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DUCIE ATOLL: ITS HISTORY, PHYSIOGRAPHY AND BIOTA

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INTRODUCTION

Remote and uninhabited Ducie Atoll (24° 40'S, 124° 47'W), more commonly known as Ducie Island, lies 293 miles east of Pitcairn and 830 miles west-northwest of Easter Island. It is the easternmost atoll of the vast Indo-Pacific biogeographical region that possesses a pure, though impoverished Polynesian biota. Clipperton Atoll (10° 18'N, 109° 13'W), the one atoll in the Pacific that lies to the east of Ducie, has a fauna and flora with a significant admixture of Eastern Pacific elements (Sachet, 1962; Salvat and Erhardt, 1970).

Ducie, only one and a third miles long and a mile wide, is one of the Pitcairn Islands, and together with the two other satellite islands, Oeno and Henderson, was officially annexed to Pitcairn in 1902.

Because of its geographically isolated and biogeographically marginal position, the authors had long desired to collect and study the marine fauna of Ducie Atoll and compare the species living there with those of the islands to the west which have a more richly developed Indo-Pacific fauna.

On two previous trips to Pitcairn in 1964 and 1967, the senior author had hoped to visit Ducie but each time both lack of available time and shortage of necessary fuel made the 300 mile trip to Ducie from Pitcairn impossible.

When the itinerary of the 1970-1971 National Geographic Society-Oceanic Institute Expedition to Southeast Oceania was set up to include an extended stay at Pitcairn Island, it was determined that a visit to Ducie Atoll would be an essential part of the program. With the 99-foot schooner WESTWARD as our means of transportation and base of operations, we foresaw bad weather as the only factor that might prevent us from at

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last visiting Ducie. On January 10, 1971, after spending 22 days on Pitcairn, the WESTWARD left for Ducie Atoll, which was reached after making a brief stop at Henderson Island. Two and a half days were spent at Ducie, after which we returned to Henderson and then Pitcairn.

The fact that so little is known of this rarely visited island has induced us to put on record not only our observations, but gather together all that was previously known of Ducie.

To the authorities of the National Geographic Society, especially the Committee on Research and Exploration, and to Taylor A. Pryor and his associates of the Oceanic Foundation, we are grateful for making this trip possible in the first place. To Captain W. Roger Gray and his crew of the WESTWARD our thanks for getting us everywhere that we wished to go, particularly to those who assisted us in our investigations at Ducie Atoll, especially Denis Hewett who made the tidal observations included in this account. We owe much to the people of Pitcairn for their hospitality and help, especially to Steve Christian and Noggy Young who accompanied us to Ducie and to Roy Clarke for passing on to us the recollections of his father who was shipwrecked on Ducie in 1881. To the Hydrographer of the Navy of the British Ministry of Defence, we are grateful for the efforts to locate the aerial photographs taken during the survey by HMS LEANDER in 1937 and for furnishing us with a copy of the original tracing made by the Commanding Officer of HMS LEANDER. We are greatly indebted to the Director of the Western Pacific Archives in Suva, Fiji, for locating and sending us a microfilm copy of the report of the survey of HMS LEANDER. Finally, our thanks go to Mrs. James P. Chapin and others at the American Museum of Natural History for furnishing us with copies of the relevant portions of the journals and letters written by Rollo H. Beck, Ernest H. Quayle, and Charles C. Curtis during the Whitney South Sea Expedition, and by James P. Chapin while on the Templeton Crocker Expedition.

We regret only that our stay on Ducie was not long enough to carry out a more comprehensive survey, particularly since in retrospect we realize that we might have made certain observations that would have added considerably to this account. We may only hope that the publication of this study will induce other workers to attempt a more thorough and extended survey of this interesting atoll.

HISTORY

Although in many recent references to Ducie Captain Edwards of the PANDORA is still cited as the discoverer of the island in 1791, the true discoverer has been identified by scholars for almost a hundred years as Pedro de Quirós in 1606. Kelly, in his study of the voyage of Quirós (Kelly, 1966, op. p. 62), gives an interesting table listing the varying identifications given over the years to the islands encountered during this voyage. From this we see that as early as 1837 Moerenhout suggested that Quirós might have discovered Ducie. The first to definitely identify Ducie with the first island encountered by Quirós on his voyage was the German geographer Meinicke in 1875-76.

Ducie was discovered on January 26, 1606, during the expedition headed by Pedro Fernandez de Quirós which sailed from Callao, Peru to carry Christianity to the peoples of the islands of the western Pacific discovered on earlier Spanish expeditions. It was the first island seen by the little flotilla of three ships after leaving Callao on December 21, 1605, the first of eighteen islands discovered by Quirós on his way to Espíritu Santo in the New Hebrides, where his expedition eventually ended.

In his narrative Quirós says that on January 25 they "saw the first weeds" (de Leza in his account adds "like sargasso"), and on the following day "birds of several kinds flying together" were seen (Markham, 1904, p. 192). On that day, at 11 o'clock they saw the atoll in latitude 25°. He described it as having "a circumference of 5 leagues, many trees, and a beach of sand. Near the land the depth was 80 fathoms. I gave it the name of 'Luna-Puesta.'" (Markham, loc. cit.). They did not land as it was late so stood off during the night, and the next morning found themselves to leeward, and did not attempt to approach the island again but sailed on towards the west. The name that Quirós first gave the island signifies "setting moon"; in his memorial of 1609 he changed the name to "La Encarnación."

The chief pilot of Quirós' fleet, Gaspar Gonzalez de Leza, has also left an account of the voyage and here he gives the following description of the discovery of Ducie:

> This day [the 26th] we saw many birds of different kinds at about eight, gulls, frigate birds, boobies and terns, and at noon we sighted land: at which all hands rejoiced, a good prize being given the look-out man. The Capitana fired a gun to announce it to the other, and we proceeded towards it, sending the launch [the LOS TRES REYES, smallest of the three ships] on ahead to find a port. Having reconnoitered, they told us they had been within arquebus-shot of the land, and that there was no bottom in 200 fathoms. It seemed to our General that, if we could get nearer, we might find a port, and take in wood and water, and some fish: for the island seemed to have these things in abundance. It was very green and seemed large from what we could see. There were 3 or 4 leagues of very white beach, backed by trees.
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> First Island: Anegada.--In 25° S, 1000 leagues from Callao. This island is very flat, so that one may be near it and never see it. It runs NW and SE . . . the Almiranta . . . told us he had found bottom is 80 fathoms, then no bottom with 300 fathoms." (Markham, op. cit., p. 329).

Fray Martin de Munilla, O.F.M. "comissary of the Franciscans in the expedition and 'Chaplain and Vicar of the Royal Fleet'" (Kelly, 1966, p. 6) also kept a journal and described Ducie as "A small island of about two leagues, level with the sea, well wooded, and of a very pleasing appearance. There was a sandy beach all around it. Apparently there was great depth because, although the launch drew quite close to it, she did not find bottom" (Kelly, op. cit., p. 153).

All the estimates of the size of the island given in the above cited accounts are far too great, if we consider the Spanish legua in these accounts to have been equal to 3.2 nautical miles (Kelly, op. cit., p. 52). The Sumario breve of Juan de Iturbe, overseer and accountant, gives its size as one and a half leagues (Kelly, op. cit., p. 279), which is still too large. We can smile at Munilla's description of this rather dreary atoll as having "a very pleasing appearance" and attribute it to the fact that it was their first island after thirty-six days of probably not too comfortable voyaging. The sandy beaches that are mentioned in several of these accounts are actually for the most part beaches and shore deposits of coral rubble that from a distance have the appearance of sand.

Almost 200 years passed before the next recorded visit in the year 1791 to Ducie. This was by HMS PANDORA, commanded by Captain Edward Edwards, while on a mission to find and arrest the mutineers of the BOUNTY. In his official report he merely lists the three islands he discovered on the voyage between Cape Horn and Tahiti: "the first, which I called Ducie's Island, lies in Latitude 24° 40'30"S and Longitude 124° 36'30"W from Greenwich. It is between 2 and 3 miles long" (Edwards and Hamilton, 1915, p. 29). The island was sighted on March 16, 1791. George Hamilton the surgeon on the PANDORA, published an account of the voyage in 1793. He says "on the 16th [of March] we discovered a Lagoon Island of about three or four miles extent; it was well wooded, but had no inhabitants, and was named Ducie's Island, in honour of Lord Ducie" (Edwards and Hamilton, 1915, p. 101). Francis Moreton, fourth Baron Ducie of Tortworth, was a captain in the Royal Navy. Apparently this expedition also did not land on Ducie.

Ducie Island appeared in certain New England newspapers in 1821 and subsequent years (Ward, 1967, pp. 198-217) as the island which the three boats from the ill-fated ESSEX, attacked by a whale in November, 1820, believed they had reached after a month of voyaging on the open sea (Chase, 1821). Actually the island on which they spent a week was Henderson Island, 200 miles to the northwest, and not Ducie.

When the three boats left Henderson on December 27, 1820, they left three crew members behind who chose to remain and await a rescue; this rescue did take place on April 5, 1821 when Captain Raine of the SURRY took them off.

Two of the boats were finally picked up by different vessels. The third boat became separated from the other two and was never seen again. Beechey, who visited both Ducie and Henderson in 1825, briefly relates the story of the ESSEX and its survivors (Beechey, 1832, pp. 50-51). In his account he says that a merchant ship, which he does not identify, found on Ducie the wreck of a boat and four skeletons, and feels it is not improbable that these remains were those of the lost third boat of the ESSEX and her crew. In Chase's account and in the contemporary newspaper accounts, the name Ducie is variously spelled as Ducie's, Dernier's, Ducier's and Duces.

The first extensive description of Ducie, reprinted below, was furnished by Captain F. W. Beechey, R.N., who visited the island in HMS BLOSSOM in November 1825. He did not land but had the small boats circumnavigate the atoll (Gough, 1973, p. 74).

"Ducie's Island is of coral formation, of an oval form, with a lagoon or lake, in the center, which is scarcely above the water's edge. The height of the soil upon the island is about twelve feet, above which trees rise about fourteen more, making its greatest elevation about twenty-six feet from the level of the sea. The lagoon appears to be deep, and has the entrance into it for a boat, when the water is sufficiently smooth to admit of passing over the bar. It is situated at the southeast extremity, to the right of two eminences that have the appearance of sand-hills. The island lies in a north-east and south-west direction, is one mile and three quarters long, and one mile wide. No living things, birds excepted, were seen upon the island; but its environs appeared to abound in fish, and sharks were very numerous. The water was so clear over the coral, that the bottom was distinctly seen when no soundings could be had with thirty fathoms of line; in twenty four fathoms, the shape of the rock at the bottom was clearly distinguished. The coral-lines [sic] were of various colours, principally white, sulphur, and lilac, and formed into all manner of shapes, giving a lively and variegated appearance to the bottom; but they soon lost their colour after being detached.

"By the soundings round this little island, it appeared, for a certain distance, to take the shape of a truncated cone having its base downwards. The north-eastern and south-western extremities are furnished with points which project under water with less inclination than the sides of the island, and break the sea before it can reach the barrier to the little lagoon formed within. It is singular that these buttresses are opposed to the only two quarters whence their structure has to apprehend danger; that on the north-east, from the constant action of the trade-wind, and that on the other extremity, from the long rolling swell from the south-west, so prevalent in these latitudes; and it is worthy of observation, that this barrier, which has the most powerful enemy to oppose, is carried out much farther, and with less abruptness than the other.

"The sand-mounds raised upon the barrier are confined to the eastern and north-western sides of the lagoon, the south-western part being left low, and broken by a channel of water. On the rocky surface of the causeway, between the lake and the sea, lies a stratum of dark rounded, particles, probably coral, and above it another, apparently composed of decayed vegetable substances. A variety of ever green trees take root in this bank, and form a canopy almost impenetrable to the sun's rays, and present to the eye a grove of the liveliest green." (Beechey, 1831, pp. 44-45).

Beechey's account is copied almost verbatim in Findlay's Directory (Findlay, 1851, pp. 844-845; 1884, pp. 595-596). Beechey's survey was the basis for the first published Admiralty chart of the island, and for a hundred years it was the only map available to navigators (Figure 1).

Two years later, on December 7, 1827, the famous traveler-collector, Hugh Cuming, reached Ducie in his vessel DISCOVERER, nine days after leaving Easter Island. He was the first to land on the atoll, and in his letter to Dr. Hooler of the Royal Botanic Gardens at Kew, he has this to say of Ducie, which he called "Ducies Island" "This is one of the low coral lagoon islands not 10 feet above the level of the sea: has a number of trees and a small stunted grass . . . . Not any fresh water could one find." (St. John, 1940, p. 86).

One year later, on December 17, 1828, the island was encountered by J. A. Moerenhout in a voyage from Cobija, then a port in Peru but now in Chile, to Tahiti (Moerenhout, 1837, vol. 1, pp. 28-30). Moerenhout, a Belgian trader in Tahiti who later became U.S. Consul in Tahiti, is the author of one of the earliest detailed descriptions of the culture of the inhabitants of French Polynesia. He spent only a few hours at Ducie, and from his account we are not certain that he actually landed on the island, as his observations are very limited. He, like Beechey, mentions the presence of a pass on the southeast side. His description of the vegetation as consisting of Pandanus and Hibiscus must be taken with reservations, and is an indication that he probably did not go ashore. Hugh Cuming, who visited the island a year earlier, does not mention these plants, and as a collector of botanical specimens would probably have commented on their presence had he found them there; in his letter to Dr. W. J. Hooker, the botanist, describing his trip and some of the plants he found, he mentions finding "shrubs and palms [Pandanus]" on Henderson Island (St. John, l.c.).

Captain J. Worth, of HMS CALYPSO sighted the island in February, 1848, and comments on the difficulty of seeing the island until within 8 or 9 miles of it. He further states that the people of Pitcairn Island believe the island to be inhabited, a statement which he doubts (Findlay, 1851, p. 845).

Since Beechey, the island has rarely been visited. The people of Pitcairn regularly sail to Oeno and Henderson Islands, visiting the latter to obtain miro wood (Thespesia populnea) for their carving, but of those living now on the island only 87-year-old Frederick Christian has been to Ducie; he was 19 at the time.

On 5 June, 1881, in calm seas and with a bright moon shining, the brig ACADIA, bound from San Francisco for Cork, Ireland, by way of Cape Horn with a cargo of wheat was wrecked on Ducie. It took the crew 15 days, struggling against bad seas and head winds in two boats to reach Pitcairn after a brief stopover on Henderson. The crew remained on Pitcairn for seven months before they were able to get back to the United States and England. Two members of the crew returned to

Pitcairn in later years to make their homes there--Philip Coffin of Massachusetts and Lincoln Clark of California. Both have descendants living on the island.

In the following year a vessel that visited the island saw the remains of "a large wreck lying on the NW side" (Findlay, 1901, p. 175), undoubtedly the remains of the ACADIA.

