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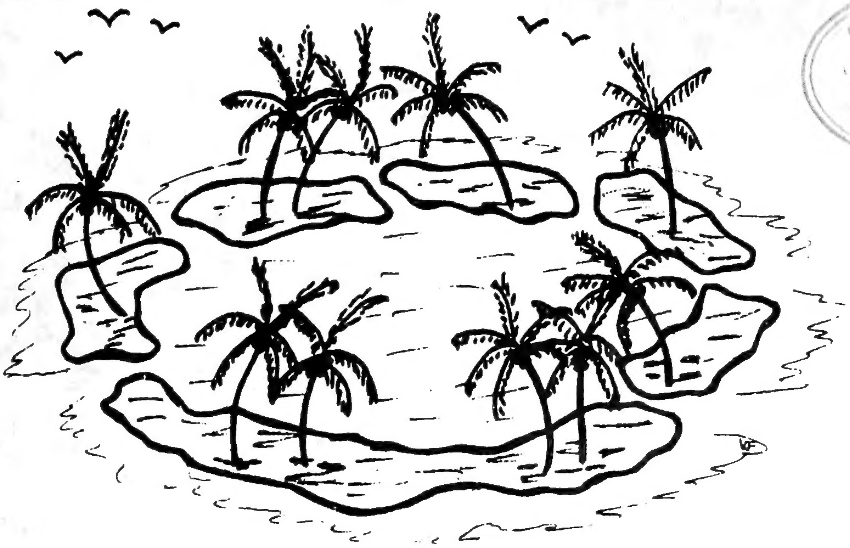

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It is a pleasure to commend the far-sighted policy of the Office of Naval Research, with its emphasis on basic research, as a result of which a grant has made possible the continuation of the Coral Atoll Program of the Pacific Science Board.

It is of interest to note, historically, that much of the fundamental information on atolls of the Pacific was gathered by the U. S. Navy's South Pacific Exploring Expedition, over one hundred years ago, under the command of Captain Charles Wilkes. The continuing nature of such scientific interest by the Navy is shown by the support for the Pacific Science Board's research programs, CIMA, SIM, and ICCP, during the past seven years. The Coral Atoll Program is a part of SIM.

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Pumice and other extraneous volcanic materials on coral atolls

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Pumice and other extraneous volcanic materials on coral atolls

by
Marie-Hélène Sachet

Introduction

"Every square inch of land in the atoll is coral ..." Wood-Jones, (1910, p . 57). Statements similar to this, varying only in their colorfulness, accuracy, or detail, together with various generalizations to the effect that atolls are made up entirely of organic limestone, are abundant through the literature of coral islands, in diaries, adventure stories, and scientific reports; and within certain limits such statements are true.

The presence on atolls of volcanic rocks such as pumice and basalt, as well as volcanic soils, has aroused much curiosity and interest.

The most conspicuous and abundant foreign rock is pumice. Examination of the literature reveals its presence in widely separated islands and shows its importance as a "natural resource." We will first cite available information on pumice, its occurrence, uses, significance, and complete this record with mention of other extraneous materials. For the purposes of this review, pumice is taken to mean volcanic ejecta that are vesicular and light enough to float. The author is aware that rocks of significantly different texture and chemical composition may be included, and that the petrologist might desire further restriction of the term, which is impractical here.

Pumice

Geographic distribution

Seurat (1903, p. 6), who spent many months in the remote Tuamotu Atolls and the neighboring Gambier Islands, reports the presence of small pieces of pumice on the beaches of South Marutea, one of the easternmost atolls of the Pacific. Pumice is not often reported from the Tuamotus, and is indeed probably not as common there as in various central Pacific groups of atolls; however, the literature on this immense archipelago is especially poor and inadequate.

On the contrary, pumice is reported by many observers in many different islands in the central Pacific and in the Micronesian Atolls.

Van Zwaluwenburg (1941, p. 15) found it on Canton Island, and W. A. Dixon (1877, p. 165) said it was abundant on Malden Island. In 1862, W. W. Gill, a missionary, was collecting idols on Pukapuka (Cook Islands) and wrote (1876, p. 60): "One old man was carrying what seemed to be a large lump of coal with evident ease. This turned out to be pumice stone blackened by long exposure to rain and wind." This piece was deposited by Gill in the museum of the University of Sydney.

The U. S. Exploring Expedition (1838-42) observed pumice in several of the many atolls visited. Dana (1849, p. 77) mentions it on Fakaafo and Howland. Of the latter he says that bits of pumice and pieces of driftwood are scattered all over the island's surface.

The abundance of this pumice at times is extraordinary. Whitmee (1878, p. 108) wrote that in that year, ships met great quantities of it in the vicinity of the Ellice group, and quoted newspaper accounts to this effect. He added: "... the shores of all the Ellice Islands are thick with it. Hundreds of tons have been thrown up on each island." An interesting note here is that the pumice when first observed (April 1878) was free of sea-weeds and barnacles, but these were noticeable by June.

Another important record of pumice in the Ellice Islands is that of Hedley (1896, p. 16) from Funafuti: "Everywhere small pieces of pumice the size of a walnut might be collected on the beaches. The natives say that a few years ago much pumice came ashore, coincident with which the fish from without the lagoon became unfit for food."

Finsch (1914, p. 43) says that he himself saw great quantities of pumice on the strand at Butaritari, Gilbert Islands. P. E. Cloud, Jr. (1952, p. 21) observed and collected it on Onotoa in the same group.

There are few records of the presence of pumice in the Marshall Islands. One of these is by Chamisso (1821, p. 156), one of the most gifted and versatile naturalists to visit Pacific atolls. Another reference is by Grundemann (1887, p. 442) on Ailuk. Still another is by Stone (1951, p. 2) on Arno Atoll. It is quite possible that pumice does not reach these islands as often or as abundantly as it does the Gilbert or Ellice Islands. However it is present now in the Marshall Islands, and F. R. Fosberg observed it in 1951-52 (unpublished) during the Northern Marshall Islands Expedition. During this investigation pumice of several distinct sorts was noted, and specimens were collected on Pokak, Utirik, Ailuk, Jemo, Kwajalein, Ujae, Wotho, and Ujelang atolls. It was ordinarily found as scattered pebbles, usually small, but larger pieces up to the size of man's head also were seen. It occurred in greatest quantities inland on the surface of the ground on Kirinyan Islet, Ujelang, and on Ebeju Islet, Ujae. On Ebeju perhaps a bushel could have been gathered in an area 20 meters square. This was a localized occurrence, though; other similar areas have little or no pumice. Much smaller amounts were scattered on the beaches, as on Jemo, above the normal wave mark; and in several places where dunes and sand spits were being cut away by wind or waves, buried pieces were exposed.

The only record of pumice in the Caroline atolls is from Kayangel Atoll, Palau (Cloud, personal communication, 1953). [But see Addenda, p.20].

Several records of the presence of pumice are available from Laysan Island, one of the northernmost atolls in the world. H. H. Schauinsland, who spent 3 months on this island in 1896, observed hard seeds, nuts, masses of resin, and rounded pieces of pumice [Bimstein] in the abundant piles of bird droppings (Schauinsland, 1899, p. 20). In an appendix (p. 89) he enlarged on the subject and noted that he did not find any pumice on the strand during his sojourn, but that it was always present in the center of the island, partly on the surface, and partly in the guano pits. An interesting sequel to this report is found in the journal of Munro (1946, p. 43). Quoting from his journal on Laysan (June 20, 1891) he writes: "On the dry surface of the lagoon there are lots of small pieces of pumice," but adds, "evidently this was cuttlefish bone disgorged by birds." He reports finding pieces of cuttlefish bone in the gizzards of young albatrosses and other birds.

It would seem that the two observers may have seen and reported the same thing. It is interesting to note that they both believed it to be pumice at the time. Since we have no idea what regurgitated cuttlefish bone may look like, it seems difficult to settle the question at this point. It is unfortunate that no one thought of bringing back a bit of the material. However, it is quite possible that Mr. Munro should not have distrusted his 1891 observations and that both he and Schauinsland did observe pumice scattered on Laysan. The fact that some of it had gone through the albatrosses' stomachs does not necessarily mean that it was not pumice. Schauinsland (1899, pp. 20, 89) remarked that these birds will swallow anything and that they may pick up the rounded pebbles intentionally "to help their digestion."

Much later (in 1912) Elschner visited the Leeward Hawaiian Islands and recorded (1915, p. 35) pumice on Laysan, Pearl and Hermes Reef, Lisianski, and Midway.

One of the most intriguing observations of pumice is that made at the time of the visit of the Austrian ship Novara in 1858, to the atoll of Sikaiana or Stewart Island. Both Scherzer (1862, p. 607) in the "Narrative" of the voyage, and Hochstetter (1866, pp. 157-158) in the "Geology," mention the abundance of pumice on Faule, one of the two larger islets of the atoll. Hochstetter pointed out that the pumice was "finely porous and brown, and floats on water." Trying to ascertain the thickness of the pumice beds, Hochstetter examined the sides of a water-hole about 18 feet in diameter, found in the middle of the forest. The rims of the hole were of "compact coral conglomerate," and the pumice lay all around but only superficially, in the humus layer covering the coral rock.

Guppy (1887, p. 140) mentions that during the surveying voyage of the "Fly" much pumice was found in various places along the eastern coast of Australia. This is reported by Jukes (1847) in his narrative of the voyage. The "Fly" visited a low coral island, Raine Islet, and Jukes (1847, p. 128) observed pumice there, embedded in the coral sandstone forming the island.

Beyond Australia, westward in the Indian Ocean, we find pumice recorded in the Cocos-Keeling Islands by several authors. The earliest such reference is by Keating (1840, p. 378) who said: "Large quantities of pumice-stone have been found on all the islands." Later pumice was recorded by Guppy (1889, pp. 284-287), who spent ten weeks on Cocos-Keeling in 1888, and by Wood-Jones (1910, pp. 170-171), who lived for fifteen months on the main atoll as a doctor and included his observations in his book "Coral and Atolls."

Further west we have records of pumice from the Chagos Archipelago: Moresby (1844, p. 309) wrote: "Masses of pumice-stone are constantly found on the beach of the islands, ... One piece in Captain Moresby's possession, measures 37 by 27 inches, and weighs 8 lbs. 12 oz." Finsch (1887, p. 42) and Wilson (1889, p. 144) observed pumice in 1884 on the beaches of Diego Garcia in the same group.

The last region in the Indian Ocean from which we have records of pumice is that of the long chain of atolls of the Maldive and Laccadive archipelagoes. Because of their proximity to India, of the activity of the British civil servants, Navy officers, and naturalists, and because several great scientific expeditions studied these islands, we have more information on them than on most atolls, and those scattered in time.

In 1892-94, a party on the ship "Investigator" surveyed the Laccadives, and Alcock (1902, p. 175), a naturalist on the 1892 campaign, reports that two of the ship's officers discovered a bed of pumice a little inland of the north end of Cardamum (Kardamat) Island. Unfortunately, he did not hear of it until the ship had steamed away. Oldham (1895, pp. 6-7) mentions this occurrence and seems to imply that he himself saw this pumice bed, but apparently at a later date. "The northern point of the island is formed by a spit of sand on which I found a quantity of pumice, extending inland for about fifty yards from the extreme point; it is strewn all over the surface, and varies in size from a marble to half a foot in diameter." The "Investigator" party also found pumice pebbles on the bottom of the Bay of Bengal (Alcock, 1902, p. 153).

Ellis (1924, p. 9) recorded pumice from the Laccadives. In 1899-1900, J. S. Gardiner visited the Maldives, Minicoy, and the Laccadives, and with his two associates, gathered vast amounts of information and extensive zoological and botanical collections. The results for the main part were included in two large volumes published in 1901 to 1906. Gardiner (1906, p. 582) found pumice on many of the atolls. In another paper (Willis and Gardiner, 1901, p. 113) Gardiner mentions finding a little pumice among foraminiferal sand on Hulele Island, Male Atoll. Soon after Gardiner, Alexander Agassiz visited the Maldives (1901-02) and published his account, accompanied by a volume of valuable photographs (1903 b). He recorded (pp. 63, 69) the presence of abundant windrows of pumice on the beaches of two atolls, South Malosmadulu (Embudu Islet) and North Malosmadulu (Medu Islet).

The latest information on pumice in the Maldives was collected during the John Murray Expedition of 1933-34 and is recorded in Sewell's accounts. On Horsburgh Atoll (Sewell, 1936 b, p. 116) lines of small pumice fragments were observed on the sandy sea beach of Goidu Islet.

On Addu Atoll (Sewell, 1936 a pp. 77, 79, 82) pumice occurred on several of the islets (Putali, Mulikadu, Maradu) inland from the sandy lagoon beaches. On Putali (p. 77) "Running along the whole length of the northern part of the island, about 10 yards to the east of the steep bank that now forms the east bank of the lakes [elongated ponds running parallel to the lagoon edge], there is a well-marked line of rounded, water-worn pieces of pumice." Sewell goes on to quote Gardiner's and Oldham's observations, and concludes that this pumice must come from Krakatau: "if this be so, then since 1885 or thereabouts the inner beach of the island has advanced towards the lagoon by some 10 yards, and sand spits have been built out into the lagoon and have cut off the lake ...."

No records were found of the occurrence of pumice on the Western Indian Ocean atolls.

Very little information is available on the atolls and low coral islands of the Gulf of Mexico and the Caribbean Sea, and there are no records of pumice on them. However, in this connection, it is interesting to note that Guppy (1917, p. 6) mentions pumice pebbles found in beach drift in the West Indies.

Probable origin and transport

Although the occurrence of pumice on coral atolls has, at times, greatly puzzled the observers -- especially when found far inland on the islets -- it has been generally accepted without argument that the pumice had been floated by the ocean after eruptions of distant volcanoes, carried about by currents, and deposited on the beaches of low islands in the same manner as other drift material.

Elschner (1915, pp. 35-36) wrote:

> "We can produce two sources of this pumice in the last decades. The Sunda Straight sustained great changes at the time of the eruption of the volcano Krakatoa, as immense quantities of pumice stone were thrown out, which were then washed ashore on the reefs and beaches of the different coral islands in the central Pacific Ocean; for instance, on Nauru, all over the Marshall Islands and the Mortlock atolls, etc., also in the northern part of the Pacific, pumice stone pieces, even though small quantities, were found drifting and washed ashore.
>
> "In the year 1906 ...., Captain Schlemmer at that time in charge of the phosphate works on Laysan Island (which have since ceased to exist) mentioned in his diary that he observed that a quake was to be felt and on the following days the sea was full of drifting pumice stone pieces. On his trip from Laysan Island to Honolulu he observed these pumice stone pieces as far as in the neighborhood of the main group near Kauai.
>
> "<u>Appearance inland</u>
>
> Seabirds, especially frigate birds, during their flight, pick up floating particles on the water and swallow them, so that the discovery of the pumice stone in the interior of the island is to be explained on the principal that undoubtedly the birds vomited these pieces.
>
> "The appearance of pumice stone in this neighborhood in March and April, 1906, is interesting; it documents the last traces of volcanic activity, which formerly were here of an imposing degree. At the mentioned time eruptions of the Hawaiian volcanoes did not take place and the occurrence of drifting stone, limited to this part of the group, was therefore of a local nature, that is, it most probably was caused by a quake of the ocean bottom in this neighborhood."

Yamanari (1935, p. 17) reports that after the eruption of a submarine volcano in 1934, large quantities of pumice drifted around in the seas near the Minami-Satsuma Islands.

The great quantities of pumice found on Sikaiana are perhaps more easily explained than if they occurred in the Tuamotus, for example. Sikaiana, a seldom described atoll, lies near many volcanoes, those of New Britain, the Solomon Islands, and the Santa Cruz Islands, to mention the nearest ones. Whichever of these the pumice came from, it did not have to travel very far and could be thrown up on the islands when great quantities of it were still floating together, before being scattered over greater expanses of the sea.

The question of how far and how long pumice can float was taken up by H. B. Guppy. He was fascinated by the factors responsible for the dispersal of plants; therefore he took great interest in the study of drift material and wrote two books on the subject. In another of his works (Guppy, 1887, pp. 137-144), he devoted a whole chapter to the drifting of pumice quoting many of the sources mentioned here and giving much information on the presence of pumice on high island beaches and at sea.

> "The pumice ejected during the volcanic outbreak at Blanche Bay in New Britain in May, 1878, was carried eastward by the drift-currents, and literally deluged the shores of the Solomon Group, both impeding navigation and temporarily suspending the beche-de-mer fishery .... Mr. Wilfred Powell, who was present at the time of the eruption in New Britain, states that Blanche Bay and a great part of St. George's Channel were so thickly covered with pumice that it was impossible for a boat or even a vessel to work its way through ....
>
> "Several agencies assist in the dispersion of a field of floating pumice. In the first place, the trituration or wear and tear of the fragments, a process by which they soon obtain the form of rounded pebbles, considerably reduces their size .... In the course of time the winds and waves scatter the floating fragments, and arrange them in long streaks a mile or more in length and some 25 or 30 yards in width .... Finally .... solitary fragments are scattered over the surface of the ocean where they may float for many years until their sodden condition causes them to sink. It is not unusual to find in the tow-net in the mid-Pacific a solitary stone, which has become so sodden that it has not sufficient buoyancy to float in fresh water.
>
> "The length of time that pumice will float in sea-water is a matter that bears on the distribution of this material over the various oceans. Judging from an experiment I made in the Western Pacific, pumice may float for several years before it becomes sufficiently sodden to sink to the bottom. I kept floating in seawater for two years and nine months three rounded pieces of andesitic pumice, which I originally obtained in the tow-net whilst cruising in the Solomon Islands. Although they had evidently been a long time in the water before

I got them, since they floated heavily and had the discolored appearance of old drift-pumice, the only evident alteration in their buoyancy produced by my experiment was that one piece which floated in fresh-water, when I first obtained it, now sank ...."

The origin of the great amounts of pumice found on Cocos-Keeling Atoll was also discussed at length by Guppy (1889, pp. 284-286):

"I shall refer more than once in these papers to the part which the pumice derived from the great Krakatoa eruption of 1883 has taken in reclaiming land from lagoon. Narrow inlets have been obliterated and the shallow water around the lagoon has been in places filled up by fields of floating pumice that drifted inside the reefs. The Krakatoa pumice, readily known by its white and fresh appearance and its unsodden texture, is to be found at present in great quantity on the beaches .... but there is another kind of this material, apparently elsewhere derived, though of somewhat similar composition, which is found inside the raised weather margins of the islands, and extends for some 20 paces or more amongst the trees. It is of much greater age; and whilst its outer surface is darkened by weathering, its interior is often sodden and half-rotten. There is also a black and heavier pumice, formed of a more basic lava, which is known (rightly or wrongly) amongst the residents as the Tomboro pumice, and is found amidst the vegetation 15-20 paces in from the weather beaches. It varies in size from a walnut to a coco-nut; and, unlike the two felspathic kinds of pumice above referred to, it withstands decay, so that although it has been known in the island for half a century and more, its internal substance is still unaltered ....

"Wherever, in these islands, a layer of old pumice overlies the sandy soil near the beach, an abundance of volcanic minerals, especially magnetite, occurs in the soil. By means of a magnet, a number of fine particles of magnetite can be collected from a saucer filled with the white calcareous sand that is found between the tide-marks upon the beaches .... The local evidence would seem to show that they [the grains of magnetite with their occasionally attached semifused feldspar crystals] are derived from the decay of pumice that is stranded in such large quantities on these beaches, especially since I found them in greatest abundance in the sandy soil underlying an old bed of pumice. Their large mean size, viz., half a millimetre, and the specific gravity of the mineral, would seem to favour this opinion. It should, however, be noted that during the night following the great eruption in the Sunda Straits, some 700 miles away, fine pumice dust fell over the Cocos-Keeling Islands in such quantity that on the succeeding morning it was found covering the deck of a schooner, that lay at anchor in the lagoon, with a layer a quarter of an inch deep ...."

Wood-Jones (1910, pp. 170-171) also discussed the origin of the Cocos-Keeling pumice:

> "On the seaward beaches is thrown the flotsam and jetsam that reaches the group from the outside world, and one of the principal items,-one that has in many places caused a considerable alteration in the character of the islands - is pumice. The greater part of the pumice found in the group arrived after the eruption of Krakatua; being washed up in 1883 in vast quantities. This pumice, lightest of all the wrack that the sea has piled up, has been carried for varying distances into the island from the seaward beach, and shows, as an index, the limit of surf action in the island building that has been reached in twenty three years. It occurs in great quantities as rounded sea-worn masses, some being a foot or more in their long axis, but the majority varying from the size of marbles to that of cricket balls. Besides the Krakatua pumice, which lies to-day mostly on the seaward beaches, and for a few paces into the island itself, there is older pumice which may be found almost anywhere in the breadth of the dry land. Pumice has been arriving from somewhere ever since the first appearance of land in the atoll ring, and has, during the period of its stay, undergone much decomposition. The Krakatau pumice is almost uniformly grey, and is fresh and clean: but pumice exists far from the sea that has become impregnated with foreign substances, and is in many places entirely fragmented. The various stages of pumice degeneration may be traced from the sea beach to the interior of the island. Some of the pumice has never been grey, and rounded blocks of a black and cinder-like substance are here and there found in parts of the island where pumice has been most freely washed ashore. This pumice does not appear to belong to any one particular period, for it is found to-day on the beaches, and in the islands, but its composition where-ever found appears to be the same, and, on fracture, it's internal part is always shining and fresh-looking, if it be picked up on the beach or far in the center of an island."

Wood-Jones, like Guppy, was interested in plant and animal dispersal and devoted a chapter of his book to this and related subjects. In it, he went back to the subject of pumice (pp. 290-291) and said of Krakatau pumice: "This pumice has been touring the ocean for over twenty years, and still, in the Sunda Straits, some set of current will send whole masses to sea, and a ship will steam for half an hour through the bobbing white balls of pumice which are launched upon an indefinite, and an irresponsible journey." Of the pumice older than that attributed to Krakatau he says: "This is most probably the pumice set adrift in the April of 1815, when the unparalleled eruption of Tomboro - the great volcano of Sumbawa took place." He adds: "The blocks of pumice set adrift by the eruptions have been navigating the Eastern seas ever since ...."

Visitors to Diego Garcia, Chagos Archipelago, were undoubtedly correct in believing the pumice they observed to be a product of the 1883 eruption: by a happy coincidence, two naturalists, Finsch and Wilson, stopped at Diego Garcia (then a coaling station) in 1884 and published their observations on the atoll. Finsch, (1887, p. 42) observed pumice on the lagoon strand and on the outer shore "in great quantity." Later, his ship encountered great drifting masses of pumice at sea. R. F. M. Wilson (1889, p. 144) spent only an hour on the atoll and mentions large quantities of pumice: "There must be tons of it lying on this beach." At sea, he also observed it, but in "wreaths." The Nautical Magazine in the last months of 1883 repeatedly warned its readers of the changes in the Sunda Strait and said (p. 852): "In some parts of the Straits the pumice stone is 7 ft. to 8 ft. deep."

Another instance in which the source of pumice was rightly identified as Krakatau is reported from Rameswaram Island, at the north-west end of "Adam's Bridge" in the Gulf of Mannar, between India and Ceylon, by Foote (1889, p. 835):

> "As we walked eastward along the beach our attention was attracted here and there by the quantity of pumice stone thrown up. Not a vestige of pumice was seen along the beach when I visited it in 1882, but now it abounded, having been drifted from the straits of Sunda after the terrible eruption of Krakatao in 1883. The pumice fragments were of all sizes, from a pin's head up to a child's head, and most of them showed signs of their long sea voyage, in the form of incrustations of nullipores of serpulae or of flustrae and other equally lovely polyzoa, together with serpulae of several species. Many specimens showed also adherent young valves of a very pretty white and crimson species of Spondylus. It was impossible not to be struck by the great number of zoological, geographical, and geological facts recorded by these interesting specimens."

Of the pumice observed in the Maldives and Laccadives during his expedition Gardiner (1906, p. 582) says: "On the shores of many of the islands there are lines of pumice, which the natives state were washed up about 1885, and would hence have probably owed their origin to the eruption of Krakatoa in 1883. In addition half-decomposed pumice is found, in places at some considerable distance inland, which evidently belonged to an earlier period." Ellis (1924, p. 9) in an account of the Laccadives, quotes Gardiner's suggestion that pumice found in the Maldives came from Krakatau, and adds that in the Laccadives, large beds of pumice were reported after 1883, "which have now entirely disappeared. Only scattered pieces much water-worn are now found." Sewell (1936 a, p. 77) also attributed the origin of the pumice observed on the Maldives to the eruption of Krakatau in 1883 (see p. 4 of this paper).

The 1883 eruption, however, despite its violence and the sensation it caused, was not the only source of pumice found in the Indian Ocean: Moresby (1844, p. 309) found pumice in the Chagos Islands when he surveyed the archipelago in 1836-37.

Most authors quoted here attribute the origin of the pumice directly to volcanic eruptions. This is undoubtedly the usual case, but it seems conceivable that some of this material might be launched onto the sea by the action of the waves undercutting the slopes of some of the numerous volcanic cones found in the Pacific. Some of this bobbing pumice may well have spent a good part of its time as part of a volcano's slope, before being freed and set adrift in the cone's erosion.

Lacroix (1939 a, p. 610) discussing the pumice collected by Seurat in South Marutea (Tuamotus) remarked that this chemical-mineralogic type of rock was known in the South Pacific only from Easter and Tutuila Islands and suggested an origin for it in a hypothetical submarine volcano that might have existed in some part of this vast region. It is not clear whether he had in mind an underwater eruption or a cone that extended above the surface and was subsequently cut away by the waves, but he probably meant the latter. In any event, it does not seem necessary to postulate the existence of such a volcano, because it is quite possible for pumice to float from Easter Island or elsewhere to S. Marutea.

The possibility should not be overlooked that some of this material, for example the coarse, black variety found by Fosberg in the Marshalls, might not be pumice at all but clinkers from the furnaces of coal-burning ships. Such have been reported cast up on the shores of Lake Michigan by Dr. Helen Foster and Mr. Gilbert Corwin (conversations, 1954). This may be determined for the Marshall Islands material by future petrological studies.

Chemical and petrological nature

An obstacle to the discussion of the origin of pieces of pumice found on atolls is the fact that few have ever been studied for their petrological character and chemical composition. Recent unpublished analyses of such material will be found in an addendum to this paper, p. 21.

Lacroix based his remarks (1939a) on several analyses including one by Raoult of South Marutea material (Lacroix 1928, pp. 44-45. This is as follows:

	Percent
SiO_2	69.40
Al_2O_3	15.29
Fe_2O_3	0.46
FeO	1.73
MgO	0.11
CaO	1.86
Na_2O	5.30
K_2O	3.91
TiO_2	0.32
P_2O_5	0.06

		Percent
H_2O (+)	....	1.57
H_2O (−)	....	0.36
MnO	....	0.07

Lacroix described this material as a rhyolithic pumice, "formed of volcanic glass with elongated cavities, which contain a few hexagonal plates of biotite" as the only crystalized minerals. He remarked that its chemical composition showed in any case that it could not be pumice from Krakatau. He pointed out a similarity with the trachyte from nearby Pitcairn Island, suggesting that the pumice might not have come from too far away.

The pumice from Funafuti was examined by Cooksey (1896, p. 77):

"Pumice Pebbles. -- Pebbles of pumice stone, the largest of which resemble a walnut in size, all much water worn and rounded, were collected from various places on the outer circumference of the Atoll, and possibly occur on all of these islets. They possess a fibrous texture, and contain macroscopic crystals of sanidine. The colour varies from light to dark grey, one or two having a brown or greenish tinge.

"An analysis of one which was much rounded by attrition, and possessed a very light grey colour, gave the following percentage composition:--

Hygroscopic moisture	... ...	.09
Loss on ignition	... ...	2.29
SiO_2	... ...	66.50
Fe_2O_3	... ...	3.21
Al_2O_3	... ...	16.84
CaO	... ...	3.03
MgO	... ...	1.03
K_2O	... ...	5.44
Na_2O	... ...	2.53
P_2O_3	... ...	trace
		100.96

"A partial analysis of another pebble of a darker shade gave 60.37% of SiO_2."

Cooksey noted that the figures in this analysis agreed very closely with results of analyses of material from the 1883 Krakatau eruption but thought this volcano too far away to be a likely source of the pumice in Funafuti.

Uses: Agricultural and abrasive

In the Gilbert Islands the U. S. Exploring Expedition learned that pumice was gathered by the inhabitants and pounded up to fertilize the soil of the taro pits; in addition, Wilkes (1845, vd. 5; p. 81) writes: "the coconut trees are fenced round, and pounded pumice is mixed with the soil near their roots. This stone is collected by the women, who are frequently to be seen in numbers on the beaches, after westerly winds, picking it up in small baskets."

Hartzer, a missionary (1900, p. 43) writes in almost the same words, and so does Kurze (1887, p. 68). Such observations on the taro-pits have been made or quoted by others, such as Meinicke (1863, p. 405) and Finsch (1893, p. 52). Gulick (1862, p. 413) also described the careful tending of the taro-pits but said that soil was brought to them in baskets and shifted. He did not mention pumice. Probably both were added to the various leaves, which were shredded and thrown into the pits. A similar instance is found in Grundemann (1887, p. 442): According to him, on Ailuk in the Marshalls, soil and leaves were thrown into the pits, and pumice, when available, was ground up and added. This is the only record of this practice in the Marshall Islands. Similarly Cloud's observation of the use of pumice as fertilizer on Kayangel Atoll, Palau (personal communication, 1953), is the only record for the Caroline Islands.

In spite of its abundance on the Ellice Islands, pumice does not seem to have been used there as in the Gilberts. It might be pointed out here that the Gilbert Islands are the most densely populated of all atolls and at the same time one of the driest and most sterile of the inhabited atolls and at the same time one of the driest and most sterile of the inhabited atoll groups. In this connection it is noteworthy that pumice is used as fertilizer in another densely populated group, the Maldive Islands. Gardiner (Willis and Gardiner, 1901, p. 121) says that on Suvadiva, plantains are grown in pits dug to below high tide level "and on Kondai [islet of Suvadiva] I saw a man put in a basket a pumice from the beach; this appeared on enquiry to be a regular custom of the island."

In addition to its role in atoll agriculture, pumice is often used on these limestone islands as an abrasive: In the Gilberts, Finsch (1914, p. 254) says that pumice was used to polish and smooth wood, shell, and coral. In Ujae (Fosberg, unpublished observations 1951-52), the Marshallese called it by the name "tilan," and they said they used it like sandpaper. A large piece of a black, coarse-grained, hard variety was seen in use as a whetstone for machetes on Bock Islet, Ujae.

Ecological significance

Very little factual information is available on the ecological significance of pumice on atolls. Several authors have discussed it, following three main lines of speculation: One is the possible role of pumice in the dissemination of animals from one shore to another. Another is the information that pumice has been supposed to furnish on ancient shore-lines. The most important is the possible influence of pumice on the growth of plants.

Some of the above-mentioned authors, such as Whitmee and Guppy, have spoken of pieces of pumice incrusted with marine animals such as annelids, cirripeds, bivalves. Wood-Jones (1910, p. 291), after his discussion of the origin of stranded pumice (see p. 8 of this paper) added: "the blocks of pumice ... have visited many shores in the course of their travels, and have constituted a mighty fleet of passenger vessels for the use of Nature's colonists." In some cases pumice may play a certain role in the dissemination of marine forms, but it seems that Wood-Jones exaggerated the "mightiness" of the effect.

Guppy's chapter on pumice drift (1887, pp. 137-144), in spite of some hasty and regrettable assertions (a footnote on p. 143 says that "the trees of the center of a coral islet grow from seeds ejected by the fruit-pigeons), contains a wealth of facts and is one of the few compilations and discussions of the intriguing problem of stranded pumice. The author attempts to clarify the ecological significance of this material. Unfortunately he had a tendency, at times, to let his keen observations be colored by the theories dear to him. Thus, in his notes on the distribution of pumice pebbles on islets (Guppy, 1887, p. 141), he mixes facts and assumptions:

> "I shall subsequently point out, that as we cross a coral islet from its weather or newer portion, the pumice pebbles become fewer and more decayed, until they finally disappear in the leeward or older part of the islet. Such a fact proves that this material has not been swept over the surface of the islet by a single wave, such as those which follow earthquakes, but that, whilst the islet has been growing sea-ward with the reef in the course of ages, pumice has at widely different times been stranded on its shores. The decayed pumice pebble, that now lies among the trees in the interior of the islet, remains where the ebbing-tide left it long ago. The same explanation is also applicable to the pumice pebbles found on coral islets and reefs that have experienced some degree of elevation. Doubtless the "great sea wave" produced by an earthquake has sometimes distributed the pumice pebbles lying on the beach over the surface of the islet; but if it will be found, as I believe, to be generally true, that the pebbles get fewer and more decayed as we proceed into the interior, we must look to some other agency than that of the "great sea wave." In some coral islands which are placed in unprotected positions in the Pacific, pumice pebbles are found only in the interior and not on the beach. It would seem most probable that the force of the wind during storms would be sufficient to sweep the light pumice pebbles off the beach and amongst the bordering vegetation.
>
> "All the evidence goes to show that in a comparatively dry climate and on porous soil stranded pumice may resist for ages the disintegrating effects of the atmospheric agencies."

Guppy goes on to describe the distribution of the pebbles on coral islets in the Solomons and shows them to be fewer and more decomposed toward the interior, disappearing eventually on the lee side.

> "Those obtained within 20 or 30 paces from the beach floated buoyantly in the sea, but out of those found at distances greater than 100 yards, more than half sank. The pumice pebbles furthest from the beach were evidently of greater age and had been exposed for a longer time to the wet."

No doubt, on certain islands -- possibly on some of those examined by Guppy -- older pumice brought by one of the variously caused "great waves", which may at times completely cover low coral islets, is partly removed from the beaches by subsequent lesser storms and later happens to be surrounded by younger pumice, left stranded in windrows by the ordinary tides. (See quotation of Gardiner on p. 9 of this paper). This does not necessarily mean that the islet has become larger, offering more space for new pumice. The contours and total area of islets do change of course, and if an islet became larger, it might be from its seaward side, but the aspect and distribution of pumice are not sufficient to permit a reconstruction of the change. However, in certain special locations and when other evidence is available, pumice pebbles arranged in lines, well inland, may indicate a change in shoreline. Stone (1951, p. 2), writing of Arno Atoll, Marshall Islands, says "The progressive widening of Arno Island, although now slow, is known to the people there because inland and parallel with the beach they find rows of pumice pebbles such as occur along the present beach." (See also quotation of Sewell on p. 18 of this paper).

That Guppy does not realize the true relationship between topography of an islet, soil and vegetation is well shown in his next topic: He assumes (Guppy, 1887, p. 143) that soil gets thicker and richer from seaward to lee side of an islet because "we pass ... from its newest to its oldest portion" and therefore pumice has had more time to form soil, has been completely decomposed, and indeed, cannot be found anymore on the lee side. Actually there may never have been as much pumice in the center and on the lee side of this islet as on the seaward side. Vegetation does change as one goes from seaward to the more protected side of the islet, but this change is brought about by the topography and structure of the islet and the diminution in the effects of wave, wind, spray, etc. The vegetation in turn, together with these same factors, determines the variation in the abundance of soil, which is indeed often thicker in the center, or toward the lee side of an island, or the lagoon side of an atoll islet. But this zonation of soil and vegetation is quite independent of the presence of pumice. It is possible, of course, that given a uniform pumice layer over an islet to begin with, the pumice might decompose somewhat faster near the center of the islet than on the seaward side, because a thicker and faster forming soil and humus layer in this center would provide a greater abundance of the substances that cause the decomposition of the pumice pebbles.

While Guppy tried to prove the beneficial influence of pumice on the vegetation of a coral islet, other authors took it quite for granted. Scherzer (1862, p. 607) says:

"Another geological peculiarity is the occurrence of heaps of pumice-stone. These are found about the size of walnuts over the entire interior of Faole at those places which the swell of the waves cannot reach even in the stormiest weather, where they occur in such immense quantities (though there are no traces of them on the sand or shingle of the actual beach) that we may take for granted that the convulsion which brought them here must have occurred in times long gone by, the more so as this superposed pumice-stone exercises a marked and obvious influence upon the vegetation of the island. So far as its soil consists of heaps of fragments of coral and mussel-shells, the cocoa-nut palm reigns almost alone, whereas as soon as the pumice-stone region is reached, there begins an exceedingly luxuriant growth of lofty forest trees with huge trunks and umbrageous foliage, and an astonishing abundant <u>flora</u> of species apparently peculiar to these Atoll Islands."

This correlation of vegetation with substratum, also mentioned by Hochstetter, may be somewhat illusory, since the coconut palms were probably planted by the natives in a ring around the islet, and the luxuriance of the mixed forest, which includes breadfruit trees, is not too unusual in a very wet atoll such as Sikaiana. Yet the observations by Scherzer and Hochstetter are very interesting. It would certainly be worthwhile to find out now, almost 200 years later, what the soil of Faule Islet is like and whether any traces remain of the abundant pumice layer observed by the naturalists of the "Novara."

Other noncalcareous rocks

Various extraneous materials other than pumice are found on atolls: these are various stones, muds, etc., found among the roots of drift trees, or supposedly brought by them, other pieces of rock or even masses of coal or soil imported by men for various reasons, and finally the mysterious "basalt blocks" described from various islands.

The latter are of special interest on Rose Atoll, in American Samoa. This very small, uninhabited, and isolated island may have been first landed on by members of the U. S. Exploring Expedition (1838-42). Dana (1849, pp. 77-78) says that the officers on the Vincennes observed blocks of compact cellular basalt on Rose, lying 200 yards inside the line of breakers. Wilkes (1845, vol. 2, p. 64) adds that "they were from twenty to two hundred pounds weight, and were found among blocks of coral conglomerate." Unfortunately, Dana himself did not land on Rose, being on another ship. Couthouy (1842, p. 138), who was probably there, says that the volcanic boulders were found on the sandy lagoon bottom and were similar in appearance and mineral structure to the rocks forming the mass of Samoa and Tahiti and that one of them weighing about 20 pounds was picked up in 4 feet of water among small rolled blocks of coral conglomerate. At least one member of the landing party of the "Vincennes" published his own account of the discovery, although his book is not part of the official edition of the Expedition results; Pickering (1876, p. 235) writes:

> "For the first time on a coral-island, the mineral kingdom was represented; several blocks of vesicular lava being met with by our party; in all instances resting upon the coral-shelf, not imbedded. Two or three of these blocks were seen by myself, the largest weighing perhaps twenty pounds. From the mineral composition, they had evidently been derived from some volcanic island; and there seemed no means of transportation, unless entangled in driftwood. This actually takes place at the Tarawan coral-islands; where Mr. Hale found a native name for "Basaltic stones in the roots of trees drifted" to those shores."

Much has been made, in later works, of the discrepancy between the various accounts, as to the location of the boulders. And when A. G. Mayor, visiting Rose Atoll in June 1920, failed to find them "after diligent search" (Mayor 1924), it was generally assumed that the U. S. Expedition had mistaken blackened coral boulders for vesicular volcanic rock. This error is not hard to make, but it should be kept in mind that Couthouy and the officers of the Vincennes were not without experience of atolls, darkened coral boulders, etc., having visited a large number of the Tuamotus before reaching Rose. Later L. P. Schultz, a member of the U. S. Navy surveying expedition to the Phoenix and Samoa Islands (U. S. S. Bushnell), spent 11 days on Rose Atoll in June 1939, and found pieces of compact olivine basalt on the reef (a dozen or more, the largest the size of a man's head) and confirmed observations of the "Vincennes" party thereby reopening the question of the origin of the material (Schultz 1940, p. 48 and unpublished data). His specimens of it are deposited in the U. S. National Museum, where they are currently being studied.

Another occurrence of mysterious volcanic material is reported by Agassiz (1903 a, p. 350) on Andema [Ant] Atoll: "On Panemur, the westernmost island of the group, large coral boulders form the outer edge of the reef flat, with here and there a few fragments of volcanic rock ...." Unfortunately, Agassiz did not always make clear whether he was writing an eye-witness account, and we cannot be sure of this record as yet. The proximity to Ant of volcanic Ponape might help to explain the presence of the rocks, besides making it rather easy to confirm their existence.

One last record of "basalt" on an atoll was discovered with great excitement in the narrative of Captain John Cameron (1923, p. 397): He described "great basaltic stones" on Caspar Rico [Pokak Atoll, Marshall Islands], one of them "fifteen feet and six inches long, five feet and four inches wide, and three feet thick," and speculated on the hazards of their transport from some high island. Great expectations were raised when the Northern Marshall Islands Expedition explored the desolate atoll in the summer of 1952. No megaliths were found, but a lot of blackened coral boulders and remnants were (Fosberg, 1955 p. 28).

A different type of volcanic rock is recorded by Guppy (1889, pp. 286-287) from Cocos-Keeling Atoll. He writes:

"Near the middle of the breadth of Horsburgh Island [islet of Cocos-Keeling], and about 300 yards from the sea, there was, when these islands were first occupied, some sixty years and more ago, a huge volcanic bomb about four feet in height. It was somewhat dome-topped, and was imbedded about six inches in the soil. By the islanders this large mass of foreign rock, with its unknown history, was regarded with much mystery. It lay concealed in the midst of an ironwood forest of great antiquity, where it must have lain for ages; and its burnt-up appearance seemed to support the prevailing opinion that it was some meteoric stone ... Pieces have been taken away by the inhabitants .... the result of this practice being that at the time of my visit in 1888 only a few fragments, none much more than a foot in size, remained to illustrate the description given to me by Mr. Ross. They were, however, sufficient to disclose to me that this mysterious stone was a huge volcanic bomb of a dark reddish cellular lava, possessing a comparatively solid outer crust. The cellular fragments floated buoyantly on the sea; but the more solid parts of the outer crust, on which I also experimented, sank. Nevertheless, as the greater part of the original mass, according to the description given to me, was evidently cellular, I had no doubt in forming the opinion that the whole bomb originally floated."

The observant natives of atolls, who have been collecting pumice stones drifting onto their beaches, have also made much use of drifting logs especially on such islands as the Marshalls or Gilberts, where the supply of usable timbers for canoes and other constructions are pitifully small. They discovered that the roots of some such trees held stones and blobs of earth or mud and carefully collected and utilized these, as well as the wood. This was observed in the Gilbert Islands by Hartzer (1900, p. 48) who says that the large trees often hold pieces of resin like those found in the New Zealand forest, and stones of fine basalt, which are much esteemed and used to make weapons. Dana (1849, p.77) saw some large logs on Enderbury, Phoenix Islands, and in the Gilberts, which carried stones in their roots, and reported that on the latter islands these stones were usually basaltic or volcanic and much prized for use as whetstones, pestles, and hatchets (see also quotation of Pickering, p.16 of this paper).

Darwin himself (1852, p.461) discusses such occurrences and mentions that on North Keeling, Captain Ross [owner of the island at the time of the Beagle's visit] had found and preserved a green stone, rather larger than a man's head, embedded in the conglomerate. Darwin supposed it to have arrived on this seldom-visited atoll caught in the roots of a tree. Wood-Jones actually saw such occurrences on Cocos-Keeling and explains (1910, p.290) that buttresses -- common in many tropical trees -- are especially suited for such transport: "I have seen a 'buttressed' tree come ashore in the atoll: from whose base a wheelbarrow-load of fine red earth might have been collected ... From the roots of such a tree I have taken small stones..."

Eilers (1935, p.151) says of the natives of Songosor [Sonsorol, Western Carolines] that they use volcanic stones found in drift wood to smooth fibers used for plaiting.

In Micronesia, at least black mud found among such roots was often use to dye fibers. Thilenius (Thilenius and Hellwig 1927, p.204) reports such a custom on Tobi.

Earlier Chamisso (1821, p.155) wrote of the Marshallese:

> "They receive, in a similar manner, another treasure, hard stones fit for whetting. They are sought for in the roots and hollows of the trees which the sea throws up: iron and stones belong to the chiefs, to whom they must be delivered, on payment of a reward ...."

When the desired stones or soils were not available, the natives of the Caroline atolls, who did much voyaging and trading with high island peoples, imported them. Chamisso (1821, p.104) describes with some emotion, how Kadu, a native of Woleai whom the "Rurick" met in the Marshalls and took along for part of the voyage, "never neglected carefully to collect pieces of iron, broken glass, and everything overlooked by us, which might be valuable to his countrymen, he looked on the shore at Oonalashka, chiefly for stones, which might serve for whet-stones ..."

Girschner (1912, p.157) reports that on Namoluk, red earth imported from Ponape was used as a dye. On Pulusuk and Satawal, Damm et al. (1935, p. 81) mention similar imports from Truk. Finally E.G. Burrows (1949, p.12) found a single igneous boulder on Falalap Islet, Ifalik Atoll in 1947-48, which the natives told him had been brought by canoe in ancient times to be used as a whetstone.

Oldham (1895, p.6) reports that he saw pieces of volcanic stone and a green stone on the north end of Chitkak Island (Laccadives), which the natives had brought from the ballast of a steamer wrecked on Byramgore Reef.

This is not the only instance of material from a wrecked ship occurring on reef or atoll: At Ujelang Atoll, F.R. Fosberg (personal communication) in 1952 found small and completely waterworn pieces of coal scattered at the top of the lagoon beach and inland on the west side of Ujelang Islet.

Of some material observed on Laysan Elschner (1915, p.35) writes:

> "... I wish to mention the occurrence [on Laysan] of smaller stones of volcanic material on the reef and beach. To prevent errors it may be remarked that they come out of the ballast of the phosphate ships formerly loading here; however the occurrence of pumice stone in the lagoon and on the shore of Laysan Island, as well as on the shores of Mecker, Pearl and Hermes Reef, Lisiansky and Midway Islands, is unusually interesting."

That natives of atolls valued foreign stones and were intrigued by them is shown further by the fact that in widely separated atolls, they made idols out of them. Gill's observation on the subject is mentioned earlier on p. 1. In addition, various missionaries and other residents have reported similar instances in the Marshalls (verbal communications).

Imported soil

But the native people are not the only ones to have carted stones and soil around. On many atolls, the white residents, in an attempt to grow the vegetables to which they were accustomed, brought soil, often as ship ballast, from neighboring high islands: the Germans did so on Jaluit, the superintendent of the Cable Station did so on Midway (Bryan 1942, p. 202), and more recently small quantities have been brought to Kwajalein, and Johnston Island.

Wood-Jones (1910, p.180) says that 40 tons of soil were brought in 1902 from the Botanical Gardens of Singapore to Pulu Tikus, islet of Cocos-Keeling. He remarks that by 1905 "any trace of it was hard to find." Further information on soil imported into Cocos-Keeling is given by Gibson-Hill (1950, p.150).

Conclusions

Floating pumice, drifting on the ocean, is deposited on the shores or inland on low islands scattered in most parts of the tropics. It is used by the natives for polishing, whetting, and above all, for fertilizing garden pits and coconut-trees; it must have some influence on plant-life; and it may indicate changes in shore lines in certain localities. It is to be regretted that so few records are available, that so few collections and analyses of the various materials observed were made, that so little is known of the ecological role of pumice, and that it is not easier to revisit some of the recognizable localities to find out what has become of the earlier recorded pumice. Has it become buried in humus? How fast is it "decomposing?" Has it left traces in the form of various minerals as assumed for Kita Daito Jima? There, the origin of the iron and aluminum in thick deposits of iron and aluminum phosphates is assumed to have been large masses of sea-borne pumice (Yamanari, 1935) some of which is still found on the island. Pumice might also be the source of the abnormally high content of aluminum found by Lipman and Shelley (1924, p.205) in the soil of Rose Island.

The widespread and, at times, extensive occurrence on coral atolls of extraneous volcanic materials so different from the normal calcareous substratum emphasizes the need for thoroughness in investigation and caution in drawing ecological conclusions. The fact that the natives of several groups of atolls have discovered the fertilizing effects of pumice applications brings out very strongly the ecological significance of this material. In any general investigation of atoll soils, attention should be devoted to discovering and assessing these effects and to isolating the properties of components of the pumice responsible for them.

Addenda

After this review was completed, the work of Tayama on Micronesian coral reefs came to hand; it contains (Tayama 1952, pp. 152, 265) in a discussion of problems offered by coral reefs, an enumeration of occurrences of non-calcareous material on coral islands, which can be quoted here from the English text (p. 265):

> "Reef building corals, Foraminifera, calcareous algae, Mollusca, Echinodermata, sponges, Bryozoa, etc. are the construction materials of a coral island. Other and non-calcareous matter is extraneous. Pumice, however, is found in all coral islands, and will not be brought under discussion here.
>
> "a. Basalt gravel, in part intercalated in limestone, has been found on an isolated reef on Truk Almost Atoll and at a few localities on outer reefs.
>
> "b. Liparite gravels, scattered locally on the Jaluit Coast and Utwa Coast of Kusaie, are apparently from ballast washed ashore from wrecked vessels.
>
> "c. Boulders of crystalline schist are present on Pakin Atoll and granite, quartzite, and andesite boulders on Merir Table Reef.
>
> "d. One pebble of crystalline schist and two pebbles of basalt gravels are included in limestone (Younger Raised Coral Reef Limestone) on Etal Atoll.
>
> "e. The phosphatic reddish brown clay intercalated in the cay sandstone (Younger Raised Coral Reef Limestone) of Gaferut Island has already been mentioned. The analysis is as follows:

SiO_2	CaO	Fe_2O_3	Al_2O_3	P_2O_5
3.28	48.97	3.17	2.50	19.35%

> "f. Beach sands on the lagoon shore of Marugai (coral islet) on Mille Atoll contain substantial amounts of magnetite and amphibole. Conditions of deposition rule out transportation by man or by wave action...."

An unpublished observation by F. R. Fosberg may also be added here: In October 1953, a worn boulder, over a foot long, seemingly of very light gray granite, was observed on Wake Islet, Wake Atoll. On inquiry of residents of the atoll, it turned out that this was brought by a Japanese party a year or so earlier, to mark a grave of Japanese soldiers killed there during the war.

During the U. S. Commercial Company's Economic Survey of Micronesia in 1946 the late Dr. Josiah Bridge found pumice on Nukuoro Atoll, south central Carolines. Details of this occurrence are not available.

In the summer of 1954, pumice was found on Kapingamarangi Atoll by members of the Pacific Science Board Expedition. Both light gray and black pumice are abundant on the back shore beaches of most islets, occasionally forming pure pumice layers. Details of occurrence and chemical analyses will appear in a later report by Edwin D. McKee who kindly provided the above information.

Of the specimens of pumice collected in the Marshall Islands by F. R. Fosberg in 1951-1952 (see p. 2 of this paper), some were submitted for quantitative spectrographic analysis for specified minor elements to the Geochemistry and Petrology Branch of the U. S. Geological Survey.

The specimens were as follows:

Field no. 242: A white pumice from Jemo Island
243: A dark fine pumice from Jemo
244: A black scoriaceous pumice from Jemo
245: A pale gray fine pumice from Ujae Atoll
246: A gray pumice from Ujelang Atoll
247: A gray pumice from Ujelang Atoll
248: A gray pumice from Wotho Atoll
249: A gray pumice from Pokak Atoll

Field no.	Cu	Mn	Co	Fe	B	% Loss on ignition
242	.0009	.1	.0009	3.3	0	2.2
243	.003	.2	.002	7.7	0	1.0
244	.009	.1	.002	5.3	.004	.14
245	.003	.1	0	2.7	0	4.3
246	.002	.09	.001	3.6	0	3.4
247	.003	.1	.001	3.5	0	4.6
248	.001	.1	0	2.9	.002	4.1
249	.001	.1	0	3.4	.002	4.1

All samples were ignited at 900°C for 15 minutes. The following elements were not detected in any of the samples: Mo, Zn, P.

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Northern Marshall Islands Expedition, 1951-1952. Narrative

by

F. R. Fosberg

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Northern Marshall Islands Expedition, 1951-1952. Narrative [1,2]

by

F. R. Fosberg [3]

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3/ Botanist, U. S. Geological Survey

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Northern Marshall Islands Expedition, 1951-1952. Narrative

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Introduction

The Northern Marshall Islands Expedition, dubbed "Project Atoll" for ready reference, was accomplished during 1951 and 1952 as a part of the Pacific Geological Mapping Program currently being carried out co-operatively by the Office of the Engineer, Headquarters, Army Forces, Far East and the U. S. Geological Survey. The expedition was attached to a large surveying project of the Office of the Engineer, Hq, AFFE for establishing mapping control on the atolls of the Marshall Islands. Transportation and logistic support were furnished by the Engineer surveying vessels. The primary objective of Project Atoll was to collect geological and botanical information. The circumstances of the trip made possible only a reconnaissance study of some of the major islets of each atoll visited. Emphasis was placed on studies of the geology, hydrology, soils, and vegetation; observations of land and marine ecology, land and marine zoology, and other subjects were made as time and circumstances permitted.

The personnel varied from time to time. The four who participated were F. Stearns MacNeil and Charles G. Johnson, geologists, Ted Arnow, hydrologist, and F. Raymond Fosberg, botanist and general ecologist. Principal attention was directed to the following atolls: Pokak, Bikar, Utirik, Taka, Ailuk, Jemo, Likiep, Kwajalein, Lae, Wotho, Ujae, Ujelang, and Wake, with minor observations, either on the ground or from the air, of a number of other islands in the Hawaiian Group, Marianas, Volcano Group, and Japan.

Since much material and information of great scientific interest was collected, and various technical papers are projected on different aspects of the results, it seems worth while to present a preliminary general account, in the form of an itinerary and informal narrative, with dates, series of collection numbers for biological material, and some description of the islands and of the scientific investigations carried out. The account will be given in more detail for the activities of the author of this paper, leaving it to the others, if they care to, to write any detailed story of their own work. Geological and hydrological observations will occasionally be mentioned, however, because of their essential connection with an understanding of the ecology of the islands.

In this article the soils and vegetation of the northern Marshalls will not be described, except incidentally. Since preliminary notes on the birds observed will be presented in papers to follow, as well as lists of plants and animals collected, these birds, plants and animals will be mentioned only in connections of very general interest in the narrative. This account will serve as a reference for future papers, in which space may not be available for more than the essential observations on the subjects treated. As formality is not necessary, the narrative will be written in the first person.

Owing to circumstances, which will become clear as the account goes on, it became necessary to divide the expedition into two separate parts; one of these, with MacNeil as party chief, worked from October 1951 to April 1952, and the other, with Johnson as party chief, from July to August 1952. The participants met in October in Tokyo, where plans and preparations for the actual trip were completed.

Trip to Japan

My own trip started from Washington, with travel by commercial and military aircraft. After a few days in California and Honolulu, conferring on coral atoll ecology with workers whose fields of knowledge have a bearing on this subject, I left for Tokyo. My first actual atoll stop was a brief one on Johnston Island on the morning of October 22, 1951.

This small patch of sand originally had a vascular flora of three species. After the development of an airbase there at the beginning of World War II, plants introduced both deliberately and accidentally raised the flora to 27 species by 1946 (see Fosberg, Pac. Sci. 3: 338-339, 1949) and to 30 species by 1950.1/ Of these several ornamentals had reached a fair size by 1951. Casuarina equisetifolia was at least 8 meters high. Calophyllum inophyllum, Thespesia populnea, Terminalia catappa, and Hibiscus tiliaceus were 2 or 3 meters high, and the last two were rather chlorotic in appearance. Most sloping surfaces, embankments, bomb shelters, and the like were quite covered by a blanket of herbaceous vegetation—Boerhavia, Cenchrus, Eleusine, and Tribulus. Most flat surfaces were kept clean by traffic. Many weeds, such as Portulaca oleracea, Amaranthus viridis, and Euphorbia hypericifolia, grew around the bases of buildings. Pluchea odorata was common, but not as common as in 1946, while Pluchea indica had also become common. Only one coconut seedling was seen.

After crossing the international date line, we sighted Wake Island late in the afternoon of October 23. The general vegetation in the neighborhood of the airstrip is a scrub of Messerschmidia argentea not over 2 to 3 meters tall, with some admixture of Scaevola locally. Open areas are occupied by pure stands of Fimbristylis, which seems to colonize the most extreme habitats, such as the edges of airstrips, and by Ipomoea tuba, which also climbs in the scrub as well as creeping over the ground. Around the buildings are various weeds, of which Cenchrus is most common and forms pure patches. Heliotropium anomalum is common, with no evident floral dimorphism. There are some marshy depressions, perhaps artificial, along the airstrip away from the terminal. The stop here was also only a brief one for fueling.

Iwo Jima was reached at midnight, therefore little was seen of its features. Chloris inflata was abundant around the airbase.

1/ Additional introductions are listed by Newhouse, Pac. Sci. 9: 91-92, 1955.

Japan, on our arrival, was completely blanketed by clouds. One glimpse through them of green terraced hills and the conical peak of Fujiyama towering far above, proved that we had reached our destination. We came down through the clouds over Tokyo Bay, with its myriad of fishing boats, rows upon rows of fences for algae cultivation, and the gray, smoky cities of Yokohama and Tokyo on its shores.

MacNeil had been in Japan for several weeks, working with Johnson on plans for the expedition. Arnow flew up from Guam for two days to talk over plans, then returned there to join the ship on its first fueling stop at Kwajalein.

The three weeks in Japan, while we waited for last minute preparations, were well spent meeting Japanese botanists, visiting Japanese herbaria, and checking equipement and supplies for the expedition. Weekends and a trip to Fukuoka to visit Prof. Hosokawa gave a few opportunities to see the interesting and beautiful Japanese countryside.

Pokak and Bikar

On November 16 the ship, the Army FS-367, Captain Marvin Shoaf commanding, carrying a Japanese surveying party of some 40 or more men, 10 U.S.Army personnel under the command of Major Paul L. Hudson, and MacNeil and myself, left Tokyo Harbor. A direct course was set for Pokak (Taongi) Atoll, the northernmost of the Marshall Islands and the first scheduled stop of the expedition. Not a living thing was seen on this stretch, except a few flying fish after the fifth day. On the night of November 24 the ship slowed down and the cries of sooty terns told us that land was nearby. Anticipation of the visit to Pokak Atoll was heightened by a rumor of mysterious basaltic megaliths, found there by John Cameron, a Pacific trader and adventurer, and recounted briefly in the story of his life , "John Cameron's Odyssey" (p.397, 1923). Such stones would indeed be remarkable on a coral atoll 600 miles from the nearest volcanic land.

On the morning of November 25 we awoke to a clamor of birds, and the low gray-green strip of vegetation and white breakers half a mile to the north was Pokak Atoll. A black-footed albatross flew by, the only one seen on the trip.

Pokak Atoll is crescent-shaped, with a single, narrow boat passage on the concave western side. This being the leeward side, at high tide the entrance should normally have been passable to small boats, but on this occasion a heavy swell was coming in from the west and breaking clear across the passage, out of which a strong current was pouring. Inspection by small boat parties convinced the Major that landing was dangerous and impractical, and a decision was made to leave for Bikar, the next atoll to the south. Before departing we were able to follow the south and east coast, where there are islets, to the eastern extremity of Kamome Islet. Sea birds were generally abundant, but over Kamome they almost darkened the sky. The vegetation here was in especially poor condition.

No further description will be given here, as Pokak Atoll was visited again later.

Bikar was sighted on the morning of November 26. Its three principal islets were completely covered by what appeared to be Pisonia forest, except for some storm-swept bare areas and a small coconut grove on Bikar Islet.

Here again, there is only one channel into the lagoon, located on the west or leeward side. A short inspection of this passage convinced the Major that this also was impassable, and we departed for Utirik Atoll, which we reached the following morning. We did not get ashore, however, until November 28, and were there until December 4.

Utirik Atoll

Utirik Islet, the main land-mass on the atoll, is very largely covered by coconut groves, except for a belt of thick scrub and forest on the northeast or windward coast and the long, almost bare projection along the reef to the west. The village is on the lagoon shore of this islet. In the northern Marshalls there is usually only one village on an atoll, commonly located on the largest islet. This islet usually bears the same name as the atoll, as also does the village.

The coconut groves on Utirik were rather open and free of undergrowth. It was immediately evident that a typhoon (Typhoon Georgia, March 21, 1951) had recently visited the island. Large numbers of coconut trees were knocked down, mostly in a southerly or southwesterly direction. Practically no ripe coconuts were to be seen in the trees or on the ground, and no copra was drying. On the western projection of the island most of the loose material was removed, exposing large root systems of dead and unrecognizable plants. The Pemphis bushes that grew here were in a very battered and ragged state. Curiously enough, though, the ridge of low dunes along the lagoon side of this strip of land was well vegetated with fair-sized bushes of Scaevola, Messerschmidia, and Pemphis and showed no signs, whatever, of typhoon damage.

Evidence of an earlier typhoon was quite clear in the form of a rubble bar in the lagoon opposite the bare portion of this extension of the island, its end at the point where the coconut grove ended. That this was not a result of the 1951 typhoon was indicated by the facts that all the fallen trees pointed in the opposite direction and that the bare area and rubble bar were both evident on aerial photographs taken in 1944. The earlier typhoon was severe enough that loose material up to substantial boulder size was swept off this narrow portion of the island and piled in the lagoon. Relatively little vegetation, except scattered Pemphis bushes adapted to growing on bare limestone rock, had reappeared in the 35 or more years since this storm. The natives tell of a storm about 1918 but are not certain of the year. It is quite possible, though that we were observing the effects of an earlier storm, in the last part of the 19th century.

Some areas of bare coral sand were characterized by a thin crust of sand held by a mass of blue-green algae. Rains were frequent enough to keep this sand washed fairly free of salt, but once in a while very high tides would give it a salt-water bath in low areas. This happened at least once or twice in the days that we spent there.

The Polynesian arrowroot, Tacca leontopetaloides, grew in unusual abundance and luxuriance as ground cover in the coconut groves here. Each year, in the late fall, it fruits and dies down to the ground. Here it was beginning to turn yellow, and the fruits were essentially mature. The tubers, mistaken for potatoes by other members of our party, were being harvested in some quantity by the Marshallese. They were grated and the starch was washed out and dried in large balls, about the size of a child's head. Whether this was normally so widely practiced was not certain. It may have been a result of food shortage because of the typhoon. There was some complaint about lack of flour.

Several pit wells were observed, and the water in them was surprisingly fresh. Dragon flies and damsel flies were seen around them, but no mosquitoes were noticed. Several holes were dug in an attempt to get water samples and to study the behavior of the ground-water body, as well as to collect soil samples. The upper layers of the soil were surprisingly black. Digging was extremely difficult because of the amount of rubble in the soil and because bedrock was usually reached above the water table. This bedrock is a curious cemented fine coral gravel, quite hard, but shattering completely under a hard blow of a hammer.

In the central part of the islet are a number of elongate depressions or trenches about 10 meters wide and 2 meters deep. They are said by the natives to have been made by the "old people," and are doubtless long-abandoned taro pits. They have been abandoned long enough to have mature coconut trees growing in their bottoms. In the bottom is a layer of black mucky soil almost 6 decimeters deep. A hole dug in the bottom of one of these reached water at less than 1 meter. The water had a strong hydrogen sulfide odor and a peculiar sweetish taste.

On the northeast part of the islet, near the edge of the coconut plantation, but within it, were noticed some curious low rounded mounds of small, sharp, broken coral fragments. Their origin was not apparent. On these mounds Fleurya ruderalis and Boerhavia diffusa are common.

On Bekrak Islet, north on the reef from Utirik, is a tiny mangrove swamp, serving as a wallow for pigs. On the north passage beach of this islet small pumice pebbles were embedded in a bank of white coral sand that was being cut away. These were, in most cases, entirely enveloped in a casing or capsule of closely matted small Scaevola roots. Apparently there is something in this pumice, floated across the sea from some far-off volcano, that the Scaevola plant needs, and that is deficient in the coral sand.

Eluk Islet, to the north of Bekrak, has few coconut trees and much natural scrub vegetation. Dark-blue velvety butterflies (Hypolimnas bolina), were abundant here, visiting the flowers of Achyranthes.

Here on Utirik, when our ship returned from fueling at Kwajalein, we were joined by Ted Arnow, third member of the scientific party. After this the task of supervising the digging of holes or wells for water and soil samples was largely taken over by him, leaving more time to tramp the islands, making geographical, vegetational and general ecological observations and collections.

At our camp on the open western projection of Utirik Islet, I had a canvas shelter built to protect my plant drying stand. Unable to get the preferred type of kerosene stove in the United States before starting on the trip I had allowed myself to be sold two stoves of a type I had not seen before. About the third evening, one of these set the plant presses and shelter on fire. Fortunately all specimens were saved, but the shelter was a total loss.

Taka Atoll

On December 4 we departed for Taka Atoll, just over the horizon, with a feeling that we had barely started to learn something about Utirik. The last observation made on Utirik was of a white-tailed tropic-bird flying over the lagoon, the only one I was to see until many months later.

We arrived at Taka the same day but did not go ashore until December 5. Because the ship could enter Taka Lagoon, we did not camp ashore but returned to the ship at night. Here, after some investigation, I decided that plant-presses could be dried in the funnel of the ship. There were doors on the funnel sides, and a rack between the hot exhaust pipes, on which the presses could be laid. Soil samples also could be placed in their bags on this rack to dry. The Chief Engineer, Charles Frey, readily consented to this use of his facilities, and plants were dried this way for the rest of this leg of the trip. For the first week or so, close watch was kept, but there seemed no danger whatever of fire. Drying was quite satisfactory, except when the ship was anchored in lagoons for considerable periods. Then there was not sufficient heat and, in spite of the use of formalin, a few specimens molded.

Taka is an uninhabited atoll with rather little land area. It has one fair-sized islet, two small ones, and several bare sand bars. The largest, Taka Islet, is roughly rectangular, and only a third or fourth of it along the lagoon beach was planted to coconuts. The rest is brushy woods with a few openings and one small grove of typhoon-beaten large _Pisonia_ trees. The ground in the coconut grove is luxuriantly covered locally by the fern _Polypodium scolopendria_, which is practically absent from nearby Utirik. This islet is occasionally visited by the Utirik people when copra is harvested.

Several pits were dug on Taka Islet to examine soil profiles and to obtain water samples. One of these, dug to a depth of over 2.5 meters, showed an interesting series of buried soil horizons. In most of the holes, rock layers were encountered that prevented us from reaching water.

Lojiron Islet, a very small one to the north of Taka Islet, has a tiny but beautiful grove of _Pisonia_ trees. Some of these had been knocked down by the typhoon, showing their very shallow root systems with no strong taproots. The trees were not dead but were sending up quantities of vigorous sprouts all along the trunks. The surface layer of the soil here is a black peaty material or raw humus a few centimeters thick with a pH of 5.6 to 6 when unmixed with sand, whereas that of the coral sand or materials mixed with it is about 8. This accumulation of humus, as well as its low pH, was a rather unexpected phenomenon on well-drained limestone soil in the lowland tropics.

The rock slope from the general level of the islet down to the reef flat demonstrated some of the processes by which raised reef surfaces are gradually reduced to a base-level at about low-tide mark. Conspicuous among these processes are the formation of solution basins and the spalling off of slabs. Where this slope was covered with sand and gravel, processes of colonization by plants were also very apparent. Portulaca and Lepturus are the most conspicuous and abundant early contingent, with Messerschmidia and Scaevola appearing in smaller numbers and apparently slightly later.

Wotwerok Islet, west of Taka on the south reef of the atoll, is a barren-looking, rocky flat only a few acres in area but inhabited by great numbers of birds. In order to have more opportunity to study the extreme ecological conditions exhibited, I had myself put ashore there alone, to be picked up the next day. The vegetation is generally a sparse to dense Messerschmidia scrub, with some mixture of Pisonia and Scaevola.

There are irregular openings with Lepturus, if the soil is sandy, and with Fleurya and Boerhavia if entirely stony, and large areas on the two seaward corners are entirely bare. The Fleurya is an unusual population in that it shows no traces of red color in stems or leaves. Obviously two species of Boerhavia are present, showing a series of distinct morphological characters as well as the fact that one is not attacked by the white rust, Albugo platensis, whereas the other is frequently attacked. This fungus changes the habit of parts of its host from elongate prostrate to short erect branches, probably a type of witches-broom effect. For this reason these infections are easily seen, and the parasite is known from plants of the Boerhavia diffusa complex from widely scattered localities in the Pacific.

This islet is a great tern rookery, as thousands of sooty terns, two species of noddies, and fairy terns, all nest there. The sooty terns, or wideawakes, lay their eggs on the bare gravel on the seaward side. When disturbed they fly up in great clouds. They so resented my presence that after I went to bed a large column of them flew screaming above my cot, circling and circling. They kept this up steadily from about 6:30 p. m. until about 7 a. m., making it rather difficult to sleep.

To the seaward of this islet is a definite coralline algal ridge, even though it is on the south reef. The tide was low enough so that a short trip out to the edge of the reef was feasible, and a number of algae, mainly lime-secreting ones, were obtained. The algal flora, however, is relatively meager. The land flora is extremely restricted, only 11 species being observed. Insects and other small land invertebrates were common, however, and a considerable number were collected.

The Taka Atoll plant and animal collections are important because they very likely come closer than those from most other islands to representing the flora and fauna of the northern Marshalls prior to the coming of man. No flies and no rats were seen; but grasshoppers, one mosquito, and two lizards-- a skink and a gecko--were noticed.

Likiep Atoll

On December 10 we left Taka bound for Ailuk. However, Ted Arnow had developed an ailment, and it was necessary to get him to more experienced medical attention than was available on the ship. By radio it was ascertained that the Air-Sea Rescue PBM plane from Kwajalein would not land in Ailuk lagoon but would come to Likiep, so we changed our plan and made Likiep our next stop. We reached it and anchored in the lagoon on December 11, and the PBM arrived promptly to take Ted to Kwajalein. We were sorry to see him go, as he was both an excellent companion and a great help with the work of the expedition. We hoped that his trouble would prove to be minor and that he would return shortly.

Likiep was an atoll that I had visited on the Economic Survey in 1946, so I chose to concentrate my efforts on a different islet than Likiep Islet, studied then. The astronomical party of the surveying team set up their station on Lado Islet, so MacNeil and I moved ashore with them. Before going to Lado, I visited Likiep Village and renewed acquaintance with the local magistrate, Anton DeBrum. Anton, a middle-aged Marshallese halfcaste, is head of the DeBrum family, rivals of the related Capelle family for leadership in northern Marshall affairs. I well remember a celebration of the birthday of an elder of the Capelle family at which I was a guest in 1946. The two families displayed their friendly rivalry in doing honor to this old gentleman, and I had a chance to observe, from a vantage point, Marshallese high society at an important function.

On Likiep, also, I met a priest, Father McCarthy, with whom I later had some interesting talks. A brief walk on the islet confirmed the impression gained in 1946 of very thin soil and sparse vegetation in the coconut groves south of the village, probably an effect of the great typhoon that swept the atoll clean about 90 years ago. This same sparseness of vegetation is apparent on Lado Islet, especially on the east end.

Being entirely planted to coconuts, Lado has a singularly uninteresting vegetation. This, with the fact that I had collected many Likiep plants in 1946, made it possible to concentrate more on other things such as collecting insects, water samples, soils, and algae on the windward reef. The moon was almost full, and one night was largely spent lobster hunting out on the reef flat and algal ridge of the windward reef. The night life of the reef was observed and, incidentally we had lobsters for breakfast next day.

My own visit to Likiep was short, as I had decided to visit Jemo Island with a small party of surveyors who were to spend several days there. Before leaving I spent one night and most of a day on Likiep Islet, talking with Father McCarthy and walking around the islet. With low-level aerial photos taken during the war, it was possible both to test my ability in identifying plants on the photos and to assess changes in the island.

Plants collected on Likiep (mostly on Lado Islet) were largely algae. A search was made for Hippobroma longiflora, a poisonous weed newly established in 1946. I had then advised the natives to destroy it, and they apparently had, as I found none on this visit. Anton confirmed that they had pulled it up whenever they had seen it.

Jemo

Departure for Jemo was on December 18, and the voyage took only two hours. Landing there is never very certain, and this landing could have been exciting, but beyond a wetting there was no especial incident. The ship left for Likiep again as soon as we were ashore.

Jemo is a tiny egg-shaped patch of land, less than one-tenth of a square mile in area, on the end of a reef about 4 1/2 miles long. In pre-European times the Marshallese kept it as a sanctuary for birds and turtles, visiting it only once a year to harvest a limited number of these animals and their eggs for food. It was largely cleared and planted to coconut trees by the Likiep people 50 or 60 years ago. Fortunately for my investigations, they left a strip of vegetation completely around the island. Jemo is uninhabited, though there is a small frame house there for use during the times when copra is harvested. Fortunately we were permitted by the owner to occupy this house during our visit, so that less of our limited time was wasted making camp, and protection from the rain was more effective. My first act on entering the house was to collect a scorpion, which was the first and only record of this species (Isometrus maculatus) from the Marshall Islands. It was the common pan-tropical house scorpion, but that it should have been collected only here, on an uninhabited island, is curious.

On landing, the enlisted men in the party were quite excited at what they first thought were tank tracks going straight up the beach from the water's edge. It was obvious that they were tracks of sea turtles that had come ashore to lay their eggs. When I walked around the island, I counted the number of fresh tracks in the undisturbed sand and found 44 in all, indicating that 22 turtles had come ashore the previous night or two. At the top of the beach, in the edge of the vegetation, were wide, shallow pits and mounds of sand. We dug in several of these pits, looking for eggs. This was exactly what the turtles had intended we should do. They had been smart enough not to lay them in the obvious place. We eventually found the eggs in a small, deep hole under the pile of sand excavated from the main pit. In this hole were 106 eggs, white, spherical, and somewhat elastic, about the size and appearance of pingpong balls, packed together under 2 feet of sand. When cooked, the whites of these eggs did not coagulate; and scrambled, they tasted more like soft cheese than chicken's eggs.

It was just past full moon the first night we were there, and at about 1:30 a. m. I went out with two of the boys to see if any more turtles had come ashore. After walking around almost the entire sandy part of the island we found two sets of fresh tracks, one going up the beach, and one down. A large dark form was seen just about to enter the water. Racing to it, we found a turtle, stopped it, and with some effort, turned it over on its back. After struggling violently for a bit, slapping wildly with its flippers, it calmed down, emitting a sighing "ah'h" sound, with tears running from its eyes. Seeing this, one of the boys, an American-born Japanese interpreter, who had been all excited about having turtle meat, asked me anxiously if I were going to kill it. When I told him that I wanted only to take pictures of it the next day and then to let it go, he was relieved. The tears had changed his mind about turtle meat.

Next day we got some excellent pictures of this large specimen of green turtle before sending it back to sea. The Japanese surveyors did not think much of this procedure, it being considered bad luck to molest turtles. In fact, when the sea got choppy later, and there was some doubt that we would be able to get off the island, there was some muttering that it would have been better if we had not bothered the turtle at all.

When the island was cleared a strip of vegetation 30 meters or more wide was left completely around the island. On the west side this strip is a magnificent forest of giant Pisonia grandis trees. Elsewhere it is lower and of mixed scrubby forest. This forest grows mostly on a ridge of dunes 5 to 6 meters above low-tide level, not high, as dunes go, but striking for a low coral island. It was fortunate for my investigations that this belt of forest was left, as in it I first got an idea of one of the most interesting sets of relationships that were to appear as results of the expedition.[1/] It was noted here that the surface of the ground in the Pisonia grove was covered by a thick layer of a peat-like material, similar to the "raw humus" or "mor" of northern forests and heaths. Under this was a layer of cemented sand, the cement dark brown, that corresponded to the descriptions I had been given of phosphate rock on Arno Atoll. Red-footed boobies were nesting in the trees, and the ground was liberally spattered with white guano. Broken and weathered pieces of rock were abundant in the half of the coconut plantation next to the Pisonia grove but were absent in the other half of it. The part of the coconut plantation with the rock fragments was dense and luxuriant; the other part was in very poor condition, and most of the older trees were dead or dying.

The island was combed for plants and land animals, and good collections were made. Descriptions were made of the vegetation, the topography, and the arrangement of beach rock and peripheral ridges; and soil profiles were examined. It would seem that more than four days on such a tiny speck of land might be almost enough, but when the ship came for us on December 23, I felt that only a preliminary examination had been made and that if only a few more days were available I might begin to learn just what was happening in this microcosm.

Much to my delight, Ted Arnow, having recovered completely, was aboard.

