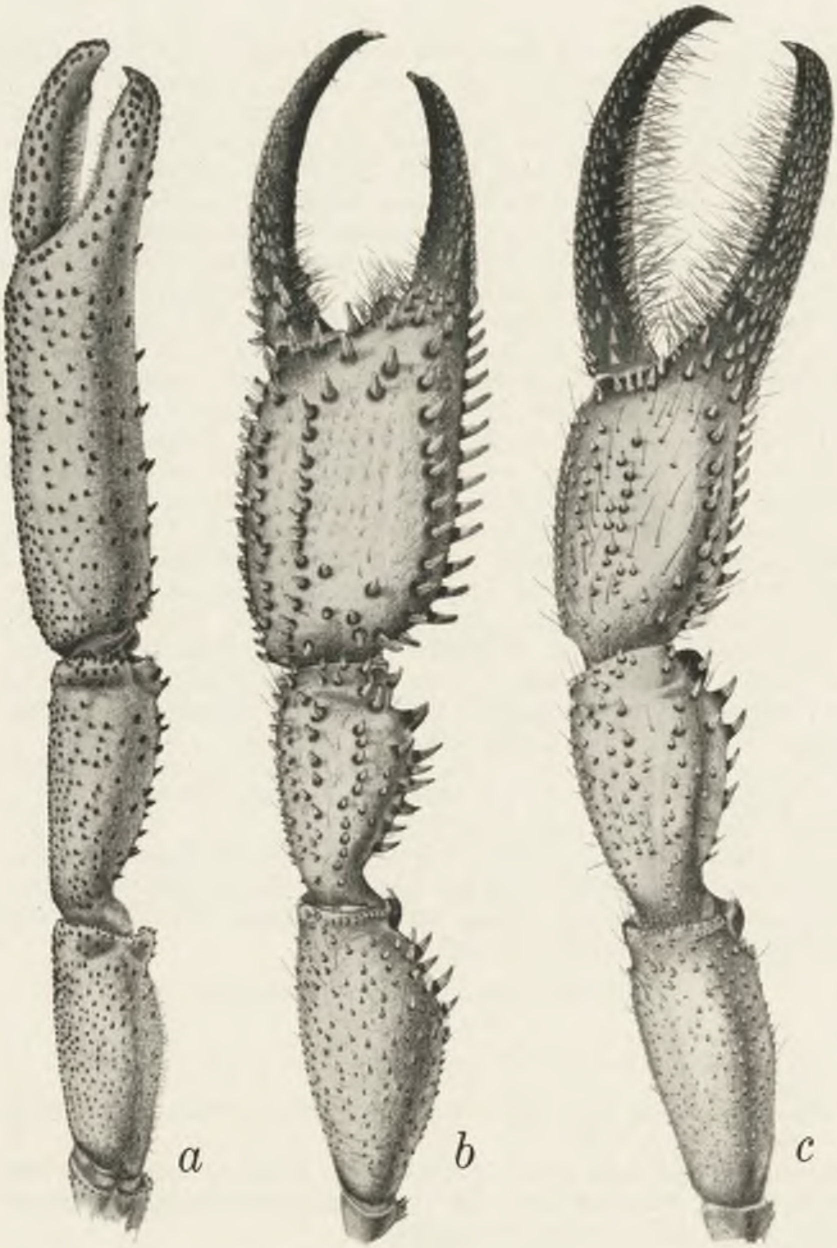

FIGURE 2. *a, Macrobrachium chevalieri* (J. Roux): larger second cheliped (× 1.5) of adult male from Ribiera de Paul, São Antão, Cape Verde Islands. —*b, Macrobrachium zariquieyi* Holthuis: larger second cheliped (× 2) of adult male from Annobón.—*c, M. zariquieyi:* smaller second cheliped (× 3) of the same specimen.

slightly beyond the end of the antennular peduncle. The upper margin is evenly and slightly convex, not very high but distinctly higher than in *M. chevalieri*, and has the teeth quite uniformly distributed over it. There are 10 to 13 dorsal teeth, 4 to 5 of which are placed behind the orbit. The lower margin bears 3 to 5 teeth. One of the ovigerous females is abnormal in that the upper margin bears only 8 teeth with great irregular gaps between those on the rostrum proper; in this specimen the lower margin bears only 2 teeth.