During our visit to Ducie in January, 1971, we found numerous pieces of wreckage that very probably are the remains of the ACADIA--pieces of wood and copper sheathing--above the high coral rubble rampart on the northwest side, under the Tournefortia trees, and on the lagoon side of the same part of the atoll more wood, iron spikes, a much-rusted pair of bollards, and a fair-lead chock. These were on the rubblestrewn area that lies between the main clumps of Tournefortia trees and the lagoon shore line; in this particular part of the island this area is fairly wide.

In 1902, Captain G. F. Jones, under a commission from Mr. R. T. Simons, British Consul at Tahiti, went in a cutter with a crew of Pitcairn Islanders, to Oeno, Henderson, and Ducie, and formally annexed these islands to the British Empire.

In March, 1922, members of the Whitney South Sea Expedition, put into the field by the American Museum of Natural History, spent eleven days at Ducie. This group with Rollo H. Beck as leader and including Ernest H. Quayle, and Charles C. Curtis, sailed from Pitcairn on the schooner, FRANCE, and after stopping briefly at Henderson Island, reached Ducie on the afternoon of March 19, 1922. For the next eleven days, they went ashore almost every day, heaving to at night and often having to beat their way back to the island after being blown out of sight of the island; during the day they were able to anchor in shallow water off the atoll. The chart that the expedition used was the currently available one based on Beechey's survey of 1825 and does not show the pass on the southwest side. None of the accounts of their visit mentions circumnavigating Ducie to discover other possible landing places. Their landings were apparently all made at one spot, on the east side of the northeast point of the atoll, where they were able to land through a space in the reef directly on the shingle beach. Most of their study was concerned with the birds of the island but the members of the party also noted other life found here, all of which is mentioned in the following section on the fauna and flora. In addition to the Tohonu trees (Tournefortia) Quayle notes "a few rare clumps of coarse grass Lepturus " and "one vine of a common Tuamotu shrub =Epigaea? " (Quayle, 1922). Considerable wreckage from the ACADIA was found, including the "bottom of the hull--keel upward" (Quayle, 1922) resting on the shore of the lagoon.

The scientific party and crew of the FRANCE suffered an attack from ciguatera poisoning, some to a greater extent than others, after partaking of a fish called by the crew "Ruhi," the Tuamotuan name for the jack Caranx lugubris. This fish was eaten without ill effects at Henderson.

On January 3, 1935, members of another ornithological expedition--the Templeton Crocker Expedition, sailing on the ZACA--landed on the Ducie. Using a tracing of a chart that the captain had found on Pitcairn, they landed on the north-west side of the atoll, actually the north side , apparently also unaware of the pass into the lagoon on the south side.

James P. Chapin, the leader, mentions (Chapin, 1936, p. 293) that the only plant they found on the atoll was Tournefortia. The stunted grass Lepturus that Hugh Cuming found over a hundred years earlier, and that was still present, along with Epigaea, when the Whitney Expedition were on Ducie, may have vanished during one of the storms that on occasion must sweep over the atoll. In his field notes Chapin lists the birds seen during the one day they spent on the atoll and mentions all other forms of life seen; these are also mentioned in the later section on the fauna of the atoll.

In January 1936, Captain Irving M. Johnson on the schooner YANKEE reached Ducie, landing also on the north side of the atoll. The crew of the YANKEE, consisting of experienced seafarers and learning young people spent only about three hours there. On leaving Ducie they also experienced an epidemic of ciguatera poisoning caused by eating fish caught while crossing Ducie's reef (Johnson, 1939, p. 83). This incident was reported to the U.S. Hydrographic Office and was duly added to the next edition of the Sailing Directions for these islands. In a personal communication from Johnson, he has said that he is ninety percent certain that the fish that poisoned them was the yellowtail (Seriola lalandi), a fish that the crew had eaten at Easter Island with no ill effects. This species has not previously been implicated, as far as we are aware, in ciguatera poisoning, though other members of the genus Seriola have been involved. The genus belongs to the same family, Carangidae, as does the fish, Caranx lugubris, that caused the poisoning experienced by the FRANCE and mentioned above.

In August, 1937, HMS LEANDER on her way from Europe to New Zealand visited Ducie as well as Henderson and Oeno, and carried out an aerial survey of all three islands. This survey forms the basis for the most recent nautical chart of Ducie. At the same time the British flag was replanted on each island (Pacific Islands Monthly, September 1937, p. 6). A new inscription was nailed up: "This Island Belongs to H.B.M. King George VI. It Was Visited by H.M.S. Leander on 4th August 1937 signed J. R. Rivett--Carnac, Capt. R.N." (Report Henderson, etc., 1937).

The LEANDER arrived off the northeast corner of Ducie in mid-morning on August 4 and almost immediately the Walrus, a single-engine amphibian biplane, was launched to carry out an aerial photographic survey. They reported to the ship that the only possible landing place was on the northwest coast, as stated in the Sailing Directions. A channel was seen running out to the reef flat in the southwestern corner but it appeared to be generally shallow and had a heavy surf breaking across the mouth. This surf was due to the big swell from the southwest noticed by the LEANDER at the time of its visit. From the aerial photographs a tracing

was made which was the basis for the revised chart of the atoll; the atoll was discovered to be more rounded and oval, with its long axis oriented on an east-west axis (Figure 2).

A half hour later a cutter with skiff in tow was launched and a shore party landed on the beach a few hundred yards east of the northwest corner of the main island, after wading across the last twenty yards of reef. Here a flagstaff was erected, the Union Jack hoisted, and the sign mentioned above was nailed up.

After an hour and a half ashore spent in investigating the island and lagoon for possible aircraft landing sites, the party returned to the ship, not without difficulty, as the skiff, while crossing the reef, was swamped by the surf. An intended further reconnaissance of the atoll was abandoned in view of the landing difficulties, and because of the reports from the aircraft, which had returned to the ship shortly after noon. In the early midafternoon, the LEANDER left Ducie and headed for Henderson.

CURRENT INFORMATION ON ISLAND

Only a few lines are devoted to Ducie in such books as The Pacific Islands Pilot, Vol. 3 (Hydrographic Dept., Admiralty, London, 8th edition, 1957, p. 61) and Sailing Directions for the Pacific Islands, Vol. 3 (U.S. Navy Hydrographic Office Pub. 80, 6th edition, 1952, p. 87).

As mentioned above, an aerial survey made in 1937 during a visit of HMS LEANDER to the island is the basis for the chart included on H.O. Chart 1977 of the U. S. Navy Hydrographic Office (here reproduced as Figure 2). The chart shows the island to be 1.3 miles in greatest diameter from NE to SW, measured to the outer edges of the islets, the largest extending along the entire north side and about halfway down the eastern side; this islet we have called Acadia Island because of the presence on it of remains of the wreckage from this vessel. The other three islets are on the south and southwest sides; from east to west we have named these Edwards, Pandora (both east of the pass), and Westward Islet on the west side of the pass. All are shown on the chart as wooded, although in actuality Westward Islet is without any vegetation.

According to the Sailing Directions, the only apparent entrance to the lagoon in 1882 was on the southeastern side, but this was blocked by a sand bar on which surf broke. The HMS LEANDER stopped at the island in 1937, and reported that there was no boat passage to the lagoon. As we have seen above, the survey did report a shallow channel leading from the lagoon, but a surf breaking across its mouth made it impractical to use. Landing was possible only, with difficulty, on the northern side, just east of the northwest point. It is furthermore reported that the island was a maximum of 12 feet above sea level, and that the highest trees were 14 feet. The lagoon appeared to observers to be deep, and some of the fishes in the vicinity of the island were said to be poisonous, a comment due to the experience of Captain Irving Johnson in 1936.

VISIT TO DUCIE IN 1971

The authors visited Ducie Island for a period of 2 1/2 days beginning January 13, 1971, on the 99-foot schooner WESTWARD of the Oceanic Foundation of Makapuu Point, Hawaii, during the course of a marine biological-archeological expedition to SE Oceania, supported by the National Geographic Society and the Oceanic Foundation. Most of the time was spent in collecting specimens in our special areas of interest, namely mollusks and fishes, leaving insufficient time for general observations.

When the WESTWARD arrived the wind was easterly, about 15 knots, the sea with a moderately heavy swell. The wind gradually abated during our stay until, at departure, it was about 5 knots, still easterly. The vessel approached from the west coming up on the island near its southwest point, just west of the opening to the lagoon as depicted on the chart. From there we turned north and completely circled the island with observers aloft (Figure 4). We saw no practicable landing place on the north coast of the atoll. Soundings were made using the fathometer, and it was found that there was an extension of the submarine shelf off both the northeast and northwest points of the atoll (Figure 2; our observations have been recorded on this chart, as the revised official chart gives no soundings). This corroborates Beechey's statement (see pp. 5, 6).

As we skirted the south side of the atoll it became apparent that a boat passage existed on the southwest side where the break in the reef is shown on the chart. There was prominent surf on either side of this broad pass, and an occasional swell came in through the outer part of the pass, but with easterly wind no swells broke entirely across the passage (Figure 5).

On the day of our arrival, at 1:30 p.m., a 15-foot, shoaldraft boat, powered by an outboard motor, was launched and taken through the passage, which became progressively more shallow as we approached the lagoon, with numerous coral heads lying just beneath the surface. For about the last 150 feet it was necessary to walk the boat to prevent the outboard propeller hitting the coral. Again, on January 15, four of us were returning from the lagoon to the ship in a 16 1/2-foot Boston whaler at 1 p.m. (extreme low water). The northwest side of the channel was impassable at this time; on the other side of the pass it was possible to walk the boat with the motor up but nearly an hour was spent in passing through the maze of coral heads in the inner part of the pass. A run through the passage within two hours on either side of high tide would be practical for an ordinary ship's boat providing there is careful surveillance for coral heads; this was actually experienced when we returned from the lagoon to the ship on the first day at about 5 p.m. With a heavy swell setting from the south or west, however, the passage would probably not be safe.

The greatest seaward extension of the reef occurs directly off the pass; the shelf beyond the breaker line extends approximately 300 yards offshore to a depth of 100 feet and then drops off more steeply. The WESTWARD anchored comfortably in 36 feet of water nearly half the distance from the pass entrance to the drop-off.

PHYSIOGRAPHY OF LAND MASSES

To the west of the boat passage at its entrance into the lagoon is an island shown on the chart as an almost circular wooded islet; this is what we are calling Westward Islet. In actuality, it appears from the sea to be a sandy island without trees, whereas it is in fact composed mostly of coral rubble, echinoid remains, and dead shells, the latter in places consisting almost entirely of Turbo argyrostomus L. (Figures 6 and 7). The islet is in the form of a horseshoe-shaped ridge with the open end facing the lagoon, and a central depression with a surface of fine sand mixed with coarser rubble. At extreme high tides and during storms with easterly winds this depression undoubtedly becomes filled with water from the lagoon which may account for the presence of sand. The highest point of this curved ridge is about 15 feet above mean high water. It seems likely to us that this islet never had any trees growing on it in modern times. It is also what Beechey in his description of Ducie called "two eminences that have the appearance of sand-hills." From certain angles viewed from off shore the horseshoe-shaped ridge does seem to consist of two low ridges, and undoubtedly the form of this island must have undergone changes during the intervening years.

From the islet a rubble spit extends along the lagoon shore in a northwesterly direction in a gently curving and narrowing arc, ending on the lagoon shore about three-fourths of the distance shown on the chart towards the western end of the large island. This spit consists of a deposit of coral rubble and some dead shells which appears to be gradually encroaching on the reef flat that in this area is an indurated pavement--a conglomerate of coral fragments and shells. Above the coarse rubble deposit is a secondary rubble ridge of more recent origin, composed of smaller fragments whose angle of repose is quite steep, and which appears to be built up by wave action from the lagoon (Figures 8 and 9). On the occasion of our visit, a channel between lagoon and reef was cut through this ridge (Figure 9).

Between the spit and the end of Acadia Island is a reef flat of a hard indurated pavement with occasional thin sand layers and some low raised rubble mounds which are just dry at high tide. Near the western end of Acadia Island is a channel between the lagoon and the reef flat, which was divided at the time of our visit by a small sand-rubble islet with the channel branch near Acadia Island deeper and about six feet wide and showing a current of about two knots at both high and low water; the other branch is somewhat wider and more shallow. Between the shallow pass on the south side of the atoll and the western end of Acadia Island is a rather broad reef flat (Figures 5 and 10) of which parts are covered by water at all times and other parts are exposed and dry most of the

time, particularly near Westward Islet and its rubble spit (Figure 11). Near the islet a considerable area of old beach rock is exposed between it and the reef flat (Figure 11).

The western end of Acadia Island is composed again of coral rubble ridges that merge on the ocean side into the rubble rampart above the shore line and that continue on the lagoon side as a steeply graded rubble beach (Figures 12 and 13) for about 800 yards before terminating in the beach rock and loose coral slabs and rubble that line the remainder of the lagoon shore of the island (Figure 14). The coral rubble rampart on the ocean side of the island is of varying height, reaching a maximum height of about 12 feet. It has a rather steep gradient and shows in places a more or less narrow platform at varying distances below the summit of the rampart which may be level with or slightly higher than the coral rubble surface of the island behind it (Figure 15). At the water line the rubble rampart either merges directly into the indurated beach rock or has stretches of sand between it and the reef flat.

The ocean reef behind the outer edge, broad on the northwestern side, becomes narrower on the northern side of the island (we did not visit the reef on the eastern side of the atoll) and consists for the most part of a somewhat uneven reef pavement flat, generally covered by a thin layer of sand and fine algal growth which may be thick in patches. On this outer third of the reef flat a conspicuous element of the fauna was the purple slate-pencil urchin Heterocentrotus trigonarius. Further in on the reef the mollusk Cerithium tuberculiferum was the most abundant species, with Conus miliaris and Morula uva less common. Also relatively abundant were specimens of the large worm shell Dendropoma gigantea, their tubes cemented to the surface of the pavement rock. In one area near the boat passage large specimens of Conus ebraeus were rather common. Scattered over the reef are occasional small patches of live coral, and erratic pieces of storm-loosed coral rock. Closer to shore are ridges of beach rock of a more or less fine texture. In some places this beach rock is restricted to the shore line and consists of broad tilted slabs (Figure 16). In other places there are a series of ridges parallel to the shore, more or less wave-worn, some showing a series of transverse solution grooves worn in the rock by the action of the water pouring over them (Figure 17). Frequently one encounters patches of irregularly consolidated fragments of reef rock strongly etched by atmospheric agencies (Figure 22).

The irregular hard bottom of the channels between these ridges is in places covered with a thin layer of sand, in some areas with an accumulation of wave-worn rocks of various sizes. In the sand Conus miliaris, C. nanus and Morula uva are moderately common, while on the ridges and shoreline rocks Drupa ricinus and Morula granulata are found intertidally.