Ailuk Atoll

Ailuk was sighted late in the afternoon, and we were able to enter the lagoon through the north passage on the west side, where we dropped anchor not far inside. Two days, including Christmas, were spent on board getting collections taken care of and notes in shape. The Christmas dinner produced by Captain Shoaf's steward's department was a great achievement, and was the gastronomic high point of the expedition. To our surprise we were served everything we would have had at home or in a fancy stateside restaurant.

MacNeil and Arnow had gone ashore on Christmas eve and had established camp on Ailuk Islet, at the south end of the lagoon. I joined them on the 26th, but spent the entire day getting there from the ship.

1/ See Soil Science 78: 99-;07, 1954.

Since we arrived at Ailuk a stiff tradewind had been blowing continuously, and it neither stopped nor slackened the entire time we were there. If I had needed to be disillusioned about calm tropical lagoons this day on Ailuk lagoon would have done it very well. The waves on the lagoon were fully as rough as on an ordinary day in the open sea. Travelling in an open motor whaleboat meant a continuous drenching. The water was not really cold, but because of the wind everyone was sure that it was. With one stop to put up a surveying signal on the reef, and an hour ashore on Akulwe Islet, the only one on the west reef of Ailuk, we spent all day going the 13 miles from the ship to the main island.

Ailuk Islet is by far the largest islet on the atoll, and is situated on the southeast corner of the elongate ring-like reef. It is almost entirely covered by coconut and breadfruit trees, which provide much of the livelihood for the 413 people. At the southwest corner of the islet is a triangular projection of sand with a hook-like spit on the end of it. This small peninsula is bare of trees except for scattered Pandanus, and here the party of surveyors had set up their camp, and MacNeil and Arnow had been comfortably established for two days when I arrived. The people of Ailuk, who are extremely friendly, had welcomed both Americans to their Christmas festivities, and after I arrived, brought presents and invitations to a village party. Their help in digging holes for water and soil samples facilitated our work greatly.

Some distance back of the village on this islet is an area of several acres where the otherwise healthy coconut groves seem to be in sorry condition. They resemble those on the eastern half of Jemo Island in that most of the old trees are dead or dying, but young ones are not present. Also, the soil here is black, as black as any seen on any of the islands visited. Nothing was apparent in the pit dug in the soil, or in the samples secured, that would account for this condition. The remaining trees still standing did show more than usual signs of fire around their bases, so that it is conceivable that a severe fire may have killed most of the trees.

Old taro pits are abundant near the center of the islet, most of them being elongate and winding, with the excavated material piled up as much as 2 meters above the general ground level between them. Coconut trees are growing on their bottoms, and they are choked with Clerodendrum and Ipomoea. One or two pits are in the village near the lagoon. These show a few persisting plants of Cyrtosperma, and still have a good muck layer in the bottom, highly organic and very wet. But taro culture is just as effectively abandoned here as in the other northern Marshalls. And here, as elsewhere, Paspalum vaginatum forms a dense mat on all recently used pits. Ailuk, like Likiep, has abundant and healthy breadfruit trees around the village. They do not, however, extend much beyond halfway to the outer side, and at this distance are very yellow and unhealthy looking. One healthy tree, however, grew on the boulder ridge on the southwest side only about 16 meters from high-tide mark.

After determining that it would be possible to walk from islet to islet at low tide, and that there were low tides about midday, I decided to walk northward along the chain of islets on the east, or windward reef of the atoll. I arranged to be picked up at one of the surveying stations on an islet about the middle of the atoll two days later. With a pandanus mat, a gift from the villagers, to sleep on, C rations for food, two canteens of water, machete, insect net, and collecting vials, I left in the middle of the morning.

These islands all seem to be remnants of an old higher reef platform that had its surface well above present high-tide level. Most of this platform on every islet is covered by loose material, but the seaward ends have been recently swept clean of loose material and vegetation. Along some passages there are wide exposures of rock surface. On these, though, there is a well developed forest of Pemphis acidula, dense and impenetrable. After a fair number of these islets were examined, a vegetation pattern became apparent. The lagoon side in most places had been planted to coconuts, leaving a crescent-shaped band of native scrub and forest around the seaward sides and extending along the passages between the islets. The outer edge of this is low scrub; principally Pemphis if the substratum is rock; Scaevola, Messerschmidia, Guettarda, and Suriana if sand and gravel. The Pemphis does not seem at all inconvenienced if its roots are covered by the sea at high tide. The trees in this band become taller inward, until a well-developed forest, principally Messerschmidia, Pandanus, Guettarda, and Ochrosia, forms an excellent windbreak to protect the coconut trees against the strong spray-laden trade winds.

The need for haste to take advantage of the low tides did not permit very careful study of these islets, but extensive notes were made and some facts became obvious. Perhaps the most interesting thing was that, at least during the trade-wind season, there is no reversal of the current flowing between these islets with the tide. The flow is always into the lagoon on this side, if the channel is deep enough to contain water at low tide. At high tide the current is like that of a millrace, quite capable of sweeping a man off his feet, as I found out. The water, of course, drains out of the lagoon over the leeward reef, which is lower, mostly below low tide level, and not obstructed by islets.

On some of the islets were native huts, not permanent residences, used apparently only during copra harvesting. On most of these islets were pigs, left to shift more or less for themselves. Correlated with the presence of pigs were plagues of flies, some of the most persistent and ravenous flies that I have ever seen.

After being picked up on schedule, I was able to examine most of the other islets to the north from a boat in the lagoon, landing on only four of them. On one of these, Enejelar Islet, was a ridge of rather well-developed sand dunes; the sand had obviously been caught by the strip of scrub vegetation growing along a long spit. On the windward side of this, as well as earlier on a sand bank on Ailuk Islet, were again found pumice pebbles enclosed in a capsule of closely matted roots, similar to those observed on Utirik, certainly roots of Scaevola, this time. It was the only plant near, and one such capsule was still attached to the root of Scaevola bush. The only reasonable explanation for this seems to be a deficiency in the coral sand of some element needed by the plant that is not serious enough to prevent the growth of Scaevola.

The last stop on Ailuk was on an open stretch of the leeward reef, where the surveyors had set up a tower. The reef here is a broad surface below low-tide level, thickly studded with coral heads and clumps, strewn with boulders thrown up by storms, some of them quite large, up to 2 meters across, and almost completely devoid of plant life. Among the abundant animal growth, bright pink clumps of Liagora were the only plants seen. The "vegetation" seemed almost entirely animal in nature.

Lae Atoll

On January 4, 1952, we left Ailuk and on January 5 arrived at Lae. Lae is a tiny atoll compared with Ailuk, but a beautiful one. From inside the lagoon the whole atoll is visible at once, and there are many well-wooded islets. For its size, Lae had more undisturbed vegetation than any other atoll we had seen up to this time. Here large patches of a peculiar forest type, very conspicuous on aerial photos, but which until now defied identification, turned out to be pure stands of Ochrosia oppositifolia, except one of very similar appearance, which is a pure stand of Barringtonia asiatica. Pure forests of neither of these trees had been reported previously, to the best of my knowledge, and the pattern that their crowns make on the photos resembles nothing else with which I am familiar.

In addition to much of scientific interest on Lae, there was other excitement aplenty. In the lagoon was anchored a small schooner that proved to be the Laura, from Likiep, which had disappeared on a voyage from Kwajalein to Likiep two and a half months previously and had been given up for lost by almost everyone. Her engine had been disabled and, with the rotten sail-canvas, she had managed to sail down-wind to Lae, far to the westward of her course and destination. Having no radio, her fate remained obscure until we were able to announce her safety.

Our own ship, after putting us ashore, left for Kwajalein. The next news we had of her over the radio was that she was laid up in Kwajalein, awaiting a replacement part, which would have to be brought from Yokohama. We thought that, perhaps, this would give us a day or two more than the scheduled time here, and would enable us to do a somewhat more thorough job of this atoll than we had been able to do on any of the others. This proved a vain hope, as the surveyors finished in less than their allotted time and a patrol boat was sent up from Kwajalein to pick us up.

Meanwhile, we got around the atoll and did the best job we could. As was expected, the vegetation was conspicuously more luxuriant here than on the atolls farther north. In the Marshalls the annual rainfall increases rapidly from north to south. Here in Lae were the first functioning taro pits, a few among the many abandoned ones. These had Cyrtosperma and Colocasia growing in a jellylike brown muck lying on a sandy bottom, with the water table practically at the surface. Alocasia has invaded these pits and in most of them has crowded out the two edible taros. The natives seem little concerned about this, as they can get rice and flour from Kwajalein only 70 miles away.

Here, for the first time on the expedition, we found Intsia bijuga, noted in Guam where it is called ifil, for its fine hard wood. This is not its northern limit in the Marshalls, however, as we later found it on Wotho. It is a notable component of the mixed forest. The mixed forest here, as well as the breadfruit forest and the coconut-breadfruit forest, have denser canopies than seen on any other atoll so far on the trip, and the usual sparseness of undergrowth when heavily shaded was apparent. In the Ochrosia forest, mentioned above, there is no undergrowth except small seedlings of Ochrosia. In the Barringtonia forest the only other plants were a small colony of Peperomia, growing on boulders, by far the northernmost record for this in the Marshalls. This forest is especially interesting because it is growing on the inner slope of the highest boulder ridge seen in the Marshalls, about 5.5 meters above low-tide level. The trees are very large, the largest being almost 4 meters through, though the average is well under 1 meter. The natives have cut a trail across the boulder ridge, digging well into the loose material. Here it can be seen that the layer 0.5 meter or more thick of boulders was deposited after the trees had reached essentially their present size.

In the mixed forest on the windward islets, which is apparently original uncleared forest, it was noticed that the only Messerschmidia trees are very old ones. Some dead logs are found, but no young trees. Young ones are abundant, on the other hand, around the peripheries of these same islets. The obvious inference from this is that Messerschmidia is not a tree of mature mixed forest. It reproduces itself only under more or less pioneer conditions.

The patrol craft from Kwajalein came for us, all too soon, before we had had a chance to visit all of the 21 islets of Lae Atoll. We left at 3 p.m. on January 11 and arrived at Kwajalein at 10 p.m. the same night.

Kwajalein Atoll

Kwajalein had changed radically since my last visit in 1950. Then it seemed in the process of being slowly abandoned, growing up to weeds. Now it had become, again, a busy base, with much construction going on, and very little to be seen in the way of plants. The prospect of an indefinite stay here was attractive only if transportation to the other islets was available. Kwajalein Islet, itself, would afford little of interest, scientifically.

On January 13 an opportunity afforded itself to fly to Majuro Atoll for a few hours. This gave me a chance to see any obvious changes there since 1950 and to talk to the Trust Territory officials at the district headquarters there. Tobin, the staff anthropologist, provided some information on the history of Pokak, Bikar, and Jemo Atolls. He had been working on land tenure and land use among the Marshallese and had found that these three atolls had been maintained as bird and turtle sanctuaries in pre-European times, and that they were visited periodically and a limited number of birds and turtles and their eggs taken.

Such a short time was available that only a brief ride in the vicinity of the headquarters was possible. The contrast with the northern atolls in greater luxuriance of vegetation even on very narrow islets, was striking. Only one plant, a conspicuous species of terrestrial Nostoc, was collected. En route from Kwajalein, we saw Nama Atoll briefly from the air. During our flight, from a short distance south of Kwajalein to Majuro, and the same distance back, the sea was almost completely covered by a thick layer of clouds, in a season when there had been few clouds and little or no rain for some time on Kwajalein and the other northern atolls.

The principal observations on Kwajalein Islet during the next two and a half weeks were of the effects of continued drought and severe winds on even the most halophytic plants. Even Triumfetta procumbens and Ipomoea pes-caprae were severely killed back, at least on the areas exposed to the wind. Coconut leaves were turned brown well back from the tips of the leaflets. The effects of even slight shelter were immediately evident in much greener weed growth and cultivated plants. A few weeds previously unrecorded from the atoll were picked up, such as Desmodium canum and Heliotropium ovalifolium, the latter, at least, an obvious recent immigrant from Guam, growing along the airstrip. Since 1950 Paspalum vaginatum had spread completely over the islet, Pluchea indica had increased greatly in abundance, and Pluchea odorata had decreased notably.

Kwajalein Atoll, in dimensions, is one of the largest, if not the largest atoll in the world, and has 92 islets, on its 195 miles of reef. Few of these, except the southernmost ones which were badly devastated during the War and since, have ever been studied scientifically. Efforts were made to get transportation to some of the others with only partial success. A visit to Lojjairok and Lojjaiong, on the windward reef, was managed on a "recreation" trip. These islets have been used as recreation spots for military personnel and have little unaltered vegetation left on them. Trips were also made to Enebuoj and Enewetak Islets, through the kindness of Mr. Henry Wahl of the Island Trading Co. These islets present an extreme contrast. Enebuoj was an active military establishment until 1948, when it was abandoned. Now it is covered by a dense blanket of Wedelia and Ipomoea pes-caprae vines that effectively conceal practically all traces of the former establishments, and certainly retard establishment of much else in the way of vegetation. A short distance off the lagoon shore of this islet lies the capsized hulk of the German cruiser Prinz Eugen.

Enewetak Islet, on the other hand, has scarcely been altered in any way by man. It is almost completely covered by a forest of giant Pisonia trees, the home of innumerable sea birds. This is unquestionably the finest native forest seen anywhere in the northern Marshalls, and probably the best single stand in any of the Marshall group. Here was afforded a further opportunity to study the type of phosphate rock formation first observed on Jemo Island. This islet differs from most atoll islets in being in the lagoon, rather than on the peripheral reef. It seems to be made up entirely of sand, except for the superficial phosphate bed. That it should have been left in forest is interesting, and the reason is not clear. It seems possible that this, also, may have been a bird sanctuary. This is more likely, in view of the discovery by Wm H. Hatheway (personal communication, 1952), that certain islets on Arno Atoll, in the southern Marshalls, were in pre-European times so preserved. It would be a fine thing if this tradition could be continued and such bits of original vegetation as that on Enewetak Islet could be set aside as bird and vegetation reserves for the future Marshallese.

MacNeil, during this time, was enabled to visit several of the southwestern islets, because an extra berth was available on the FS-216, another ship of the survey then operating in Kwajalein. He made important geological observations during this period.

I was afforded a complete, if extremely quick, look at the rest of the atoll when Lt. Comdr. C.K.Brust, U.S.N., took me on a low-altitude flight around the atoll in a small training plane. Rough notes on the general vegetation patterns on many of the islets were made. On Bikej Islet, which had been visited in 1946 and 1950, it was possible to note that the scrub forest in the old U.S.Navy tank-farm had grown perceptibly, but that the airstrip was still about as bare of vegetation as in 1946. On some of the southern islets, Pemphis forest makes up a conspicuous part of the vegetation. On Nimur and Ruot Islets, at the northern point of the atoll, abandoned military establishments were covered by the usual blankets of Wedelia and Ipomoea. Ochrosia and Pisonia forests occur on some of the smaller islets. At the westernmost point of the atoll, where the reef extends for some distance beyond the lagoon, broad expanses of bare reef were marked by transverse strips of boulders, which from a distance resemble causeways. The origin of these strips does not seem evident.

Several visits to Ebeye Islet were possible through the courtesy of the Island Trading Co. officials, who have their headquarters in the native village there. This islet, also, has little or nothing left of its original character. The most striking observation made here was the amount of spray carried by the strong trade winds. The inside of the porch of the Island Trading Co. house was continually wet and dripping salt water, even though somewhat protected from the wind. The windward windows of the house had to be kept closed in order to keep anything dry in the house, even tough no rain fell during the entire period. The drinking water situation in the native village would have been serious if the Naval Air Station authorities had not sent over water from the station supply.

Ujelang Atoll

After the ship was repaired we promptly left Kwajalein on February 1, arriving at Ujelang on February 3. Here it was again possible to take the ship into the lagoon and work from her. This is a long narrow atoll with about 24 islets scattered fairly well around it. Ujelang, the largest of them, was a German coconut plantation, and the trees are consequently planted in an exact checkerboard arrangement. No Marshallese had lived there for many years until, in 1948, the people from Eniwetok Atoll were moved to Ujelang in order to permit the use of Eniwetok as a testing site for atomic weapons. These people live in a village built for them by the U.S.Navy, on Ujelang Islet. One of the things of interest to me here was to see how well these people had reacted to transplanting. When I had seen them in 1946 on Eniwetok, the war and subsequent events had reduced them to a sad state of dependence. It was interesting that there was little or no complaining, in spite of some obvious homesickness, and that these people were already much at home, though such signs as most of the canoes being out of repair did not look too encouraging.

For the first two days of our visit I had a fast sailing outrigger canoe with a crew of four enthusiastic Marshallese men at my disposal. Consequently I was able to visit briefly most of the islets on the atoll.

This type of canoe, with its lateen sail, is remarkably fast and will sail almost straight into the wind.

Here, on one of the smaller islets, I found coconut crabs for the first time on the trip, small ones only. My boat crew gathered turtle eggs, sooty tern eggs, and young noddy terns for food. Inland on Kirinyan Islet was quite an abundance of pumice pebbles about the size of a man's fist, scattered on the surface of the ground, especially on the lagoon half of the islet. The lower sides of the pebbles were closely invested in a "basket" or cup of closely grown roots. The gregarious nesting habit of the white-capped noddies was very noticeable here, also.

Comparison of photographs taken in 1944 with present conditions showed remarkably rapid growth of Pemphis forest on bare rock flats just at or above high-tide level on Enimoni Islet. On Ujelang Islet was one of the few cases seen anywhere of Pemphis growing in sand.

After two days with the canoe, the rest of the available time was spent on shore on Ujelang Islet. Along the lagoon shore, at about low tide level, was found a rather extensive strip of a sod of Thalassia hemprichii, or turtle grass, the second occurrence of this plant, and the only extensive one, known in the Marshalls. Stenotaphrum micranthum, a grass hitherto unknown from the Marshalls, possibly introduced, was found here, also. These were the only plants seen that are not common generally in the Marshalls, save a few weeds that date from Japanese or German contact with Ponape. It had been thought that, because Ujelang is so far west, there might be some relationship to the Caroline flora, but the two species mentioned are the only suggestions of such a relationship.

My attention was called to a few ostracods, minute crustacea, which were swimming in a water sample brought from Raij Islet by Arnow. To collect some I made a special trip to Raij on the last day of our stay. Returning with a good sample, I found that MacNeil had found them independently in the same well and had brought a bottle full.

Visiting a large number of islets, while giving a better geographical picture of the atoll, resulted in the number of collections of plants and animals from Ujelang being comparatively small. This should not be taken to indicate a smaller fauna than on atolls where more animals were collected.

Wotho Atoll

On January 10, with the usual feeling of not having had quite enough time to make even a good superficial survey, we left for Wotho. We arrived there on January 12. This atoll promised to be very interesting. Its land area is large and its human population small, and the aerial photos showed large areas of apparently undisturbed forest. There actually is on Wotho much more native forest in its original condition than on any other atoll in this climatic belt, and probably more than on any other of the Marshalls, excepting possibly Pokak.

Our camp was set up on the west end of Wotho Islet, the largest of the islets on the atoll. The first distinctive thing noticed here was that the mixed forest contained a large percentage of Soulamea amara, a small tree which, though widespread in the northern Marshalls, is generally quite local and not very common. The soil in this rather open mixed forest is also unusual, of a fine grayish silty character and naturally rolled up into small pellets like BB shot.

The total population of this atoll is 26. The people live in a row of widely scattered houses along the broad sand ridge at the top of the lagoon beach. These houses are connected by the usual perfectly straight, wide path, lined with slabs of coral set on edge, dating from the German period. Such paths may be seen on every inhabited atoll that I have visited in the Marshalls and Carolines. Here are a very few breadfruit trees. The vicinity of this "village" is well planted to coconut trees, most of which appear to be very healthy. However there is an area of some acres in extent back of the houses that has no coconuts and is in grass, except for scattered Guettarda and Scaevola bushes and some Wedelia. There are no dead coconut trunks and only a few very yellow coconut seedlings; the origin of this grass-covered opening is not clear. Although there are only three or four men who make copra, a considerable amount was piled up, waiting for the Island Trading Co. ship. Something about the bags in which the copra was packed seemed familiar. On examination they turned out to be "fique" coffee bags made in Bogotá, Colombia, identical with many thousands in which we had shipped Cinchona bark from the South American republic during the war. The little old man who was chief of Wotho could be seen husking and chopping coconuts for copra at any time during the day. These people were friendly and helpful and seemed glad to have visitors.

The center of the islet has a series of long, winding troughs and ridges, remains of ancient taro pits. Here and there these have been cleaned out and Cyrtosperma planted, which is struggling with the weeds. Most of the pits support dense tangles of Clerodendrum, Pandanus, Vigna, Canavalia, Wedelia, and breadfruit trees. The breadfruit trees also surround the pits.

Back of the plantation and taro pits stretches a fine expanse of pure Ochrosia forest, identical with that studied on Lae. One could walk for a good distance in the dim light that diffused through the dense canopy of this interesting woods. A feature noted in most large stands of Ochrosia studied here and on other atolls was the presence of patches where the trees are yellow and unhealthy, some even dead. There is no obvious reason for this, but the patches are apparently of long duration, as they were to be seen in exactly their present positions on aerial photos taken eight years before. On the east side of the islet, between the Ochrosia and the beach scrub is a fine strip of Messerschmidia forest of large trees with little undergrowth. The scrub belt is unusually broad here, and the Scaevola leaves at its outer edge are thickened and twisted, somewhat yellow, apparently showing the effects of too much salt spray. Scaevola does not usually demonstrate such symptoms.

The inadequacy of the published charts of these atolls is nowhere better demonstrated than on Wotho Islet. Not showing at all on the available H.O. chart is a tremendous shallow embayment on the windward side that cuts a roughly rectangular section to the middle of the islet. This embayment runs out into a sort of inlet of sand that rapidly narrows and pinches out just back of the lagoon ridge. It has every appearance of an old stream bed, though stream beds do not exist on coral islands. A similar channel, but one that does not pinch out, cuts the northeast corner of the islet off as a separate islet, "Enerikan" of the natives, which is not shown at all on the chart. Whether these features were simply missed during the surveys on which the chart is based, or whether they came into existence subsequently, and if so, how, are interesting questions.

Ujae Atoll

Before our exploration of Wotho was well started an accident to one of the small boats necessitated stopping work and leaving for Kwajalein, to await spare parts, again to be sent from Yokohama. We left on February 15. The Major decided to call at Ujae on the way, to see what small-boat transportation might be obtained there. We anchored off Ujae on February 16 and went from the passage to the village, on Ujae Islet, in our remaining small boat. To have quieter water, as the wind was making the lagoon very choppy, we crossed to the windward side and skirted the leeward side of the windward reef. This trip to the village took several hours.

On this trip I first noticed a phenomenon frequently seen afterward. Extending out into the lagoon from the reef in the direction parallel with the wind were a series of narrow strips of smooth water resembling oil "slicks." They ranged from several centimeters to half a meter or even a meter in width. They extended out into the lagoon for several hundred meters, becoming more broken up and "braided" by the choppiness further from the reef. They also seemed to be of different "ages," judging by the freshness of appearance and sharpness of margins, the "older" ones appearing "braided" and showing signs of breaking up. They seemed to start at the reef itself, where water from the open sea was crossing it. These were seen actually in hundreds, unevenly distributed along the entire distance from Wotya Islet to Ujae Islet, at the south end of the atoll. Their origin and actual nature are completely obscure.

Ujae Village seemed unusually well kept and prosperous looking, and the people were very friendly. They had a community-owned small sailboat, the "Helper," which they were willing to rent to the surveying party, so it was decided to start surveying this atoll while waiting for the spare parts that had been requested from Yokohama by radio.

Bock Islet, on the north side of the entrance to the lagoon, was selected for the astronomical station. This islet looked very well wooded and only partly disturbed by man, so I took advantage of the opportunity and set up camp on shore with the surveying party. Only about one-fourth of the islet had been cleared and planted to coconuts, so that an excellent sample of what seemed to be the original vegetation was preserved. On the south end enormous Pisonia trees towered to about 30 meters, and in the center were Intsia at least 25 meters in height. The undisturbed parts of the islet were quite rocky. Some of this rocky ground supported a few coconut trees, as though an attempt at cultivation had been made at one time. The coconut trees there did not seem to be bearing as well as those on the sandier parts. A small family group of Marshallese had a temporary encampment on this islet and were making some copra.

Large numbers of white-capped noddies were nesting in the Pisonia trees, and the almost full-grown young were being killed and eaten in large numbers by the Marshallese. Since the Pisonia branches are very brittle, the men did not care to climb the trees to get thebirds. One day I heard a tremendous crash in the forest. When I reached the spot I found half a large tree down and the natives catching the young birds in dozens. They had some hours before lit a fire in a hollow part of the trunk and burned it until it split apart and one half fell. The fallen part was 30 paces long.

A stay of four days made it possible to investigate this islet more leisurely and thoughtfully than was feasible on any of the previous stops. Better collections and perhaps a better understanding resulted. It was also possible to collect a series of logs of the common trees for testing. However, the first attempt of the surveyors to use the local schooner ended in disaster. They tried to enter the narrow curved passage at dusk and ran the boat on the reef, breaking several holes in the hull.

Several days of frantic efforts followed, which resulted in floating the boat off the reef, putting in temporary patches, and towing it across the lagoon to Ebeju Islet, where it was beached. Then we left for Kwajalein to get repair materials, as well as the spare parts for our own disabled whaleboat..

While at Kwajalein, through the courtesy of the Administrative Officer of the Naval Air Station, I was able to accompany a routine photographic flight over Likiep, Jemo, Ailuk, Utirik, Taka, and Kwajalein Atolls. It was most interesting to study from the air the atolls we had previously seen on the ground. Many geographical questions were cleared up, and corrections were made in the sketch maps prepared on the ground. The vegetation was quite drab and brownish after several months of dry weather and wind. Some kodachrome photographs were taken, to record the vegetation patterns of the smaller islets. It was noticed that most of the passes, especially on the leeward sides of the larger atolls, have islets or reef patches in the lagoon opposite them. Some of them also have inward-curving sand horns extending from the corners of the adjoining islets.

Captain Fretz arrived at Kwajalein, from Tokyo, as a replacement for Major Hudson as officer in charge of the surveying party. As soon as the whaleboat was repaired, on March 1, we returned to Ujae to finish the survey, as well as to finish the repairs to the wrecked schooner "Helper." The latter task was taken in charge by our able chief engineer, Charlie Frey, and the hull, when finished, was undoubtedly in better condition than before the boat was wrecked.

During this period I was able to spend time on most of the islets on the windward reef, as well as on the larger islets at the north and south ends of the atoll. Ebeju, at about the center of the east side, has a fair-sized patch of Ochrosia forest showing the same yellow patches as noted on Wotho.

In the interior of Anuij, the small islet connected to Ebeju on the south by a ridge of small dunes, was a patch a few yards square where the sand was literally covered by pumice pebbles. In places where these were very abundant the surface of the ground was made up of a peat-like mat of roots in which the bottoms of the pebbles were embedded. This seems to be an elaboration of the phenomena described earlier, in which the pumice pebbles were surrounded by roots or enclosed in a basket-like cup of roots.

On this islet Ximenia americana is fairly common, forming small spiny thickets. Elsewhere in the Marshalls it has appeared to be exceedingly rare or absent. Its yellow, acid, plumlike fruit is quite agreeable to the palate on a hot day.

On Wojia Islet, south of Ebeju, the scrub belt, normally found on the seaward sides of windward islets, is lacking. Its place is taken by an irregular platform of rock 3 to 12 decimeters above the level of the reef flat. This platform is of several layers, which are being removed by the waves and other agents. The top layer is of very rough conglomerate, not as well consolidated as the lower, finer layers and only a portion of it, on the outer edge of the platform, remains. The lower harder layers are actively spalling off or exfoliating. It seems probable that the vegetation was at some recent time removed from this platform, exposing it to destruction by waves and weather. On this islet two interesting vegetational phenomena were evident. One was the tendency of Pisonia trees, when knocked down by wind, to send up copses of sprouts, which develop into dense thickets. The other was the ability of Ochrosia to establish itself under Pisonia. Solid stands of Ochrosia saplings were seen in the Pisonia forest wherever a seed tree was present. This suggests that once an Ochrosia tree becomes established in such a forest, eventually the forest will be changed to Ochrosia. That all the forests in this belt are not pure stands of Ochrosia may well be due only to the poor dispersal powers of the seeds. The fruits are about the size and shape of eggs, with a thick layer of corky floating tissue inside the fleshy layer and surrounding the seeds. They float very effectively and are often cast up in drift, but are probably only carried into the shady interior of an islet, where they will become established, by the relatively rare storm waves. Once established they would normally spread by being dropped from the ends of the branches of the parent trees, certainly an extremely slow dispersal. Of course storms and other accidents might greatly increase this rate. The slowness of this succession from Pisonia or mixed forest to Ochrosia forest is one of the best reasons for considering the Ochrosia forest to be one of the original vegetation types of these atolls. Stands of Ochrosia forest such as on Wotho could scarcely have come into existence in less than hundreds of years.

During our stay on this atoll there were several opportunities for further observation of the "oil slicks" extending downwind from the reefs, and described on our first visit to Ujae. These were seen to extend at least half a mile into the lagoon and, some distance from the reef, to become as much as 6 to 8 meters wide. Near the reef, where they are more sharply defined, they range from a few centimeters to 1 meter in width, and are characterized by an abrupt damping out of the surface disturbance of the water and an accumulation of small bubbles and flecks of foam in a streak near the center of the strip. They seem obviously to be caused by continuous emission for a period of time of some substance which changes the surface tension of the water. They are remarkably stable, considering the choppiness of the water, and are much straighter and more visible when there is a fair breeze than when there is little. They present exactly the appearance that would be expected from a series of small vents of oil situated at close but irregular intervals along the reefs. It was at first thought that oil or some other substance was being carried over the reef from the open sea, but they were observed clearly in the lee of some of the islets, especially the large Enelamoj at the north end of Ujae. An attempt was made later, on Wotho, to follow one of these mysterious "slicks" to its source on the reef. It obviously originated in a consolidated rubble-flat, barely exposed at low tide, but was impossible to follow in the very quiet water in the immediate lee of the reef.

In a small area on Alle Islet, near the north end of Ujae Atoll, pure Cordia forest was seen for the first time. Here also were enormous numbers of hermit crabs, hiding in the day time in and under rotten coconut logs. They occupied many kinds of shells, but mostly those of several kinds of cerithids. A large series of the crabs was collected, as they had various markings.

The chief of Ujae Atoll is a young man named Enti, who had learned to speak English very well at one of the Navy Civil Administration schools on Kwajalein. His father, a dignified, middle-aged man, had also learned English at the same time. Both seemed to grasp very well our reasons for wanting information on the natural history of the island and on the customs of their people. Many points that had previously been in doubt were cleared up in conversation with them, and much information, especially on the utilization of fish, birds, and other animals, as well as the names by which these were called, was obtained. These people are a very attractive and interesting group.

We left Ujae for Kwajalein on March 14 and arrived there the next day. Our stay on Kwajalein this time was brief, with no opportunity to do much more than answer mail and lay in a few supplies. Ted Arnow left the party here and returned to Guam, his part of the expedition finished.

Wotho Atoll

On March 17 we left Kwajalein for Wotho to finish our work there and to make another attempt to visit Bikar and Pokak Atolls. This time, on Wotho, we spent most of our time on the islets other than Wotho itself, which we had not visited at all on our earlier stay on the atoll. These are all completely uninhabited and, except for Kabben, relatively little disturbed. On the east reef is a narrow spitlike islet, several miles long, which does not appear on the hydrographic charts at all. That it is not merely an ephemeral sand spit is evidenced by the presence of beach-rock on one side or other of it for most of the length of the part examined. Near the north end the beach-rock on the lagoon side is conspicuously pot-holed. This ridge of sand is mostly covered by a scrub of Messerschmidia, Scaevola and Terminalia, varying from scattered to continuous, and one large clump of Pemphis, a second occurrence on sand. The effect of vegetation on sand accumulation is very obvious on this islet. Where the scrub is continuous the sand ridge is conspicuous and several feet higher than in the gaps, where it is low and very flat.

On Enejelto Islet, near the south end of the east reef, the lagoon beach is covered by piled-up slabs of beach-rock, apparently thrown there by lagoon waves during storms. The process of quarrying these slabs from the beach-rock beds by small lagoon waves was very obvious, certain beds being more susceptible to solution by the continuously moving water than others, causing the harder upper ones to collapse and crack into large sections.

Kabben Islet, a large triangular piece of land at the southern tip of the atoll is partly in coconut trees and partly in completely undisturbed forest. Much of this forest is solid Ochrosia. The coconut plantation is generally sparse and has a rather dense undergrowth of bushes and small trees. On the south point of the islet is an enormous boulder ridge. Drift seeds were more abundant on the beaches of this and some of the islets on the west reef than anywhere else visited on the expedition. Most of them were of Mucuna, but some other kinds were collected also. The islets on the west reef had conspicuous sand dunes and conspicuous patches of Pisonia forest. Humus underlain by thin layers of phosphate hardpan was found on several of these islets, as well as on Eneobnāk Islet on the n north reef. Birds were abundant and the humus was liberally stained with guano. On Eneobnāk the origin of the curious low mounds of coral rubble noticed on Utirik, Likiep and other atolls was clarified. Such mounds were seen around the roots of blown down Pisonia trees, with, in some cases, the mass of roots partially or almost completely decayed away. Some of the Pisonia root systems are enormous and the trees might well pry up a very sizable pile of stones. Once formed, though the sand might wash down from its surface, such a mound would likely persist for a long time, unless swept away by typhoon waves.

On our last day at Wotho, Charlie Frey, the chief engineer, took Captain Fretz trolling in a small boat, and I went along to take advantage of a chance to get ashore on Mejurwon, the third largest islet of the atoll. The fishing was exciting, several large jack and other more unusual fish being brought aboard. Mejurwon was of interest in that it had the only apparently unplanted stands of Calophyllum inophyllum seen in the northern Marshalls. This is ordinarily a tree found in villages and near houses, or solitary along paths. Here, on this completely uninhabited islet were large patches of it, clumps of good sized trees, on sandy areas near the lagoon beach. While we were on the islet we met some of the Marshallese from Wotho Islet, who had been there on a food collecting expedition. They had gathered a large bundle of dried Pandanus leaves for plaiting or thatching, a small amount of copra, a batch of turtle eggs, and three or four dozen coconut crabs (Birgus). They had roasted some of the latter and gave us several of the great claws to eat. They were still hot and the meat was delicious, somewhat similar to lobster, but with a very distinctive flavor of its own. They gave us three enormous live specimens, tied with strips of coconut leaflet. One got loose in the boat and caused quite a commotion. I preserved mine, and it is now in the U.S. National Museum collection.

Bikar and Pokak

Leaving Wotho on March 23 we proceeded northward for another try at Bikar and Pokak. We arrived off Bikar the next day and investigated the channel. The current flowing out of the passage was too strong for the small motorboat to make any progress against it so the attempt was given up. We spent the rest of the day examining the atoll from all sides, making what notes we could from the ship. On the leeward side the "oil slicks" described above were very conspicuous, extending out from the south half of the reef as much as half a mile. Birds were abundant, and great numbers were scared up by blasts from the whistle.

Departing in the late afternoon, we were off Pokak the next morning. The passage, at low tide, again resembled the traditional millrace. There was obviously no point in trying to enter at this time. We cruised around the atoll examining the islets through binoculars, taking notes. The vegetation had a definitely dry, gray appearance. At almost high tide we revisited the passage. There seemed to be almost no current at that time, and that would clearly be the proper time to enter. However, a west swell had set in and was breaking at times clear across the entrance, so no attempt was made to get a boat in. Again, on the lee side, especially near the passage, the "oil slicks," seen on previous atolls, were very conspicuous, this time extending as much as several miles to leeward and becoming very diffused. In the neighborhood of the mouth of the passage the water seemed to have a somewhat lighter blue color, suggesting the effect of colloidal calcium carbonate. It is possible that a certain amount of very fine sediment was being swept out of the lagoon.

It was with a considerable feeling of frustration that we received the Captain's decision to give up any attempt to land on Pokak. An opportunity to investigate a place never before visited by a scientist does not come every week. Its bleak appearance did not lessen at all its interest. And John Cameron's story of the basalt blocks remained as tantalizing as ever. We started back for Kwajalein that evening and arrived the morning of March 27.

Return Trip

The next two days were spent in packing and stowing our gear in the hold of the ship, and in arranging for air transportation to Guam and Tokyo. Early in the morning of March 31 MacNeil and I left for Guam, arriving at about the middle of the morning. We planned to spend a couple of days here, discussing some of our findings with the party of geologists engaged in working out the geology of Guam. Joshua I. Tracey, chief of the party, was in the hospital, but not especially incapacitated. Ted Arnow met us at the airport, and we had a good visit. He was busy getting ready to go to Palau, so the others in the party took us around Guam, enabling me to check a few details of the vegetation, which I had studied some two years before. Some of the areas of swordgrass that have not been burned since before the war are now conspicuously covered by _Casuarina_ saplings. The obvious effects of the 1949 typhoon have in many places almost disappeared. Rocks that were completely denuded of vegetation, except for root crowns in crevices, are now fairly well covered again by low _Pemphis_ brush. The forest on the north plateau seems to be generally in rather decadent condition. Field work on Guam for the next year was planned to fit in with the program of the geological party.

On April 2 MacNeil and I left for Tokyo. We stopped at Iwo Jima long enough for a stroll around the airport and to make a few observations on the weedy vegetation that had appeared since the War. We arrived in Tokyo in the afternoon.

Two and a half weeks in Japan were spent in writing preliminary reports, making plans for the reports and papers that will embody the results of the expedition, and in packing and shipping the specimens. The FS-367 arrived a bit late with our collections, having been badly battered by a storm on the way up. We were able to take two short trips into the countryside of Japan, being fortunate enough to arrive during the season of the cherry blossoms, for which Japan is famous. This country was fully as beautiful in the spring as it was when we saw it in the fall.

Wake Island

I had arranged to spend two days making a quick reconnaissance of Wake Island on the way home, so I left Tokyo on the night of April 18 and sighted Wake on the afternoon of the 19th. I was able, while we were landing, to take some kodachrome photos of the atoll from the air. The vegetation seemed to be noticeably affected by the dry weather, the atoll appearing quite as gray as Pokak had looked from the sea.

Good fortune was definitely with me here. One of the first persons I met was Mr. Fred Schultz, in charge of pest-control on the island. He offered to drive me around the island and act as guide. This was an excellent arrangement, as he knew where all of the variations in the vegetation could be seen and was also quite willing to explain his very successful campaign of pest-control. He had, within a year, brought the island's three plagues--rats, flies, and mosquitoes-- so completely under control that in two days we had trouble finding any, even for specimens. We saw one rat, three or four flies, and no mosquitoes at all. He had applied what he knew or could learn of the ecology and habits of these creatures, destroying the breeding places of the insects and systematically poisoning the rats. In poisoning the rats he had apparently accidentally destroyed the hermit crabs also, as we saw none, and he said they were common a few months before.

The vegetation of Wake, described quite well by E.H. Bryan in 1923 (published by Christophersen, 1931), was almost entirely destroyed during the War. The remains of fortifications, Japanese and American, are to be seen practically everywhere. Only three rather small areas of the original forest cover remained. The astonishing thing about the vegetation was the rapidity with which it had recovered. Large Messerschmidia bushes, 3 to 5 meters tall, dominate the landscape; they cover the ditches, tank-traps, platforms, gun emplacements, and revetments and give the appearance of long-established vegetation. Four years earlier the general plant cover on the island was said to have been no more than a foot high. On favorable, sandy places, according to the Civil Aeronautics Administration officials, Messerschmidia had grown as much as 2 meters in a year. Pemphis here seems to favor situations of broken coral rock and of fine silty sand. Two very obvious plants not found in the Marshalls but common here are Sesuvium portulacastrum and Heliotropium anomalum. Quite a flora of introduced weeds has established itself. Indeed it is hard, sometimes, to tell which plants really belong here. Ipomoea pes-caprae and Gossypium hirsutum var. religiosum, of which one plant of each was reported by Bryan, were now common. One of the old patches of forest, persisting from before the War, was an interesting mixed forest of large low trees of Pisonia and Cordia.

After two very busy days here, I left for Honolulu early in the morning of April 22. There an opportunity was afforded to see Kilauea volcano in eruption, and incidentally to make some study of the vegetation. The return to Washington with a stop in California was without incident.

Another Attempt

Mail and many questions had piled up in my absence, so I settled down to take care of them and to work on reports of the expedition and its results. But only a few weeks had passed, when a cable came from Tokyo asking if I were interested in joining the FS-216 at Wake Island for another attempt at Pokak and Bikar. I was taken aback by this; my mail was scarcely answered, but nevertheless I decided to go.

So preparations were again in order and a few weeks later, on July 9th, I was again flying westward. The principal incidents of this flight were a three-day enforced wait at Travis Air Force Base, California, and notification on arrival in Honolulu that I was expected in Wake within four hours.

Needless to say, I was not there by that time. Several appointments in Honolulu had to be kept. There was also the matter of transportation from Honolulu to Wake to be arranged; and such arrangements are not usually made on a moment's notice. However, because of superb cooperation of the Visitor's Bureau of the U. S. Army, at Fort Shafter, which put a car at my disposal and took care of all the arrangements with Military Air Transport Service, I was on a plane again by the middle of the afternoon and on Wake Island by 2 o'clock the next morning. Enroute I had a short stop, unfortunately just after dark, at Midway and was able to examine briefly from the air Niihau, Gardner Rocks, and Pearl and Hermes Reef, of the Leeward Hawaiian Islands. The size of the trees on Midway was surprising. Some of the Casuarina trees, planted many years ago when the Cable Station was established there, were at least 15 meters high and almost 0.5 meter through above the base. From the air in the dusk the island presented an almost wooded appearance. Albatrosses were to be seen along the runway as the pilots played a searchlight on them. Young ones were objects of much passenger curiosity around the terminal, too.

Arriving at the Wake Island terminal at 2 a. m., I was dismayed at finding no one who had the slightest idea whether or not the FS-216 was still at Wake or had departed. After exhausting the possibilities of finding out, I went to bed for the remaining few hours of the night. In the morning it was almost as hard to find out anything definite. But after the superintendent of the island came to his office it was possible to get transportation to the boatlanding, and it was a relief to see the FS-216 still at anchor and to meet its captain coming in to get his final clearance for departure for Pokak and the Marshalls. On climbing aboard I was greeted by Charles Johnson, my geologist companion for the expedition.

Our first lunch-table conversation with Captain Clover, the officer-in-charge, allayed, somewhat, my skepticism about getting ashore which was natural after two abortive attempts. There seemed no doubt in his mind about it.

During the drive from the Pan-American terminal to the boatlanding it was possible to observe the striking change from the dry aspect of Wake Island exhibited in April. The herbaceous layer, especially Euphorbia heterophylla, gray and dry then, was green and attractive now. The Messerschmidia trees looked more luxuriant now, but those near the Transocean Air Lines compound that had appeared dead were still very much so. The dry season had been too much for them, especially where they were growing on the loose rubble piled up in the fortifications. Heliotropium anomalum was flowering abundantly south of the airstrip.

Pokak Atoll

On the morning of July 20 we were off Pokak Atoll once again. The sea was quiet, and no breakers were to be seen on the leeward side. A strong current was running out of the narrow crooked passage, just as on the two previous visits, but the small motorboat negotiated the passage easily and the landing operation was under way. Crossing the lagoon to the northeast end of Sibylla Islet, the largest of the string of rock and sand heaps that occupy most of the southeast reef of this remote atoll, we stopped ashore on one of the bleakest, loneliest spots that it has been my privilege to explore.

Pokak is a crescent-shaped atoll, about 11 miles from tip to tip, oriented north and south with the convex reef to the east, and with all the land on the southeast quadrant. At high tide water pours in over the reefs. But as soon as the tide begins to go down, only the single narrow passage on the west serves as an outlet. Though the water rushes out of this as through a millrace, in 6 hours the water level inside is not lowered much, and the level in the lagoon is at all times except at high tide, significantly above that of the surrounding sea. This, of course, makes surveying and the determination of land area a less than usually exact procedure, as altitudes are commonly expressed in relation to mean low tide.

The usual conception of a palm-bedecked atoll does not fit Pokak at all. The vegetation is a low scrubby wood of Messerschmidia trees and bushes, very sparse and, at this season, grayish and dry looking. Large areas in the interior and toward the lagoon side on the wider parts are covered by a thin bunch grass, honeycombed by burrows of wedge-tailed shearwaters, each burrow marked by a pile of white coral sand. These piles of white sand explained the curious salt-and-pepper appearance of these areas on aerial photographs. On the seaward side are vast boulder ridges and boulder flats, some wooded with scattered low Messerschmidia, others open, or with occasional plants of Ipomoea tuba. These presented a curious appearance. Normally this plant is a liana, climbing to the treetops in forest, forming dense tangles over trees and bushes, the stems reaching several centimeters in thickness. Here, in this dry climate the elongate twining stems die during the dry season, remaining in the form of a thin network over the bare rock flats. These dead stems are utilized by the frigate birds for nesting material. These branches die back practically to the root crown, which forms an erect stem a foot or so tall and half that or more thick, crowned with stubs of branches with a few green leaves and buds ready to produce next season's vegetative growth as soon as sufficient moisture is available. There seems little doubt that this is the same plant that is a liana elsewhere, and that this curious habit is induced by the severe dry seasons common in this forbidding habitat. Scaevola scrub, curiously enough showing less signs of drought than the other vegetation, covers some areas, especially ones where flat reef-rock lies at the ground surface and a few small areas of dune sand. Elsewhere this bush may be mixed with the Messerschmidia. In some of the sand-flats dominance is shared between the bunch grass, Lepturus repens, and the slender low shrub, Sida fallax. In other places, especially certain areas on Kamome Islet, the widest and, curiously, the most treeless of the atoll islets, Sida assumed complete dominance, here reaching a height of two meters, making a thin gray scrub. The response of this plant to the drought is also interesting. At the time of our visit practically every individual plant had all but one or two of its branches leafless, gray, and dead--brittle with no sign of living tissue. Almost invariably, however, one or two branches were healthy, leafy, and even flowering. Also on Kamome Islet are several low patches of Pisonia grandis. This tree, which forms magnificent forests on wetter atolls, there is low, not more than 5 or 6 meters tall, and with small trunks. At this season the canopy is very thin, as the trees lose most of their leaves in the dry season, and here the leaves are not as large as they are elsewhere. The patches are circular and obviously are slowly spreading, as is easily seen by comparing aerial photos taken even as little as eight years apart. These are the only colonies of this tree on the atoll and probably have not been there long. The fruits of Pisonia are extremely sticky and quite capable of being carried stuck to birds' feathers from either Wake or Bikar, on both of which the trees are found.

Previous information on this atoll has been almost wanting. Kotzebue, on his voyage around the world, passed by in 1819, and Chamisso, the famous German naturalist and writer who accompanied him, described it from half a mile away. This description, only two paragraphs long has provided the only reliable information to the time of our visit. John Cameron, Pacific wanderer, adventurer, trader, and guano-digger, visited it in 1893, as recounted in his "Odyssey". He describes huge basalt blocks--one of them 15 feet 6 inches long, 5 feet 4 inches wide, and 3 feet thick--comparable to those on Ponape, and wonders about their origin. The German writer Irmer, in 1896, speaks of the atoll as being covered with guano several meters thick. These last two accounts are interesting but quite untrue. A week of constant searching by Charles Johnson and myself, as well as by the surveyors, revealed no basalt and no thick deposit of guano. Other than coral limestone, there were a few of the usual smaller gray fine-grained pumice pebbles and a large chunk of black scoriaceous pumice cast up on the beach. Great boulders of coral, darkened by algae in their outer layers, some of them of rectangular shape, are scattered over the surface of islets and reefs; also a few remnants of an older, higher reef surface remain in place, especially on the bare southwesternmost islet. The coral boulders may have been mistaken for basalt, or the story may have been pure invention. As for guano, in spite of the presence of incredible numbers of birds, practically no guano exists on the island. Under trees where birds roost there may be up to an inch or so, very locally, but guano was so scarce that it was difficult to get a proper specimen for analysis. And in the great rookeries of sooty terns, according to some authorities the source of large guano deposits, there was no visible accumulation on the ground, even around the nesting places.

The largest islet is called Sibylla. On its lagoon shores are conspicuous lobes of blackened reef-rock, with rough pitted surfaces just above high-tide level. At several places these lobes are arranged in pairs, as though they marked the inner ends of channels. No evidence of the former existence of channels across the islet at these places was to be found on large-scale aerial photos or on the ground, though considerable search was made. However, on photos at a scale of 1: 20,000 or smaller, traces of the channels were quite evident. Further to the southwest were several much more obvious former channels across the islet, now filled with sand and gravel. In fact, it was possible to walk dry-shod as far as Pokak Islet, the next to the last on the reef, with the channels becoming more and more obvious until the last, west of Pokak Islet, was impassable. On Sibylla some elongated areas looked, on the photographs, to be grassy, at least similar to areas on photos of other islets known to be grassy. Here, however, examination showed them to be enormous boulder or cobble flats, in places absolutely bare of vegetation.

Pokak Islet was the site of the Japanese establishment on the atoll, said to have been a radio relay station and obviously, also, a small bomb dump. The pathetic remains of this tiny base, a blackened heap of rusted-through galvanized iron, half burned timbers, broken bottles and utensils, a cement cistern, scattered unexploded bombs, and, off to one side, a rude "torii" marking a temple site, even here, should serve very well as a lesson to would-be empire builders. Here was the remotest outpost of the former Japanese Empire, a place of unimaginable loneliness and discomfort for the exiled, normally socially inclined Japanese garrison. It was bombed completely out of existence in one day, in April 1944.

A well at this site, dug down through the sand and gravel to the water table, had only salt water at the time of our visit, during a long dry season. It seems reasonable, however, that the water may have been useful during more favorable seasons. Two other wells that we dug at the widest part of Sibylla Islet also yielded water too salty for drinking purposes.

South Islet, or Bokdik of the Marshallese, is bare of all visible vegetation. Its exposed rock platform is interesting geologically. The general level is above high tide. On the lagoon side it is conspicuously undercut. Here and there on its surface are masses of rock, at first appearing to be boulders cast up on the platform by storm waves, as seen elsewhere. Examination showed, though, that they are actually a part of the island, itself, remnants of a higher surface, with no joint or suture between them and the underlying rock. This is an important part of the overwhelming mass of evidence to be seen on this atoll, of a relatively higher sea level in the not too remote past. The surface of the general platform of this islet is most peculiar in being scarcely pitted, with no sharp edges to the pits and solution surfaces. Also it is light gray, rather than the usual dark or almost black. It is clearly a surface subjected to abrasion, and the low deposit, on the seaward side, of white cobbles and gravel is the obvious abrasive. This is well above high-tide level, but its whiteness and rounded character is mute evidence of the fury and frequency of the storms that must roll these pebbles around to abrade the general surface of the islet.

Another spectacular evidence of a higher sea level was found on the south coast of Sibylla Islet. It is a huge perched boulder, resting on a much narrower pedestal of reef rock, the base of the boulder about 2 meters above the present reef flat. The top of this pedestal corresponds in level with remnants of reef rock which protrude from under the mass of loose material that make up the islet nearby. This mushroom-shaped structure stands erect at the outer edge of the beach and inner edge of the present reef flat. A distinct suture is obvious between the boulder and its supporting column. Clearer proof could not be wanted of a higher stand of the sea in relation, at least, to this island. The boulder is in no way different from the ones which occur sporadically scattered on the present reef flat, on this and other atolls. In a wetter climate it would probably have been gradually dissolved away. The impressive thing is the enormous expanse of reef flat that has been planed from this level down to the present lower level at about mean low tide. Even with maximum estimates of time involved since the post-glacial high stand of the sea this cutting has been remarkably rapid. One of the major interests of the geologists on the expedition was to discern and establish the processes responsible for this degradation.

Except for the enormous numbers of sea birds, the land fauna of Pokak is meager. The Polynesian rat, Rattus exulans, is present in some abundance. That the birds, even ground-nesting ones, do not seem to be seriously bothered by these rats is most interesting. A lizard, a dwarfed form of the common blue-tailed skink, was occasionally seen. Here it is to be found most frequently under loose bark of dead trees, rather than in its usual habitat on the ground, though it is also seen on the ground at times. The most evident animal is the large red hermit crab, Coenobita perlata, which inhabits Turbo shells. It would be interesting to know if the factor that limits the population of this animal is the restricted food supply or the number of Turbo shells. The shell commonly used by this species of hermit crab, when adult, is Turbo lajonkairi, apparently not a common shell elsewhere, but by far the commonest Turbo seen here. Its habitat is in cavities in the flat reef surface, expecially on the small reef patches in the lagoon. None of these shells were seen empty on the beaches or islets. And since very few of the large hermit crabs were seen inhabiting any other shell, and of course none were without shells, the relation between the number of crabs that reach maturity and the number of available Turbo shells is close, indeed.

Two species of moths were very common, and they were the only ones seen in any abundance. One or two individuals of other kinds were caught, including a sphinx moth. A few other kinds of insects were found, including a large carrion fly, several species of ants, several bugs and a number of beetles. Two wingless primitive insects, belonging to the Lepismidae and Psocidae, respectively, were common, as were one or two kinds of spiders. Mites and pseudoscorpions were also present. It is not immediately obvious how the wingless creatures, including a minute land snail, came here. Absent were termites, houseflies, mosquitoes, and butterflies.

The heat on this waterless, practically shadeless atoll was, at least in this midsummer season, excessive. It was noticeable even to one sitting quietly. Tramping around the island was a desiccating experience. But the fascinating studies to be made, and the shortness of the visit and resulting urgency about making them caused a certain amount of forgetfulness of the heat. When the available week was up, and it was time to leave on July 27 for Kwajalein, I, at least, thought more of the things I had not yet got to look at than of the frying-panlike surroundings I was leaving behind.

Back aboard the ship there was the problem of getting my plant specimens and soil samples dry. On the FS-367 I had dried them in the funnel of the ship, next to the hot exhaust pipes. The arrangement on the FS-216 was a bit different, but this seemed a practical solution. So I got permission from the Chief Engineer and piled plant presses and soil bags around the hot pipes. The first few times I had done this on the FS-367 I had kept careful watch over the materials, being afraid of fire. It soon was evident that the problem was to get the things warm enough, not danger of overheating. So, on the FS-216 I paid no attention to the specimens after putting them in to dry. That evening, before we had left the vicinity of Pokak the crew began to smell smoke. Soon it was discovered that my specimens were on fire. Getting them out, putting out the fire, and keeping the sailors from throwing everything overboard provided a busy two hours. Most of the plants were saved, but, surprisingly enough, most of the soil samples were lost. The bags were charred and burst when they were thrown out on deck. A few of the plants, mainly calcareous algae, were lost in the fire.

Kwajalein Atoll

We went to Kwajalein to refuel and to enable the surveyors to recheck their astronomical observations made there the previous winter. We renewed acquaintance with a few of our friends from the previous visits, but the usual Navy turnover had replaced most of the ones we knew. The vegetation on Ebeye and Kwajalein Islets had practically recovered from the winter's drought. A short visit was made to Enelapkan Islet, on the south reef, where there is a small amount of forest vegetation in addition to coconut groves. By no means all of the islets of Kwajalein have been studied, in spite of its being the center of activity in the Marshalls. It is so big that transportation is a major problem. The demand for boats is always greater than the small number available, and seldom do the boats go to the more remote islets.

On this visit only one plant was collected, and a few animals. Some of these were insects that were infesting stored rice in the Island Trading Co. warehouse at Ebeye.

Bikar Atoll

On August 4 we left for Bikar and arrived there on the 6th. Here we did not even bother about the narrow passage but landed over the reef on the leeward side of Bikar Islet in rubber rafts. At high tide this presented no problems at all, but as the tide went down there was some danger of the corals on the reef edge tearing the bottoms of the rafts. On this side of the islet there is no algal ridge, and the reef has a rounded sloping edge.

Bikar, previous to our visit, was almost as little known as Pokak, but there were no reputed mysteries or exaggerated accounts to disprove. We knew, from our own examination from the sea last winter, that the islets are mostly densely wooded with Pisonia, that there are a few coconut trees that have been planted by visitors from Likiep, that a few birds have been recorded from there, and that the Japanese had found a thick buried layer of phosphate rock. Mr. Jack Tobin had also found out from the Marshallese that, previous to annexation by Europeans, Bikar, along with Pokak and Jemo, had been regarded by them as a bird reserve. Birds, their eggs, and turtles could be taken in limited numbers, after proper ceremonies, on the one visit made during the year. That this wise policy was effective was immediately obvious to us when we arrived. Birds were present in large numbers, and it was clear that this is the turtle breeding-place above all others in the Marshalls.

The Bikar reef is oval, about 6 miles long, and has three wooded islets and two small gravel bars on its southeast quarter. Its one pass is on the west side, and is rather narrow, but not like the one on Pokak. The water rushes out of this one most of the time, also, but not in the torrent found in Pokak Channel. The boats used it repeatedly and had no difficulty at any time. The largest islet, Bikar, is on the south point of the atoll. It is actually very tiny, and the south third of it is bare reef-rock, stripped of all soil and vegetation, probably by storms. This rock flat is mostly above even extreme high-tide mark and has some small ridges and irregularities that are even a meter or more higher than the general surface. There is practically no loose material accumulated here. The north point is a sand flat with scattered bushes of Scaevola and Messerschmidia, both of which form a thin belt around the periphery of the wooded part of the islet. We camped on this open north part. The small coconut grove is at the north edge of the forest next to our camp spot. We had looked forward to a supply of drinking coconuts on Bikar, an island luxury which we had sadly missed on Pokak. In this we were disappointed. There were few nuts on the trees and what there were were small, malformed, and had bitterish water. Shells of large nuts littered the ground, so it is probable that the dry season just ending was responsible for this stunted condition.

Turtle tracks across the beaches were even visible on our large-scale aerial photos of Bikar Islet, so we were not surprised to find tracks in abundance when we arrived. My first activity after getting our equipment carried up the beach to the campsite was to walk around the island and count the turtle tracks. There were almost 600 of these, representing 300 turtles. The pits from which sand had been scooped to cover the egg-pits were so abundant that they were the dominant feature of the surface of the sand in the peripheral belt of this island. That night young turtles hatching out scurried through camp, heading directly for the sea; but only a few escaped the clutches of rats and hermit crabs. Several adults came ashore and were seen laying eggs. One blundered right through the cook tent. Observations on their habits will be given in a later article on the reptiles collected on the expedition. Curiously enough, turtle tracks were almost absent from the other islets, probably because of the lack of loose sand, of which a large part of Bikar Islet is made up.

The *Pisonia* forest, which covers the greater part of this islet, is dense and contains some great trees, though it is uneven and shows the usual effects of typhoons in the form of fallen trees. Ordinarily these take root wherever they touch the ground, but a number seen here on Bikar were dead. Probably they were blown down during a severe dry spell. The *Pisonia* forest contained two remarkable things--white-tailed tropic birds nesting in holes in the tree trunks, and water collected in cavities and irregularities in the large tree bases containing swarms of ostracods. Where these fresh-water animals came from on an island that has absolutely no other fresh water is indeed a mystery.

By this time I had learned to look for a humus layer underlain by phosphatic hardpan on the floor of a *Pisonia* forest. Here was no exception. Aso, a Japanese expert on phosphate deposits, had reported phosphate on Bikar, but he reported it buried under 2 feet of sand and gravel. The buried layer was easily found. In places it was under as much as 2 feet of sand, elsewhere much less, and in places it was not buried at all. Usually where it was buried there was also an additional layer of very fresh brown hardpan near the surface, under an inch or so of humus. The situation was clear after a study was made of the terrain, of the bases of the trees, and of a few test holes. Apparently a severe storm from the west had spread the material of the large dune ridge along the west side inward in a layer thinning toward the east, burying the greater part of the surface of the islet. The humus thus buried had gradually disappeared by oxidation, staining the sand, and leaving the hardpan layer. Then another layer had started to form on the surface of this new sand. Birds are abundant enough on Bikar to provide the necessary guano for this process almost everywhere in the forest.

Rats and blue-tailed skinks were here, as on Pokak. The big red hermit crab, *Coenobita perlata*, again inhabits the two kinds of *Turbo* shells, but the proportions were different, the common *Turbo setosus* here supplying about one-fourth of the shells. Land shells were not common but at least two genera were represented. Insects were much more abundant than on Pokak, but by no means as varied as on the atolls to the south. As on Pokak, the higher plant species numbered nine, but the lists differ somewhat. And the vegetation is almost completely different. On the three principal islets the main body of the vegetation is *Pisonia*, surrounded by a thin sparse belt of *Messerschmidia*, this on Bikar Islet mixed with *Scaevola*. Bare areas have a thin cover of *Portulaca* and *Lepturus*, very locally mixed with *Boerhavia*, or nothing at all. On Jaboero Islet, which is a gravel bar and a sooty tern rookery, the entire vegetation is made up of *Portulaca lutea*.

Jaliklik Islet is interesting in having a well-developed boulder ridge along its lagoon side. Its seaward side has extensive denuded reef-rock flats. Almeni Islet is of rather coarse gravel. On Bikar Islet we attempted to dig down to the water table. This islet is higher than usual, and no water was reached after a laborious full day of digging by two strong boys, surveyor's helpers. Sand kept caving down, so the hole had to be made very large. It afforded an interesting opportunity to study the buried phosphate layer and the stratification of the materials of which the islet is built.

The reef to the east of the south point of Bikar Islet was briefly examined and showed several interesting features. A conspicuously undercut "mushroom" rock a meter or more high protrudes above high-tide level on the outer reef flat. It was not easy to be sure whether it was part of the reef or the remains of a boulder that had been cast up by a storm. There were striking tide pools on the outer part of this reef, with bright-green coral (Millepora) and pink algae, and with great numbers of the large black-purple slate-pencil sea urchin, Heterocoentron trigonarius Lam. The edge of the reef here is especially interesting. It appears to be an algal ridge in the last stages of being removed by solution. Apparently the rate of deposition of calcareous material in this position is barely or not quite able to keep up with the rate of removal by solution. North of this there is a better developed ridge, while around the point in the other direction the ridge disappears altogether. Well back of this, on the flat, the tops of the corals are abruptly truncated, as though they had been shaved off, presumably indicating the exact level at which there is too much exposure to air for survival of the corals.

As usual, we had to leave before we were completely satisfied with our survey. Even islands as small as these provide much opportunity for observation. And in such relatively simple situations one feels that perhaps only a little more time would have sufficed to give an understanding of what is actually happening, ecologically. It is to be hoped that the present-day Marshallese and the American Administration will see fit to continue the wise policy of the ancient Marshallese and maintain this atoll, and Pokak, as bird and turtle reserves. Then, perhaps, another expedition can start where this one left off and really get a grasp of the ecology of these tiny bits of land. Certainly the number of people that would ever be able to eke out an existence on them would not justify destroying these fascinating microcosms.

On August 12 we left for Kwajalein, spending a last night there on August 14, entertained by my friend Kenneth Moy and his wife, of the Island Trading Co., to whom thanks are due for many favors and assistance both while we were there and later, when I wrote for needed specimens and observations. Here the expedition ended, Charles Johnson leaving for Tokyo and I for Honolulu.

Condensed Itinerary of Localities where Collections and Observations were made

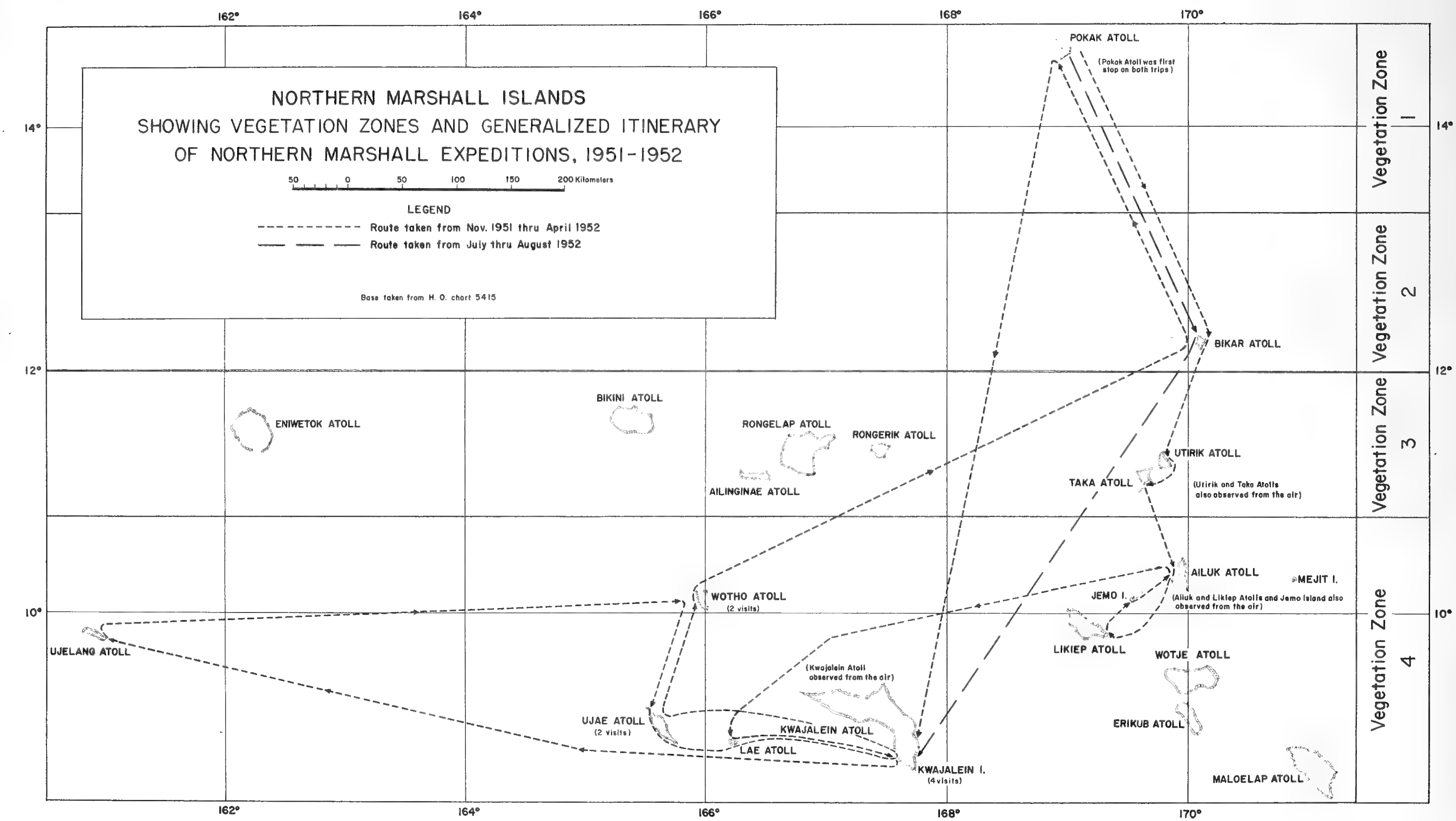
Date	Locality	Collector or Observer
Oct. 22, 1951	Johnston Island	Fosberg
23	Wake Island	Do.
23-24	Iwo Jima	Do.
24	Tokyo, Japan	Fosberg, MacNeil
28	Hakone, Japan	Do.
	Kanagawa Pref., Japan	Do.

Date	Locality	Collector or Observer
Nov. 3	Chiba Peninsula, Japan	Fosberg
6-8	Fukuoka, Japan	Do.
16-25	At sea, Yokohama to Pokak	MacNeil, Fosberg
25	Pokak Atoll*	Do.
26	Bikar Atoll*	Do.
Nov. 26-Dec. 4	Utirik Atoll	MacNeil, Arnow, Fosberg
Dec. 4-9	Taka Atoll	Do.
11-18	Likiep Atoll	MacNeil, Fosberg
18-23	Jemo Island	Fosberg
18-23	Likiep Atoll	MacNeil
Dec. 23, 1951-Jan. 4, 1952	Ailuk Atoll	MacNeil, Arnow, Fosberg
Jan. 4-10	Lae Atoll	Do.
10-Feb. 1	Kwajalein Atoll	Do.
13	Majuro Atoll	Fosberg
Feb. 3-10	Ujelang Atoll	MacNeil, Arnow, Fosberg
12-16	Wotho Atoll	Do.
16-24	Ujae Atoll	Do.
Feb. 25-Mar. 1	Kwajalein Atoll	Do.
28	Air circuit of Likiep, Jemo, Ailuk, Utirik, Taka, and Kwajalein	Fosberg
Mar. 1-14	Ujae Atoll	MacNeil, Fosberg
15-17	Kwajalein Atoll	Do.
18-23	Wotho Atoll	Do.
24	Bikar Atoll*	Do.
25	Pokak Atoll*	Do.
27-30	Kwajalein Atoll	Do.
Mar. 31-Apr. 2	Guam	MacNeil, Arnow, Fosberg
Apr. 2	Iwo Jima	MacNeil, Fosberg
6	Yokosuka, Japan	Do.
13	Chichibu Mountains, Japan	MacNeil, Fosberg
19-21	Wake Island	Fosberg
July 16	Niihau Island**	Do.
16	Gardner Rocks**	Do.
16	Pearl and Hermes Reef**	Do.
16	Midway Island	Do
16-18	Wake Island	Johnson, Fosberg
20-27	Pokak Atol	Do.
July 29-Aug. 4	Kwajalein Atoll	Do.
Aug. 6-12	Bikar Atoll	Do.
14-15	Kwajalein Atoll	Do.

* Did not go ashore.
** Observed from air.

List of Collection Numbers by Islands

	Plants		Animals
Wake	33614-33628		
Iwo Jima	33629		
Japan	33630-33641		
Utirik	33642-33719	....	45-50 111-181
Taka	33720-33778	....	51-59 182-302
Likiep	33779-33861	....	60-63 303-368
Jemo	33862-33907	....	64-72 369-484
Ailuk	33908-33990	....	73-79 485-556
Lae	33991-34107	....	84-90 557-663
Majuro	34108		
Ujelang	34142-34216	....	36-44 692-750
Kwajalein	34109-34141 34381-34382 34422 34549	....	80-83 664-691 1299-1327 1438-1447 1494-1496
Ujae	34284-34380 34383-34421	....	1-24 874-1063
Wotho	34217-34283 34423-34443	....	25-35 751-863 872-873 1484-1493
Pokak	34497-34548	....	1064-1072 1092-1120 1184-1298
Bikar	34550-34596	....	1073-1091 1121-1182 1328-1437


NORTHERN MARSHALL ISLANDS
SHOWING VEGETATION ZONES AND GENERALIZED ITINERARY
OF NORTHERN MARSHALL EXPEDITIONS, 1951-1952
50 0 50 100 150 200 Kilometers
LEGEND
Route taken from Nov. 1951 thru April 1952
Route taken from July thru August 1952
Base taken from H. O. chart 5415
162°
164°
166°
168°
170°
14°
12°
10°
Vegetation Zone 1
Vegetation Zone 2
Vegetation Zone 3
Vegetation Zone 4
POKAK ATOLL
(Pokak Atoll was first stop on both trips)
BIKAR ATOLL
UTIRIK ATOLL
TAKA ATOLL
(Utirik and Taka Atolls also observed from the air)
AILUK ATOLL
MEJIT I.
JEMO I.
(Ailuk and Likiep Atolls and Jemo Island also observed from the air)
LIKIEP ATOLL
WOTJE ATOLL
ERIKUB ATOLL
MALOELAP ATOLL
KWAJALEIN I.
(4 visits)
KWAJALEIN ATOLL
(Kwajalein Atoll observed from the air)
LAE ATOLL
UJAE ATOLL
(2 visits)
WOTHO ATOLL
(2 visits)
UJELANG ATOLL
ENIWETOK ATOLL
BIKINI ATOLL
RONGELAP ATOLL
RONGERIK ATOLL
AILINGINAE ATOLL

ATOLL RESEARCH BULLETIN

No. 39

Northern Marshall Islands Expedition,
1951-1952. Land biota: Vascular plants.

by

F. R. Fosberg

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May 15, 1955

Northern Marshall Islands Expedition, 1951-1952. Land biota: Vascular plants.[1,2]

by

F. R. Fosberg [3]

1/ Publication authorized by the Director, U. S. Geological Survey

2/ Preliminary results of the Expedition to the Northern Marshall Islands, 1951-1952, no.2.

3/ Botanist, U. S. Geological Survey

Northern Marshall Islands Expedition, 1951-1952. Land biota: Vascular plants.

by
F. R. Fosberg

Following the narrative of the expedition to the northern Marshalls made in 1951 and 1952, it seems worth while to present the raw data collected in a series of preliminary papers, to make them available for general use and reference without waiting until they are completely studied and interpreted. Formal publication of a more permanent character is planned as detailed studies are completed. This paper presents distributional and ecological records, as well as native names, of the vascular plants collected on the expedition. To these have been added records from the author's 1946 and 1950 collections, a few Wake Island collections made in 1953, and a few miscellaneous collections by others. Other significant collections from the northern Marshalls, not included here, are those of Wm. Randolph Taylor, published by him in his "Plants of Bikini," those made by Adelbert de Chamisso while on the Kotzebue Expedition, and those made on several trips by Harold St. John, mostly as yet unpublished.

The Marshallese plant names are recorded here in the form in which they were written down in the field, an attempt being made to reproduce the sounds as heard. Thus, they include, sometimes, a number of variants of the same word which simply indicate differences in the way the word was heard. No attempt has been made to edit these names according to any of the existing Marshallese orthographies. As this series of papers is intended to preserve raw data, it is felt that the names will be of more use exactly as recorded. When a definitive flora of the Marshalls is written, a more satisfactory orthographic form should be sought.

Place names are given as they appear on the labels of the collections, with an occasional correction given in parentheses. Thus the localities for the 1946 and 1950 collections are given, generally, as on the Hydrographic Office charts, whereas those for the 1951 and 1952 collections are given according to the revised list of names supplied by Mr. E. H. Bryan and Mr. Leonard Mason of Honolulu, as a result of their work on the Marshall Islands Atlas (unpublished).

The determinations of the plants are all by the author. They represent the present state of the taxonomy of these species. Some of them are in need of revision and may later be changed. All of the Marshallese <u>Pandanus</u> are here referred to <u>P. tectorius</u> Parkinson, as the numerous "species" that have been described or recorded from these islands are considered to be, actually, nothing more than horticultural forms and genetic segregates. One or two plants are determined to genus only, either because the species has not yet been described, or because the material available or the state of the classification is such that convincing specific identification is at present impossible. No new taxa are described and no nomenclatural changes are made in this paper.

Collection numbers cited are from the author's consecutive series except those few definitely ascribed to other collectors. This series applies only to plants.

Polypodium scolopendria Burm.f.

Utirik Atoll: Utirik Islet, 33674. Taka Atoll: Taka Islet, 33723. Likiep Atoll: Likiep Islet, 27010; Lado Islet, 33789. Ailuk Atoll: Akulwe Islet, 33913. Lae Atoll: Lae Islet, 33994. Kwajalein Atoll: Enewetak Islet, 34135. Ujelang Atoll: Bieto Islet, 34144. Wotho Atoll: Wotho Islet, 34237. Ujae Atoll: Bock Islet, 34328.

Indigenous. Common, mainly terrestrial but found also on the bases of coconut trees and, more rarely, on the lower trunks of other trees, principally in coconut plantations and mixed forest. Marshallese: "kino."

Pandanus tectorius Park.

Utirik Atoll: Utirik Islet, 33697. Taka Atoll: Taka Islet, 33725. Likiep Atoll: Likiep Islet, 27047; Aikini (Aekōne) Islet, 27048, 27055; Lado Islet, 33818. Jemo Island: 33900, 33905, 33906. Ailuk Atoll: Ailuk Islet, 33927. Lae Atoll: Loj Islet, 34040. Kwajalein: Bennett (Bikej) Islet, Islet, 26496; Enewetak Islet, 34131. Ujelang Atoll: Ujelang Islet, 34212. Wotho Atoll: Wotho Islet, 34280. Ujae Atoll: Bock Islet, 34346. Bikar Atoll: Bikar Islet, 34568. Eniwetok Atoll: Japtan Islet, 24317.