The second pereiopods of the adult males are strongly unequal. Sometimes the right is the larger of the two, sometimes the left. The larger cheliped (Fig. 2b) has the fingers about as long as the palm and strongly gaping. The cutting edges of the fingers are crenulate by the presence of low blunt teeth, which are placed one next to the other; the crenulation is most distinct in the basal part and becomes fainter distally. Stiff hairs fill the larger part of the gap. The lower margin of the palm shows a longitudinal row of strong, slender, but bluntly topped spines. These spines are placed closer together distally, and on the base of the fixed finger form an almost continuous ridge. A second row is placed on the outer surface of the palm just above the ventral row. The central part of both the outer and inner surface of the palm bear a conspicuous rather large hairy area in which there are no spines. Above this hairy area the outer surface again shows a longitudinal row of blunt spines and above that 3 more parallel rows of spines which dorsally become gradually smaller. Before and behind the hairy patch some scattered large blunt spines are present. On the fingers there are numerous very small, appressed, blunt spinules, which are irregularly arranged but all of which point anteriorly. On the inner surface there is a single row of blunt spines in the lower half; these spines are indistinct and are largely obscured by the pubescence. Above the hairy area there are four longitudinal rows of small blunt spinules. The merus and carpus show no pubescence apart from a few scattered hairs; they have long and slender but blunt spinules ventrally. The spinules on the rest of the surface become smaller dorsally. The carpus is about as long as or slightly shorter than the merus, which is about as long as the palm. The small chela (Fig. 2c) has the palm distinctly (about 2/3) shorter than the fingers, which are strongly gaping, the gap filled with stiff inward directed hairs. Apart from scattered hairs the palm shows no pubescence. The spinulation of palm, carpus and merus is similar to that of the merus and carpus of the large leg, although the spines are shorter and far less conspicuous. The larger the males are, the larger also the length of the fingers of both chelae relative to that of the palm.

In medium sized females the second legs are practically identical, one being only slightly longer than the other. The fingers close over their whole length; they are about as long as the palm. The spinulation of the

FIGURE 3. *Macrobrachium zariquieyi* Holthuis. Specimen from Annobón: anterior part of carapace and right eye in lateral view, × 6.

chela is more or less like that of the smaller chela of the male. The carpus is slightly shorter than the merus and distinctly shorter than the palm. In very large females the chelipeds look somewhat more like those of the males.

The eggs are numerous and small; their diameter is 0.4 to 0.6 mm.

The ground colour of the living specimens is uniformly bluish grey. The first and second abdominal somites have two narrow dark bands along the central part of the posterior margin. In the third somite there is only one such dark band which is much broader, and before which there is a distinct white band. The fourth and sixth somites sometimes also have a dark band, before which there is a median white spot. The tailfan is of a uniformly dark grey colour. The chelipeds are bluish grey with the fingers dark blue. The big spines on the palm, carpus and merus are dark blue with a grey top. The following pereiopods are uniformly grey with uncoloured dactyli. The dark blue colour of the chelipeds persists in alcohol (it is found equally in males and females) and proved also an easy means to separate this species from *M. chevalieri.*

Distribution. — *Macrobrachium zariquieyi* so far is only known from the West African islands of Fernando Póo, São Thomé and Annobón. Type locality is Rio Consul, Fernando Póo. It is possible that all records in the literature dealing with *Palaemon Olfersi* (or *P. olfersii* or *P. spini-*

manus) from these islands actually pertain to the present species. The previous records from Annobón are: Rio São João (Osorio, 1895) and Crater Lake (Balss, 1914). Though it is possible that the material from Annobón identified by Osorio and Balss as *Palaemon olfersii* contains some specimens of *M. chevalieri,* it is probable that it for the larger part is based on the present species which of the two indeed is far more closely related to the east American *Macrobrachium olfersii* (Wiegmann).

Apart from the present material and the types, I examined 2 specimens from Ilha de Bombom, São Thomé (17 August 1956, leg. Th. Monod, coll. IFAN).