Behind the crest of the ocean-side beach rubble rampart, the gray coral fragments that cover the surface of the island stretch across to the lagoon side. Almost immediately on leaving the rampart crest,

specimens of Tournefortia are encountered, a tree that is found over the entire interior of the island, forming in places dense thickets (Figures 18 and 19). Under the trees and available debris on or just behind the crest one can find the hermit crab Coenobita perlata usually inhabiting shells of Turbo argyrostomus. The surface of the interior of the island consists of irregular coral rocks exposed to view. There are in places shallow depressions and ridges in the interior that bring the maximum height of the island to about 15 feet.

On the lagoon side there is in most places a greater expanse of open ground between the vegetation and the water than on the ocean side. Near the trees, the surface is covered with irregular coral fragments, but towards the shoreline one often encounters stretches of bare coral rock, a conglomerate of coral fragments and sand and occasional shells such as Turbo argyrostomus and Tridacna maxima, the latter often with both valves still together. Interspersed with these areas of bare rock are low ridges or tongues of loose coral rubble, some of which consist almost entirely of small fragments of Acropora nasuta. The shoreline is rather irregular with occasional little embayments, and consists mainly of loose coral blocks and fragments, although in some places solid and irregular coral rock fringes the water.

From visual observation, and from statements made by the two Pitcairn Islanders who accompanied us to Ducie, and who did walk around the lagoon completely, on the eastern part of Acadia Island the lagoon shore is similar to that of the western part, except that it is narrower between the trees and the water.

The two smaller islands east of the boat passage which we have named Pandora Islet (the larger, more western one) and Edwards Islet (the smaller one to the east) have a sand or sand and fine coral rubble beach bordering the lagoon. These beaches merge above into the weathered coral blocks and rubble as found on the surface of Acadia Island.

The stretch of open reef between Acadia Island and Edwards Islet is apparently dry most of the time under normal tidal conditions. Steve Christian and Noggie Young, the Pitcairn Islanders who were with us on our visit, crossed this reef at approximately mean high tide level and stated there was no water coming over it and no channel evident. It appears, therefore, that the main and possibly only channels between the lagoon and the ocean are the boat passage on the southwest side and the small channels that are situated between Westward Islet and the western end of Acadia Island.

LAGOON

When the LEANDER surveyed the atoll in 1937, observations from the western end of Acadia Island and from the air showed that the lagoon was rather shallow in the center and had apparently two almost parallel channels of deeper water on the western side.

During our stay at the atoll about eight hours were spent by various members of our party in exploring the lagoon by diving, snorkeling, and being towed on the surface.

The lagoon is heavily interlaced with irregular coral heads, many interconnected at their bases. Some of the heads nearly reach the surface but away from the shore and the channel most are at least 6 feet below the surface. Fully half of the bottom is hard, the remainder sandy or silty sand. The sandy floor of the deeper part of the lagoon has a depth of about 50 feet; the deepest sounding we made was 53 feet.

Visibility in the lagoon was about 75 feet, and the water had a dark green color. A water sample from the deepest part of the lagoon had a salinity of 38‰. The temperature of the lagoon water at noon near the center, both at the surface and at 53 feet, was 26.5 °C. We failed to take a temperature reading of the water outside the reef, but we noticed while diving there that the water was cooler. The sea temperature five days earlier at Pitcairn, which lies at nearly the same latitude as Ducie, was 24.8 °C.

These readings, limited though they are, show temperatures noticeably cooler than those cited for Kapingamarangi in the Caroline Islands, an atoll close to the equator, and considerably deeper and larger than Ducie. Here in the summer months the surface temperature near the center of the lagoon was found to be between 29.5 °C. and 30.0 °C., while the sea surface temperature in the vicinity of the atoll averages 28.6 °C. (McKee, et al., 1959, p. 553). Lagoon temperatures for the more comparable atoll of Ifaluk, Caroline Islands, were also higher, showing a mean of 28.4 °C. near the shore (Tracey, et al., 1961, p. 12).

The most striking thing about the lagoon is the paucity of life. Most of the coral heads consist primarily of dead coral rock. Usually small colonies of live coral, mainly Montipora species, are found. Occasionally, one may encounter a head which is nearly all live coral (Figure 20), of which the principal sort is Montipora sp. cf. M. bilaminata. The dominant algae on the coral heads are the coralline red alga (probably Porolithon onkodes (Heydrich) Foslie and P. gardineri (Foslie) Foslie, according to Roy T. Tsuda), which forms small projections and gives the coral heads a pale pinkish hue near the surface, and the green Microdictyon. The latter can cover nearly half of the area of the dead surface of some of the heads. One other green alga, Caulerpa racemosa (?), grew in profusion in sheltered locations in some coral heads in the lagoon near the small boat passage. Except for a few bluegreens, no other algae were seen in any quantity.

The overturning of rocks and the cracking of dead coral rock with a geologist's hammer revealed very few invertebrates, such as ophiuroids, crustacea, and mollusks. A prolonged search for mollusks around a dead coral head near the lagoon edge, in about 4 feet of water uncovered only scattered dead valves of the bivalve Barbatia parva. A black holothurian, about 8 inches long, to which sand grains adhere was common on the lagoon shoals.

Most obvious was the dearth of fishes. One could swim around some coral heads 20 feet or more in height, and not see a single fish in spite of close inspection of holes and underneath ledges. This was particularly true away from the lagoon shore. A coral head of comparable size and shape to those of the Ducie lagoon would be populated by several hundred small fishes in the lagoon of a typical Pacific atoll.

During a total of about 8 hours of towing, snorkeling, and diving in the Ducie lagoon, 47 species of fishes were sighted. The most common species, relatively speaking, on or near the lagoon coral heads were Kyphosus fuscus, Acanthurus leucopareius, Scarus gibbus, an undescribed yellow pomacentrid (perhaps Glyphidodontops) and Thalassoma lutescens, all of which are abundant in outer reef areas. Of the seven species of butterfly fishes observed, Chaetodon ulietensis was most often encountered (Figure 25). Along the shore occasional small schools of Kuhlia marginata and Neomyxus leuciscus were seen, and in the rocky shallows on the north shore of the lagoon, at least, the blenny Istiblennius paulus was abundant.

None of these fishes appear to be plankton-feeding species which may also be reflecting the apparent low level of circulation in the lagoon. Zooplankton feeders, such as species of Chromis encountered outside the reef at Ducie, are tied to specific areas of reef and are thus dependent on current to bring their food to them.

CHANNELS AND WATER EXCHANGE

As has been mentioned earlier the only channels between the lagoon and the ocean are the boat passage on the southwest side, and the small channels situated at the northermost extension of Westward Islet and the western end of Acadia Island. These smaller channels, however, do not appear to have a great influence on the water exchange between ocean and lagoon.

The boat passage on the southwest side of the atoll, between Pandora and Westward Islets, is about 100 yards wide, and is very shallow, especially on the western side. At the ocean end of the passage there is a broad shelf that extends seaward some 300 yards from the outer end of the channel. At low tide, which at the time of our visit was about 1230, even a shallow-draft boat must be pushed over and around the many coral heads that are scattered throughout the pass. At high tide, a boat can be maneuvered through the pass, but even then a close watch must be kept to avoid the coral heads.

Observations on tides were made on January 14 (full moon was on January 11), principally by Denis N. Hewett, and we are indebted to him for the preparation of the tidal graph (Figure 3).

With the pass so shallow and broad no strong current was encountered on any of our passages. Denis Hewett, in making his tidal observations, noted that at 0930 the current near the pass was negligible, and at 1600,

about midway between low and high water, the current was about 2 knots. The shallowness of the boat passage, the fairly small tidal fluctuation, about 14 to 15 inches, and the fact that there are no channels on the northern or eastern sides of the atoll open to the prevailing currents, lead to the conclusion that the lagoon is not well flushed. This may be a major factor accounting for the relative paucity of life in the lagoon.

SUBMARINE FEATURES OF OCEAN REEF

Most of the bottom off the outer reef consists of dead coral encrusted with red coralline algae. At one time in the not-too-distant past, the outer reef of Ducie at the areas we investigated was nearly completely covered with live coral of several species, particularly an Acropora with branches of only a few inches in length. The coralline red alga has not grown to the extent of bridging over the tips of the branches of this coral, whereas it completely covers the plate-like or encrusting species. An observer was towed over a depth of about 20 to 30 feet from the boat channel to the northwest corner of the atoll where there is another seaward extension of reef. This entire distance presented a somewhat undulating bottom of a uniform pale pinkish hue from the nullipores. Grooves with coral rubble and coarse sand and large coral blocks occasionally broke the monotony of the expanse of dead reef. One dive in 30 to 40 feet in this area on the west side resulted in the finding of only a few small colonies of live coral. An exception was the colony of Acropora nasuta about a foot in diameter, from which diver Rich Costello is shown taking a sample (Figure 21). The deep blue Diadema (D. savignyi or D. setosum, and the slate pencil urchin Heterocentrotus mamillatus (Figure 23) were very common on the outer reef from about 20 to at least 80 feet; the latter ranged in colors from light red to light yellowish green. Inshore where the surge is stronger and up onto the outer third of the reef flat, the deep purple slate-pencil urchin was abundant.

A brief exploratory dive from 100 to 180 feet directly off the boat passage revealed a sloping bottom mainly of coral rubble consisting of small branches of Acropora.

Everyone diving at Ducie came up in wonderment at the obvious mass mortality of the corals in all areas we investigated. Although we did not dive outside the atoll on the northern or eastern sides, we strongly suspect that the corals will be dead and encrusted with nullipores there too. It is only natural to speculate on the cause of the death of the corals. One possibility would be the crown-of-thorns starfish, Acanthaster planci; however, we collected only a single large individual of this asteroid on a lagoon coral head and saw no others in spite of special effort to find more. Of course, a huge infestation of the starfish which might kill off the corals of the area could die off after the coral food supply was eliminated. A more plausible explanation would be a kill by a drop in temperature. At 24°40' south latitude, Ducie might be subject at rare intervals to an intrusion of cold water from more southern latitudes.

Outside the lagoon, the number of species of fishes was much greater than inside the lagoon, as were the number of individual fishes, but still the reef had notably fewer fishes than one would expect to find on a Pacific atoll--particularly an uninhabited one not subject to any fishing pressure.

In addition to the species which were most common in the lagoon, the fish fauna of the outer reef area was dominated by the wrasse Thalassoma quinquevittata? (especially inshore), the damselfish Eupomacentrus sp., the goatfishes Parupeneus bifasciatus (Figure 29) and P. cyclostomus, Chromis margaritifer and an undescribed species of Chromis-like pomacentrid. Among the larger fishes the wrasse Coris aygula, the groupers Variola louti, Epinephelus fasciatus and E. tauvina, and the jacks Caranx lugubris and Seriola lalandi were most common (Figure 28). When the WESTWARD first circled the island five of the Seriola, from 500 to 1080 mm fork length, were caught trolling along, with one yellowfin tuna 850 mm fork length. At anchorage black jacks (Caranx lugubris) accumulated in such numbers, along with Kyphosus, that it was usually not possible to get a baited hook through these fishes to the bottom without the bait being seized. After keeping enough for shark bait, further C. lugubris which were caught were marked by tying a scrap of rag to the tail. Some of these were caught again the same day. While swimming next to the WESTWARD, one of the crew, James R. Haywood, was able to feed the black jacks by hand with pieces of octopus.

In "A Guide to Pitcairn" (revised edition, 1970) eight lines are devoted to Ducie. Among the remarks is the statement, "The sharks at Ducie Island are said to be extremely dangerous, . . ." While shark fishing at anchorage the first afternoon and evening, we caught three Galapagos sharks from 7 to 7.5 feet long and one gray reef shark (C. amblyrhinchos) 5.6 feet long. This would certainly seem to corroborate that statement. In spite of continued shark fishing, however, during the rest of our stay we caught only a single small gray, and while diving only one shark, a gray about 5 feet long, was sighted in the small boat passage.

While handline fishing in about 120 feet off the small boat channel, Guy S. Haywood, M.D., and his son James of the crew of the WESTWARD brought a small shark to the boat which they believed was the white-tip reef shark, Triaenodon obesus, but it was lost. Their catch for three hours in the morning consisted of 28 individuals of Variola louti (245-480 mm SL), 8 of Epinephelus fasciatus (220 to 240 mm SL), 4 of Bodianus bilunulatus, and one each of the following: Epinephelus tauvina (350 mm SL), Coris aygula (460 mm SL), Parupeneus trifasciatus, P. cyclostomus, and Cheilinus rhodochrous.

Most of the fishes enumerated in the list to follow were taken with rotenone and by spearing. Those listed as sight records are usually represented by specimens from Pitcairn, Oeno, or Henderson Islands. Although two and a half days would seem insufficient to claim to have collected most of the species of fishes of an island, we believe we have

taken or observed more than three-fourths of the inshore fish fauna of Ducie. Our last afternoon of towing on the outer reef along the west side and diving at two locations revealed only two species of fishes that we had not seen previously at the island. It is evident that Ducie has a very impoverished fish fauna--even more than the islands of Pitcairn, Oeno and Henderson. In view of its greater isolation, this is not unexpected. Also there may be ecological reasons for the absence of some species. For example, unicornfishes Naso unicornis and N. lituratus, which were not seen at Ducie, are common at Pitcairn where the many rocks of the inshore waters are thickly carpeted with brown algae (particularly Sargassum coriifolium J. Ag., and the branching form of Lobophora variegata (Lam.) Womersley; see Tsuda, in press. These species of Naso feed heavily on brown algae. No brown algae were seen at Ducie.

BOTANY

As mentioned earlier, the only Phanerogam that we saw on Ducie is the tree heliotrope Tournefortia argentea Linnaeus f., found abundantly on all the islands of the atoll except Westward Islet. Earlier visitors record a grass, probably of the genus Lepturus (Cuming, 1827, in St. John 1940, p. 86; Quayle, 1922), and "one vine of a common Tuamotu shrub" (Quayle, 1922). In 1936, Chapin (1936, p. 293) could find only the Tournefortia present on Acadia Island.

Species of lichens were seen on the bark of the Tournefortia but were not collected.

Two species of crustose coralline algae were collected, and identified by Dr. Roy T. Tsuda (in litt.) as Porolithon onkodes (Heydrich) Foslie and P. gardineri (Foslie) Foslie.

ZOOLOGY

Mammals

We saw none during our visit, but E. H. Quayle, in his journal for March 22, 1922, notes that he "chased a rat into an old hollow log." This is probably the Polynesian rat Rattus exulans Peale. The crew of HMS LEANDER also noted seeing several rats during their visit.

Birds

The bird life on Ducie is the most striking element of the land fauna, but as none of our group were ornithologists we made no lists of the species we encountered. In my diary (HAR) I did note the prevalence of the fairy and sooty terns and the presence of several species of boobies.

The following list is a collation of the species mentioned in the journals of E. H. Quayle, R. H. Beck, and James P. Chapin, as having been collected and observed. In addition the list published by King (King, 1967) has been utilized in the preparation of the present one.