Of aboriginal introduction (?). Many varieties, both wild and planted, the latter used as food and thatch. The varieties differ mainly in fruit size, shape, juiciness, flavor, and other edible qualities. Planted forms usually around villages and forming a second story in coconut groves, wild ones in mixed forest, rarely in pure stands. Marshallese: "bop."

Thalassea hemprichii (Ehrb.) Aschers.

Ujelang Atoll: Ujelang Islet, 34189.

Indigenous. Forms a thin sod at low tide level on lagoon beach on the east end of Ujelang Islet, Ujelang Atoll; otherwise unknown in the northern Marshalls.

Cenchrus brownii R.& S.

Wake Atoll: Peale Islet, 34929.

Introduced weed. Common locally.

Cenchrus echinatus L.

Wake Atoll: Wake Islet, 33624, 34477. Utirik Atoll: Utirik Islet, 33665. Jemo Island: 33868. Kwajalein Atoll: Kwajalein Islet, 26486, 34140; Bennett (Bikej) Islet, 26504. Ujae Atoll: Ujae Islet, 34310. Eniwetok Atoll: Eniwetok Islet, 24300; Japtan Islet, 24324; Engebe Islet, 24378. Likiep Atoll: Likiep Islet, 27036.

Introduced weed. In open, sandy disturbed areas, especially around villages and military establishments, and in thin coconut plantations. In places very abundant. Marshallese: "lek e lek."

<u>Chloris inflata</u> Link
Kwajalein Atoll: Bennett (Bikej) Islet, 26522, 31202; Kwajalein Islet, 31187. Eniwetok Atoll: Engebe Islet, 24407. Wake Atoll: Peale Islet, 34928.
Introduced weed. In disturbed places where there have been military operations.

<u>Cynodon dactylon</u> (L.) Pers.
Wake Atoll: Wake Islet, 34450; Peale Islet, 34931. Eniwetok Atoll: Eniwetok Islet, 24292; Engebe Islet, 24379. Kwajalein Atoll: Kwajalein Islet, 26489.
Introduced weed. Common in open places around military establishments, persisting from plantings made in 1945-46, when there was concern about revegetation of the devastated areas.

<u>Dactyloctenium aegyptium</u> (L.) Richt.
Wake Atoll: Wake Islet,33617. Kwajalein Atoll: Kwajalein Islet,31188.
Introduced weed. Occasional in open disturbed places around military establishments.

<u>Digitaria microbachne</u> (Presl) Henr.
Likiep Atoll: Lado Islet, 33790; Likiep Islet, 27018. Jemo Island, 33870. Ailuk Atoll: Ailuk Islet, 33946. Lae Atoll: Loj Islet, 34050. Wotho Atoll: Wotho Islet, 34240. Ujae Atoll: Bock Islet, 34363. Kwajalein Atoll: Kwajalein Islet, 31161, 26475; Bennett (Bikej) Islet, 26498. Eniwetok Atoll: Japtan Islet, 24340; Aomon Islet, 24355; Eniwetok Islet, 24369; Engebe Islet, 24373.
Introduced (?) weed. Occasional to common in coconut plantations. Marshallese: "ujoij," "ujos kulkuli," "inikan pueue."

<u>Digitaria timorensis</u> (Kunth) Bal.
Utirik Atoll: Utirik Islet, 33664. Taka Atoll: Taka Islet, 33751.
Introduced weed. Villages and plantations. Marshallese: "ujoij."

<u>Eleusine indica</u> (L.) Gaertn.
Wake Atoll: Wake Islet, 33623, 34482. Utirik Atoll: Utirik Islet, 33663. Ailuk Atoll: Ailuk Islet, 33971. Lae Atoll: Lae Islet, 34060. Ujelang Atoll: Ujelang Islet, 34182. Wotho Atoll: Wotho Islet, 34235. Ujae Atoll: Ujae Islet, 34309. Eniwetok Atoll: Eniwetok Islet, 24289; Japtan Islet, 24320; Engebe Islet, 24384. Kwajalein Atoll: Kwajalein Islet, 26485; Bennett (Bikej) Islet, 26517. Likiep Atoll: Likiep Islet, 27013. Jemo Island, 33876.
Introduced weed. Common around villages and in disturbed places. Marshallese: "ujoij." A giant form occasional in openings in coconut plantations on Jemo Island (33876) is possibly only a response to abundant phosphate in soil.

<u>Eragrostis amabilis</u> (L.) W.& A.
Utirik Atoll: Utirik Islet, 33653. Likiep Atoll: Lado Islet, 33791; Likiep Islet, 27017. Jemo Island, 33875. Ailuk Atoll: Ailuk Islet, 33944. Lae Atoll: Lae Islet, 34065. Ujelang Atoll: Raej Islet, 34153. Wotho Atoll: Wotho Islet, 34230. Ujae Atoll: Ujae Islet, 34305. Wake Atoll: Wake Islet, 34459. Eniwetok Atoll: Eniwetok Islet, 24290; Japtan Islet, 24344; Aomon Islet, 24347; Engebe Islet, 24387. Kwajalein Atoll: Kwajalein Islet, 26483; Bennett (Bikej) Islet, 26505.

Introduced weed. Very common around villages, in disturbed places, and in coconut groves. Marshallese: "ujoij," "ujos."

Eragrostis poaeoides Beauv.

Wake Atoll: Wake Islet, 34458.

Introduced weed. On bare ground near air strip. Not previously known from the Pacific Islands.

Lepturus repens (Forst,f.) R.Br.

Wake Atoll: Wake Islet, 33627, 34950, 34462; Peale Islet, 34941, 34942, 34943, 34944. Utirik Atoll: Utirik Islet, 33861. Taka Atoll: Taka Islet, 33732. Jemo Island: 33864. Ailuk Atoll: Ailuk Islet, 33923. Lae Atoll: Lae Islet, 34064. Ujelang Atoll: Ujelang Islet, 34173. Wotho Atoll: Wotho Islet, 34271. Ujae Atoll: Bock Islet, 34359; Rua Islet, 34378. Pokak Atoll: Sibylla Islet, 34504; Kamome Islet, 34506, 34509. Bikar Atoll: Bikar Islet, 34571; Jaliklik Islet, 34577. Eniwetok Atoll: Eniwetok Islet, 24298; Japtan Islet, 24325; Aomon Islet, 24353; Engebe Islet, 24395. Kwajalein Atoll: Kwajalein Islet, 26477; Bennett (Bikej) Islet, 26510. Likiep Atoll: Likiep Islet, 26995.

Indigenous. A very common grass, found in open places, in plantations and forests, but mostly confined to places with at least some sand or fine gravel. Extremely variable in habit and luxuriance, with great latitude in tolerance of different moisture conditions. Pioneer species on newly deposited sand and fine gravel. Marshallese: "ujoj," "ujos aitok" (Eniwetok), "ujuj."

Lepturus sp.1/

Pokak Atoll: Kamome Islet, 34511. Wake Atoll: Peale Islet, 34940.

Indigenous. A form with extremely coarse habit. Probably a distinct species, found only very locally on open gravel, growing with, but not intergrading with, *Lepturus repens*. Apparently endemic to Pokak and Wake Atolls. Common on Pokak only on a part of Kamome Islet, and on Wake only in a small area on the west end of Peale Islet.

Paspalum vaginatum Sw.

Likiep Atoll: Likiep Islet, 33854, 27039. Kwajalein Atoll: Kwajalein Islet, 34123, 31189; Ebeye Islet, 31207. Wake Atoll: Peale Islet, 34932; Wake Islet, 34949. Ailuk Atoll: Ailuk Islet, 33969a.

Introduced weed. In open places and especially luxuriant in taro pits. An aggressive weed, recently introduced but spreading rapidly, forming a dense tough sod. Possibly responsible for the failure of the revival of taro culture in the northern Marshalls.

Setaria verticillata (L.) Beauv.

Wake Atoll: Wake Islet, 34470. Eniwetok Atoll: Japtan Islet, 24327; Engebe Islet, 24392.

Introduced weed. In disturbed places, not yet common.

Sorghum vulgare var. *technicum* (Koern.) Fiori & Paoli

Eniwetok Atoll: Engebe Islet, 24383.

Introduced. Apparently persisting from planting by Japanese, rare when collected, probably not a permanent member of the flora.

1/ See Fosberg, F. R., The Pacific forms of Lepturus R. Br. (Gramineae). Occ. Pap. Bishop Mus. 1955 (in press).

Stenotaphrum micranthum (Desv.) Hubb.
Ujelang Atoll: Ujelang Islet, 34200, 34201.
Introduced weed. A widespread but not common Pacific species, found here for the first time in the Marshall Islands, growing along paths in coconut plantation.

Thuarea involuta (Forst.) R.& S.
Utirik Atoll: Utirik Islet, 33692. Likiep Atoll: Lado Islet, 33841; Likiep Islet, 26993. Ailuk Atoll: Ailuk Islet, 33922. Lae Atoll: Lae Islet, 34020. Ujelang Atoll: Ujelang Islet, 34174. Wotho Atoll: Wotho Islet, 34238. Ujae Atoll: Ujae Islet, 34300; Bock Islet, 34360. Eniwetok Atoll: Eniwetok Islet, 24295; Japtan Islet, 24341; Aomon Islet, 24354. Kwajalein Atoll: Kwajalein Islet, 26474; Bennett (Bikej) Islet, 26524.
Indigenous. In sandy places, shaded or in the open, locally very common, forming a soft green ground cover. Marshallese: "ujoij," "ujuj," "ujos maroro" (Eniwetok).

Tricachne insularis (L.) Nees
Wake Atoll: Wake Islet, 34476. Eniwetok Atoll: Japtan Islet, 24328. Kwajalein Atoll: Bennett (Bikej) Islet, 26502.

Introduced weed. Occasional in disturbed places around abandoned military installations.

Cyperus compressus L.
Kwajalein Atoll: Kwajalein Islet, 31189.
Introduced weed in disturbed places.

Cyperus javanicus Houtt.
Likiep Atoll: Likiep Islet, 33859, 26989.
Indigenous(?). Rare around village. Marshallese :"săpâsăp."

Cyperus odoratus L.
Likiep Atoll: Lado Islet, 33845; Likiep Islet, 27043. Ailuk Atoll: Ailuk Islet, 33967. Lae Atoll: Lae Islet, 34014. Wotho Atoll: Wotho Islet, 34260. Kwajalein Atoll: Kwajalein Islet, 31172, 26484.
Introduced (?) weed. Common in taro pits and other wet places.

Cyperus rotundus L.
Kwajalein Atoll: Kwajalein Islet, 31200. Wake Atoll: Peale Islet, 34933; Wake Islet, 34948.
Introduced weed in gardens.

Eleocharis geniculata (L.) R.& S.
Likiep Atoll: Lado Islet, 33825. Ailuk Atoll: Ailuk Islet, 33969.
Introduced (?) weed. In taro pits.

Fimbristylis spathacea Roth
Wotho Atoll: Wotho Islet, 34259, 34272. Wake Atoll: Wake Islet, 33619, 34457, 34478. Utirik Atoll: Utirik Islet, 33642. Taka Atoll: Taka Islet, 33737. Likiep Atoll: Lado Islet, 33835. Ailuk Atoll: Ailuk Islet, 33941. Lae Atoll: Lae Islet, 34062. Ujelang Atoll: Raej Islet, 34154. Ujae Atoll: Bock Islet, 34327. Kwajalein Atoll: Bennett (Bikej) Islet, 31204, 26518; Kwajalein Islet, 26488. Likiep Atoll: Likiep Islet, 27016.

Indigenous. Common to abundant in open places, coconut plantations and mixed woods, variable in habit, tolerant of a great range of moisture conditions. Pioneer in disturbed places. Marshallese: "derelij'man," "dralij'man," "perelijman," "ujoj maroro," "berejisman."

<u>Cocos</u> <u>nucifera</u> L.
Jemo Island: 33899. Eniwetok Atoll: Igurin Islet, 24316.
Introduced. Planted in large numbers on all atolls except Pokak and Wake. Dominant in the most extensive vegetation type. Marshallese "ni."

<u>Alocasia</u> <u>macrorrhiza</u> (L.) Schott
Ailuk Atoll: Ailuk Islet, 33970. Ujelang Atoll: Bieto Islet, 34145.
Of aboriginal introduction. Planted around villages, and spontaneous in coconut plantations, also a weed in taro pits. Marshallese: "wot," "wat."

<u>Colocasia</u> <u>esculenta</u> (L.) Schott
Lae Atoll: Lae Islet, 34013.
Of aboriginal introduction. Rare, persisting in taro pits. Marshallese: "katak."

<u>Cyrtosperma</u> <u>chamissonis</u> (Schott) Merr.
Ailuk Atoll: Ailuk Islet, 33968. Wotho Atoll: Wotho Islet, 34261. Ujae Atoll: Ujae Islet, 34302. Likiep Atoll: Likiep Islet, 27040.
Of aboriginal introduction. Planted and persisting in taro pits. Marshallese: "iarij" or "iarej."

<u>Rhoeo</u> <u>discolor</u> (L'Her.) Hance
Ailuk Atoll: Ailuk Islet, 33974.
Introduced. Rare garden plant.

<u>Agave</u> <u>sisalana</u> Perr.
Jemo Island: 33862. Likiep Atoll: Aikini (Aekōne) Islet, 27050 (?).
Introduced. Rarely planted.

<u>Crinum</u> <u>procerum</u> Carey
Utirik Atoll: Utirik Islet, 33686. Likiep Atoll, Lado Islet, 33820. Ailuk Atoll: Ailuk Islet, 33956. Wotho Atoll: Wotho Islet, 34278, 34225(?).
Of aboriginal introduction (?). Widely planted and persisting. Marshallese: "kiep," "kieb."

<u>Crinum</u> <u>rumphii</u> Merr.
Lae Atoll: Loj Islet, 34051. Ujelang Atoll: Ujelang Islet, 34197.
Ujae Atoll: Ujae Islet, 34311 (?); Bock Islet, 34345.

Of aboriginal introduction (?). Widely planted and persisting. Marshallese: "kiep," "kieb."

<u>Crinum</u> <u>asiaticum</u> L. (?)
Likiep Atoll: Likiep Islet, 27001.
Introduced. Planted. Marshallese: "kieb."

<u>Hymenocallis</u> <u>littoralis</u> (Jacq.) Salisb.

Ailuk Atoll: Ailuk Islet, 33976. Lae Atoll: Lae Islet, 34093. Ujelang Atoll: Ujelang Islet, 34185. Ujae Atoll: Ujae Islet, 34284. Likiep Atoll: Likiep Islet, 26992.

Introduced. Planted in villages. Marshallese: "kiep," "small kiep."

<u>Zephyranthes</u> <u>rosea</u> (Spreng.) Lind.

Likiep Atoll: Likiep Islet, 27033.

Introduced. Planted around dwellings.

<u>Tacca</u> <u>leontopetaloides</u> (L.) O.Ktze.

Utirik Atoll: Utirik Islet, 33695. Likiep Atoll: Lado Islet, 33839; Likiep Islet, 27000. Jemo Island: 33877. Ailuk Atoll: Ailuk Islet, 33938. Lae Atoll: Lae Islet, 34009. Ujelang Atoll: Ujelang Islet, 34206. Wotho Atoll: Wotho Islet, 34242. Ujae Atoll: Ujae Islet, 34288; Ebeju Islet, 34398. Eniwetok Atoll: Japtan Islet, 24333. Kwajalein Atoll: Bennett (Bikej) Islet, 26493.

Of aboriginal introduction (?). Abundant and spontaneous in coconut plantations, especially so on Utirik and Ailuk Atolls. Tubers used for food, especially in northern atolls. Marshallese: "mokemok," "mokmok."

<u>Musa</u> <u>sapientum</u> L.

Ailuk Atoll: Ailuk Islet, 33965. Lae Atoll: Lae Islet, 34021. Ujae Atoll: Ujae Islet, 34287. Kwajalein (not collected).

Introduced. Planted in shaded and sheltered places, especially on Ujae. Becoming chlorotic when exposed to salt spray. Marshallese: "banana."

<u>Peperomia</u> sp.

Lae Atoll: Lae Islet, 34027.

Indigenous. Very rare, one colony on rocks in <u>Barringtonia</u> forest: first record from northern Marshalls. Marshallese: "rabikiaga."

<u>Fleurya</u> <u>ruderalis</u> (Forst.) Gaud. ex Wedd.

Utirik Atoll: Utirik Islet, 33679. Taka Atoll: Taka Islet, 33744; Watwerok Islet, 33764. Likiep Atoll: Likiep Islet, 27004; Lado Islet, 33794. Jemo Island: 33880. Ailuk Atoll: Ailuk Islet, 33939. Lae Atoll: Lae Islet, 34030. Ujelang Atoll: Ujelang Islet, 34175. Ujae Atoll: Bock Islet, 34341. Eniwetok Atoll: Japtan Islet, 24321; Engebe Islet, 24399.

Indigenous. Common locally, especially in very rocky places with little soil, principally in the shade but also in full sun. Marshallese: "nen kutekut."

<u>Pipturus</u> <u>argenteus</u> (Forst.) Wedd.

Lae Atoll: Loj Islet, 34047. Kwajalein Atoll: Enebuoj Islet, 34129; Bennett (Bikej) Islet, 26509. Ujelang Atoll: Ujelang Islet, 34176. Ujae Atoll: Ujae Islet, 34299.

Indigenous. Common in mixed forest and thickets, as well as in undergrowth in coconut plantations in the southern tier of atolls of the northern Marshalls. Marshallese: "arme," "areme," or "arume."

<u>Artocarpus</u> <u>altilis</u> (Park.) Fosb.

Utirik Atoll: Utirik Islet, 33683, 33691. Likiep Atoll: Lado Islet, 33840; Aikini (Aekōne) Islet, 27054. Jemo Island: 33901. Ailuk Atoll: Ailuk Islet, 33924, 33957, 33980. Lae Atoll: Lae Islet, 33992, 34091.

Ujelang Atoll: Ujelang Islet, 34198. Wotho Atoll: Wotho Islet, 34233. Ujae Atoll: Bock Islet, 34361; Ujae Islet, 34417. Eniwetok (Oakley).

Introduced. Planted, the seeded form possibly spontaneous, around villages and houses and in coconut plantations on the lagoonward half or two thirds of islets, especially from Ailuk south. Two forms, one with seeds, the other seedless. Trees were found growing within 15 m. of passage and lagoon beaches, without apparent ill effects. None were found close to the outer beach. Marshallese: "mă," "mei," "me."

Ximenia americana L.

Lae Atoll: Lwejap Islet, 34073. Ujae Atoll: Ebeju Islet, 34399, 34400, 34383. Eniwetok Atoll: Japtan Islet, 24319.

Indigenous. Rare in thickets and in undergrowth in plantations. Marshallese: "kailikelik," "kalikelik."

Coccoloba uvifera L.

Wake Atoll: Wake Islet, 34471; Peale Islet, 34935. Kwajalein Atoll: Ebeye Islet, 31212.

Introduced. Occasionally planted around American installations.

Boerhavia diffusa L.

Wake Atoll: Wake Islet, 33626, 34453, 34946. Utirik Atoll: Utirik Islet, 33680. Taka Atoll: Taka Islet, 33743, 33748; Watwerok Islet, 33765. Ailuk Atoll: Ailuk Islet, 33931. Kwajalein Atoll: Enewetak Islet, 34136. Pokak Atoll: Breje Islet, 34503; Kamome Islet, 34517, 34546. Bikar Atoll: Bikar Islet, 34572. Eniwetok Atoll: Igurin Islet, 24306; Japtan Islet, 24334; Aomon Islet, 24356. Likiep Atoll: Likiep Islet, 27006; Aikini (Aekōne) Islet, 27058. Jemo Island: 33879.

Indigenous. Common, especially in rocky and sandy places, not too much shaded; more abundant in the drier northern atolls. Apparently occasionally hybridizes or intergrades with B. tetrandra (33748, 34136, 24306, 24356). Marshallese: "matok" (Eniwetok), "rebijraka."

Boerhavia form with leaves as in B. mutabilis R. Br.

Wake Atoll: Wake Islet, 34947.

Introduced? Common locally on coral sand and gravel.

Boerhavia tetrandra Forst.f.

Utirik Atoll: Utirik Islet, 33644. Taka Atoll: Taka Islet, 33746; Watwerok Islet, 33761, 33762 (hybrid?). Jemo Island: 33881. Ailuk Atoll: Ailuk Islet, 33937. Lae Atoll: Bikenaj Islet, 34074, 34076. Ujelang Atoll: Bokan Islet, 34163. Wotho Atoll: Wotho Islet, 34277. Ujae Atoll: Bock Islet, 34320. Wake Atoll: Wake Islet, 34454. Eniwetok Atoll: Aomon Islet, 24362; Engebe Islet, 24394. Likiep Atoll: Aikini (Aekōne) Islet, 27057.

Indigenous. Common in rocky or gravelly, even sandy places, especially in the open, also in open coconut groves. Apparently intergrades or hybridizes with B. diffusa (33746, 34074, 34076, 24362, 24394, 27057 33881). Marshallese: "năt'to," "perial," "matok aitok" (Eniwetok).

Mirabilis jalapa L.

Utirik Atoll: Utirik Islet, 33657. Ailuk Atoll: Ailuk Islet, 33960. Eniwetok Atoll: Eniwetok Islet, 24370. Likiep Atoll: Likiep Islet, 27029.

Introduced. Planted in gardens and around houses and graves.

Pisonia grandis R.Br.
Utirik Atoll: Utirik Islet, 33676. Taka Atoll: Taka Islet, 33735. Likiep Atoll: Lado Islet, 33852; Aikini (Aekōne) Islet, 27052. Jemo Island: 33895, 33898. Ailuk Atoll: Akulwe Islet, 33910. Lae Atoll: Lae Islet, 34026. Ujelang Atoll: Ujelang Islet, 34208. Wotho Atoll: Wotho Islet, 34263, 34268; Ombelim Islet, 34430. Ujae Atoll: Bock Islet, 34336, 34337. Pokak Atoll: Kamome Islet, 34507. Bikar Atoll: Bikar Islet, 34569. Wake Atoll: Wake Islet, 34472. Eniwetok Atoll: Igurin Islet, 24304, 24308; Japtan Islet, 24332, 24337; Aomon Islet, 24357; Engebe Islet, 24402. Kwajalein Atoll: Kwajalein Islet, 26512.
Indigenous. Frequent tree in mixed forests, usually away from direct exposure to wind. Important in forming pure stand forests. Favored by birds for roosting and nesting. Marshallese: "kangl," "kangae" (Eniwetok).

Achyranthes aspera L.
Eniwetok Atoll: Aomon Islet, 24348.
Introduced weed. Rare in disturbed places. Marshallese: "kaleklek."

Achyranthes canescens R. Br.
Utirik Atoll: Bekrak Islet, 33714. Taka Atoll: Taka Islet, 33729. Jemo Island: 33894.
Indigenous. Very local in scrub on drier islets.

Amaranthus dubius Mart.
Kwajalein Atoll: Kwajalein Islet, 31178, 31185; Bennett (Bikej) Islet, 26503. Wake Atoll: Wake Islet, 34452; Peale Islet, 34938. Eniwetok Atoll: Engebe Islet, 24390.
Introduced weed. Common around military installations.

Amaranthus spinosus L.
Kwajalein Atoll: Kwajalein Islet, 31174.
Introduced weed. Infrequent around military installations.

Amaranthus viridis L.
Wake Atoll: Wake Islet, 34446. Eniwetok Atoll: Eniwetok Islet, 24372.
Introduced weed. Infrequent around military installations.

Gomphrena globosa L.
Ujae Atoll: Ujae Islet, 34294.
Introduced. Rare in gardens.

Portulaca lutea Sol.
Utirik Atoll: Eluk Islet, 33701. Pokak Atoll: Kamome Islet, 34510. Wotho Atoll: Biken Islet, 34434. Bikar Atoll: Bikar Islet, 34567, 34570; Jaliklik Islet, 34578. Wake Atoll: Wake Islet, 34468. Eniwetok Atoll: Igurin Islet, 24307; Japtan Islet, 24326; Aomon Islet, 24358.
Indigenous. Abundant in the northern atolls, less so southward, in open sandy or gravelly places and under trees where other ground cover is not thick. Pioneer on new sand and gravel bars, beaches, and typhoon-stripped areas. Marshallese: "purya," "kiran."

Portulaca oleracea L.

Wake Atoll: Wake Islet, 33620, 34481. Taka Atoll: Taka Islet, 33742. Ujae Atoll: Ujae Islet, 34308. Eniwetok Atoll: Eniwetok Islet, 24296; Engebe Islet, 24408. Kwajalein Atoll: Kwajalein Islet, 26491; Bennett (Bikej) Islet, 26500.

Introduced weed. Common in sandy places around villages and in disturbed places.

Portulaca samoensis v. Poelln.

Utirik Atoll: Utirik Islet, 33675. Likiep Atoll: Lado Islet, 33848; Likiep Islet, 27005. Ailuk Atoll: Ailuk Islet, 33940. Ujelang Atoll: Ujelang Islet, 34216. Wake Atoll: Wake Islet, 34460. Eniwetok Atoll: Eniwetok Islet, 24297; Japtan Islet, 24323; Engebe Islet, 24400. Kwajalein Atoll: Kwajalein Islet, 26469, 26513.

Introduced (?) weed. Common in sandy open or disturbed places. Marshallese: "nat'to," "bujang."

Sesuvium portulacastrum L.

Wake Atoll: Wake Islet, 34461.

Indigenous. Common on open saline flats.

Cassytha filiformis L.

Utirik Atoll: Utirik Islet, 33694. Taka Atoll: Taka Islet, 33724. Jemo Island: 33889. Ailuk Atoll: Ailuk Islet, 33936. Lae Atoll: Lae Islet, 34080. Ujelang Atoll: Ujelang Islet, 34172. Wotho Atoll: Wotho Islet, 34266. Ujae Atoll: Bock Islet, 34330. Eniwetok Atoll: Eniwetok Islet, 24288; Igurin Islet, 24313; Japtan Islet, 24330; Aomon Islet, 24365. Kwajalein Atoll: Bennett (Bikej) Islet, 26497. Likiep Atoll: Likiep Islet, 27009.

Indigenous. Common generally in openings, in open coconut groves, and in loose scrub, parasitizing grasses, shrubs and even small trees; forming loose mats covering vegetation. Marshallese: "kaanin," "kani," "kenen," "kānun."

Hernandia sonora L.

Lae Atoll: Lae Islet, 33997; Loj Islet, 34041. Ujelang Atoll: Ujelang Islet, 34211. Likiep Atoll: Aikini (Aekōne) Islet, 27060.

Indigenous. Rare in mixed forest and in coconut groves. Seedling found in germinated beach drift at top of beach (33997). Marshallese: "pingiping," "bing bing."

Brassica sp.

Eniwetok Atoll: Engebe Islet, 24388.

Rare, persisting after cultivation, probably has now disappeared.

Lepidium o-waihiense Cham. & Schlecht.

Wake Atoll: Peale Islet, 34930.

Indigenous. Very common locally on steep banks of "Lake Peale."

Bryophyllum pinnatum (Lam.) Kurz

Likiep Atoll: Lado Islet, 33850.

Introduced. Planted in garden.

Caesalpinia pulcherrima (L.) Sw.
Likiep Atoll: Likiep Islet, 27031.
Introduced. Rare. Planted in gardens.

Caesalpinia bonduc (L.) Roxb. (?)
Ujae Atoll: Alle Islet, 34416.
Indigenous. Rarely seen as seedling from drift seeds; seems not to persist in northern Marshalls.

Caesalpinia major (Medic.) Dandy & Exell (?)
Lae Atoll: Lae Islet, 34034.
Rarely seen as seedling from drift seeds; seems not to persist in northern Marshalls.

Canavalia microcarpa (DC.) Piper
Likiep Atoll: Likiep Islet, 33857. Jemo Island: 33888. Lae Atoll: Lae Islet, 34012, 34031. Ujelang Atoll: Bieto Islet, 34146; Ujelang Islet, 34204. Wotho Atoll: Wotho Islet, 34227; Kabben Islet, 34431. Ujae Atoll: Bock Islet, 34319. Eniwetok Atoll: Igurin Islet, 24309. Kwajalein Atoll: Bennett (Bikej) Islet, 26515.
Indigenous. Common but local in coconut plantations and in mixed forests. Roots of seedlings, at least, bear bacterial nodules. Marshallese: "manlap," "marlap."

Cassia occidentalis L.
Ujelang Atoll: Ujelang Islet, 34184.
Introduced. Persisting after planting by Japanese; said to have been used by them as coffee substitute.

Desmodium canum (Gmel.) Schinz & Thell.
Kwajalein Atoll: Kwajalein Islet, 34125.
Introduced weed. Common around military establishment on Kwajalein. When clipped makes fairly attractive lawn.

Erythrina variegata var. orientalis (L.) Merr.
Likiep Atoll: Likiep Islet, 27045.
Introduced. Rarely planted.

Intsia bijuga (Colebr.) Ktze.
Lae Atoll: Lae Islet, 33995; Bikenaj Islet, 34077; Bikelabet Islet, 34079; Enemanman Islet, 34099. Wotho Atoll: Wotho Islet, 34246. Ujae Atoll: Bock Islet, 34317; Wojia Islet, 34387.
Indigenous. Component of mixed forest on southern atolls of northern Marshalls. Marshallese: "kubuk."

Leucaena glauca (L.) Benth.
Utirik Atoll: Utirik Islet, 33669. Ailuk Atoll: Ailuk Islet, 33972. Kwajalein Atoll: Kwajalein Islet, 31176.
Introduced. Persisting after cultivation. Rare around former Japanese establishments. Sets seed but seems not to establish itself in northern Marshalls. Hawaiian: "koa haole."

Sophora tomentosa L.

Ujelang Atoll, Ujelang Islet, 34210. Ujae Atoll: Ebeju Islet, 34385. Likiep Atoll: Aikini (Aekōne) Islet, 27065.

Indigenous (?). Along lagoon sides of islets, just back of beaches in edges of coconut plantations, not common. Marshallese: "kile," "kuli."

Vigna marina(Burm.) Merr.

Lae Atoll: Loj Islet, 34054; Lae Islet, 34036. Likiep Atoll: Aikini (Aekōne) Islet, 27062; Lado Islet, 33822. Ujelang Atoll: Ujelang Islet, 34179. Wotho Atoll: Wotho Islet, 34234. Ujae Atoll: Ujae Islet, 34285. Kwajalein Atoll: Bennett (Bikej) Islet, 26521.

Indigenous. Common ground cover in coconut groves, climbing in bushes in mixed forest, pioneer on cleared areas and on new sand and gravel bars. Roots bear bacterial nodules. Marshallese:"marukunenjojo," "marlap" (Ujelang).

Tribulus cistoides L.

Eniwetok Atoll: Engebe Islet, 24403.

Introduced (?) weed. Rare on open sand; probably introduced accidentally with military equipment.

Citrus aurantifolia (Christm.) Swingle

Ujae Atoll: Ujae Islet, 34303 (?). Likiep Atoll: Aikini (Aekōne) Islet, 27051.

Introduced. Rarely planted in villages.

Soulamea amara L.

Ailuk Atoll: Akulwe Islet, 33912. Lae Atoll: Enemanman Islet, 34100. Wotho Atoll: Wotho Islet, 34269. Ujae Atoll: Ebeju Islet, 34384.

Indigenous. Locally common in mixed forest. Marshallese:"kil'li," "kabijiling."

Suriana maritima L.

Utirik Atoll: Utirik Islet, 33668; Eluk Islet, 33699. Taka Atoll: Taka Islet, 33738. Likiep Atoll: Lado Islet, 33788; Likiep Islet, 26996; Aikini (Aekōne) Islet, 27066. Ailuk Atoll: Akulwe Islet, 33909; Ailuk Islet, 33947. Lae Atoll: Lae Islet, 34033. Ujelang Atoll: Bokan Islet, 34166. Wotho Atoll: Wotho Islet, 34273; Bokanaetok Islet, 34441. Ujae Atoll: Bock Islet, 34335. Eniwetok Atoll: Igurin Islet, 24310; Puraai Islet, Hosaka 2691.

Indigenous. Common in sandy places in scrub, especially along outer beaches, occasionally dominant. Marshallese: "ngienge," "kalangi," "ngiangi."

Acalypha godseffiana Mast.

Likiep Atoll: Likiep Islet, 27022.

Introduced. Rarely planted; does not appear healthy.

Acalypha hispida Burm.f.

Likiep Atoll: Likiep Islet, 27027.

Introduced. Rarely planted; does not appear healthy.

Acalypha wilkesiana M.-A.

Ailuk Atoll: Ailuk Islet, 33977. Lae Atoll: Lae Islet, 34097.

Introduced. Uncommon in villages, does not appear healthy.

Codiaeum variegatum (L.) Bl.
Likiep Atoll: Likiep Islet, 27024.
Introduced. Rarely planted.

Euphorbia chamissonis Boiss.
Utirik Atoll: Utirik Islet, 33662. Likiep Atoll: Lado Islet, 33793; Likiep Islet, 27012. Ailuk Atoll: Ailuk Islet, 33921. Lae Atoll: Enemanman Islet, 34102. Ujelang Atoll: Ujelang Islet, 34207. Wotho Atoll: Wotho Islet, 34232. Ujae Atoll: Bock Islet, 34329. Eniwetok Atoll: Eniwetok Islet, 24286; Engebe Islet, 24385. Kwajalein Atoll: Kwajalein Islet, 26470.
Indinegous. In coconut groves, dominant in ground cover in many places. Marshallese: "mal dok," "beran," "puripur," "perul."

Euphorbia heterophylla L.
Utirik Atoll: Utirik Islet, 33672. Likiep Atoll: Lado Islet, 33842; Likiep Islet, 27011. Wake Atoll: Wake Islet, 34474. Ailuk (not collected). Kwajalein Atoll: Kwajalein Islet, 31162, 26482.
Introduced weed. Common in disturbed places, abundant locally, especially so on Wake Atoll. Marshallese: "nukuni."

Euphorbia hirta L.
Wake Atoll: Wake Islet, 33628, 34465. Jemo Island: 33873. Kwajalein Atoll: Bennett (Bikej) Islet, 26501. Eniwetok Atoll: Eniwetok Islet, 24367. Likiep Atoll: Likiep Islet, 26991.
Introduced weed. Common in disturbed places.

Euphorbia hypericifolia L.
Wake Atoll: Wake Islet, 33618, 33622. Kwajalein Atoll: Kwajalein Islet, 31166.
Introduced weed. In disturbed places, local but common where found.

Euphorbia prostrata Ait.
Likiep Atoll: Lado Islet, 33829. Jemo Island: 33874. Kwajalein Atoll: Kwajalein Islet, 34122, 26473 (?). Ujae Atoll: Ujae Islet, 34307. Wake Atoll: Wake Islet, 34455; Peale Islet, 34939.
Introduced weed. Common in disturbed places and around villages.

Euphorbia thymifolia L.
Kwajalein Atoll: Kwajalein Islet, 34137. Ujelang Atoll: Ujelang Islet, 34181.
Introduced weed. Very locally common in disturbed places. Marshallese: "nat'to."

Phyllanthus niruri L.
Utirik Atoll: Utirik Islet, 33688. Likiep Atoll: Lado Islet, 33832; Likiep Islet, 27015. Jemo Island: 33869. Lae Atoll: Lae Islet, 34092. Ujelang Atoll: Ujelang Islet, 34183. Ujae Atoll: Ujae Islet, 34306. Kwajalein Atoll: Kwajalein Islet, 31173, 26487.
Introduced weed. Common in disturbed places and around villages.

Ricinus communis L.
Eniwetok Atoll: Engebe Islet, 24377.
Introduced. Occasionally planted around military installations, probably by Japanese.

Allophyllus timorensis (DC) Bl.

Utirik Atoll: Bekrak Islet, 33710. Lae Atoll: Lae Islet, 33991. Kwajalein Atoll: Enewetak Islet, 34134; Bennett (Bikej) Islet, 31201, 26511. Ujelang Atoll: Ujelang Islet, 34199. Wotho Atoll: Wotho Islet, 34226. Ujae Atoll: Bock Islet, 34333; Ujae Islet, 34419.

Indigenous. Common in mixed forest in southern atolls; in Utirik in scrub. Marshallese: "kåtak," "kutak," or "keda."

Dodonea viscosa (L.) Jacq.

Likiep Atoll: Likiep Islet, 26998.

Indigenous. Rare in openings in coconut plantations. Marshallese: "kămin."

Triumfetta procumbens Forst.

Utirik Atoll: Utirik Islet, 33693. Taka Atoll: Taka Islet, 33721. Jemo Island: 33863. Ailuk Atoll: Ailuk Islet, 33932. Lae Atoll: Lae Islet, 34107. Ujelang Atoll: Ujelang Islet, 34193. Wotho Atoll: Wotho Islet, 34270. Ujae Atoll: Bock Islet, 34321. Bikar Atoll: Bikar Islet, 34575. Eniwetok Atoll: Eniwetok Islet, 24299; Igurin Islet, 24311; Japtan Islet, 24322; Aomon Islet, 24366; Engebe Islet, 24401. Kwajalein Atoll: Kwajalein Islet, 26478; Bennett (Bikej) Islet, 26514. Likiep Atoll: Likiep Islet, 27014.

Indigenous. Very general in disturbed places, coconut groves, mixed forest, at top of beaches, and other pioneer habitats, sometimes forming pure ground cover. Flowers open in morning and afternoon, closed in middle of day. Marshallese: "at'at," "atat."

Abutilon indicum (L.) Sweet

Wake Atoll: Wake Islet, 34451; Peale Islet, 34937.

Indigenous (?). Common locally in open scrub.

Gossypium barbadense L.

Utirik Atoll: Utirik Islet, 33656. Kwajalein (not collected).

Introduced. Rare, planted in village. Seen but not collected in nursery on Kwajalein.

Gossypium hirsutum var. religiosum (L.) Watt

Wake Atoll: Wake Islet, 34469.

Introduced. Persisting after cultivation. Common, especially around old Japanese installations. This plant is identical with a specimen collected in 1923, Pollock & Bryan 33, when it was reported to be rare, only one plant seen.

Hibiscus tiliaceus L.

Likiep Atoll: Lado Islet, 33823. Lae Atoll: Loj Islet, 34042. Ujelang Atoll: Ujelang Islet, 34214. Ujae Atoll: Ujae Islet, 34297. Kwajalein Atoll: Kwajalein Islet, 34549.

Of aboriginal introduction. Rare, growing in or near villages and around dwellings, not generally appearing healthy. Marshallese: "law."

Hibiscus (hybrid)

Likiep Atoll: Likiep Islet, 27026.

Introduced. Rarely planted.

Sida acuta Burm.f.

Ujelang Atoll: Ujelang Islet, 34180.

Introduced weed. Very local, only seen in Ujelang village.

Sida fallax Walp.

Utirik Atoll: Utirik Islet, 33687. Taka Atoll: Taka Islet, 33726. Likiep Atoll: Lado Islet, 33844. Ailuk Atoll: Ailuk Islet, 33962. Lae Atoll: Lae Islet, 34096. Ujelang Atoll: Nelle Islet, 34142; Bokan Islet, 34164. Wotho Atoll: Wotho Islet, 34241. Ujae Atoll: Ujae Islet, 34304. Pokak Atoll: Kamome Islet, 34505, 34518. Eniwetok Atoll: Aomon Islet, 24359; Eniwetok Islet, 24371; Engebe Islet, 24389, 24393. Kwajalein Atoll: Kwajalein Islet, 26481. Wake Atoll: Peale Islet, 34945.

Indigenous. Very abundant on Pokak in open areas; local in openings on drier or more saline islets on other atolls; planted and persisting after planting on more favorable islets where not found naturally. Marshallese: "kio."

Thespesia populnea (L.) Sol.

Kwajalein (not collected).

Introduced. Planted in military establishment. Hawaiian: "milo."

Calophyllum inophyllum L.

Utirik Atoll: Utirik Islet, 33678. Jemo Island: 33871. Ailuk Atoll: Ailuk Islet, 33926. Ujelang Atoll: Enellap Islet, 34139. Wotho Atoll: Wotho Islet, 34228. Ujae Atoll: Bock Islet, 34343. Likiep Atoll: Likiep Islet, 27020.

Of aboriginal introduction. Planted in villages, especially along lagoon beaches: occasionally established in mixed forest near lagoon side of islets. On Medjurwon Islet, Wotho, this species forms conspicuous thickets. Marshallese: "lũĕj," "lugej," "luech."

Pemphis acidula Forst.

Utirik Atoll: Utirik Islet, 33682. Taka Atoll: Taka Islet, 33747. Likiep Atoll: Lado Islet, 33847. Ailuk Atoll: Ulika Islet, 33984. Lae Atoll: Lae Islet, 34032. Kwajalein Atoll: Enebuoj Islet, 34127; Bennett (Bikej) Islet, 26499. Ujelang Atoll: Ujelang Islet, 34188. Ujae Atoll: Bock Islet, 34334. Wotho Atoll: Bokanaetok Islet, 34442. Eniwetok Atoll: Puraai Islet, Hosaka no.2690.

Indigenous. Common, growing especially on denuded rock flats, rarely on sand. Forming dense pure stands. Marshallese: "ngiengie," "kengi," or "kungi."

Citrullus vulgaris Schrad.

Eniwetok Atoll: Engebe Islet, 24375.

Introduced. Rare, persisting after military occupation.

Cucumis melo L.

Eniwetok Atoll: Engebe Islet, 24409.

Introduced. Rare, persisting after military occupation.

Cucurbita maxima Duch.

Ujelang Atoll: Bieto Islet, 34147. Eniwetok Atoll: Engebe Islet, 24376, 24380 (?) (no gray spots on leaves).

Introduced. Persisting after military occupation; also planted by Marshallese on Ujelang.

Carica papaya L.
Utirik Atoll: Utirik Islet, 33760. Taka Atoll: Taka Islet, 33736. Jemo Island: 33882. Ailuk Atoll: Ailuk Islet, 33961. Lae Atoll: Lae Islet, 34059. Kwajalein Atoll: Enebuoj Islet, 34128. Ujelang Atoll: Ujelang Islet, 34213. Ujae Atoll: Bock Islet, 34344.
Introduced. Commonly planted in interiors of islets in coconut groves, sometimes persisting there. Fruit appreciated by Marshallese. Marshallese: "papaya."

Bruguiera conjugata (L.) Merr.
Utirik Atoll: Bekrak Islet, 33712. Ailuk Atoll: Ailuk Islet, 33964. Lae Atoll: Lae Islet, 33993; Loj Islet, 34043.
Indigenous (?). Rare, in wet depressions. Marshallese: "chong," "jong."

Terminalia catappa L.
Likiep Atoll: Likiep Islet, 27019. Kwajalein Atoll: (not collected).
Introduced. Rarely planted in villages. Marshallese :kutil."

Terminalia samoensis Rech.
Ujelang Atoll: Bieto Islet, 34143; Enellap Islet, 34150. Utirik Atoll: Bekrak Islet, 33713. Taka Atoll: Taka Islet, 33739. Likiep Atoll: Lado Islet, 33783; Likiep Islet, 26997; Aikini (Aekōne) Islet, 27059. Jemo Island: 33891. Ailuk Atoll: Akulwe Islet, 33911. Lae Atoll: Enemanman Islet, 34037. Kwajalein Atoll: Enewetak Islet, 34138; Bennett (Bikej) Islet, 26495. Wotho Atoll: Wotho Islet, 34274; Eneobnak Islet, 34439; Bokanaetok Islet, 34440. Ujae Atoll: Bock Islet, 34331;Wojia Islet, 34388. Eniwetok Atoll: Japtan Islet, 24331.
Indigenous. Common component of scrub and mixed forest, occasionally in coconut groves. Marshallese: "eking," "akungkung," "kukung."

Barringtonia asiatica (L.) Kurz
Likiep Atoll: Lado Islet, 33860. Lae Atoll: Lae Islet, 34028.
Indigenous. Forming pure forest in one area on Lae, seen as drift seedling on Likiep, not seen otherwise except as drift fruits on beaches. Marshallese: "wuj," "woij."

Jussiaea suffruticosa L.
Likiep Atoll: Likiep Islet, 33853, 27044.
Introduced (?) weed. In taro pits.

Polyscias scutellaria (Burm.f.) Fosb.
Ailuk Atoll: Ailuk Islet, 33959. Lae Atoll: Lae Islet, 34066. Ujae Atoll: Ujae Islet, 34289. Kwajalein Atoll: Ebeye Islet, 31211.
Introduced. Occasionally planted around villages.

Polyscias sp.
Likiep Atoll: Likiep Islet, 27034.
Introduced. Rarely planted.

<u>Centella</u> <u>asiatica</u> (L.) Urb.
Likiep Atoll: Lado Islet, 33830; Aikini (Aekōne) Islet, 27064. Ailuk Atoll: Ailuk Islet, 33943. Ujae Atoll: Ujae Islet, 34298. Kwajalein Atoll: Kwajalein Islet, 26490.
Local introduced weed in villages, plantations, and around military establishments. Marshallese: "marukko," "margo," "mariko."

<u>Catharanthus</u> <u>roseus</u> (L.)
Likiep Atoll: Lado Islet, 33843; Likiep Islet, 27037. Ailuk Atoll: Ailuk Islet, 33978. Wake Atoll: Wake Islet, 34456.
Introduced. Planted around houses and graves, sometimes persisting.

<u>Nerium</u> <u>indicum</u> Mill.
Ujae Atoll: Ujae Islet, 34291. Likiep Atoll: Aikini (Aekōne) Islet, 27063.
Introduced. Planted around villages.

<u>Nerium</u> <u>oleander</u> L.
Lae Atoll: Lae Islet, 34000. Ujae Atoll: Ujae Islet, 34293.
Introduced. Planted around villages.

<u>Nerium</u> sp.
Utirik Atoll: Utirik Islet, 33685.
Introduced. Planted around house.

<u>Ochrosia</u> <u>oppositifolia</u> (Lam.) K. Schum.
Likiep Atoll: Likiep Islet, 33782. Ailuk Atoll: Akulwe Islet, 33914. Lae Atoll: Enemanman Islet, 34038. Kwajalein Atoll: Enewetak Islet, 34133; Bennett (Bikej) Islet, 26492. Ujelang Atoll: Ujelang Islet, 34215. Wotho Atoll: Wotho Islet, 34262, 34279. Ujae Atoll: Ebeju Islet, 34377. Eniwetok Atoll: Japtan Islet, 24329.
Indigenous. In mixed forest and forming pure forests. Marshallese: "kabuijiling," "kijbar," "kejebar," "kejbar."

<u>Plumeria</u> <u>rubra</u> L.
Utirik Atoll: Utirik Islet, 33689. Jemo Island: 33865. Ailuk Atoll: Ailuk Islet, 33966. Lae Atoll: Lae Islet, 34094. Ujae Atoll: Ujae Islet, 34296. Likiep Atoll: Likiep Islet, 27021.
Introduced. Planted around villages. Marshallese: "meria."

<u>Asclepias</u> <u>curassavica</u> L.
Utirik Atoll: Utirik Islet, 33658. Ailuk Atoll: Ailuk Islet, 33975. Lae Atoll: Lae Islet, 34068.
Introduced weed. Planted around houses and graves, occasionally escaped. Marshallese: "yelo."

<u>Ipomoea</u> <u>batatas</u> L.
Wake Atoll: Wake Islet, 34449. Likiep Atoll: Likiep Islet, 27038.
Introduced. Rarely planted; not doing well; on Wake persisting around Japanese garden site.

<u>Ipomoea</u> <u>littoralis</u> Bl.
Lae Atoll: Loj Islet, 34053. Ujelang Atoll: Ujelang Islet, 34202.
Introduced (?) weed. Occasional around villages, houses and paths.

Ipomoea pes-caprae (L.) Roth.
Lae Atoll: Lae Islet, 33999; Loj Islet, 34044. Wake Atoll: Wake Islet, 34473. Eniwetok Atoll: Eniwetok Islet, 24287; Engebe Islet, 24404. Kwajalein Atoll: Kwajalein Islet, 26480; Bennett (Bikej) Islet, 26506.
Introduced (?) weed. Very abundant around military installations, especially abandoned ones; seen elsewhere only as drift seedling.

Ipomoea tuba (Schlecht.) G.Don
Wake Atoll: Wake Islet, 33614. Utirik Atoll: Utirik Islet, 33661, 33677; Eluk Islet, 33700. Jemo Island: 33890. Ailuk Atoll: Ailuk Islet, 33942. Lae Atoll: Loj Islet, 34056; Enenbao Islet, 34083. Kwajalein Atoll: Lojjairong Islet, 34119; Kwajalein Islet, 26472; Bennett (Bikej) Islet, 26519. Ujelang Atoll: Ujelang Islet, 34178. Wotho Atoll: Wotho Islet, 34239. Ujae Atoll: Bock Islet, 34362. Pokak Atoll: Sibylla Islet, 34526. Eniwetok Atoll: Eniwetok Islet, 24285; Igurin Islet, 24305; Japtan Islet, 24342; Aomon Islet, 24349. Likiep Atoll: Aikini (Aekōne) Islet, 27053.
Indigenous. Very common to abundant in coconut plantations, mixed forest and scrub: also on open rock flats on Pokak Atoll. Marshallese: "marbele," "bele" (Ujelang, Eniwetok).

Cordia subcordata Lam.
Utirik Atoll: Utirik Islet, 33671. Likiep Atoll: Lado Islet, 33784. Jemo Island: 33883. Lae Atoll: Lae Islet, 34035; Enenbao Islet, 34082. Kwajalein Atoll: Enewetak Islet, 34132. Ujelang Atoll: Ujelang Islet, 34205. Ujae Atoll: Bock Islet, 34332. Wotho Atoll: Enearik Islet, 34427; Kabben Islet, 34435. Wake Atoll: Wake Islet, 34480. Eniwetok Atoll: Igurin Islet, 24303; Japtan Islet, 24338; Aomon Islet, 24351.
Indigenous. Rare to common in mixed forest and scrub, locally forming pure stands. Marshallese: "kāno," "kōno."

Heliotropium anomalum H. & A.
Wake Atoll: Wake Islet, 33625.
Indigenous. Common on open ground between trees and around buildings.

Heliotropium ovalifolium var. depressum (Cham.) Merr.
Kwajalein Atoll: Kwajalein Islet, 34124.
Introduced weed. Occasional along air strip.

Messerschmidia argentea (L.f.) Johnst.
Wake Atoll: Wake Islet, 33615. Utirik Atoll: Utirik Islet, 33643. Taka Atoll: Taka Islet, 33722. Jemo Island: 33886. Ailuk Atoll: Ailuk Islet, 33930; Ulika Islet, 33985. Lae Atoll: Lae Islet, 34089. Ujelang Atoll: Ujelang Islet, 34195. Wotho Atoll: Wotho Islet, 34267. Ujae Atoll: Bock Islet, 34314. Pokak Atoll: Kamome Islet, 34508. Bikar Atoll: Bikar Islet, 34574. Eniwetok Atoll: Eniwetok Islet, 24293; Igurin Islet, 24315; Japtan Islet, 24339; Aomon Islet, 24352; Engebe Islet, 24396. Kwajalein Atoll: Kwajalein Islet, 26479; Bennett (Bikej) Islet, 26520. Likiep Atoll: Likiep Islet, 26994.
Indigenous. Common to abundant generally, except in mature forest in interior of islets, pioneer on new sand and gravel and in disturbed areas. Marshallese: "kirin."

Cestrum nocturnum L.
Likiep Atoll: Likiep Islet, 27035.

Introduced. Rarely planted.

<u>Nicotiana tabacum</u> L.
Wake Atoll: Wake Islet, 34448.
Introduced. Persisting after cultivation. Rare, around old Japanese garden site.

<u>Physalis angulata</u> L.
Jemo Island: 33872. Ujae Atoll: Ujae Islet, 34286. Kwajalein Atoll: Kwajalein Islet, 34381.
Introduced weed. Occasional in disturbed places.

<u>Solanum lycopersicon</u> L.
Eniwetok Atoll: Engebe Islet, 24374.
Introduced. Persisting after military occupation.

<u>Solanum nigrum</u> L.
Kwajalein Atoll: Kwajalein Islet, 31177, 31180.
Introduced weed. Occasional in disturbed places around military installations.

<u>Clerodendrum inerme</u> (L.) Gaertn.
Utirik Atoll: Utirik Islet, 33673. Likiep Atoll: Lado Islet, 33846; Likiep Islet, 27008. Jemo Island: 33867. Ailuk Atoll: Ailuk Islet, 33945. Lae Atoll: Lae Islet, 34067. Ujelang Atoll: Ujelang Islet, 34186. Wotho Atoll: Wotho Islet, 34229. Kwajalein Atoll: Ebeye Islet, 31213; Kwajalein Islet, 26468 (planted).
Indigenous. Common as undergrowth in coconut plantations. Also filling abandoned taro pits. Planted near house on Jemo. Marshallese: "ulij," "ulej."

<u>Premna obtusifolia</u> R.Br.
Utirik Atoll: Utirik Islet, 33696; Bekrak Islet, 33711. Likiep Atoll: Lado Islet, 33821, 33849; Aikini (Aekōne) Islet, 27061. Ailuk Atoll: Ailuk Islet, 33963. Lae Atoll: Lae Islet, 34011. Ujelang Atoll: Ujelang Islet, 34203. Wotho Atoll: Wotho Islet, 34250. Ujae Atoll: Ujae Islet, 34418.
Indigenous. Occasional in mixed forest and around villages and houses. Marshallese: "kaar," "kar."

<u>Stachytarpheta jamaicensis</u> (L.) Vahl
Likiep Atoll: Likiep Islet, 27028.
Introduced. Planted in garden.

<u>Stachytarpheta indica</u> Vahl
Kwajalein Atoll: Kwajalein Islet, 34121, 31182.
Introduced. Weed around military installations.

<u>Ocimum sanctum</u> L.
Utirik Atoll: Utirik Islet, 33659. Ailuk Atoll: Ailuk Islet, 33979. Lae Atoll: Loj Islet, 34052. Ujae Atoll: Ujae Islet, 34292.
Introduced. Planted in gardens. Marshallese: "katarin."

Russelia equisetiformis Schlecht. & Cham.
Likiep Atoll: Likiep Islet, 33858, 27046.
Introduced. Rarely planted in gardens.

Scoparia dulcis L.
Kwajalein Atoll: Kwajalein Islet, 31184.
Introduced weed. Rare around military establishments.

Graptophyllum pictum (L.) Griff.
Likiep Atoll: Likiep Islet, 27023.
Introduced. Rarely planted.

Pseuderanthemum atropurpureum (Bull.) Bailey
Jemo Island: 33866. Ailuk Atoll: Ailuk Islet, 33973. Lae Atoll: Lae Islet, 34063. Ujae Atoll: Ujae Islet, 34290, 34421. Kwajalein Atoll: Ebeye Islet, 31206. Likiep Atoll: Likiep Islet, 27025.
Introduced. Commonly planted around villages.

Pseuderanthemum carruthersii Seem.
Utirik Atoll: Utirik Islet, 33690. Lae Atoll: Lae Islet, 34098. Wotho Atoll: Wotho Islet, 34236. Ujae Atoll: Ujae Islet, 34295. Kwajalein Atoll: Ebeye Islet, 31206. Likiep Atoll: Likiep Islet, 27030.
Introduced. Commonly planted around villages. The form with entirely green leaves and white flowers with crimson dots in the center. Marshallese: "ulij," "wut tiroj."

Guettarda speciosa L.
Utirik Atoll: Utirik Islet, 33667. Taka Atoll: Taka Islet, 33740. Jemo Island: 33897. Ailuk Atoll: Ailuk Islet, 33934. Lae Atoll: Lae Islet, 34106. Ujelang Atoll: Ujelang Islet, 34196. Wotho Atoll: Wotho Islet, 34276. Ujae Atoll: Bock Islet, 34316. Eniwetok Atoll: Aomon Islet, 24364; Eniwetok Islet, 24294; Igurin Islet, 24312; Japtan Islet, 24318; Engebe Islet, 24398. Kwajalein Atoll: Bennett (Bikej) Islet, 26494. Likiep Atoll: Likiep Islet, 27002.
Indigenous. Common in mixed forest and scrub, also in coconut groves. Marshallese: "wut," "wut i lomar."

Hedyotis biflora (L.) Lam.
Likiep Atoll: Lado Islet, 33792; Likiep Islet, 27041; Aikini (Aekōne) Islet, 27049.
Introduced (?) weed. Rare in coconut plantations.

Ixora casei Hance
Likiep Atoll: Likiep Islet, 27032.
Introduced. Rarely planted.

Morinda citrifolia L.
Utirik Atoll: Utirik Islet, 33684. Taka Atoll: Taka Islet, 33734, 33745. Jemo Island: 33878. Ailuk Atoll: Ailuk Islet, 33955. Lae Atoll: Lae Islet, 34008. Ujelang Atoll: Ujelang Islet, 34177. Wotho Atoll: Wotho Islet, 34231. Ujae Atoll: Bock Islet, 34315. Eniwetok Atoll: Igurin Islet, 24302; Japtan Islet, 24335; Aomon Islet, 24350; Engebe Islet, 24381. Kwajalein Atoll: Bennett (Bikej) Islet, 26507. Likiep Atoll: Aikini (Aekōne) Islet, 27056.

Of aboriginal introduction. Common in coconut and breadfruit groves and in mixed forest. Marshallese: "nen," "nin."

Scaevola frutescens (Mill.) Krause

Wake Atoll: Wake Islet, 33616. Utirik Atoll: Utirik Islet, 33715. Taka Atoll: Taka Islet, 33720. Jemo Island: 33887. Ailuk Atoll: Ailuk Islet, 33933. Lae Atoll: Lae Islet, 34090. Ujelang Atoll: Ujelang Islet, 34194. Wotho Atoll: Wotho Islet, 34275. Ujae Atoll: Bock Islet, 34318. Pokak Atoll: Pokak Islet, 34524. Bikar Atoll: Bikar Islet, 34573. Eniwetok Atoll: Eniwetok Islet, 24291; Igurin Islet, 24314; Japtan Islet, 24336; Aomon Islet, 34361; Engebe Islet, 24397. Kwajalein Atoll: Kwajalein Islet, 26471; Bennett (Bikej) Islet, 26516. Likiep Atoll: Likiep Islet, 26999.

Indigenous. Common in scrub and as undergrowth in coconut plantations, usually forms a fringe along top of beach. Marshallese: "kānnat," "mar" (Ujelang), "mar kinat" (Eniwetok), "konnat."

Hippobroma longiflora (L.) G.Don

Likiep Atoll: Likiep Islet, 27042.

Introduced weed. Rare around taro pits on Likiep, now probably gone, as natives were advised in 1946 to destroy it; not seen in 1951.

Adenostemma lavenia (L.) O.Ktze.

Lae Atoll: Lae Islet, 34025.

Introduced (?) weed. In coconut and breadfruit groves, but only seen on Lae. Marshallese: "bulibulgas."

Conyza bonariensis (L.) Cronq.

Wake Atoll: Wake Islet, 34463. Kwajalein Atoll: Kwajalein Islet, 31168, 31171.

Introduced weed. Common around air strips.

Conyza canadensis (L.) Cronq.

Kwajalein Atoll: Kwajalein Islet, 31169.

Introduced weed. Around airstrip.

Eclipta alba (L.) Hassk.

Kwajalein Atoll: Kwajalein Islet, 31163.

Introduced weed. Occasional around airstrip.

Emilia javanica (Burm.f.) Rob.

Kwajalein Atoll: Kwajalein Islet, 31186.

Introduced weed. Common around military installations.

Pluchea indica (L.) Less.

Kwajalein Atoll: Kwajalein Islet, 26523; Ebeye Islet, 31210.

Introduced weed. Abundant around military installations.

Pluchea odorata (L.) Cass.

Wake Atoll: Wake Islet, 34447. Kwajalein Atoll: Kwajalein Islet, 31170; Ebeye Islet, 31208. Eniwetok Atoll: Engebe Islet, 24405.

Introduced weed. Abundant around military installations.

<u>Sonchus</u> <u>oleracea</u> L.
Wake Atoll: Wake Islet, 34464, 34483.
Introduced weed. In disturbed area.

<u>Synedrella</u> <u>nodiflora</u> (L.) Gaertn.
Kwajalein Atoll: Kwajalein Islet, 34120.
Introduced weed. Around military installations.

<u>Tridax</u> <u>procumbens</u> L.
Kwajalein Atoll: Kwajalein Islet, 31165.
Introduced weed. Around airstrip.

<u>Vernonia</u> <u>cinerea</u> (L.) Less.
Kwajalein Atoll: Ebeye Islet, 31209. Eniwetok Atoll: Eniwetok Islet, 24368; Engebe Islet, 24382. Likiep Atoll: Likiep Islet, 26990.
Introduced weed. Common around military installations; in Likiep village.

<u>Wedelia</u> <u>biflora</u> (L.) DC.
Likiep Atoll: Lado Islet, 33819; Likiep Islet, 27003. Ailuk Atoll: Marib Islet, 33983. Lae Atoll: Lae Islet, 34061. Ujae Atoll: Ujae Islet, 34301. Eniwetok Atoll: Engebe Islet, 24391. Kwajalein Atoll: Kwajalein Islet, 26476; Bennett (Bikej) Islet, 26508.
Indigenous. Common as ground cover and undergrowth in plantations, climbing in trees in mixed forest, and forming dense thick blanket over abandoned military installations. Marshallese: "margueue," "marajej."

ATOLL RESEARCH BULLETIN

No. 40

Bryophytes collected by F. R. Fosberg in the Marshall Islands

by

Harvey Alfred Miller

Issued by

THE PACIFIC SCIENCE BOARD

National Academy of Sciences--National Research Council

Washington, D. C.

May 15, 1955

Bryophytes collected by F. R. Fosberg in the Marshall Islands [1]

by

Harvey Alfred Miller [2]

1/ Preliminary results of the Expedition to the Northern Marshall Islands, 1951-1952, no.3.

2/ Department of Biological Sciences, Stanford University, California.

Bryophytes collected by F. R. Fosberg in the Marshall Islands

by

Harvey Alfred Miller

F. R. Fosberg collected bryophytes in the Marshall Islands from November, 1951 to April, 1952 on Utirik, Ailuk, Likiep, Wotho, Ujae, Lae and Ujelang atolls (see fig. 1.) as a part of "Project Atoll" of the U.S. Geological Survey. The collections cited herein and those previously reported survey the bryophyte flora of the Marshalls but further collections are desirable for specimens, especially Hepaticae, of plants now incompletely identified or as yet undiscovered. Mosses and liverworts should preferably be collected during the rainy season when many species (e.g., Riccardia spp.), dormant or present only as spores during the dry season, are actively growing and reproducing.

I thank F. R. Fosberg for allowing me to study his collections. A. L. Andrews has been of considerable aid in identifications and has given much time and encouragement. E. B. Bartram has also been of kind assistance. The Farlow Herbarium of Harvard University and the New York Botanical Garden provided research facilities during visits sponsored in part by a Sigma Xi-RESA Grant in Aid of Research. The Department of Biological Sciences of Stanford University generously provided equipment and laboratory space. To these and others who have aided me I express my deepest gratitude.

MOSSES (MUSCI)1/

Calymperes hyophyllaceum C. Müll. var. robustum Fleisch. Musci Fl. Buitenz. I:265. 1904.

Lae Atoll: Bwi Islet, Jan. 9, 1952, Fosberg 34078a.

Distribution: Sumatra, Java, Philippines, Marshalls (Arno (2)).

The distribution given is that of the typical form of the species of which var. robustum may be only a luxuriant form due to optimal growth conditions.

Calymperes tenerum C. Müll. Linnaea 37:174. 1871-73.

Utirik Atoll: Utirik Islet, Nov. 29, Fosberg 33660, 33652. Ailuk Atoll; Ailuk Islet, Dec. 27, Fosberg 33929; Akulwe Islet, Dec. 26, Fosberg 33915, 33916. Likiep Atoll: Likiep Islet, Dec. 12, Fosberg 33780; Lado

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1/ Specimens cited will be deposited in the U.S.National Herbarium and the herbaria of the B. P. Bishop Museum and of the author.

Islet, Dec. 14, Fosberg 33824. Wotho Atoll: Wotho Islet, Feb. 13, Fosberg 34253a, 34254. Ujae Atoll: Ujae Islet, Feb. 16, Fosberg 34373b, Feb. 20, Fosberg 34374b, Mar. 9, Fosberg 34402c; Ebeju Islet, Mar. 9, Fosberg 34403b, 34407b; Bock Islet, Feb. 17-20, Fosberg 34326. Lae Atoll: Lae Islet, Jan. 6-7, Fosberg 34001, 34002b, 34017b. Ujelang Atoll: Raej Islet, Feb. 5, Fosberg 34155b, 34156b, 34157, 34160b; Kiloken Islet, Feb. 5, Fosberg 34162.

Distribution: India, Malaysia, Philippines, Pacific Islands to Hawaii - Marshalls (Rongerik, Rongelap, Bikini, Eniwetok (5), Arno (2)).

This moss is very common and widespread in tropical Pacific Oceania. The known distribution in the Marshall Islands is shown on figure 1. Calymperes tenerum has been collected on every atoll in the Marshalls which has recently been explored bryologically although Stone (4) did not find it on Arno and the Horwitz collection from there was small (2).

Splachnobryum indicum C. Müll. Linnaea 37:174. 1871-73.

Wotho Atoll: Wotho Islet, Feb. 14, Fosberg 34257b.

Distribution: India, Java, Philippines (?), Marshalls (Arno (2)).

This collection, as the previous one from Arno (2), consists of scattered plants growing among other mosses—in this case Bryum nitens.

Bryum nitens Hook, in Wall. Cat. n. 7592 et Icon. pl. rar. t. 20, fig. 6. 1837.

Ailuk Atoll: Ailuk Islet, Dec. 28, Fosberg 33981. Likiep Atoll: Likiep Islet, Dec. 12, Fosberg 33779, 33781; Lado Islet, Dec. 14, Fosberg 33817, 33827. Wotho Atoll: Wotho Islet, Feb. 14, Fosberg 34257a. Ujae Atoll: Ujae Islet, Feb. 21, Fosberg 34376. Lae Atoll: Lae Islet, Jan. 10, Fosberg 34103.

Distribution: Nepal, Ceylon, Java, Bali, Fiji, Marshalls (Arno (2)).

Pelekium velatum Mitt. Journ. Linn. Soc. Bot. (1869) 176.

Ujelang Atoll: Ujelang Islet, Feb. 7, Fosberg 34209.

Distribution: Malay Peninsula, Siam, Malaysia, Pacific Islands to Samoa (1).

New to the Marshall Islands. Pelekium velatum is common in the Philippines and provides further evidence that the bryophyte flora of the Marshalls must have originated there. It has not, to my knowledge, been reported from the Carolines but I should not be surprised to learn that it does exist there.

Ectropothecium sandwichense (Hook. & Arn.) Mitt. in Seeman, Fl. Vit., p. 400. fig. 185. 1873.

Ujae Atoll: Bock Islet, Feb. 17-20, Fosberg 34340, 34364, 34365; Enelamoj Islet, Mar. 9, Fosberg 34413. Lae Atoll: Lae Islet, Jan. 7, Fosberg 34015, 34023; Loj Islet, Jan. 8, Fosberg 34049.

Distribution: Australia, New Zealand, Pacific Islands to Hawaii.

This moss has been previously reported from Arno by Stone (4) and by Miller and Doty (2). The latter reported it as E. monumentorum, a closely related species with similar distribution.

LIVERWORTS (HEPATICAE)

Lopholejeunea subfusca (Nees) Steph. Spec. Hep. V:86. 1912.

Ujae Atoll: Ujae Islet, Feb. 16, Fosberg 34375a.

Distribution: Indomalaya and Oceania.

Lopholejeunea subfusca was first reported from the Marshall Islands by Stephani (3) who described it as a new species, L. finschiana, apparently based on a collection from Jaluit Atoll. Stone (4) reported this hepatic from Arno.

Archilejeunea mariana (Gott.) Steph. Spec. Hep. IV:729. 1911.

Ujae Atoll: Ujae Islet, Feb. 16, Fosberg 34375c, 34373a--Feb. 20, Fosberg 34374a--Mar. 9, Fosberg 34402a; Bock Islet, Feb. 17-20, Fosberg 34324, 34367; Ebeju Islet, Mar. 9, Fosberg 34403a, 34404. Lae Atoll: Lae Islet, Jan. 7, Fosberg 34017a; Bwi Islet, Jan. 9, Fosberg 34078b. Ujelang Atoll: Raej Islet, Feb. 5, Fosberg 34155a, 34160a, 34156a.

Distribution: Indomalaya and Oceania.

New to the Marshall Islands. Archilejeunea mariana is a very widespread species in Oceania and fits well into the distribution patterns of bryophytes known from the Marshalls.

Hygrolejeunea vesicata (Mitt.) Steph. Sp. Hep. V:572. 1914.

Wotho Atoll: Wotho Islet, Feb. 13, Fosberg 34247, 34253b. Ujae Atoll: Bock Islet, Feb. 17-20, Fosberg 34325b. Lae Atoll: Lae Islet, Jan. 6 Fosberg 34002a.

Distribution: Samoa.

Stone (4) reported this plant from Arno as "Lejeunea sp., (Subgenus Cheilolejeunea)." I have compared Stone's material with the type of Lejeunea vesicata Mitten and find the material inseparable except for a minor size variation. The plant probably does belong in Cheilolejeunea but further study seems desirable at this point.

Lejeunea spp.

Ujae Atoll: Ujae Islet, Feb. 16, Fosberg 34375b--Mar. 9, Fosberg

34402b; Bock Islet, Feb. 17-20, Fosberg 34325a; Ebeju Islet, Mar. 9, Fosberg 34407a, 34408.

Distribution: Worldwide.

All of the collections cited above belong in the Schizostipae, an extremely large and poorly understood group of hepatics. Three species are represented in the above collections but they are almost uniformly sterile and it seems impossible, for the present at least, to even place them in the correct segregate genera of Lejeunea.

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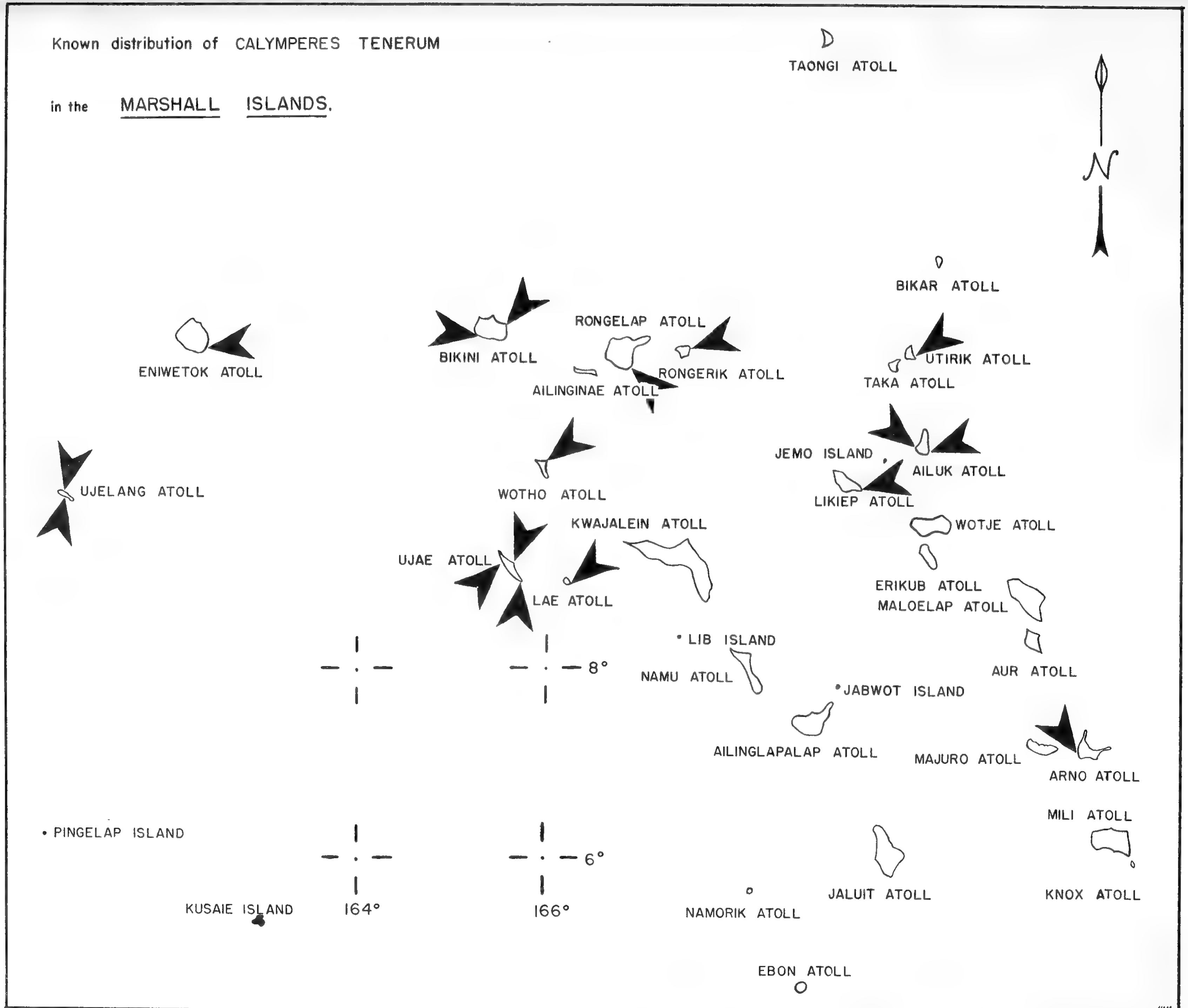
Known distribution of CALYMPERES TENERUM
in the MARSHALL ISLANDS.
N
TAONGI ATOLL
BIKAR ATOLL
ENIWETOK ATOLL
BIKINI ATOLL
RONGELAP ATOLL
RONGERIK ATOLL
AILINGINAE ATOLL
UTIRIK ATOLL
TAKA ATOLL
JEMO ISLAND
AILUK ATOLL
LIKIEP ATOLL
UJELANG ATOLL
WOTHO ATOLL
KWAJALEIN ATOLL
WOTJE ATOLL
UJAE ATOLL
LAE ATOLL
ERIKUB ATOLL
MALOELAP ATOLL
LIB ISLAND
8°
NAMU ATOLL
AUR ATOLL
JABWOT ISLAND
AILINGLAPALAP ATOLL
MAJURO ATOLL
ARNO ATOLL
MILI ATOLL
PINGELAP ISLAND
6°
KUSAIE ISLAND
164°
166°
JALUIT ATOLL
KNOX ATOLL
NAMORIK ATOLL
EBON ATOLL
HAM.

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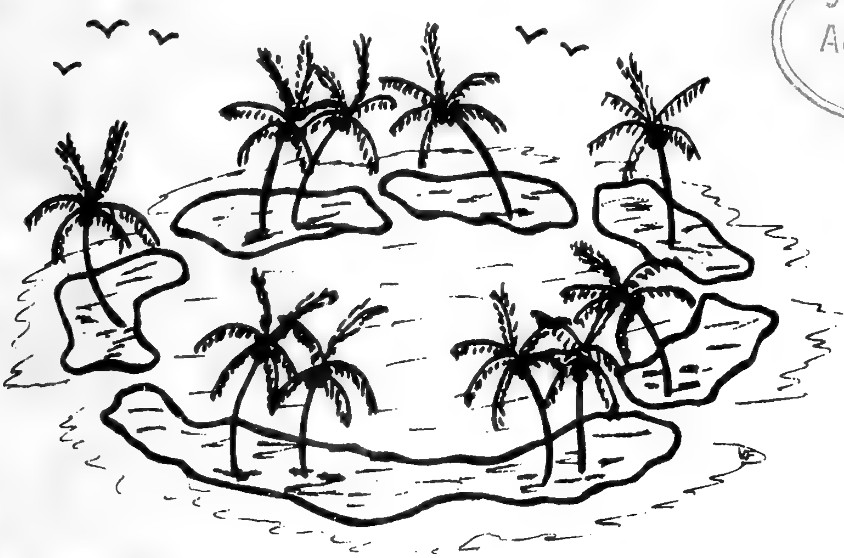

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ACKNOWLEDGMENT

It is a pleasure to commend the far-sighted policy of the Office of Naval Research, with its emphasis on basic research, as a result of which a grant has made possible the continuation of the Coral Atoll Program of the Pacific Science Board.