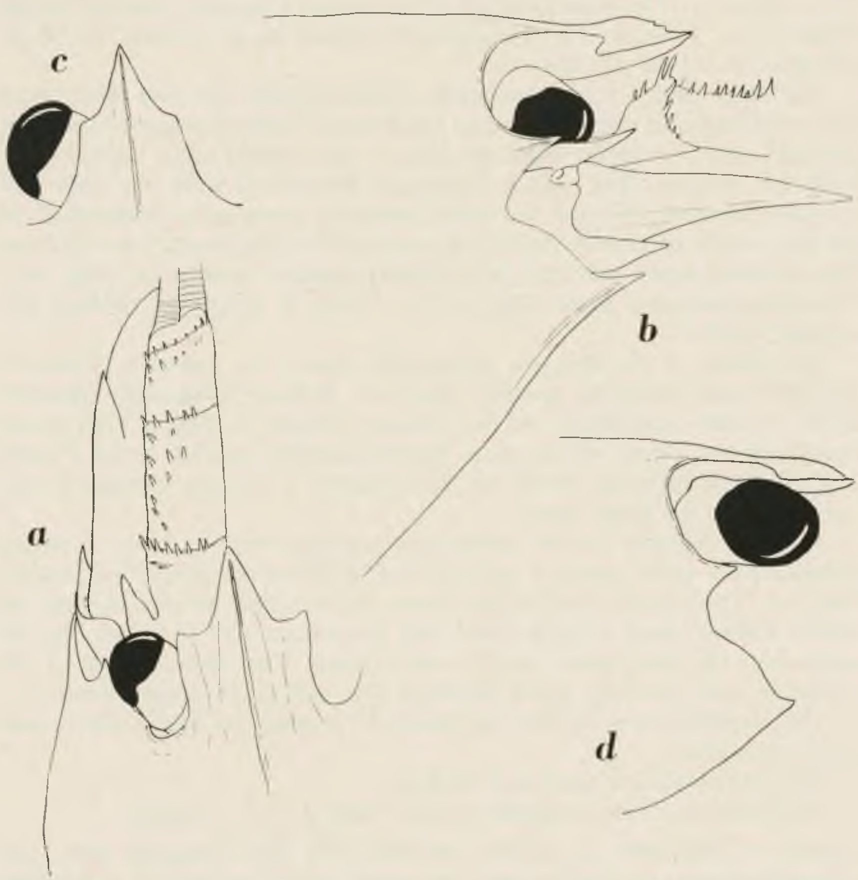

FIGURE 4. *Atya sulcatipes* Newport. Specimens from Annobón: *a-b,* adult male (× 7); *c-d,* juvenile (× 10). a, Anterior part of body in dorsal view; *b,* anterior part of body in lateral view; *c,* rostrum and left eye in dorsal view; *d,* anterior part of carapace and right eye in lateral view.

ATYIDAE

Atya sulcatipes Newport, 1847

Fig. 4

Atya scabra Osorio, 1895, Jorn. Sci. math. phys. nat. Lisboa, ser. 2 vol. 3, p. 249.

Atya scabra Balss, 1914, Ergebn. 2. Deutsch. Zentral-Afrika Exped., vol. 1, p. 98.

Material. — Annobón, upper reaches of effluent of Crater Lake, 20 May 1965, PILLSBURY Sta. 278: 12 specimens, including large males and ovigerous females.

Description. — The specimens are 29 to 69 mm long, the carapace length being 11 to 29 mm. The 4 ovigerous females have a length of 30 to 49 mm (cl. 11 to 18 mm).

The large male is very scabrous, being entirely covered with short erect stiff hairs. In the females and small males this pubescence is present but very short, while the hairs are placed more widely apart. In the adult male the rostrum (Fig. 4*a*) is tridentate, the lateral teeth are wide and directed forwards. Behind the lateral teeth the rostrum is constricted. In the very small specimens the lateral teeth are far less sharply set off from the rostrum proper and only form bluntly angular convexities (Fig. 4*c*). The pterygostomian angle (Fig. 4 *b*, *d*) ends in a narrow, slender, triangular tooth.