Procellariidae

Pterodroma neglecta (Schlegel) Kermadec Petrel

For a discussion of the coloration of this and the following three species see Murphy and Pennoyer, 1952. Quayle's journal should be consulted for interesting notes and sketches on these and other birds found on Ducie.

Pterodroma alba (Gmelin) Phoenix Petrel
Pterodroma arminjoniana heraldica (Salvin) Herald Petrel
Pterodroma ultima Murphy Murphy's Petrel
Puffinus nativitatus Streets Christmas Shearwater

Phaethontidae

Phaethon rubicauda Boddaert Red-tailed Tropicbird

Sulidae

Sula dactylatra Lesson Blue-faced Booby
Sula sula (Linnaeus) Red-footed Booby

Fregatidae

Fregata minor (Gmelin) Great Frigatebird

Laridae

Sterna fuscata Linnaeus Sooty Tern
Procelsterna cerulea (Bennett) Blue-gray Noddy

"Obtained four little ternlets of the half dozen pairs and a single or two observed. The pairs were evidently on their way seaward early in the morning, but two singles I found hanging around much later" (Quayle, p. 386).

Anous stolidus (Linnaeus) Brown or Common Noddy
Anous tenuirostris (Temminck) Black or Lesser Noddy
Gygis alba (Sparrman) White or Fairy Tern

Scolopacidae

Numenius tahitiensis (Gmelin) Bristle-thighed Curlew

"Two curlews . . . were seen" (Beck, p. 104)

Crocethia alba (Pallas) Sanderling

"A single sanderling . . . seen" (Beck, p. 104)

Heteroscelus incanus incanus (Gmelin) Wandering Tatler

"Several tatlers . . . were seen" (Beck, p. 104)

Dead birds were plentiful on the atoll, most of them more or less mummified. On a sloping, curved rubble beach the bodies of dead birds formed a windrow a foot above the water's edge (Figure 13). Several birds in obviously weakened condition were seen near the lagoon shore and in the nearby shallow water.

We were very much struck by this phenomenon, never having encountered this on any of the numerous coral atolls we had visited, and discussed the possible causes of this mortality. Regrettably we did not bring back with us any bodies of the dead birds.

That we were not the only ones to meet with this occurrence is seen in the following excerpt from the entry for January 3, 1935, in J. P. Chapin's journal: "Some of these petrels [Murphy's Petrel] today were found in the water as tho sick. Jaques got one. Jack and I saw another (the larger species) Kermedec Petrel struggling in surf. Two dead ones (long decomposed) found on land."

The fact that none of the accounts of the participants of the earlier Whitney South Sea Expedition mention seeing dead birds lying on the ground during their ten-day visit, makes it appear likely that this occurrence is of relatively recent date. Chapin mentions seeing only two dead birds in 1935, whereas during our visit we must have seen several hundred bodies in varying stages of decomposition.

Reptiles

Scincidae

Emoia cyanura (Lesson)

One specimen was shot by E. H. Quayle (AMNH No. 23719). This species is found from the Solomon Islands eastward to the Marquesas, Ducie, and Rapa.

Gekkonidae

James P. Chapin reports in his journal for January 3, 1935: "Dr. Lyman reported seeing one lizard, which he did not catch. He seemed sure it was not a skink, and said it looked more like a small gecko, with dark chevrons on back, and a swollen (or broad) tail." This may be either of the two common Polynesian geckos - Gehyra oceanica (Lesson) or Lepidodactylus lugubris (Duméril and Bibron).

Fishes

(by John E. Randall)

The only fishes hitherto recorded from Ducie are single specimens of two oceanic species taken from sea birds during the Whitney South Sea Expedition in 1922 and reported by Nichols (1923). He identified these as the flyingfish Halocypelus evolans (Linnaeus) and the snake mackerel Lemnisoma thyrsitoides Lesson. These specimens were kindly sent on loan by Gareth J. Nelson of the American Museum of Natural History. The flyingfish (AMNH 6266, about 140 mm standard length) is in very poor condition. It appears to be Exocoetus, hence probably E. volitans (Linnaeus). The other specimen (AMNH 8261, 193 mm SL) is a Gempylus with 31 dorsal spines.

List of Fishes Collected

Carcharhinidae
- Carcharhinus galapagensis (Snodgrass and Heller)

Muraenidae
- Anarchias seychellensis Smith
- Gymnothorax eurostus (Abbott)
- Gymnothorax panamensis (Steindachner)

Ophichthidae
- Muraenichthys laticaudata (Ogilby)

Moringuidae
- Moringua cf. ferruginea Bliss

Synodontidae
- Saurida gracilis (Quoy and Gaimard)

Fistulariidae
- Fistularia petimba Lacépède

Ophidiidae
- Dinematichthys sp. (yellow)

Holocentridae
- Adioryx spinifer (Forsskål)
- Flammeo sammara (Forsskål)
- Myripristis sp. (to be described by D. W. Greenfield)
- Myripristis amaenus (Castelnau)
- Myripristis murdjan (Forsskål)

Scorpaenidae
- Scorpaena sp.; possibly tinkhami Fowler
- Scorpaena sp.

Apogonidae
- Apogon sp.
  with dark stripes
- Apogon sp.
  Red, blackish posteriorly on caudal peduncle
- Apogon coccineus Rüppell
- Cheilodipterus quinquelineatus Cuvier and Valenciennes

Serranidae
- Genus sp.
- Cephalopholis argus Bloch and Schneider
- Epinephelus fasciatus (Forsskal)
- Epinephelus melanostigma Schultz
- Epinephelus socialis (Günther)
- Epinephelus tauvina* (Forsskal) (350 mm SL)
- Variola louti (Forsskal)

Pseudogrammidae
- Pseudogramma polyacantha (Bleeker)

Cirrhitidae
- Paracirrhites forsteri (Bloch and Schneider)
- Paracirrhites hemistictus (Günther)

Kuhliidae
- Kuhlia marginata (Cuvier and Valenciennes)

Kyphosidae
- Kyphosus fuscus* (Lacépède)

Priacanthidae
- Priancanthus cruentatus (Lacépède)

Carangidae
- Caranx lugubris Poey
- Seriola lalandi Cuvier and Valenciennes

Lutjanidae
- Lutjanus kasmira (Forsskal)

Mullidae
- Mulloidichthys vanicolensis (Cuvier and Valenciennes)
- Parupeneus bifasciatus (Lacépède)
- Parupeneus cyclostomus (Lacépède)
- Parupeneus trifasciatus (Lacépède)

Chaetodontidae
- Chaetodon auriga Forsskal
- Chaetodon flavirostris Günther
- Chaetodon lunula (Lacépède)
- Chaetodon mertensii Cuvier and Valenciennes

Chaetodon ornatissimus Cuvier and Valenciennes
Chaetodon quadrimaculatus Gray
Chaetodon reticulatus Cuvier and Valenciennes
Chaetodon ulietensis Cuvier and Valenciennes
Chaetodon unimaculatus Bloch
Forcipiger flavissimus Jordan and McGregor

Pomacanthidae
Centropyge hotumatua Randall and Caldwell
Centropyge flavissimus (Cuvier and Valenciennes)
Centropyge loriculus (Günther)

Pomacentridae
Abudefduf sordidus (Forsskål)
Genus sp. (Abudefduf sp. one of Harry, 1953)
Chromis agilis Smith
Chromis vanderbilti (Fowler)
Glyphidodontops sp. (yellow)
Eupomacentrus sp.
(blackish near-vertical lines on body; caudal peduncle and fin yellow)
Eupomacentrus fasciolatus (Ogilby)
Plectroglyphidodon imparipennis (Sauvage)

Labridae
Anampses caeruleopunctatus Rüppell
Bodianus bilunulatus (Lacépède)
Cheilinus rhodochrous Günther
Coris aygula Lacépède
Labroides dimidiatus (Cuvier and Valenciennes)
Labroides rubrolabiatus Randall
Macropharyngodon meleagris (Cuvier and Valenciennes); "pardalis" phase
Pseudocheilinus tetrataenia Schultz
Stethojulis bandanesis (Bleeker)
Thalassoma sp. close to quinquevittatus (Lay and Bennett)
Thalassoma lutescens (Lay and Bennett)
Thalassoma purpureum (Forsskal); including "umbrostygma" phase

Scaridae
Scarus chlorodon* (Jenyns) (405 mm SL. male; dorsal filament 62 mm)
Scarus fasciatus* Cuvier and Valenciennes ("schlegeli" phase, but deformed)
Scarus fraenatus Lacépède
Scarus ghobban Forsskål
Scarus gibbus Ruppell
Scarus jonesi* (Streets) (345 mm SL. male)
Scarus lepidus Jenyns
Scarus sordidus Forsskål

Blenniidae
- Cirripectes sp.
  Close to jenningsi Schultz; with dark spot behind eye.
- Cirripectes sp.
  Brown, the postorbital part of head orange-red.
- Entomacrodus caudofasciatus (Regan)
- Entomacrodus rofeni Springer
- Entomacrodus striatus (Quoy and Gaimard)
- Istiblennius gibbifrons (Quoy and Gaimard)
- Istiblennius paulus (Bryan and Herre)
- Rhabdoblennius rhabdotrachelus (Fowler and Ball)

Tripterygiidae
- Helcogramma sp.

Gobiidae
- Eviota spp. (3 species)
- Quisquilius cinctus (Regan)
- Trimma eviotops Schultz
- Zonogobius semidoliatus (Cuvier and Valenciennes)

Trichodontidae
- Crystallodytes sp.

Acanthuridae
- Acanthurus achilles Shaw
- Acanthurus leucopareius (Jenkins)
- Acanthurus nubilus (Fowler and Bean)
- Acanthurus triostegus (Linnaeus)
- Ctenochaetus hawaiiensis Randall
- Ctenochaetus strigosus (Bennett)
- Zebrasoma rostratum (Günther)

Scombridae
- Thunnus albacares* (Bonnaterre)

Bothidae
- Bothus mancus (Broussonet)

Balistidae
- Rhinecanthus rectangulus (Bloch and Schneider)
- Sufflamen bursa (Bloch and Schneider)

Monacanthidae
- Cantherhines dumerili (Hollard)
- Cantherhines pardalis (Rüppell)

Tetraodontidae
- Arothron meleagris (Lacépède)

Diodontidae
- Diodon hystrix* Linnaeus (380 mm SL)

*Specimens not retained.

Fishes Observed but not Collected

Carcharhinidae

Triaenodon obesus (Rüppell) (observed by G. S. and J. R. Haywood)

Mugilidae

Neomyxus leuciscus (Günther) (*chaptalii* of most authors)

Belonidae

Platybelone argala (LeSueur)

Aulostomidae

Aulostomus chinensis (Linnaeus)
In both a striped and a yellow phase.

Holocentridae

Adioryx tiere (Cuvier and Valenciennes)

Serranidae

Pseudanthias sp.
(Abundant at 120-150 feet; to be described by J. Randall)

Carangidae

Carangoides ferdau (Forsskål)
One individual of this barred species speared in the lagoon but it escaped.
Caranx ignobilis (Forsskål)
Caranx melampygus (Cuvier and Valenciennes)

Lethrinidae

Monotaxis grandoculis (Forsskål)

Mullidae

Mulloidichtys flavolineatus Lacépède
Several observed in lagoon, but not common
Parupeneus sp. (close to *pleurostigma* (Bennett))

Pempheridae

Pempheris sp.

Chaetodontidae

Chaetodon pelewensis Kner

Pomacanthidae

Genicanthus sp.
Light blue with numerous dark bars; speared one of about 200 mm in 180 feet, which escaped

Pomacentridae

Chromis margaritifer Fowler
Chromis sp.
Bluish, the median fins dark except posteriorly; a large black spot at pectoral base.

Labridae
- Coris sp.
- Halichoeres trimaculatus (Quoy and Gaimard) (one seen in lagoon)
- Hemigymnus fasciatus (Bloch)
- Leptojulis sp. (to be described by J. Randall)
- Pseudocheilinus sp.
  Yellow; to be described by J. Randall
- Pseudocheilinus octotaenia Jenkins

Acanthuridae
- Acanthurus thompsoni (Fowler)
- Naso brevirostris (Cuvier and Valenciennes)
- Naso hexancanthus (Bleeker)

Zanclidae
- Zanclus cornutus (Linnaeus)

Zoogeographic comments on fish fauna

As mentioned, Ducie has a very impoverished fish fauna; only 138 species were collected or observed at the atoll. Of these about 15 are confined to southeastern Oceania (three of these range also to Easter Island: Myripristis species, Centropyge hotumatua, and Gymnothorax panamensis, the latter occurring in the eastern Pacific as well). Two species, Seriola lalandi and Chaetodon flavirostris, are found at islands across the southern part of Oceania to Australia (the Seriola in the eastern Pacific too). Three species, Gymnothorax eurostus, Acanthurus leucopareius, and Atenochaetus hawaiiensis appear to be peripheral in their distribution in Oceania. Only one, Genicanthus species, is restricted to the Pitcairn group. However, there are a few other endemics among the fishes when the fauna of all four of the Pitcairn Islands is considered.

All the remaining fishes are tropical species that occur throughout Oceania, and most of them range into the western Pacific and the Indian Ocean.

Insects

We have been unable to locate identifications for any of the insects observed and possibly collected by members of the Whitney and Crocker expeditions. Chapin says that he believes that Mr. Crocker collected about six species. These may be in the collections of the California Academy of Sciences.

Both Chapin and Quayle report seeing "a small fly resembling the fruit flies" (Quayle, p. 392). Chapin describes it as a "tiny light-brown fly not quite as big as a Drosophila." Quayle mentions capturing eight of these flies.

Flying about the blossoms of the Tournefortia was a small moth whose wings "were veined with blackish and had a little pinkish orange as well near the ends" (Chapin in journal).

Quayle lists "a red and black bug and a Hymenoptera also living upon the blossom and seed of the one tree" (Quayle, p. 395).

The only other insects mentioned are a caterpillar seen by Quayle, and a large, blackish hippoboscid fly of which Chapin found usually 12-18 about the face and neck of the Phaethon.

Crustaceans

The identifications of the few crustacea that were gathered have been furnished by Henry B. Roberts and Fenner A. Chace of the Division of Crustacea, National Museum of Natural History. Time unfortunately did not permit the systematic collecting of groups of organisms other than fish, mollusks, and corals.

Paguridae

Numerous fragments, especially of chelae and walking legs, were found in the stomach and gut contents of Coris aygula and Diodon hystrix speared in the lagoon and off the outer reef.

In addition several species were encountered inhabiting dead shells along the shore of both lagoon and outer reef flat.

Coenobitidae

Coenobita perlata Milne-Edwards. This large, red hermit crab was found abundantly under coral slabs and driftwood underneath Tournefortia trees along the top of the rubble rampart on the outer side, inhabiting the shells of Turbo argyrostomus.