It is of interest to note, historically, that much of the fundamental information on atolls of the Pacific was gathered by the U. S. Navy's South Pacific Exploring Expedition, over one hundred years ago, under the command of Captain Charles Wilkes. The continuing nature of such scientific interest by the Navy is shown by the support for the Pacific Science Board's research programs, CIMA, SIM, and ICCP, during the past seven years. The Coral Atoll Program is a part of SIM.

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ATOLL RESEARCH BULLETIN

No. 41

Canton Island, South Pacific

by

Otto Degener and Edwin Gillaspy

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CANTON ISLAND, SOUTH PACIFIC

By

Otto Degener [1] and Edwin Gillaspy [2]

Mr. Garrison Costar, Engineer with the Civil Aeronautics Administration, in June 1950 commissioned Mr. Otto Degener, Collaborator in Hawaiian Botany of the New York Botanical Garden, to cover Canton Island with vegetation. Degener consulted with Col. Edwin H. Bryan, Jr., for firsthand information regarding the atoll. Bryan had visited Canton as early as 1924 for study and, when the "Southern Cross" was about to fly south in 1928, advised Sir Charles Kingsford-Smith to select this atoll as the best emergency landing place between Hawaii and Fiji. Degener flew from Honolulu to Canton for a week's stay in July 1950 - a distance of 1,630 nautical miles - with Mr. Costar and Mr. William H. Hatheway, a graduate assistant in botany at the University of Hawaii, whom he had selected as the man best qualified to assist him.

Degener returned to Canton for six weeks in April and May of 1951 to continue his biological studies and to prepare the present paper jointly with Mr. Edwin Gillaspy, then Island Manager, who is most familiar with the administrative and non-biological aspects of the island. The following pages contain a conglomeration of personal observations and a compilation of observations already in print by others or recently expressed to the two writers by various observant friends.

PURPOSE

Now that Canton Island is the site of an important airfield, there are two reasons for wishing to cover its bare wastes of coral rock and sand with plants. First, a cover of vegetation will stabilize the land. It will keep the sand from blowing about and away, and from penetrating costly wireless transmitters and other instruments to foul them. Second, it will be a boon to the 300-odd people stationed there. They will no longer be obliged to inhale clouds of dust nor be exposed to glare so intense as to cause in some cases symptoms of snow blindness. It will make living there much more pleasant and worthwhile.

1/ New York Botanical Garden

2/ Civil Aeronautics Administration

TOPOGRAPHY

Canton is the most northern of eight low coral islands known as the Phoenix Islands and lying between latitude 2° 30' and 4° 40' S., and longitude 170° 40' and 174° 40' W. It is a typical atoll with presumably a volcanic core. Its fringing reef rises so abruptly from the deep in most places that effective anchorage facilities are practically lacking for a vessel too large to enter the lagoon.

In 1943 one natural channel through the rim of the island was deepened by dredging, and a new one cut so that sea-going vessels not exceeding 420 feet in length can now tie up at a wharf 385 feet long in the lagoon. The current, however, through the channels between lagoon and open ocean can be very strong and treacherous, running at six to eight knots at flood and ebb tides. Ebb currents likewise produce a marked rip when mixing with the ocean currents up to a mile or more off the channel entrance. The hazard to which ships are exposed at Canton is apparent. In 1942, the SS "President Taylor", formerly the "President Polk", under contract from the President Lines to the United States Army as a troop ship, was caught in the channel current while trying to disembark troops as close to shore as possible because of enemy submarine danger. As a result she piled up on the reef at the entrance of the channel with her bow 270 yards from Musick Light. Salvage operations were abandoned when attempts to refloat her proved unsuccessful. The Army and Navy personnel, numbering up to 10,000 on Canton, soon stripped her of all usable gear, and to this day odd pieces of ship furniture and ventilators may be seen still in use on the island. A Japanese submarine once in late 1942 ineffectually shelled the useless hulk. The "President Taylor" became a favorite haunt for an afternoon of fishing or to while away a few hours from duty by island residents until it was gutted by fire in May 1948, rumored to have started from the explosion of an illicit whiskey still in her hold. She burned four days. The rusted and fire-blackened wreck then served as the most prominent landmark of the island, her funnel and masts being visible for eighteen miles at sea. In 1954, according to Mr. William J. Evans, the present U. S. Resident Administrator, the vessel is being cut up for scrap and hauled away.

Canton has been likened in shape to a pork chop. Its rim, now served with an auto road, is 150 to 1,800 feet wide. This encloses a lagoon of twenty-five square miles, which is about eight miles long and four miles wide at the west end. Until dredged out to a depth of about ten fathoms near the dock and the 1,600 by 1,800 foot ship turning basin, the lagoon was badly choked up with live coral near the entrances where the fresh ocean water enables the organisms to grow. The natural depth of the lagoon is seldom more than two and a half fathoms, and extensive whitish mudflats, inhabited by colorful fiddler crabs, adjoin the shore. The lagoon, warmer than the surrounding ocean, is stocked with fish of many kinds, as well as with sting rays and sharks which last make swimmers keep a sharp lookout.

The island rim varies in height from twenty to ten feet or less. At certain areas along the outer or seaward coasts, where the waves hit the shore with great violence during storms, large flat polished boulders of broken reef, of breccia consisting of reef fragments, of hardpan consisting of consolidated sand, and tridacna clam shells are piled up to considerable heights. The inner shore slopes gently to the lagoon, ending in a white sandy beach or in low ledges of overhanging rock. The island has no supply of fresh water except the little that may be trapped during showers in upturned tridacna shells - natural Holy Water fonts. Such water, due to the humid atmosphere, evaporates but slowly during the day.

The average annual rainfall of about 19 inches is sparse for a tropical latitude and there is a scarcity of fresh water. To augment the supply that is caught in the form of rain from roofs of buildings and led into individual cisterns, both the Civil Aeronautics Administration (CAA) and the Pan American World Airways (PAA) have elaborate installations for the distillation of fresh water from the sea. This is a costly process making, of course, the watering of garden plants impracticable. An indication of the costliness of this process is shown by the fact that one good shower in April 1951 saved PAA about $3,000 in distillation costs.

The surface soil of Canton contains not a particle of autochthonous or native lava, notwithstanding the island's presumed igneous foundation. But here and there, particularly along the windward shores, are fragments of pumice. These are mostly tawny in color and less than six inches in diameter, though a few may be as large as a man's head. Several rounded pieces about a foot in diameter, for example, were discovered by Dr. S. G. Ross in April 1951. Such stones have been cast ashore after having floated here from some actively volcanic region perhaps thousands of miles distant. Another unexpected though extremely rare source of foreign soil is rocks embedded in the firm grasp of the roots of trees that have washed ashore. One large tree observed had transported six rocks, about a foot in diameter, to the island. Two of these rocks crumbled into fragments upon being hit with a club.

The surface of the land varies. The finest calcareous "clay" or silt occurs chiefly along the lagoon. Light, readily blown, pink sand consisting of Foraminifera shells of the genus Baculogypsina, and less abundantly of Spaerulata lessoni and a species of Heterostegina, is common along the beach and far to the lee of it. It sifts in among coral fragments, shells and rubble. But where these are exposed to the full force of the wind, this pink sand hardly covers them, being blown away to find a wind-free resting place elsewhere. Canton, by the way, is the farthest north from which the almost microscopic organism, Baculogypsina, is yet known. The coral fragments are of all sizes up to about five inches in diameter. Elsewhere, especially along the beach, occur wave worn, solid platforms of consolidated reef fragments and sand half a mile and more long. The soil consists mostly of calcium carbonate derived from marine animals and plants comminuted in the main by wave action. In addition, there are extensive thin areas of porous hardened guano, the legacy left by myriads of sea birds of past ages. Such deposits were formerly exploited by man for fertilizer. The ruins of a stone wharf, perhaps built about 1870 and jutting out into the lagoon, and rusted iron rails overgrown with kou tree trunks remain today as a souvenir of this industry on the north central side of the island. Here and there are smaller but distinct areas of decayed vegetation forming an acid, moisture holding humus. Around large boulders, logs or other objects casting shade, is a very curious friable and rare soil consisting of the accumulated excrement of the terrestrial hermit crab (Coenobita perlatus) that may congregate by the hundreds in such situations during the heat of the day. Thus Canton soil varies from basic all the way to very acid, depending to what extent these types of soil are intermixed. Areas of acid soil, however, are very sparse indeed. In addition, these types of soil and their mixtures bear a trace to very high concentrations of salts derived from ocean spray, from flooding, and from capillary rise from the water table. These soils are rarely if ever leached out by an adequate supply of rainfall.

In many regions of the atoll the loose sand grains are cemented together to form at various depths a sidewalk-like hardpan. This cannot be penetrated by deep taproots, thus giving advantage to plants with shallow spreading roots or to quick-growing annuals that complete their entire life span after a few strong showers have drenched the upper inches of ground.

Canton, situated at latitude 2° 46' S., is sun baked. This, and the fact that many areas have been cleared of the little native vegetation they ever possessed by the bulldozers of the military during the war, makes the glare from the alabaster-white ground still more intense. The resulting heat, coupled with the warm water of the lagoon, causes a current of warm air to rise.* When large rain clouds approach such an island during the day, they sometimes split, drift around the island, and then coalesce again as they have passed; or if

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* See Appendix A, p. 51.

these clouds are small, they tend to skirt the edge of the island, shedding most of their rain in the ocean. On the other hand at night, when the island heat no longer rises appreciably, the clouds no longer bypass the island and thus most of the rain falling on it consists of light night showers. Covering the island with more vegetation will slightly increase the fall of rain during the day which, in turn, will promote a slightly better growth of vegetation, a very desirable condition. If it were not for the warm water of the lagoon, almost landlocked, such an increase might be as much as six to ten inches annually. In time it may be found practicable to construct channels through various narrow parts of the rim into the lagoon to cool its waters, to reduce the salinity so as to increase plant and indirectly fish life, and to reduce the hazardous current that ships must now buck to tie up at the wharf.

Due to man's changes in the surface of Canton, it will be interesting to compare the future climate with that of the past. The following tables are reproduced from "Local Climatological Data", U. S. Weather Bureau, 1954.

Some weather statistics for early years, not shown below, have been consulted also. These, however, appear to be garbled in several instances. It is thought by some that for two years the figures for barometric pressure may have been added in error to rainfall, giving unusually high and spurious records of 80 and 100 inches. Be that as it may, the average rainfall based on carefully kept records is but 19 inches, with a recorded low of 8.71 inches in 1938 and a high of 35.97 in 1953. Most of the precipitation falls in showers during the period from March to August, with April and May often the wettest months. When the rainfall is scant during these two months, then the island vegetation becomes truly dry and sere.

Lightning and thunder are rare; hurricanes are unknown. Barometric pressure, following an almost regular semidiurnal tide-like movement, is worthless as an indication of weather changes. Average visibility is from 12 to 30 miles. Low clouds are few, and fog or mist is unknown. A haze, known to Hawaiians as ehukai and caused by salt particles cast into the atmosphere by waves breaking on the reef, may at times prove troublesome to land aircraft.

The air temperature is practically constant throughout the year, reaching about 88° F., in the afternoon and dropping to 78° F. at night. The following shows the temperature, taken over a period of eight years.

The prevailing winds blow from E.N.E. to E.S.E. West win are very rare. The breeze is usually a steady one of 12 to 14 miles per hour. This refreshing breeze makes this equatorial atoll livable for man. It makes it more difficult for plants, however, to retain in their tissues the scant amount of water they have absorbed from the soil.

Because of local weather conditions, such as strength and direction of wind, it is difficult to predict the tide and current accurately for navigation. The mean high water interval is exactly 5 hours. The mean range is 3.3 feet, and the spring range is 4.0 feet. As there are but two breaks through the surrounding rim of land into the lagoon, the movement of water within the lagoon lags behind the ocean tides. When driving along the narrow southwest rim of the atoll with both expanses of water in full view at close range, the difference in water level between lagoon and ocean is at times so great as to look strangely unnatural. Because of the great shallow expanse of almost landlocked seawater exposed to the tropic sun, the lagoon water is far saltier than that of the open ocean.

The influence of the tide is noticeable throughout the entire rim of the island, no matter where test holes are bored to the water table. From tests made in early 1950 by Dr. L. H. MacDaniels, we find that the salt content varies tremendously on or in the rim. That of water from the open ocean has (as chloride) 20,300 mg. of chlorine per liter. Water from a drying pool at the extreme southeast end of the island was actually supersaturated and had a content of 90,000 mg. That of the Frigate Pool, where the birds with open beaks and lowered heads swoop down to dip up a drink of water in their lower bills measures but 4,200 mg. The new British well, three hundred feet northwest of the old one and three hundred feet from the lagoon, had only 2,000 mg., at a depth of three feet.

HISTORY

As prehistoric ruins prove, Sydney and Hull Islands, south of Canton, were evidently inhabited for some time by Pacific islanders before the coming of the white man. There is, however, no good evidence to show that such islanders ever lived on Canton for any length of time, though according to Carl E. Meinicke* quadrangular ruins of large coral blocks occur there which he considers as certainly ancient temples. Such people, with the aid of a large shell, could have dug down to potable, though salty, water. Whether they did so no one presently knows.

The whaler "Phoenix" discovered Winslow Reef, northwest of Canton, in 1851, and the name of this vessel became attached to the entire group of islands. As guano had become a commodity of great value, the American Guano Company, the United States

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*Meinicke, C. E. Die Inseln des Stillen Ozeans. 2 : 265 - 268. 1888.

LATITUDE 2° 46' S
LONGITUDE 171° 43' W
ELEVATION (ground) 9 feet

METEOROLOGICAL DATA FOR THE CURRENT YEAR

CANTON IS., SOUTH PACIFIC
TOPHAM FIELD
1954

Month	Temperature: Averages: Daily maximum	Daily minimum	Monthly	Extremes: Highest	Date	Lowest	Date	Degree days	Precipitation: Total	Greatest in 24 hrs.	Date	Snow, Sleet, Hail: Total	Greatest in 24 hrs.	Date
JAN.	90.2	77.3	83.8	92	25#	74	19	0	0.43	0.22	23-24	0.0	0.0	
FEB.	88.4	77.0	82.7	92	27#	73	10	0	0.20	0.18	9-10	0.0	0.0	
MAR.	89.5	77.9	83.7	95	13	76	23	0	0.09	0.05	31	0.0	0.0	
APR.	89.1	77.6	83.4	93	15	75	27#	0	1.09	0.50	27	0.0	0.0	
MAY	90.3	78.7	84.5	93	19#	75	2	0	0.35	0.21	2	0.0	0.0	
JUN.	89.5	77.7	83.6	94	14	71	5	0	0.82	0.46	5	0.0	0.0	
JUL.	88.3	77.8	83.1	92	11	74	26#	0	2.27	1.44	22-23	0.0	0.0	
AUG.	88.7	77.1	82.9	94	6	73	21	0	1.98	0.63	3-4	0.0	0.0	
SEP.	89.8	77.8	83.8	92	25#	76	28#	0	0.13	0.07	4	0.0	0.0	
OCT.	90.4	78.1	84.3	97	29#	77	26#	0	0.24	0.15	31	0.0	0.0	
NOV.	88.2	78.0	83.1	94	21	77	27#	0	0.03	0.03	21	0.0	0.0	
DEC.	87.6	78.1	82.9	91	14#	75	3	0	0.16	0.15	3	0.0	0.0	
Year	89.2	77.8	83.5	95	MAR. 13	71	JUN. 5	0	7.79	1.44	JUL. 22-23	0.0	0.0	

Month	Relative humidity: 1:00 a. BST	7:00 a. BST	1:00 p. BST	7:00 p. BST	Wind: Average hourly speed	Prevailing direction	Fastest mile ø: Speed	Direction	Date	Percent of possible sunshine	Average sky cover sunrise to sunset	Number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Sleet, Hail 1.0 inch or more	Thunderstorms	Heavy fog	Temperatures: Maximum: 90° and above	32° and below	Minimum: 32° and below	Zero and below
JAN.	82	80	65	77			32	ESE	27		5.9	5	15	11	7	0	0	0	21	0	0	0
FEB.	80	82	66	76			23	ENE	17		6.1	6	11	11	4	0	0	0	10	0	0	0
MAR.	81	80	65	76			27	ENE	19		5.1	10	15	6	4	0	0	0	15	0	0	0
APR.	84	84	66	79			22	ENE	11		5.7	7	14	9	5	0	0	0	12	0	0	0
MAY	82	86	70	80			19	NE	11		5.4	7	17	7	4	0	0	0	22	0	0	0
JUN.	79	79	64	75			28	ESE	28		3.9	16	13	1	3	0	0	0	11	0	0	0
JUL.	81	81	66	77			28	ESE	22		5.7	7	15	9	8	0	0	0	9	0	0	0
AUG.	80	80	64	76			22	ESE	13		4.7	11	15	5	11	0	0	0	8	0	0	0
SEP.	80	79	61	75			23	ESE	9		3.4	22	6	2	5	0	0	0	17	0	0	0
OCT.	75	74	58	71			21	E	27		4.9	13	12	6	3	0	0	0	20	0	0	0
NOV.	77	75	62	73			23	ENE	4		5.1	8	15	7	1	0	0	0	9	0	0	0
DEC.	76	75	61	73			23	ENE	27		5.4	5	20	6	2	0	0	0	8	0	0	0
Year	80	80	64	76			32	ESE	JAN. 27		5.1	117	168	80	57	0	0	0	162	0	0	0

ø Fastest observed one minute wind speed and its direction. This station is not equipped with automatic recording wind instruments

NORMALS, MEANS, AND EXTREMES

Month	Temperature: Normal: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Normal degree days	Precipitation: Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, Sleet, Hail: Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)	(b)	(b)	(b)	8		8			(b)	13		13		8		8	8		8	
J	88.0	78.0	83.0	98	1947	74	1954#		1.08	4.94	1940	T	1950#	1.99	1951	0.0	0.0		0.0	
F	88.0	78.0	83.0	96	1952#	73	1954#		0.54	2.10	1949	0.04	1945	1.69	1949	0.0	0.0		0.0	
M	88.5	77.6	83.1	96	1949	71	1953		1.92	9.34	1940	0.07	1951	1.86	1953	0.0	0.0		0.0	
A	89.3	78.0	83.7	97	1951#	70	1953		3.78	11.50	1940	0.90	1945	4.15	1953	0.0	0.0		0.0	
M	90.0	78.3	84.2	98	1953	71	1953#		2.86	8.33	1953	0.35	1954	2.09	1953	0.0	0.0		0.0	
J	90.0	78.5	84.3	96	1953#	71	1954		2.80	5.26	1945	0.65	1947	1.78	1948	0.0	0.0		0.0	
J	90.0	78.4	84.2	96	1953#	71	1952		2.33	5.73	1945	0.60	1947	2.12	1950	0.0	0.0		0.0	
A	90.0	78.3	84.2	97	1951	71	1953#		2.40	6.78	1943	0.18	1949	2.00	1950	0.0	0.0		0.0	
S	90.3	78.4	87.4	97	1952#	72	1953		0.69	1.69	1947	0.05	1950	1.51	1948	0.0	0.0		0.0	
O	90.2	78.0	84.1	97	1951	73	1947		0.39	1.41	1953	0.03	1942	0.70	1953	0.0	0.0		0.0	
N	89.3	78.0	83.7	98	1947	74	1947		0.27	0.97	1953#	T	1945	0.53	1952	0.0	0.0		0.0	
D	88.0	78.0	83.0	95	1953#	71	1948		0.95	4.81	1939	0.06	1947#	1.81	1951	0.0	0.0		0.0	
Year	89.3	78.1	83.7	98	MAY 1953#	70	APR. 1953		20.01	11.50	APR. 1940	T	JAN. 1950#	4.15	APR. 1953	0.0	0.0		0.0	

Month	Relative humidity: 1:00 a. BST	7:00 a. BST	1:00 p. BST	7:00 p. BST	Wind: Mean hourly speed	Prevailing direction	Fastest mile: Speed	Direction	Year	Pct. of possible sunshine	Mean sky cover sunrise to sunset	Mean number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Sleet, Hail 1.0 inch or more	Thunderstorms	Heavy fog	Temperatures: Max.: 90° and above	32° and below	Min.: 32° and below	0° and below
(a)	8	8	8	8							8	8	8	8	8	8	8	8	8	8	8	8
J	80	79	65	75							5.8	4	18	9	6	0	0	0	16	0	0	0
F	80	80	64	76							5.6	5	17	6	5	0	0	0	12	0	0	0
M	83	83	66	79							5.7	6	17	8	9	0	*	0	14	0	0	0
A	85	85	68	81							5.8	7	19	7	14	0	1	0	18	0	0	0
M	83	83	67	79							5.9	7	15	9	12	0	2	0	21	0	0	0
J	81	80	66	77							5.7	6	16	8	11	0	1	0	19	0	0	0
J	80	79	64	77							5.8	5	19	7	11	0	1	0	20	0	0	0
A	80	80	64	76							5.4	6	17	8	11	0	*	0	18	0	0	0
S	78	77	60	74							4.6	11	15	4	6	0	0	0	11	0	0	0
O	78	75	60	74							5.1	10	15	6	5	0	0	0	22	0	0	0
N	77	75	60	73							5.4	7	18	5	4	0	0	0	18	0	0	0
D	77	76	64	75							6.2	5	16	10	4	0	0	0	12	0	0	0
Year	80	79	64	76							5.6	76	202	87	98	0	5	0	201	0	0	0

(a) Length of record, years. (b) Normal values are based on the period 1921-1950, and are means adjusted to represent observations taken at the present standard location. Partial years' data, 1940 and 1942 considered in extracting maximum and minimum monthly precipitation values.

Pages 7 and 8 reproduced from "Local climatological data with comparative data 1954 Canton Island, South Pacific" issued by U. S. Weather Bureau, 1955

AVERAGE TEMPERATURE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l.
1947	84.9	84.8	85.3	85.2	84.8	85.0	84.4	84.2	84.2	83.6	84.0	83.8	84.5
1948	83.4	83.2	83.6	83.8	85.3	85.8	85.2	84.6	84.8	84.7	84.3	83.8	84.4
1949	85.2	84.9	83.9	83.9	84.4	84.8	84.9	84.4	84.6	83.6	83.5	83.2	84.3
1950	81.4	82.4	81.9	82.6	83.1	82.3	82.3	82.3	82.4	84.1	83.1	82.5	82.5
1951	82.8	83.3	83.4	84.7	85.2	84.2	85.2	84.6	85.8	85.1	85.9	83.6	84.5
1952	84.7	84.8	84.6	84.6	85.1	85.0	84.5	84.2	84.6	84.6	84.6	83.7	84.6
1953	84.6	84.1	83.5	84.1	83.7	84.4	83.7	83.7	84.7	84.9	84.8	83.6	84.1
1954	83.8	82.7	83.7	83.4	84.5	83.6	83.1	82.9	83.8	84.3	83.1	82.9	83.5
RECORD MEAN TEMP	83.9	83.8	83.7	84.0	84.5	84.4	84.1	83.9	84.4	84.4	84.2	83.4	84.1
MAX	89.3	89.1	89.1	89.9	90.7	90.4	90.3	90.0	90.6	90.6	90.0	88.6	89.9
MIN	78.4	78.4	78.3	78.1	78.3	78.3	77.9	77.8	78.1	78.1	78.3	78.2	78.2

TOTAL PRECIPITATION

CANTON IS., SOUTH PACIFIC
TOPHAM FIELD
1954

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1937									.85	.41	.41	.03	-
1938	.23	.18	.82	1.93	.57	2.38	.85	.55	.66	.27	.21	.06	8.71
1939	.15	.05	.10	1.58	3.75	1.55	3.01	1.79	.25	1.23	.30	4.81	18.57
1940	4.94	.75	9.34	11.50	2.92	4.80	3.03	3.04	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	.15	.03	.37	.20	-
1943	.12	.17	.11	1.17	1.92	2.56	1.23	6.78	.30	.28	.60	.29	15.53
1944	2.96	.52	2.12	3.02	5.37	1.83	1.17	1.05	1.24	.08	.40	.74	20.50
1945	T	.04	1.21	.90	2.60	5.26	5.73	.54	.53	.61	T	.23	17.65
1946	-	-	-	-	-	-	-	-	-	-	-	-	-
1947	.17	.26	.08	1.59	.65	.65	.60	1.40	1.69	.89	.42	.06	8.46
1948	.86	1.24	5.99	10.32	4.44	3.19	1.20	3.18	1.64	.17	.06	.88	33.17
1949	T	2.10	1.16	2.16	3.45	1.00	.98	.18	.19	.09	.02	.17	11.50
1950	T	.29	.08	1.83	.44	2.36	5.50	4.04	.05	.16	.24	.10	15.09
1951	2.40	.32	.07	5.55	5.36	5.19	2.35	3.81	.77	.44	.22	3.88	30.36
1952	.19	.05	.97	2.67	5.21	2.10	3.23	3.48	.80	.79	.97	.27	20.73
1953	.77	.61	3.41	6.46	8.33	4.14	3.55	4.77	.65	1.41	.97	.90	35.97
1954	.43	.20	.09	1.09	.35	.82	2.27	1.98	.13	.24	.03	.16	7.79
RECORD MEAN	.64	.46	1.25	3.10	3.26	2.54	2.44	2.58	.68	.51	.34	.97	18.77

Records Sept. 1937 - April 1940 incl., Gilbert and Ellice Island Colony Administration (U.K.), 2° 49' S., 171° 43' W.; May-August 1940, US. Dept. of Interior, 2° 49' S., 171° 43' W.; Sept. 1942 - December 1945, U.S. Army Air Force at or within 2000 Ft of 2° 46' S., 171° 43' W. prior to August 1943 and at that location thereafter; Jan. 1947 - Present , U.S. Weather Bureau Office, 2° 46' S., 171° 43' W.

STATION LOCATION

Location	Occupied from	Occupied to	Airline distance and direction from previous location	South Latitude	West Longitude	Elevation above: Sea level: Ground	Sea level: Actual barometer elevation (H_s)	Ground: Wind instruments	Extreme thermometers	Psychrometer	Telepsychrometer	Tipping bucket rain gage	Weighing rain gage	8" rain gage	Solar recorder		Remarks
BRITISH HEADQUARTERS RADIO	SEP 1937	PRESENT		2° 49'	171° 43'	-											Good exposure.
PRESENT HOTEL AREA, DEPT INTERIOR	SEP 1937	OCT 1940	-	2° 49'	171° 43'	-											Details not known.
HOTEL AREA IN BLDG, AT APPROACH TO FIRST SEA-PLANE DOCK (PAA)	SEP 1939	NOV 1941	-	2° 49'	171° 43'	-											
NAVY ADMINISTRATION BLDG (PAA EMPLOYEES IN NAVAL RESERVE)	NOV 1941	APR 1945	-	2° 49'	171° 43'	-											Move may have been a bit later than this.
TOPHAM FIELD, TERMINAL BLDG	MAY 1942	OCT 1946	-	2° 46'	171° 43'	9											AF station moved into terminal bldg. in July 1943. Prior location not known. Many details not known as part of this time Canton was a combat area.
" " "	OCT 1946	1/24/47	-	" "	" "	9	11										Between time AF abandoned station and the Weather Bureau took over with its own personnel, the WB contracted with PAA to man the station. On 12/28/46 the first WB employee arrived and on 1/24/47 the last PAA employee was relieved.
" " "	1/1/47	PRESENT	-	" "	" "	"	"	30	19	19			3	3	25		Good exposure.

This small land mass, being at most 20 feet above sea level, presents the minimum topographical influence.

REFERENCE NOTES

Unless otherwise indicated, dimensional units used in this bulletin are: temperature in degrees F.; precipitation and snowfall in inches; wind movement in miles per hour; and relative humidity in percent.

Record mean values at the end of the Average Temperature and Total Precipitation tables are long-term means based on the period of record beginning in 1947 and 1938 respectively. Values have not been corrected for changes in instrument location listed in the Station Location table. Partial years' data, 1940 and 1942, not used in computing precipitation means.

Sky cover is expressed in a range of 0 for no clouds or obstructions to 10 for complete sky cover. The number of clear days is based on average cloudiness 0-3 tenths; partly cloudy days on 4-7 tenths and cloudy days on 8-10 tenths. Degree days are based on a daily average of 65° F. Sleet and hail were included in snowfall totals, beginning with July 1948.

Data for earlier years may be obtained by contacting the Weather Bureau Office for which this publication was issued.

Heavy fog in the Means and Extremes Table also includes data referred to at various times in the past as "Dense" or "Thick". The upper visibility limit for heavy fog is 1/4 mile.

- * Less than one half.
- \- No record.
- \# Also on earlier dates, months, or years.
- T Trace, an amount too small to measure.

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NWRC, Asheville, N.C. --- 2/15/55 --- 350

Guano Company, and the Phoenix Guano Company were formed. Then in the Honolulu missionary publication "The Friend" of April 20, 1859, and elsewhere, the claim of ownership by these companies of about fifty guano islands was recognized by the United States Government. It stated that these islands which "have become the property of citizens of the United States. . . have been recognized by the Government as pertaining to its territories under the act of Congress approved August 18, 1856." One of these islands now newly under the American flag was Mary's Island. Its longitude and latitude were given, and these practically coincide with those of Canton. When Mary's Island was actually first discovered by the white man is not known, but it must have been previous to 1828 because that year it was listed in the Reynold's Report on page 12 as Mary Balcout's Island.

On March 4, 1854, the New Bedford whaleship "Canton", Capt. Andrew J. Wing, piled up on the reef of Mary Balcout's Island or, briefly, Mary's Island. After a short sojourn on the waterless island, the captain and crew took to their open boats and reached Guam after forty-nine days at sea. Commander R. W. Meade of the U.S.S. "Narragansett" surveyed Mary's Island in 1872, and at that time renamed the island "Canton" to commemorate the shipwreck eighteen years before. The name, though inappropriate, stuck. Unlike that of the city of southern China, however, the name Canton is now pronounced with the first syllable accented.

As the supply of guano became depleted in the Phoenix Islands, the American companies abandoned them. John T. Arundel and Company, a London concern, then stepped in and took over the islands between 1883 and 1890, the British flag being hoisted and a protectorate declared. In 1916 Canton and the neighboring islands were leased for eighty-seven years to Capt. Allen of the Samoan Shipping and Trading Company. He planted some coconut trees, with the purpose of starting a copra industry. The last tree, now an erect dead trunk thirty feet high, survived until 1950. Because this tree was visible to ships at sea, Canton was often known as the Lone Tree Island to sailors.

After Capt. Allen's death in 1925, the islands were again abandoned. But with aviation coming to the fore and the Phoenix Islands being possible airplane stepping stones between North America and Australia, the United States and Great Britain both became vitally interested in the Phoenix Group.

Though the British sloop "Leith" claimed Canton for the crown in 1936, when H.M.S. "Wellington" brought New Zealand scientists to this atoll on May 26, 1937 to study a solar eclipse, a U.S. Navy - National Geographic Society eclipse party aboard the Navy seaplane tender U.S.S. "Avocet" was already there. It had erected a concrete monument bearing embedded in it two American flags of porcelain enamel on stainless steel, claiming ownership of the atoll for the United States. One flag faces the rising sun; the other, the setting sun. On one side of the cement block, at right angles to the flags, is the small brass seal of the National Geographic Society. On Memorial Day the monument was unveiled with appropriate ceremonies. The "Avocet" had selected the best anchorage in the channel and refused to move when the British demanded it. The British then fired a shot across the bow of the American vessel and, according to some reports, the Americans retaliated in like manner. Both captains, realizing that their behavior in this affair smacked of a Gilbert & Sullivan operetta, then wired their respective governments in London and Washington what to do next. Both received quite similar instructions to do nothing rash. Scientists of both nations then studied the eclipse of June 8, personally cordial though officially a bit cool. Then before departing to leave Canton to her sea birds and crabs, they left the flags of their respective nations flying, their flagpoles embedded firmly in stone foundations. In July the U.S. minesweeper "Swan" sailed to Canton in a vain search for the tragic Amelia Earhart Putnam and her navigator Fred Noonan. The following month Great Britain landed two radio operators and equipment there. The British Ambassador in Washington asked the U.S. State Department to remove the American markers claiming sovereignty. Instead of complying, President Franklin D. Roosevelt on March 3, 1938, put Canton, as well as neighboring Enderbury Island, under the jurisdiction of the Secretary of the Interior. Four days later four Americans of Hawaiian ancestry were disembarked from the U.S. Coast Guard cutter "Roger B. Taney" on Canton as colonists. On April 1 the Secretary of the Interior granted Pan American Airways a license to use Canton as a stop on the California-Hawaii-South Pacific flying route, all personnel to be American citizens.

Full title to Canton has not yet been settled. England claims ownership of the island because of her hoisting her flag on various members of the Phoenix Group, though not actually on Canton itself, between 1889-1892. The United States claims ownership because of discovery and advertised claims of ownership during whaling days, and particularly on the proclamation issued in the President's name on the general subject of islands, which reads as follows:

> "The first claim to title over undiscovered territory rests on the discoverer.
> 2. Under this point, many islands in the Pacific were first discovered by American flag ships.
> 3. The United States has always held that mere discovery does not give final title. If it is not followed by reasonable occupation it is insufficient.
> 4. In relation to the islands in question, of which there are many, the United States is assuming the right to occupy either because of (a) discovery,

(b) former occupation, or (c) failure of any other nation to occupy, or a combination of (a), (b), and (c)."

Differences regarding Canton were finally resolved between the two Powers on April 6, 1939, when U.S. Secretary of State Cordell Hull and British Ambassador Sir Ronald Lindsay signed a treaty whereby British aircraft are guaranteed equal use of American aviation facilities on Canton, the island to be an Anglo-American condominium for fifty years or until later modified or terminated. As a result, a distinct American and a distinct British community were built on the island in close proximity to one another on the southwest rim. The pioneer in this work was Pan American Airways, which commissioned the "North Haven" to leave San Francisco in May 1939 and to place a construction crew of forty-three and a great quantity of supplies on Canton. In seven months these men had built a modern hotel, a hospital and a radio station on Canton and had blasted dangerous coral heads out of the seaplane runway in the lagoon. The first plane flight occurred in August 1939. With outbreak of war, PAA service was temporarily suspended, and the Army and Navy made extensive improvements on the island. Thereafter the company resumed flights, operating under contract to the Naval Air Transport Service. In late 1942 Japanese submarines shelled the island thrice. On March 25, 1943, Japanese aircraft bombed the island, inflicting "slight damage."

The island was surveyed between March and July 1938 for the Department of the Interior and recently revised, chiefly vegetationally by Hatheway, see Fig. 1 of Atoll Research Bulletin 43.

As Canton provides the best facilities for landing both sea and land planes in the Equatorial Pacific, the United States first dredged out parts of the lagoon for a seaplane runway. But as seaplanes became obsolete, landing strips were built by U.S. Army engineers, one running east and west and the other north and south. Revetments, for the protection of fighter planes, also were built, and still remain. The east-west runway was extended and resurfaced by CAA in 1950. The north-south runway has since been abandoned as well as a fighter strip about three miles east of the main runway. The present runway is built to handle the largest commercial airliners now in use. It has a rotating beacon approximately forty feet above mean sea level with a split white light turning at 6 r.p.m. This has been reported as visible at distances of sixty miles by approaching planes, and thirty-six miles by surface vessels. It is lighted from dusk to dawn. The construction of this beacon makes Musick Light, a white cylindrical stone tower twenty-eight feet above the water on the south side of the lagoon entrance, less important. For some time it was lighted by request only. In 1954 it was maintained by the U. S. Coast Guard, and burned every night.

Musick Light was named in honor of Capt. Edwin C. Musick who inaugurated the first scheduled cargo and mail service between the United States and New Zealand on December 23, 1937. He and his crew perished off Samoa during the second flight in the following January. The plaque on the monument, erected in July 1938, reads as follows:

DEDICATED BY THE UNITED STATES
DEPARTMENT OF THE INTERIOR
TO THE CREW OF
PAN AMERICAN AIRWAYS
"SAMOAN CLIPPER"
LOST AT SEA ON JANUARY 11, 1938
WHILE SURVEYING FIRST SOUTH
PACIFIC AERIAL TRADE ROUTE
* * * * *
Captain E. C. Musick

C. G. Sellers	P. S. Brunk, Jr.
F. J. MacLean	J. W. Stickrod
J. A. Brooks	T. J. Findley

During the war pillboxes and other fortifications were erected, their cement remains still dotting the flat landscape. With the fall of Tarawa, Canton declined in military importance and in 1946 aviation facilities were transferred from the War Department to the Department of Commerce. In 1950, modern housing units for the CAA personnel were constructed near the runway on the northwest rim of the island. Plans are under way to consolidate all activities on the north side of the island. Pan American Airways, now renamed Pan American World Airways, and the British community are still on the south rim, as well as the quarters for American bachelor employees of CAA.

Canton Island gains its present importance from its strategic location. It is the fueling stop for three different commercial airlines, namely, Pan American World Airways, Qantas Empire Airways (QEA), and Canadian Pacific Airlines (CPA). These fly an aggregate of fifty passenger planes per month between Hawaii and Fiji. From these centers, as hubs, passengers can radiate by plane or boat to all parts of the earth. Canton Island has a wharf where vessels of 5,000 gross tons can tie up if necessary. It boasts two post offices in the very same building; one American, the other British. Postal service by air is available twice a week both north and south; by surface carrier at irregular intervals, averaging perhaps once in four to five months. Wireless service is available to the public. Being a center of air transport, installations are of the best. It has a modern weather bureau, employing seven men.

A hotel operated by PAA provides room and board at approximately $10.00 per day for transients. Moving the American population from the southside of the atoll to the northside has gone apace. By 1954 CAA had ready for occupancy in the latter area 25 modern family quarters, had set up five quonsets, and had rehabilitated five former military quarters. PAA now has five family quarters; and Standard Oil, a two-family house there. A hospital, with a physician in constant attendance, is in the vicinity.

In 1951 there was no school for American children; but the few children of Gilbert and Ellice Islanders living in the British settlement were being taught by the fifteen year old daughter of the Chief of Police, a native of the Ellice Islands. By 1954, according to Evans, Canton "has a good school with a teacher furnished by the Department of the Interior, and a kindergarten-nursery school with a teacher hired by the residents. Twenty-six children attend the "grade" school, and twelve are in kindergarten. Three of the grade school pupils are Gilbertese - two girls and a boy. These Gilbertese children are bright. There is also a Gilbertese school in the British Compound."

Three oil companies do business on Canton. According to their announcements Asiatic Petroleum Corporation specializes in aviation gasoline and aircraft oils; Standard Oil Company of California, in Chevron aviation gasoline and R.P.M. aviation oil; and Standard-Vacuum Oil Company, in aviation gasoline 100/130 and Esso-aviation oil 120.

The only industry, not connected with air travel, is fishing. Three concerns are now licensed by the American and British governments to engage in this enterprise. Their catch is shipped by air to Honolulu. An impression of the relative importance of this business may be gained from the catch of one of the companies in July 1950. It removed a total weight of 17,984 pounds of fish from Canton, this amount breaking up into:

Mullet------	13,488	lbs.
Manini------	1,798	"
Aholehole---	1,079	"
Oio---------	899	"
Uu----------	719	"

The census of Canton Island, as of December 31, 1949 , is illuminating:

1. Population

Nationality	Men	Women	Children	Total
U. S. citizens	117	15	15	147
Gilbert and Ellice Islanders	106	15	13	134
New Zealanders	18	2	0	20
Fijians	12	0	0	12
Australians	8	0	0	8
Tongans	3	0	0	3
Part-Fijians	2	0	0	2
French	1	0	0	1
Total	267	32	28	327

2. <u>Employer Organizations</u> (employees only; dependents shown in totals above)

a. Fisher Associates
U. S.citizens---------------------32
Gilbert and Ellice Islanders------ 9
New Zealanders------------------- 1

b. Pan American World Airways (estimated)
Gilbert and Ellice Islanders------66
New Zealanders-------------------15
Fijians--------------------------12
Australians--------------------- 5
U. S. citizens------------------ 4
Tongans--------------------------3
Part-Fijians-------------------- 1
French-------------------------- 1

c. Oil companies
U.S. citizens------------------- 5
Gilbert and Ellice Islanders------ 5
Australians--------------------- 3

d. British Station
Gilbert and Ellice Islanders------16
New Zealanders------------------- 1
Part-Fijians-------------------- 1

e. Private
Gilbertese----------------------- 1

(The 42 Fisher Associates personnel and the 5 U.S. citizens under Oil Companies are engaged in construction and do not represent "permanent" population, nor does the personnel of R.C.S. "Margaret", which vessel was in port on December 31, 1949.)

3. <u>Federal Personnel</u>
Civil Aeronautics Administration-----70
U.S. Weather Bureau----------------- 7
U.S. Post Office Department---------- 1

The U.S. Government on Canton Island is administered like a ship at sea. The U.S..Administrator represents other government agencies in the following capacities: for example, for the CAA he is Island Manager; for Treasury he is Disbursing Agent/Cashier; for Justice he is Deputy Marshall; for Coast and Geodetic Survey he is Tide Observer.

(Of the 70 CAA employees shown, 25 are engaged in construction and do not represent "permanent" population.)

4. Traffic Data

Carrier	Weekly Flights	Passengers
Pan American World Airways	6	90
British Commonwealth Pacific Airlines	6	90
Canadian Pacific Airlines	1	15
U. S. Navy (Samoa)	1	15
Civil Aeronautics Administration	2/3	10
Weekly total	14 2/3	220
Annual total	762 2/3	11,440

(PAA has two weekly round trips from the U.S. mainland to Australia and one to New Zealand. BCPA has four round trips. CPA from Canada to Australia transits south one week and north the next. CAA aircraft fly from Oahu, Hawaiian Islands, to Canton Island and return approximately every three weeks. In 1954 Qantas Empire Airways replaced BCPA.)

5. Ships calling at Canton during the year

CAA-----------------------------------9
Oil companies-------------------------4
Gilbert and Ellice Islands Colony----3

The British Government on Canton is administered by the Colonial Office, and is in perfect harmony with the United States Administrator. British subjects are governed by British law; American citizens, by U.S. maritime law. Each nation respects the other's laws. It is forbidden under British law for Fijians and Gilbert and Ellice Islanders to drink intoxicating liquors; they have their harmless and refreshing kawa or yangona as a substitute. It is likewise forbidden for any British subject to supply any alcoholic drinks to such Pacific islanders, the punishment being imprisonment for three months or a fine of £50/0' or both. For an American, for example, to aid a British subject in breaking this British liquor law might subject him to dismissal from his position on the island as an undesirable troublemaker. For any heinous crime, on the other hand, the suspect would be tried in Federal court in Honolulu, Hawaii.

In this condominium, American workmen receive wages as high as or higher than workmen performing similar tasks in Hawaii or the continental United States. British workmen under British rule receive wages according to British standards. For instance, according to a regulation posted by the District Officer, June 14, 1950, the following wages for the employment of domestic colored labor were established as the legal rate:

Duties	Frequency	Rate per month
Washing and/or ironing	Once per week	$4.00
" "	Twice per week	7.00
General housework	Up to 3 hrs. per day (6 days per week)	12.00

"(Employers are not expected to maintain employees as regards rations, should they desire to do this, the District Officer will immediately be advised of this intention and will determine a reduction in the salary or salaries concerned, to meet such a contingency.)"

LAND FLORA

From the biological standpoint it is more logical to begin a discussion of a flora with the most primitive plants, aquatic ones, and to end with the most complex. But as the purpose of the visit to Canton dealt primarily with land plants, we shall begin our discussion with these.

According to a manuscript of Bryan's, who visited the island in 1924: "The rim varies in height from ten to twenty feet, and is for the most part covered only with low, prostrate vegetation, consisting of herbs and vines of common wide-spread Pacific species of Portulaca, Boerhaavia, Sesuvium, patches of Lepturus (bunch grass), Triumfetta, two species of Ipomoea, and stunted Sida bushes. A stretch of about two miles along the south side is covered with scaevola bushes, from 8 to 12 feet high. There are a few scattered Pemphis* bushes, a few Morinda, Tournefortia [Messerschmidia], and dry, scrubby Cordia trees. Most of the trees are scattered along the middle portion of the north rim; there are two patches near the N.W. point. Near the main lagoon entrance (on "Observation Point") are half a dozen coconut palms, the remnant of a number which were planted; and two other coconut palms are standing on the N.W. point. In 1937 the New Zealand solar eclipse expedition planted about 3,000 sprouted coconuts, some on the S.W. side and some on the N.E.; in time some of these may grow."

Before dealing briefly with the plant communities, each kind of plant observed or collected up to May 1951 is listed, with pertinent notes, below. These are arranged taxonomically. Numbers after the names of Fosberg and Walker refer to actual specimens collected in January or March 1949 and to be deposited in the U.S. National Herbarium in Washington. These have not been studied by the writers, but are here recorded on the basis of personal information submitted by F. R. Fosberg. Numbers after the names of Degener and/or Hatheway refer to specimens collected by these workers in 1950 or 1951 and deposited at the New York Botanical Garden, at the Bishop Museum in Honolulu, in the U. S. National Herbarium, and usually elsewhere.

Pandanaceae

Pandanus tectorius, the screwpine or hala, is native to the tropics but not to Canton. It is cultivated on the grounds of the PAA hotel on the southwest side of the island. The larger of

*Evidently in error for Suriana.

the two specimens is about ten feet high, picturesque and moderately healthy. Degener shipped seeds from Honolulu to Canton in July 1950. These germinated and are now planted out in the CAA housing area. They should thrive with perhaps a little watering during the driest seasons until their roots penetrate the sandy soil to depths allowing them to draw upon the layer of lighter brackish water which floats upon the heavier sea and lagoon water underlying every part of Canton's rim of land, and rises and falls with the tide.

Gramineae

Cenchrus echinatus (Fosberg & Walker 30,202, 30,217; Degener & Hatheway 21,252), the common sandbur, is a grass native to tropical America and obviously of recent accidental introduction. It was first recorded as collected on Canton in late 1949 or early 1950 by Katharine Luomala in her "Plants of Canton Island, Phoenix Islands", in Occas. Pap. B. P. Bishop Mus. 20 : 172, 1951. This, however, is not the first collection of the species as Fosberg & Walker had collected it January 30 - 31, 1949. It is ubiquitous about the airport and the civilized areas and still rare or wanting where man, carrying the burs on his socks, has not gone. It is an annual, springing up quickly during rainy weather, maturing its troublesome burs and then dying until the next rains come to wake the seeds into life.

Chloris inflata (D. & H. 21,251), a finger grass, was growing naturalized in a small patch in July 1950 near the abandoned runway. Seeds scattered by Degener about the same time had grown and matured by May 1951 in a thick stand near the wharf and oil tanks on the north side of the island, and near the hotel on the south side.

Cynodon dactylon (D. & H. 21,286), the Bermuda grass, is sparingly naturalized and carefully planted by residents near the hotel, at the airport and in the CAA housing area. According to Van Zwaluwenburg in the Haw. Pl. Record for 1941, this grass came to the island in importations of soil from Oahu. Seeds were also imported by a resident of the CAA housing area for planting in 1950.

Digitaria sanguinalis (D. & H. 21,315), a slender creeping grass, was found sparingly naturalized about the airport in July 1950.

Digitaria pacifica (Fosberg 30,886; D. & H. 21,316 -21,318) is the native annual bunchgrass known as D. stenotaphrodes to some authorities. It has fingered flower heads. It is found scattered here and there, preferably in recently disturbed areas such as along the sandy side of the road. It is a lush green, grows quickly after rains and usually dies shortly before the next rainy season. It is variable on Canton, requiring extensive study and probably segregating into several varieties. It has been collected since early days. This grass is badly eaten by a grasshopper (Ailopus tamulus), accidentally introduced from perhaps Samoa or Tonga.

Digitaria timorensis (Hatheway 518) is an Oriental grass of accidental introduction growing in a few waste places near the hotel. It was first collected in February 1951.

Eleusine indica (F. & W. 30,211; D. & H. 21,254), the goosegrass, is native to the Old World. It is naturalized and very common only near human habitations. It is evidently of recent introduction, being first collected by Fosberg and Walker in January 1949. It is very successful because it is a quick-growing annual that can complete its life span during the short wet season.

Eragrostis amabilis (D. & H. 21,297), a pretty and delicate grass, is naturalized mainly about the hotel, and will undoubtedly extend its range. It is of recent accidental introduction.

Eragrostis whitneyi (F. & W. 30,206; D. & H. 21,319 and 21,320), very closely related and perhaps not specifically distinct from E. paupera, is a native grass first collected by Bryan in 1938. It is a pretty, dwarf, tufted annual growing on hard, sandy plains as, for example, near the airport.

Eragrostis pectinacea (D. & H. 21,312) is a very rare grass growing near the wharf on the north side. It is of recent accidental introduction.

Lepturus pilgerianus (D. & H. 21,291) is a very rare, native bunchgrass thus far known only from Canton, where it grew in sand. It is peculiar in being the only annual in the genus.

Lepturus repens (F. & W. 30,212; D. & H. 21,311) is a native perennial bunchgrass with columnar flower stalks. It has been collected since early times. It is somewhat variable. It is darker, harsher, denser and more abundant than the native Digitaria, and is tolerant of drier, more firmly packed areas. Its leaves are eaten by the introduced grasshopper. The terrestrial hermitcrab, described later, may kill certain tussocks by pulling out with the roots clawfuls of culms, starting these depredations from the outside of the cluster and gradually working toward the center. Perhaps their tender bases taste akin to corn on the cob.

Panicum miliaceum (D. &. H. 21,314) was found growing very localized near the hotel in 1950. It is of accidental introduction, perhaps derived from spilled canary bird seed.

Setaria verticillata (D. & H. 21,253), the bristly foxtail, is a nasty weed native to Europe. It is found everywhere near habitations and is obviously of recent accidental introduction. The clusters of seeds adhere to clothing of all kinds. This grass is a successful annual, disappearing during the dry season.

Cyperaceae

Cyperus rotundus (Degener 21,413), the nutgrass, is a troublesome sedge of lawns and gardens throughout the tropics. It was one of the plants recorded by Van Zwaluwenburg in the Haw. Pl. Record for 1941 as imported in "soil from Oahu." Degener observed a few good stands in 1951 growing near the hotel but nowhere else.

Fimbristylis diphylla (D. & H. 21,288 and 21,289), a perennial sedge, grows near the outdoor theater. Because of its proximity to human structures or habitations, it is suspected to be foreign to Canton. It was probably accidentally introduced as seed from some other South Sea island, perhaps in a clod of earth stuck to machinery or to the shoe of some member of the Armed Forces.

Fimbristylis pycnocephala (D. & H. 21,290), another perennial sedge, grows on a barren plain near the CAA housing area. It forms harsh tussocks with pincushion-like flower-heads radiating in all directions. Because of its occurrence only in an area disturbed by man, it likewise is suspected to be a foreigner. This is probably the species recorded by Luomala as occurring on Canton in 1949 - 1950 (ibid. 168) and identified as F. cymosa.

Palmaceae

Cocos nucifera, the coconut. Not a single coconut palm is native to Canton. All were obviously planted. As mentioned above, Capt. Allen planted some coconut trees in 1916. Two, probably relics of that planting, grew for many years on the northwest point and were conspicuous and useful landmarks for ships at sea. They had become about 10 feet tall by 1924. The last survivor died in 1950, at a height of about 25 feet. In 1937 the New Zealand eclipse expedition set out about three thousand, but few survived. According to H. W. Bigelow in 1939, there were "nine scattered palms," and according to E. J. Witt in April of the same year also "many very small ones" about 18 inches high. There are some nice trees of medium size about the hotel, unfortunately infested by the Florida red scale insect (Chrysomphalus ficus), evidently due to the introduction of unfumigated plants. Small coconut palms are no longer rare elsewhere on the atoll, but grow only successfully where given a little care.

Araceae

Anthurium and Philodendron of several species were being grown as house plants in 1951, as well as a number of other plants, belonging to various botanical families, which will probably never survive to become an element in the local flora. Many of these are purchased in flowershops in Australia, Fiji or Hawaii, carried in ladies' handbags on the planes, and then kept alive on Canton for a limited length of time. To list such casual and ephemeral introductions kept on bookcases and dining-room tables is hardly worthwhile.

Amaryllidaceae

Crinum asiaticum, the grand crinum, is native to the Orient. This hardy herb was introduced recently from Hull Island for planting about the hotel and the Terminal Building. The plants readily propagate from the base and become crowded. They then need thinning and replanting for best results.

Musaceae

Musa nana and other kinds of bananas have been imported from various regions and planted out. They persist with some care. It is recorded that some were set out in 1937 and later, but in July 1950 none was observed. By April 1951 new corms had been imported and were growing nicely where properly watered.

Casuarinaceae

Casuarina equisetifolia (Fosberg 30, 876; D. & H. 21,303), the horsetail beefwood or ironwood, is native to Australia and elsewhere in the South Seas. It is not native to Canton. Several trees are growing near the hotel, and are quite healthy. More should be introduced, even though no other plants, excepting perhaps the tree heliotrope, will grow beneath their falling branches, which simulate pine needles.

Casuarina glauca (Degener 21,372), the coarse ironwood tree, is likewise native to Australia and is foreign to Canton. It grows near the hotel, where it was planted many years ago. It is peculiar in sprouting from the roots at considerable distances from the main trunk.

Polygonaceae

Coccolobis uvifera (Fosberg 30,878), the seagrape, is native to the Bahamas. It is a densely leaved shrub or small tree planted and thriving about the hotel. The fruit is edible and can be made into jam and jelly. The plant was recorded by Van Zwaluwenburg in 1943 (Proc. Haw. Ent. Soc. 11. 3 : 306) as "recently introduced." The trees flower and fruit abundantly after rains, the seeds often germinating in the rainy season where they fall under the trees. These seedlings die for the most part during the prolonged drought. The annual supply of seeds from these trees, properly planted out, could soon markedly improve the entire aspect of the atoll. The plants are often infested with the long-tailed mealybug (Pseudococcus adonidum), for the control of which an insect enemy can be introduced.

Amaranthaceae

Amaranthus dubius (D. & H. 21,295), an amaranth possible to use as a potherb in time of famine, now grows sparingly as an introduced weed near human habitations as, for example, about the hotel. It is a welcome addition to the island, which the spiny one, not yet here, would not be. Should the latter come, it should be eradicated before it has the opportunity to spread and become another prickly pest. An amaranth, species not given, was mentioned first by Van Zwaluwenburg in the Haw. Pl. Record for 1941 as reaching Canton in importations of soil from Oahu. Then in 1943 in the Proc. Haw. Ent. Soc., he refers to it again as "the recent immigrant Amaranthus."

Nyctaginaceae

Boerhavia tetrandra (F. & W. 30,207; D. & H. 21,305, 21,313), is a native perennial herb. It is found throughout the island, thriving everywhere excepting in the lowest, saltiest area. It has a few exceedingly long, fleshy, juicy roots at the surface of the ground to take advantage of the gentlest showers whose rainfall fails to penetrate the soil deeply. Its leaves are fleshy and its long-stalked flower clusters are white, not pink, as reported by some writers. The entire group is a difficult one. Some authors consider our plant to be B. diffusa, perhaps correctly so. It is subject to a native fungus disease (Albugo sp.) that dwarfs its leaves.

Aizoaceae

Sesuvium portulacastrum var. griseum (F. & W. 30,203 - 30,205; D. & H. 21,373; Degener 21,451) is a prostrate herb forming extensive mats of thick stems and leaves, preferably in depressions near the lagoon beach where salts may accumulate on drying. The plant is somewhat evil smelling. Being fleshy and rather brittle, it dies in solid black lines soon after the wheels of a car have passed over it. Its pale pink flowers are hunted out by the hermitcrab which, as in the case of the native purslane, eats stamens and ovary. In this case these crabs also extract the ripening seeds from the somewhat fleshy capsules for food. Perhaps in doing so, some escape, thus aiding the plant's dissemination. The plant readily roots at the nodes. The species itself has been recorded in error from the atoll by previous writers.

Portulacaceae

Portulaca lutea (F. & W. 30,208; D. & H. 21,285), the native yellow portulaca or purslane, is a beautiful succulent, pale green perennial, resembling the jade plant. It grows everywhere. Its thick branches rise slightly from the ground. Its flowers open tardily in the morning and do not wilt uhtil sunset or shade overtakes the plant. It can be eaten as a potherb in times of famine. The terrestrial hermitcrab feeds on the stamens and ovary, usually leaving the rest of the flowers attached to the plant.

Portulaca oleracea (Fosberg 30,881; D. & H. 21,283), the common purslane of Europe and America, is obviously of recent introduction. It may well have come from Hawaii to which Don Marin purposely introduced it in the early part of the nineteenth century. It is still of local distribution, growing mostly near human habitations. It is bound to spread and, from the appearance of a few plants, may be sparingly hybridizing with the native species. It differs from its native relative in being more prostrate, more slender, often somewhat red-stemmed, and in bearing smaller flowers opening usually in the morning and wilting at noon. It is used as a potherb, especially in France.

Cassythaceae

Cassytha filiformis (D. & H. 21,282), the love-vine, is native to Canton. It was first collected by Bryan in 1938. It is a rootless parasite consisting of pale green, intertwining string-like branches bearing tiny whitish flowers and marble-like fruits. Its sucking organs or haustoria rob other plants of sap. One love-vine may twine and gain nourishment from many different kinds of hosts. In one instance it was observed that one plant was growing on the native triumfetta alone, and thriving on this limited diet.

Leguminosae

Leucaena glauca (Fosberg 30,882; D. & H. 21,296), the haole koa of Hawaii, is a small tree with feathery leaves, pompons of small white flowers and flat brown beans. It is native to tropical America. A few mature plants are in cultivation about the hotel, where they flower and sparingly reseed themselves. Van Zwaluwenburg stated in 1941 that the haole koa reached Canton in the importation of soil from Oahu. Thousands of seeds planted in April 1951 in many parts of the island appear to be tolerant of salt in the soil, and the seedlings are maintaining themselves in most cases where not exposed to extreme dryness.

Zygophyllaceae

Tribulus cistoides, the large-flowered caltrop or puncture vine, is typically a beach plant with flowers resembling a buttercup, and with nasty spiny fruits. These are a menace to barefoot bathers and may even puncture auto tires. This pretty weed was recorded from Canton by Van Zwaluwenburg in the Haw. Pl. Record 45 : 17. 1941. It has not been observed by the writers who therefore consider the record erroneous.

Simaroubaceae

Suriana maritima (D. & H. 21,305), the baycedar, is native t coastal regions of both the Atlantic and the Pacific. It is a densely leafy shrub with small yellow flowers, and commonly grows gregariously. It is often used as a shelter by the ground-nesting tropic bird. This plant may have been mistaken for Pemphis by earlier writers.

Euphorbiaceae

Acalypha wilkesiana, the painted copperleaf, is a Fijian shrub now planted throughout the tropics as an ornamental hedge plant. A few specimens were observed cultivated in 1951 about the hotel. They were responding favorably to a little care and watering.

Chamaesyce hirta (Fosberg 30,873; D. & H. 21,298), the hairy-leaved spurge, is a low spreading herb with milky juice native to tropical America. It is a recent accidental introduction and grows well and often common in many areas influenced by man. It is a welcome addition to the ground cover of the island. More conservative botanists place this and the following two species in the genus Euphorbia.

Chamaesyce hypericifolia (F. & W. 30,216; D. & H. 21,300), the hypericum-leaved spurge, is related to the above. It is taller and is still rather rare, being known as yet only from the vicinities of the hotel and the airport.

Chamaesyce prostrata (D. & H. 21,299), the prostrate spurge, is another South American relative. It lies flat on the ground, has thread-like branches and tiny leaves. It is locally naturalized near the airfield, about the hotel and elsewhere but not away from the influence of man. This in itself proves its recent introduction. These three species may be the ones mentioned by Van Zwaluwenburg in 1941 as having come from Oahu in imported soil. The erect specimens collected by Luomala and recorded as E. prostrata were either parasitized by the fungus Nigredo proeminens or the specimens were misidentified.

"Euphorbia" (Fosberg 30, 214, 30,880), not seen by writers.

Euphorbia, see under Chamaesyce and Poinsettia.

Phyllanthus niruri, the niruri, a pantropic weed of American origin, was growing in 1951 in and about a box of soil imported from Fiji. It appeared to be spreading rapidly from seed to the surrounding area.

Poinsettia cyathophora (Fosberg 30,885; D. & H. year 1951) is sometimes called *Euphorbia heterophylla* var *cyathophora*. It is the fiddle-leaved poinsettia native to tropical America. Its upper leaves are basally blotched with bright red, adding color to the landscape. This erect herb is sparingly naturalized and protected in the spic and span British Settlement, where it grows on sun-scorched coral rubble that may act in part as a mulch to conserve ground moisture. It is of course a modest, wild relative of the garden poinsettia (*P. pulcherrima*), of which recently imported cuttings were being propagated in 1951 in cans by a resident of the CAA housing area.

Tiliaceae

Triumfetta procumbens (F. & W. 30,215; D. & H. 21,281), the trailing burbush, is native to Canton. It is a shrub with extremely long, trailing, woody branches and very long, spreading roots running just below the surface of the ground in all directions. It prefers arid dunes. The branches occasionally strike root five to six feet away from the mother plant, and from such centers additional trailing branches arise. The leaves are thick, roundish to slightly lobed, and bright green. The flowers are yellow and soon mature into spherical, spiny burs that lie in black masses where the mother plant may have eventually succumbed to an especially dry year. This plant could be mistaken for *Tribulus*.

Malvaceae

Hibiscus rosa-sinensis, the common hibiscus, is represented in gardens by less than a dozen plants.

Hibiscus tiliaceus, see under *Pariti*.

Pariti tiliaceum (Fosberg 30,888; D. & H. 21,284), the *hau* or *vau* of South Sea Islanders, is a relative of the hibiscus and by more conservative botanists placed in the same genus. It is a small tree with yellow flowers having a maroon center. These flowers fade reddish at night. In 1943 Van Zwaluwenburg reported insects "on the recently introduced 'hau'," thus giving us an approximate date as to the plant's coming to Canton. One slowly growing tree, suffering from drought, stands near the hotel laundry; a few others in neighboring gardens, and one at Musick Light. It produces flowers in spite of abuse. This tree, like many others introduced by Degener in 1950 for CAA, thrives when exposed to a little brackish water. A deep hole should have been dug for it through the coral rock and hardpan down to the water table. Into this hole a few posts or old boards should have been placed in an upright position before refilling with earth and planting the tree. The presence of the decaying boards would deter future formation of a troublesome hardpan and would facilitate root growth down toward water.

Sida carpinifolia, the hornbeam-leaved sida, is a native of tropical America but is now almost pantropic in distribution. It was represented in 1951 by a single wild plant growing near the hotel from a box of soil imported from Fiji.

Sida fallax (F. & W. 30,201; D. & H. 21,329), the ilima of the Hawaiian lei vendors, is a twiggy perennial shrub with finely velvety leaves and many small orange-yellow hibiscus-like flowers. It is native, and almost everywhere. For their dances, the South Sea islanders on Canton bedeck themselves with garlands made from this plant. The red-tailed tropic bird prefers to nest under its spreading canopy of branches and under the Suriana. Unlike the common ilima of Hawaii, whose flowers usually possess a dark eye, all flowers on Canton are uniformly colored. In studying thousands of plants, a few freaks or sports were observed. Should such plants become isolated on some island devoid of Sida otherwise and thus be prevented from cross-pollinating with more normal plants, they might develop into entirely new species or kinds. Such freak plants, therefore, are worthy of mention. One (D. & H. 21,330)possessed an unusually pale corolla; another (D. & H. 21,331), growing near the old guano diggings, bore filled flowers; and a third (D. & H. 21,332), growing near the CAA housing area, was densely twiggy and bore innumerable small leaves. These Sida, and the Scaevola as well, may be attacked by aphids. The ladybird beetle, Harmonia arcuata, however, tends to keep them under control.

Thespesia populnea (D. & H. 21,308), the milo of the Hawaiians, is a small tree with numerous leaves that can be eaten raw during times of famine. It bears an attractive hibiscus-like pale yellow flower with dark eye, and roundish corky seed pods that break open irregularly. Van Zwaluwenburg, at a meeting in May 1942 (published in the Proc. Haw. Ent. Soc. 11. 3 : 306.1943.), mentioned the occurrence of certain insects "On the introduced malvaceous tree 'milo'", thus proving that this species was on Canton previous to 1942, and even at that time was considered foreign to the native flora. In 1950 several trees were observed cultivated at the hotel and growing near the wharf on the north side of the island. This tree prefers access to brackish water.

Guttiferae

Calophyllum inophyllum, the true kamani of the Hawaiians, is native from India to the South Seas, exclusive of Canton. Where native, it grows to be a huge tree, bearing attractive white flowers and large round corky fruits from whose kernel a medicinal oil is expressed. The logs were used for canoes. A few trees were observed planted near the hotel. Their seemingly parallel-veined leaves were badly infested with the Florida red scale. Potted plants shipped to Canton by Degener in July 1950 and set out in the open were thriving in May 1951.

Tamaricaceae

Tamarix aphylla (Fosberg 30,877; D. & H. 21,306), the European tamarix, confusingly resembles the beefwood or ironwood. It bears, however, pink, heather-like flowers. Beautiful specimens have been planted on the hotel grounds. Cuttings from Oahu plants set out about some buildings in July 1950 were growing in April of the following year but were suffering from drought. They require a little watering and aid for their roots to penetrate the soil to greater depths.

Passifloraceae

Passiflora foetida, the foetid passionflower, native of tropical America, was observed in July 1950 growing carefully tended at the hotel and near the airport building. It is a recent introduction. Seeds planted in July 1950 by Degener did not germinate until after the unusual rains of April 1951.

Caricaceae

Carica papaya, the papaya, is native to tropical America and frequently grown locally from seeds derived from imported fruits. The seeds readily germinate and some of the resulting trees may grow to good size. Those observed are fruitless and invariably chlorotic, or yellowish. This is due either to the lack of some necessary mineral or more likely to the plant's inability to extract it from Canton, this soil perhaps holding it too firmly in some complex chemical bondage. Success might be gained by planting the seeds in a compost pit and adding a little solution recommended by local devotees of hydroponics. Reducing exposure to the intense sunlight might also be helpful in stimulating production of a crop.

Combretaceae

Terminalia catappa (Fosberg 30,875), the Indian almond, is native to the Old World. It is one of the few tropical trees that exhibits autumn coloration in its foliage. The kernel is edible and, rarely, the outer part of the fruit. It has been planted on the hotel grounds and would thrive excepting for insect injury. Seedlings, introduced in July 1950, were in a thriving condition the following May.

Terminalia samoensis (Fosberg 30,879), collected by Fosberg on March 6, 1949, was not collected by the writers. Nor did they notice T. melanocarpa or T. littoralis mentioned by Luomala.

Araliaceae

Polyscias guilfoylei, the panax of Hawaiian residents, was recorded in 1951 by Luomala as having been planted recently and to have died later. It was noticed growing by Degener in the British Settlement in May 1951, but not thriving.

Apocynaceae

Ochrosia, species not determined, was observed in cultivation in 1950 on Canton by MacDaniels according to a personal communication.

Plumeria rubra (Degener, year 1951), the pink flowered frangipani, is native to tropical America. Several trees, cultivated in the hotel grounds living in July 1950 and covered with the crater scale, succumbed shortly after. Only one was surviving in May 1951. This scale insect is just another foreign pest that has been able to slip into the island for lack of proper regulations of inspection and fumigation. A few trees with small flowers from New Providence Island, Bahamas, where they are native and still growing wild, were set out in 1950 by Degener and are thriving.

Asclepiadaceae

Calotropis gigantea forma *wilderi* (D. & H. 21,294), the white crown flower, is a color form of the more common purple crown flower native to tropical Asia. It is commonly planted and grows well from cuttings. It, however, also suffers from chlorosis and its leaves may be eaten badly by caterpillars of the monarch butterfly, an insect occasionally flying here from over the ocean. The plant was recorded from the island for the year 1940 when Van Zwaluwenburg wrote about "the introduced Calotropis or 'crown flower'." Today a huge shrub grows near Musick Light, from which residents commonly gain cuttings.

Convolvulaceae

Calonyction species (D. & H. 21,309, 21,310), a moonflower, is obviously the second native morning glory recorded from Canton. It has been variously identified as *Ipomoea grandiflora* and *I. tuba*. It grows chiefly among arid guano deposits inland along the northeast rim. It is a climber bearing dark green, heart shaped leaves and large white flowers that bloom at night. By the time dry weather comes, it has matured its seeds and has died back to a massive rootstock. It is occasionally planted as an ornamental on trellises.

Ipomoea pes-caprae (Degener, year 1951), the beach morning glory, is practically pantropic, being limited in its extensive range, however, almost solely to sandy beaches. It was collected in 1924 by Bryan from "Canton Island, Obs. Point, lagoon side, small patch, el. ½ - 2 m. " and in 1938 on "west end, near camp, on sandy beach, alt. 2 - 3 m." Van Zwaluwenburg recorded it from Canton in the Haw. Pl. Record 45 : 17. 1941. Degener found an old flowerless plant with massive rootstock near the hotel rubbish dump in April 1951. The plant grew inland near the remains of an army camp. No other mature plants are known to him. And as the cotyledons of seeds he planted in April 1951 were injured as soon as they appeared above the ground by land hermitcrabs, he suspects that the one old plant may have been planted by a soldier and partly guarded by him from injury until it had become established. The previously recorded plants, likewise, may have been protected by man. Because of the abundance of this creeper along tropical shores, new wave-borne introductions to Canton probably arrive from time to time and may persist until they succumb to the ravages of the crabs during some period of food scarcity.

Boraginaceae

Cordia sebestena (Fosberg 30,874; Degener 21,374), the geigertree, is native to Florida and the Bahamas. It is a small tree with sandpapery leaves, brilliant scarlet flowers, and whitish fruit. From the size of the trees about the hotel grounds, this ornamental must have been planted ten or so years ago. It suffers a bit from dryness, but more from leaf-eating insects and from scales. It fruits freely and some of the seeds germinate where they fall. These should be planted in new localities as this tree is worthy of more extensive cultivation on the island.

Cordia subcordata (Fosberg 30,887; D. & H. 21,287), the kou of the Hawaiians, has corky seeds adapted for dispersal by ocean currents. The kou may have reached Canton without human aid. If it did, it is interesting to speculate how many seeds reached the atoll before one finally escaped destruction by hermitcrabs and grew to maturity. Two small healthy patches of kou forest, occurring on the southwest end of the island have long been shown on maps and used as landmarks at sea. One of these interesting groves is unfortunately being damaged by picnic parties, some of whose members are apt to wield an ax indiscriminately. Other clusters of kou trees grow mainly near the old guano wharf, practically at the edge of the lagoon. These are said to have been planted years ago. Seeds from such trees should be collected for cultivation elsewhere on the island. The branches of the kou grow mostly erect, making them impossible nesting sites for clumsy nest builders like boobies and frigate birds. These branches bear large, pale leaves and nectar-filled orange flowers followed by the corky fruits enclosing several seeds. The trees near the lagoon are sickly, their branches often dying back to near the base during dry seasons and thus lending to the tropical landscape a wintry appearance. Death of the branches is hastened by land hermitcrabs which climb them to shred and eat the cripp, juicy bark on one side, usually the upper, for a considerable length. Though many fruits are produced to litter the ground under the trees year after year, only those that are fortunate enough to get buried can sprout their seed. The seedlings bear two dark green, longitudinally pleated cotyledons, As the kou casts welcome shade about itself, it is always the resting place for hundreds of hermitcrabs. Some of these may wander about in the grove any time of day, while the majority sleep until the heat of the sun has waned and it is time to sally forth for food. Thus, every hour of the day, these seedlings are at the mercy of an army of voracious crabs. Though many seedlings appear above ground after a period of rainy weather, the writer has yet failed to see a single one escape annihilation. Obviously, seedlings arising from seeds transported away from crab-infested groves have a better chance for survival. In spite of the destruction of seedlings, the groves often increase in size. This is accomplished mainly by suckering. The kou grows rapidly, seeds planted in July 1950 being erect trees a foot or more high by the following April. Trees are often badly defoliated, particularly on the lee side, by the caterpillars of a moth (Achaea janata), which prefers to lay its eggs on the side of the tree protected from the wind. About the only natural enemy this caterpillar has on Canton is a true, evil-smelling bug. This predator inserts its needle-like beak into its victim, sucking its juices and killing it. It is called Oechalia consocialis.

Messerschmidia argentea (Fosberg 30,884), the tree heliotrope, is the most beautiful tree on the island. It is incorrectly known as Tournefortia and "skayviola." It is native and most commonly forms clumps or small groves, a typical one persisting at the newly established plant nursery near the airport. It bears small white flowers and silvery leaves which, when dried, may be used as a substitute for tobacco. The leaves are often eaten by caterpillars of an ornamental moth (Utetheisa pulchelloides), but seldom seriously. Near the hotel one of the trees has become badly infested with the minute hibiscus snow scale (Pinnaspis strachani). As long as the tree is allowed to stand in this condition, it remains a menace as this insect may spread from it to all the tree heliotropes on the island. It reproduces rarely from seed, clumps increasing their size from shoots arising from reclining branches.

Solanaceae

Lycopersicon esculentum var. (D. & H. 21,307), the wild tomato, grows near the airport near the ruins of army shacks. It was observed first in July 1950 and, almost dead, again in April 1951. It is a sprawling plant with unusual leaves. It matches perfectly tomato plants growing wild in the Galapagos Islands and may prove to be an undescribed variety.

Nicotiana glauca (D. & H. 21,305), the tree tobacco, is native to the New World. It is a slender tree with bluish stems and leaves, and yellow flowers. A single plant was found in July 1950 near the CAA housing area. It was without flower and fruit, and had been badly mauled by a bulldozer. Seeds brought from Honolulu in July 1950 and sown among coral rock had flowered by April of the following year. The plants had been blown flat by the prevailing wind and were chlorotic. It is a very desirable introduction of great promise.

Physalis angulata (Degener 21,411), the husk tomato, is sparingly introduced, a few plants growing naturalized in the British Settlement in May 1951.

Rubiaceae

Morinda citrifolia (Degener 21,412), the *noni* of the Hawaiians, is native to Pacific Islands and can be readily transported by water from one region to another because of a special air chamber located at one side of the seed. If it were native to Canton, one should expect to find seedlings, but none was observed. Bryan in 1924 reported the *noni* as occurring "Single or in clumps." Degener found a single large tree, loaded with flowers and fruit, near the old guano wharf. Scores of hermitcrabs were resting in its shade, and not a single seedling anywhere. The seeds are probably eaten upon germination.

Cucurbitaceae

Cucumis melo, the muskmelon, was found growing near some abandoned shacks in July 1950. The seeds probably came to the island in a breakfast fruit.

Goodeniaceae

Scaevola frutescens (Fosberg 30,872; D. & H. 21,301, 21,302), known as *naupaka* in its Hawaiian variety *sericea* by the Hawaiians, is found in many varieties and forms along many coastal regions of the Pacific. Through local confusion, its name obviously has been transferred to *Messerschmidia* as "skaviola." The plant native to Canton is a shrub eight or more feet high bearing large shiny smooth leaves, and white flowers and fruits. It grows gregariously. It is extremely important as, from time immemorial, its extensive groves were preferred as rookeries by boobies and frigate birds. The accumulation of their excrement, century by century, built up the guano deposits for which Canton first gained commercial recognition. Being gregarious, these birds avoid isolated *naupaka* bushes and instead nest in those growing in dense groves. Isolated bushes and groups of young bushes too small for nesting sites are usually a beautiful, crowded mass of healthy green leaves and white flowers and fruits. Bushes in the rookeries, in contrast, are sickly, dying or dead.

This unfavorable condition of the *naupaka* in the rookeries is not due so much to mechanical injury caused by the heavy birds clumsily alighting among the branches, as to the chemical action of the bird droppings. The details of these chains of chemical reactions, especially in a calcareous soil impregnated with sea salt, still remain to be worked out. Nevertheless, we are reasonably sure that two types of injury occur: first, the excrement of birds, rich in uric acid, is splattered wet over the leaves, in part absorbed by them, variously modified into other poisonous substances, and then translocated throughout the plant to its great detriment; second, much fresh excrement litters the ground. To this mass are added the whitewashed dying leaves as they fall or, in case of rare, cleansing showers, their coating of filth. Simply explained, the naupaka in Canton rookeries are very like garden plants dying from an excess application of chicken manure. They just can't tolerate these various nitrogenous compounds in such concentrated form.