The pleura of the first two abdominal somites are rounded. Those of the third and following somites end in a distinct, posteriorly directed tooth in some specimens, but are bluntly pointed in others. The lower margin of the pleura of the third, fourth and fifth somites bears a short row of horny tubercles which are very distinct in the old specimens, but are absent in the small ones.

The first segment of the antennular peduncle bears a row of strong spines on the upper anterior margin, while 2 spines are placed just behind this row. The second segment has spines on the upper anterior margin; its dorsal surface bears a longitudinal and an oblique row of spines. In the adult male all these spines are of a dark colour. The third segment of the peduncle also bears an upper anterior row and some dorsal spines.

The scaphocerite is slender and narrowly pointed. Its final tooth is narrowly triangular.

The pereiopods are short and thickset.

The diaeresis of the uropodal exopod bears 16 or 17 spines.

Colour. — The body is entirely mottled with dark greenish grey; the chromatophores are spread over the entire body and give it a peculiar marbled appearance. The anterior half of the sixth abdominal somite is very dark; this dark area is separated from the light posterior half by a narrow white band. The light area extends onto the base of the tailfan and sometimes over the entire tailfan. In some specimens there is a light longitudinal median band over the full length of the body. This light band is flanked at each side with a darker band and sometimes shows a darker line at some places in its middle.

Comparisons. — The present species has usually been considered conspecific with the east American *Atya scabra* (Leach). Oliveira (1946, p. 179, 180), however, listed an impressive number of differences between the American and West African forms, using the name *A. sulcatipes* for the latter. Not all of the differences listed by Oliveira hold good. Some characters show a greater variation than supposed by Oliveira, while the ranges of variation overlap entirely or for the greater part, like with his characters f, g, v, and 2. Others are incorrectly interpreted: so the branchial formula in the two species proves to be identical. The branchial formula given by Oliveira for *A. scabra* is correct but for the podobranch on the third maxilliped which is absent in that species. The formula given for *A. scabra* by Villalobos (1943, p. 63) correctly leaves out the podobranch on the third maxilliped, but does not give the pleurobranch of that appendage, which Oliveira did indicate. This pleurobranch is small and hidden by the single arthrobranch of the first pereiopod and the larger of the two arthrobranchs of the third maxilliped, and therefore is easily overlooked. The branchial formula for *A. sulcatipes* given by Oliveira evidently is taken from Bate (1888, p. 698) and as shown by my material is incorrect. In both species the branchial formula is as follows:

	Maxillipeds			Pereiopods				
	1	2	3	1	2	3	4	5
pleurobranchs	-	-	1	1	1	1	1	1
arthrobranchs	-	-	2	1	-	-	-	-
podobranchs	-	1	-	-	-	-	-	-
epipods	1	1	1	1	1	1	1	-
exopods	1	1	1	-	-	-	-	-

The male pleopods of the two species do not show any appreciable constant differences.

As far as I could make out, the only character that proved to be constant is the shape of the antennula. It is possible that also the colour pattern of the living animals may provide characters for distinguishing the two species.

Bouvier (1925) reported *Atya scabra* from West Africa (Cameroons, Angola, Cape Verde Islands, Fernando Póo, São Thomé, Annobón), East America (Mexico to Brazil and the West Indies), West America (Mexico to Colombia), New Caledonia and Australia. It is almost certain that the records from New Caledonia and Australia are based on erroneously labeled specimens. The West African material should be transferred to *Atya sulcatipes* Newport as pointed out above. The western American material also evidently is distinct from the true *Atya scabra.* A comparison of E. Atlantic *A. scabra* with material from Ecuador (Chula, September 1956, leg. W. Forster.—8 specimens) and Peru (Rio Tumbes, coll. W. K. Weyrauch.—1 specimen; Peru, coll. Mus. Hist. nat. Lima.—1 specimen) present in the Rijksmuseum van Natuurlijke Historie, Leiden, showed the following differences between the E. and W. American forms: (a) the segments of the antennular peduncle in the western species are relatively shorter and wider; (b) compared to the third segment of the peduncle the second is much longer; (c) the inner anterior lobe of the merus of the third pereiopod of the western species is strongly produced as a bluntly triangular process; (d) the legs of the western species are more robust, the segments being relatively wider in all legs. For the West American species the name *Atya rivalis* Smith, 1871 (type locality western Nicaragua) is available. The West African species should be known, as Oliveira (1946, p. 179) already pointed out, as *Atya sulcatipes* Newport, 1847, of which *Atya margaritaria clavipes* Aurivillius, 1898 (type locality: Etome, Cameroons) is a synonym.