Calappidae

Chelae and fragments of carapace and limbs of a species of Calappa, possibly C. hepatica (Linnaeus), were found among the contents of the digestive system of Coris aygula captured in the lagoon.

Portunidae

A few fragments of carapace and cheliped were found with those of the preceding crab.

Xanthidae

Fragments of cheliped, carapace and eyestalk of a member of this family were found in the contents of gut and stomach of a Diodon hystrix speared in the lagoon.

Grapsidae

Grapsus tenuicrustatus (Herbst). Specimens of this species were seen clambering over rocks along the inner shore of the outer reef. Its presence at Ducie is also mentioned by Chapin in his journal.

Marine Mollusks

(by Harald A. Rehder)

Haliotidae

Haliotis pulcherrima Gmelin, 1791

A species restricted to southeastern Polynesia, found only in the Tuamotus from Tikehau to Temoe, including the barrier reef motus in the Gambier Islands, and in the coral islands of the Pitcairn Islands, namely Oeno, Henderson, and Ducie. Dead shells found among coral rubble.

Turbinidae

Turbo petholatus Linnaeus, 1758

A dead specimen of this widely distributed Indo-Pacific species found among the coral rubble.

Turbo argyrostomus Linnaeus, 1758

Dead shells very abundant on the shell and coral rubble ridge on Westward Islet. A small specimen was found in shallow water on the west side of the boat channel, and numerous fragments were recovered from the gut and stomach contents of two specimens of the fish Coris aygula and one Diodon hystrix both speared in 8 to 15 feet in the lagoon.

These specimens represent the large, broad, strongly spinose form found in the Pitcairn group, the Line Islands, eastern Tuamotus, and the Austral and Cook Islands.

Astralium confragosum (Gould, 1849)

Fragments of this species were found in the stomach and gut of two specimens of the wrasse Coris aygula, caught in 8-10 ft. on the north side of the lagoon. This species occurs throughout Micronesia and Polynesia.

Nerita plicata Linnaeus, 1758

This common Indo-Pacific species was found along the shore of both the lagoon and the outer coast.

Nerita haneti Recluz, 1841

One specimen was found on the rocks on the north side of Acadia Island. This black species is restricted to the southern islands of the Polynesian Province, from the Austral Islands (Tubuai and Raevavae) to the Gambiers, Rapa, Pitcairn Islands and Easter. Though most common on high volcanic islands, specimens are found on coral islands and atolls--Henderson, Oeno, and Ducie in the Pitcairn group, and motus on the barrier reef of the Gambier Islands.

Cerithiidae

Rhinoclavis sinensis (Gmelin, 1791)

A single dead specimen was found in shallow water on the reef flat at the western end of the atoll. The species is widely distributed in the Indo-Pacific region.

Pseudovertagus clava (Bruguière, 1792)

Four specimens of this handsome species were found in the northern part of the lagoon in 12-20 feet. This uncommon species has to date been found only in New Caledonia, certain localities in French Polynesia - Tahiti, Rurutu, certain atolls in the southern Tuamotus, Gambier Islands - and in the Pitcairn Islands - Pitcairn, Oeno, and Ducie.

Cerithium sandvichense 'Sowerby' Reeve, 1865

Fragments of this relatively rare species were found in the stomach and gut of a puffer, Diodon hystrix. We have additional specimens in the National Museum collections from Tahiti, Gambier Islands, and the Pitcairn Islands. It is not known to occur in the Hawaiian Islands.

Cerithium tuberculiferum Pease, 1869

This species was the most abundant mollusk on the flat pavement of the outer reef flat off the western end of Acadia Island. It was found crawling here in 1/2 to 2 ft. of water in the thin sand layer covering the reef rock. It was also found elsewhere on the outer reef, as well as the gut and stomach of Coris aygula and Diodon hystrix caught both within the lagoon and off the outer reef.

The species is close to Cerithium mutatum Sowerby, but the spiral sculpture is stronger, the grooves above and below the series of larger nodes being deeper, and the resulting ridges more nodulose. Geographically it appears to be restricted mainly to the coral atolls of Polynesia, from the atolls of the Samoan Islands to the Line Islands. It has not been found on the volcanic Society Islands, but has been collected at Pitcairn, and Rurutu in the Austral Islands.

Vermetidae

Dendropoma maximum (Sowerby, 1825)

This large species was relatively common on the flat pavement of the reef off the western end of Acadia Island. Commonly found living in and on corals of massive and dense growth habit, it was found here closely fixed to the surface of the moderately coarse reef rock. The three specimens collected on a slab of reef rock measuring roughly 12 by 10 inches varied in length from 7 1/2 to 9 1/2 inches with the aperture measuring 3/4 inches in diameter.

Hipponicidae

Sabia conica (Schumacher, 1817)

This common Indo-Pacific species was encountered sparingly, once as a dead shell in the beach drift, and once in the stomach and gut of Diodon hystrix speared in the lagoon.

Cypraeidae

Cypraea caputserpentis Linnaeus, 1758

Four dead shells found in the beach drift and in shallow water on the outer reef.

Cypraea helvola Gmelin, 1791

A dead shell in the drift, and an immature specimen collected in 100 ft. off the southwest edge of the reef.

Cypraea testudinaria Linnaeus, 1785

A dead shell found in the beach drift.

Cypraea maculifera (Schilder, 1932)

Also found in the beach drift.

Cypraea (Lyncina) schilderorum (Iredale, 1939)

Two specimens picked up in the beach drift. This common Polynesian species is found from northern and eastern Micronesia (Guam and the Marshall Islands) eastward to Hawaii and southeastward to Ducie Island.

Cassidae

Casmaria erinacea (Linnaeus, 1758)

One specimen of this widely distributed Indo-Pacific species was found in the beach drift. Other specimens were found during the same trip on Oeno and Henderson of the Pitcairn group. The Polynesian specimens of this species belong to the nominate subspecies, the subspecies kalosmodix Melvill being restricted to the leeward islands of the Hawaiian chain.

Muricidae

Drupella elata (Blainville, 1832)

Fragments of this species were found in the stomach and gut of specimens of Coris aygula speared off the outer reef. The species is found throughout the western and central Pacific, from Cocos-Keeling, Indonesia, and southern Japan to Hawaii and the Pitcairn Islands. The Indian Ocean specimens sometimes referred to this species represent Drupella cornus (Röding, 1798), a distinct species.

Morula uva (Röding, 1798)

This widely distributed Indo-Pacific mollusk was one of the most ubiquitous species on Ducie, being especially common on the reef rock and coral fragments of the outer reef near the shore.

Morula granulata (Duclos, 1832)

Found with the above species but not as abundantly; an exceptionally large specimen, 30 mm in height, was collected here.

Drupa ricinus (Linnaeus, 1758)

Only two specimens were found on the coral rocks close to the shore on the north side. Undoubtedly this common species is more abundant on other parts of Ducie's reef.

Drupa grossularia Röding, 1798

This species was moderately common on the hard bottom of the shallow channels between the ridges of beach rock parallel to the shore.

Drupa elegans (Broderip and Sowerby, 1829)

Fragments of a specimen of this species were found in the digestive system of a wrasse, Coris aygula, speared off the outer reef. This species is found only in the atolls of eastern Micronesia, the Tuamotus, and Henderson and Ducie in the Pitcairn group.

Drupa morum Röding, 1798

A large specimen was found in shallow water on the western side of the boat passage.

Nassa sertum (Brugiere, 1789)

Two worn shells of this widely distributed western and central Pacific species were found in the beach drift.

Columbellidae

Columbella (Euplica) aff. palumbina Gould, 1845

Fragments of a shell resembling those of C. (E.) palumbina Gould were found in the gut and stomach of Coris aygula speared off the outer reef. The latter species is found in the Hawaiian Islands, with closely related forms occurring in the Line Islands, and in Polynesia. The Ducie shell most closely resembles specimens found in the Gambiers and Austral Islands.

Fasciolariidae

Latirus nodatus (Gmelin, 1791)

Three dead specimens were found in the beach drift on the north coast. This species is not rare in Polynesia, from the Cook Islands to the Marquesas, Pitcairn Islands, and Rapa. In Micronesia it is found less frequently.

Mitridae

Mitra (Strigatella) litterata Lamarck, 1811

A few specimens were found on and near rocks close to the shore on the north coast and near the boat pass.

Conidae

Conus ebraeus Linnaeus, 1758

Twelve large specimens were found in one to four feet of water on the west side of the boat passage. The bottom was hard coral with patches of gravel and coarse sand.

Conus nanus Sowerby, 1833

This species was found with the preceding species as well as along the north coast, on sand-covered hard coral bottom in the shallow channels between the ridges of tilted beach rock. The majority of the specimens collected were unusually large.

Conus miliaris Hwass, 1792

This appears to be the most abundant species on the atoll. It was found with the preceding species, and in shallow water, on the outer reef flat where it was crawling in the thin sandy layer covering the hard coral substrate.

Conus retifer Menke, 1829

Conus geographus Linnaeus, 1758

Conus tulipa Linnaeus, 1758

Conus chaldeus (Röding, 1798)

Conus lividus Hwass, 1792

Dead shells of the above species were found in the beach drift on the north coast.

Conus rattus Hwass, 1792

A fragment of this species was found in the gut and stomach of a Coris aygula collected off the outer reef.

Terebridae

Terebra subulata (Linnaeus, 1767)

A dead but fresh specimen was found in 12 to 20 feet in the northern part of the lagoon.

Aplysiidae

Dolabrifera cf. fusca Pease, 1868

A shell was found in the gut and stomach of a Coris aygula speared off the northwest corner of the atoll. Without a knowledge of the animal it is difficult to ascertain the proper name of this shell.

Bivalvia

Arcidae

Barbatia parva (Sowerby, 1833)

Ducie is the type locality for this species. Numerous dead valves of this species were found on the western side of the lagoon, in the sand at the base of coral heads in 3-4 feet of water. Fragments were also found in the gut and stomach of two specimens of *Coris aygula* caught in the lagoon. A junior synonym of this species is *Calloarca (Barbarca) maunaluana* Dall, Bartsch, and Rehder, 1938, from the Hawaiian Islands.

Isognomonidae

Isognomon (Melina) perna (Linnaeus, 1767)

This common western and central Pacific species was found rather abundantly attached by the byssus to the under side of coral rocks near the shore on the western side of the lagoon. Fragments of this species were found also in the stomach contents of *Coris aygula* speared in the northern end of the lagoon.

Isognomon (Parviperna) dentifera (Krauss, 1848)

Specimens were found nestling in the crevices of coral rock, along the outer shore at the edge of the reef flat. Fragments were also found in the digestive system of a specimen of *Coris aygula* speared in the lagoon.

Pteriidae

Pinctada margaritifera (Linnaeus, 1785)

A large specimen of the common pearl oyster was collected in 12 to 20 feet in the northern end of the lagoon.

Pinctada maculata (Gould, 1850)

Numerous fragments of this species were found in the stomach and gut of a *Coris aygula* speared in the northern end of the lagoon.

Ostrea species

Unidentifiable fragments of a species of oyster were found in the stomach and gut of a *Coris aygula* speared in the lagoon.

Spondylidae

Spondylus species

A worn valve was found in 20 to 30 feet off the northwest corner of the reef, and two smaller valves were found in the beach rubble on the north side of Acadia Island. Until the species of this genus are critically revised it is impossible to identify postively specimens such as these.

Chamidae

Chama iostoma Conrad, 1837

Two valves of this rather common tropical Western Pacific species were found in the beach rubble. This species has been called *Chama imbricata* Broderip, 1835, pre-occupied by *C. imbricata* Lamarck, 1801.

Lucinidae

Codakia (*Epicodakia*) *bella* (Conrad, 1837)

Fragments of this widely distributed species were found in the stomach contents of *Coris aygula* captured off the northwest corner of the atoll in 20 to 30 feet.

Tridacnidae

Tridacna maxima (Röding, 1798)

Two valves of this common Indo-Pacific species were found in the beach rubble on the north side of the atoll.

Semelidae

Semele australis (Sowerby, 1833)

A valve was found on the north side of Acadia Island. This species is found most abundantly in Polynesia from the Cook Islands to Hawaii and Easter Island; but we also have specimens reputed to have come from Eniwetok in the Marshalls, and Lifu in the Loyalty Islands.

Semelangulus nebulosus Dall, Bartsch, and Rehder, 1938

Four valves very closely resembling this species described from Hawaii were found in the contents of the digestive system of *Coris aygula* collected in the north end of the lagoon.

Because of the decidedly internal ligament found in this genus I cannot subscribe to its allocation in the family Tellinidae by some recent authors.

Cephalopoda

Chapin reports seeing squid come to a submerged light while the ZACA was off Ducie. He relates that "3 squid (10-11 inches long) came round it, swimming backward, tentacles usually pressed tightly together, and fins seeming to open and shut. When below light they looked pinkish or salmon-color. As active and swift as fish, when they first appeared, rather deep down and looking greenish gray, I thought they might be flying fish" (Chapin, 1934-35).

Biogeographical Comment

Of the 50 identified species 34 or 68% are wide-ranging species found either throughout the Indo-Pacific Region or the Western and Central Pacific. Nine species or 18% are restricted to the Micronesian and Polynesian Provinces, while 6 or 12% are found only in Polynesia. One species, Pseudovertagus clava (Bruguière), inhabits various separated localities from New Caledonia to Ducie Atoll.

The fauna of Ducie is therefore basically a depauperate Indo-Pacific one. It is also typically Polynesian and points up moreover, the fact that the Polynesian fauna is more closely related to that of Micronesia than to the eastern Melanesian fauna (Samoan Islands, Tonga).

Echinoderms

Asteroidea

Acanthasteridae

Acanthaster planci (Linnaeus)

One specimen was collected on a coral head in the lagoon.

Echinoidea

Diadematidae

Diadema savignyi Michelin or *D. setosum* (Leske)

Very common on the outer reef from 20 to at least 80 feet. Specimens were not kept, and thus it is impossible to know to which of these closely related species the Ducie specimens should be referred.

Echinometridae

Heterocentrotus mamillatus (Linnaeus)

Very common with the preceding species. They ranged in color from light red to light yellowish green.

Heterocentrotus trigonarius (Lamarck)

This deep-purple slate-pencil urchin was abundant on the outer third of the reef flat in several feet of water.

Corals

The corals, collected by Richard R. Costello, were identified by Dr. John W. Wells, Cornell University. All are more or less well-known Indo-Pacific species.

Pocilloporidae

Pocillopora elegans (Dana)

Collected in 100 feet off the reef on the southwest side.

Pocillopora sp. cf. P. modumanensis Vaughan

Found on the outside reef in 20 to 40 feet.

Acroporidae

Acropora nasuta (Dana)

This species found in the boat pass and on the outer reef, as well as in the middle of the lagoon in 50 feet.

Astreopora myriopthalma (Lamarck)

Found in the western part of the lagoon.

Montipora caliculata (Dana)

Found together with the preceding species.