As a result of this interaction between nesting birds and plants, there appears to exist something of a cycle, not clear cut, to be sure. Under simplified, ideal conditions it might best be explained as consisting of flocks of birds gradually killing with their excrement a grove of naupaka bushes in one area. While this is transpiring, seedlings of naupaka are growing healthily elsewhere undisturbed by nesting birds. As the old poisoned bushes finally succumb and break to the ground, the birds, somewhat unwillingly at first, are forced to shift their rookeries to the stands of naupaka which by this time have grown sufficiently tall and sturdy for nesting sites. The cycle then repeats itself as these plants, in turn, gradually succumb to poisoning and crumble away, obliging the birds to shift to still another stand of young bushes, probably actually growing in a locale where their ancestors had been killed out several hundred or thousand years before. Test holes dug by Hatheway show deposits of guano where no shrubs now exist. We cannot imagine that the ancestors of our present guano-producing birds had radically different nesting habits from the present generation. The presence of guano almost certainly indicates the former presence of groves of vegetation.

Compositae

Emilia sonchifolia, the purple emilia, was not observed by the writers in 1950-51. But Van Zwaluwenburg in the Haw. Pl. Record for 1941 stated that "Importations of soil from Oahu have resulted in the recent establishment on Canton of several weeds such as Emilia sonchifolia. . ."

Pluchea odorata (F. & W. 30,210; D. & H. 21,295), the shrubby fleabane, is native from Florida to northern South America. It is naturalized here and there about the airfield and disturbed areas, and is evidently of recent accidental introduction. It is expected to extend its range.

* * *

Thus far, individual kinds of plants have been discussed. Now we shall deal briefly with associations* of plants.

Portulaca lutea and Boerhavia grow together, with the exclusion of every other kind of plant, in large areas of consolidated reef and rubble. When even slight showers fall, their shallow roots can absorb the rain, and this water is stored in their tissues for use during long periods of drought. In other places the rootless Cassytha likewise occurs, parasitic on the two plants. Where the soil is more sandy, Portulaca and Boerhavia may be associated with the perennial bunchgrass Lepturus. In general, Portulaca and Boerhavia are the two commonest native plants on Canton, growing almost everywhere,

* A more technical paper, with statistics, on plant communities is presented by Hatheway as Atoll Research Bulletin 43.

associated with practically every other plant excepting with Messerschmidia, Scaevola and kou. The reason is not that these three shrubs and trees are poisonous, like the Eucalyptus and Casuarina to other plants, but that they cast too much shade for these sun-loving herbs to tolerate.

Another close community, since historic times, grows only near the influence of man and consists of the annuals Cenchrus, Eleusine and Setaria; Cenchrus being the most abundant and, because of its prickly burs, the most annoying.

Suriana often grows alone in slab areas and less often in sandy areas swept by waves during violent storms. In 1951 many of the largest plants were dead, leaving fantastically gnarled branches and twigs reaching toward the sky. The frigate bird often roosts upon the sturdier branches but does not nest among them.

The native annual varieties of Digitaria often grow alone, preferably in recently disturbed sandy soil, as along the shoulders of roads. They require more moisture than Lepturus repens and can survive from year to year on Canton by having speeded up their life cycle. Being unable to survive periods of drought as growing plants, they survive them in the form of seed lying dormant on the ground.

A plant that occurs mostly amid rock slabs or on sand dunes nearest the ocean breakers is Triumfetta. This perennial creeping shrub has incredibly long, shallow roots able to absorb rain from gentle showers, and thick leaves with water storage tissues.

Scaevola grows gregariously mostly on the southeast, or windward, part of the atoll rim, perhaps because the rainfall there is slightly more than on the lee side of the island. A few isolated bushes occur across the lagoon on the opposite side, the corky fruits having been blown across the surface of the lagoon to that shore by the prevailing wind. Sporadic plants grow in a few other places as well.

The kou, probably due to the influence of man, is most abundant along the lagoon side near the old guano diggings. The plants grow alone or perhaps with a few Messerschmidia interspersed.

Sida, a sun-loving shrub, grows preferably in good sandy soil in association with any plants that do not subject it to shade.

The Sesuvium is most tolerant of salt and consequently grows alone; other kinds of plants cannot survive in low areas that are inundated by the lagoon. During dry weather and exceptionally low tides the ground where it grows glitters with salt crystals.

The native land flora of Canton Island, excluding the kou and the beach morning glory as plants of questionable nativity, comprises only fourteen kinds of flowering plants. Not a single fern, moss nor slime-mold is native. How many fungi and terrestrial true algae and blue-green algae occur is not yet known. There are quite a number to be found in unexpected places, as in the turbo shells carried about by the hermitcrabs on land. Due to commerce, the common molds found on foodstuffs have reached Canton. There are doubtless numbers of native fungi yet to be discovered, especially after spells of wet weather. Thus far a powdery mildew was collected by Degener on the native Sida; an Albugo on the leaves of Boerhavia; and a saprophytic, dirty yellow ascomycete, about 1 cm. wide, on introduced rubbish.

The paucity of native land plants on Canton is due to the scarcity of rain and its unfavorable distribution during the year, to the salty or nitrogen- and phosphates-impregnated character of the barren soil, to the low elevation enabling waves during storms and very rare tsunamis or tidal waves to scour the atoll bare of most life, and to the army of omnivorous hermitcrabs. Canton is not so isolated that seeds and other propagules of land plants cannot reach its shores. Almost all such castaways evidently find conditions too unfavorable for survival.

Even though Canton is unfavorable for the growth of plants, similarly arid, salty or chemically-poisoned regions throughout the world have been successfully invaded by various rugged plant pioneers. Some are peculiar to the Mojave and other alkali deserts in America; some to the calcareous soils of Florida, the Bahamas or Dalmatia; some to the Sahara; to Madagascar; to India; to Australia and the South Seas; or to the leeward sides of the Hawaiian Islands; etc. To cover Canton with a mantle of vegetation, however, is more than just selecting seeds of such pioneer species and sowing over the rim of the atoll. As a fundamental practice, seeds of potentially poisonous plants, such as those of the yellow oleander (Thevetia peruviana), or of thorny plants, such as the klu (Vachellia farnesiana) and algaroba (Prosopis chilensis), have been omitted. The following is a list of plants or seeds, with their native home, shipped by the writer to Canton chiefly in 1950. All were properly fumigated by the Board of Agriculture and Forestry, Honolulu, to guard against the danger of introducing insect pests. Some seeds of plants that should be able to grow on Canton could be supplied in only small quantities due to their extreme rarety. Others, of plants that probably will not grow there, were sent anyway because of their availability without extra cost or labor. After all, some of these may germinate and grow in particularly sheltered places. Only after these plants have actually become naturalized will it be worthwhile describing them in a supplement to the present paper.

Species sent to Canton in 1950, unless other date given, and place of origin:

MARSILEACEAE
Marsilea villosa - Hawaii

GRAMINEAE
Dactyloctenium aegyptium - Egypt
Digitaria henryi - Formosa
Echinochloa colonum - Pantropic
Ischaemum brachyatherum - Africa
Lagurus ovatus - Yugoslavia (1953)
Panicum cinereum - Hawaii
Panicum nubigena - Hawaii
Panicum pellitum - Hawaii
Pennisetum sp.
Polypogon monspeliensis - Europe
Sporobolus virginicus - Southern United States
Tricholaena repens - Africa

CYPERACEAE
Cyperus javanicus - Hawaii
Cyperus trachysanthus - Hawaii
Fimbrystylis cymosa - Hawaii

PALMAE
Phoenix dactylifera - Africa
Pritchardia pacifica- Fiji
Pritchardia sps. - Hawaii

COMMELINACEAE
Commelina benghalensis - India
Rhoeo discolor - Bahamas

LILIACEAE
Sansevieria cylindrica - Africa
Sansevieria guineensis - Africa

AMARYLLIDACEAE
Furcraea gigantea - America

SANTALACEAE
Santalum ellipticum - Hawaii

POLYGONACEAE
Antigonon leptopus - Mexico
Coccolobis uvifera - Bahamas

CHENOPODIACEAE
Atriplex angulata - Australia
Atriplex halimoides
Atriplex semibaccata - Australia
Chenopodium oahuense - Hawaii
Kochia sp. - Australia

NYCTAGINACEAE
Mirabilis jalapa - Mexico

AIZOACEAE
Dorotheanthus criniflorus - Africa
Tetragonia expansa - New Zealand

PORTULACACEAE
Portulaca cyanosperma - Hawaii

PAPAVERACEAE
Argemone glauca - Hawaii

CAPPARIDACEAE
Capparis sandwichiana - Hawaii

CRUCIFERAE
Coronopus didymus - Europe
Lepidium o-waihiense - Hawaii

CRASSULACEAE
Kalanchoe tubiflora - Africa

LEGUMINOSAE
Acacia choriophylla - Bahamas
Desmanthus virgatus - Tropical America
Chamaecrista leschenaultiana - India
Dolichos lablab - Africa
Erythrina sandwicensis - Hawaii
Indigofera suffruticosa - West Indies
Medicago hispida - Asia
Medicago lupulina - Asia
Phaseolus lathyroides - Tropical America
Phaseolus trilobus - Asia
Sesbania tomentosa - Hawaii
Sophora tomentosa - South Seas
Tephrosia purpurea - Hawaii
Vigna marina - Hawaii

ZYGOPHYLLACEAE
Guaiacum officinale - Bahamas

MELIACEAE
Melia azedarach - India

SAPINDACEAE
Sapindus oahuensis - Hawaii

RHAMNACEAE
Colubrina asiatica - Hawaii

MALVACEAE
Abutilon mollissimum var. *sandwicense* - Hawaii
Gossypium brasiliense - South America
Gossypium tomentosum - Hawaii
Pariti tiliaceum - South Seas
Sida fallax - Hawaii
Thespesia populnea - Hawaii

STERCULIACEAE
Heritiera littoralis - South Seas
Waltheria americana - Hawaii

GUTTIFERAE
Calophyllum inophyllum - Hawaii

TAMARICACEAE
Tamarix aphylla - Asia

PASSIFLORACEAE
Passiflora foetida - Bahamas

CARICACEAE
Carica papaya - Tropical America

PUNICACEAE
Punica granatum - Mediterranean

LECYTHIDACEAE
Barringtonia asiatica - India

RHIZOPHORACEAE
Bruguiera sexangula - Malaya
Rhizophora mangle - Tropical America

COMBRETACEAE
Conocarpus erectus - Bahamas
Terminalia catappa - Malaya

PLUMBAGINACEAE
Plumbago zeylanica - Hawaii

OLEACEAE
Noronhia emarginata - Madagascar

GENTIANACEAE
Centaurium sebaeoides - Hawaii

APOCYNACEAE
Plumeria rubra - Tropical America

ASCLEPIADACEAE
Calotropis gigantea - Egypt

CONVOLVULACEAE
Ipomoea cairica - Egypt
Ipomoea cordofans - Africa
Ipomoea indica - Hawaii
Ipomoea japonica - Japan
Ipomoea pes-caprae - Hawaii
Ipomoea triloba - America
Jacquemontia sandwicensis - Hawaii
Operculina aegyptia - Egypt

BORAGINACEAE
Cordia subcordata - Hawaii
Heliotropium anchusaefolium - South America
Heliotropium curassavicum - Hawaii

VERBENACEAE
Stachytarpheta jamaicensis - Bahamas
Stachytarpheta urticaefolia - South America
Vitex trifolia var. simplicifolia - Hawaii

LABIATAE
Leonurus sibiricus - Asia
Marrubium vulgare - Asia
Ocimum gratissimum - India
Phloemis fruticosa - Yugoslavia (1953)
Plectranthus australis - Hawaii
Salvia coccinea - Mexico

SOLANACEAE
Capsicum frutescens - Tropical America
Lycium sandwicense - Hawaii
Lycopersicon esculentum var. galeni - South America
Nicandra physalodes - South America
Solanum nigrum - Hawaii

ACANTHACEAE
Asystasia gangetica - India

MYOPORACEAE
Myoporum sandwicense - Hawaii

RUBIACEAE
Canthium odoratum - Hawaii
Casasia clusiifolia- Bahamas
Morinda citrifolia var. Potteri - Fiji

CUCURBITACEAE
Citrullus vulgaris - Africa
Cucumis dipsaceus - Arabia
Momordica charantia var. abbreviata - Asia
Sicyos microcarpus - Hawaii

GOODENIACEAE
Scaevola frutescens var. sericea - Hawaii

COMPOSITAE
Bidens amplectens - Hawaii
Borrichia sp.
Eclipta alba - Asia
Gaillardia picta - Texas
Helianthus annuus - Kansas
Heterotheca grandiflora - California
Inula candida - Yugoslavia (1953)
Lipochaeta integrifolia - Hawaii
Lipochaeta romyi - Hawaii
Pluchea indica - India
Reichardia picroides - Southern Europe
Sonchus cornutus - Africa

After Degener with his efficient assistant returned to Hawaii from a week's stay on Canton in July 1950, he never expected to see the atoll again. From Honolulu, as per contract, he shipped the proper seeds, some in enormous quantities, and a few kinds of living plants, by CAA plane to their destination. Numerous residents of Canton, all busy with their professional duties, tried to sow the seeds during their spare time and even watered some choice plants with precious distilled water. But the task was so Herculean that the greater part of the shipments simply reposed in a warehouse, slowly deteriorating.

On the invitation of CAA for transportation and lodging, and PAA for meals, Degener volunteered his services for six weeks to bring the project to a successful close. Back on Canton in April 1951, he noticed numerous damselflies near the airport. Knowing these pretty, delicate insects to be aquatic in the larval stage, their presence proved the existence of fresh, or nearly, fresh water - SOMEWHERE!

The source was soon found - a rectangular body of water about 20 by 50 feet, and 3 to 4 feet deep. The site may have been excavated by some branch of the Armed Forces as an emergency source of water to fight conflagrations during the war. The sides were of wooden beams; the bottom, natural coral sand and rubble. The location, near a grove of "skayviolas" (Messerschmidia) not far from the airport, was ideal. It lay near the center of a wide part of the atoll's rim, just about right to take advantage of the so-called Ghyben-Herzberg lens.

Disturbing factors absent, this double-convex lens consists of a body of fresh ground water, originally derived from Canton rain, floating on top of the heavier sea water that has percolated under it from the ocean since prehistoric times (See Arnow, T., 1954, "The Hydrology of the Northern Marshall Islands"; Atoll Research Bull. 30, May.). Here, then, was a never failing source of water that barely tasted salty, regularly rising and falling with the tide, though with a certain lag in time, and in height and depth. With the help of a gang of Gilbert and Ellice Islanders under the kinky-haired Melanesian Seitoa, a wooden platform was built so that the fluctuation in water level would alternately cover it a few inches and then leave it exposed to drying. With such labor, it took little time to gather from a neighboring kitchen midden thousands of discarded tins, stab holes in them, fill them with the best earth available, and then plant seeds of the more ornamental plants therein. Many of the species shipped to Canton, as study of the accompanying list shows, are more or less halophytic - salt-loving or at least salt-tolerant. Naturally they throve, irrigated by every tide with an abundant supply of near-sweet water. By the time Degener left the atoll in May 1951, this self-watering nursery was green with seedlings of many kinds, available for any one who wished to plant them about their barren, arid grounds. Many of these plants survived transplanting, particularly when occasionally watered with waste from the dishpan or bath.

The great majority of the seeds, particularly of grasses, were scattered, hit or miss, over the atoll in likely places. Others were planted in holes made in the sand and rubble with the human heel or with the spade. To ascertain what species on Canton can survive and maintain themselves from year to year in spite of drought, salt, intense sunlight, insects, sea birds, voracious hermitcrabs and competition with other plants, will be of considerable importance not only to tiny Canton but to similar islands throughout the world. The Canton project will help show workers elsewhere what activities to repeat or modify and what pitfalls to avoid.

AQUATIC FLORA

A discussion of the aquatic flora and fauna hardly concerns the present immediate problem of augmenting the flimsy mantle of vegetation on Canton's arid rim of land. Yet were it not for the aquatic flora and fauna, Canton Island would not even be in existence. It consists almost entirely of the accumulated remains of coral, mollusk, sea urchin and star fish, coralline alga, pink foraminifera shell, and the droppings of sea birds that have eaten free- swimming organisms of the open ocean as food. The terrestrial hermitcrabs that are such a hazard to the land plants are aquatic in their larval stage. So with the importance of the sea life in mind, the reader will perhaps excuse a continuation of this article about Canton. It will be brief, not purposely, but because of our present ignorance. This state of affairs should stimulate the resident having a flair for biology to spend some of his spare time collecting the yet unknown plants and animals of Canton to ship to eager specialists at the Bishop Museum and elsewhere for technical study. The amateur collector and careful observer on Canton, collaborating with the museum expert surrounded by his musty books and pickled specimens thousands of miles distant, can solve so many fascinating and important puzzles. As such knowledge accumulates, a more complete article than the present one can be written for later readers. This one is but a beginning and barely scratches the surface.

Of blue-green algae, no one had collected any specimens previous to 1951, thus leaving practically an open field for a local resident in pursuit of an important hobby. The three specimens collected that year were actually found on land, but are being classified as aquatic because they developed mainly during an unusual period of rainy weather or were found in ditches occasionally subject to flooding by rain or tidal seepage. They are hardly land plants. Though microscopic, such plants, because of their enormous numbers, may help bind sand grains together and reduce drifting. This action may be mechanical, by means of the gelatinous plant surface, as well as chemical, by the liberation of carbon dioxide and the partial dissolving of the calcareous sand grains followed by cementation.

Microcoleus paludosus (Degener 21,341) forms a tough gelatinous coating over the surface of the sand on the atoll rim during periods of rainy weather. Of the blue-green algae on Canton it is the most useful sand binder.

Porphyrosiphon sp. (Degener 21,338) grows on or in the sand during periods of rainy weather but does not form a gelatinous coating. It is similarly useful, but to a lesser degree.

Scytonema hofmannii (Degener 21,347), like the previous two species, is dormant during dry weather. Soon after the coming of rain, it reproduces prodigiously, often washing into puddles in loosely flocculent masses to stain them a pale olive green.

A blue-green alga, not yet identified, is paradoxically beautifully pink. It imparts its color to extensive areas of drying salt flats near the narrow end of the atoll, occurring among crystals of sea salt.

Of the green, brown and red algae, commonly known as seaweeds, we likewise know very, very little so far as Canton is concerned. Some are important reef builders while others constitute the fundamental and first link in the complicated food chain terminating, we like to believe, in serving the highest type of organism, man, at the dinner table and elsewhere. It is an old story known to most of us but worth repeating.

These plants, bathed by sea water, actually a nutrient solution or nourishing soup to them, vary in size from the microscopic to about a foot in length, like the Turbinaria and the

Sargassum that are cast ashore so often. Employing sunlight as a source of energy - an activity not ordinarily possible to members of the Animal Kingdom - they manufacture sugar, starch and allied products for the purpose of growth and activity. Minute and often humble animals like worms, mollusks and crustaceans browse upon these algae for food. These animals in turn usually end up as food for larger and ever larger kinds until we realize that our economic fishes, sea birds, seals and even whales are, in a sense, simply reincarnations on a higher plane of the energy of algae originally trapped from the sun.

If conditions for the growth and abundance of algae are favorable, as along the Humboldt Current of South America, the surrounding water and air just teem with valuable fish and sea bird life. If conditions for algae are unfavorable, however, fish and bird life are scant, and our dining table may be missing a fish course and, as lack of guano fertilizer makes farming expensive, an extra vegetable or a salad. Thus the fluctuation in the growth and abundance of algal life in the ocean may affect man most intimately.

The first true alga collected on Canton may be Turbinaria ornata (F. & W. 30,213), gathered by Fosberg and Walker January 30 - 31, 1949. Subsequent collections, made mostly by Degener in abundance in 1951 and eventually to be deposited in the herbaria of the New York Botanical Garden, the Bishop Museum and elsewhere, were turned over to Dr. Maxwell Doty and kindly identified by him as follows:

CHLOROPHYTA

Ulvaceae

Enteromorpha sp. (Degener 23,660)
Ulva lactuca ? (Degener 23,661)

Cladophoraceae

Cladophora sp. (Degener 23,662)
Cladophoropsis membranacea (Degener 23,663)

Caulerpaceae

Caulerpa crassifolia (Degener 23,664)
Caulerpa peltata (Degener 23,665)
Caulerpa serrulata (Degener 23,666)

Valoniaceae

Dictyosphaeria cavernosa (Degener 23,667)
Valonia sp. (Degener 23,668)

PHAEOPHYTA

Fucaceae

Turbinaria ornata (Degener 23,669)

RHODOPHYTA

Gelidiaceae

Gelidium sp. (Degener 23,670)

Gigartinaceae

Ahnfeltia concinna (Degener 23,671)

Sphaerococcaceae

Gracilaria lichenoides ? (Degener 23,672)
Hypnea spinella (Degener 23,673)

Rhodomelaceae

Chondria sp. (Degener 23,674)
Herposiphonia tenella (Degener 23,675)

Ceramiaceae

Centroceras clavulatum (Degener 23,676)
Ceramium sp. (Degener 23,677)

Grateloupiaceae

Halymenia sp. (Degener 23,678)

Corallinaceae

Jania capillacea (Degener 23,679)
Lithothamnion sp. (Degener 23,680)

Among diatoms, a species of Navicula (Degener 21,337) was collected.

AQUATIC FAUNA

No worms seem to have been recorded from Canton thus far. Degener in 1951 observed some wide, colorful planarians, and under rocks on the ocean reef worms (Eurythoe pacifica) armed with stinging bristles; and earthworm-like worms in the fine sand of shallow areas of the lagoon. Lack of proper equipment, unfortunately, made their collecting impracticable at the time.

Apparently the first starfish ever collected was Linckia multifora (No. 271) by Bryan in 1925. Degener collected L. diplax (No. 1205) and a serpent star (No. 1206) twenty-six years later on the ocean reef. He of course observed sea urchins. Their spines can inflict dangerous wounds. Corals and sponges are everywhere, yet remain to be collected and studied. These can cause scratches and abrasions that at first sight appear trivial yet may cause stubborn ulcers. Application of a poultice wet with a solution of epsom salt to such wounds is a useful home remedy that may forestall the need of visiting a physician later. Mollusks are probably the best known of the marine animals native to the atoll. Though somewhat disappointing in form and coloration for what one would ordinarily expedt on a tropic island, they are so easy to preserve that most people wandering along the shore gather them in a casual way. There have been some serious amateur collectors whose finds may have reached museums for determinations, but where is not presently known. Determination of the mollusks, collected chiefly by Degener, was begun by Dr. Louis Brand of Cincinnati and continued by Mr. A. Wmay Harris of Honolulu. Due to the latter's untimely death on December 17,1953, the complete list of Canton mollusks will appear as a supplement in the Hawaiian Shell News. The shipworms presently known from the atoll are:

Teredo samoaensis (R. S. Danner), 1941.
Teredo gregoryi (Van Zwaluwenburg), 1941.
Teredo bensoni (C. H. Edmondson), 1940 (?). This new species of shipworm was discovered in the "dredger Benson on its return to Honolulu after completing operations at Canton Island."

Nonmicroscopic crustaceans are abundant in species where coral or other kinds of rocky marine shelves and shores exist. There they find suitable shelter and food. The unusually salty lagoon of Canton with its barren sand and choking calcareous mud, particularly distant from the channel, is like a desertton land, able to support but little life. But the collector who can search the steep ocean bottom about Canton's rim from a depth of about 25 fathoms to the limit of high water will be rewarded with innumerable species never before recorded. Thus far the only crustaceans known to the writers from Canton, mostly from the ocean side, are the following: They were identified for the most part by Dr. C. H. Edmondson. Due to an oversight, original ecological data on the labels were discarded in transferring the specimens to permanent museum jars for preservation.

Limnoriidae

Limnoria multipunctata (U.S.N. Survey 5734), 1950. An isopod destructive to wood exposed to sea water, by excavating small burrows in it.

Palaemonidae

Anchistus miersi (Degener), 1951.

Stenopodidae

Gonodactylus sp. (Degener 5658), 1951.

Pontoniidae

Conchodytes meleagrinae (Degener 5685), 1951. A shrimp living in the mantle of the tridacna.

Coenobitidae

Coenobita perlatus (Degener 5661, 5662), 1951. The ubiquitous land hermitcrab; listed by Luomala in 1951 as C. olivieri.

Paguridae

Calcinus elegans (Degener 5665), 1951. A hermitcrab with orange markings.

Calcinus elegans var. (Degener 5669). The blue variety of the above; more abundant.

Calcinus herbstii (Degener 5666 - 5668), 1951. A hermitcrab, brown and white.

Clibinarius corallinus (Degener, 5670, 5671), 1951.

Porcellanidae

Pachycheles pisoides ? (Degener 5684), 1951. Not a typical crab though like one in appearance.

Inachidae (Majidae)

Micippa patypes (Degener 5667), 1951.

Portunidae

Thalamita picta (Degener 5682), 1951. A very active crab, running as well as swimming.

Xanthidae

Actaea sp. (Degener 5675),1951.

Carpilodes bellus (Pan American World Airways 5449), 1949.

Chlorodopsis scabricula (Bryan 2386), 1924.

Chlorodposis areolata (Degener 5677),1951.Common; legs hairy.

Eriphia scabricula (Degener 5678), 1951.

Eriphia laevimana (Degener 5672), 1951.

Leptodius sanguineus (Degener 5679), 1951.

Phymodius ungulatus (Degener 5683), 1951.

Polydectus cupulifer (Degener 5663), 1951. Crab carrying sea anemones.

Grapsidae

Geograpsus grayi (Degener 5681), 1951.

Metopograpsus messor (Degener 5680), 1951. Crab of mud and rocks, often going into brackish water.

Pachygrapsus minutus (Degener 5676), 1951. Crab of mud and rocks of lagoon shore and often crawling onto land.

Percnon planissimum (Degener 5664), 1951. Very active crab walking upside down on under side of flat rocks along reef.

Ocypodidae

Ocypode ceratophthalma (Degener 5659), 1951.

Lepadidae

Lepas anatifera (Van Zwaluwenburg 302), 1941. A goose barnacle.

Scalpellidae

Lithotrya pacifica (Degener 386), 1951. A stalked barnacle on reef exposed at low tide.

Fishes are plentiful and colorful. Casual observation of reef fishes of Canton by one familiar with those of Hawaii will reveal a high proportion of species common to both areas. Yet. usually a subtle difference is observable perhaps in color, shape or activity, differences lost upon death and preservation for later study in a museum. Too, food fishes that are wholesome in Hawaiian waters and elsewhere may be poisonous in Canton, especially if caught in the lagoon. Savory looking red snapper and rock cod are usually poisonous to eat. Such fish when eaten may cause paralysis, at times severe enough to endanger life unless the prompt aid of a physician is sought. This fact suggests that plant or microscopic animal life, the source of fish food, is fundamentally responsible. This problem presently is being investigated by Dr. S. Gregory Ross and a very few other pioneer workers. Sharks, sting rays and moray eels are common in the lagoon, making bathing exciting if not dangerous. Of course, all these creatures, when caught by birds, may add to form guano deposits of the future. Fishes of Canton are studied in Schultz' Fishes of the Phoenix and Samoan Islands collected in 1939 during the expedition of the U.S.S."Bushnell," Bull. U.S.N.M.180:1943.

Except for this the scientific study of the fishes of Canton is still in a preliminary stage. The first fishes collected for serious study appear to be Eviota viridis (E. H. Bryan, Jr., 4819) and Echeneis remora (Bryan 4895) in March 1924.

Land Fauna

The land fauna of Canton is meagre. The only wild mammal noticed was a single rat which ran with a strange jogging gait across the road at night before the car. It lost itself in a maze of trunks and twigs of a frigate bird rookery of scaevola bushes far from human habitations. It was the Polynesian rat whose ancestors may have reached the atoll in the double canoe of some adventurous Polynesian centuries ago, or perhaps on a larger vessel during the later guano digging days. It is not unlikely that the kou reached the island on the same canoe or vessel with the Polynesian rat. Besides man, of all possible ethnological strains imaginable, who is now furiously changing the sleepyatoll to his peculiar aims, the only other introduced mammals are dogs and cats. The dogs are of many breeds, have many friends and many masters, and are treated far more humanely than in the Hawaiian Islands where neglected, starving and mangy curs abound. None of these dogs is thus forced to run wild to forage for itself, a habit that might be disastrous to the rookeries. Some, strangely enough, enter the shallow water of the lagoon for their peculiar form of sport fishing: pouncing upon an occasional unwary mullet that may swim by. Cats, escaped from domestication, have run wild and obviously take their toll of nesting sea birds.

All Canton crustaceans have aquatic larvae. But a few crustaceans have become adapted for life on land toward maturity. Such, for instance, are the fiddler crabs. I observed hundreds of these brilliantly colored, gregarious animals about their burrows in the pale mud along the lagoon's edge. But the crabs that are really best adapted to terrestrial life, arouse interest and cause worry are the countless small pale hermitcrabs Coenobita perlatus. Every small dead spiral mollusk shell - there must be hundreds of thousands available about Canton - houses one of these lopsided, soft abdomened animals. They are particularly numerous feeding on the jetsam along the beach facing the lagoon, and also penetrate inland. Here they may be found seeking protection from the heat of the day under branches, fallen leaves and coral slabs, and in shaded crevices. As these crabs increase in size their housing shortage, for lack of an abundant supply of large mollusk shells, must be so acute as to cause a catastrophe eventually among them. Only those that can find the comparatively rare, catseye shell (Turbo), measuring up to about three inches in diameter, survive. Even so, these mature hermitcrabs, now red like boiled lobsters, are numerous enough to over-run the island. To be sure, they are useful scavengers, cleaning the rookeries of dead fledglings, the shores of dead fish and lobsters and the land, in general, of all dead animal matter. But as this supply is certainly insufficient to keep these creatures well fed, they obviously must feed also on plants, those living miles from the rookeries being per force mainly vegetarian. They seem to browse among the vegetation, and even climb kou trunks and branches as high as four and a half feet in search of food. They eat the bark along the upper side, most kou trees showing long scars, the result of past injury. A common habit, especially of the less heavy individuals is to cleverly tear off and eat only the ovary and stamens of the flowers of *Portulaca lutea* and of the local *Sesuvium*. In the latter, I also observed them boring out of the ovary the ripening seeds for food, These are certainly not isolated acts, but ones perfected by practice and perhaps instinct. They probably decimate the flora, feeding particularly on tender seedlings of certain species, which ones have not yet been determined. I believe these hermitcrabs are largely responsible for the paucity of different kinds of plants on Canton, any seeds of new kinds of plants washing to its shores being subject to their inspection on germination and, if palatable, sacrificed to their appetite. The foreign plants now being introduced as seeds and seedlings to Canton likewise must not only surmount the drastic conditions of drought and salinity, but must surmount the hurdle of voracious hermitcrabs.

Though a nuisance in many ways, these land hermitcrabs are used as bait and as chumming material. They are interesting and, to Canton, economically important creatures. We know far too little about them. A complete life history would be a fascinating problem for some resident of Canton to work out during his spare time. In the month of April, for example, the females carry their numerous maroon eggs attached to their abdomens. When do they return to the ocean to allow these eggs to hatch their free-swimming larvae, that resemble so closely the shrimp-like ancestor of all hermitcrabs? Where do the hermitcrabs molt their hard unexpanding shells as they grow in size? Do they do so in burrows on land or in the ocean? How, with gills adapted for respiration in water, have they perfected respiration on land? How long do they live? Must they leave their borrowed mollusk shell kilt to defecate, or can they remove their body wastes otherwise? I have observed a loving pair beside a bunch of grass not too tenderly clawing at one another with legs and chelipeds, at the same time uttering their subdued *chick, chick, chick, chick* - *chick, chick, chick, chick* love song. How do they emit this sound without a voice or hear it without ears? Scores of similar questions remain to be answered, not all academic ones.

Native spiders are rare in kinds. The wolf spider, which weaves no web, is everywhere, running about in the open on the ground in search of insects. It is very beneficial to the atoll, probably the most efficient insect killer, the second being the migratory plover. The female carries its flat egg case wherever it goes. This spider not only sucks the juices of its victim but comminutes, like its common relative the house spider of

Hawaii, their bodies to almost dust-like particles. A spider found more often in abandoned shacks and bushes is Latrodectus geometricus. It is mostly immobile in its sprawling web, and parks its spherical egg cases in a corner of it. Though related to the infamous black widow, no cases of bites from this arachnid are known from Canton.

The number of native species of insects are few, as expected considering the difficulty for these small terrestrial creatures crossing extensive wastes of ocean to Canton and, when once there, finding suitable fare with such a limited flora. There is some injury to native plants by native insects, but in the main this is not serious. They have always been exposed to such depredations, and survived. What is, however, very serious is the habit of amateur plant lovers introducing plants of their choice by boat and plane from Fiji, Hawaii and elsewhere without fumigation against insect pests. As a result Canton Island is a safe, enemy free Paradise for some foreign insects such as mealy bugs that harass native and introduced grasses, scale insects that weaken coconut palms about the hotel grounds, crater scale on the single remaining Plumeria, etc. This unnecessary introduction of insect pests not only adds one more hurdle for plants to surmount for survival, it likewise makes Canton a very dangerous stepping stone for the passage of injurious pests to and from all regions touched by planes using the atoll for refueling or otherwise. An up-to-date list of insects of Canton, collected by Van Zwaluwenburg, Degener and others, will be found in Atoll Research Bulletin 42, by R. H. Van Zwaluwenburg.

Amphibians are entirely wanting. Of reptiles a gecko with its glue-tipped toes may climb slowly about the island shrubbery, driftwood and rocks at night for insects; and a graceful skink, differing in color from those in the Hawaiian Islands, may rush over the level sand and smooth rocks during the day for his fare. This last, if careless, may be snapped up for food by the migratory plover. A turtle may occasionally climb out of the sea to lay her eggs in the warm sand of the beach. No other reptiles occur.

Of birds Bryan recorded the following from the Phoenix Islands: "the frigate or man-o'-war; three species of boobies or gannets; the red-tailed tropic bird or bos'n bird; several species of terns, including the sooty, gray-backed, noddy, small noddy, white, and gray; three or more species of petrels and shearwaters. Several kinds of migratory birds are to be found in the winter, during their migrations; a few may be found at other times. These include the curlew, Pacific golden plover, wandering tatler, turnstone, and a few others." The boobies and frigate birds take up a stretch of about eight miles of Canton for their rookeries. There are no native land birds on Canton, but about the British community the Gilbertese residents own interesting looking chickens, which never stray far.

A few red-tailed tropic birds (Phaeton rubricauda) nest under thick tangles of sida bushes or in cavernous retreats under coral rock ledges. They make a frightening, metallic, machine like noise when disturbed. These birds affect vegetation but little.

Black, vulture-like frigate birds (Fregata minor palmerstoni), known in Hawaiian as iwa or "thief," are extremely common, nesting by the thousands in the scaevola bushes and very rarely on bunch-grass. After driving through such a rookery, our windshield and car body were found to be finely bespattered with minute droplets of whitish excrement, that had rained down from the birds flying overhead. Occasionally a parasitic Hippoboscid louse fly, looking like a large flattened black housefly, is knocked off a frightened bird and flies to the car, mistaking its dark body for that of its host.

The nests are coarse, excrement soiled and cemented affairs constructed of twigs and driftwood. During rare downpours, this filthy binding material may dissolve away, allowing the eggs to fall to the ground. Nesting material is evidently rare and highly prized, giving rise to cases of theft, a bird in flight occasionally filching a loose piece from a carelessly guarded nest. The iwa will even stoop to murder and cannibalism, flying off with an egg or newly hatched young to eat on the wing. There is usually one egg to a nest, entirely white and a bit larger than that of a chicken. Both sexes take turns setting on the egg, and later sitting on or over the growing chick. This is not only necessary to incubate the egg and later keep the chick warm in cool weather, but also as protection from too intense sunshine. At that time the males are resplendent with blood red, semitransparent throat pouches blown to balloon size, extending forward to the beak and downward to hide the breast. This color is supplied by innumerable blood-filled capillaries in the tissue of the pouch.

Not far from the rookeries of the iwa or frigate birds, which act like the harpies of Greek mythology in stealing food from the more industrious, are the rookeries of the stupid red-footed boobies or gannets (Sula sula rubripes). The name booby is from the Spanish word bobo, meaning "dunce" or "idiot." At times the rookeries of the aggressive marauder and boob-victim overlap at the edges. The nests of the booby contain a single white egg or a fluffy fledgling apiece.

According to T. Truman Wright,* the frigate birds "escort the stupid, spoon billed Ganets out to feed on schools of squid and small fish. When the Ganets get craws full and set sail for home to feed their young, the cruel curve beaked Frigates dive screaming after them, seize them by the tails and sling the food out of the smaller birds' mouths, which the Frigates scoop up on the wing. This goes on from dawn to dusk. The war cries of the Frigates and the plaintive screams of fleeing Ganets

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*Wright, T. T., Canton Coral Capers, Trade Winds, Mimeographed publication by C.A.A., July 1951.

quiver down the trade winds like the wailings of lost souls."

It is commonly reported that frigate birds, lacking webbed feet, never land on the surface of the water because they cannot take off again. This is not true. I have seen a small flock of them playfully land, float and rise again from the placid surface of the lagoon.

The birds nesting in the scaevola are tame or, depending upon one's point of view, too innocent and stupid to fly from their nests when approached. The explanation for this habit is their nesting from time immemorial in areas where no predatory animals, two- or four-legged, have ever existed. Tame birds were not killed off but survived to reproduce their kind. Now, unfortunately, Pacific islanders employed as laborers, occasionally club the nesting birds at night, preparatory to a feast. Such vandalism and resulting pandemonium in the rookeries should be stopped by legislation in a condominium involving two great humane nations.

The ancestors of these and other kinds of sea birds have inhabited Canton Island during the nesting seasons ever since its existence, catching fish, squid and other sea life for food for themselves and their fledglings. Their droppings have accumulated and, because of the climate, have only in part leached away - certain constituents disappearing faster than others. The remaining decomposed and more or less fossilized excrement is known as guano, rich in phosphates, ammonium oxalate and urate. Because of its commercial value as fertilizer, Canton, as we have learned before, first received attention from man.

Canton, a Beautiful Oasis in a Desert of Ocean

When the native flora, as in the case of Canton, is incapable of covering the land to protect it from blowing away and from making it decently habitable for man, proper exotics should be introduced to meet this lack. In 1950, as mentioned above, CAA therefore engaged the writer to begin to improve Canton floristically. Though a good beginning has been made, present residents should not remain satisfied. The seeds of so many more desirable and beautiful plants suitable for Canton are waiting for them in the arid, saline regions of the tropics. They can import these to make their atoll an ever more beautiful oasis in a desert of ocean. They can show how bare islands through the tropics can be made decently livable for the ever-increasing hordes of mankind seeking a place in the sun - a fascinating challenge!

Appendix A

Excerpt from a letter to the author from Mr. Myron H. Kerner, Meteorologist In Charge, U. S. Weather Bureau, Canton Island, dated Nov. 25, 1954..

The statements regarding the local heating effect are in serious variance with the accepted theories. If vertical currents are created by local heating of the atoll of Canton, the effect would increase the amount of cloudiness and resulting rainfall, not divert it. As air is lifted, it is cooled adiabatically and if lifted far enough, will condense. Lifting may be caused when air is heated locally or when it climbs up the slope of terrain or up the slope of a more dense air mass or by converging air masses. Once started and with the initial force removed, it may or may not continue to rise, depending upon the vertical temperature distribution of the air mass. If the atoll afforded any of the lifting forces there should be a marked increase in cloudiness as a result but there appears to be no difference in cloudiness between that over the atoll and that over the ocean. In my 16 months of continous duty here, I have never observed any deviation in a cloud's course due to the island and there appears to be no reason to believe that the island has any effect on the rain.

Our precipitation is caused in three different ways. There are always some cumulus present; these are probably a result of local heating due to distant variation in the sea surface and converging air. Precipitation from these clouds is infrequent, light and spotty. The greatest amount occurs when the inter-tropical convergence zone (the narrow band where the trade winds converge on the doldrum belt giving large scale up lift to the air resulting in thunderstorm activity and copious rain showers) lying to the south of us moves over us for a few hours to a few days. Then Canton may get several inches in a day. The third source of precipitation results from small scale equatorial low pressure systems that move slowly from the Gilberts. The occurrence of precipitation from either of these latter two reasons is very irregular, which accounts for Canton's being a place of great extremes in seasonal precipitation.

However, there does appear to be a diurnal variation in precipitation, based on 26 months of record available since the installation of our recording rain gage. This period is still too short to come to any quantitative conclusions, but during this time over one half of the precipitation fell between the hours of midnight and 8:00 a.m. Of course, the diurnal variation in ocean temperature results in a slightly greater instability at night and we should expect more cloudiness then.

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No. 42

The insects and certain other arthropods of Canton Island

by

R. H. Van Zwaluwenburg

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The Insects and Certain other Arthropods of Canton Island

R. H. Van Zwaluwenburg

The basis of the present list of arthropods known to occur on Canton Island, in the Phoenix group, is the writer's paper "The Insects of Canton Island", which appeared in 1943 in the "Proceedings" of the Hawaiian Entomological Society (vol.11: 300-312). Ninety-six species were listed in that paper. Since then, following increased air transportation to and from Canton during the recent war, several additions have been made to the fauna of the atoll. Besides including the new records, the present list corrects a few earlier errors of identification, omits some doubtful records, and supplies synonymous names whenever these have been discovered.

CRUSTACEA

Isopoda

Metaponorthrus pruinosus Brandt. Under heaps of old coconuts.

Undetermined sp. Found in similar locations with the preceding sowbug.

Amphipoda

Undetermined sp. Beneath stranded timbers on the lagoon beach.

ARACHNIDA

Scorpionoidea

Isometrus maculatus Degeer. Occasionally found in buildings.

Araneida

Lycosidae

Undetermined sp. In and about buildings.

Sicariidae

Scytodes sp.

Oonopidae

Gamasomorpha minima Berland. Described from Canton Island in Bishop Museum, Occ. Papers, 17 (1): 5, 1942.

Pholcidae

Undetermined sp. A single specimen in a building, September, 1941.

Theridiidae

Latrodectus mactans (Fabricius). The black widow spider was first found on Canton in July, 1949.

Argiopidae

Undetermined sp. The orb-webs of a spider are conspicuous about buildings.

Acarina

Gamasidae

Laelaps sp. On the ground-nesting Polynesian rat. Dr. C. E. Pemberton studied this material and reports that the Canton species more closely resembles Laelaps hawaiiensis Ewing, than L. echidninus (Berlese).

Listrophoridae

Listrophorides sp. A hair mite on the Polynesian rat.

Oribatidae

Undetermined sp. In vegetable mould under Sesuvium plants.

Ixoidea

Argasidae

Ornithodoros sp. The exuvium of an argasid tick was found on a shrub; no other material is available.

MYRIOPODA

Chilopoda

Mecistocephalus maxillaris (Gervais). In soil beneath old coconuts, and under sacking in outbuildings. The species is probably the same as that occurring in Hawaii.

INSECTA

Thysanura

Lepismidae

Undetermined sp. A single specimen among papers.

Collembola

Entomobryidae

Undetermined sp. One or more species in moist soil beneath old coconuts.

Orthoptera

Blattidae

Cutilia soror (Brunner). Under bags on the beach, and in soil beneath fallen coconuts.

Periplaneta americana (L.). Common both indoors and out.

Pycnoscelus surinamensis (L.). This cockroach was found under coconuts.

Supella supellectilium (Serville). A single specimen was found indoors, November, 1940.

Blatta sp. Collected in the housing area by Degner in April, 1951.

Gryllidae

Gryllodes sigillatus (Walker). Numerous in dwellings.

Tettigoniidae

Aiolopus tamulus (Fabricius). First noted on Canton by N.L.H. Krauss in September, 1950, and more recently reported to be numerous. One of the few grasshoppers which is attracted to lights.

Note- The record of *Conocephalus saltator* (Saussure) from Canton was based on a dead specimen taken to the island in glassware from Honolulu; it should be deleted from the list.

ISOPTERA

Kalotermitidae

Kalotermes immigrans Snyder. Dr. A. E. Emerson considers *Calotermes curvithorax* Kelsey to be a synonym; this latter name was proposed for termites first found on Canton in May, 1937.

EMBIOPTERA

Oligotomidae

Oligotoma saundersii (Westwood). Not uncommon under dead birds, in soil beneath old coconuts and in debris of rats' nests.

DERMAPTERA

Labiduridae

Anisolabis eteronoma Borelli. A single specimen was found among plants brought from Honolulu in June, 1941. The species probably is not established on Canton.

ODONATA

Libellulidae

Diplacodes bipunctata (Brauer). First noted in June, 1941.

Pantala flavescens (Fabricius). First noted on Canton in February, 1941. Dragon fly populations on Canton presumably die out during adverse periods, but are continually being recolonized by adults flying in from other Pacific islands.

CORRODENTIA

Liposcelidae

Undetermined sp. Taken in vegetable mould under Sesuvium bushes.

Peripsocidae

Ectopsocus perkinsi Banks. One specimen collected by N. L. H. Krauss in September, 1950, was identified as this species by Dr. D. E. Hardy.

HOMOPTERA

Cicadellidae

Orosius argentatus (Evans). The synonym, Nesaloha cantonis Oman, was described from material first collected on Canton in August, 1940. This leafhopper has a wide range in the Pacific. On Canton it was numerous on Boerhavia diffusa and is suspected of being a possible vector of a "yellows" disease of Boerhavia leaves.

Aphididae

Aphis gossypii Glover. Very common on Portulaca lutea and on the introduced Coccolobis uvifera; less common on Sida fallax and Scaevola.

Coccidae

Asterolecanium pustulans (Cockerell). On Sida and on the introduced Thespesia populnea. Probably an intorduction from Hawaii.

Chrysomphalus aonidum (L.). On coconut foliage and on introduced Callophyllum.

Coccus hesperidum L. On introduced milo and oleander; an accidental immigrant, probably from Hawaii.

Pinnaspis strachani (Cooley). This is the species previously listed from Canton as Hemichionaspis minor (Maskell), a misidentification. On Canton it was found on Tournefortia argentea.

Pseudococcus palmarum (Ehrhorn). On coconut; this is the species listed as Ripersia palmarum in the 1943 list of Canton insects.

Pseudococcus adonidum (L). On Scaevola; this is the species which earlier was recorded as P. longispinus (Targioni-Tozzetti).

Saissetia hemisphaerica (Targioni-Tozzetti). A probable immigrant from Hawaii, on introduced plants such as Hibiscus tiliaceus and Calotropis gigantea ("crown flower").

Undetermined sp. A mealybug was common on Sida, on the stem at the base of the plant, and on the leaves, which were distorted as a result of the infestation.

HETEROPTERA

Cynidae

Geotomus pygmaeus (Dallas). At light.

Pentatomidae

Oechalia, probably consocialis (Boisduval). Nymphs and adults of this bug were taken in the housing area on Canton by Otto Degener in April, 1951. It is probably consocialis which is a widespread species in the Pacific and occurs on Fanning and Christmas islands to the northeast of Canton.

Nabidae

Nabis capsiformis Germar. This predaceous bug is common on low herbage; it was recorded earlier under the generic name Reduviolus.

Miridae

Campylomma near hawaiiensis Usinger. Collected in the housing area in April, 1951 by Otto Degener.

Trigonotylus brevipes Jakowlef. A nearly cosmopolitan grass-inhabiting bug. Two specimens were collected by Van Zwaluwenburg in August, 1940.

Cyrtorhinus zwaluwenburgi Usinger. Described from material swept from Boerhavia in 1940 ("Proceedings", Hawaiian Entomological Society, 12 (1): 148, 1944). Dr. Usinger suggests that this species which preys on leafhopper eggs, may, in the absence of Delphacidae on Canton, be feeding on the eggs of the cicadellid, Orosius argentatus (Evans).

Note- The undetermined mirid listed in the 1943 paper was later identified by Dr. R. L. Usinger as Pycnoderes quadrimaculatus Guerin. The species has not been seen on Canton since 1940, and there is good reason to believe it was brought there from Honolulu in a collecting bottle.

Gerridae

Halobates micans Eschscholtz. This marine strider is often found stranded on the ocean beach at Canton.

COLEOPTERA

Carabidae

Tachys mucescens Blackburn. Two specimens at light in June, 1941. Identified by E. C. Zimmerman as this species, known previously only from Hawaii.

Tachys sp. A single specimen in the hotel kitchen, March, 1941.

Histeridae

Carcinops quatuordecimstriata (Stephens). In bird droppings under rockeries.

Corynetidae

Necrobia rufipes (Degeer). The "copra" or "ham" beetle.

Elateridae

Conoderus pallipes (Eschscholtz). First taken on Canton by Otto Degener, in May, 1951.

Dermestidae

Dermestes cadaverinus Fabricius. Adults in dead mollusk shells.

Nitidulidae

Carpophilus hemipterus (L.).

Coccinellidae

Harmonia arcuata (Fabricius). Often numerous on Sida, the adults clustering on the undersides of the leaves. Also associated with Aphis gossypii on Scaevola; on Boerhavia the larvae have been observed to feed on droplets excreted by Orosius.

Anthicidae

Anthicus oceanicus Laferte. Under dead seabirds.

Tenebrionidae

Gonocephalum adpressiforme Kaszab. First taken on Canton in January, 1951, by Dr. P. M. Corboy. Occurs also on Luzon in the Philippines, and on Oahu.

Scarabaeidae

Pleurophorus parvulus Chevrolat. A single specimen taken in July, 1941.

Saprosites pygmaeus Harris. One specimen in soil under old coconuts, September, 1940.

Anthribidae

Araecerus vieillardi (Montrouzier). First taken on Canton by Otto Degener, April 28, 1951.

Curculionidae

Calandra oryzae (L.). In hotel kitchen.

Dryotribus mimeticus Horn. Two specimens taken by N.L.H. Krauss in September, 1950.

LEPIDOPTERA

Tineidae

Petrochroa dimorpha Busck. This tiny moth feeds in the dead trash about bunchgrass clumps, and is often exceedingly abundant. It occurs on Wake Island also.

Hyposmocomidae

Aphthonetus sp. Taken at light; first noted in October, 1940.

Pyralidae

Hymenia recurvalis (Fabricius). Adults come to lights; the larvae will probably be found to feed on Amaranthus on Canton.

Arctiidae

Utetheisa pulchelloides Hampson. Breeds on Tournefortia, on the leaves of which the early stages of the larvae produce a "window pane" effect.

Phalaenidae

Achaea janata (L.). The larvae feed on Cordia subcordata.

Amyna octo Guenee. The green caterpillars feed on Sida leaves.

Heliothis armigera (Hubner). The notorious "corn ear" worm, or "tomato worm".

Laphygma exempta (Walker). The larvae of this armyworm feed on bermuda grass, and on the bunch grasses, Digitaria pacifica and Lepturus repens. An egg-parasite, Telenomus nawai was introduced from Honolulu in 1941, and promptly began breeding in Laphygma eggs; it is not known if it still survives on Canton.

Prodenia litura (Fabricius). On Canton the larvae of this destructive species feed on *Lepturus*, *Digitaria*, *Sida*, tomato and sweet-potato.

Undetermined sp. Irregular feeding holes are common on *Scaevola* leaves, made by a bright-green caterpillar probably belonging to this family of moths. The damage is conspicuous, but during my stay on the island caterpillars were rare. Apparently they feed by night and hide in the sand during the day. Attempts to rear caterpillars to the adult stage were unsuccessful.

Danaidae

Danaida plexippus (L.). Occasional tattered specimens of the monarch butterfly were seen on Canton during 1940 and 1941, but the species was not breeding there at that time. Since then occasional fresh specimens have been taken which suggest that they are breeding locally, perhaps on the introduced crown-flower.

Nymphalidae

Hypolimnas bolina (L.). Well established in 1941 and breeding on *Sida*.

DIPTERA

Mycetophilidae

Undetermined sp. On soil under old coconuts.

Tendipedidae

Undetermined sp. On native vegetation.

Sciaridae

Undetermined sp. On vegetation.

Dolichopodidae

Chrysosoma sp.

Hydrophorus sp. Abundant on brackish pools.

Syrphidae

Ischiodon penicillatus (Hull). This fly was misidentified as *Ischiodon scutellaris* (Fabricius) in the 1943 list.

Lonchaeidae

Lamprolonchaea aurea (Macquart). First taken on Canton by Krauss in September, 1950; identified by D. E. Hardy.

Otitidae

Pseudeuxesta prima Osten Sacken. Determined by D. E. Hardy. A synonym is Euxesta semifasciata Malloch. This is probably the Euxesta sp. of the 1943 list, on bits of organic matter along the beach.

Scholastes bimaculatus Hendel. Breeds in rotten meat of green coconuts.

Tethinidae

Tethina insularis Aldrich.

Ephydridae

Hecamede persimilis Hendel.

Paralimna lineata de Meijere. Collected in November, 1940 by R. R. Danner; identified by Dr. W. W. Wirth.

Scatella sp. On brackish ponds.

Agromyzidae

Ophiomyia scaevolae Frick. A leafminer in Scaevola frutescens; it is parasitized by a eulophid, Pnigalio sp. The description of O. scaevolae appeared in the "Proceedings" of the Hawaiian Entomological Society, 15:209, 1953.

Milichiidae

Desmometopa m-nigrum Zettersted. Breeds in dead mollusks.

Milichiella lacteipennis (Loew). Common, hovering over foliage.

Chloropidae

Cadrema pallida (Loew). In the 1943 list as Prohippelates.

Siphunculina signata Wollaston. Not common.

Muscidae

Atherigona excisa trilineata Stein.

Musca domestica L.

Calliphoridae

Phaenicia sericata (Meigen). Bred from dead rat; very common.

Sarcophagidae

Sarcophaga dux Thomson. Very common.

HYMENOPTERA

Evaniidae

Evania appendigaster (L.). This species was introduced to Canton from Honolulu in August, 1940, and soon became well established in the egg-cases of *Periplaneta americana*. It apparently continues to be present, for Otto Degner collected a specimen in May, 1951.

Eulophidae

Pnigalio sp., probably *external* (Timberlake). This insect was bred from mines of the agromyzid leafminer in *Scaevola*, *Ophiomyia scaevolae* (called *Notonisomorphomyia* in the 1943 list).

Note - In September, 1941, adults of *Euplectrus plathpenae* Ashmead, were brought to Canton from Honolulu to parasitize the larvae of *Laphygma*. There appears to be no evidence that this wasp became established.

Scelionidae

Telenomus nawai Ashmead. This egg parasite of *Laphygma exempta* was introduced from Honolulu in August, 1941, and one month later was reared from eggs of the army worm moth. It is not known if it still survives on Canton.

Formicidae

Tetramorium Guineense (Fabricius).

Tetramorium simillimum (F. Smith). In soil beneath piles of coconuts, etc.

Tapinoma melanocephalum (Fabricius). On *Sida* plants.

Camponotus variegatus hawaiiensis Forel. The first specimens of the carpenter ant to be known from Canton, were collected there in the housing area by Otto Degener in April, 1950.

Paratrechina longicornis (Latreille). The "crazy ant" was the dominant species on Canton in 1940-41.

Paratrechina bourbonica hawaiiensis Forel..

Sphecidae

Sceliphron caementarium Drury. This mud-dauber wasp was first collected on Canton by N. L. H. Krauss in October, 1950. It was collected subsequently by Degener also.

Vespidae

Pachodynerus nasidens (Letreille). First collected on Canton by J. P. Martin on December 30, 1946. It appears to be abundant there now.

Megachilidae

Undetermined sp. Found as early as November, 1941. A series was collected later by Degener.

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Numerical summary of Canton Island arthropods

Isopods	2	Insects	
Amphipods	1	Dermaptera	1
Scorpions	1	Embioptera	1
Spiders	6	Dragon flies	2
Mites	3	Corrodentia	2
Ticks	1	Homoptera	10
Myriopods	1	Heteroptera	7
Insects		Coleoptera	15
Thysanura	1	Lepidoptera	12
Collembola	1	Diptera	22
Orthoptera	7	Hymenoptera	12

The above list gives a total of 108 arthropods, 93 of them insects, and 15 belonging to related orders.

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ATOLL RESEARCH BULLETIN

No. 43

The natural vegetation of Canton Island, an equatorial Pacific atoll

by

William H. Hatheway

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INTRODUCTION

Canton Island (Lat. 2° 50'S., Long. 171° 38'W), a British-American condominium situated in the Phoenix Group, has gained in political and economic importance since 1939, largely because Pan-American Airways in that year established a permanent refueling station there, building a hotel on the south side of the island. In 1946 the United States Civil Aeronautics Administration set up a base on Canton. The island was occupied by United States military forces during the war years 1942-1945, when extensive construction and grading work was done. Before 1939 the island was uninhabited, being visited only infrequently by occasional guano diggers (Bryan 1942).

At the request of Mr. Garrison Costar, of the Civil Aeronautics Administration, a floristic and vegetational survey of Canton Island was conducted by Dr. Otto Degener and the author from July 11 to July 19, 1950. The island was revisited by the author in February 1951 and by Dr. Degener in April and May 1951. As a result of these surveys, recommendations were made leading to the introduction of many species of ornamental and otherwise useful plants. This paper is a report on the structure, distribution and ecology of the natural vegetation of Canton Island.

PHYSICAL ENVIRONMENT

Canton Island is a coral atoll approximately 21 miles in circumference (Fig. 1). The land surface is at no place wider than 3200 feet, and maximum elevation is about 20 feet above mean sea level. Local relief is slight, but a considerable proportion of the land surface is of sufficiently low elevation to be subject at high tide to the influence of a brackish water table. Such swales are occupied by a characteristic vegetation, as is discussed below, Along the ocean side of the northern portion of the island high dunes have formed, and the scanty vegetation of Triumfetta procumbens which occurs there has a distinctly xeric aspect.

The soil of Canton Island is derived from fragments of coral rock and calcareous sand deposited by waves and wind on a reef flat. Its texture is mostly rather coarse. In all places investigated a dark brown layer, from 7 to 15 inches thick, underlies the upper inch of sand or coral rock, or occurs at the surface of the ground. This dark layer, which contains a large proportion of guano, is believed to be of considerable significance in the development of the present vegetation of Canton Island.

During most of the year Canton Island is hot and humid, although actual precipitation is scanty. Mean annual rainfall is about 19 inches,

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1/ The Rockefeller Foundation, Medellin, Colombia.

only the months March through August receiving over one inch of precipitation, on the average. Indeed, the months September through February constitute a well defined dry season, which attains its greatest intensity, on the average, in November. Extremely heavy precipitation has been reported in two years. In 1940, 70.60 inches of rainfall were recorded, while in the first eight months of 1941, 90.80 inches were reported. The records are to be interpreted with some caution, for there are indications that in at least one case data was incorrectly reported. It is undoubtedly true, however, that exceptionally heavy precipitation was received in those years, since Van Zwaluwenburg (1943) has shown by photographs the unusually luxuriant vegetation that developed in 1941, and stated that pools of standing water were of sufficient duration to allow insects with aquatic larvae to complete their life-cycles. Additional evidence for the great variability in annual rainfall on Canton can be derived from reliable records of only 8.46 inches total precipitation in 1947 and as much as 33.17 inches in 1948. It should also be emphasized that exceedingly heavy downpours often are followed by weeks of drought: thus the total precipitation of even a wet month may be received in two or three storms.

Very little variation in temperature occurs throughout the year. Mean annual temperature is about 84°F. The maximum recorded temperature for the three year period 1947-1949 was 98°F., the minimum 71°F. Relative humidity is constantly rather high, varying from a recorded minimum of 57 per cent to a maximum of 85 per cent. Average relative humidity at 1 p.m. is about 62 per cent. A very constant strong easterly wind is an outstanding feature of the Canton climate, and may affect the development of the natural vegetation. Planted ornamental trees and shrubs are commonly severely wind-clipped. Salt spray is undoubtedly a factor contributing to the stunting of the vegetation in some locations on Canton.

FLORA

The native flora of Canton Island is not rich, consisting of 14 species of vascular plants in as many genera. In addition, approximately 150 species have been introduced as ornamentals or adventive weeds. With only a few exceptions, the native flora is composed of wide-ranging Indo-Pacific strand plants, of which Scaevola frutescens may be cited as a typical example. The fruits or seeds of most of these species exhibit striking adaptations for floating.

The native vascular flora is largely confined to those parts of Canton Island which have not been subject to grading or other cultural operations. A weedy flora best characterized by the troublesome but short-lived sandbur, Cenchrus echinatus, dominates the semi-natural vegetation in the vicinity of the Pan-American Hotel, the Airlines Terminal, and the CAA Housing Areas during the wetter months of the year. It is a striking fact that this introduced flora has had very little tendency to invade the vegetation of those parts of the island which have not been subject to much human disturbance. Since this paper is concerned only with this "natural" vegetation, no further reference to the weed flora will be made.

NATURAL VEGETATION

The natural vegetation of Canton Island can be conveniently separated into three major types: communities dominated by trees, shrubs or herbs. All are relatively simple in composition and can easily be delineated on a map (Fig. 1). The results of planimeter measurements of the areas dominated by the plant communities recognized on Canton Island are presented in Table I.

TABLE I

Approximate areas included in the plant communities of Canton Island

Vegetation Type	Per cent of total land area	Per cent of land area covered by native vegetation	Approximate area in acres
Cordia forest	0.29	0.81	8.3
Messerschmidia forest	1.05	2.92	30.0
Scaevola scrub	6.17	17.11	176.0
Suriana-Sesuvium flats	88.58	23.80	244.9
Portulaca herbaceous community	19.96	55.37	569.6
Areas naturally bare	23.37	---	667.0
Disturbed areas	40.60	---	1,158.7
Total	100.02	100.01	2,854.5

<u>The Cordia Forest</u>--Well developed stands of <u>Cordia</u> <u>subcordata</u> exist today only on the south side of the island, less than one mile from Musick Light (Fig. 1). There two groves of trees flourish, covering about 3500 and 2700 square feet respectively. Other small groves of <u>Cordia</u> occur scattered around the island, but in those the trees are mostly leafless and in some cases actually dead.

The two groves of vigorous trees consist of pure stands of <u>Cordia</u> averaging about 19 feet in height; the tallest tree observed was 24 feet tall. Both forests are in reality nearly impenetrable thickets. Since <u>Cordia</u> on Canton Island reproduces chiefly by ground layering, the numerous shoots arising from decumbent branches make walking through the grove in a straight line virtually impossible. On the basis of a sample plot of approximately 400 square feet, in which 23 upright stems between 2 and 9 inches in diameter were counted, basal area was approximately 272 square feet and density about 2450 stems per acre. Average height to the first branch was only 29 inches, greatest length of clear bole being 75 inches. Light reaching the ground level in <u>Cordia</u> forest is rather diffuse; intensities as measured with a Weston photographic light meter inside the grove were only 5 to 10 per cent of those obtained outside. The ground is littered with dead branches, fruits, and a few leaves. Reproduction from seed within the grove is practically non-existent, but many <u>Cordia</u> seedlings which had recently germinated were observed near the periphery of the groves, most of them severely wilted. A small pit dug in the soil inside the larger grove revealed a very dark sandy loam extending from the ground surface to a depth of about seven inches. Underlying the dark horizon was a layer of coarse sand which graded into fragments of coral rock and sand at a depth of 10 to 21 inches. The dark surface layer is interpreted as being composed chiefly of a mixture of guano and sand with addition of humus derived from rotting leaves and wood.

The Cordia groves are during the heat of the day a shelter for land hermit crabs (Coenobita perlatus). Large numbers of crabs may be found under fallen logs and branches and even climbing in the trees; two hermit crabs were discovered perched in a tree 69 inches above the ground. The crabs seem to do little damage to the trees. In some cases, however, young shoots have been stripped of bark and this mischief possibly may be attributed to the crabs.

A much more serious enemy of Cordia is the moth Achaea janata (L.) Caterpillars were abundant in both groves in July 1950, and it was observed that many shoots had been completely defoliated by these insects; nearly every leaf showed some damage. About 8 months later the author observed that the smaller of the two groves had been completely defoliated. Because of the depredations of this insect, it appears unlikely that Cordia subcordata will extend its range on Canton Island in the absence of control measures. This is unfortunate, since this tree is perhaps the most desirable species now known for purposes of afforestation. It is relatively large, has attractive flowers and foliage, and appears to be well adapted to the physical environment of Canton Island.

The Messerschmidia Forest--Only one healthy, well developed stand of Messerschmidia argentea exists on Canton Island. This grove is situated a few hundred yards west of the principal airstrip, on the north side of the island. Another grove consisting of dead or dying trees was found southeast of the "fighter airstrip," and many isolated trees grow scattered about the island.

The healthy grove was studied in some detail. It was 158 feet long and from 35 to 51 feet wide; total area was about 7000 square feet, or 0.6 acre. The average height of the trees was about 15 feet, the largest tree in the grove being 19 feet tall. Like the Cordia forest, the Messerschmidia grove was in most places a tangle through which one proceeded only with difficulty. The trees branched at an average of 18 inches above the ground, and reproduction within the grove was apparently entirely by root suckers. A sample plot of 675 square feet was set out inside the grove, within which 18 living upright stems between two and eight inches in diameter were counted. The calculated density was therefore about 1160 stems and the basal area approximately 132 square feet per acre. Thus both in density of stems and basal area the figures for Messerschmidia forest were about one half those obtained in Cordia forest. The light intensity at ground level was correspondingly greater than in Cordia forest, being about 25 per cent of that outside the grove. Possibly because of the relatively high light intensity, a scattering of plants of Portulaca lutea, Boerhavia tetrandra, Setaria verticillata and Lepturus repens, all shade-intolerant plants, were established in the understory of the Messerschmidia grove. Soil profile studies revealed a pattern similar to that in the Cordia grove. A dark sandy loam, presumably derived chiefly from coral sand, guano and leaf and branch litter overlay a light-colored sand, which contained fragments of coral rock.

Like the Cordia grove, the Messerschmidia forest is a favorite shelter during the warm daylight hours for large numbers of hermit crabs. No damage attributable to the crabs or to insects may be observed in the grove. It is believed that the crabs forage chiefly by night, but feeding habits are imperfectly known. One crab was observed to devour a flower of Portulaca lutea, however, and it is suspected that damage done to planted New Zealand spinach (Tetragonia tetragonioides) may be attributed to the crabs.

The Scaevola Scrub--On Canton Island Scaevola frutescens becomes a shrub ten feet tall and in some places nearly 50 feet in diameter. Reproduction proceeds radially from the oldest and tallest plant in the center of a clump, so that what may appear to be a single enormous bush may actually consist of many individuals belonging to several generations. Scaevola occurred in extensive, nearly pure stands at the southeast corner of Canton Island; other species occurring occasionally in the Scaevola scrub are Messerschmidia argentea, Sida fallax, Boerhavia tetrandra and Portulaca lutea.

In order to determine the approximate density of the Scaevola scrub, a sample plot of 625 square feet was laid out in a randomly selected area within the vegetation type. 12 Scaevola bushes were counted, the tallest eight feet high. This is a density of one bush per 52 square feet. Along a 1000-foot line transect, 115 bushes were counted, or one bush per 8.7 feet. The surface horizon of the soil is a stony sandy loam, containing considerable amounts of guano.

An interesting feature of this tract of Scaevola scrub is the enormous number of seabirds roosting and nesting in the shrubs. Frigate birds (Fregata minor palmerstoni) and red-footed boobies (Sula sula rubripes) predominate. In July many adults, young and eggs of both species were observed, but by February the boobies had largely disappeared. To estimate the number of birds roosting in a single bush, counts were made on the night of July 16 in the Scaevola scrub in the southeast corner of the island. Five bushes, each about 10 feet tall and ranging in area from 300 to 2000 square feet each were studied. As many as 45 birds were counted in a single bush; the average population for the five bushes studied was 34 birds per bush, that is roughly one bird per 30 square feet of bush. It appears not unlikely that the principal factor limiting the size of the Canton Island bird population is the absence of more such roosting and nesting sites. Indeed, at times the bushes are so crowded that frigate birds are forced to roost on the Sida fallax plants: these are spindly dwarf shrubs only about 10 to 12 inches high, and form a very insecure perch for a large bird. It is the opinion of the author that the large populations of roosting sea birds, which tend to congregate in relatively small areas, are of great significance in the development of the present natural vegetation of Canton Island.

The Suriana-Sesuvium Flats--Bordering extensive areas of tidal mudflats or covering small pockets of land influenced by the diurnal variation in the depth of the ground-water table is a plant community dominated by Sesuvium portulacastrum and Suriana maritima. The former is a fleshy decumbent herb, which occurs in striking bright green mats about 20 to 50 square feet in size. It usually occupies the centers of swales, or occurs near the high-tide level of mudflats of the sheltered lagoon side of the island. Suriana is a woody shrub, commonly about four feet tall, with fleshy yellow-green leaves. It characteristically borders the Sesuvium mats on the gently sloping edges of mudflats and swales. Large numbers of frigate birds are commonly observed in bushes of Suriana maritima.

The Portulaca Herbaceous Community--Portulaca lutea, together with Lepturus repens, Boerhavia tetrandra and Sida fallax dominates by far the largest area of natural vegetation on Canton Island. Portulaca lutea on Canton averages 6.5 inches in height and about 12 inches in lateral spread. It has a very fleshy taproot and main stem, up to one inch in diameter, and many branches radiating from the stem, each about 0.3 inches in diameter. Lepturus repens is a caespitose grass up to 19 inches in height (but averaging about 11.5 inches). It propagates itself at the periphery of clumps by ground-layering. The mats thus formed are occasionally quite extensive, the largest measured being 17.6 feet long and 9.3 feet wide, but covering only about 100 square feet. Generally, however, the clumps cover only about 1.25 square feet, the average diameter of the clumps being about 15 inches. Boerhavia tetrandra is a trailing vine with a large fleshy taproot up to 1.5 inches in diameter. Sida fallax, a dwarf shrub seldom over 12 inches tall on Canton Island, is a very common member of the community.

The Portulaca herbaceous community was studiede quantitatively at two stations about nine miles apart. As is suggested by the data in Tables II and III, Portulaca is a consistent dominant in the community, while the frequency and cover degree of its associates are somewhat variable. In general it appears that the abundance of Sida and Boerhavia is correlated with a somewhat stony soil phase, while Lepturus is more prominent in areas of even-textured sand.

TABLE II

Frequency and Foliage Cover in the Portulaca Herbaceous Community. Data from five meter-square plots. Station I, about 10 miles by road from "Turning Basin."

Species	Frequency	Foliage Cover (Per cent)
Portulaca lutea	100	42
Lepturus repens	60	3
Sida fallax	40	2
Boerhavia tetrandra	20	5
Total		52

TABLE III

Frequency and Foliage Cover in the Portulaca Herbaceous Community. Data from 10 square-meter plots. Station II, about 19.5 miles by road from "Turning Basin."

Species	Frequency	Foliage Cover (Per cent)
Portulaca lutea	100	22
Sida fallax	100	18
Boerhavia tetrandra	100	15
Total		55

Beaches, Dunes and other naturally Bare Areas--About 23 per cent of the land surface of Canton Island has little or no natural vegetation cover. Such areas include beaches and other places subject to ocean wave action, and high dune. Triumfetta procumbens, a creeping perennial vine occurs occasionally on dunes on the north side of the island but its cover degree is very low. Ipomoea pes-caprae, which often is predominant in such situations in the Pacific is very rare on Canton Island. Only a single plant of this species was found in 1951, growing among rocks near fortificatinns erected in the war. It may have been planted by a soldier. Lepturus repens, reported by Christophersen (1937) to be characteristic of beach crests and shifting dunes on other Pacific equatorial islands, was not found in these sites on Canton.

DISCUSSION

The most striking features of the natural vegetation of Canton Island are the areal predominance of the Portulaca herbaceous community and the paucity of forest. This is perplexing in view of the fact that two native trees, Cordia subcordata and Messerschmidia argentea, are known in certain instances at least, to grow vigorously and to reproduce from seed. The forest communities thus formed tend to exclude the shade-intolerant herbaceous species of the Portulaca community. Moreover, the large shrub, Scaevola frutescens, is apparently invading the Portulaca herbaceous community about 9.5 miles by road from the "Turning Basin," on the north side of the island and possibly in other places. A relatively open stand of Scaevola might form a nurse crop favorable for the establishment of occasional seedlings of Cordia and Messerschmidia. Seedlings of Cordia soon wilt after ferminating in the open herbaceous communities. It is quite possible that existing groves of Cordia and Messerschmidia may be traced to the successful establishment of single seedlings which by vegetative propagation have come to occupy their present areas. Thus it would appear that in the absence of disturbing factors the development of the natural vegetation of Canton Island might trend toward greater areal extent of forest and scrub, at the expense of the hearbaceous communities.

It is evident, however, that such development is in process in only a few localities. Indeed, in most places the trend appears to be taking a different direction. Patches of native forest and scrub which are situated more than one mile from human habitation are generally dead or dying. Extensive areas of Messerschmidia and Cordia forest about 10 miles by road from the "Turning Basin" are leafless and apparently dead. Counts of Scaevola bushes 16.5 miles from the "Turning Basin" revealed in a 1000-foot strip 35 vigorous plants, 40 dying plants and 40 dead ones. In a 625 square-foot plot, seven dead and five living bushes were counted.

Since healthy groves of Cordia and Messerschmidia exist on Canton Island possible climatic deterioration is not sufficient to explain the dying condition of most stands. No evidence has been found that the healthy stands owe their vigor to any possible cultural operations carried on within them. Instead, there is much evidence that a causal connection exists between the dead or dying condition of native forest and scrub in areas not affected by human activity and the enormous populations of fish-eating seabirds which roost and nest in the trees and shrubs. The arguments favoring such an hypothesis are listed briefly below:

1. Patches of native forest and scrub heavily populated with frigate birds and boobies invariably show high proportions of dying or dead trees and shrubs.

2. Patches of native forest and individual volunteer shrubs of Scaevola near human habitation and not visited by frigate birds and boobies are vigorous except when damaged by insects. Only Cordia exhibited noteworthy insect injury.

3. Soil profile studies in the Portulaca herbaceous community show beneath the surface inch of bleach sand a dark brown sandy loam to a depth of 15 inches. This dark layer is indistinguishable in the field from the guano soil at present developing under dying Messerschmidia, Cordia and Scaevola. The frigate birds and red-footed boobies at present visit only the forest and scrub, and other, smaller birds were observed only occasionally in the Portulaca community. It is suggested, therefore, that those areas in the Portulaca community exhibiting guano soil profiles were once covered with forest or scrub supporting large populations of roosting and nesting seabirds, at which time the guano was formed.

The mechanism by which birds might damage or destroy the native forest and scrub is not clear, although it appears likely that highly concentrated bird droppings might be as damaging to the trees and shrubs as would be excessive doses of nitrate and phosphate fertilizer. Stewart (1933) reported that roosting blackbirds severely injured a plantation of White Pine (Pinus strobus L.), and demonstrated that the concentration of soluble nitrates in the area of dying trees was enormously greater than in the unaffected area. The present author has conducted no experiments on the nature and properties of Canton Island guano soils. It is the experience of CAA personnel stationed on Canton, however, that ornamental plants potted in guano soil obtained from Canton Island forests grow much less vigorously than those potted in coral sand from the beach; these observations have been confirmed by the writer.

SUMMARY

1. Canton Island is a coral atoll situated at Lat. 2° S, Long. 171° W, in the Phoenix Group, Pacific Ocean. The total land area of the island is about 2,850 acres.

2. The climate is warm and humid, but rainfall is scanty and seasonal.

3. The native flora is scanty consisting chielfy of a few wide-ranging Indo-Pacific strand plants.

4. Natural vegetation consists of forests of Cordia subcordata and Messerschmidia argentea, scrub of Scaevola frutescens and Suriana maritima, and herbaceous communities dominated by Portulaca lutea. The last is much the most extensive type of natural vegetation on Canton Island.

5. Most native forest and scrub is in a dead or dying condition. It is suggested that the agents chiefly responsible for the death of native woody species are frigate birds, red-footed boobies and other fish-eating seabirds, which roost in enormous numbers in the forest and scrub. Observations are presented suggesting that certain areas presently covered by Portulaca and its associates formerly may have been dominated by forest or scrub. It is believed that in the absence of large populations of birds, native forest and scrub would tend to extend their present areas at the expense of herbaceous communities.