The name *Atya scabra* (Leach, 1815) is thus restricted to the East American species. However, the type locality of the species is not known: Leach (1815, p. 345) indicated it as *"Habitat———"*. Newport (1847, p. 158) made the following remark about *Atya scabra*: "There are four specimens of this in the cabinets of the British Museum, but nothing whatever is known of their habits, or from whence they were obtained." In White's (1847, p. 74) list of the Crustacea in the British Museum, however, is indicated under *Atya scabra* "a-d. Mexico. From the collection of Dr. Leach." It is impossible therefore that the locality of Leach's type material has been discovered later and that the material listed by White indeed is the type material. It seems safe to restrict the type locality to the Atlantic drainage of Mexico and more accurately to the area of Veracruz. Synonyms of *Atya scabra* (Leach) are: *Atya mexicana* Wiegmann, 1836 (type locality: Misantla, province Veracruz, Mexico), *Atya margaritacea* A. Milne Edwards, 1864 (type locality: cited as New Caledonia, but evidently in error), *Atya punctata* Kingsley, 1878 (type locality: Haiti).

Atya sulcatipes Newport, 1847, was originally reported by Newport from São Nicolau, in the Cape Verde Islands, which therefore is the type locality. Since then the species has been reported from the Cape Verde Islands, Fernando Póo, Ilha do Principe, São Thomé, Annobón, Cameroons, Belgian Congo and N. Angola. An enumeration of the West African localities for this species is given by Holthuis (1951, p. 25, under the name *A. scabra*). The Annobón records in the literature are: Rio São João (Osorio, 1895), and Crater Lake (Balss, 1914). Material from the following additional localities was examined by me: Ribeira Grande, São Antão, Cape Verde Islands (27-28 December 1953, H. Lindberg; 5 specimens).—Ribeira de Paul, São Antão altitude 341 m (May 1950, leg.

J. Cadenat, coll. IFAN; 12 specimens including 3 ovigerous ♀♀).—Preguiça, São Nicolau (13-17 December 1953, H. Lindberg; 4 specimens).—Faja Agua, Brava (25 February 1954, H. Lindberg; 11 juveniles).—Lagoa, São Tiago (15 February 1954, H. Lindberg; 9 specimens).—Praia, São Tiago (5-14 February 1954, H. Lindberg; 64 juveniles).—Ribeira dos Picos, near Picos, São Tiago, Cape Verde Islands (June 1950, J. Cadenat, coll. IFAN; many specimens).—Bombom, São Thomé (17 August 1956, Th. Monod. coll. IFAN; 7 specimens).—Sheffelinsville, between Monrovia and Marshall, Liberia (1887, J. Büttikofer; 1♂).—Waterfalls of the Lobé River, about 9 km S of Kribi, Cameroons (among Podostemonaceae, 7 August 1964, leg B. de Wilde-Duyfjes; 16 specimens).—In pools in the bed of the Lobé River, about 9 km S. of Kribi, Cameroons, (7 August 1964, leg. B. de Wilde-Duyfjes; 22 specimens).

Atya intermedia Bouvier, 1904
Figure 5

Material.—Crater lake, Annobón, in upper reaches of effluent near western shore of the lake, 20 May 1965, PILLSBURY Sta. 278: 3 adult and 5 juvenile specimens.—Annobón, 1959, coll. R. Zariquiey Alvarez: 1 specimen.

Description.—The adult PILLSBURY specimens measure 79 to 83 mm (cl. 30-32 mm), and the juveniles are 19 to 29 mm long (cl. 8-10 mm).

The present material of *A. intermedia* was caught together with that of *A. sulcatipes* and though at first I had some difficulties to distinguish the juveniles of the two species, several characters were found to make the separation easy.