Montipora composita Crossland

Collected in 100 feet off the outer reef on the southwest side of the atoll.

Montipora complanata (Lamarck)

This and the following species were collected in 50 feet in the middle of the lagoon.

Montipora sp. cf. M. venosa (Ehrenberg)

Montipora sp. aff. M. bilaminata Bernard

Found in 50 feet in the middle and western part of the lagoon.

Agariciidae

Pavona (Pseudocolumnastraea) sp. cf. P. (P.) pollicata Wells

This possibly new species was collected in 100 feet off the southwest side of the outer reef.

Leptoseris incrustans (Quelch)

This and the following two species were found together with the preceding species.

Fungiidae

Fungia (Pleuractis) scutaria (Lamarck)

Poritidae

Porites australiensis Vaughan

Faviidae

Plesiastraea versipora (Lamarck)

The small-caliced variety was collected both on the outer edge of the outside reef in 20 to 40 feet of water and in the western part of the lagoon.

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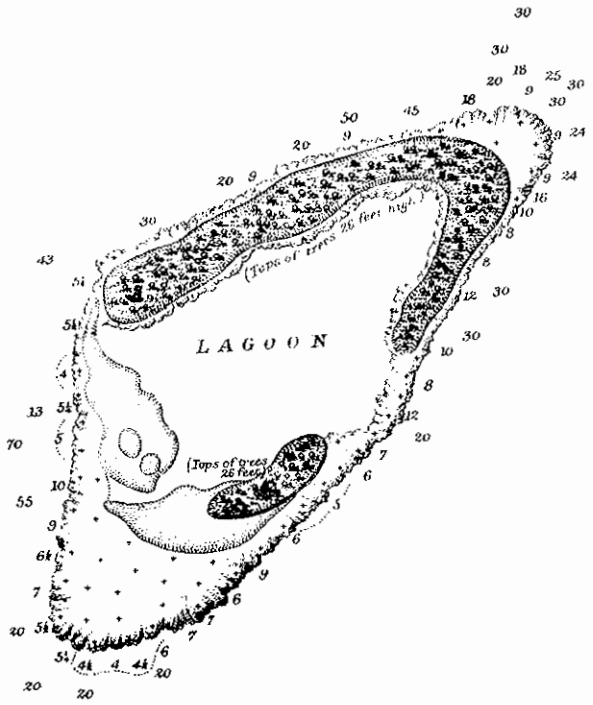

Figure 1. Ducie Atoll from British Admiralty Chart No. 1176, based on survey by F.W. Beechey, 1826.

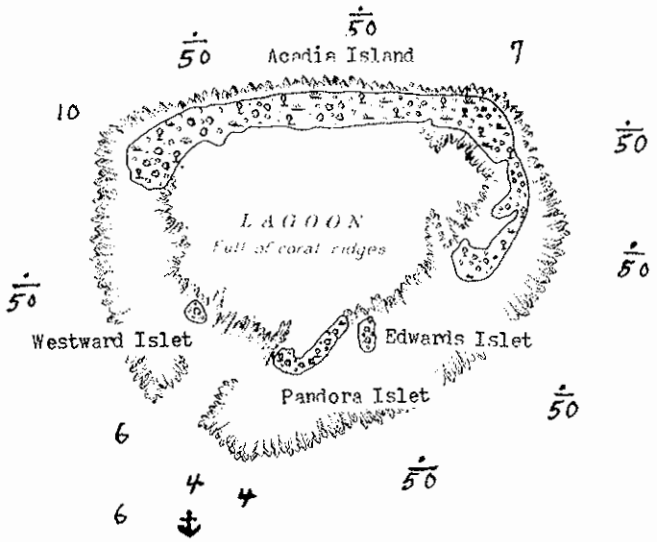

Figure 2. Ducie Atoll, from British Admiralty Chart No. 897 (U.S. Hydrographic Office Chart No. 1977), based on survey by H.M.S. LEANDER, 1937, showing soundings from R.S. WESTWARD, 1971, and proposed names of islands.

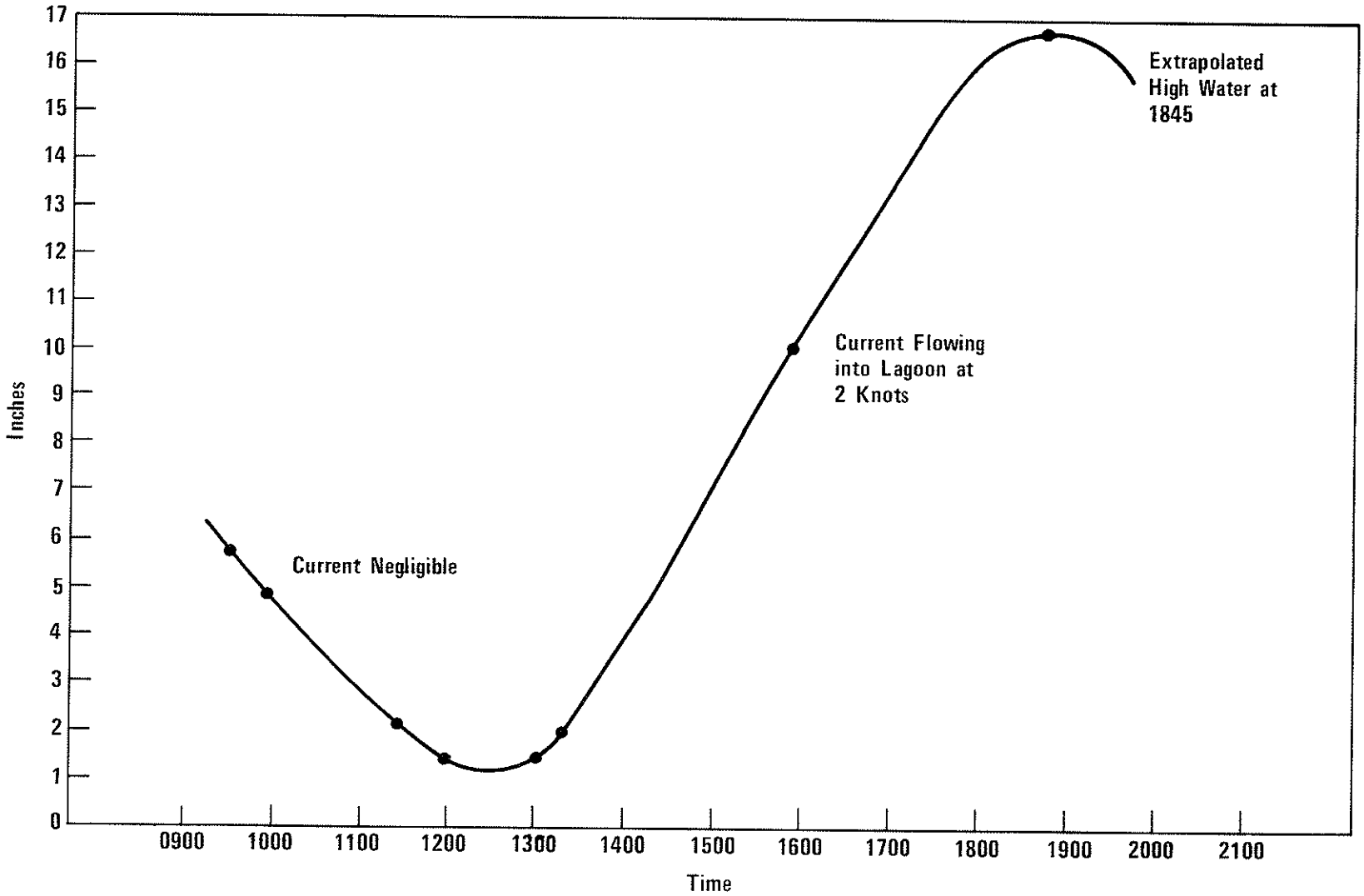

Figure 3. Tidal curve for January 14, 1971, drawn from observations at tidal gauge on north side of Westward Islet, west of lagoon end of pass.

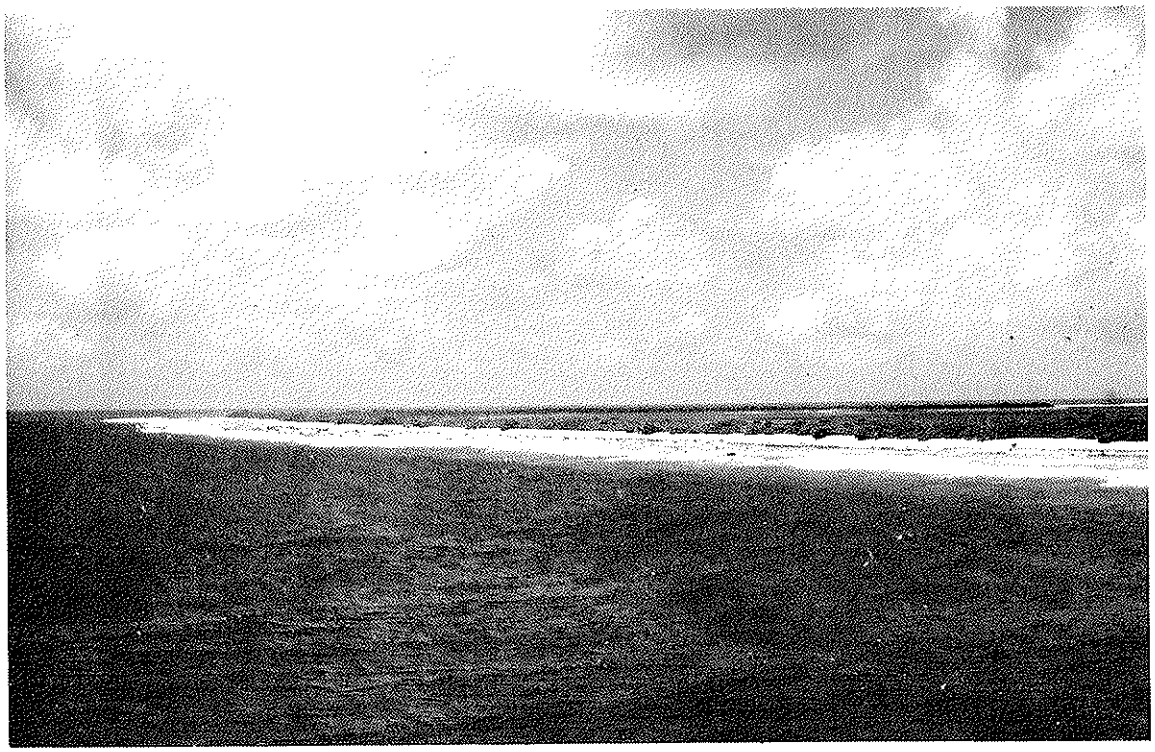

Figure 4. Reef along northern coast of atoll, (Acadia Island with lagoon beyond.

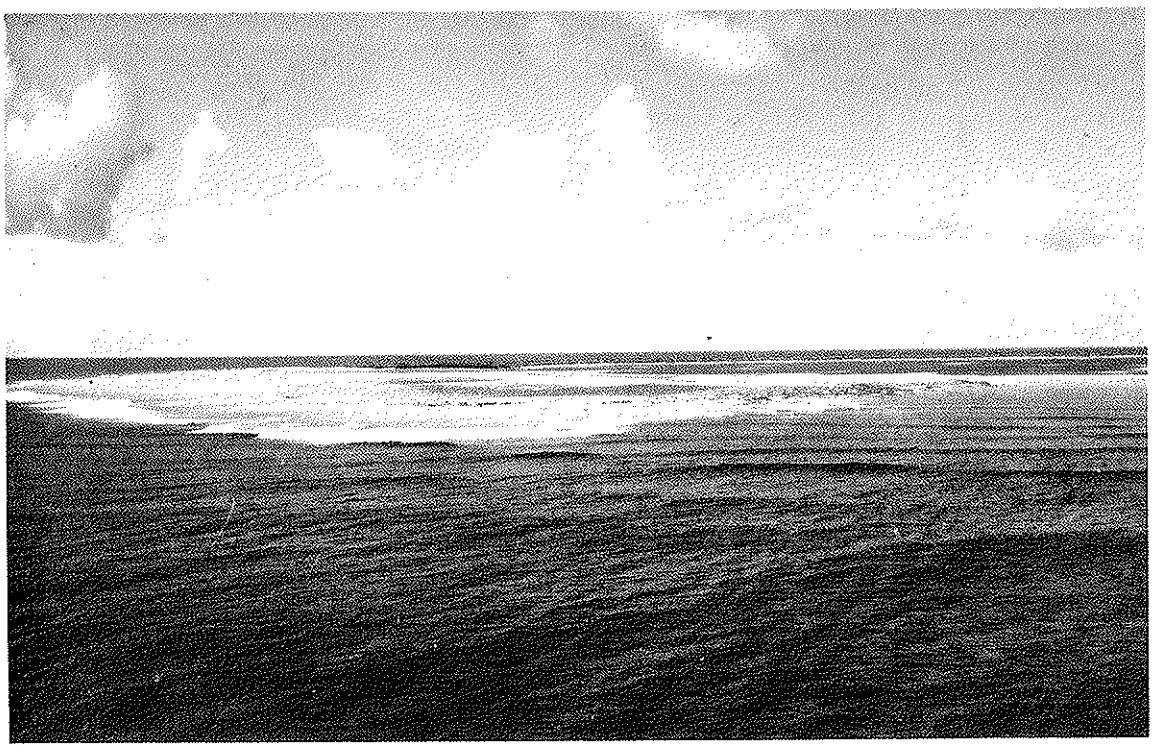

Figure 5. Broad outer reef west of boat passage which is seen on right. Westward islet is in the right center. This and preceding picture taken from aloft on schooner WESTWARD.

Figure 6. Coral rubble of Westward Islet; looking towards western end of Acadia Island.

Figure 7. Close up of surface of rubble on Westward Islet, showing predominance of dead shells of Turbo argyrostomus.

Figure 8. View towards Acadia island showing coral rubble rampart, and inner edge of reef flat on left.

Figure 9. View towards Westward Islet showing coral rubble ridge between lagoon on left and reef flat on right; Pandora Islet in left background.

Figure 10. View over reef flat west of pass from Westward Islet. The Schooner WESTWARD can be seen beyond the surf of the seaward edge of the reef.

Figure 11. Old beach rock near Westward Islet, and dried reef flat on left. Acadia Island in background.

Figure 12. Rampart of coral rubble on lagoon side of western end of Acadia Island. Tournefortia trees in background. The black objects on the rubble are bodies of dead birds.

Figure 13. A close-up of steeply sloping coral rubble ridge with lagoon in back. A windrow of dead birds lies at the base of the upper rubble slope, and a Japanese glass fishing float may be seen on the coral rubble ridge to the left.

Figure 14. Old rubble-strewn pavement on lagoon side of Acadia Island, showing coral rubble deposits near lagoon.