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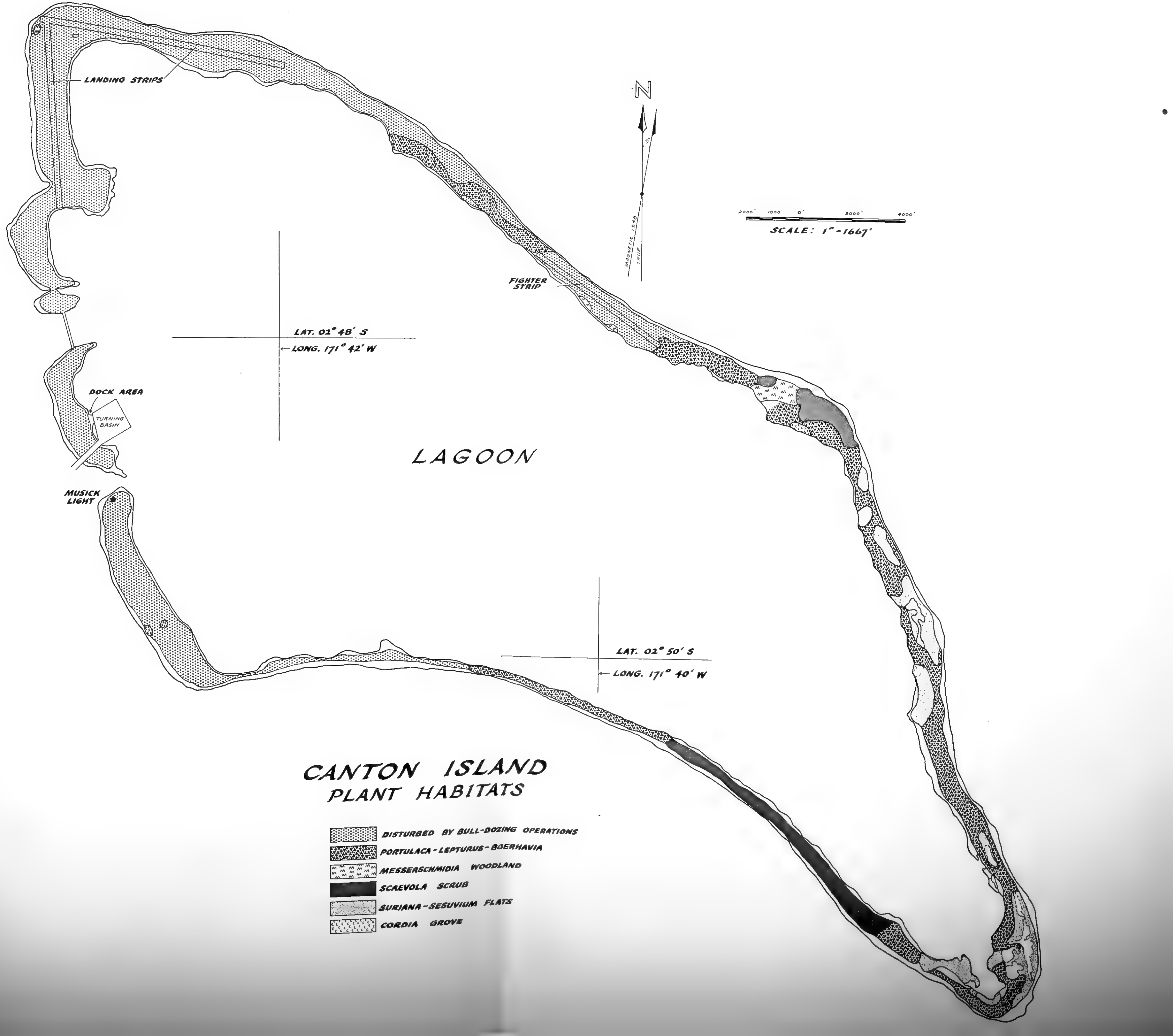

LANDING STRIPS
N
MAGNETIC 1948
TRUE
2000' 1000' 0' 2000' 4000'
SCALE: 1" = 1667'
FIGHTER STRIP
LAT. 02° 48' S
LONG. 171° 42' W
DOCK AREA
TURNING BASIN
LAGOON
MUSICK LIGHT
LAT. 02° 50' S
LONG. 171° 40' W
CANTON ISLAND
PLANT HABITATS
DISTURBED BY BULL-DOZING OPERATIONS
PORTULACA - LEPTURUS - BOERHAVIA
MESSERSCHMIDIA WOODLAND
SCAEVOLA SCRUB
SURIANA - SESUVIUM FLATS
CORDIA GROVE

ATOLL RESEARCH BULLETIN

No. 44

The hydrology of Ifalik Atoll, Western Caroline Islands

by

Ted Arnow

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By

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INTRODUCTION

The fieldwork for this report was done as a part of more extensive hydrologic investigations carried on by the U. S. Geological Survey in the Trust Territory of the Pacific Islands and was coordinated with the 1953 Scientific Investigation of Micronesia of the Pacific Science Board of the National Research Council, which was supported by funds granted by the Office of Naval Research by Contract N7onr-29104 (NR 388 001). Logistic support for the work was provided by the U. S. Navy, the U. S. Coast Guard, and the Trust Territory administration. Tide data were analyzed by the U. S. Coast and Geodetic Survey. The writer was on Ifalik from June 22 to 24, and September 12 to 26, 1953.

The Ifalik project was essentially a group undertaking of several specialists, each working in his own field but coordinating his activities with those of the others. The writer would like to express his gratitude to "Tom" Totogoeiti who supervised the digging of the observation wells, to Marston Bates who collected the bulk of the climatic data, and to D. P. Abbott who collected additional climatic and ground-water data after the writer left Ifalik. Geological studies and water-level determinations were made together with J. I. Tracey, Jr. Finally, appreciation is expressed to the people of Ifalik for their hospitality and assistance, without which completion of the project would not have been possible.

The primary purpose of this report is to present the data observed at Ifalik so that they may be available to other workers in the Pacific at an early date. A more comprehensive report of hydrologic conditions on Ifalik will be included in a later report which will cover all phases of the investigations on Ifalik.

GEOGRAPHIC SETTING

Ifalik Atoll is in the Western Caroline Islands, which are part of the Trust Territory of the Pacific Islands (fig. 1). Ifalik lies 360 nautical miles due south of Guam, 440 miles due west of Truk, and 400 miles southeast of Yap.

Ifalik is a small circular atoll having a total land area of 0.569 square statute mile and a lagoon area of 0.939 square mile (Bryan, 1946). The lagoon has one deep-water entrance. There are four islands - Falarik, Falalap, Ella, and Elangalap. (See fig. 2). Approximately 260 people live on Falarik and Falalap, but neither Ella nor Elangalap is regularly inhabited.

1/ Publication authorized by the Director, U. S. Geological Survey.
2/ Geologist, U. S. Geological Survey, Austin, Texas.

CLIMATE

The 1953 expedition to Ifalik obtained measurements of rainfall, atmospheric pressure, temperature, and relative humidity for a period of approximately 4 months. These data are shown in tables 1 to 4. The atmospheric pressure as measured daily between 0800 and 0900 hours ranged from 1004 to 1011 millibars (29.65 to 29.86 inches), 85 percent of the readings falling between 1007 and 1010 millibars. Relative humidity as measured between 0800 and 0900 hours ranged from 77 to 100 percent and averaged 86 percent.

Daily maximum and minimum temperatures were measured in the school building (see table 4) which is a thatched structure open on two sides. The extremes observed were 91 and 73 degrees Fahrenheit. The maximum daily range was 15 degrees, the minimum daily range was 5 degrees, and the average daily range during the 4-month period of observation was 11 degrees.

The rainfall measurements at Ifalik were made during the rainy season (see table 1). At least a trace was recorded on 83 percent of the days of observation, and the rainfall exceeded 1 inch on 11 percent of the days of observation. Although a total of 54.25 inches of rainfall was measured in only 131 days, it is probable that the average annual rainfall at Ifalik is between 100 and 120 inches. This estimate is based on a consideration of annual-precipitation data for Guam (91 inches, length of record, 41 years, Yap (119 inches, length of record, 27 years), Truk (127 inches, length of record, 7 years), and Lamotrek (104 inches, but only a 4-year record).

In general it can be stated that Ifalik has a tropical rainy climate with relatively small seasonal changes of the various climatic factors. The temperature and barometric pressure are monotonously uniform throughout the year and the most variable factors are wind and rainfall.

TIDES

Tide data were obtained for the period September 13 to 25, 1953, by means of a Stevens type-F water-level recorder which was placed in the lagoon near Falarik Island (see fig. 2). Part of the actual tide record is shown in figure 3. The tide data were analyzed by the U. S. Coast and Geodetic Survey, which computed the following elevations shown in feet:

Mean higher high water	0.95
Mean high water	0.75
Mean sea level	0.00
Mean low water	-0.75
Mean lower low water	-1.55

The primary benchmark established in Ifalik is an "X" chiseled in a limestone slab on Falarik Island. The slab is embedded in the ground 20

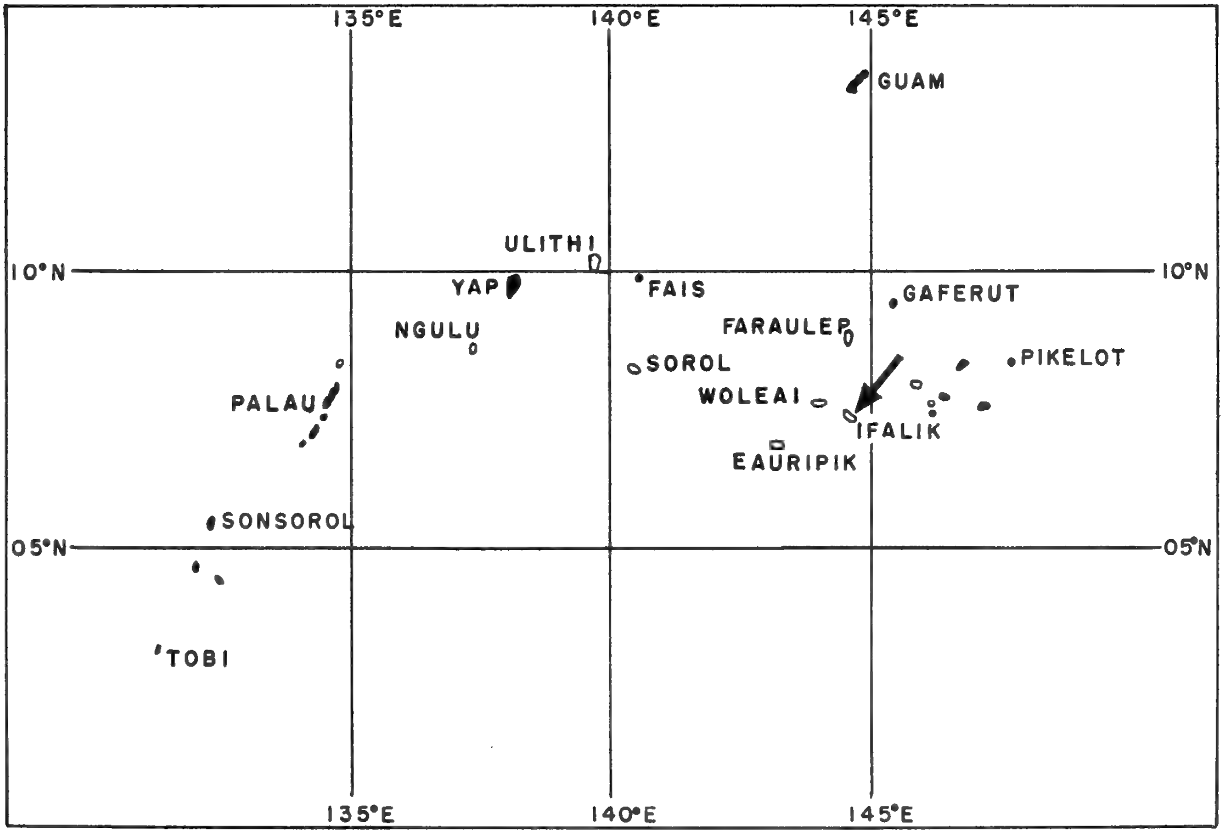
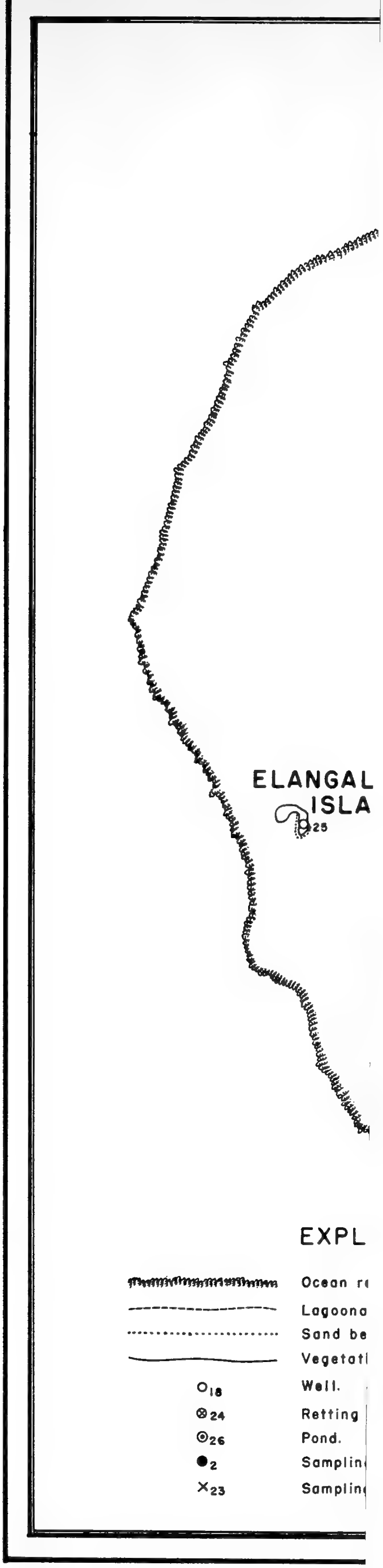


Figure I.– Outline map of the Western Caroline Islands.


ELANGAL
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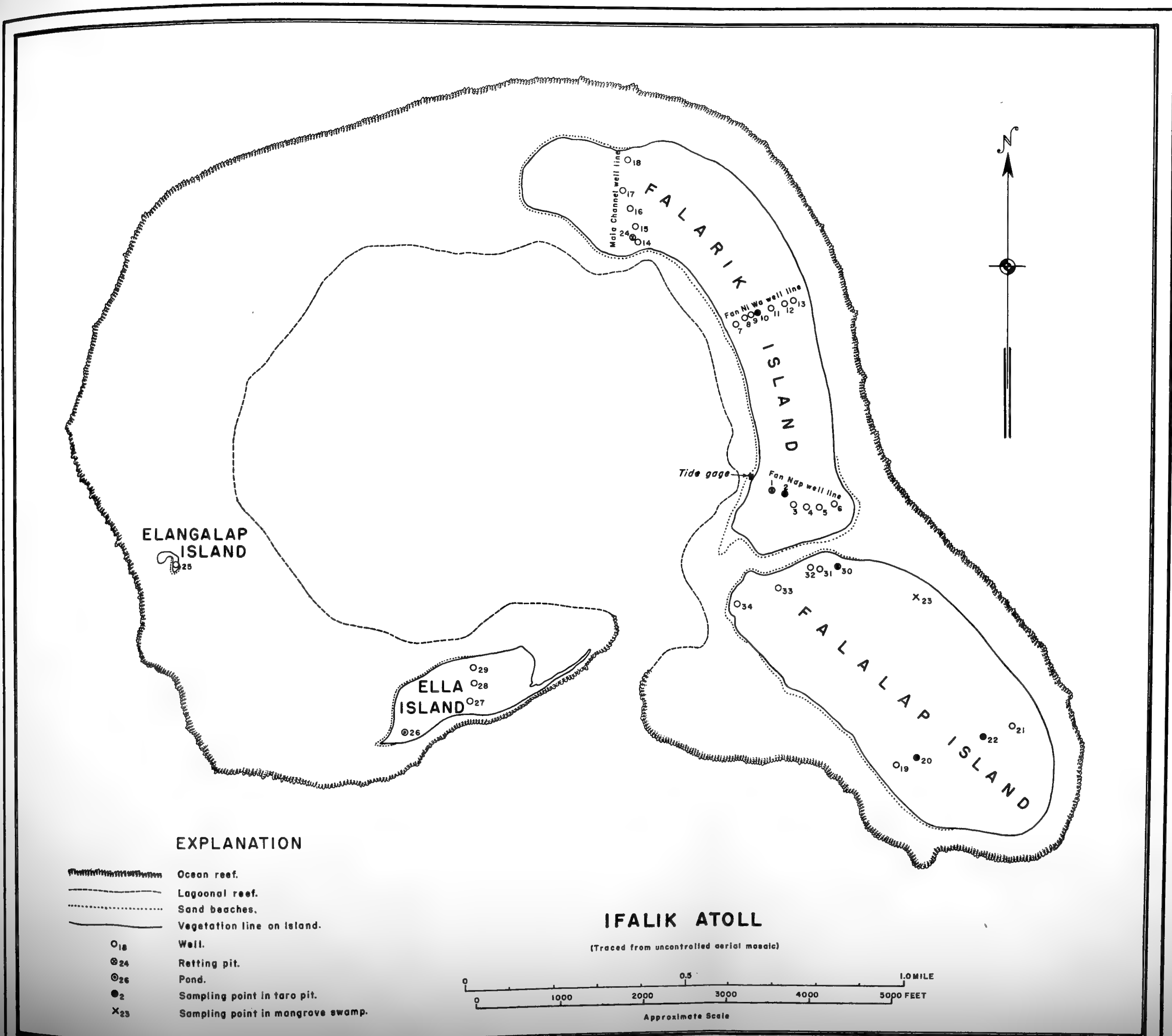

Figure 2.- Outline map of Ifalik Atoll, Western Caroline Islands, showing locations of wells and other sources of water.

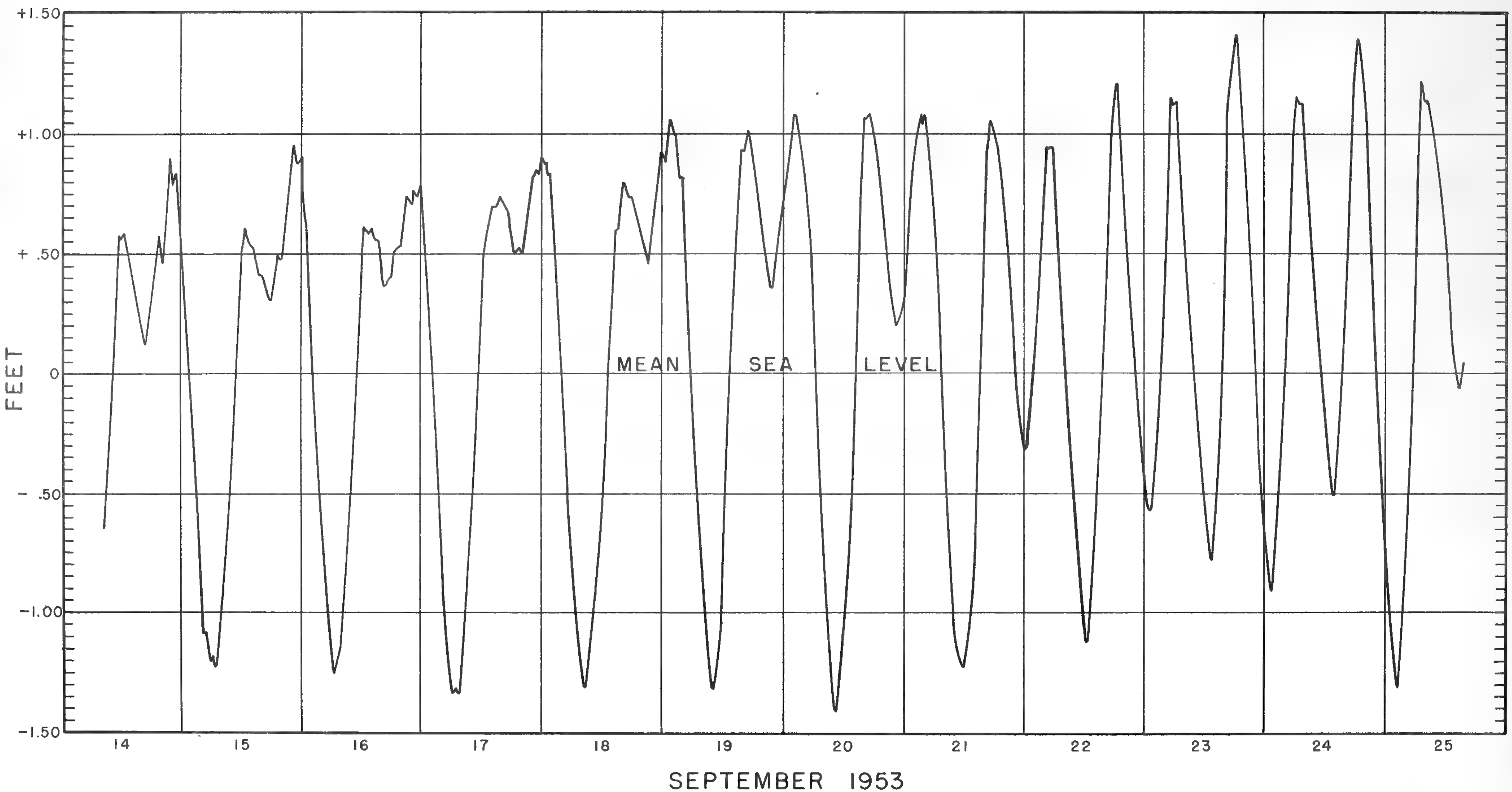

Figure 3.- Tidal graph in lagoon at Ifalik Atoll, September 14-25, 1953.

Table 1.--Rainfall at Ifalik Atoll, 1953, in inches

Day	July	August	September	October	November
1	0	0.24	0.30	0.01	0.18
2	.54	.15	.16	.55	2.03
3	.34	1.90	0	.02	--
4	.12	.54	.19	.12	1.35 1/
5	.20	.18	0	.14	.01
6	0	.95	.74	T	T
7	0	.05	.02	0	.03
8	T	2.55	.39	.10	.05
9	T	3.20	0	.13	
10	.02	.81	.15	.28	
11	.02	1.15	.13	--	
12	.20	.11	--	.84 1/	
13	.25	.25	1.97 1/	.53	
14	.08	.61	.76	.01	
15	0	.50	.91	.70	
16	2.98	1.06	.54	.40	
17	.68	0	.15	.01	
18	1.44	0	2.70	.92	
19	.24	0	1.03	.99	
20	.16	.02	.40	.24	
21	.16	.33	.09	.35	
22	.30	.15	.12	0	
23	0	1.67	0	.32	
24	.05	0	--	.04	
25	.32	0	.87 1/	.51	
26	0	.59	.11	--	
27	.05	.25	T	.13 1/	
28	.11	1.16	0	.47	
29	.10	.09	.25	3.56	
30	.30	0	0	.02	
31	.06	0		0	
TOTAL	8.72	18.51	11.98	11.39	

1/ 48-hour reading.

Table 2.--Atmospheric pressure at Ifalik Atoll, 1953, in millibars observed between 0800 and 0900 hours

Day	July	August	September	October
1	--	1008	1008	1010.5
2	--	1009	1008	1010.5
3	1009	1009	1008.5	1010
4	1009	1007.5	1008.5	1010
5	1010	1009	1009	1009
6	1010	1009	1010	1009.5
7	1010.5	1009	1010	1009
8	1011	1006.5	1008	1009
9	1010	1007.5	1008.5	1008
10	1009	1006	1009	1010
11	1010	1008	1008	--
12	1010	1007	--	1008
13	1010	1008	--	1007
14	1009	1007	1008.5	1006
15	1008	1007	1008.5	1006
16	1008	1008	1008.5	1007
17	1009	1009	1008.5	1007
18	1008	1009	1006	1007
19	1008	1009	1005.5	1007
20	1007.5	1009	1007	1008
21	1007	1008	1008.5	1009
22	1009	1007	1009	1008
23	1007.5	1006	1008	1007
24	1008	1006.5	--	1008
25	1008	1006	1008.5	1009
26	1008	1005	1009.5	--
27	1006	1004	1009.5	1007.5
28	1007	1006	1009.5	1008.5
29	1007.5	1008	1010	1008
30	1007.5	1008	1010	1008
31	1007	1008.5	--	1008

Table 3.--Relative humidity at Ifalik Atoll, 1953, in percent observed between 0800 and 0900 hours

Day	July	August	September	October
1	84	88	87	89
2	88	90	85	96
3	92	100	85	78
4	95	81	90	95
5	90	84	78	92
6	84	85	85	84
7	84	86	81	85
8	84	88	82	82
9	83	100	92	85
10	84	88	82	95
11	92	98	81	--
12	85	83	--	85
13	81	91	93	89
14	84	85	85	82
15	100	90	100	78
16	95	83	83	78
17	100	81	89	80
18	89	85	96	82
19	92	84	91	86
20	82	82	96	84
21	89	88	91	82
22	89	89	82	82
23	85	85	80	--
24	85	86	--	--
25	90	81	85	--
26	79	82	87	--
27	80	81	77	--
28	79	88	88	--
29	85	93	81	--
30	100	85	85	--
31	83	83	--	--

Table 4.--Air-temperature data at Falarik Island, Ifalik Atoll, 1953
Maximum and minimum measurements in degrees Fahrenheit.
All measurements made in the school building

Day	July		August		September		October	
1	--	--	91	76	90	77	91	79
2	86	76	90	77	90	80	88	75
3	87	76	88	74	90	80	87	77
4	89	76	84	73	90	76	91	77
5	87	76	82	75	89	77	90	77
6	90	77	82	76	88	75	89	78
7	88	77	82	77	85	77	90	78
8	90	78	86	75	88	78	90	78
9	90	78	80	74	91	76	90	77
10	88	77	82	74	88	76	90	77
11	90	76	84	74	86	76	--	--
12	89	78	84	76	--	--	90	75
13	89	77	87	78	90	76	88	76
14	89	78	88	76	86	76	87	79
15	90	75	82	76	89	74	--	--
16	80	73	83	74	84	74	84	77
17	88	76	88	78	87	76	87	80
18	81	73	86	77	88	73	85	86
19	88	75	89	76	82	75	87	76
20	82	76	89	77	86	76	86	76
21	88	77	88	77	84	76	87	77
22	89	76	88	77	--	76	87	78
23	85	78	86	75	89	79	89	75
24	86	76	86	77	--	--	87	78
25	89	76	85	80	88	77	90	76
26	87	77	88	75	87	77	--	--
27	90	78	88	77	88	77	90	76
28	89	77	85	74	90	77	88	77
29	91	77	88	78	90	76	87	74
30	91	77	87	80	91	78	82	77
31	88	78	90	78	--	--	86	79

feet west of the west end of the Fan Nap, which is the chief's clubhouse. The altitude of the "X" is 3.57 feet above mean sea level as determined from the tide data.

Tide data were not obtained for the ocean. A comparison was made between the tide data obtained in the lagoon and the predicted ocean tides as published by the Coast and Geodetic Survey for Woleai Atoll, which is about 45 miles from Ifalik. No direct correlation was observed, other than that the observed tide in the lagoon preceded the predicted tide in the ocean 90 percent of the time. The averaged calculated precedence of the lagoon tides was 45 minutes and the maximum precedence was 1 hour 48 minutes. This order of sequence is a reversal of what would normally be expected, and at present no explanation can be offered other than possibly that the actual tides in the open ocean at Ifalik are considerably different from the predicted tides.

WATER SUPPLY

Rainwater

There is practically no artificial catchment of rainwater on Ifalik. Only two catchment systems were observed, each consisting of an oil drum receiving water from the trunk of a palm tree. One provided a household with water for cooking and the other supplied water to irrigate half a dozen puny tobacco plants which were being carefully nurtured to alleviate the island's tobacco shortage.

Three sample of rainwater were obtained for analysis, one from the rain gage, the second from catchment on the roof of a canvas tent, and the third from a drum fed by catchment on a palm tree. The sample from the rain gage had a chloride content of 5 parts per million (ppm) and a hardness of 12 ppm. The sample from the tent had a chloride content of 10 ppm and a hardness of 10 ppm. The sample from the drum had a chloride content of 52 ppm and a total hardness of 36 ppm. The sample from the drum had a higher salt content than those from the gage and the tent because, in the course of running through the crown of the tree and down the trunk, the water presumably had greater opportunity to dissolve salt crystals blown in by the wind from the ocean.

Ground Water

Occurrence.--The only source of fresh water on any island in Ifalik Atoll is the rain that falls directly on that island. Part of the rainfall evaporates or is transpired by plants, and the remainder, because of the high permeability of the island sediments, seeps directly into the ground. There is no significant surface runoff. The fresh water, which is only about 40/41 as heavy as salt water, floats on the surface of the salt water roughly in the shape of a dome, the edges of which coincide approximately with the edges of the island. The fresh water displaces a volume of salt water equal to its own weight and depresses the fresh-salt-water interface below sea level under the island. Under ideal conditions in a homogeneous island, because of the 40/41 weight relationship of fresh to salt water, for every foot the water table is above sea level the interface is about 40 feet below sea level. Actually the shape of the fresh-water body varies, depending upon local geologic conditions and variations in rainfall, and the 40-to-1 depth ratio is modified by a transition zone of variable thickness in which there is a mixture of fresh and salt water. This double-convex fresh-water body floating on sea water is known as the Ghyben-Herzberg lens. It is the only source of potable ground water in Ifalik and is tapped by means of shallow dug wells.

Three lines of wells for ground-water observations were established on Falarik Island - the Fan Nap line, the Fan Ni Wa line, and the Maia Channel line, as shown in figure 2. Benchmarks for determination of altitudes of water levels at 15 of the wells were tied in with mean sea level as determined by the tide gage. The surveying was done with a telescopic alidade, but because of difficulty with the instrument some of the water-level determinations may be inaccurate by several tenths of a foot. Water-level measurements were made on Falarik Island only. Wells on the other islands were used only for sampling purposes.

Continuous measurements of water levels by means of a Stevens type-F recorder were made at nine wells on Falarik Island. The length of observation at each well was 1 day (figure 4 shows a representative day's record), and the mean water levels determined at each well by the day's observation are shown in figure 5. The value of the mean water levels is somewhat doubtful because records of water levels in the wells were obtained on separate days during the rainy season over a period of 11 days, during which more than 7 inches of rain fell. The effect of rainfall on the water level in each well was variable and depended on the day during the 11-day period on which the well was measured. The mean water levels, therefore, are not completely comparable and also probably are not representative of the means that would be determined if measurements were made over a period of time long enough to average seasonal fluctuations. The configuration of the ground-water body as determined by the water-level measurements does not agree with the configuration suggested by chloride determinations, which are discussed in the next section of this report. The chloride data are believed to be more reliable.

The mean water levels, however, do give an indication of the thickness of the Ghyben-Herzberg lens on Falarik. Even allowing for errors due to surveying and shortness of record, the lens on Ifalik undoubtedly attains a head of at least 1 foot and possibly 1-1/4 feet above mean sea level. The depth to salt water below mean sea level, therefore, probably is 40 feet or more. The area of maximum thickness in general is in the center of the island or on the lagoon side of the center and from there the thickness of the lens diminishes to zero at both shorelines. The 40-foot figure is a

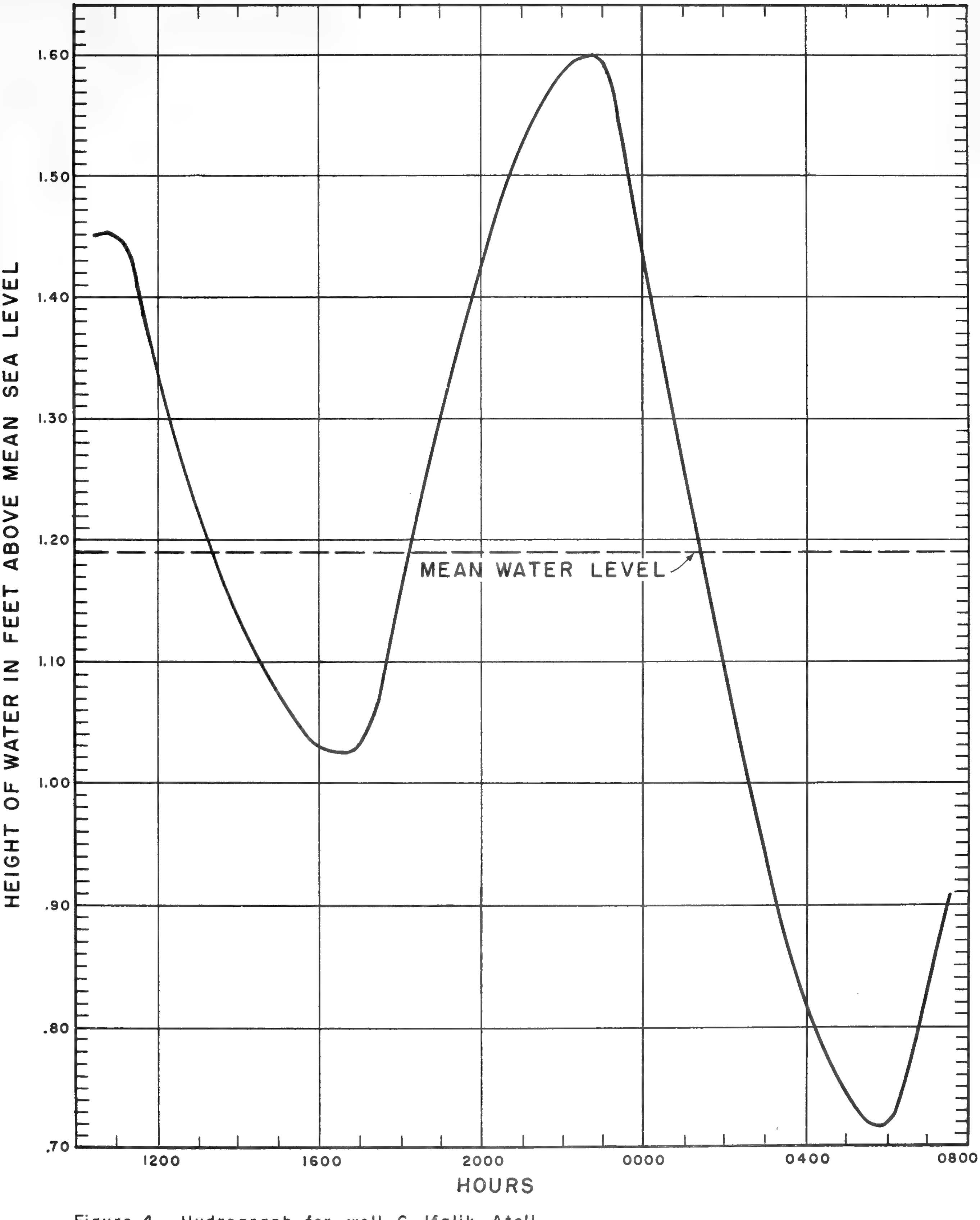

Figure 4.- Hydrograph for well 6, Ifalik Atoll.

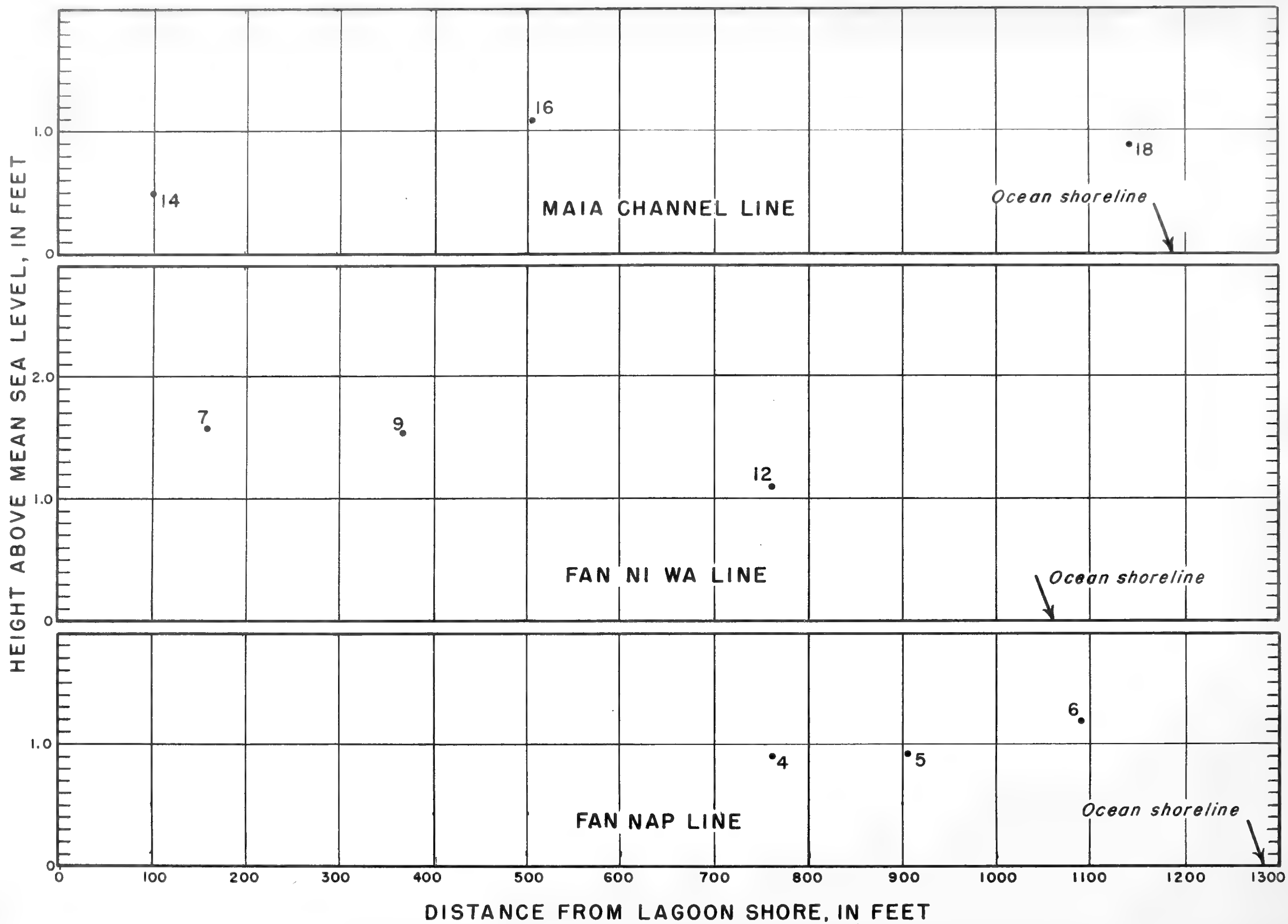

Figure 5. – Mean water levels in wells, Falarik Island, Ifalik Atoll.

wet-season figure, and the depth undoubtedly decreases during normal dry seasons and during extended periods of drought. Native informants state that they have no recollection of a drought on Ifalik. It is assumed, therefore, that the lenses on Falarik and Falalap have never shrunk to the point where food plants or well-water supply have been noticeably affected.

The amount of damping and lag of the tides as they move through Falarik Island is shown in figures 6 and 7 by a comparison of the tidal curve obtained in the lagoon and the tidal fluctuations of the water table observed in wells on Falarik. The data for each well were obtained by means of continuous observations over a period of 1 day. Both the damping and lag increase progressively from the lagoon shore toward the ocean shore. The full significance of this progressive change cannot be completely explained because of the lack of tidal data from the ocean side of the island. If such data were integrated with the tidal data obtained in the lagoon, a significant change might result in the slope of the curves shown in figures 6 and 7.

The Ghyben-Herzberg lens is incompletely developed on Ella Island and apparently not developed at all on Elangalap Island. These islands are discussed more fully in the section on Quality of water.

Quality.--The extent of development of the Ghyben-Herzberg lens controls the quality of the ground water in the islands in Ifalik Atoll. The lens is well developed in Falarik and Falalap Islands.

The three lines of wells on Falarik Island were sampled on September 21, 1953, and again during the period November 1 - 3. Partial chemical analyses were made for all samples and the results are shown in table 5. The relation of chloride content to distance from the shore is shown in figure 8 for the samples obtained on September 21, and in figure 9 for the samples obtained November 1 - 3. The chloride content of the water along the Fan Nap and Maia Channel lines is greatest near the ocean shore, decreases to a minimum about two-thirds of the way across the island, and rises again near the lagoon shore. These relationships suggest that the Ghyben-Herzberg lens has its thickest development about one-third of the way inland from the lagoon shore and from there thins toward both shores. The displacement of the point of maximum development of the lens from the center of the island toward the lagoon shore could be the result of high permeability in the rocks on the ocean side. The chloride content of the water along the Fan Ni Wa line of wells suggests that the maximum development of the lens along this line may be nearer the ocean side of the island than it is along the other two lines. If this is so, it may be due to the presence along the ocean shore of well-cemented beach rock which acts as a relatively impermeable barrier which retards the mixing of fresh and salt water that results from tidal fluctuations. The beach rock is not exposed throughout, but according to J. I. Tracey, personal communication (1954) it probably extends along most of the northeast coast of Falarik. It terminates, however, before reaching the Fan Nap and Maia Channel well lines.

Table 5.--Partial chemical analyses (ppm) and temperature (°F) of water from various sources in Ifalik Atoll (Field determinations by Ted Arnow)

No.	Source	Date (1953)	Chloride	Total hardness as $CaCO_3$	Calcium hardness as $CaCO_3$	Temperature
	Falarik Island					
1	Shallow pond, 30 feet in diameter	Sept. 21	28	240	132	79.5
		Nov. 1	35	210	129	--
2	Taro pit	Sept. 21	12	290	242	79.5
3	Dug well	Sept. 21	16	100	71	77.5
		Nov. 1	5	170	88	--
4	do.	Sept. 21	52	170	132	79
		Nov. 3	5	100	82	---
5	do.	Sept. 21	44	230	181	--
		Nov. 1	55	190	132	--
6	do.	Sept. 21	84	250	132	79
		Nov. 1	95	210	66	--
7	do.	Sept. 21	48	320	275	79
		Nov. 1	50	320	269	--
8	do.	Sept. 21	8	220	170	76
9	do.	Sept. 21	8	140	132	77
		Nov. 1	20	220	170	--
10	Taro pit	Sept. 21	10	--	--	79
11	Dug well	Sept. 21	6	210	93	78
		Nov. 1	10	120	104	--
12	do.	Sept. 18	8	140	93	78
		Nov. 1	25	170	132	--
13	do.	Sept. 21	14	120	93	79
		Nov. 3	40	340	286	--
14	do.	Sept. 21	28	290	192	79.5
		Nov. 1	35	190	104	--
15	do.	Sept. 21	16	240	187	80
		Nov. 1	15	210	176	--
16	do.	Sept. 21	24	240	105	81
		Nov. 1	27	160	124	--
17	do.	Sept. 21	44	220	165	79
		Nov. 1	35	230	165	--

Table 5.--Partial chemical analyses (ppm) and temperature (°F) of water from various sources in Ifalik Atoll--Continued

No.	Source	Date (1953)	Chloride	Total hardness as $CaCO_3$	Calcium hardness as $CaCO_3$	Temperature
18	Dug well	Sept. 21	68	290	132	80
		Nov. 1	1,160	660	242	--
24	Coconut retting pit	Sept. 21	28	340	302	--
-	Rain sample from canvas tent	Sept. 18	10	10	7	--
-	Rain sample from palm tree	Sept. 26	52	36	17	--
-	Rain sample from rain gage	Sept. 26	5	12	9	--
	Falalap Island					
19	Dug well	Sept. 21	252	390	215	--
		Nov. 3	445	400	247	--
20	Taro swamp	Sept. 21	12	170	148	--
21	Dug well	Sept. 21	40	180	121	--
		Nov. 3	10	110	104	--
22	Taro swamp	Sept. 21	16	140	71	--
23	Mangrove swamp	Sept. 21	5,500	2,020	462	--
30	Shallow pond, 12 by 25 feet	Sept. 21	24	200	132	--
31	Dug well	Sept. 23	44	320	247	--
32	do.	Sept. 23	32	270	198	--
33	do.	Sept. 23	20	280	264	--
34	do.	Sept. 23	48	280	214	81
	Ella Island					
26	Shallow pond, 50 by 350 feet	Sept. 20	10,200	4,100	660	--
27	Dug well	Sept. 20	108	230	170	--
		Nov. 4	80	210	165	--
28	do.	Sept. 20	1,090	1,090	330	--
		Nov. 4	3,060	1,270	407	--
29	do.	Sept. 20	204	280	181	79
		Nov. 4	180	250	176	--
	Elangalap Island					
25	Dug well	Sept. 20	10,900	3,920	616	--
		Nov. 4	15,000	3,800	616	--

The chloride content of the ground water throughout Falarik Island rose slightly between the two periods of sampling, but the only significant change was at well 18, where the chloride content rose from 68 to 1,160 ppm. This sharp rise indicates that the lens is thinner in the vicinity of well 18 than elsewhere along the three lines of wells. According to native informants, the northwest corner of Falarik Island was once separated from the remainder of the island by a narrow channel. The channel was filled during a typhoon early in the 20th century and is now marked by the Maia Channel line of wells. Well 18, however, is east of the filled channel which, north of well 17, curves toward the northwest (J. I. Tracey, personal communication). According to Tracey, well 18 is in bedded sands and gravels that are typical of bar or beach deposits. These deposits are very permeable and permit free movement of water during the tidal cycle. The high permeability coupled with the fact that the shoreline is only 110 feet away may well explain the poor development of the fresh-water lens in the vicinity of well 18.

The relation of total hardness of the ground water to distance from the shoreline for the three lines of wells on Falarik in general follows the same pattern observed for the chloride data (fig. 10). Because of the acid environment created by decaying vegetation, sampling points 2 and 24, a small taro pit and a coconut retting pit, yield water harder than that of nearby wells.

In addition to the partial analyses discussed above, a set of water samples from the Fan Ni Wa line was analyzed for all major dissolved constituents (see table 6). The results in general agree with those discussed above. The only significant departure from what would generally be expected in the composition of ground water from a coralline atoll is the high silica content, which in four of the six wells exceeded that of sea water. The source of the excess silica may possibly be a concentration of sponge spicules or large amounts of drift pumice.

Analyses of water samples obtained on Falalap Island indicate that the Ghyben-Herzberg lens is as well developed there as it is on Falarik Island. Much of the central part of the island is a fresh-water swamp (see samples 20 and 22 in table 5), but closer to the coasts where boulder ramparts exist the ground water becomes more saline as the lens becomes thinner (see sample 19 in table 5). The northwest coast of Falalap, however, is formed by finer grained sediments which are conducive to the formation of a well-developed Ghyben-Herzberg lens. Samples from wells 30 to 34, which are 125 to 180 feet from the coast, all showed less than 50 ppm of chloride. The fresh-water lens in Falalap Island is disrupted along the ocean shore by brackish or saline areas in which mangrove trees grow. A ground-water sample obtained from one such mangrove swamp (see sample 23 in table 5) had a saline content approximately one-third that of sea water.

Three wells were dug on Ella Island along a line where the island is approximately 700 feet wide (fig. 2). The two outer wells, numbers 27 and

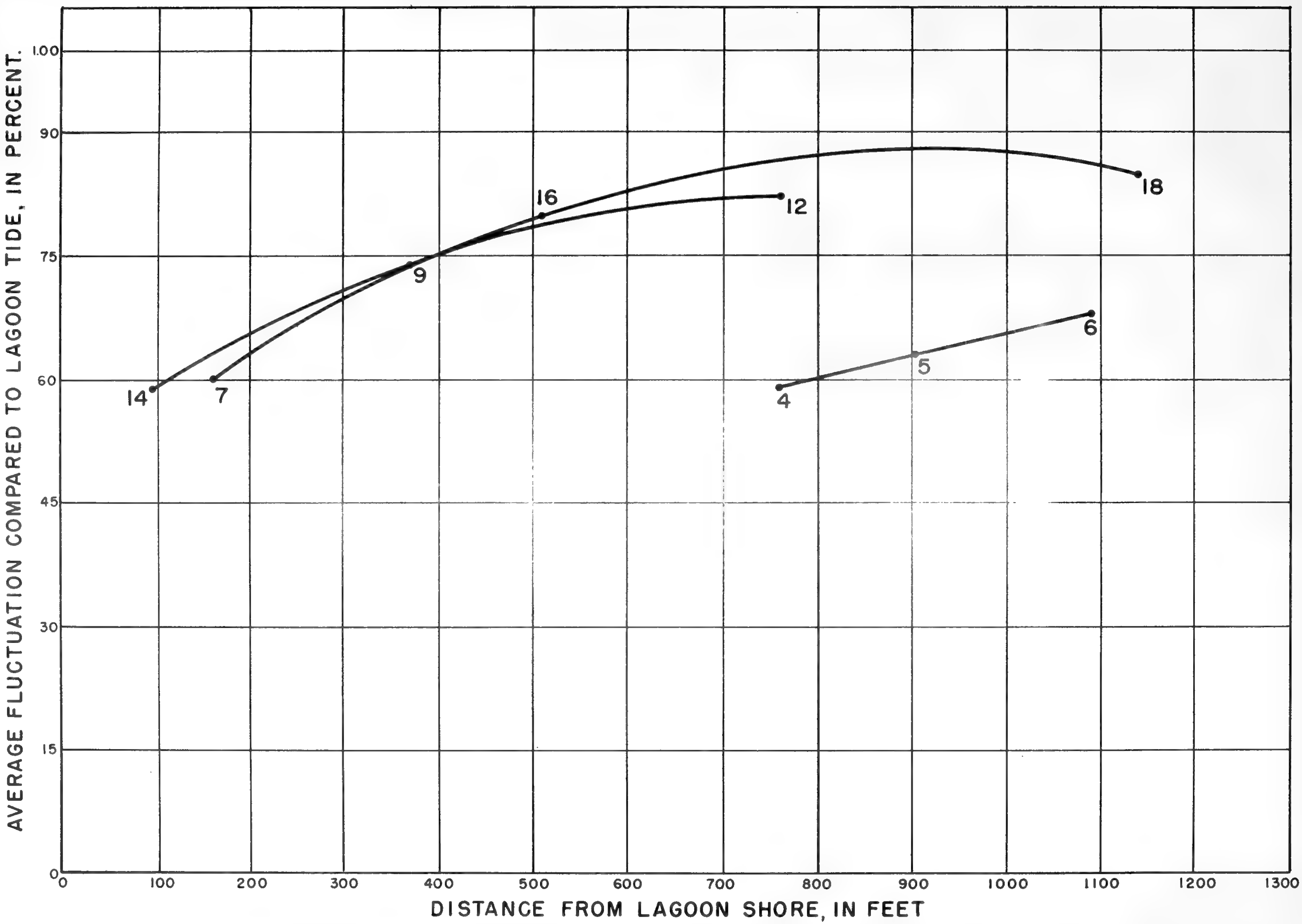

Figure 6.— Relation of damping of tidal fluctuations in wells to distance of wells from shoreline, Falarik Island, Ifalik Atoll.

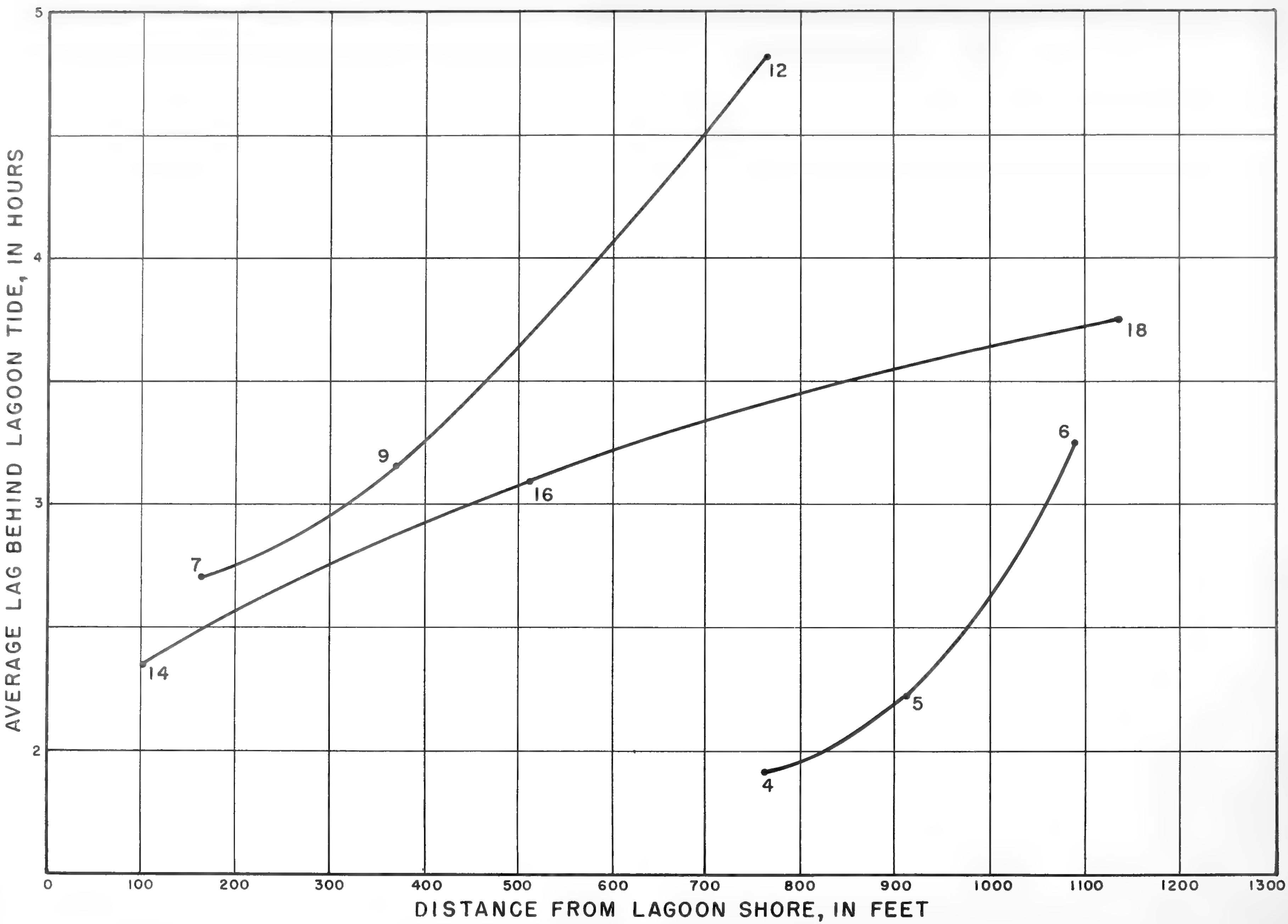

Figure 7.– Relation of lag of tidal fluctuations in wells to distance of wells from shore line, Falarik Island, Ifalik Atoll.

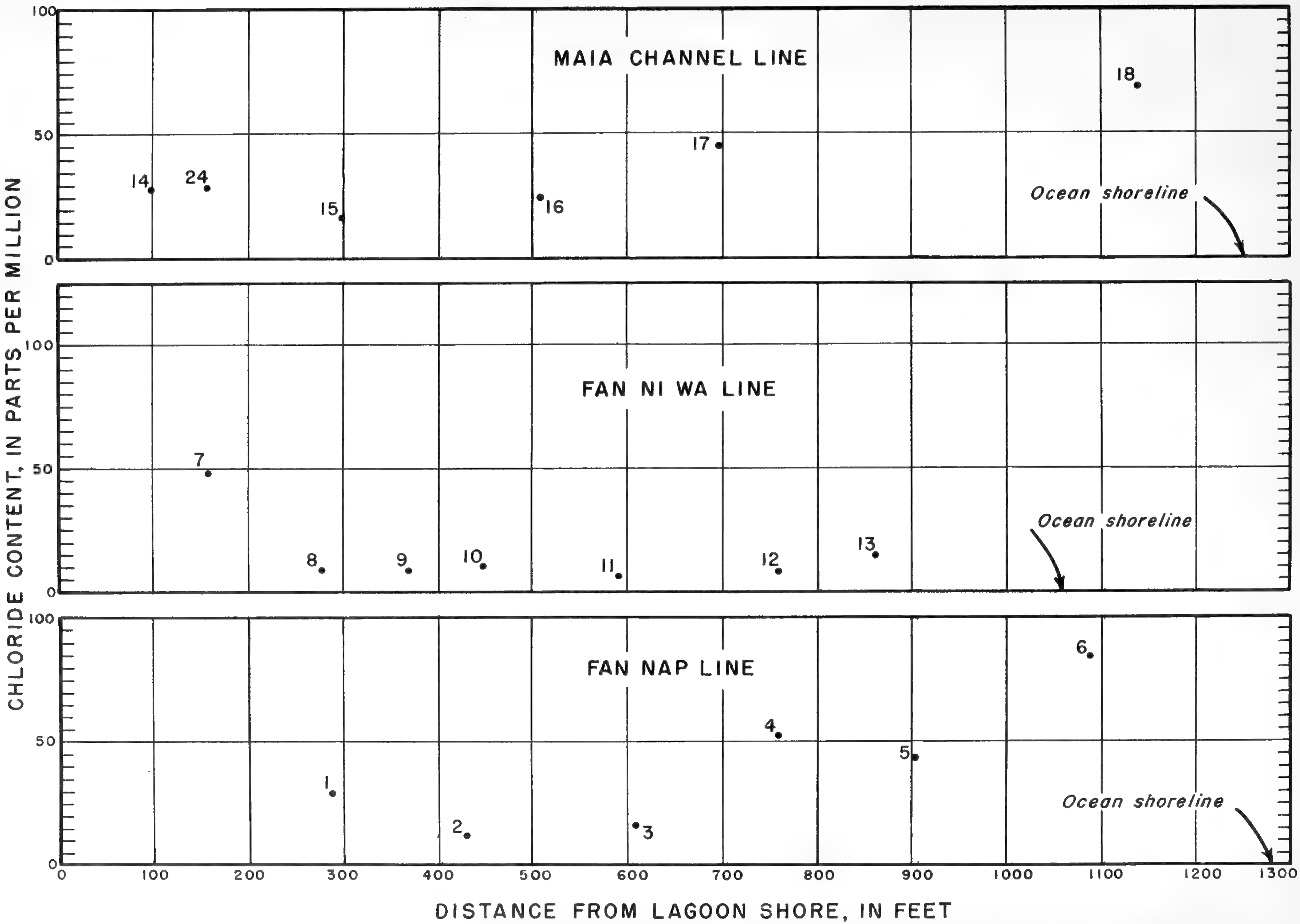

Figure 8.— Relation of chloride content of ground water to distance from shore, Falarik Island, Ifalik Atoll, September 21, 1953.

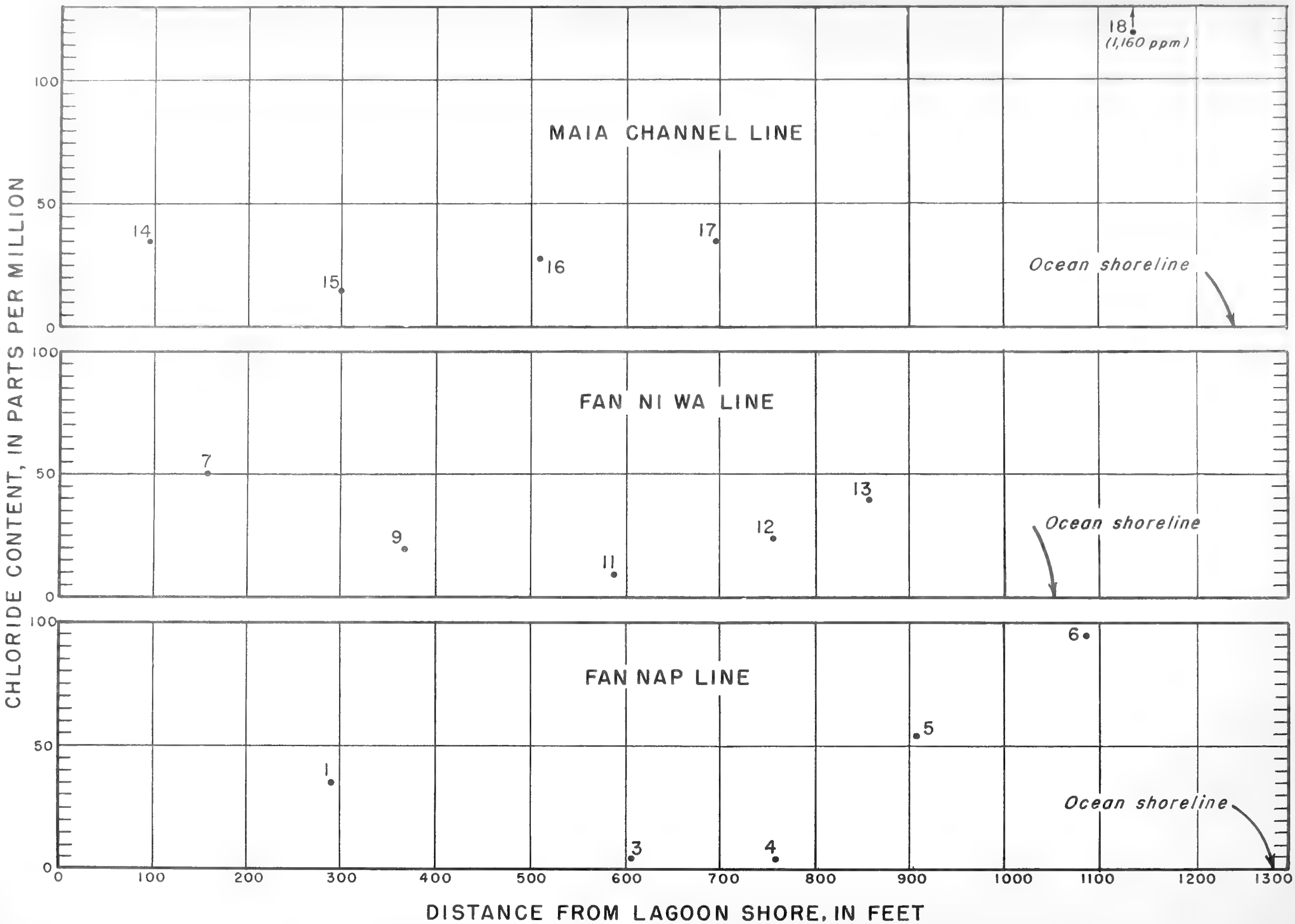

Figure 9.— Relation of chloride content of ground water to distance from shore, Falarik Island, Ifalik Atoll, November 1-3, 1953

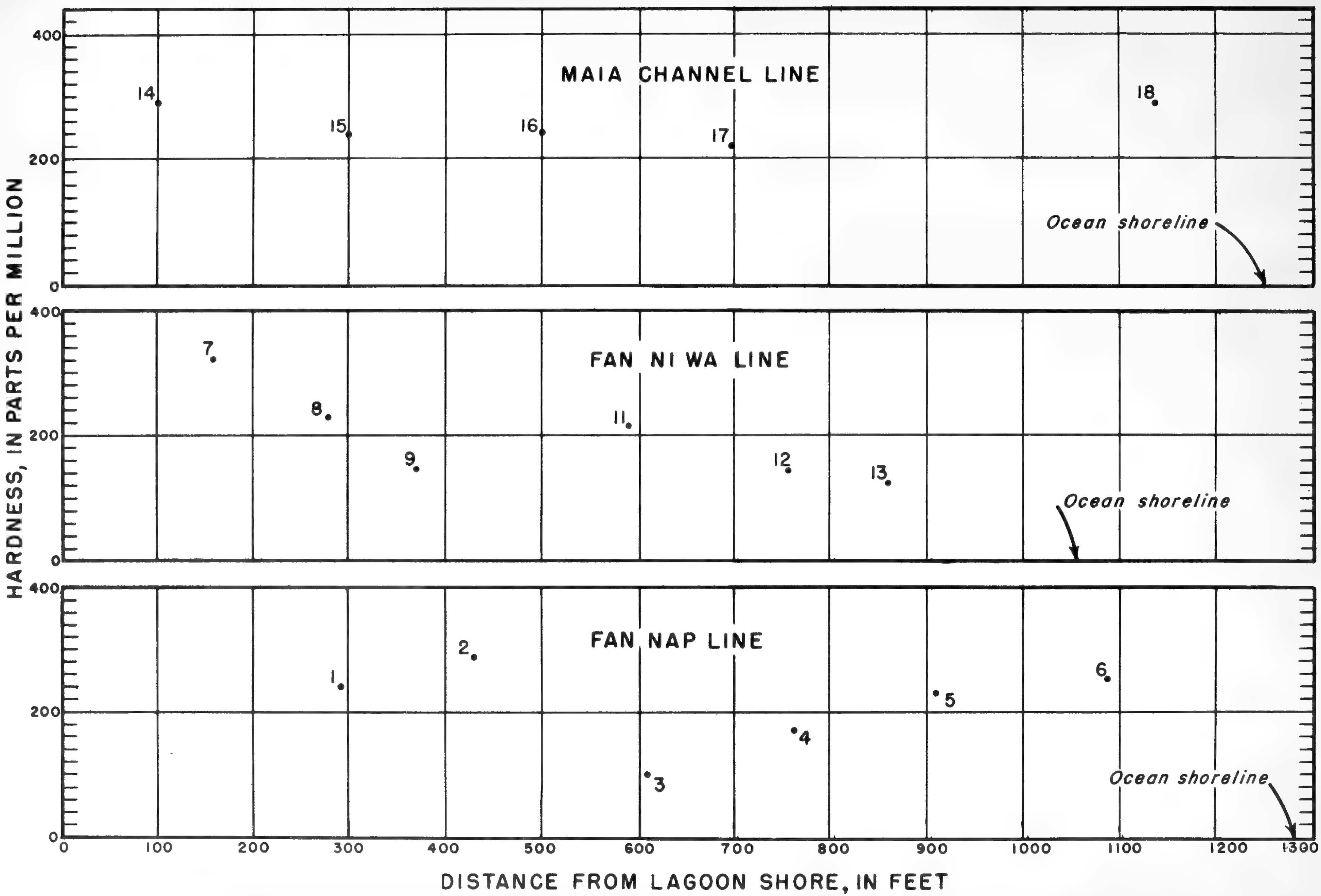

Figure 10.— Relation of hardness of ground water to distance from shore, Falarik Island, Ifalik Atoll, September 21, 1953.

Table 6.--Chemical analyses of water samples (ppm) from Fan Ni Wa well line, Ifalik Atoll
Analyses by U. S. Geological Survey, Quality of Water Branch

Well number	Well 7	Well 8	Well 9	Well 11	Well 12	Well 13
Date of collection	9/23/53	9/23/53	9/23/53	9/23/53	9/23/53	9/23/53
Dissolved solids	446	271	232	157	233	174
Specific conductance (micromhos at 25°C)	748	467	290	272	399	311
Hardness (as $CaCO_3$)	331	242	204	134	172	132
Non-carbonate hardness (as $CaCO_3$)	0	0	10	8	13	0
Silica (SiO_2)	15	8.8	13	4.0	9.5	3.6
Iron (Fe)	.17	.37	.06	.03	.07	.03
Calcium (Ca)	103	82	68	47	59	44
Magnesium (Mg)	18	9.2	8.3	4.1	6.0	5.4
Sodium (Na)	29	4.7	5.8	3.9	15	12
Potassium (K)	8.3	1.7	3.0	.4	1.7	2.5
Carbonate (CO_3)	0	0	0	0	0	0
Bicarbonate (HCO_3)	408	298	237	154	194	163
Sulfate (SO_4)	5.8	3.5	4.1	2.6	8.7	7.7
Chloride (Cl)	47	6	10	5	26	14
Fluoride (F)	.2	.3	.4	.5	.5	.2
Nitrate (NO_3)	.6	.5	.2	3.8	.3	.6

29, which are about 175 feet from the ocean and lagoon shores respectively, contain fresh water, whereas, oddly enough, the middle well, number 28, contains water averaging about 2,000 ppm in chloride. (See table 5.) The higher salinity at well 28 may be due to the presence of a section of underlying reef which has a more permeable matrix or a larger number of cracks than the sections of reef underlying wells 27 and 29. The greater tidal mixing would permit the development of a thicker zone of mixture within the Ghyben-Herzberg lens. Presumably at well 28 the edges of the zone of mixture extend to the water table. The lens is practically undeveloped in the southwest end of Ella Island where the land is only about 350 feet wide. There a shallow ground-water pond, with dimensions of about 50 by 350 feet, has salinity greater than half that of sea water (see sample 26 in table 5).

Elangalap Island is divided into two roughly equal segments which are independent hydrologic units. The larger segment has maximum dimensions of about 75 by 150 feet and an area of 0.0004 square mile. It does not support a fresh-water lens. Two samples obtained from a well in the center of that land unit ranged in chloride content from 60 to 80 percent of that of sea water (see sample 25 in table 5).

The temperature of the ground water at Ifalik ranged from 76° to 81° Fahrenheit and averaged 79° Fahrenheit.

Use of Water

Ground water is used by the people on Ifalik for drinking, cooking, and washing. Bathing is done in the lagoon or in wells. The ground water is obtained from shallow dug wells which, for the most part, are uncased and uncurbed. Several wells which are reserved for drinking and cooking purposes have wooden covers and curbs and are cased with limestone blocks. Practically no rainwater is caught or used directly. This is in contrast to the Marshall Islands, where the people prefer rainwater to well water for all purposes (Cox, 1951; Arnow, 1954).

Ground water is equally important to the people of the atoll through its control of vegetation. The existence of extremely fresh ground water permits the growth of taro and breadfruit in widespread areas in Falarik and Falalap. Breadfruit will not grow successfully in certain parts of Falarik - notably in the filled Maia Channel and along a narrow strip of gravelly sand which parallels the lagoon shore and expands to cover about half of the southwest corner of the island. The ground water underlying these areas is fresh however, and the failure of the breadfruit is apparently due to a soil deficiency. The explanation offered by the people of Ifalik is that not enough "brown soil" is present.

The coconut palm, the backbone of the Ifalikian way of life, grows successfully almost wherever planted on the three larger islands in Ifalik and is even found on tiny Elangalap. There is no fresh-water lens in Elangalap, but because of the heavy rainfall the palms evidently obtain sufficient fresh water directly from the zone of soil moisture.

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A partial list of the plants of the Midway Islands

by

Johnson A. Neff and Philip A. DuMont

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A partial list of the plants of the Midway Islands

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The Midway Islands, 1,300 statue miles northwesterly from Honolulu and only 56 miles southeast of Ocean Island, the end of the Leeward chain, are known to tens of thousands of Americans. Sand Island, the larger of the two, was an operating base for Pan-American Airways from 1935 to 1950. It has been an east-bound refueling stop for Armed Forces trasnport planes since the end of World War II. During one stage of the hostilities the 1,282 acres of the two islands held more than 15,000 fighting men, their equipment, housing, shops and warehouses. Sand Island, too, has long been an active U. S. Navy base.

The Midway Islands were discovered in 1859 when Captain W. C. Brooks took possession of them from the U. S. Government. Being very near the exact center of the north Pacific they were termed the Midway Islands, or just Midway. Eastern Island, the older of the two geologically, covers 334 acres and is composed of broken coral, shells and coarse sand. Sand Island, 948 acres, is made up largely of white coral sand. Except for a survey in 1867 by personnel from the U.S.S. Lackawanna, only shipwrecked sailors saw these islands until the Rothschild Expedition visited them in 1891.

Eastern Island has been somewhat vegetated for a much longer period than Sand Island. Photographs taken in 1891 be members of the Rothschild Expedition show fairly dense grass, some Boerhavia and extensive low Scaevola bushes on Eastern, but only a few Scaevola and a few Boerhavia vines on Sand Island.

When the Commercial Pacific Cable Company came to Sand Island in 1902 the island was described as a level waste of glaring white sand with only a few bunches of grass, a few Boerhavia vines and one or two small Scaevola bushes. In 1907 the company planted hundreds of ironwoods, Casuarina, and San Francisco grass, Ammophila, around their coumpound. Within a few years the trees were large enough to protect the northern end of the island from the winter storms and the Scaevola, Boerhavia and Ammophila began to spread. By the beginning of World War II some of the original ironwoods were 70 feet tall and natural re-seeding had spread them over most of Sand Island and even onto Eastern Island.

In the years that followed the original plantings, other plants were introduced, largely close to the Cable Company buildings on the north end of the island. When Pan-American Airways set up their operating base on Sand Island in 1935, a number of plants, largely from Hawaii, were set out near their Gooneyville Lodge. According to Hadden, who was their unofficial gardener from 1936 to 1941, over 200 species of plants were tested on this island. Some of the ornamentals now growing about the residential area of the island were listed in his report of successful introductions, and many of the ornamentals planted about Gooneyville Lodge are still thriving.

During the intervening years, new introductions have occurred as seeds were introduced in packing materials, and as flowers or shrubs were brought in by resident Navy personnel. We find no record of actual plantings on Eastern Island, but either through man or natural means a number of the plants found on Sand Island are now established on Eastern; in some instances their smaller size indicates their relative youthfulness in this location.

In the autumn of 1954 the authors were assigned by the U. S. Fish and Wildlife Service to study bird problems on the Midway Islands, and were there from November 6 to December 5. Enroute to the islands, while conferring with Mr. E. H. Bryan, Jr., of the Bishop Museum in Honolulu, we learned that the Museum herbarium lacked specimens of many plants known to be growing on Midway. It seemed small repayment for Mr. Bryan's many courtesies that we attempt to add to the Museum's Midway herbarium.

Our objective concerned the bird life of the islands, and plant collecting was entirely a side-line. Plants were picked up during the course of other work so a complete collection was not attempted. We did not search the residential area for flowering plants, nor did we collect specimens of a number of larger ornamentals such as banana, coconut and banyan. At the end of our stay we had transmitted to the Bishop Museum specimens of 48 species of plants. Duplicate specimens of 46 of these were placed in the herbarium of the Wildlife Research Laboratory in Denver. Plant identifications were made by Marie C. Neal of the Museum.

In suggesting a modernized report on the plants of the Midway Islands Dr. Fosberg generously contributed his own notes covering observations made on Sand Island on February 13, 1954. He further abstracted information from two earlier lists of Midway plants (1931, 1935) and furnished a list of principal references on Midway plants.

Neither we nor Dr. Fosberg saw any specimens of a considerable number of the plants listed by these earlier writers. Ecological conditions have changed greatly on the Midway Islands since 1940 when defense preparations were put into high gear there. Some of the earlier species may have passed from the picture, or may now be so restricted in their distribution that we did not encounter them. There has been little attention to gardening on Sand Island since Hadden left there in 1941. Soon after Pearl Harbor military activity on the two islands literally changed the face of the landscape. Bulldozers cleared off the brush and miles of hard-surfaced runways were built. Bulldozers also threw up hundreds of yards of sand revetments and cleared plane parking behind them. Literally hundreds of buildings were scattered all over both islands. Though many of the latter are now falling down, and though Scaevola bush has covered the top of most of the revetments, the mark of wartime activity on the plant ecology of these islands remains clearly visible.

On Eastern Island, slightly more than 100 acres are in runways, buildings, and plane parking strips, to say nothing of the great area of revetments. On Sand Island, more than 200 acres are occupied by the runways, plane parkings, roads, tumbledown wartime buildings, and the residential and administrative area of the active Naval base. Bulldozed areas of ironwoods, Scaevola and other plants that had spread from Cable Company and Pan-American plantings, have in large part been replaced by apparent later introductions, many of them weed plants.

In the following report of plants that have grown or are now growing on Midway it has been necessary to make use of a series of symbols. C. & C. refers to plants reported by Christophersen and Caum in 1931. St. J. refers to plants listed by St. John in 1935. The symbol FWS refers to observations made by the authors, and FWS-C to those species where specimens were collected by us. FRF refers to plants observed by Dr. Fosberg on February 13, 1954. Comments made are necessarily general, mostly based on our own observations and such notes and records as we made.