The shape of the rostrum (Fig. 5*a*), which is an exceedingly good character to distinguish the adults, in the juveniles is of far less value as in the young of *A. sulcatipes* the lateral teeth are reduced to broadly rounded angles. In the juveniles of *A. intermedia* (Fig. 5*c*) the lateral angles are also more broadly rounded than in the adults and do resemble those of juvenile *A. sulcatipes* (Fig. 4*c*), although they are even still less conspicuous than in that species. All the specimens show short erect hairs on the body, but even in the old males these are so short and so few that the specimens seem glabrous to the naked eye. A dense pubescence like that in the adult male of *A. sulcatipes* is never present in *A. intermedia.* In the adult males of *A. intermedia* the carapace is irregularly and rather coarsely pitted, but it is less rugose than in the old males of *A. sulcatipes.* An extremely good difference which distinguishes the two species in all stages is the shape of the pterygostomian tooth (Fig. 5*b, d*) which in *A. intermedia* is far less narrow and slender than in *A. sulcatipes.*

The pleura of the first two abdominal somites are rounded; those of the third to sixth somites are angular posteriorly. None of the pleura bears horny spinules on the lower margin, not even in the adult males.

The first segment of the antennular peduncle bears a single row of horn colored spinules on the anterior margin. The stylocerite is shorter, less slender and blunter than in *A. sulcatipes*. The second segment of the peduncle is relatively longer and slenderer than in *A. sulcatipes* and only shows an inconspicuous row of spinules along the anterior margin and a few inconspicuous ones on the upper surface. Not even the adult males show any spines on this segment that are visible with the naked eye.

The final tooth of the scaphocerite is broadly triangular, and is far less slender than in *A. sulcatipes*.

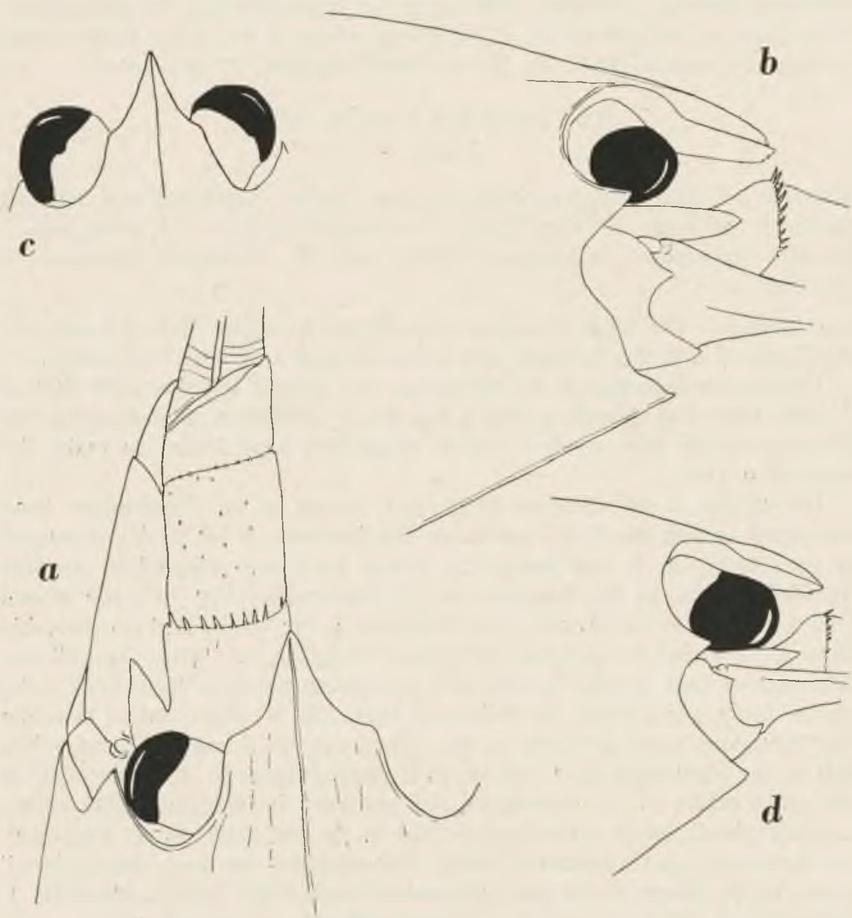

FIGURE 5. *Atya intermedia* Bouvier. Specimens from Annobón: *a-b*, adult male (× 7); *c-d*, juvenile (× 10).—a, Anterior part of body in dorsal view; *b*, anterior part of body in lateral view; *c*, rostrum and eyes in dorsal view; *d*, anterior part of carapace and right eye in lateral view.