Figure 15. Ocean side of Acadia Island with coral rubble rampart, and layers of fractured beach rock on left.

Figure 16. Tilted beach rock at inner edge of ocean reef, north side of Acadia Island.

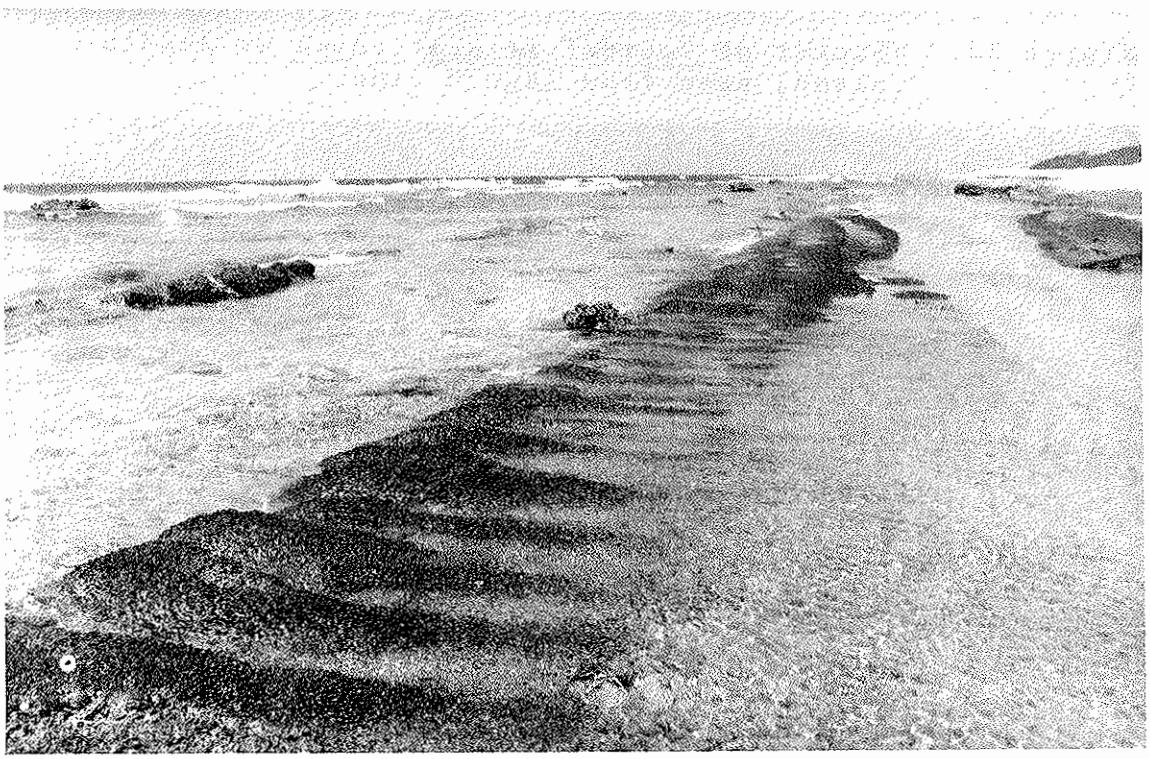

Figure 17. Tilted layer of beach rock with solution channels; inner edge of ocean reef, north side of Acadia Island. Beach rock shown in Figure 16 is seen in upper right-hand corner.

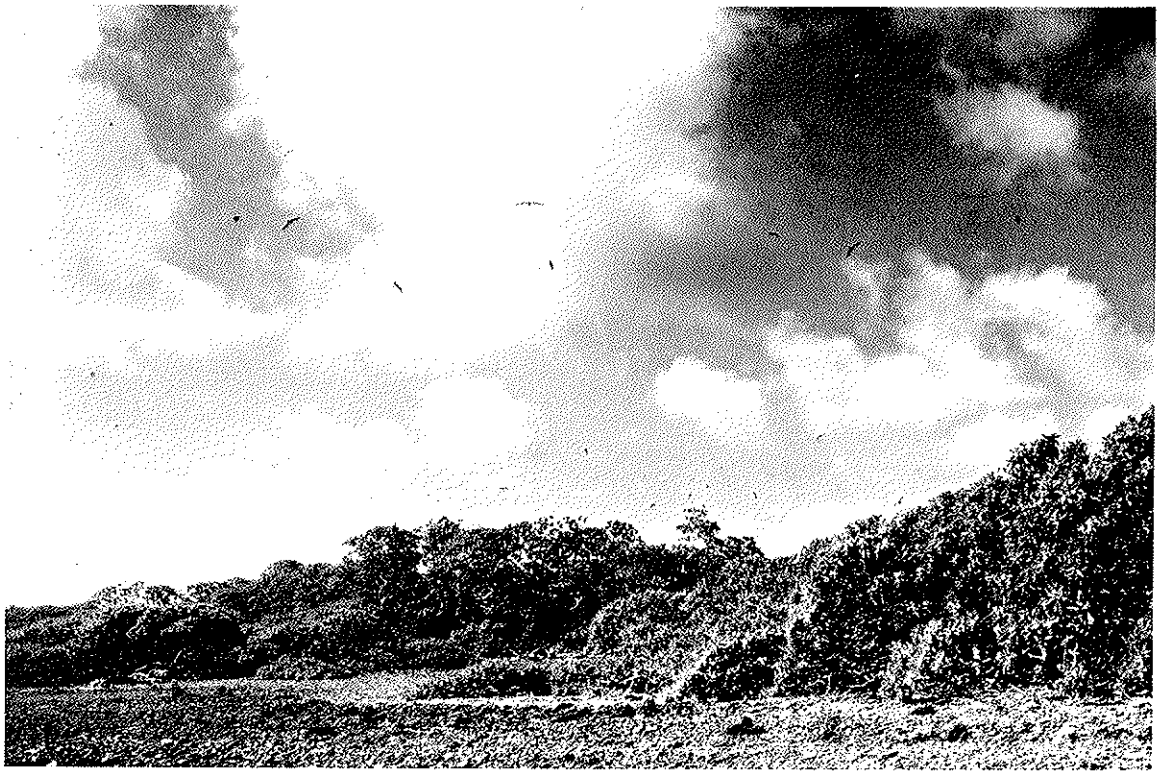

Figure 18. Thicket of Tournefortia argentea on Acadia Island, seen from lagoon side.

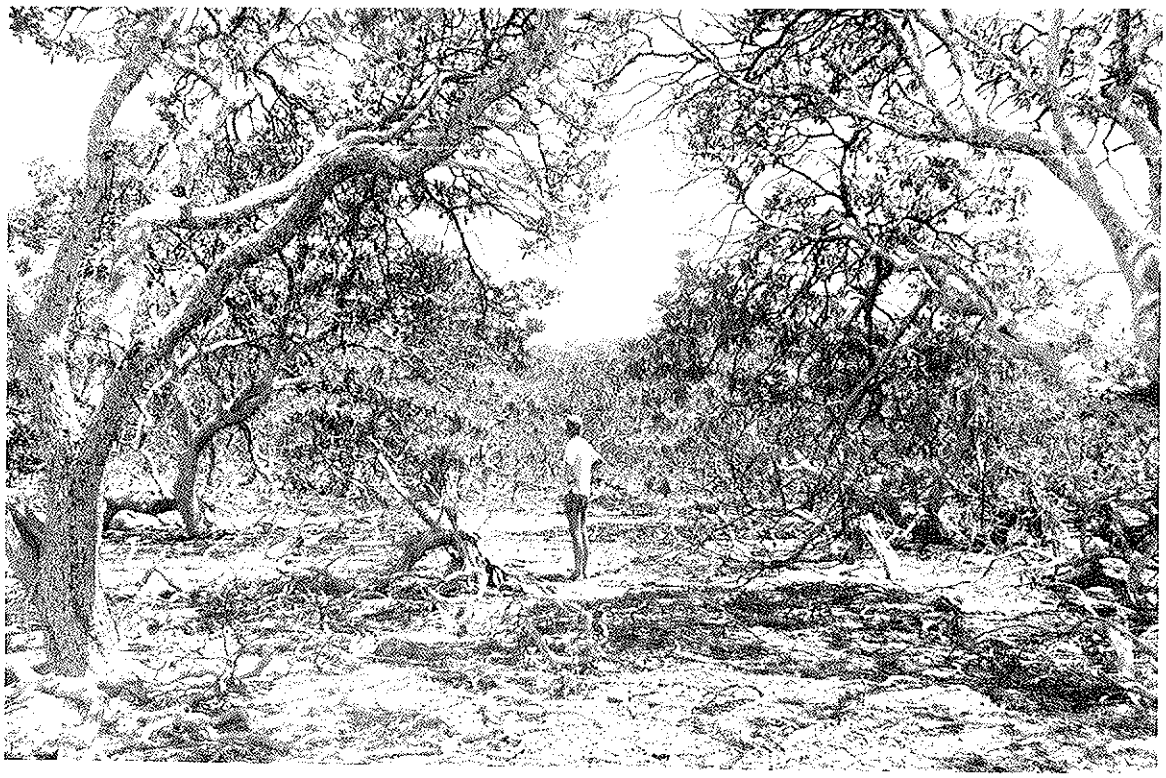

Figure 19. Center of groove of Tournefortia argentea on Acadia Island.

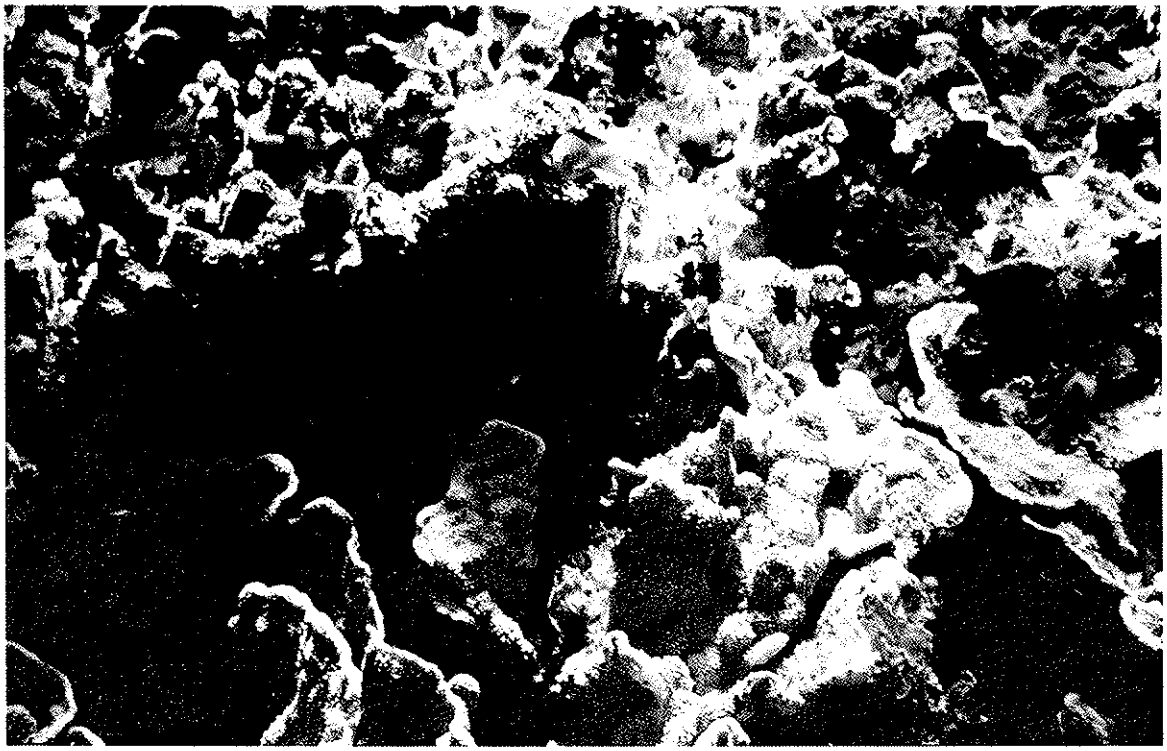

Figure 20. Coral head in lagoon with Montipora sp. aff. bilaminata as dominant coral.

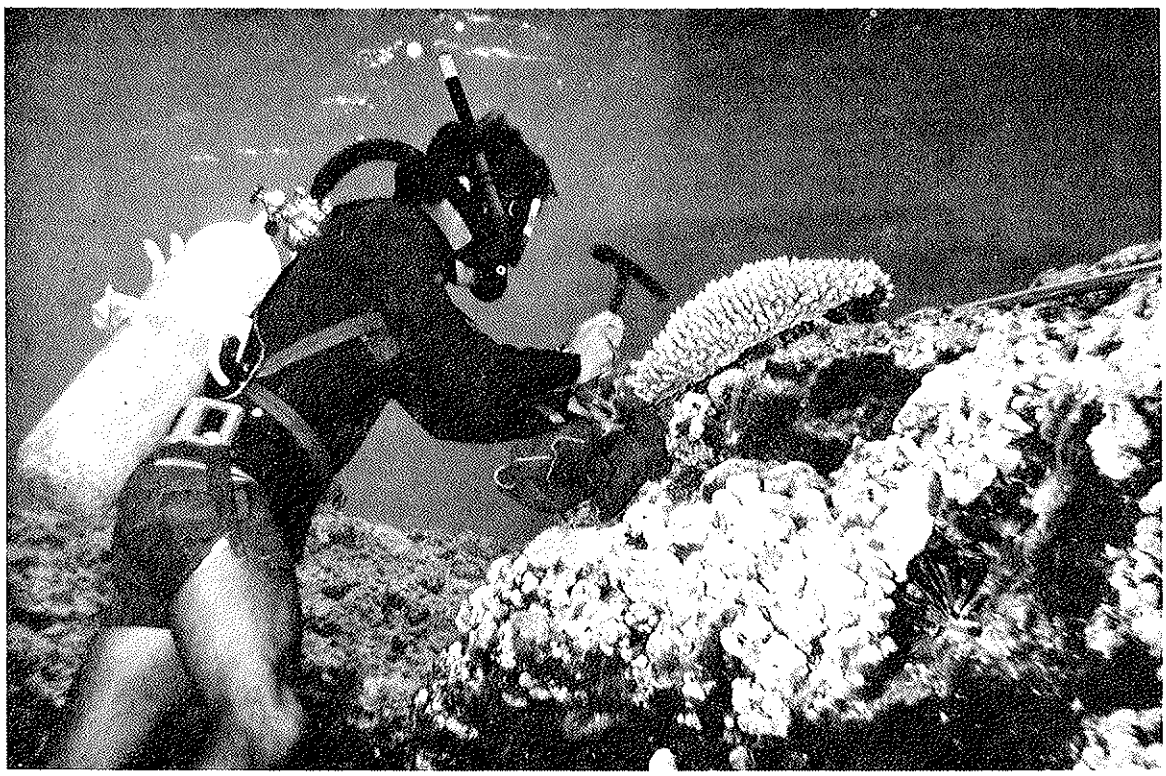

Figure 21. Outer coral reef with diver Richard Costello taking sample from colony of Acropora nasuta. Just below this colony is a small nodule of Plesiastrea versipora.