Since it is necessary that in such a paper there be but one taxonomic standard, we have followed Dr. Fosberg's recommendations on such matters wherever questions arose. Without the generous assistance of Dr. Fosberg, Mr. E. H. Bryan and Miss Marie Neal of the Bishop Museum, neither this paper nor the collection upon which it is largely based would have been prepared.

Psilotum nudum (L.) Griseb.
C. & C.

Araucaria excelsa R. Br. — Norfolk Island pine.
FWS. A few fine specimens are growing in the old Cable Company coumpound area and on the lawns of a few of the officers' quarters, Sand Island.

Pandanus tectorius Park. — Screwpine; Hala.
FWS. Occasional specimens occur in the administrative and residential area, two of them at the Administration Building. One was seen in the Scaevola scrub near the south end of Sand Island.

Ammophila arenaria (L.) Link — San Francisco grass
C. & C. The planting of San Francisco grass as a soil binder by the Cable Company is reported in every description of the flora of Sand Island. Late in our stay the senior author had not found any grass that seemed to be this species, and spent a number of hours looking for new types; several were collected, but none turned out to be Ammophila.

Cenchrus agrimonoides var. laysanensis F. Br.
C. & C.

Cenchrus echinatus L. — Sand bur.
C. & C.; FRF; FWS-C. Locally common, found mostly along the edges of runways, roads and about the larger buildings on Sand and Eastern Islands.

Chloris inflata Link
FRF. FWS-C. Locally common in open spaces on Sand and Eastern Islands.

Cynodon dactylon (L.) Pers. Bermuda grass.

FRF; FWS-C. Abundant. The common lawn grass and spread over much of Sand Island. Locally common on Eastern Island. Now the best sand-binder growing on the islands.

Digitaria ciliaris (Retz.) Koel. Crab grass.

FRF. Dr. Fosberg calls it rare in open sandy areas on Sand Island.

Eleusine indica (L.) Gaertn. Goose grass.

FRF; FWS-C. Locally common, scattered about in open spaces on both Sand and Eastern Islands.

Eragrostis amabilis (L.) W. & A. Love grass.

FRF, FWS-C. Locally common in open spaces on Sand Island. Was not noted on Eastern Island.

Eragrostis variabilis (Gaud.) Steud.

C. & C.; FWS-C. Rare. Found in only two places on Sand Island, one of them a large patch near the terminal.

Eragrostis whitneyi var. caumii Fosberg

C. & C.; FWS-C. Fairly abundant on parts of Sand Island, locally common on Eastern Island. Found growing along edges of runways, and in cracks in runways and plane parking stands.

Lepturus repens (Forst.) R. Br.

C. & C.

Panicum purpurascens Raddi Para grass.

FWS-C. Occasional; found in only two areas on Sand Island, under the ironwoods near the Cable Company compound.

Rhynchelytrum roseum (Nees) Stapf and Hubb. Natal redtop.

FWS-C. Rare, found in only two or three small areas on the older, undisturbed part of Sand Island.

Setaria verticillata (L.) Beauv.

FWS-C. Locally abundant in open spaces on both Sand and Eastern Islands.

Sporobolus virginicus (L.) Kunth

St. J.

Stenotaphrum secundatum (L.) O. Ktze. Buffalo grass.

FRF; FWS-C. Occasional, in open spots in the older vegetated section of Sand Island.

Cyperus alternifolia L. Umbrella plant.

FRF; FWS-C. Two or three densely grown clumps were seen under old ironwoods near the Cable Company compound, a few small plantings about residences, on Sand Island only.

Cyperus javanicus Houtt.
St. J.

Cyperus rotundus L. Nut grass.
FRF; FWS-C. Found locally abundant on both Sand and Eastern Islands, mostly along the margins of runways, along edges of paved roads, and near foundations of larger buildings where run-off of rainfall apparently controls its distribution.

Fimbristylis cymosa R. Br.
FWS-C. Locally common in same general locations as the last, but more restricted in distribution, on both Sand and Eastern Islands.

Cocos nucifera L. Coconut.
FWS. Planted originally by the Cable Company and later by Pan-American, the coconut palms seem to be doing well; on Sand Island only.

Phoenix sp.
FWS. A number of palms of the _Phoenix_ type are to be found on Sand Island among the Cable Company and Pan-American plantings, and on lawns of a few residences.

Commelina diffusa Burm. f. Day flower.
St. J.

Crinum sp.
FRF; FWS. Occasional fine specimens of "spider lilies" may be seen on Sand Island on the lawns of residences and about administrative buildings.

Agave sp. Century plant.
FWS. Occasional plants locally called sisal occur on Sand Island in the residential and administrative area.

Musa sp.
FWS. Some few banana plants were found on Sand Island in the older area near the Cable Company and Pan-American buildings, and an occasional one as an ornamental about a residence. They appear to be surviving but not thriving.

Casuarina equisetifolia L. Ironwood.
FRF; FWS-C. Abundant on both Sand and Eastern Islands. The original plantings appear to have reached maturity and some are dying. Spreading by natural means the ironwoods have scattered all over Sand Island and trees dully 30 feet high were seen on beach-line dunes on the opposite end of the island from the original plantings. A few trees of similar height were found on Eastern Island and small seedlings occur almost all over this island. Within a few years it, too, will very likely be ironwood-covered.

Morus alba L. ? Mulberry.
FRF. Reported by Hadden as growing here; we did not find it but Fosberg located one unhealthy-looking specimen growing in an opening in the scrub on Sand Island.

Ficus retusa L. Chinese banyan.
FWS. A number of banyans of varying size appear to be doing well about the old Cable Company area and about Pan-American's deserted Gooneyville Lodge, on Sand Island.

Coccoloba uvifera (L.) Jacq. Sea grape.
FRF; FWS-C. Not uncommon, single trees growing widely scattered over both Sand and Eastern Islands.

Achyranthes splendens var. reflexa Hbd.
C. & C.

Boerhavia diffusa var. tetrandra (Forst.) Heimerl
C. & C.; FRF; FWS-C. Common trailing vine found in much of the open or very slightly shaded sandy area of both Sand and Eastern Islands.

Bougainvillea sp. Bougainvillea.
FWS. A few very nice vines noted growingon residential porches on Sand Island.

Portulaca lutea Sol.
C. & C.

Portulaca oleracea L. Purslane.
FWS-C; FRF. Locally abundant, widespread in open sandy areas on both Sand and Eastern Islands.

Capparis sandwichiana DC.
C. & C.

Lepidium o-waihiense C. & S.
C. & C.

Lepidium virginicum L. Pepper-grass.
FWS-C. Rare, only two or three plants noted on each of the islands.

Lobularia maritima (L.) Desv. Sweet alyssum.
FRF; FWS. Sweet alyssum grows in abundance over large portions of both Sand and Eastern Islands.

Desmodium uncinatum (Jacq.) DC.
St. J.

Medicago lupulina L. Nonesuch.
FRF; FWS. Fosberg found it growing as an escapee from a lawn. We found a few specimens about the residential area, on Sand Island.

Trifolium sp.
St. J.

Crotalaria incana L. Rattle-pod.
FWS-C. Only two or three plants were seen growing on each of the islands.

Crotalaria mucronata Desv. Rattle-pod.
St. J.

Leucaena glauca (L.) Benth. Koa haole.
FWS-C. The only plant seen was growing on the lawn of the Administration Building on Sand Island.

Acacia farnesiana (L.) Willd. Klu.
St. J.; FWS-C. Found as a planted ornamental in some places on Sand Island. One small wild spot has grown up near the enlisted men's residential area.

Albizzia lebbeck (L.) Benth. Woman's tongue.
FWS-C. Found as an ornamental and in a few scattered small wild patches about the older part of Sand Island.

Oxalis corniculata L. Sorrel.
FWS-C. Occasional, scattered about on both Sand and Eastern Islands.

Tribulus cistoides L.
C. & C.; FWS-C. Locally abundant trailing ground cover on sandy areas on both Sand and Eastern Islands.

Murraya paniculata (L.) Jack Mock orange.
FWS-C. Seen only as a planted hedge in the residential area on Sand Island.

Euphorbia geniculata Ort. Spurge.
St. J.

Euphorbia heterophylla L. Wild poinsettia.
FRF; FWS-C. Abundant on Sand Island, common as an understory among the thinner stands of ironwoods and as dense marginal growth about the edges of thick stands. Also present on Eastern Island.

Euphorbia hirta L. Spurge.
St. J.; FRF; FWS-C. Occasional or locally common. Most frequently seen in open sandy utility areas where the soil has been disturbed during recent years.

Euphorbia prostrata Ait. Spurge.
FWS-C. Seen only occasionally on Sand Island, growing along the edge of paved runways.

Euphorbia pulcherrima Willd. Poinsettia.
FWS-C. Found growing as an ornamental at one residence formerly occupied by Pan-American employees, on Sand Island.

Ricinus communis L. Castor-oil bean.
FRF; FWS. An occasional small plant was seen on Eastern Island. On Sand Island there are several fairly large patches, some of them far distant from the residential area.

Schinus terebinthifolius Raddi Christmas berry.
FRF; FWS-C. Noted only as a hedge plant on Sand Island.

Hibiscus tiliaceus L. Hau.
FWS-C. Hau trees are to be found about the residential sector on Sand Island, and one or more near the old control tower on Eastern Island. Occasional specimens occur widely scattered about the Sand Island scrub.

Hibiscus sp. Hibiscus.
FWS. Quite a few nice specimens of flowering hibiscus shrubs occur in the residential sector on Sand Island.

Malvastrum coromandelianum (L.) Garcke
St. J.; FWS-C; FRF. Occasional plants may be found about the residential area on Sand Island, and two or three are growing near the old control tower on Eastern.

Sida fallax Walp. Ilima.
C. & C.

Thespesia populnea Sol. ex Correa Milo.
FWS. One milo tree was noted growing on the lawn of the Administration building on Sand Island.

Waltheria indica L.
St. J.

Terminalia catappa L. Tropical almond; false kamani.
FWS. Scattered trees may be found almost all over Sand Island, and a few nice specimens were seen on Eastern Island.

Carissa grandiflora A. DC. Natal plum.
FWS-C. Found growing only as a hedge plant in the residential area of Sand Island.

Catharanthus roseus (L.) G. Don Periwinkle.
FWS-C. Seen only as a flowering ornamental near the old Pan-American Gooneyville Lodge on Sand Island.

Thevetia peruviana (Pers.) K. Schum. Bestill tree.
FWS-C. Found only as an ornamental in the residential area of Sand Island.

Nerium oleander L. Oleander.
St. J.; FWS-C. Seen only as an ornamental and hedge plant in the residential area of Sand Island.

Ipomoea indica (Burm.f.) Merr. Morning glory.
C. & C.; FWS-C. Growing profusely near one residence on Sand Island. Several plants growing near an old building in the revetment area on the south shore of the island.

Ipomoea pes-caprae (L.) Sweet Beach morning glory.
C. & C. FWS-C. Locally common, this plant is most often found in open sandy areas in the interior of both islands, or along the sandy upper beach-lines.

Messerschmidia argentea (L.f.) Johnston. Tree heliotrope.
FRF; FWS-C. Not uncommon, but widely scattered on both Sand and Eastern Islands. Often seen emerging above the Scaevola scrub.

Lantana camara L. Lantana.
FWS-C. Found only as a hedge and ornamental plant in the residential and administrative area of Sand Island.

Stachytarpheta jamaicensis (L.) Vahl. False vervain.
St. J.

Vitex trifolia var. bicolor (Willd.) Mold.
FRF; FWS-C. Found only as an ornamental planting in the residential area on Sand Island.

Phyllostegia variabilis Bitter
C. & C.

Solanum nigrum L. Nightshade.
St. J.; FRF; FWS-C. Occasional, found mostly in utility areas about buildings.

Solanum laysanense Bitter
C. & C.

Solanum nelsoni var. intermedium F. Br.
C. & C.

Plantago lanceolata L. Plantain.
St. J. While this plant was reported 20 years ago, the senior author, thoroughly familiar with it at home, did not find it.

Scaevola frutescens (Mill.) Krause Naupaka.
C. & C.; FRF; FWS-C. Abundant. The dominant vegetation of both islands. It is gradually creeping to the tops of the old revetments, recapturing areas lost to military destruction. Where undisturbed, in vacant lot, and in waste land.

Conyza bonariensis (L.) Cronq. Horseweed.
St. J.; FRF; FWS-C. Locally abundant, mostly along the margins of runways and unpaved roadways; also noted in utility areas where the sand has been disturbed, in vacant lots, and in waste land; on both Sand and Eastern Islands.

Gnaphalium purpureum L. Purple cudweed.

FRF. Very rare, found in the shade of a building at the Air Terminal on Sand Island.

Gnaphalium sandwicensis f. canum Sherff

FWS-C. Locally common along margins of runways and in old administrative areas on Eastern Island, and thinly but widely scattered in similar locations on Sand Island.

Pluchea odorata (L.) Cass.

FRF; FWS-C. More widespread on Eastern Island than on Sand Island, but abundant on both. This weed species has taken over many open areas where the soil was disturbed by construction work, such as along the margins of runways, and now forms an almost impenetrable barrier to heights of four to five feet.

Bidens pilosa L. Spanish needle.

FRF. Dr. Fosberg found it common in weedy ground on Sand Island.

Sonchus oleraceus L. Sow thistle.

FRF; FWS-C. Rare; only an occasional plant was seen growing along utility toads and in service areas on both Sand and Eastern Islands.

Xanthium saccharatum Wallr. Cocklebur

St. J. We knew of St. John's report of cockleburs on Midway, but did not find the plant.

Verbesina encelioides Gray

FRF; FWS-C. Abundant on both islands, though more widespread on Eastern than on Sand. Forms a dense cover on many of the open areas in the interior of the islands, taking over areas that would be better vegetated if in grasses. Offers the only bit of color on the islands with its multitude of golden blossoms.

The plants reported herein represent 35 families and 91 species. Of these, 24 species listed in the 1931 and 1935 papers were not seen by either Dr. Fosberg or the authors in 1954. Their present status is therefore unknown. In addition to these, Hadden (1941) and Bryan (1942) listed a variety of plants that had grown on Midway, some of them by common name. We did not find the following group of plants listed by Hadden and Bryan:

Kou	Baobab	Coprosma	Flame tree	Papaya
Tamarix	Brassaia	Cypress	Acalypha	Dieffenbachia
Sanseveria	Panax	Plumeria	Ti	Pinus, Oregon forms.
Limes	Dracaena	Buttonbush	Croton	

The Midway Islands of today are a different sight than that seen by the early explorers, or the first Cable Company employees of fifty years ago. There is little expanse of glaring white sand. As the plane approaches the islands, and as the newcomer catches his first glimpse of them, his first reaction is to note the geometric pattern of runways, and the second is to comment that these are green islands, not deserts. As the plane comes closer the green of the uneven forest of Casuarina and the Scaevola scrub begins to outline the working facilities of the islands, and as the plane sinks down onto the runway it flashes, in early November, past bright golden Verbesina growing along the runway's edge and in the open spaces. We board the bus and drive into the shaded ironwood section that is the residential portion of Sand Island, where, as we listen to the ocean breeze through the ironwoods, we may easily forget that we have travelled to the islands Midway of the north Pacific and think ourselves back home again - until the bus driver slams on the brakes and we wait while a strolling gooney bird parades across the road. Whereupon we either smile or cuss a bit, and say "This is Midway."

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ATOLL RESEARCH BULLETIN

No. 46

Conspicuous features of organic reefs

by

J. I. Tracey, Jr., P. E. Cloud, Jr. and K. O. Emery

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Conspicuous Features of Organic Reefs[1]

by

J. I. Tracey, Jr.,[2] P. E. Cloud, Jr.,[2] and K. O. Emery[3]

Introduction

Cooperative studies of Pacific reefs, especially in the last 10 years, have brought together oceanographers, biologists, and geologists, each dependent on the work of others and each to some degree inconvenienced by the diversity of names used to denote parts of reefs. The nomenclature of even the conspicuous features of reefs has varied widely. Although the field is much too active for stabilization in detail to be practicable, agreement is desirable for those features of reef and lagoon that appear to be generally present and therefore especially important in reef studies. The following list is purely utilitarian and descriptive; it is not intended as a comprehensive terminology with established priority of usage.

The immediate stimulus to this paper was provided by D. P. Abbott, Marston Bates, F. M. Bayer, and R. R. Harry of the Pacific Science Board's 1953 Ifaluk Atoll team, who worked up a set of names and discussed them with Tracey at Ifaluk and Guam. Discussion of these and other terms by Tracey, Cloud, and Emery at Manila in November 1953 led to the circulation of a provisional draft of the present paper to 17 colleagues for review and criticism. The replies were generally favorable and the comments that were received on specific features and terms helped greatly in preparing the final revision.

The following list, then, sets forth what we consider to be the most widely distinctive zones or features of reefs, illustrated by a hypothetical cross-section of an atoll (fig. 1). The zonation of barrier reefs (which are separated by a lagoon from preexisting land) and of fringing reefs (which border preexisting land) is close enough to that of atoll reefs so that most of the names are generally applicable.

Discussion

An atoll consists of a ring-shaped organic reef that encloses a lagoon in which there is no preexisting land, and which is surrounded by the open sea. The primary distinctions to be drawn are between outer slope, reef, island, lagoon, and smaller reef structures within the lagoon.

1/ Publication authorized by the Director, U. S. Geological Survey.

2/ U. S. Geological Survey, Washington 25, D. C.

3/ U. S. Geological Survey, University of Southern California, Calif.

Channels and passes between ocean and lagoon are also of primary importance. Most of the difficulty with names, especially for those who must rely on collections and data gathered by others, lies in boundaries between the principal zones. The following terms are suggested, with purposely broad definitions:

1. Outer slope.--the steeply descending outer slope of the reef below the dwindle point of abundant living coral and coralline algae, which is ordinarily at about 10 fathoms.

2. Reef front.--the upper seaward face of the reef, extending above the dwindle point of abundant living coral and coralline algae to the reef edge. This zone commonly includes a shelf, bench, or terrace that slopes to 8-15 fathoms, as well as the living, wave-breaking face of the reef. The terrace may be an eroded surface or may be veneered with organic growth. The living reef front above the terrace in some places is smooth and steep; in other places it is cut by grooves separated by ridges that together have been called groove and spur systems, forming comb-tooth patterns. If the terrace is broad and well defined it may be well to designate it a separate reef zone.

3. Seaward reef margin.--the seaward edge of the reef flat, marked in places by an algal ridge and cut by surge channels, which are the landward extensions of the reef-front grooves.

4. Reef flat.--the upper surface of the reef, commonly exposed or awash at lowest tide. The presence of islands on the flat modifies the ecology of the reef; therefore, an important distinction should be drawn between island reef flats, or flats seaward from islands, and inter-island reef flats or flats between islands.

   The reef flat is commonly divisible into outer and inner reef flats, or outer, central, and inner reef flats; but one "inner" or "outer" zone may not be the close ecologic equivalent of another "inner" or "outer" zone.

   On inter-island reefs, and on seaward reef flats adjoining islands, the outer zone is toward the ocean, the inner is toward lagoon or shore. In rare instances a broad reef flat on the lagoon shore of an island may be subdivided into an outer lagoon reef flat, near the lagoon reef edge, and an inner lagoon reef flat, near the island; but careful distinction should be made between its parts and those of reef flats that abut the open sea. If a reef flat is not present on the lagoon side of an island, its place may be taken by a lagoon shelf, on which detrital sediments predominate over organic growth.

5. <u>Seaward beach</u>.--the seaward-facing beach of reef islands.

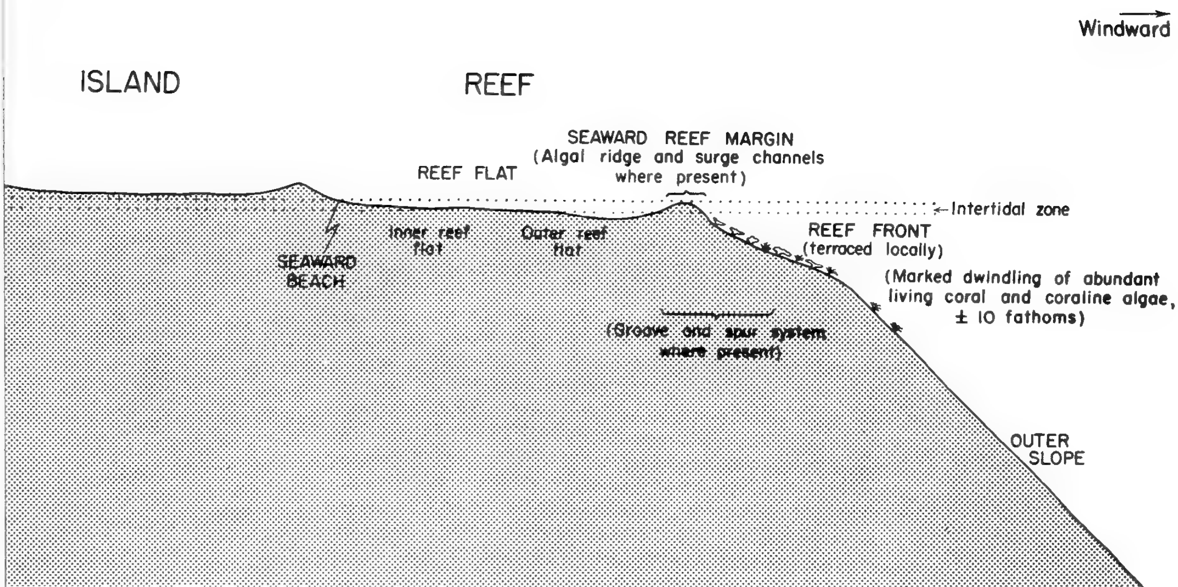
6. <u>Lagoon beach</u>.--the lagoonward-facing beach of reef islands.

7. <u>Lagoon reef margin</u>.--the lagoonward margin of the reef; unlike the seaward reef margin, it is not necessarily defined by growth. In some places, especially where islands are present, there may be no lagoon reef margin at all. If the lagoon reef margin is well defined, a lagoon reef front may be present and even a lagoon terrace, comparable to the seaward reef front and terrace. If the lagoon reef margin is poorly defined, a lagoon shelf may separate lagoon slope from reef flat or lagoon beach (fig. 2).

8. <u>Lagoon slope</u>.--the border zone of the lagoon that slopes downward from the lagoon reef margin or lagoon beach to the lagoon floor.

9. <u>Lagoon floor</u>.--the undulating to nearly level floor of the lagoon.

Minor organic prominences on lagoon floors or slopes, all broadly related, range from small mounds or tall narrow pinnacles to large masses, hundreds of feet in diameter. Some prefer to use a single term for all such features, for example, coral knoll, bioherm, or patch reef. The considerable physical and organic variety of these features is ecologically significant, however, and should be indicated in some way. In general it seems preferable to use informal names that will describe both the dominant organism and the physical appearance. Examples are: algal knoll; coral-algal mound; millepore patch; <u>Acropora</u> thicket, etc.


Windward
ISLAND
REEF
SEAWARD REEF MARGIN
(Algal ridge and surge channels
where present)
REEF FLAT
Intertidal zone
Inner reef
flat
Outer reef
flat
SEAWARD
BEACH
REEF FRONT
(terraced locally)
(Marked dwindling of abundant
living coral and coraline algae,
± 10 fathoms)
(Groove and spur system
where present)
OUTER
SLOPE

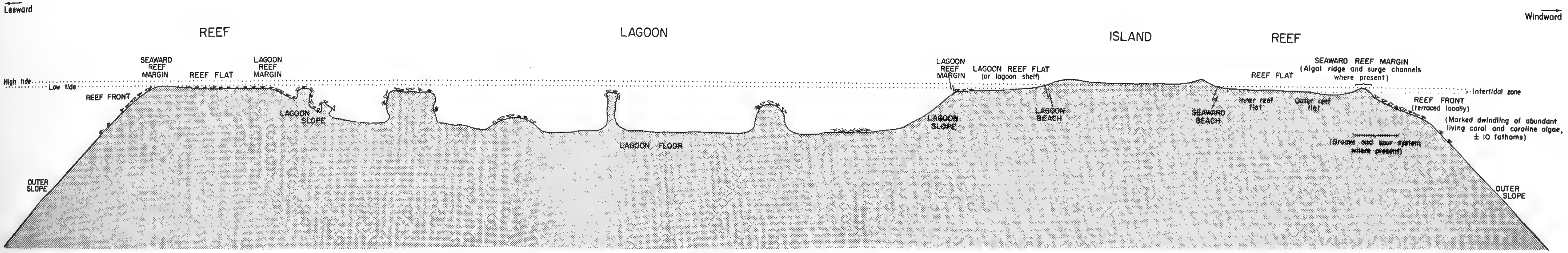


FIGURE I. CONSPICUOUS FEATURES OF AN ATOLL AND ITS PERIPHERAL REEF

Hypothetical section, not to scale, shows principal features by capital lettering; other features, subdivisions, and explanatory notes are indicated by lower case letters.

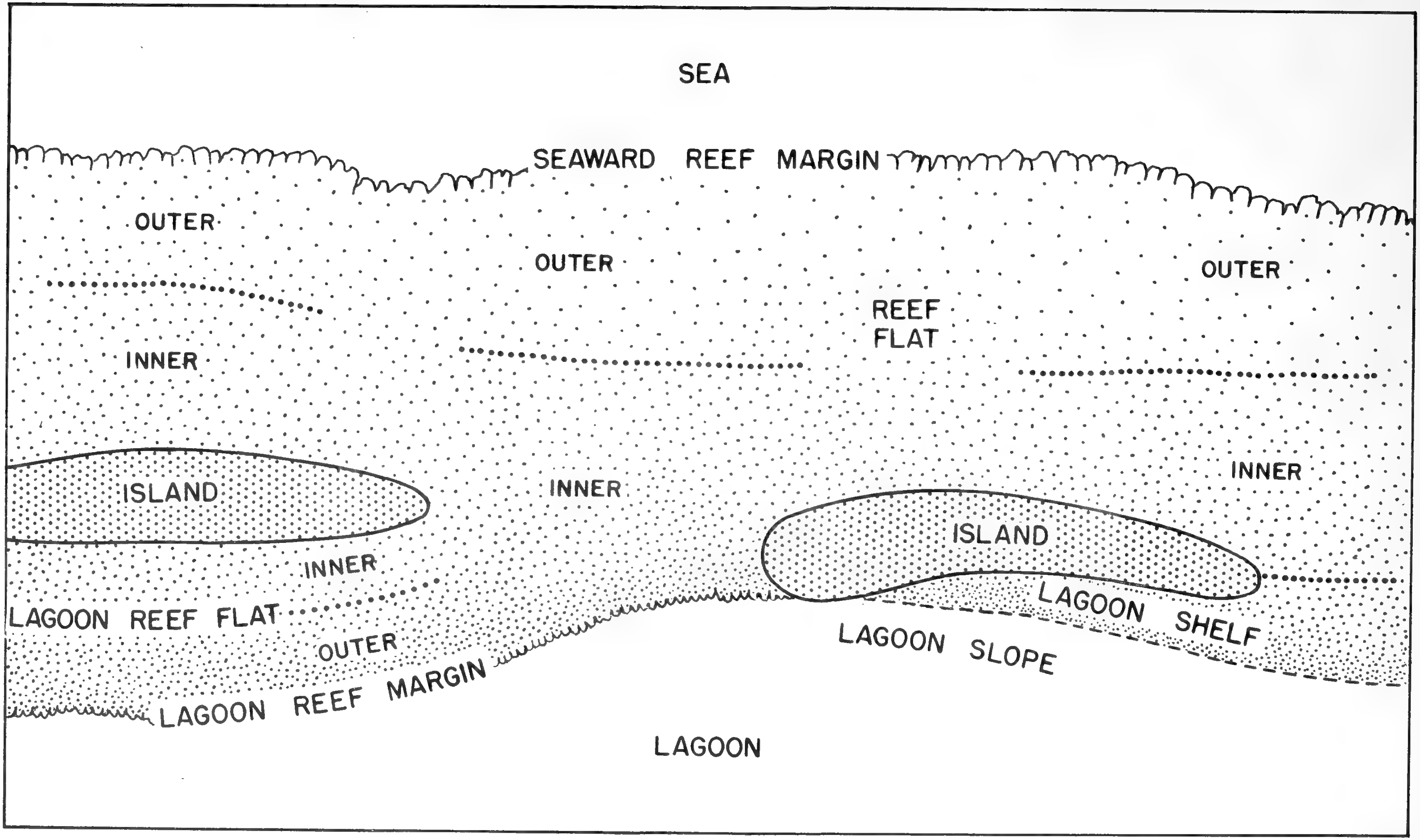


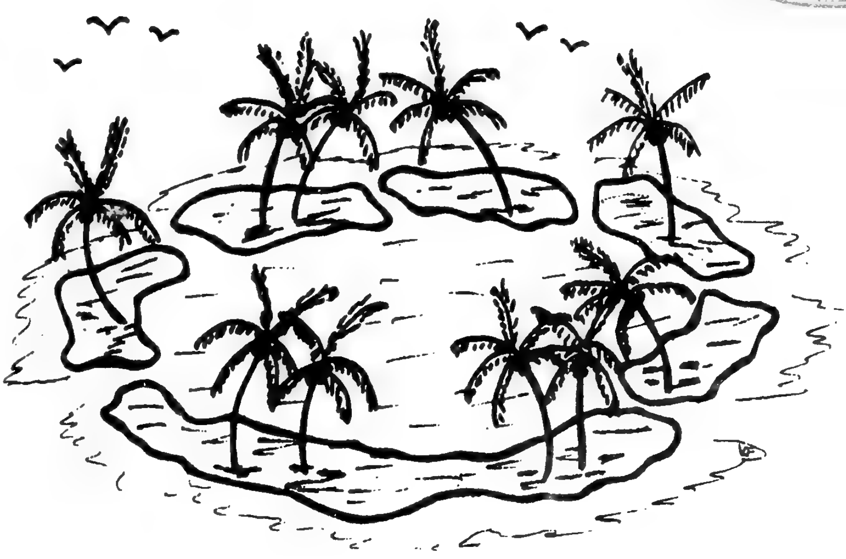
FIGURE 2. COMMON SUBDIVISIONS OF UPPER REEF SURFACE SEEN IN PLAN VIEW

No. 47 August 31, 1955

ATOLL RESEARCH BULLETIN

47. Fishes of the Gilbert Islands

by John E. Randall



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It is a pleasure to commend the far-sighted policy of the Office of Naval Research, with its emphasis on basic research, as a result of which a grant has made possible the continuation of the Coral Atoll Program of the Pacific Science Board.

It is of interest to note, historically, that much of the fundamental information on atolls of the Pacific was gathered by the U. S. Navy's South Pacific Exploring Expedition, over one hundred years ago, under the command of Captain Charles Wilkes. The continuing nature of such scientific interest by the Navy is shown by the support for the Pacific Science Board's research programs, CIMA, SIM, and ICCP, during the past seven years. The Coral Atoll Program is a part of SIM.

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Washington 25, D. C., U.S.A.

FISHES OF THE GILBERT ISLANDS

by John E. Randall

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Submitted as a report for the Office of Naval Research
Contract No. 695(00)

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ACKNOWLEDGMENTS

The present systematic work constitutes the final report for a part of the research conducted under Contract 695(00) between the Office of Naval Research of the Navy Department and the University of Hawaii. It is based largely on a collection of fishes made by the author while a member of an expedition to the Gilbert Islands in 1951, the second in a series of five in connection with the Coral Atoll Research Project of the Pacific Science Board of the National Research Council. The field work in the Gilberts was supported by Contract N7onr-29104 (NR 089 001) between the Office of Naval Research of the Navy Department and the National Academy of Sciences.

The study of the fishes has been undertaken at both the University of Hawaii and the United States National Museum. I am very grateful for the guidance of Dr. William A. Gosline of the University of Hawaii who has supervised much of this work. Dr. Leonard P. Schultz, the Curator of Fishes of the United States National Museum, Dr. Ernest A. Lachner and others of the National Museum have been most cooperative. Dr. Schultz has made the extensive collections of fishes of the northern Marshall Islands and the manuscripts of his work and that of his collaborators on these fishes freely available to me. The identifications of Gilbert Islands parrot fishes (Scaridae) and frog fishes (Antennariidae), difficult taxonomic groups, were made by Dr. Schultz who is monographing these families. The gobies and eleotrids from the Gilberts will be worked up by Dr. Lachner and the results incorporated with Bikini material for volume 2 of Fishes of the Marshall and Marianas Islands. Dr. Lachner kindly confirmed my identifications of the goatfishes (family Mullidae) for this report. Dr. Earl S. Herald identified the seven specimens of pipefishes from Onotoa. The identifications and meristic data of the blennioid fishes (families Blenniidae and Tripterygiidae) were made by Dr. D. W. Strasburg.

I wish to express thanks to the former director, A. B. Walkom and the ichthyologist, Gilbert P. Whitley of the Australian Museum for the loan of a collection of fishes made in the Gilbert Islands by Dr. R. Catala.

My associates in the field, Dr. Preston E. Cloud Jr., the leader of the expedition, Dr. Albert H. Banner, the senior marine zoologist, Dr. D. W. Strasburg, Dr. W. H. Goodenough, and Dr. E. T. Moul were most helpful in innumerable ways.

Special thanks are due Mr. Harold Coolidge, Miss Ernestine Akers, and Mrs. Lenore Smith of the Pacific Science Board who worked tirelessly organizing and equipping the expedition. Assistance was also provided by personnel of the Armed Forces. In the Gilbert Islands the Colony Lands Commissioner Mr. Richard Turpin and his wife at Onotoa and the British officials at Tarawa were exceedingly cooperative.

INTRODUCTION

The Gilbert Islands are a part of the Gilbert and Ellice Islands Crown Colony of Great Britain. They lie in the Pacific Ocean directly southeast of the Marshall Islands and straddle the equator from 3 degrees North Latitude to 3 degrees South Latitude. All are low islands and most are atolls. They are densely inhabited by Micronesian people who are greatly dependent on the sea for food.

In 1951 a research team of six men was sent by the Pacific Science Board of the National Research Council to the Gilbert Islands, specifically Onotoa (1° 47'S., 175° 32' E.), where from June 24 to August 30 a general study of the geology, biology, and anthropology of the atoll was made. The author was given the task of studying the fishes and native fishing methods. In view of the paucity of records of fishes from the Gilbert Islands, the necessary first step was the collection and identification of the fishes of the area. The limited time in the field did not permit much investigation beyond this approach; therefore the present report is largely systematic. A preliminary report on the marine biology of Onotoa has been published (Banner and Randall, 1952). The section of fishes was devoted mainly to fishing methods of the Gilbertese.* An approximate breakdown of the number of species of fishes taken in each family was given, and the methods of collecting fishes were described.

This constitutes the final report on the ichthyofauna of the Gilbert Islands. The majority of the specimens reported on are from Onotoa. A few were taken at Tarawa and Butaritari (Makin). Specimens of 98 species of fishes (excluding gobies and eleotrids) were collected in 1951 by R. Catala at Tarawa, Abemama (Hydrographic Office chart spelling, Apamama), Nukunau, and Marakei (see Figure 1). The Catala collection was loaned by G. P. Whitley of the Australian Museum in order that it might be combined with the collections made by the author.

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*I wish to report an error which appeared on page 43. The Resident Commissioner of the Gilbert and Ellice Islands Colony, through Mr. R. Davies, informed me that the outrigger canoes on Onotoa are not built of Australian plank lumber but Canadian red wood which is imported both by way of Ocean Island and Tarawa. Also it was felt that my statement on page 57 concerning the short time required by the Onotoan fisherman for his daily catch of fish should be qualified by adding "when tides, weather, etc. are suitable". I concur in this.

Also included are all records of Gilbert Islands fishes from the literature which appear to be valid. Those with insufficient descriptive information which could be confused with closely related forms are excluded. In spite of my caution, some misidentifications probably occur among the literature records I have chosen to incorporate.

A list of works in which Gilbert Islands fishes are cited is given at the end of this report. Only three of these contain more than a few records of fishes from the Gilberts: Günther's Andrew Garrett's Fische der Südsee (1873-1910), Fowler's Fishes of Oceania (1928) and Whitley and Colefax' Fishes from Nauru, Gilbert Islands, Oceania (1938). Like Günther, Fowler based his Gilbert Islands fish records on the specimens collected by Garrett. He examined many of these at the Museum of Comparative Zoology, Harvard College. Although he duplicated many of Günther's references to fishes from the Gilberts, some original records are to be credited to him. Günther often generalized on the range of widely distributed species whereas Fowler listed most of the localities by island groups. Both Günther and Fowler often employed the locality name Kingsmill Islands. This is probably equivalent to the Gilbert Islands as a whole; however the name Kingsmills has also been applied to Tabiteuea and subordinate islands within the Gilberts. Therefore all locality records of Kingsmill Islands are cited as such. Whitley and Colefax added new records to those already known for Nauru and reviewed the literature for reports of collections of fishes from this island and Ocean Island. The most important prior work was that of Waite (1903). Although Nauru and Ocean lie about 370 and 220 miles, respectively, from the nearest of the Gilbert Islands proper, they are often treated as part of the Gilbert Islands. Therefore I am including herein the seemingly authentic records from Whitley and Colefax. These should be regarded with even more suspicion than records from Fowler, however, for most are mere listings of the scientific names of fishes without any descriptive data. Mr. Whitley has informed me by letter that the majority of the specimens of the Australian Museum upon which the Nauru-Ocean study was based are no longer in existence.

When specimens of a species reported in the literature were available to me, the previous records are not included, generally, unless there is a disparity in nomenclature to which I wish to call attention.

No new species are described in this report.

A total of 396 species of inshore marine and pelagic fishes are here recorded from the Gilbert Islands. An estimated 16 more in the families, Gobiidae and Eleotridae will be reported on by E. A. Lachner in volume 2 of Fishes of the Marshall and Marianas Islands. It should be emphasized that this is not even a near-definitive list of all the species which occur in the Gilberts, a fact which is readily apparent when the number of species in almost any family of fishes from the northern Marshall Islands treated by Schultz and collaborators (1953) is compared with the same family in this report.

The fish fauna of the oceanic islands of the tropical Pacific is particularly uniform (the Hawaiian Islands excepted) for so vast an area. It is therefore not surprising that the fishes of the Gilbert Islands are very similar to those of the Marshall Islands, especially since only about 170 miles separate the northern Gilberts from the southern Marshalls. The similarity was evident from underwater observation by the writer in the southern Marshalls prior to and following the expedition to Onotoa. Subsequent study of the Gilberts collections and comparison with Marshall Islands material clearly demonstrated the high percentage of species of fishes common to both island groups. Disparity in the recorded faunas, such as the greater number of species known from the Marshalls, is undoubtedly a result of differences in the intensity of collecting. Of the species from the Gilberts of which I have seen specimens, only 31 in the families treated by Schultz et al in volume 1 of Fishes of the Marshall and Marianas Islands are here listed from the Gilbert Islands and are unrecorded from the northern Marshalls. These are as follows:

Harengula kunzei
Chanos chanos
Murenophis pardalis
Uropterygius micropterus
Uropterygius macrocephalus
Hemiramphus marginatus
Cypselurus suttoni
Prognichthys albimaculatus
Myripristis adustus
Mugil seheli
Epinephelus horridus
Epinephelus coeruleopunctatus
Epinephelus flavocoeruleus
Cephalopholis hemistiktos
Cephalopholis sonnerati
Anthias squamipinnis
Mirolabrichthys tuka
Apogon auritus
Apogon doryssa
Pseudamia polystigma
Gymnapogon philippinus
Lutjanus vaigiensis
Caesio caerulaureus
Gerres oblongus
Chaetodon bennetti
Chaetodon vagabundus
Chaetodon meyeri
Heniochus acuminatus
Heniochus varius
Acanthurus maculiceps
Paracanthurus hepatus

Nine of the above, H. kunzei, C. chanos, U. micropterus, M. adustus, M. tuka, G. philippinus, L. vaigiensis, C. vagabundus, and C. meyeri have been recorded by D. W. Strasburg from the southern Marshall Islands in a mimeographed report for the Office of Naval Research. Most of the rest will probably ultimately be taken from the Marshalls for they are known from other island groups in Oceania. Only Cephalopholis hemistiktos, Anthias squamipinnis, Pseudamia polystigma, Acanthurus maculiceps, and Paracanthurus hepatus are here recorded from the Gilbert Islands and not elsewhere from oceanic islands of the Pacific.

Nearly all of the Gilbert Islands fishes listed in the present report are also found in the Indo-Malayan region. This is contrary to Ekman (Zoogeography of the Sea, 1953: 19) who states, "In 1905 Jordan & Seale listed 475 species of fish from Samoa of which 92 (or 19%) were new to science, although they belonged to Indo-Australian genera." "The great number of endemic species among the Samoan fish fauna which we have just mentioned suggests that the present faunistic connections between Polynesia-Micronesia and the Indo-Australian centre of distribution are rather weak." It is unfortunate that Ekman chose the work of Jordan and Seale upon which to draw conclusions concerning the zoogeography of marine fishes in the tropical Pacific, for many of the species described as new by these authors are no longer valid (or are valid but have turned up in the Indo-Malayan region). 65 of their new species are listed as synonyms by the authors of The Fishes of the Indo-Australian Archipelago (Weber, de Beaufort, Chapman, and Koumans) (1911-1953), and by Schultz and collaborators (1953) and by Fowler (1928). Species placed in synonymy by one of these authors (except Fowler) but recognized as good species by others are not included among the 65. Although some of these 65 synonyms may ultimately prove to be valid species, still others not yet in synonymy will probably become synonyms.

Although there is no large number of species apparently endemic to Oceania in general, a sufficient number exists to indicate that some are truly confined to the oceanic islands of the tropical Pacific. A few of these, apparent examples being Acanthurus achilles, Pomacentrus vaiuli, and Apogon snyderi, are abundant in the Pacific. All such species need not be regarded as truly endemic in the sense that they arose in Oceania. It is possible that some of them were once present in the Indo-Malayan region but are surviving only in the Pacific.

Endemic species of fishes with pelagic larvae would not be expected, a priori, to arise in the waters of the islands of most of Oceania because of insufficient isolation. Of the major island groups in Oceania, only the Hawaiian Islands are well isolated, and the high percentage of endemism in Hawaiian fishes attests to the efficacy of such isolation.

One possible means of increasing the number of species of fishes peculiar to broad areas of Oceania makes use of Hawaiian endemism. If a species of fish of the western Pacific reached the Hawaiian Archipelago at such infrequent intervals that it was effectively isolated in Hawaii and evolved to a degree that it was no longer capable of interbreeding with the progenitor stock, it might invade more southern and western areas from Hawaii if a niche were available. Apogon snyderi and Apogon menesemus represent possible examples of this mode of evolution and distribution (see discussion under A. snyderi).

The enormous number of species of marine organisms of the Indo-Malayan region, along with a large number peculiar to this area, has led to its designation as the center of distribution of the Indo-Pacific fauna. It is generally accepted that most of the fishes of Oceania have been distributed out into the Pacific from the East Indies and Philippines. Since these islands are not isolated from other islands or continents, the explanation of the evolution which has occurred in these waters would seem to demand some effective means of isolation within the area. The islands are numerous, volcanic, and many are large. It is known that they have been variously connected in the past. It is not difficult to suppose that good-sized arms of the sea might have been isolated for long periods of time. Perhaps even the tropical Indian and Pacific Oceans were separated by land, resulting in a situation comparable to that at the isthmus of Panama (witness the geminate species of Jordan).

The identifications of the fishes in this report and the original citations of the genera and species are based largely on volume 1 of Fishes of the Marshall and Marianas Islands (1953) by Schultz et al and the manuscripts to volume 2. This work supercedes Schultz' Fishes of the Phoenix and Samoan Islands (1943) as the most important and useful taxonomic treatise of the fishes of the oceanic islands of the tropical Pacific (except Hawaii). As pointed out by Schultz (1953: xix) the vast Indo-Pacific fauna cannot be interpreted on a local basis. More than most authors of faunal studies, Schultz et al have not restricted themselves to the mere tagging of species with the most convenient names at hand but have attempted tentative revisions of many of the genera. Complete revisions are, of course, beyond the scope of their study. In spite of the great improvement they have brought to the systematics of fishes in Oceania, many of the groups treated are in need of further revision, not from the faunal approach, however, but on a world-wide basis. Therefore some of the names in Fishes of the Marshall and Marianas Islands and hence of this report will eventually be changed.

In my write-up, I have sought to provide sufficient diagnostic information for each species to enable subsequent workers to resolve their identity with assurance, name changes notwithstanding. The importance of coloration as a factor in the recognition of fishes has been stressed by Schultz (op. cit: xix). A detailed color description alone will serve to distinguish the majority of the species herein, even from closely related forms. I have therefore placed considerable emphasis on color. The life colors of many of the species are given from notes made when they were collected. The colors of still more are described from 35 mm Kodachrome transparencies taken by me in the Gilberts. Some of these descriptions represent the first records of the color in life of the species. Meristic data are tabulated for the following families: Exocoetidae, Cirrhitidae, Pomacentridae, Acanthuridae, Balistidae, Monacanthidae, and Tetraodontidae. These tables appear at the end of the respective family sections. The counts made for other families are given for the individual species in abbreviated style after the listing of the number of specimens examined and the island where collected. The number of specimens on which counts were made is indicated in parenthesis following the counts. Too few species have been collected in the Gilbert Islands from most of the families to warrant the preparation of keys. Keys are given only for the Apogonidae, Cirrhitidae, Pomacentridae, Acanthuridae, Balistidae, and Monacanthidae. Generally, the keys presented by Schultz et al work very well for the identification of Gilbert Islands fishes.

All lengths of specimens are standard length. Gill raker counts include all rudiments. When a single number is given, it represents the total count on the first gill arch. Counts of pectoral fin rays include all elements.

In addition to descriptive data, there are often remarks on the relative abundance of the species, and the areas within the atolls where they were collected and/or observed are usually given. No field data of any sort were available with the fishes collected by Catala, however. It should be noted that the relative abundance of many of the species varied markedly from atoll to atoll and even at what seemed to be equivalent localities within the same atoll. Also the listing of the area where a particular species was collected or observed does not imply that this area represents the physical habitat of the species, although such is probably often the case.

The areas from which species of fishes were taken were usually designated by the following: lagoon (with qualifications), channel, outer reef flat, surge channel, coralliferous terrace (outer reef bench), or pelagic (open sea). Figure 2 may assist the reader in visualizing these localities. The lagoon is the body of water enclosed by the ring of coral reef and islands that comprise the atoll. Onotoa is lacking land area on the lee or southwest side of the atoll; nevertheless the customary reef occurs here to more or less complete the ring. The lagoon side of this reef is designated lagoon or west reef (no collections were made from the ocean or western side of this reef). Much of the Onotoa lagoon is shallow and sandy with only occasional isolated coral heads reaching near the surface. The greatest depth is 8 fathoms. Channels connecting the lagoon and the open sea are very shallow on the weather or northeast side of the atoll; they are usually exposed or nearly exposed at low tide. Breaks or passes through the reef on the lee side are of greater depth, up to 2 fathoms or more. The term outer reef is applied to reef areas outside of the lagoon. Extending out from shore on the weather side of the atoll there is a reef flat which varies from about 600 to 2000 feet in width. It is entirely covered at high tide and exposed with numerous shallow tide pools at low tide. The outer edge of this reef is dissected with highly tortuous surge channels of about 40 to 80 feet in length and sloping from about 4 feet in depth down to 8 or 10 feet at the reef front. Surf breaks heavily against the reef front and sweeps into the surge channels. The reef area between the surge channels is somewhat elevated and pink in color due to the encrusting growth of coralline red algae, largely Porolithon. Behind the surge channel area there is a distinct shallow depression in the reef flat, the so-called back ridge trough. Beyond the surge channel zone is the coralliferous terrace sloping from 8 or 10 feet down to about 50 feet in depth over a distance of about 200 feet or more. This bench ends suddenly with a cliff-like drop into deep water. The coralliferous terrace is very rich in coral growth, being dominated by low flattened stands of Acropora. It possesses an abundant and highly varied fish fauna. Unfortunately it was not adequately sampled. For a more detailed account of the geology and marine environments of Onotoa, see Cloud (1952).

An analysis of the stomach contents of some of the fishes was made, especially when a surplus of specimens was available.

The local Gilbertese names for fishes are recorded on pages 238 to 240. These were obtained by interviews with natives on Onotoa. It was found that many of the smaller species had no names. Collecting with rotenone resulted in the taking of many fishes which the natives had never seen and for which they obviously had no names. There was not always complete agreement among the Gilbertese on Onotoa for their names of fishes. Also it is expected that considerable variation of local names will be found from atoll to atoll.

The first series of specimens from the Onotoa fish collection is deposited in the United States National Museum in Washington, D. C. The bulk of this series is cataloged under U.S.N.M. numbers 167177 to 167553. A second series is located at the University of Hawaii, Honolulu. The Catala collection was returned to the Australian Museum at Sydney.

The typewritten field notes are on file at the Division of Fishes, United States National Museum.

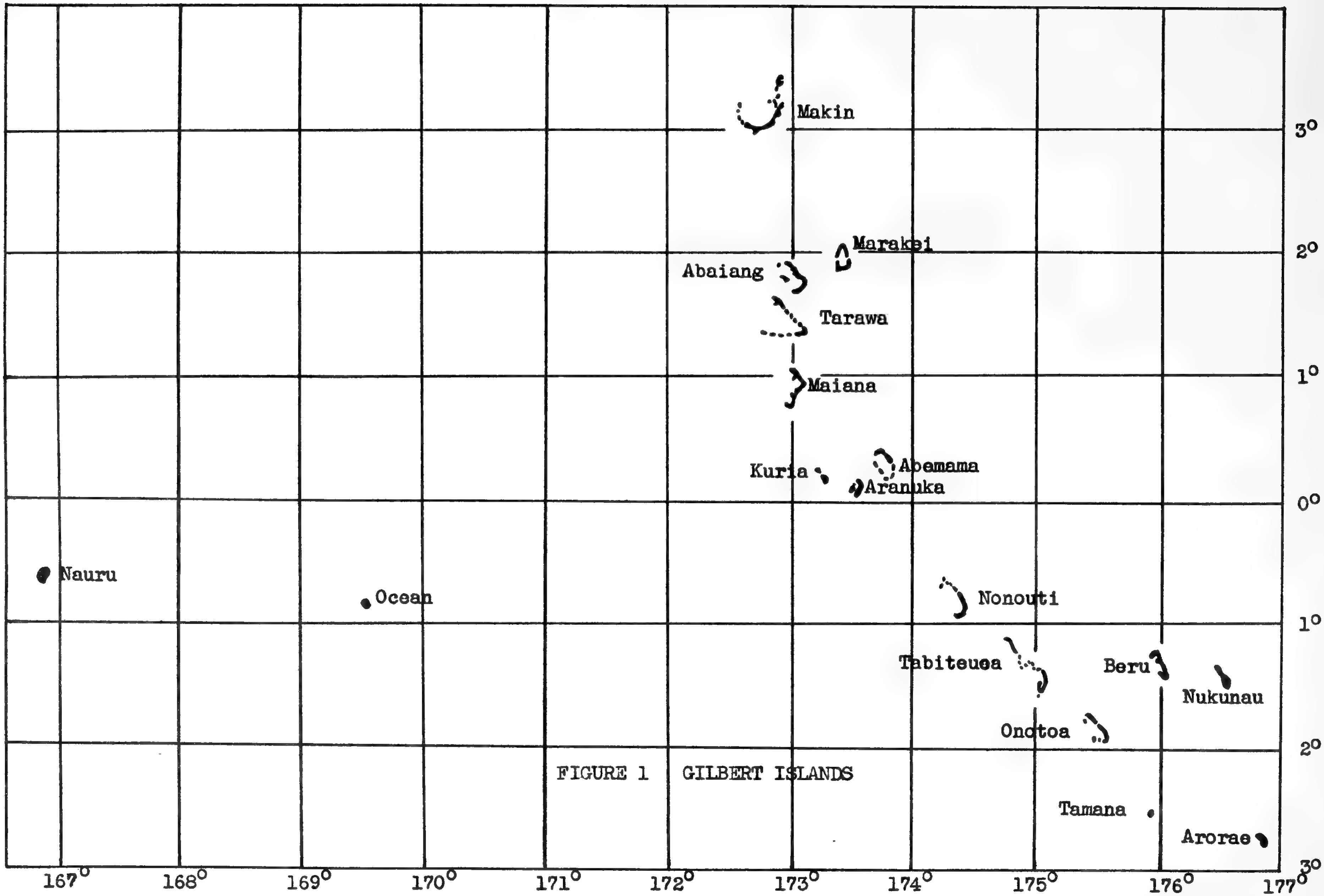

FIGURE 1 GILBERT ISLANDS

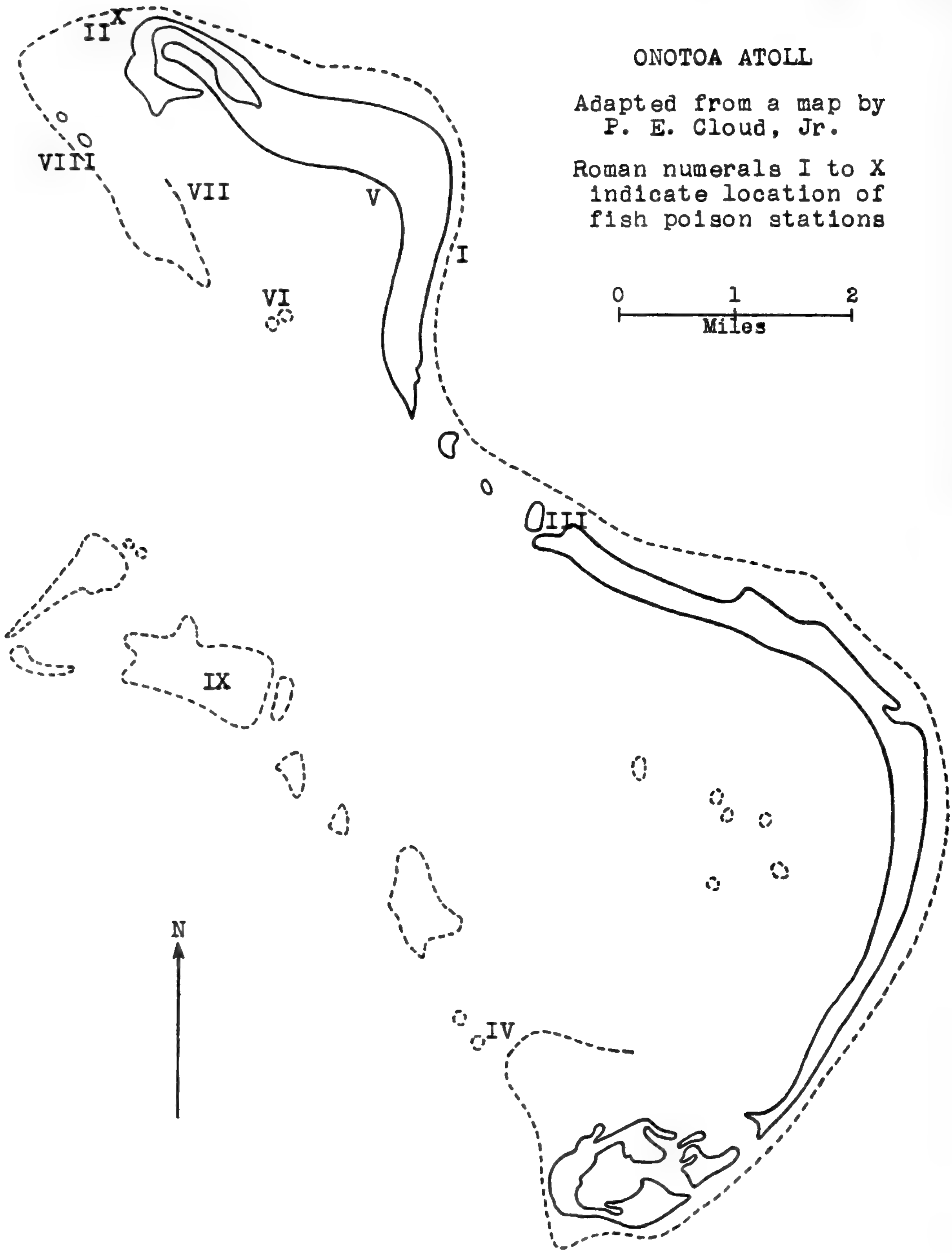
ONOTOA ATOLL
Adapted from a map by
P. E. Cloud, Jr.
Roman numerals I to X
indicate location of
fish poison stations
0
1
2
Miles
N
I
II
III
IV
V
VI
VII
VIII
IX
X

Figure 2

Family ORECTOLOBIDAE

Genus GINGLYMOSTOMA

Ginglymostoma Müller and Henle 1837. Sitz-Ber. Ada. Wiss. Berlin, p. 113. (Type species Squalus cirratus Bonnaterre).

Ginglymostoma ferrugineum

Scyllium ferrugineum Lesson 1830. Voyage autour du monde... "Coquille", Zool., vol. 2, pt. 1, p. 95. (Type locality, Port Praslin, New Ireland and Offack Bay, Waigiu).

1 specimen. 877 mm (total length). Onotoa.

Snout blunt, the distance from tip to mouth aperture 26 mm; interorbital space 90 mm; eye small, its greatest diameter 9 mm; spiracle 13 mm behind eye and slightly ventral to eye, its diameter about 2 mm; third gill opening just above origin of pectoral fin; fourth and fifth gill openings close together; length of first gill opening 21 mm, of last 22 mm; horizontal distance from snout to first gill opening 122 mm; nasal opening with an elongate papilla, 15 mm in length; all fins pointed, posterior margins slightly concave; origin of first dorsal fin slightly in advance of origin of pelvic fins; origin of second dorsal fin about 15 to 20 mm in advance of origin of anal fin; length of caudal fin from origin of lower lobe to outer tip of upper lobe 275 mm; tip of caudal fin bilobed ventrally, the outer lobe about 8 mm wide, the inner about 17 mm; teeth small (one upper tooth measured 1.5 mm in height and 2.5 mm in width), the margin rounded, with 14 denticulations; centermost denticulation about twice as broad as adjacent denticulations and projecting slightly more than others.

Color yellowish brown, shading to tan ventrally.

The specimen was captured by a Gilbertese native who grabbed it by the tail when he observed the shark with its head in a hole in the coral, apparently trying to feed on fish poisoned by rotenone. The poison station was run on the lagoon side of the west reef in about 5 feet of water. The shark seemed quite unaffected by the rotenone.

This specimen compares closely with the description given by Schultz (1953: 4) for an 885 mm specimen of the species. The most notable difference is in the teeth. Schultz states that the teeth of his specimen had a central pointed cusp, notably projecting. In my specimen there is a broad central denticulation, but it projects only slightly more than the others. I was unable to locate the head of the 2260 mm specimen from Bikini in the U. S. National Museum for direct comparison. The 885 mm Bikini specimen is at the University of Washington and was not seen by me.

Family TRIAKIDAE

Genus TRIAENODON

Triaenodon Müller and Henle 1837. Sitz.-Ber. Akad. Wiss. Berlin, p. 117. (Type species, Carcharias obesus Rüppell).

Triaenodon obesus

Carcharias obesus Rüppell 1835. Neue Wirbelth, Fische. p. 64, pl. 18, fig. 2. (Type locality, Red Sea).

No specimens of this blunt-nosed species were secured; however, it was often seen in both the outer reef areas and the lagoon. The tips of the dorsal fins and both lobes of the caudal fin were white and in sharp contrast to the dark gray color of the rest of the shark.

Family CARCHARHINIDAE

Genus CARCHARHINUS

Carcharhinus Blainville 1816. Bull. Soc. Philom., p. 121. (Type species, Squalus commersonii Blainville).

Carcharhinus menisorrah

Carcharias (Priodon) menisorrah Müller and Henle 1841. Syst. Beschreibung Plagiostomen, p. 46, pl. 17. (Type locality, Java, Australia, and Red Sea).

> 1 specimen (dorsal fin, caudal fin, and part of upper jaw only). estimated length 6 feet. Onotoa.

The specimen was seen only after it was cut into pieces by Gilbertese fishermen. It was dark gray in color. The largest upper teeth measure 9 mm at the base and 6.5 mm in vertical height from the gums; edge of these teeth serrated, the serrations becoming very small at the tip; largest denticulations on basal third of anterior margin (this margin showing a slight angular indentation at this point); posterior margin of teeth indented about 2 mm at half-way mark, the two edges of this indentation being nearly straight; length of upper lobe of caudal fin 450 mm; end of upper lobe of caudal fin with 2 small ventrally-directed lobes, the outer one pointed and measuring 11 mm at its base, the more anterior one 64 mm at the base, with outer margin concave; dorsal fin (probably the second dorsal) measures 144 mm at the base and 145 mm in height; it has a long (about 70 mm) pointed postero-basal projecting portion; 23 round radial elements of the fin have been cut in cross-section.

Carcharhinus melanopterus

Carcharias melanopterus Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 194, pl. 43, figs. 1, 2. (Type locality, Waigiou Island).

1 specimen. 415 mm (total length). Onotoa.

1 specimen (fins only). Tarawa.

Color in alcohol: upper two-thirds of body grayish brown, lower third light tan; a light tan band in lower part of gray-brown region from above pectoral fin to above origin of anal fin (this band only faintly visible); tips of all fins and margins of lobes of caudal fin jet black.)

This was the most common reef shark at Onotoa. It was rarely troublesome.

Genus NEGAPRION

Negaprion Whitley 1940. Fish. Aust., vol. 1, p. 111. (Type species, Aprionodon acutidens queenslandicus Whitley).

Negaprion acutidens

Carcharias acutidens Rüppell 1835. Neue Wirbelth., Fisch., p. 65, pl. 18, fig. 3. (Type locality, Red Sea).

Aprionodon acutidens Garman 1913. Mem. Mus. Comp. Zool., vol. 36, p. 118. (Abaiang, Gilbert Islands).

Bigelow and Schroeder (Fishes of the Western North Atlantic, pt. 1, 1948: 304) referred Carcharias acutidens Rüppell to the genus Negaprion.

Family MYLIOBATIDAE

Genus AETOBATUS

Aetobatus Blainville 1816. Bull. Soc. Philom. Paris, vol. 8, p. 127. (Type species, Raia narinari Euphrasen).

Aetobatus sp.

A white spotted eagle ray was observed to leap free of the water in the Onotoa lagoon. It may have been *A. narinari*. Shallow, roughly circular excavations were found in channel areas separating islets at Onotoa. The presence of pelecypod shell fragments suggested that these excavations were dug by rays. *A. narinari* is well known for such a mode of feeding; however, many other rays also feed in this manner.

Genus PTEROMYLAEUS

Pteromylaeus Garman 1913. Mem. Mus. Comp. Zool., vol. 36, p. 437. (Type species, *Myliobatis asperrimus* Jordan and Evermann).

Pteromylaeus punctatus

Myliobates punctatus Maclay and Macleay 1886. Proc. Linn. Soc. N. S. Wales, vol. 10, p. 675, pl. 46, figs. 1-6. (Type locality, Admiralty and Lub or Hermit Islands) (Reference copied from Fowler, 1928; Herre, 1942, gives the authors as Mikluho-Maklai and Macleay).

Pteromylaeus punctatus Herre 1942. *Copeia*, no. 3, p. 194. (Nauru).

Family MOBULIDAE

Genus MANTA

Manta Bancroft 1828-29. Zool. Jour., vol. 4, p. 144. (Type species, *Cephalopterus manta* Bancroft).

Manta sp.

A large manta ray, at least ten feet in total width was observed swimming slowly near the surface at the outer edge of the coralliferous terrace at Onotoa. It appeared to be entirely black on the dorsal surface; however, it was viewed from the side and distinctive markings could have been missed.

Family CLUPEIDAE

Genus CLUPEA

Clupea Linnaeus 1758. Syst. nat., ed. 10, p. 522. (Type species, *Clupea harengus* Linnaeus).

Clupea sirm

Clupea sirm Forskål 1775. Descr. animalium, p. 17. (Type locality, Red Sea).

Clupea sirm Günther 1910. Jour. Mus. Godeffroy, vol. 16, pt. 8, p. 383. (Kingsmill Islands).

Both Jordan and Seale (1906) and Fowler (1928) placed this species in genus Sardinella Cuvier and Valenciennes).

Genus HARENGULA

Harengula Cuvier and Valenciennes 1847. Hist. nat. poiss., vol. 20, p. 277. (Type species, Harengula latulus Cuvier Valenciennes = Clupea macrophthalma Ranzani).

Harengula kunzei

Harengula kunzei Bleeker 1856. Nat. Tijdschr. Ned.-Ind., vol. 12, p. 209. (Type locality, Ternate).

6 specimens. 81 - 94 mm. Tarawa.

D II,16 or 17; A I,16 or 17; P 15 or 16; V 8; transverse scale rows from gill opening to base of caudal fin 42 or 43; scutes in midventral line posterior to origin of ventral fins 13. (2 specimens).

Color in alcohol silvery, brown on back; tips of jaws blackish; a short black line mid-dorsally on snout.

Depth of body 3.8 in standard length; head 3.5 in standard length; eye 3.2 in head; adipose eyelid covering iris anteriorly and posteriorly.

A school of this species was observed at the surface next to a dock in the lagoon at Tarawa. Large carnivorous fishes (probably barracuda or carangids) were preying upon it from below.

Family DUSSUMIERIDAE

Genus SPRATELLOIDES

Spratelloides Bleeker 1851. Nat. Tijdschr. Ned.-Ind., vol. 2, p. 214. (Type species, Clupea argyrotaenia Bleeker).

Spratelloides delicatulus

Clupea delicatula Bennett 1831. Proc. Zool. Soc. London, pt. 1, p. 168. (Type locality, Mauritius).

97 specimens. 7 - 24 mm. Abemama,

11 specimens. 35 - 45 mm. Marakei.

D 12; A 10; P 11 to 13; V 8. (4 specimens).

The specimens are in very poor condition. No scale counts could be made.

Family CHANIDAE

Genus CHANOS

Chanos Lacépède 1803. Hist. nat. poiss. vol. 5, pp. xxix, 395. (Type species, Chanos arabicus Lacépède).

Chanos chanos

Mugil chanos Forskål 1775. Descr. animalium, pp. xiv, 74. (Type locality, Djedda, Red Sea).

3 specimens. 117 - 400 mm. Onotoa.

D 15; A 10; V 10; P 18; lateral line scales 83. (2 specimens).

Color in life silvery.

This species is well known to the Gilbertese who used to capture the young and place them in brackish ponds, ultimately to harvest them as adults. Such a practice has only recently been discontinued.

Family SYNODONTIDAE

Genus SYNODUS

Synodus Scopoli 1777. Introductio ad histor. natur...p. 449. (Type species, Esox synodus Linnaeus).

Synodus variegatus

Salmo variegatus Lacépède 1803. Hist. nat. poiss., vol. 5, p. 157, pl. 3, fig. 3. (Type locality, Mauritius).

3 specimens. 90 - 148 mm. Onotoa lagoon.

D 11; A 9; P 12; V 8; lateral line scales 61; scales from lateral line to origin of dorsal fin $5\frac{1}{2}$. (2 specimens).

Color in alcohol tan with about 9 vertical dark brown bars dorsally on body, the lower part of each being spot-like and centered on lateral line; all fins pale; 3 pairs of small black dots on upper surface of snout; a black dot at anterior base of anterior nostril.

Palatine teeth in a single band. Teeth nearly completely covered by lips.

Genus SAURIDA

Saurida Cuvier and Valenciennes 1849. Hist. nat. poiss., vol. 22, p. 499. (Type species, *Salmo tumbil* Bloch).

Saurida gracilis

Saurus gracilis Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 224. (Type locality, Hawaiian Islands and Mauritius).

9 specimens. 108 - 150 mm. Onotoa.

D 11; A 10; P 13; lateral line scales 52; scales from lateral line to origin of dorsal fin $3\frac{1}{2}$. (3 specimens).

Color from 35 mm Kodachrome transparency white, densely mottled with blackish brown, the most conspicuous markings being a series of nine blotches along the side of the body, each of which extends slightly above lateral line; a pair of smaller blackish blotches, one above the other, (or a single small blotch) in the pale area between each of the larger blotches; caudal fin and posterior half of dorsal fin with irregular vertical blackish markings; paired fins with dusky spots; anal fin pale; adipose fin with a single blackish spot; dusky spots on chin; pupil of eye green.

Teeth on palatine in two rows, the inner row much shorter than the outer; teeth in jaws extend laterally and are exposed when mouth is closed.

All of the specimens but one were taken from sandy areas of the lagoon.

Family MURAENIDAE

The moray eels were abundant at Onotoa, and a good representation of all of the genera except *Anarchias* were taken. Apart from one instance of biting a fish impaled on a spear, no morays exhibited any overt viciousness such as is often attributed to them. The Gilbertese valued eels as food and captured them with traps, by spearing, and with hook and line. An old method, not much used today, involves a noose which can be tightened on the end of a stick. This is placed over an eel's hole and drawn tightly around his body after he is lured out with bait.

Genus ECHIDNA

Echidna Forster 1777. Icones ineditae, p. 181. (Type species, Echidna variegata Forster).

Echidna zebra

Gymnothorax zebra Shaw 1797. Nat. Misc., vol. 9, pl. 322.

2 specimens. 550 and 600 mm. Onotoa.

Color in alcohol dark brown with numerous pale yellowish lines encircling body more-or-less vertically (the 550 mm specimen has 55 such lines and several shorter lines dorsally which do not encircle body); vertical lines about one-third to one-fourth as narrow as intervening dark areas; anterior part of head with short irregular pale yellow lines and spots.

The teeth are molariform, as in other species of Echidna.

The two adult specimens were taken with rotenone from the lagoon side of the west reef.

Echidna polyzona

Muraena polyzona Richardson 1844. Zool. voyage "Sulphur", Ichthyology, p. 112, pl. 55, figs. 11-14.

1 specimen. 160 mm. Onotoa.

Color in alcohol light reddish tan with 30 broad black vertical bars on the body which extend and become narrower on dorsal and anal fins; vertical black bars about 2 to 3 times broader than intervening pale areas; head with a broad vertical band which passes through eye on to chin; tip of snout and lower jaw dusky; nostrils pale.

The specimen was collected from a coral-rich area of the outer reef in about 7 feet of water.

Echidna nebulosa

Muraena nebulosa Ahl 1789. Specimen ichthyologicum de Muraena et Ophichtho (Thunberg), p. 7, pl., right fig.

(Type locality, East India).

1 specimen. 220 mm. Tarawa.

Color in alcohol light brown with 24 round black circles in a row on side of body, each with arboreal-like projections radiating from outer margin; a second row of similar blotches dorsal to the first, each of which is usually in line with a blotch of the row below; blotches of dorsal row extend into dorsal fin; a third row of blotches anterior to anus and ventral to mid-lateral row (these blotches are solid black and less dendritic); between the major black blotches on the body are tiny short irregular lines and spots, many of which are stellate or dendritic.

Echidna leucotaenia

Echidna leucotaenia Schultz 1943. Bull. U. S. Nat. Mus. 180, p. 22, pl. 3. (Type locality, Phoenix and Samoa Islands).

2 specimens. 280 and 420 mm. Onotoa.

Color in alcohol brown; fins dark brown with broad whitish margins (the margins are about twice as broad relative to the rest of the fins in the 280 mm specimen as in the 420 mm specimen); head anterior to a line running from just behind rictus to just behind eye dark brown with whitish blotches surrounding the mucous pores on the sides of the jaws.

The two specimens were taken from the same habitat as the specimen of Echidna polyzona.

Genus ENCHELYNASSA

Enchelynassa Kaup 1855. Arch. Naturg., vol. 21, p. 213. (Type species, Enchelynassa bleekeri Kaup = Muraena canini Quoy and Gaimard).

Enchelynassa canini

Muraena canini Quoy and Gaimard 1824. Voyage autour du monde..."Uranie"...Zool., p. 247. (Type locality, Waigiou and Rawak).

1 specimen. 750 mm. Onotoa.

Color in life dark brown with very narrow irregular vertical blackish lines on body.

The single specimen taken was poisoned with rotenone in a surge channel.

Genus MURENOPHIS

Murenophis Cuvier 1798. Tableau élémentaire de l'histoire naturelle des animaux, p. 329. (Type species, Muraena helena Linnaeus).

Murenophis pardalis

Muraena pardalis Temminck and Schlegel 1846. Fauna Japonica, Pisces, pt. 5, p. 268, pl. 119.

2 specimens. 76 and 180 mm. Onotoa surge channel.

Color from 35 mm Kodachrome transparency orange-brown with prominent white spots and smaller dark brown spots on body and fins; head with alternating vertical white and dark brown, orange-centered bands.

Genus GYMNOTHORAX

Gymnothorax Bloch 1794. Natur. ausländ. Fische, vol. 9, p. 83. (Type species, Gymnothorax reticularis Bloch).

Gymnothorax schismatorhynchus

Muraena schismatorhynchus Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol.4, p. 301. (Type locality, Sumatra).

6 specimens. 190 - 750 mm. Onotoa.

Color in alcohol grayish brown with a narrow whitish margin on fins.

This species has slender, slightly hooked jaws similar to those of Enchelynassa canini and Murenophis pardalis. The dentition fits the diagram given in Fig. 4 by Schultz (1943).

All of the specimens were taken from two stations of the outer reef in the northern part of the atoll in about 6 to 7 feet of water where coral was abundant.

Gymnothorax monostigma

Muraena monostigma Regan 1910. Ann. Mag. Nat. Hist., ser. 8, vol. 4, p. 438. (Type locality, Tahiti and Raiatea).

12 specimens. 90 - 500 mm. Onotoa.

Color in alcohol orangish brown; fins orangish, especially posteriorly; a large black spot immediately behind eye (this is missing on the 90 mm specimen and just making its appearance in a 130 mm specimen); posterior nostrils white; two mucous pores below eye and 4 or 5 on lower jaw surrounded by white, thus appearing as spots (in the 130 mm specimen the white spots are large and co-joined).

The specimens were taken from four stations, each quite different; surge channel, windward side; surge channel, leeward side; backridge trough; lagoon reef. The specimen from the backridge trough was the 130 mm one mentioned above. It was caught by hand by A. H. Banner from a small head of Pocillopora meandrina. In life it had a bright orange border on its fins which was broad caudally, and the eye was bright red.

Gymnothorax picta

Muraena picta Ahl 1789. Specimen ichthyologicum de Muraena et Ophichtho, p. 8. (Type locality, East India).

2 specimens. 340 and 450 mm. 2 specimens. 70 and 85 mm. Onotoa.

2 specimens. 250 and 310 mm. Tarawa.

Color in life white, densely speckled with black except ventrally.

This eel is a common inhabitant of the crevices of the outer reef flat. At low tide it was at times encountered by turning over rocks exposed on the reef. Gilbertese natives were occasionally seen hunting for it in just this manner for use as food.

Gymnothorax petelli

Muraena petelli Bleeker 1856. Nat. Tijdschr. Ned.-Ind., vol. 11, p. 84. (Type locality, Java).

Siderea picta Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 287. (Nauru).

5 specimens. 110 - 300 mm. Onotoa.

Color from 35 mm Kodachrome of 200 mm specimen white with 19 vertical bars on body, about equal or slightly smaller in width than white inter-spaces (posterior 14 dark bars do not extend to extreme margin of dorsal fin); a black band across head slightly behind eye, this band not extending ventral to eye; a blackish area from eye anterior to nostril; a black mark on chin next to mouth. Larger specimens were browner and the black bars did not stand out in such sharp contrast.

Specimens were collected from both lagoon and outer reefs.

Gymnothorax rupelli

Dalophis rupelliae McClelland 1845. Calcutta Jour. Nat. Hist., vol. 5, p. 213. (Type locality, Red Sea?)

Lycodontis ruppeli Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 55. (Abaiang, Kingsmill Islands).

1 specimen. 250 mm. Onotoa.

Color in alcohol light brown with 17 black rings which completely encircle head and body; dorsal half of body between dark bars dusky.

G. *rupelli* can most readily be distinguished from the similar *petelli* by the nature of the rings. In the latter those anteriorly on the body and head do not circle the ventral part of the body.

Gymnothorax zonipectis

Gymnothorax zonipectis Seale 1906. Occ. Pap. B. P. Bishop Mus., vol. 4, p. 7, fig. 1. (Type locality, Tahiti).

Gymnothorax zonipectis Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol, 63, p. 285. (Nauru).