The pereiopods are distinctly more slender than in *A. sulcatipes;* this is especially distinct in the third leg of the male. In my largest specimen the merus of this leg is 4 times as long as high, against less than 2.5 times in a smaller specimen of *A. sulcatipes.*

The uropods of *A. intermedia* are more elongately pointed than in *A. sulcatipes,* while the diaeresis has more spinules (20 to 22).

Color.—The whole body is of a more even dark greenish grey color; it is not marbled as in *A. sulcatipes.* There is a light median spot on the fourth and sixth abdominal somites. The latter does not show the dark transverse band so conspicuous in *A. sulcatipes.*

A. intermedia so far has been reported only from its type locality, the island of São Thomé. The present material extends the range of the species to Annobón.

Bouvier's (1925, p. 308) remark that the rostrum bears no ventral carina is not quite correct. In my specimens such a carina is distinct, though not very high.

Comparisons.—This species is closely related to *Atya africana* of the West African mainland. The differences between the two species enumerated by Bouvier (1925, pp. 292, 308-310) are very clear in our material and there can be no doubt that Bouvier was correct in separating the two.

A. intermedia is also close to *Atya innocous* (Herbst, 1792) from the West Indies. *Atya innocous* (Herbst, 1792) (type locality: Martinique) has several times been described under different names: *Astacus Nasoscopus* Meuschen, 1778, is a senior objective synonym of *Cancer (Astacus) Innocous* Herbst, 1792, but is unavailable as Meuschen's publication is ruled invalid under Opinion 260 of the International Commission on Zoological Nomenclature (1954, Opin. Decl. Int. Comm. zool. Nomencl., vol. 5, pt. 21, p. 267). Both names *(nasoscopus* and *innocous)* are based on the specimen described and figured by Gronovius (1764, Zoophyl. Gronov., p. 231, pl. 17, fig. 6) as Astacus 988, from "Oceano Americano ad Martinicam." Meuschen (1778, Mus. Gronov., p. 86) gave just a Latin name to Gronovius's species, while Herbst (1792, Vers. Naturgesch. Krabben Krebse, vol. 2, p. 62, pl. 28, fig. 3) provided a free translation of Gronovius' description and copied his figure. He erroneously stated the type locality to be unknown, even though Gronovius indicated it clearly. The specimen figured by Gronovius is the holotype of Herbst's species. In 1847 Newport described the species again as new, now under the name *Atya occidentalis* (type locality: Jamaica). In his original description Newport referred also to Gronovius, stating that *A. occidentalis* "appears to be that [species] which is figured and described, but not named, by Gronovius, tab. 17 fig. 6 . . . ," evidently overlooking the fact that Herbst had provided Gronovius's species with an available name. There can be little doubt that *Atya robusta* A. Milne Edwards, 1864, also belongs here. Together with *Atya margaritacea* this species was described as new by A.

Milne Edwards and both species were said to originate from New Caledonia. *A. margaritacea* proves to be identical with *A. scabra;* its type locality evidently is erroneous and it most certainly originates from East American waters. As *A. robusta* is indistinguishable from *A. innocous* which so far also is only known from E. American waters it may safely be assumed that the types of *A. robusta* and *A. margaritacea* actually came from the same locality in eastern America and that the indication "New Caledonia" is incorrect.

Bouvier (1925, p. 312) synonymized *Atya tenella* Smith, 1871 (type locality: western Nicaragua) with the present species. An accurate comparison of specimens of *A. tenella* from the Pacific drainage with *A. innocous* from the Atlantic drainage of America is needed to definitely decide this matter. Until then I am inclined to treat *A. tenella* as a distinct species.

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