Figure 22. Young Blue-faced booby, Sula dactylatra on consolidated reef rock fragments on north coast of Acadia Island with reef flat in background.

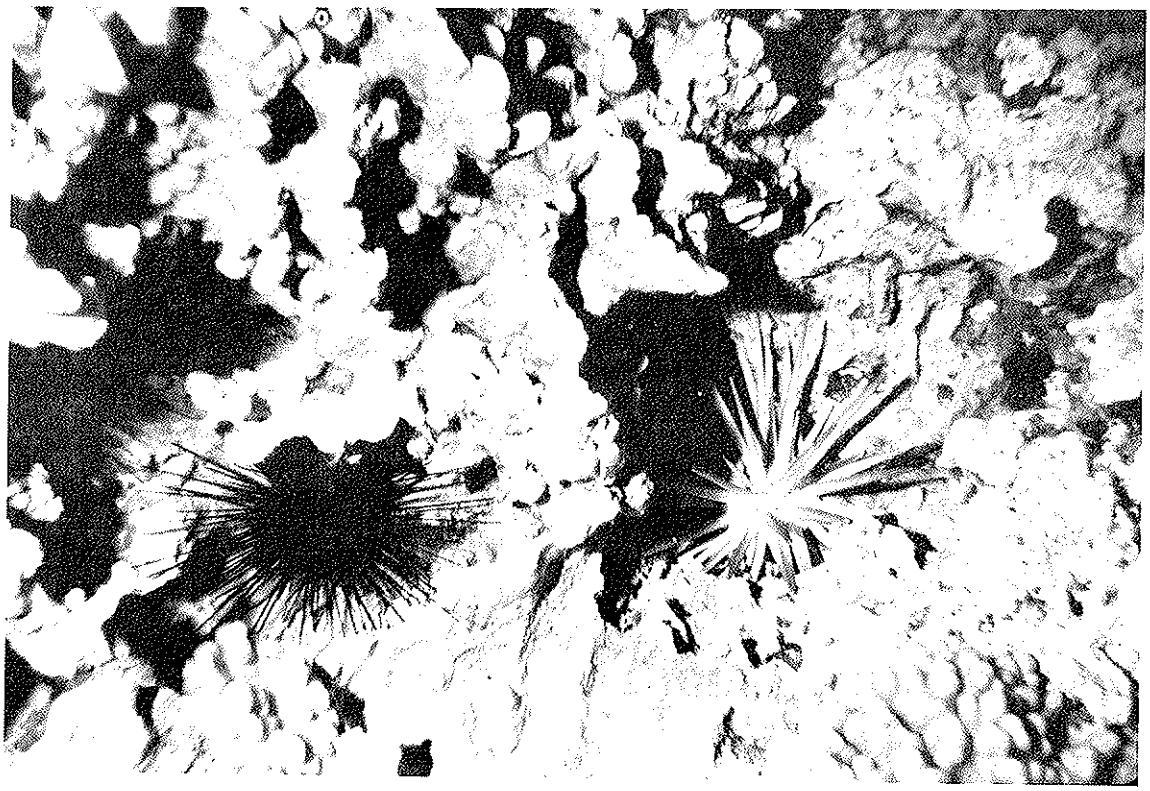

Figure 23. Echinoderms, Heterocentrotus mamillatus and Diadema sp., on outer slope of oceanic reef.

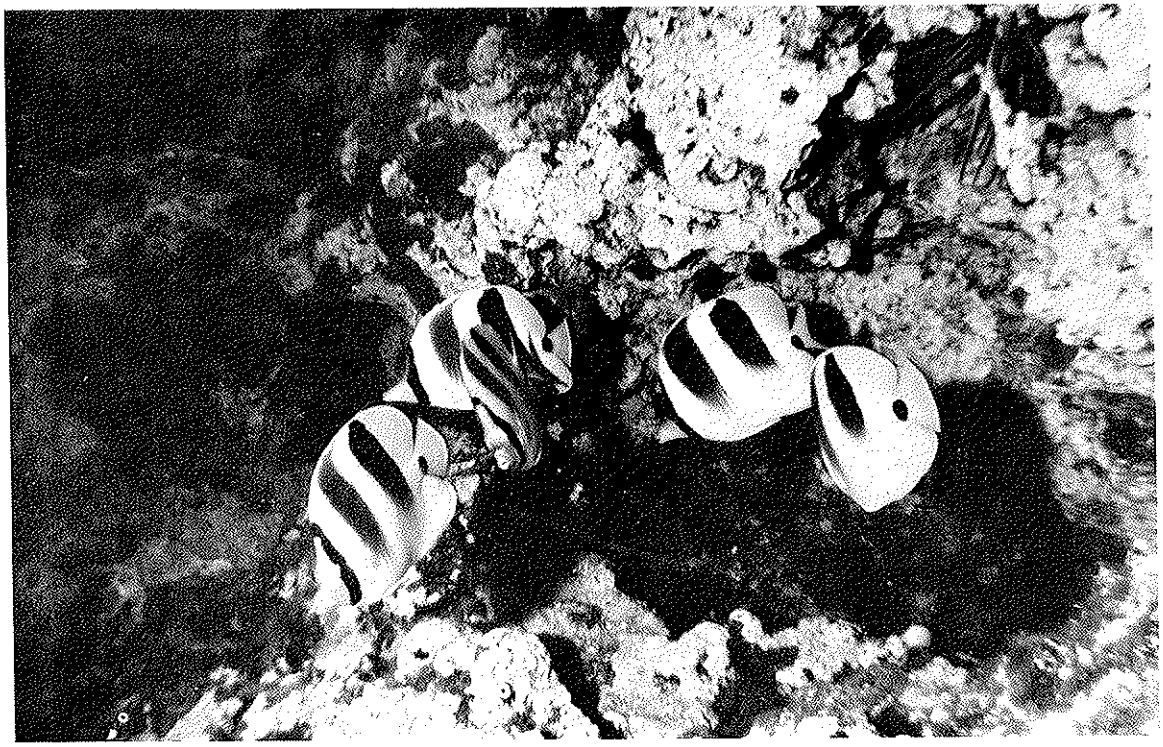

Figure 24. Butterflyfish, Chaetodon ulietensis, outside the oceanic reef.

Figure 25. Three butterflyfish, Chaetodon ulietensis on coral

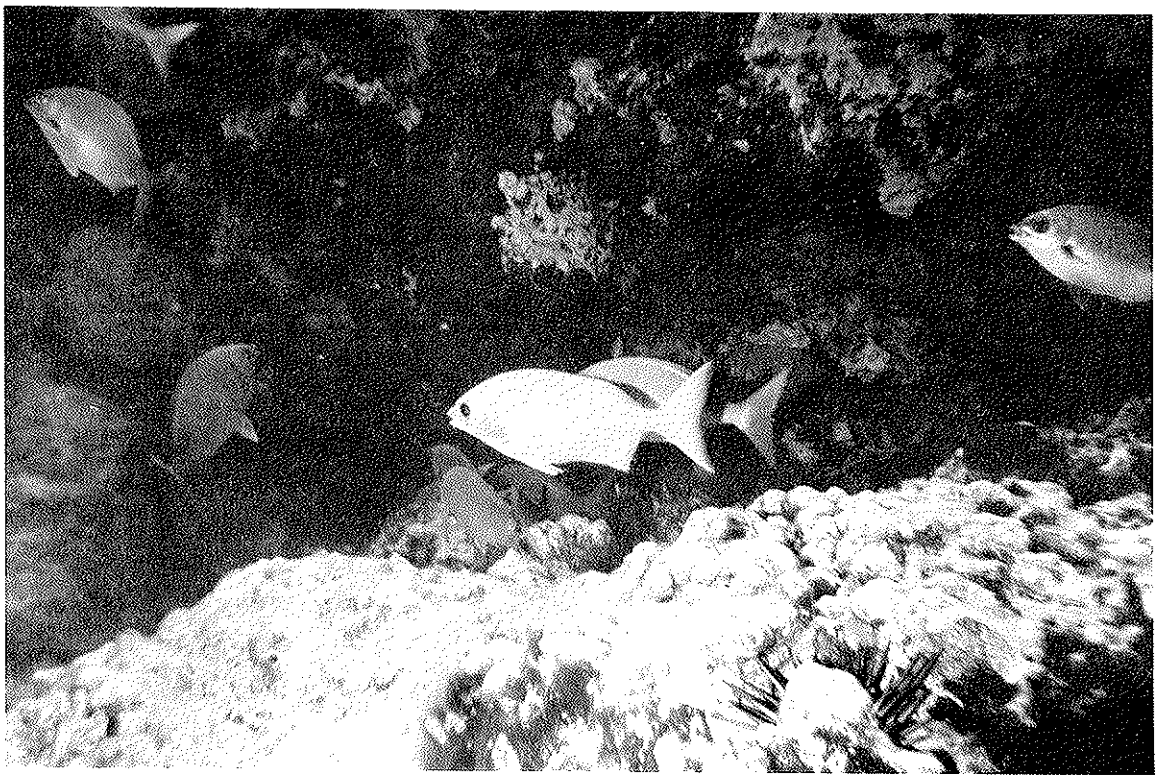

Figure 26. The rudderfish, Kyphosus fuscus outside the reef. One fish displays the light yellow form.

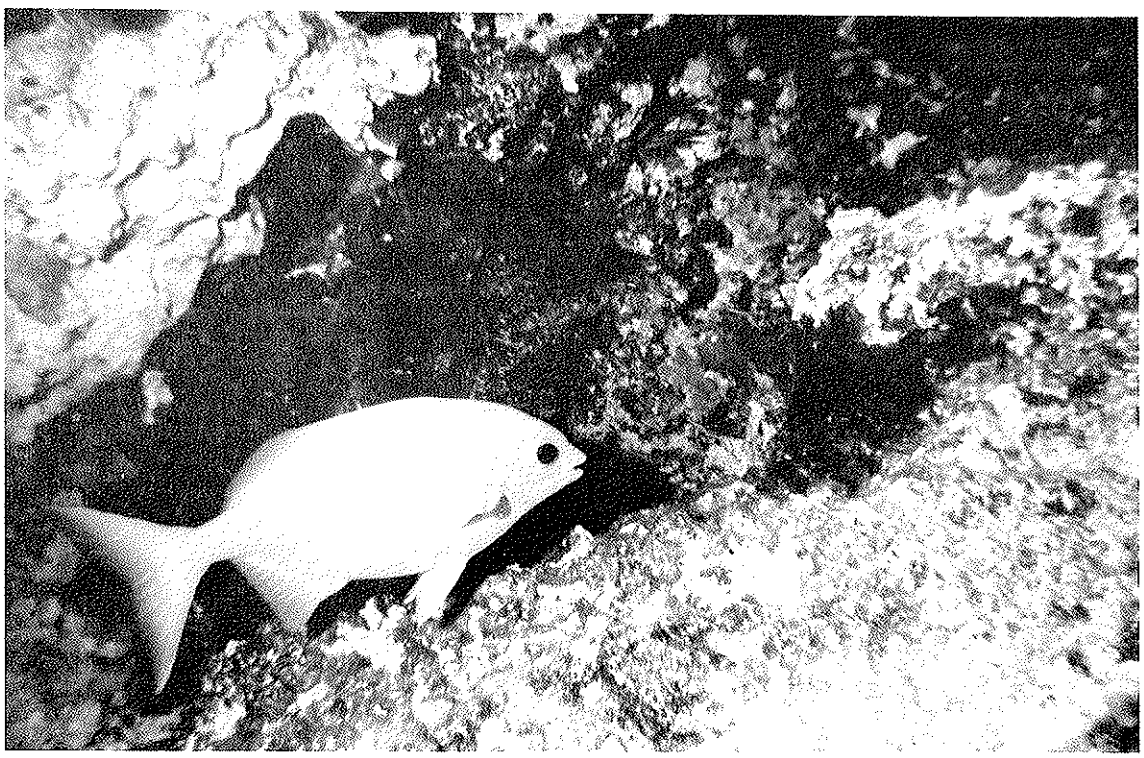

Figure 27. The light yellow form of the rudderfish, Kyphosus fuscus outside the reef.

Figure 28. Two of the WESTWARD's divers in 40 feet outside the reef off the channel. Numerous black jacks, Caranx lugubris, and three yellowtail, Seriola lalandi, are visible.

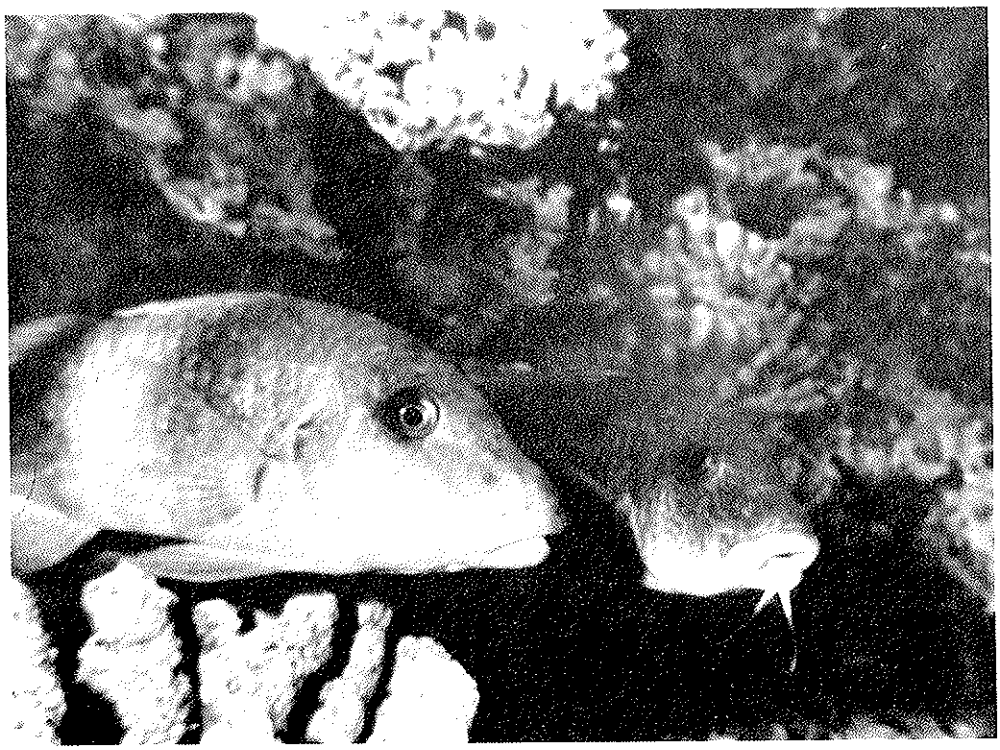

Figure 29. Two goatfish, Parupeneus bifasciatus outside the reef.