Gymnothorax gracilicauda

Gymnothorax gracilicauda Jenkins 1903. Bull. U. S. Fish Comm., vol. 22, p. 426, fig. 6. (Type locality, Honolulu).

4 specimens. 88 - 240 mm. Onotoa.

Color in alcohol light brown with dendritic dark brown blotches in two to three irregular lengthwise series on body; two irregular vertical dark brown bars on head between eye and origin of dorsal fin which reach from mid-dorsal line to mid-lateral line; an irregular dusky area behind eye which extends to rictus; a dusky area from snout to nostrils; fins paler than body.

I compared my specimens with Jenkins' type. The dentition is the same and the color pattern very similar.

The specimens were collected from lagoon and leeward outer reefs.

Gymnothorax fimbriata

Muraena fimbriata Bennett 1831. Proc. Zool. Soc. London, pt. 1, p. 168. (Type locality, Mauritius).

1 specimen. 80 mm. Onotoa lagoon.

Color in alcohol tan with highly irregular brown markings vertically aligned on body except ventrally anterior to anus; 2 brown spots behind eye and an irregular brown line over top of head behind eye; snout mottled with brown.

Gymnothorax margaritophorus

Gymnothorax margaritophorus Bleeker 1865. Ned. Tijdschr. Dierk., vol. 2, p. 53. (Type locality, Ambon, East Indies).

6 specimens. 160 - 350 mm. Onotoa.

Color in alcohol reddish brown, orange-brown ventrally, with pale spots and blotches on the body, these more distinct caudally (in some specimens the pale blotches are interconnected, and the color pattern would more appropriately be considered as dark blotches on a pale brown ground color); a series of about three to six dark brown elongate blotches behind eye; a pale band mid-dorsally on head running from snout posterior to level of eyes.

G. margaritophorus was collected in coral areas of the lagoon and outer reef.

Gymnothorax flavimarginata

Muraena flavimarginata Rüppell 1828. Atlas Reise nord. Afrika, Fische Rothen Meers, p. 119, pl. 30, fig. 3. (Type locality, Red Sea).

2 specimens. 320 and 396 mm. 1 specimen. 80 mm. Onotoa.

Color in alcohol orangish brown with a fine mottling of dark brown blotches; gill opening in a black spot (this spot just forming in 80 mm specimen); posterior margins of fins narrowly white (bright green-yellow in life).

The two large specimens were taken from a surge channel on the windward side of the atoll. The 80 mm was collected from a small coral head in a shallow, sandy channel.

Gymnothorax javanica

Muraena javanicus Bleeker 1859. Nat. Tijdschr. Ned.-Ind., vol. 19, p. 347. (Type locality, Java).

2 specimens. 170 and 1000 mm. Onotoa.

Color in alcohol of large specimen reddish brown with numerous irregular black spots and blotches covering head, body, and fins (these blotches of two different sizes, the large ones about the size of a dime or larger and often containing irregular brown areas, the others smaller than size of the eye); no large-sized black blotches on anterior fifth of body except one which encloses gill opening; corner of mouth blackish. In the 170 mm specimen there are only large-sized blotches which are rounder than those of the 1000 mm specimen and extend on to head; also there is narrow pale margin posteriorly on fins.

Smaller javanica have a color pattern similar to G. fimbriata. In the latter the spots are, in general, smaller, more scattered, yet more inclined to co-join with other spots; pale margins extend the whole length of the fins in fimbriata, and the gill opening is not surrounded by a large black blotch.

The dentition of the large specimen compares closely with that given in the diagram for this species by Schultz (1953; fig. 27); the small specimen, however, has several large teeth in an inner row on the maxillary and small teeth interspersed between the large marginal intermaxillary teeth, similar to the pattern for fimbriata.

The large specimen was encountered with its head protruding from a crevice in a coral head near the center of the lagoon. Three spears were shot into its head before it could be pulled from its hole, and even then it was a difficult task.

Gymnothorax undulata

Muraenophis undulatus Lacépède 1803. Hist. nat. poiss., vol. 5, pp. 629, 642, 644, fig. 2.

3 specimens. 240 - 600 mm. Onotoa.

Color from 35 mm Kodachrome transparency of 600 mm specimen chestnut brown anteriorly, dark brown posteriorly, with narrow white lines dividing body color into irregular blocks; anterior half of head with only traces of whitish spots and short lines; gill opening not in a black blotch (though the margin is darker than rest of body); no definite pale margin on fins. In the smaller specimens there is a pale margin posteriorly on the fins, and the pale lines on the body are broader and less irregular; thus the dark brown of the body is more spot-like.

The specimens were secured from both lagoon and seaward reefs.

Gymnothorax buroensis

Muraena buroensis Bleeker 1857. Nat. Tidschr. Ned.-Ind. vol. 13, p. 79. (Type locality, Nova-Selma, Buro, Ambon, and Ceram).

24 specimens. 92 - 245 mm. Onotoa.

Color in alcohol dark brown with numerous close-set black blotches, more or less arranged in bars (posteriorly on body these blotches are so large that the pale areas between are restricted as small spots which tend to form rows); fins with pale margins posteriorly (bright orange in life). Many specimens are almost black, and the color pattern can be perceived only with difficulty.

There are two rows of teeth on the maxillary, the teeth of the inner row being longer. There are three rows of long canines on the intermaxillary in addition to the marginal teeth.

This melanistic eel appeared to be the most abundant species of the genus at Onotoa and was taken from many different habitats.

Gymnothorax (favaginea?)

Gymnothorax favagineus Bloch and Schneider 1801. Systema ichth., p. 525. (Type locality, Tranquebar, India).

1 specimen. 60 mm. Onotoa.

Color in alcohol light brown with large round black spots in a row on the body and a second series of spots dorsally, each spot cut off at edge of dorsal fin.

I assign this tiny juvenile specimen to favaginea mainly on color pattern. The dentition is different than that given by Weber and de Beaufort (1916: 379). There are three rows of three fangs mesially on the intermaxillary which are longer than the lateral series. Smaller teeth extend posteriorly from the first and third rows to meet in the midline at the anterior end of the single row of vomerine teeth.

Gymnothorax moluccensis

Priodonophis moluccensis Bleeker 1864. Atlas ichth., vol. 4, p. 108, pl. 187, fig. 1. (Type locality, Ambon, East Indies).

1 specimen. 300 mm. Onotoa.

Color plain brown, a little darker posteriorly.

Teeth on dentary very finely serrated on posterior edges; two medial canine teeth on intermaxillary, the more posterior one the longest tooth in the jaw (there are sockets, however, for two more, one on either side and slightly anterior to the long tooth); no inner row of maxillary teeth; a single row of short teeth on vomer; roof and floor of mouth finely papillate; eye 1.5 in snout; snout 6.5 in head; fins somewhat elevated, though not as much as described by Schultz (1943: 38) for G. pseudothyrsoidea.

The specimen was taken with rotenone from an area of the outer reef with numerous coral heads at a maximum depth of about 7 feet.

Gymnothorax bikiniensis

Gymnothorax bikiniensis Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, pp. 109, 116, figs. 23 e, 24. (Type locality, Bikini Atoll, Marshall Islands).

1 specimen. 263 mm. Onotoa surge channel.

Color in alcohol brown (under a dissecting microscope one can see a fine mottling of light and dark brown); edges of fins a little paler than body; snout darker than lower jaw. I have in my field data a note on the color in life which reads, "Narrow dendritic vertical dark brown bars on a dusky greenish yellow background. Snout and anus dark; belly pale." I can find no evidence of bars on the preserved specimen.

The specimen was compared with Schultz' type.

This species resembles Enchelynassa canini especially in dentition, and may form the basis for considering the genus Enchelynassa a synonym of Gymnothorax.

Gymnothorax thyrsoidea

Muraena thyrsoidea Richardson 1844. Zool. voyage "Sulphur", Fishes, p. 111. (Type locality, China Seas and Canton).

Lycodontis thyrsoidea Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 52. (Abaiang, Kingsmill Islands).

2 specimens. 70 and 155 mm. Onotoa.

Color in life white; in alcohol, light brown.

The teeth are short and conical, none of them being long and fang-like as in most species of <u>Gymnothorax</u>; two stout medial teeth on the intermaxillary, one behind the other in the mid-line; two rows of short teeth on vomer which join posteriorly to a single row; Snout 6 in head; eye 1.4 in snout.

Richardson's specimens were brown with a reticulation of white lines. My specimens are everywhere pale and may thus be distinct from <u>thyrsoidea</u>. Because of the similarity in dentition, however, I prefer to consider the Onotoa ones a color variant. In view of their small size, they may be exhibiting juvenile coloration.

<u>Gymnothorax</u> sp.

3 specimens. 190 - 220 mm. Onotoa lagoon.

Color in alcohol light yellowish brown with a dense reticulation of slightly browner, highly tortuous lines.

Maxillary teeth in one row (a single inner tooth in two of the specimens); three elongate canines in mid-line of intermaxillary; a single row of vomerine teeth; six inner elongate canines in two rows anteriorly on dentary; snout 5.8 in head length; eye 1.6 in snout; origin of dorsal fin 1 to 2 snout lengths anterior to gill opening.

I am unable to identify this species.

Genus UROPTERYGIUS

<u>Uropterygius</u> Rüppell 1835. Neue Wirbelth., Fische, p. 83. (Type species, <u>Uropterygius</u> <u>concolor</u> Rüppell).

<u>Uropterygius</u> <u>concolor</u>

<u>Uropterygius</u> <u>concolor</u> Rüppell 1835. Neue Wirbelth., Fische, p. 83, pl. 20, fig. 4. (Type locality, Red Sea).

4 specimens. 100 - 140 mm. Onotoa lagoon.

1 specimen. 185 mm. Tarawa.

Color in alcohol uniform light brown; four mucous pores on side of upper jaw posterior to anterior nostril, their margins slightly paler than rest of head.

Two rows of maxillary teeth those of the inner row much longer than the outer and well-spaced; one row of short, stout vomerine teeth; two large canine teeth in mid-line on intermaxillary; snout 5 in head length; eye 1.9 in snout; center of eye slightly closer to rictus than tip of snout; posterior nostril above center of eye and with a slightly elevated rim; distance from tip of snout to anus contained 2.2 times in total length.

Uropterygius sp.

1 specimen. 184 mm. Onotoa lagoon.

Color in alcohol uniform light brown; rims and interior of four mucous pores on side of upper jaw behind anterior nostril pale.

A single row of about ten teeth on maxillary which project backward at about a 45 degree angle; a cluster of about four stout teeth on median part of intermaxillary, the most posterior and median one the longest; no teeth visible on vomer; anterior nostril tubular; posterior nostril with a slightly elevated rim, located above center of eye, and followed by a depression in the head; distance from tip of snout to anus 2.1 in total length; distance from tip of snout to rictus 2.7 in head length (to gill opening); snout length 4.8 in head length; eye 2.2 in snout length.

This specimen was not distinguished from U. concolor until the teeth were examined. I follow Schultz in considering the above species, and not this one, U. concolor.

Uropterygius xanthopterus

Uropterygius xanthopterus Bleeker 1859. Nat. Tijdschr. Ned.-Ind., vol. 19, p. 350. (Type locality Java and Ambon, East Indies).

20 specimens. 125 - 350 mm. Onotoa.

Color in alcohol dark brown, mottled with darker brown, with numerous tiny white spots, most evident on head and anterior part of body; margin of tail broadly pale orangish.

Sixteen of the specimens were collected from the lagoon side of the west reef in from 6 to 8 feet of water. The remaining four were from the outer reef.

Uropterygius marmoratus

Gymnomuraena marmorata Lacépède 1803. Hist. nat. poiss., vol. 5, pp. 648, 649. (Type locality, New Britain).

1 specimen. 380 mm. Tarawa.

Color in alcohol light brown, mottled with blackish patches, and this overlain with numerous black spots (mostly larger than diameter of eye) which tend to be larger dorsally than ventrally; nostrils blackish.

Uropterygius supraforatus

Gymnomuraena supraforata Regan 1909. Ann. Mag. Nat. Hist., ser. 8, vol. 4, p. 439. (Type locality, Savay and Tahiti).

4 specimens. 170 - 250 mm. Onotoa lagoon.

Color in life light greenish gray with about 5 rows of irregular brown blotches which are slightly larger posteriorly than anteriorly (average size about equal to size of eye) (posteriorly on body the blotches tend to join vertically to form irregular bars); spots on head not arranged in rows and of a size about equal to size of pupil; a slight bluish cast over abdomen.

Numerous sharp elongate teeth in jaws, the longest maxillary teeth being the innermost of many rows; a single row of long teeth on vomer, continuous with teeth on midline of intermaxillary.

Uropterygius micropterus

Muraena micropterus Bleeker 1852. Nat. Tijdschr. Ned.-Ind., vol. 3, p. 298. (Type locality, Flores, Buro, Morotai, Ambon, Ceram, Aru, and Timor).

3 specimens. 210 - 245 mm. Onotoa.

Color in life light grayish, almost white ventrally, with a fine reticulation of small blackish dendritic blotches.

Two rows of teeth on the maxillary, the teeth of the inner row about four times longer than those of the outer; a single row of long teeth on the vomer; eye slightly closer to end of snout than rictus; diameter of eye contained 1.9 in length of snout.

The specimens were collected by hand from beneath exposed rocks on the outer reef flat.

Uropterygius macrocephalus

Gymnothorax macrocephalus Bleeker 1865. Ned. Tijdschr. Dierk., vol. 2, p. 54. (Type locality, Ambon, East Indies).

1 specimen. 200 mm. Onotoa lagoon.

Color in life light gray-brown, with reticular white blotches in irregular bars along side of body; end of caudal fin whitish; posterior nostril above center of eye, rim slightly elevated, interior pale; anterior nostril brown, like rest of snout.

Two rows of teeth on maxillary, those of the inner row close-set and about one-fourth to one-third as long as the well-spaced teeth of the inner row; a single row of 7 teeth on vomer; three rows of 2 teeth each on median part of intermaxillary, those of the middle row the longest; two rows of teeth on dentary, similar to those on maxillary; no elongate canines anteriorly on dentary; snout contained 7 times in head length; eye 1.8 in snout; center of eye closer to tip of snout than corner of mouth; distance from snout to anus 2.3 in total length.

Genus RABULA

Rabula Jordan and Davis 1888. Rep. U. S. Comm. Fish. and Fisheries, vol. 16, pp. 590, 598. (Type species, Rabula davisi Fowler).

Rabula fuscomaculata

Rabula fuscomaculata Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, pp. 139, 147, fig. 30. (Type locality, Rongerick Atoll, Marshall Islands).

3 specimens. 120 - 160 mm. Onotoa.

Color in alcohol light brown with numerous dark brown spots about the size of the eye covering body and fins (anteriorly these spots are smaller and indistinct); mucous pores on side of upper jaw (and to a lesser extent those of the lower jaw) broadly outlined with white.

The Onotoa specimens were compared with the holotype in the United States National Museum and found to be the same.

Two of the specimens were collected on the lagoon side of the west reef and the third on the outer reef in the northernmost part of the atoll. In each case the depth of the water was about 8 feet.

Family OPHICHTHIDAE

The snake eels are sand dwellers and often occur in areas where few other fishes are found. Usually a large amount of rotenone is needed to poison them. There was not sufficient rotenone on hand at Onotoa to warrant its use for ophichthids alone; thus only one species was taken. A large specimen of another species, probably either Myrichthys colubrinus (Boddaert) or Myrichthys bleekeri Gosline, was seized in ankle-deep water on a tidal flat zone of the lagoon, but it escaped, as snake eels are prone to do.

The specimens from Tarawa and Abemama were collected by R. Catala.

Genus MYRICHTHYS

Myrichthys Girard 1859. Proc. Acad. Nat. Sci. Phila., p. 58. (Type species, Myrichthys tigrinus Girard).

Myrichthys maculosus

Muraena maculosa Cuvier 1817. Règne animal, vol. 2, p. 232. (Type locality, European seas).

1 specimen. 241 mm. Onotoa.

Color in life pale greenish yellow on back, shading to whitish on sides and ventrally, with 31 round black spots (not all the spots are in alignment with ones on the other side); a black saddle on head over both eyes; 4 elliptical black marks on chin at level of eye.

The single specimen was taken with rotenone from a sandy region of about 8 foot depth between coral heads on the outer reef in the northernmost part of the atoll.

Myrichthys colubrinus

Muraena colubrina Boddaert 1781. Neue Nord. Beytr., vol. 2, p. 56, pl. 2, fig. 3. (Type locality, Ambon, East Indies).

1 specimen. 290 mm. Abemama.

Color in alcohol brown with 32 semicircular black saddles in line on body and 2 such saddles on head between gill opening and eye (these saddles are twice as broad dorsally as intervening pale areas; they do not extend into dorsal fin and reach to or slightly below the lateral line).

Snout pointed and flattened dorso-ventrally; length of snout 6.5 in head length (to gill opening); pectoral 5 in head length; eye 2 in length of pectoral.

I am uncertain of the use of the name colubrinus for this specimen. It has been returned to the Australian Museum.

Genus LEIURANUS

Leiuranus Bleeker 1853. Verh. Batav. Genootsch., vol. 25, p. 36. (Type species, Leiuranus lacepedei Bleeker).

Leiuranus semicinctus

Ophisurus semicinctus Lay and Bennett 1839. Zool. Capt. Beechey's voyage, Fishes, p. 66, pl. 20, fig. 4. (Type locality, Oahu).

1 specimen. 580 mm. Tarawa.

Color in alcohol brown with 31 narrow black bars on the body which extend up into dorsal fin but which do not meet ventrally (the posterior end of the body is blunt and it is believed that the hind section of the body was lost during life; the maximum body depth of the specimen is 12 mm); maximum width of black bars contained nearly 4 times in width of pale interspaces; head which 1 such bar between gill opening and eye; a black saddle over interorbital space with bifurcates at upper edge of eye, one limb extending antero-ventrally to mouth, the other forming a spot adjacent to posteroventral edge of eye; black spots on chin.

Length of snout contained 6 times in length of head to gill opening; diameter of eye 2.2 in snout; length of pectoral fin nearly equal to diameter of eye.

Genus CALLECHELYS

Callechelys Kaup 1856. Cat. apodal fish in collection of British Mus., p. 51. (Type species, Callechelys guichenoti Kaup).

Callechelys melanotaenia

Callechelys melanotaenia Bleeker 1864. Atlas ichth...., vol. 4, p. 66, pl. 193, fig. 2. (Type locality, Ambon, East Indies).

Callechelys melanotaenia Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 43. (Abemama, Gilbert Islands).

Genus MURAENICHTHYS

Muraenichthys Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol. 4, p. 505. (Type species, Muraenichthys gymnopterus Bleeker).

I follow Myers and Storey (Stanford Ichth. Bull., vol. 1, 1939: 157) and Gosline (Pacific Sci., vol. 4, 1950: 313) in considering the genus Muraenichthys as belonging in the Ophichthidae.

Muraenichthys gymnotus

Muraenichthys gymnotus Bleeker 1864. Atlas ichth...., vol. 4, p. 33. (Type locality, Ambon, East Indies).

8 specimens. 103 - 121 mm. Onotoa.

Color in alcohol light brown; scattered, tiny, dark brown flecks dorsally on body and on head, the most pronounced accumulation being on head posterior to eye.

Anterior nostril tubular, directed antero-ventrally from front part of upper lip at base of proboscis-like end of snout; posterior nostril with an elongate flap at front edge which hangs downward from upper lip just anterior to eye; teeth short and inconspicuous; vomerine teeth in two, close-set, irregular rows (hence appearing as single narrow band); maxillary and dentary teeth in a narrow band, usually no more than two teeth in width; origin of dorsal fin slightly anterior to anus; snout moderately pointed; anterior edge of eye about equidistant between rictus and tip of snout; eye about 3 in snout length; distance from tip of snout to rictus contained about 3.7 times in length of head.

The specimens were not distinguished in the field from Muraenichthys laticaudata. Labels were mixed, therefore there are no reliable locality data.

Muraenichthys laticaudata

Myropterura laticaudata Ogilby 1897. Proc. Linn. Soc. N. S. Wales, vol. 22, p. 247. (Type locality, Fiji).

5 specimens. 91 - 120 mm. Onotoa.

Color in alcohol uniform brown; median fins light brown.

Nostrils as in preceding species except posterior nostril lacks a projecting flap and is not visible in lateral view; teeth moderately conspicuous, about twice as long as those of the preceding species; vomerine teeth uniserial; maxillary teeth in two rows; teeth on dentary in a single row; origin of dorsal fin slightly posterior to anus; snout blunt, its length contained about 5 times in head length; posterior edge of eye only slightly anterior to rictus; diameter of eye about 3 in snout length; distance from tip of snout to rictus contained about 4 times in head length; body depth at anus 36 to 43 in total length.

Family MORINGUIDAE

In the classification of the worm eels I have followed Gosline and Strasburg, "The Hawaiian fishes of the family Moringuidae: another eel problem", in press, Copeia, 1955.

Genus MORINGUA

Moringua Gray 1831. The illustrations of Indian zoology... Hardwicke, vol. 1, pt. 5, pl. 95. (Type species, Moringua raitaborua Cantor).

Moringua macrochir

Moringua macrochir Bleeker 1855. Nat. Tijdschr. Ned.-Ind., vol. 9, p. 71. (Type locality, Batu).

5 specimens. 88 - 285 mm. Onotoa.

Pores in lateral line from gill opening to near end of body (not including vestigial pores which are closely spaced at extreme end of body) 103 to 109. (3 specimens).

Color in alcohol uniform light yellowish brown.

The following proportional measurements from a 280 mm. specimen: body depth contained 47 times in total length; distance from tip of snout to rictus 4.6 in head length; snout 6.4 in head length; eye about 6 in snout; pectoral fin about the size of the eye.

Lower jaw projects anterior to upper jaw; caudal fin slightly pointed; a single row of teeth on maxillary; a single row of vomerine teeth; six prominent canines on intermaxillary; posterior nostril located immediately anterior to eye.

The specimens were secured with rotenone from sandy areas of both the lagoon and outer reef.

Moringua javanica

Aphthalmichthys javanicus Kaup 1865. Cat. apodal fish in collection British Mus., p. 105, fig. 71. (Type locality, Java).

2 specimens. 510 and 740 mm. Onotoa.

Pores in lateral line from gill opening to near end of body 139. (1 specimen).

Color in alcohol light grayish brown.

The following proportional measurements from the 510 mm specimen: body depth contained 78 times in total length; distance from tip of snout to rictus contained 5.8 times in head length; snout about 8 in head length; eye about 7 in snout length; pectoral fin tiny, its length equal to about one-half the diameter of the eye.

Lower jaw projects anterior to upper jaw; caudal fin slightly pointed; dentition and nostrils similar to above.

One specimen was collected from a shallow channel between islets and the other from a surge channel.

Moringua sp.

1 specimen. 390 mm. Onotoa.

Number of lateral line pores on posterior 155 mm. of body 17 (difficult to count anterior to this because of twisting of the body); thus the total number of pores to the gill opening is estimated at 40.

Color in alcohol yellowish brown.

Body depth 52 in total length; distance from tip of snout to rictus contained 4 times in head length; snout about 7 in head length; eye about 4.7 in snout length; pectoral fin about the size of the eye.

Lower jaw projects anterior to upper jaw; caudal fin pointed; teeth similar to above two species except they are directed more sharply backward.

I am unable to identify this moringuid to species. It appears to be distinct in its low pore count and moderately stout body.

The specimen was collected from a protected outer reef area.

Family AULOSTOMIDAE

Genus AULOSTOMUS

Aulostomus Lacépède 1803. Hist. nat. poiss., vol. 3, p. 356. (Type species, *Aulostomus chinensis* Lacépède = *Fistularia chinensis* Linnaeus).

Aulostomus chinensis

Fistularia chinensis Linnaeus 1766, Syst. nat., ed. 12, p. 515. (Type locality, India).

1 specimen. 300 mm. Onotoa.

D XII, 27; A 30; V 6; P 16; lateral line scales 260.

Color in life brown, becoming abruptly black posterior to origin of soft dorsal and anal fins (this black area with linearly-arranged light brown spots or elongate blotches, mostly in 2 rows which continue on to caudal peduncle); maxillary with an elongate black blotch; anus black; soft dorsal reddish, black anteriorly and basally; anal fin reddish, black basally; caudal fin yellow with a black spot in the upper central part of the fin; ventral fins with a black spot basally.

The trumpet fish was not common at Onotoa, with only 2 specimens being seen. One of these was speared for the collection at a depth of 12 feet in the lagoon.

Family FISTULARIIDAE

Genus FISTULARIA

Fistularia Linnaeus 1758. Syst. nat., ed. 10, p. 312. (Type species, Fistularia tabacaria Linnaeus).

Fistularia petimba

Fistularia pétimba Lacépède 1803, Hist. nat. poiss, vol. 5, pp. 349, 350 (pl. 18, fig. 3, in vol. 2). (Type locality, New Britain; Union Island).

Fistularia depressa Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 287 (Nauru and Ocean Island).

2 specimens. 130 and 530 mm. Onotoa.

2 specimens. 159 and 403 mm. Tarawa.

Fin ray counts of 530 mm specimen: D 14; A 13; P 15; V 6.

The cornet fish was occasionally sighted in the Onotoa lagoon. The 530 mm specimen was speared in water of about 4 foot depth over an eel grass (Thalassia) flat. It was a dark forest green in color and matched its surroundings well. On being speared it immediately flashed its body color to light gray. The 130 mm specimen was caught by hand from a shallow outer reef flat tide pool at low tide.

Family SYNGNATHIDAE

The Onotoa pipefishes were identified by Earl S. Herald, to whom I am very grateful.

Genus CORYTHOICHTHYS

Corythoichthys Kaup 1853. Arch. Naturg., vol. 19, pt. 1, p. 231. (Type species, Syngnathus fasciatus).

Corythoichthys flavofasciatus conspicillatus

Syngnathus conspicillatus Jenyns 1842. Zool. voyage "Beagle", Fish, p. 147, pl. 27, fig. 4. (Type locality, Tahiti).

5 specimens (4 female, 1 male). 56 - 81 mm. Onotoa.

2 specimens (female). 58 and 62 mm. Abemama.

Color in alcohol light tan with dendritic brown blotches in a row on the side and in line with a similar row on dorsal surface of trunk; a horizontal brown line from middle of posterior margin of eye to pectoral, a portion curving dorsally on opercle; a similar line extending posteriorly from lower edge of eye, and anteriorly on to snout as a row of elongate spots; anal region of male with a large blue spot, of female whitish. In life the male had short yellow lines across the back and a bright red caudal fin; the females had a red spot on the caudal fin.

Genus DORYRHAMPHUS

Doryrhamphus Kaup 1856. Cat. lophobranchiate fishes British Mus., p. 585. (Type species, Doryrhamphus excisus Kaup).

Doryrhamphus melanopleura melanopleura

Syngnathus melanopleura Bleeker 1858. Nat. Tijdschr. Ned.-Ind., vol. 15, p. 464. (Type locality, Cocos Islands, Indian Ocean).

2 specimens (female). 33 and 45 mm. Onotoa.

Color in life brilliant orange with a median black line from snout to base of caudal fin and irregular black markings on caudal fin.

Family BELONIDAE

Genus BELONE

Belone Cuvier 1817. Règne animal, ed. 1, p. 185. (Type species, Esox belone Linnaeus).

Belone platyura

Belone platyura Bennett 1831. Proc. Zool. Soc. London, pt. 1, p. 168. (Type locality, Mauritius).

Platybelone platura Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 287. (Nauru and Ocean Island).

8 specimens. 215 - 280 mm (rictus to base of caudal). Onotoa.

1 specimen. 270 mm. Tarawa.

1 specimen. 188 mm. Nukunau.

D 13 or 14; A 17 or 18; P 12. (5 specimens). Gill rakers (including all rudiments) 25 or 26. (2 specimens).

Color from 35 mm Kodachrome transparency: back blue, sides and ventral part of body silvery.

Teeth in jaws of approximately the same size; width of body slightly greater than depth; width of body contained about 14 times in length from rictus to base of caudal fin; caudal peduncle on each side with a prominent lateral scaly keel which extends out on central part of caudal fin; least depth of caudal peduncle half as wide as width; greatest diameter of eye 1.7 to 1.9 in postorbital length of head.

All of the Onotoa specimens were taken in outer reef areas. The Gilbertese often caught this species at night by wading on the outer reef flat with a torch and striking the backs of the fish with a long sharp knife or stick as they were attracted to the light.

The stomachs of two specimens taken at night on the outer reef flat contained fragments of unidentified red crustaceans. Of five poisoned with rotenone during the day, four were empty and one had recently eaten a small fish.

Genus STRONGYLURA

Strongylura van Hasselt 1823. Alg. Konst. Letterbode, no. 35; 1824. Bull. Sci. Nat. (Férussac), vol. 2, p. 374. (Type species, Strongylura caudimaculata van Hasselt = Belone strongylura van Hasselt).

Strongylura incisa

Belone incisa Cuvier and Valenciennes 1846. Hist. nat. poiss., vol. 18, p. 451. (Type locality, Indian Ocean).

1 specimen. 310 mm (from rictus to base of caudal). Tarawa.

D 18; A 22; P 12.

Gill rakers rudimentary, with only 9 perceptible near angle of first arch; teeth in jaws of two different sizes, the long canines being 4 to 5 times longer than the numerous short teeth lying between the canines; canine teeth vertical or angling slightly backwards in jaws; no well-developed keel on side of caudal peduncle; least depth of caudal peduncle about equal to width of peduncle at this point; lateral line ends ventral to mid-lateral point of caudal peduncle at its least depth; greatest diameter of eye 2.3 in post-orbital length of head.

Family HEMIRAMPHIDAE

Genus HEMIRAMPHUS

Hemi-Ramphus Cuvier 1817. Règne animal, ed. 1, vol. 2, p. 186. (Type species, Esox brasiliensis Linnaeus).

Hemiramphus marginatus

Esox marginatus Forskål 1775. Descr. animalium, p. 67. (Type locality, Djedda, Red Sea).

1 specimen. 215 mm. Onotoa.

1 specimen. 198 mm. Tarawa.

D 13; A 12; P 12; transverse scale rows from gill opening to base of caudal fin 51; gill rakers 43. (1 specimen).

Inner pelvic ray decidedly longer than other rays; upper jaw without scales; body in cross-section less angular than Hyporhamphus; length of lower jaw anterior to tip of upper jaw contained 3.4 times in body length from tip of upper jaw to base of caudal fin; eye 4.2 in head length; depth of body 5.7 in standard length; length of pectoral fin 4.7 in standard length.

The Onotoa specimen was captured with a dip net at night at the surface in deep water west of the atoll. It was attracted to a canoe with the light of a torch.

Genus HYPORHAMPHUS

Hyporhamphus Gill 1859. Proc. Acad. Nat. Sci. Phila., p. 131. (Type species, Hyporhamphus tricuspidatus Gill = Hyporhamphus unifasciatus Ranzani).

Hyporhamphus laticeps

Hemirhamphus laticeps Günther 1866. Cat. fishes British Mus., vol. 6, p. 267. (Type locality, Fiji Islands).

12 specimens. 57 - 235 mm. Onotoa.

4 specimens. 78 - 220 mm. Tarawa.

D 14 or 15; A 14 or 15; P 12; transverse scale rows from gill opening to base of caudal fin 56 to 59; gill rakers 40 to 42. (5 specimens).

Color in life of specimens 180 to 244 mm in length: dorsal part of body to lateral line bright metallic blue; lateral line dark blue; sides and belly silvery; caudal fin bluish; remaining fins hyaline; tip and underside of lower jaw bright red.

Depth of body about equal to width; body depth of 244 mm specimen about 9 in standard length; width of upper jaw about 1.5 times longer than length of jaw; lower jaw of 244 mm specimen extends 52 mm beyond tip of upper jaw.

During the course of an afternoon poison station just beyond the breaker line on the southwest side of Aunteuma, a small island in the northern part of Onotoa Atoll, many large specimens of this species were seen at the surface swimming in and out of the cloud of rotenone. Over 15 were killed. The stomachs of 10 of these were opened but found to be empty except for a small amount of thick, cream-colored liquid.

Hyporhamphus dussumieri

Hemiramphus dussumieri Cuvier and Valenciennes 1846. Hist. nat. poiss., vol. 19, p. 33, pl. 554. (Type locality, Seychelles).

?Hemiramphus affinis Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl., vol. 26, p. 251. (Tarawa).

8 specimens. 65 - 162 mm. Onotoa.

D 15 or 16; A 15 or 16; P 12; transverse scale rows from gill opening to base of caudal fin 65 or 66; gill rakers 34 to 36. (3 specimens).

Depth of body greater than width; greatest depth of body about 10 in standard length; greatest width of body 12.5 in standard length; lower jaw of 162 mm specimen extends 39 mm beyond tip of upper jaw; maximum width of upper jaw greater than length.

This species was taken both in surface waters of the lagoon and the outer reef.

Hyporhamphus georgii

Hemiramphus Georgii Cuvier and Valenciennes 1846. Hist. nat. poiss., vol. 19, p. 27, pl. 555. (Type locality, Mahe Bay, Coromandel).

Hemiramphus (Rhynchorhamphus) georgii Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 75. (Kingsmill Islands).

I do not believe Fowler (1928: 75) is justified in setting up the subgenus Rhynchorhamphus for this species. His primary basis for the subgenus was the very long lower jaw. The relative length of the jaw of half beaks varies with age.

Family EXOCOETIDAE

The flying fishes were caught at night by participating with Gilbertese natives who catch these fishes with long-handled dip nets after attracting them with the light of torches. The fishing is done from outrigger canoes while under sail. The Onotoa exocoetids were all caught outside of the lagoon, though I was told that fishing for flying fishes is at times undertaken in the lagoon. The general Gilbertese name for flying fishes is Teonauti.

The meristic data for all of the specimens are given in Table 1. Apparently scale counts are variable within the species.

Fowler (1928: 80) identified a specimen in the Museum of Comparative Zoology from the Kingsmill Islands as Evolantia microptera (Valenciennes).

Genus CYPSELURUS

Cypsilurus Swainson 1838. Nat. hist. class. fishes, amphibians,..., vol. 1, p. 299. (Spelling changed to Cypelurus Lowe 1841 by the International Commission on Zoological Nomenclature).

Cypselurus spilonotopterus

Exocoetus spilonotopterus Bleeker 1866. Ned. Tijdschr. Dierk., vol. 3, p. 113. (Type locality, Padang, Sumatra).

2 specimens. 267 and 273 mm. Onotoa.

Color from 35 mm Kodachrome transparency: upper one-third of body gun metal blue, lower two-thirds silvery white; a large black area in dorsal fin from the third to the tenth ray; caudal fin dark purplish; pectoral fin dark purplish with a silvery sheen centrally; anal and pelvic fins white. In alcohol the pectoral membranes are blackish except extreme outer portions which are hyaline.

Cypselurus unicolor

Exocoetus unicolor Cuvier and Valenciennes 1846. Hist. nat. poiss., vol. 19, p. 97. (Type locality, Vanikoro and Java).

2 specimens. 230 and 265 mm. Onotoa.

Color in alcohol: upper half to third of body dark gray-brown, lower part of body light tan; horizontal area from gill opening to pelvic fins at level of lower base of pectoral fin with a sparse stippling of tiny black dots; dorsal, anal, pectoral, and pelvic fins pale; caudal fin brownish; outer axil of pelvic fins blackish.

Cypselurus suttoni

Maculocoetus suttoni Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 288, pl. 14, fig. 1. (Type locality, Nauru and Ocean Island).

2 specimens. 253 and 267 mm. Onotoa.

Color in alcohol: upper half of body dark gray brown, lower half tan; dorsal fin brown with a large black spot on the fifth to tenth rays; pectoral fin membranes hyaline brown with black spots; caudal fin light brownish; pelvic fins pale.

Genus PROGNICHTHYS

Prognichthys Breder 1928. Bull. Bingham Oceanogr. Coll., vol. 2, p. 20. (Type species, *Exocoetus gibbifrons* Cuvier and Valenciennes).

Prognichthys albimaculatus

Cypselurus (*Exonautes*) *albimaculatus* Fowler 1933. (on *Cypselurus speculiger* Kendall and Goldsborough, 1911). Proc. Acad. Nat. Sci. Phila., vol. 85, p. 327, fig. 81. (Type locality, Guam).

1 specimen. 165 mm. Tarawa.

Color in alcohol: upper half of body dark gray-brown, lower half tan; dorsal and caudal fins light brownish; pectoral fin membranes blackish, especially lower outer portions, (except center of fin which is light dusky); anal and pelvic fins pale like ventral half of body.

Unlike *Cypselurus* in which only the upper pectoral ray is branched, *Prognichthys* has the upper two pectoral rays unbranched. Also, the anal and dorsal fins in *Prognichthys* are about the same length at their base and have about the same number of rays. In *Cypselurus* the dorsal fin base is longer and there are more rays than the anal. In my single specimen of Prognichthys albimaculatus (and in the type which was examined by me) the anal fin takes its origin just beneath the origin of the dorsal fin.

Table 1 Counts Made on the Exocoetidae Collected in the Gilbert Islands

	Dorsal rays					Anal rays	
	10	11	12	13	14	9	10
C. spilonotopterus				2			2
C. unicolor			1	1		1	1
C. suttoni				1	1		2
P. albimaculatus	1						1

	Gill rakers						Pectoral rays					
	20	21	22	23	24	25	13	14	15	16	17	18
C. spilonotopterus		2					2					
C. unicolor	1		1					1	1			
C. suttoni		1			1		2					
P. albimaculatus						1						1

	Scale rows from upper end of gill opening to base of caudal fin											
	44	45	46	47	48	49	50	51	52	53	54	55
C. spilonotopterus					1		1					
C. unicolor	1					1						
C. suttoni									1			1
P. albimaculatus					1							

	Predorsal scales											
	28	29	30	31	32	33	34	35	36	37	38	39
C. spilonotopterus					1							1
C. unicolor	1					1						
C. suttoni									1	1		
P. albimaculatus			1									

Family HOLOCENTRIDAE

The squirrel fishes are well represented among the collections from the Gilbert Islands. They are spiny, usually red, with large eyes, a pelvic fin formula of I,7, and nocturnal habits. The Gilbertese valued them as food fish and caught them while fishing with torches at night.

Genus HOLOCENTRUS

Holocentrus Scopoli 1777. Introductio ad historiam naturalem..., p. 449. (No type species designated, but after Gronow's Holocentrus maxilla).

Holocentrus spinifer

Sciaena spinifera Forskål 1775. Descr. animalium, pp. 12, 49. (Type locality, Red Sea).

1 specimen. 222 mm. Onotoa.

2 specimens. 150 and 170 mm. Tarawa.

D XI-15; A IV,10; P 15; lateral line scales 44. (1 specimen).

Spine at corner of preopercle long, its length measured to center of the corner 3.3 in head length; profile of head very slightly concave.

Color from 35 mm Kodachrome transparency red; each body scale with a narrow white outer edge; extreme ventral part of body white; spinous dorsal fin bright red; soft dorsal fin light red; caudal fin red except distal part which shades to orange; anal and pectoral fins orange yellow; pelvic fins red with a white margin.

Although the only specimen from Onotoa was taken from an outer reef area, the species was otherwise seen only in relatively shallow areas of the lagoon hiding in interstices in dead coral.

Holocentrus opercularis

Holocentrum operculare Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 501. (Type locality, Carteret Harbor, New Ireland).

3 specimens. 185 - 192 mm. Onotoa.

D X-I,13; A IV,9; P 14; lateral line scales 40. (2 specimens).

Color in alcohol light brown, darker dorsally, with the centro-basal part of each scale dark brown; a broad, uninterrupted, jet black band in spinous dorsal fin; outer part of each interspinous membrane and an irregular pale blotch near base of each membrane pale; remaining fins light brown except upper and lower parts of caudal fin which are slightly dusky.

The three specimens were taken in poison station number II at the northern part of the atoll.

Holocentrus sammara

Sciaena sammara Forskål 1775. Descr. animalium, pp. 12, 48. (Type locality, Djedda, Red Sea).

28 specimens. 31 - 123 mm. Onotoa.

1 specimen. 155 mm. Tarawa.

D X-I,12; A IV,8; P 13 or 14; lateral line scales 41 and 42. (2 specimens).

Color in alcohol light brown with a row of close-set, dark brown spots down the center of each scale row (the rows of spots in many of the specimens are faint); a round, jet black spot anteriorly in dorsal fin (between the first and fourth spines); a light dusky band in middle of fin posterior to black spot; anterior margin of soft dorsal fin, upper and lower lobes of caudal fin, and region of fourth anal spine and first soft ray dusky.

Specimens were collected from both the lagoon and outer reef areas.

Holocentrus laevis

Holocentrum laeve Günther 1859. Cat. fishes British Mus., vol. 1, p. 47. (Type locality, Louisiade Archipelago; Guadalcanal, Solomon Islands; Ambon, East Indies).

11 specimens. 30 - 138 mm. Onotoa.

D X-I,12; A IV,8; P 12; lateral line scales 41. (2 specimens).

Color from 35 mm Kodachrome transparency: silvery blue dorsally, shading to white on sides and ventrally, with a row of dark brown spots down the center of each row of scales; spinous dorsal fin yellowish with a faint dusky lengthwise band in outer part of fin; soft dorsal fin whitish except anterior margin which is dusky red; caudal fin whitish with upper and lower margins broadly dark reddish brown; anal fin whitish except region of last anal spine and first anal ray which is dusky red; pelvic fins white; pectoral fins hyaline.

Specimens were collected from around coral heads in shallow areas of the lagoon, channels, and outer reef.

Holocentrus diadema

Holocentrus diadema Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 335, 372. (Type locality, South Seas).

8 specimens. 47 - 108 mm. Onotoa lagoon.

1 specimen. 110 mm. Tarawa.

D XI,13; A IV,9; P 14; lateral line scales 48. (2 specimens).

Color in alcohol light brown with a pale line narrowly bordered with brown in the center of each scale row; an indistinct elongate brown patch on back beneath posterior part of spinous dorsal fin; membranes of spinous dorsal fin black (spines hyaline), with a narrow lengthwise pale band running from base of first spine to one-fourth up on sixth spine and a similar band from two-thirds out on seventh spine to juncture of spinous and soft dorsal fins; remaining fins pale.

Holocentrus lacteoguttatus

Holocentrum lacteo-guttatum Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 214. (Type locality, Mer des Indes).

11 specimens. 46 - 120 mm. Onotoa.

1 specimen. 39 mm. Tarawa.

D XI-13 or 14; A IV,9; P 15; lateral line scales 44 to 48. (4 specimens).

Color from 35 mm Kodachrome transparency: body silvery; scales on dorsal third of body margined with red and dotted with fine brown spots; dorsal part of head red; outer third of spinous dorsal fin bright red, the rest pale; remaining median fins light red; paired fins whitish.

Ten of the specimens were taken with rotenone from a surge channel of the outer reef on the windward side of the atoll; one specimen was taken from the lagoon side of the west reef.

Holocentrus violaceus

Holocentrum violaceum Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol. 5, p. 335. (Type locality, Ambon, East Indies).

2 specimens. 158 and 166 mm. Onotoa.

D XI,14; A IV,9; P 15; lateral line scales 35. (2 specimens).

Spine at corner of preopercle very long, its length 2.8 in head length; spinous dorsal fin short, longest dorsal spine 2.7 in head length.

Color in life reddish brown. Color in alcohol dark brown, each body scale with two indistinct pale spots, one in upper central part of scale, the second in lower central part; opercular membrane dark brown, almost black in dorsal portion; fins light brown.

The specimens were taken from coral rich areas, one from the west reef of the atoll and the other from the northern outer reef.

Holocentrus microstomus

Holocentrum microstoma Günther 1859. Cat. fishes British Mus., vol. 1, p. 34. (Type locality, Ambon, East Indies).

13 specimens. 43 - 134 mm. Onotoa.

D XI-12 or 13; A IV,9; P 15; lateral line scales 50 or 51. (5 specimens).

Third anal spine very long, its length about 1.3 in head length; maxillary ends at a vertical passing through anterior one-fourth of eye.

Color from 35 mm Kodachrome transparency: body red with a broad white band down the center of each scale row; head red except ventrally and margin of preopercle which are white; median fins light red; pelvic fins whitish; pectoral fins hyaline.

One 132 mm specimen is more melanistic than the others, with streaks of blackish pigment in the soft dorsal and anal fin. It has only 47 lateral line scales. In other respects it appears like the other specimens of H. microstomus.

Most of the specimens were taken from around coral heads in shallow lagoon and channel areas.

Holocentrus tiere

Holocentrum tiere Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 202. (Type locality, Tahiti).

Holocentrus erythraeus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 289. (Ocean Island) (after Holocentrus erythroeus Waite, 1903: 3).

10 specimens. 120 - 195 mm. 5 specimens 38 - 49 mm. Onotoa.

2 specimens. 142 mm. Tarawa.

D XI-14; A IV,9; P 14 or 15; lateral line scales 48 to 51. (4 specimens).

Spinous dorsal fin short, longest spine 3.1 in head length; depth of body 2.7 in standard length; third anal spine 1.9 in head length; spine at corner of preopercle 4 in head length; posterior end of maxillary in line with a vertical through center or slightly posterior to center of eye.

Color from 35 mm Kodachrome transparency bright red; alternating longitudinal bands of dark red and light red (nearly white ventrally) on body, the darker red bands running down the center of the scale rows; spinous dorsal fin bright red except tips of membranes and a white spot basally on each membrane; remaining fins red.

Woods in Schultz and collaborators (1953) has concluded that Holocentrum erythraeum Günther is a synonym of Holocentrus tiere Cuvier and Valenciennes.

H. tiere appeared to be the most common member of the genus at Onotoa. It was certainly the most common in coral-rich areas of the outer reef. Some of the Onotoa and the two Tarawa specimens were taken from surge channels.

The stomachs of 15 adult specimens which were collected in the afternoon were opened. All were empty except two which contained well digested remains of small fish. Since holocentrids probably feed mainly at night, the food habits should be investigated from specimens taken at night or early in the morning.

Holocentrus caudimaculatus

Holocentrus caudimaculatus Rüppell 1835. Neue Wirbelth., Fische, pp. 97, 103. (Type locality, Red Sea).

Holocentrum caudimaculatum Günther 1874. Jour. Mus. Godeffroy, vols. 2-3, pts. 5-6, p. 95. (Abemama, Gilbert Islands).

Genus HOLOTRACHYS

Holotrachys Günther 1874. Jour. Mus. Godeffroy, vols. 2-3, pts. 5-6, p. 93. (Type species, Myripristis lima Cuvier and Valenciennes).

Holotrachys lima

Myripristis lima Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 493. (Type locality, Mauritius).

1 specimen. 70 mm. Onotoa.

D XII-15; A IV,11; P 17; lateral line scales 42.

No elongate spine at corner of preopercle; third anal spine only slightly longer and stouter than fourth spine.

Color in life bright red.

The one specimen taken was collected from the lagoon side of the west reef of Onotoa.

Genus MYRIPRISTIS

Myripristis Cuvier 1829. Règne animal. ed. 2, p. 150. (Type species, *Myripristis jacobus* Cuvier and Valenciennes).

Myripristis adustus

Myripristis adustus Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol. 4, p. 108. (Type locality, Ambon, East Indies).

2 specimens. 185 and 190 mm. 14 specimens. 33 to 63 mm. Onotoa.

1 specimen. 235 mm. Tarawa.

D X-I,15; A IV,13; P 15 or 16; lateral line scales 28; gill rakers 38. (2 specimens).

Color from 35 mm Kodachrome transparency of a 190 mm adult: centers of scales pale, nearly white, rims dark blue dorsally, shading to salmon pink on sides and ventrally; spinous dorsal fin black except for a broad pale lengthwise band down the middle; distal part of soft dorsal, caudal, and anal rays black; basal part of these fins pale pinkish shading to orange red next to black outer part; a blackish spot at postero-medial part of opercle; axil of pectoral fin blackish; iris of eye pale yellow.

The stomachs of four large specimens from Tarawa (not retained for the collection) were opened. Two were empty and two contained one shrimp each.

Myripristis microphthalmus

Myripristis microphthalmus Bleeker 1852. Nat. Tijdschr. Ned.-Ind., vol. 3, p. 261. (Type locality, Ambon, East Indies).

8 specimens. 97 - 148 mm. Onotoa.

D X-I,15 or 16; A IV, 13; P 15; lateral line scales 28; gill rakers 42 or 43 (27 or 28 on lower limb of arch). (3 specimens).

Diameter of eye equal to or less than postorbital part of head (measured to opercular spine); depth of body 2.2 in standard length; head length 3.3 in standard length.

Color from 35 mm Kodachrome transparency: centers of scales light bluish gray (almost white) edges reddish brown (purplish in nape region); posterior edge of opercle broadly margined with reddish brown, this most pronounced at level of eye; brownish red spot in axil of pectoral; spinous dorsal fin light red; soft dorsal, caudal, and anal fins pink basally, shading to red anterodistally in the dorsal and anal and distally in the caudal fins; anal spines white; pectoral fins hyaline red; pelvic fins white.

All of the specimens were obtained in poison station II in the northern part of the atoll.

Myripristis murdjan

Sciaena murdjan Forskål 1775. Descr. animalium, pp. xii, 48. (Type locality, Arabia).

4 specimens. 71 - 155 mm. Onotoa surge channel.

D X-I,14; A IV,11 or 12; P 15; lateral line scales 31 to 33; gill rakers 43 (26 or 27 on lower limb). (2 specimens).

Diameter of eye slightly greater than postorbital part of head; depth of body 2.4 in standard length; length of head 3 in standard length; patch of teeth on anterior part of each side of lower jaw directly below similar but broader patch on each side of upper jaw.

Color of 105 mm specimen from a 35 mm Kodachrome transparency bright red, the centers of the scales white; spinous dorsal fin pink basally, red distally; soft dorsal fin with rays red, membranes yellowish except distal half or more of those between the first five rays which are solid red, shading to brown outwardly; anal fin with similar coloration except anterior spinous portion which is white; caudal fin solid red except upper and lower margins which are white; opercular membrane reddish brown (dusky in preservative); axil of pectoral fin reddish brown; rays of pectoral fin faintly red; pelvic fins with anterior margin white, followed by a narrow red area, the rest whitish; inner two-thirds of iris red, outer one-third white.

Myripristis pralinius

Myripristis pralinius Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 170. (Type locality, Port Praslin, New Ireland).

6 specimens. 51 - 134 mm. Onotoa.

D X-I,15 or 16; A IV,14 or 15; P 15; lateral line scales 37 or 38; gill rakers 36 to 38 (23 or 24 on lower arch). (3 specimens).

Diameter of eye slightly greater than postorbital length of head (measured to end of opercular spine); greatest body depth 2.35 in standard length; head length 3.4 in standard length.

Color from 35 mm Kodachrome transparency rosy red; brown on opercular membrane does not extend below opercular spine; a brown spot at axil of pectoral fin; all fins except pelvics rosy red, the anterior margins of the soft dorsal and anal and margins of caudal lobes narrowly white; rosy red color of soft dorsal and anal fins darkest anterodistally in these fins; pelvic fins whitish; iris red.

The specimens were collected at poison stations II and IV, both regions of numerous small coral heads.

Myripristis multiradiatus

Myripristis multiradiatus Günther 1874. Jour. Mus. Godeffroy, vol. 1, p. 93. (Type locality, Vavau, Tonga Islands).

3 specimens. 103 - 128 mm. Onotoa.

D X-I,16 or 17; A IV, 15; P 14 or 15; lateral line scales 38; gill rakers 38 (24 on lower limb). (2 specimens).

Diameter of eye slightly greater than postorbital length of head (measured to end of opercular spine); body depth 2.35 in standard length; length of head 3 in standard length.

Color in alcohol light yellowish brown; dark brown region from upper edge of gill opening to axil of pectoral fin, this color on edge of opercular bone, on opercular membrane, and exposed part of posttemporal bone; fins color of body except base of caudal fin which is slightly dusky.

The two specimens were collected with rotenone at station IV on the west reef in a maximum of 11 feet of water.

Myripristis argyromus

Myripristis argyromus Jordan and Evermann 1902. Bull. U. S. Fish Comm., vol. 22, p. 172. (Type locality, Hilo, Hawaii).

5 specimens. 105 - 162 mm. Onotoa.

2 specimens. 166 and 168 mm. Tarawa surge channel.

D X-I,14 to 16; A IV,13 or 14; P 14 or 15; lateral line scales 30 to 33; gill rakers 37 to 42 (24 to 26 on lower limb of arch). (5 Onotoa specimens). D X-I,14; A IV,13; P 15; lateral line scales 31; gill rakers 36 and 38 (23 on lower limb). (2 Tarawa specimens).

Diameter of eye equal to or slightly greater than post-orbital length of head measured to tip of opercular spine; depth of body 2.4 in standard length; length of head from tip of snout to end of opercular spine 2.8 in standard length; a cluster of 4 or 5 short teeth on a small bony prominence on each side of anterior part of lower jaw medial to a similar but broader patch on each side of upper jaw; patches in lower jaw separated by a distance about twice as great as the diameter of one of the patches.

Color from 35 mm Kodachrome transparency of an Onotoa specimen: light red dorsally, shading to light silvery pink on sides and ventrally; margins of scales bluish brown; darker dorsally than ventrally; brown spot on opercular membrane at level of pupil of eye which extends slightly more above opercular spine than below it; dark brown spot in axil of pectoral fin; spinous dorsal fin pink except distal part which is bright red; soft dorsal and anal fins pink basally, light red distally (red area broader anteriorly in these fins than posteriorly); caudal fin reddish brown, shading to deep red on posterior fourth of fin; paired fins light pink, the pelvics with a white lateral margin; inner half of iris white, outer half dusky.

Color in alcohol of Tarawa specimens: centers of scales light golden, margins light yellowish brown; dark brown pigment on operculum confined to membrane and extending below opercular spine a distance of about 7 mm; axil of pectoral fin dark brown; anterodistal part of soft dorsal and anal fins slightly dusky; iris yellow.

The Onotoa specimens were collected with rotenone from station IV on the west reef of the atoll.

Myripristis sp.

1 specimen. 192 mm. Tarawa.

D X-I,14; A IV,10; P 14 and 15; lateral line scales 32; gill rakers 28-1-16 (total 45).

I am unable to identify this specimen to species. It is very similar to M. argyromus, differing in color only in the reduced pigment on the opercular membrane (the membrane from slightly below the opercular spine to upper edge of gill opening is only faintly dusky). The counts of 10 anal soft rays and 45 gill rakers of this specimen clearly separate it, however, from argyromus, unless it is aberrant in this regard.

The specimen was collected from the same surge channel at Tarawa as the two specimens of argyromus.

Myripristis berndti

Myripristis berndti Jordan and Evermann 1902. Bull. U. S. Fish Comm., vol. 22, p. 170. (Type locality, Honolulu, Hawaii).

3 specimens. 145 - 175 mm. Onotoa.

D X-I,14 or 15; A IV,12 or 13; P 15; lateral line scales 30; gill rakers 38 or 39 (24 or 25 on lower limb of arch). (3 specimens).

Diameter of eye slightly greater than postorbital length of head measured to end of opercular spine (just equal to this length if it is measured to end of opercular membrane); depth of body 2.3 in standard length; length of head 3.05 in standard length; patches of teeth anteriorly on jaws similar to those of M. argyromus; snout length measured from anterior edge of eye to middle of upper lip slightly greater than interorbital width.

Color from 35 mm Kodachrome transparency of a 175 mm specimen: light red, the edges of scales brownish red; centers of some scales, especially those on sides or ventrally, whitish or with two or three small whitish areas; spinous dorsal fin with spines red, membranes rosy red on basal half, orange yellow on outer half; soft dorsal and anal fins bright red with a narrow white anterior margin; caudal fin bright red, upper and lower lobes with a white margin; paired fins red, the pelvics with a lateral white margin; opercular membrane brown almost to level of upper base of pectoral fin (lower third of brown portion of opercular membrane mottled); a brown area in axil of pectoral fin; iris of eye red with marginal white areas.

The specimens were collected at poison station IX on the west reef of Onotoa Atoll.

The stomachs of five specimens discarded in the field (140 to 160 mm in standard length) were opened and found to be empty.

Family MUGILIDAE

The mullets, like the goatfishes, were most commonly seen in shallow, sandy areas of the lagoon at Onotoa. On two occasions small schools of a large species believed to be Mugil cephalus were sighted in surge channels of the outer reef. The usually common Neomyxus chaptili was not seen, nor is it recorded from the Gilbert Islands, but it probably occurs there.

The species which I designate below as Mugil seheli, M. engeli, and M. vaigiensis are considered as belonging to the genus Chelon Rose by Schultz in Schultz and collaborators (1953), although he admits Chelon is a "catch-all" genus in need of further refinement. The characters used by Schultz to separate Chelon from Mugil involve the position of the nostrils and the nature of the adipose eyelid. He points out, however, (p. 312) that the adipose eyelid in Chelon loses much of its significance because the amount of its development varies. I experienced difficulty with the characters involving the position of the nostrils, and therefore prefer to leave these three species, at least, in *Mugil*. I am in agreement with Schultz in not recognizing *Ellochelon* Whitley (with *Mugil vaigiensis* as its type species) and *Valamugil* Smith (with *Mugil seheli* as its type species).

Genus MUGIL

Mugil Linnaeus 1758. Syst. nat., ed. 10, p. 316. (Type species, *Mugil cephalus* Linnaeus).

Mugil seheli

Mugil crenilabis var. *seheli* Forskål 1775. Descr. animalium, pp. xiv, 73. (Type locality, Red Sea).

1 specimen. 310 mm. Tarawa.

D IV-I,8; A III,9; P 18; scale rows from upper end of gill opening to base of caudal fin 39.

Color in alcohol dusky brown dorsally shading to light brown on sides and ventrally; an indistinct blackish spot at upper edge of base of pectoral fin.

No adipose eyelid; lips smooth; ventro-anterior margin of preorbital straight and finely serrate; maximum body depth contained 3.7 times in standard length; caudal fin, though damaged, appears to be lunate; second dorsal and anal fins scaly; pectoral slightly shorter than length of head, axillary scale at level of upper margin of pectoral nearly half the length of the pectoral.

Mugil engeli

Mugil engeli Bleeker 1858. Nat. Tijdschr. Ned.-Ind., vol. 15, p. 385. (Type locality, Batavia, Java).

3 specimens. 110 - 123 mm. Onotoa.

1 specimen. 111 mm. Tarawa.

D IV-I,8 or 9; A III,8 or 9; P 16; scale rows from upper end of gill opening to base of caudal fin 32 or 33. (4 specimens).

Color in alcohol: dorsal half of body dusky brown (consisting of a dense stippling of tiny brown dots); lower half of body tan; operculum and chest largely silvery; fins pale with fine speckles of dark brown.

Adipose eyelid only slightly developed; lips smooth; depth of body contained about 4 times in standard length; ventro-anterior margin of preorbital with an angular concavity; length of pectoral fin about equal to length of head; caudal fin slightly forked.

One of the specimens was obtained from a Gilbertese fisherman who had several for use as bait while trolling for tuna. The hook was completely imbedded in the mullet for this purpose.

Mugil vaigiensis

Mugil vaigiensis Quoy and Gaimard 1824. Voyage autour du monde... "Uranie"...Zool., p. 337, pl. 59, fig. 2. (Type locality, Waigeo Island, New Guinea).

Ellochelon vaigiensis Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 289. (Nauru).

2 specimens. 93 and 205 mm. Onotoa lagoon.

2 specimens. 92 and 93 mm. Tarawa.

D IV-I, 7 or 8; A III,8; P 16; scale rows from upper end of gill opening to base of caudal fin 25 or 26. (2 specimens).

Color in life of large specimen silvery white; scales on back with blackish edges; upper half to two-thirds of pectoral fin black, lower half pale; other fins dusky bluish except pelvics which are white. The 93 mm specimen had a yellowish caudal fin in life.

Mugil tade

Mugil crenilabis var. tade Forskål 1775. Descr. animalium, pp. xiv, 74. (Type locality, Red Sea).

Mugil tade Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 122, fig. 26. (Abaiang, Kingsmill Islands).

Genus CRENIMUGIL

Crenimugil Schultz 1946. Proc. U. S. Nat. Mus., vol. 96, p. 387. (Type species, Mugil crenilabis Forskål).

Crenimugil crenilabis

Mugil crenilabus Forskål 1775. Descr. animalium, pp. xiv, 73. (Type locality, Red Sea).

1 specimen. 108 mm. Onotoa lagoon.

D IV-I,8; A III,9; P 17; scale rows from upper end of gill opening to base of caudal fin 39.

Color in alcohol dark brownish dorsally shading to tan on sides and ventrally; a black spot at upper edge of base of pectoral fin.

Margin of lower lip strongly crenulate; inside of margin a row of ridge-like, irregular papillae; upper lip with about 4 rows of small papillae on outer edge.

Family ATHERINIDAE

Genus ALLANETTA

Allanetta Whitley 1943. Proc. Linn. Soc. N. S. Wales, vol. 68, p. 135. (Type species, Atherina mugiloides McCulloch).

Allanetta ovalaua

Atherina ovalaua Herre 1935. Publ. Field Mus. Nat. Hist., zool. ser., vol. 18, p. 401. (Type locality, Fiji Islands).

3 specimens. 27 - 61 mm. Onotoa lagoon.

3 specimens. 24 - 43 mm. Abemama.

D VI or VII-I,9 or 10; A I, 9 or 10; P 17. (4 specimens). Transverse scale rows from gill opening to base of caudal fin 43. (1 specimen).

Color of 61 mm specimen in alcohol light brown with a dusky bluish line about equal to diameter of pupil in width running from upper axil of pectoral fin to base of caudal fin; scales on dorsal part of body edged in black; end of snout and lower jaw with a concentration of black pigment; a narrow black dotted line at base of pectoral fin; a tiny black spot anterior to upper base of pectoral fin; all fins hyaline except a bilobed area in mid-base of caudal fin which is dusky.

Rami of mandibles distinctly elevated at rear of toothed area; anus between pelvic fins; depth of body 6.5 in standard length.

Family SPHYRAENIDAE

Genus SPHYRAENA

Sphyraena Walbaum 1792. Petri Artedi sueci genera piscium, pp. 94, 584. (Type species, Esox sphyraena Linnaeus).

Sphyraena forsteri

Sphyraena forsteri Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 353. (Type locality, Tahiti).

1 specimen. 820 mm. Onotoa. (Only head and caudal fin preserved).

D V-I,9; A II,8; P 14; lateral line scales 116.

Angle of preoperculum rounded; maxillary reaches a vertical through anterior edge of eye; no elongate gill raker at angle of first gill arch; numerous tiny bony spinules on gill arch from angle over half way to ventral origin of arch; eye 7.7 in length of head from tip of upper jaw to end of operculum; eye 3.3 in postorbital part of head; no rasp-like teeth visible on tongue; an elongate canine tooth in upper jaw about an eye diameter distance from tip of upper jaw, this tooth flanked with one anteriorly and one posteriorly about one-third to one-half as long; a gap slightly less than an eye diameter in distance separates the long anterior canine tooth from a series of four of comparable length posteriorly in the jaw which, in turn, are followed by teeth of gradually smaller length; teeth in posterior part of lower jaw short, shark-like, the anterior edge of each somewhat longer than the posterior edge; edge of opercle with two flexible flattened spines, the lowermost more projected than the upper; posterior margin of caudal fin deeply concave with two prominent bumps in mid-portion.

This specimen differs from forsteri as described by Weber and de Beaufort (1922: 223) in lacking rasplike teeth on the tongue, and having a smaller eye, and a bi-lobed shape to the postero-central margin of the caudal fin. The eye is smaller than specimens of this species reported by Schultz (1953: 284) from the Marshall Islands. Since my specimen is larger than any seen by Weber and de Beaufort and by Schultz, it is possible that the differences in size of eye and shape of caudal fin are a function of age.

The specimen was caught by a Gilbertese fisherman by trolling.

Family SERRANIDAE

This family, as based on Gilbert Islands collections, includes the groupers, anthiids, and the genus Ypsigramma. The groupers were numerous at Onotoa. The young of some species were very abundant in tidepools and were caught by the Gilbertese and dried in the sun for food. Adult groupers were not so commonly seen because of their procilivity for hiding in holes and caverns in the reef, but now and then one could be observed purposefully swimming from one part of the reef to another.

Genus EPINEPHELUS

Epinephelus Bloch 1793. Natur. ausländ. Fische, vol. 7, p. 11. (Type species, Epinephelus marginatus Bloch = Perca fasciatus Forskål)

Epinephelus fuscoguttatus

Perca summana var. fusco-guttata Forskal 1775. Descr. animalium, pp. 11, 42. (Type locality, Red Sea).

Serranus fuscoguttatus Rüppell 1828. Atlas Reise nörd. Afrika, Fische des rothen Meers, p. 108, pl. 27, fig. 2.

Epinephelus fuscoguttatus Schultz 1943 (in part). Bull. U. S. Nat. Mus. 180, p. 108.

1 specimen. 288 mm. Onotoa.

D XI,15; A III,8; P 17; gill rakers 25.

Color in alcohol brown with large irregular dark brown blotches on head and body (most prominent dorsally) and everywhere covered with numerous, small, close-set dark brown spots; a prominent black saddle dorsally on caudal peduncle.

Another grouper, Epinephelus horridus (Cuvier and Valenciennes), has a very similar color pattern to fuscoguttatus, and the two have long been confused. It is difficult to decide from Forskal's brief description of fuscoguttatus which species should bear his name. I have chosen the more slender form as figured by Rüppell (1828) from the Red Sea. I am influenced further by seeing three specimens of this species from the Red Sea among the collections in the United States National Museum and failing to find any (nor any definite reference from the literature) of the deeper bodied form which I am designating horridus from this locality. Forskål's description of the spots as reddish brown supports my decision, for there are several preserved specimens from the Marshall Islands in the museum on which the spots are still slightly reddish. A Kodachrome transparency of horridus from life shows the spots as definitely not reddish. In view of the well known ability for the groupers to attain varied hues, this bit of evidence must be taken lightly, however.

Counts were made from one of the Red Sea specimens and one of the Marshall Islands specimens. The counts were the same as those of the Gilbert Islands specimen except for the dorsal soft rays and pectoral rays of the one from the Red Sea which were 14 and 18, respectively. For further discussion of fuscoguttatus, see horridus below.

Epinephelus horridus

Serranus horridus Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 321. (Type locality, Java).

Serranus fuscoguttatus Day 1876. Fishes of India, p. 22, pl. 5, fig. 3.

Epinephelus fuscoguttatus Schultz 1943 (in part). Bull. U. S. Nat. Mus. 180, p. 108.

1 specimen. 304 mm. Onotoa.

D XI,14; A III,8; P 19; gill rakers 36.

Color from 35 mm Kodachrome transparency light yellowish brown with large irregular dark brown patches on head and body (darkest dorsally) and numerous, close-set, small brown spots on head, body, and fins; a very dark brown saddle dorsally on caudal peduncle.

E. horridus may be told at a glance from fuscoguttatus by body depth and by the profile of the head. The latter is a more slender species and has a slightly and smoothly convex forehead; in horridus there is a distinct indentation at the eye where the convexity of the snout meets a marked convexity of the nape. Gill raker and pectoral fin ray counts provide conclusive meristic separation. Gill raker counts included all rudiments. A specimen of horridus from Canton Island, Phoenix Group, identified as fuscoguttatus by Schultz (1943), gave the same meristic data as the Onotoa specimen.

Epinephelus corallicola

Epinephelus corallicola Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 336.

Epinephelus macrospilus Bleeker 1873-76. Atlas ichth., vol. 7, pp. 33, 52, pl. 290, fig. 2.

Epinephelus altivelioides Bleeker ibid, pl. 308, fig. 1

Epinephelus macrospilus Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, pp. 330, 344, pl. 25, B.

Epinephelus spilotus Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, pp. 332, 352, fig. 55.

5 specimens. 72 - 310 mm. Onotoa lagoon and lee reefs

2 specimens. 98 and 160 mm. Nukunau.

D XI (one with XII), 16 or 17; A III,8; P 17 to 19; gill rakers 24 or 25. (3 specimens).

Color from 35 mm Kodachrome transparency of 120 mm specimen: body dull white with widely scattered blackish orange spots (slightly smaller than pupil of eye in average size); caudal fin yellowish white with scattered black spots, a concentration of these forming a submarginal band; margin of caudal fin light yellow; dorsal fin dull white with scattered black spots and pale margin; anal fin similar to dorsal but duskier; paired fins blackish, the pectorals with narrow light yellow margin and the pelvics with narrow white margin; iris yellow; pupil bluish. The 72 mm specimen has fewer spots (a total of 23 appearing on head and body, the most prominent being the 5 at the base of the dorsal fin and one dorsally on caudal peduncle. In the 310 mm specimen (which differed from the rest in having XII dorsal spines and 17 pectoral rays), the spots are relatively more numerous and smaller than the 120 mm specimen, but still well-spaced. There is a slight concentration of spotting at the base of the last few spines of the dorsal fin and dorsally on caudal peduncle to form a small black saddle.

A 126 mm specimen included among the five above is dark brown with black spots instead of light brown with black spots.

Gill rakers of 5 specimens from the Marshall Islands (paratypes of spilotus) numbered 25.

The stomach contents of a 275 mm specimen were examined. The specimen had eaten a scyllarid lobster. The stomach of a 150 mm specimen was empty.

Epinephelus sp.

1 specimen. 215 mm. Onotoa lagoon.

D XI,17; A III,8; P 17; gill rakers 25.

I am unable to identify this species. In color it is more-or-less intermediate to fuscoguttatus and corallicola. The body is brown with irregular darker brown areas and faint spots; there are 4 darker areas along the base of the anal fin, but these can be perceived only with difficulty. The head is densely spotted with small brown dots like fuscoguttatus; the fins are brownish with dark brown to black spots (larger and more evident than those on body) and pale margins. The edge of the hollow area in the cheek into which the maxillary fits when the mouth is closed is blackish.

The scales are more evident on the body than the previous epinephelids, and 100 were counted from upper edge of gill opening to base of caudal fin. Caudal fin rounded; longest dorsal soft ray about equal in length to longest dorsal spine;

head 2.7 in standard length; pectoral fin 1.7 in head; greatest diameter of eye 5.5 in head; depth of body 2.9 in standard length.

There is no definite black saddle on the caudal peduncle; there are no white spots on the body or fins.

Epinephelus socialis

Serranus socialis Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 7, pl. 8, fig. B. (Kingsmill Islands).

Epinephelus merra

Epinephelus merra Bloch 1793. Natur. ausländ. Fische, vol. 7, pt. 10, p. 17, pl. 329. (Type locality, Sea of Japan).

10 specimens. 40 - 132 mm. Onotoa.

D XI,16; A III,8; P 17 or 18; gill rakers 22 to 24. (3 specimens).

Color from 35 mm Kodachrome transparency of a 145 mm specimen (discarded in field): white with numerous close-set roundish brown spots on head, body, and fins (those on body mostly larger than size of pupil but smaller than size of eye); spots on pectoral fin smaller and darker than spots elsewhere on body or other fins; ground color of pectoral fin light yellowish; spots distally on caudal and soft portions of dorsal and anal fins smaller and darker; no large black spot or spots at base of dorsal fin or dorsally on caudal peduncle.

Depth of body 3 to 3.2 in standard length; length of pectoral fin 1.5 in head length.

This was apparently the most common species of Epinephelus at Onotoa. It was confused in the field with E. hexagonatus, and many specimens of both species were discarded. It is now impossible to decide on the exact localities at Onotoa where the two were collected. It is definite, however, that the young of merra were abundant in the outer reef tidepools.

The two species may be separated by gill raker counts (see table under hexagonatus below).

Both E. merra and E. hexagonatus appear to be small species, rarely exceeding 200 mm in standard length.

Epinephelus hexagonatus

Holocentrus hexagonatus Bloch and Schneider 1801. Systema ichth., p. 323. (Type locality, Tahiti).

Epinephelus _melanostigma_ Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, pp. 331, 348, fig. 54. (Type locality, Swains Islands, Samoa Group).

Epinephelus _spilotoceps_ Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, pp. 332, 357, figs. 56, 57. (Type locality, Bikini Atoll, Marshall Islands).

7 specimens. 25 - 91 mm. Onotoa.

2 specimens. 42 and 102 mm. Tarawa.

1 specimen. 148 mm. Nukunau.

D XI, 15 or 16; A III,8; P 18, (2 specimens).

Color in alcohol light brown with numerous close-set roundish to hexagonal dark brown spots on body (in average diameter about one half eye diameter); 4 to 5 very dark brown to black blotches along base of dorsal fin and another dorsally on caudal peduncle; spots in fins generally not dark and often with pale centers; outer half of pectoral fin unspotted or very faintly spotted.

I examined type material of _Epinephelus_ _spilotoceps_ Schultz and _E_. _melanostigma_ Schultz, and I am convinced that these are the same as _hexagonatus_. Schultz separated _spilotoceps_ from _hexagonatus_ primarily on the presence of small black spots on the front part of the head of the former and white triangular spots at the angles between brown spots on the body of the latter. I found examples from the Marshall Islands collections which were intermediate between these two color patterns. One showed very distinctly both the small white spots between the large hexagonal brown spots on the body and the tiny black spots anteriorly on the head. Gill raker counts were made on the type and paratypes of _spilotoceps_ and are given in the table below where they can be compared with the counts of _hexagonatus_. Intermediate specimens were not counted.

Schultz separated _melanostigma_ from other similar groupers primarily by its lacking a black dorsal saddle on the caudal peduncle and in having only one large black spot at the base of the dorsal fin. Actually most of the type material shows a darkening of spots dorsally on the caudal peduncle and the four or five dark blotches along the dorsal base as in _hexagonatus_, although the large spot at the rear base of the spinous portion of the dorsal fin is relatively more prominent in _melanostigma_ than _hexagonatus_. In the table of gill raker counts it will be observed that _melanostigma_ has more gill rakers. In most of the specimens this higher count was due to the addition of two tiny rudiments, on the average, at the extreme upper end of the arch. The type and all of the paratypes of _melanostigma_ are from the Phoenix and Samoa

Islands; Schultz records no specimens of hexagonatus from these island groups. His spilotoceps and hexagonatus are from the Marshall and Marianas Islands. Until melanostigma and hexagonatus can clearly be shown to occur in the same area, I prefer to consider the slight differences which separate these two forms as subspecific.

Table 2 Gill Raker Counts of Species of *Epinephelus* of the "*merra*" Complex

	Number of rakers (including rudiments) on the first arch								
	21	22	23	24	25	26	27	28	29
merra									
Marshall and Gilbert Islands	1	3	5	2					
hexagonatus									
Marshall and Gilbert Islands			1	2	2	4	2		
spilotoceps									
Marshall Islands			1	1	5	4	1		
melanostigma									
Phoenix and Samoa Islands					1	3	3	3	

Epinephelus flavocaeruleus

Holocentrus flavo-caeruleus Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 331, 367. (Type locality, Mauritius).

Epinephelus Hoedti Bleeker 1873-76. Atlas ichth., vol. 7, pp. 32, 45, pl. 283, fig. 2.

Serranus flavo-caeruleus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 177. (Gilbert Islands).

10 specimens. 50 - 104 mm. Onotoa.

1 specimen. 310 mm. Tarawa.

D XI,16 or 17; A III,8; P 19 or 20; gill rakers 26. (2 specimens).

Color from 35 mm Kodachrome transparency of 104 mm specimen purplish blue, shading to yellow on caudal peduncle; blue part of body and head with numerous small black spots; spinous dorsal fin blue with small black spots except margin which is broadly yellow; soft part of dorsal fin yellow except antero-basal portion which is blue with small black spots; anal fin yellow; caudal fin yellow with whitish posterior margin; pectoral fins hyaline yellow; pelvic fins yellow, the tips blackish.

Caudal truncate; depth of body 2.4 in standard length; middle of three opercular spines nearest the lowest spine.

This colorful grouper was common in shallow sandy areas of the lagoon with scattered, well-isolated coral heads. It was seen in no other habitat.

Epinephelus caeruleopunctatus

Holocentrus caeruleo-punctatus Bloch 1790. Natur. ausländ. Fische, vol. 4, p. 94, pl. 241, fig. 2.

1 specimen. 44 mm. Tarawa.

D XI,16, A III,8, P 18; gill rakers 15.

Color in alcohol dark brown with scattered small white spots of different size on head and body (38 spots in all on one side); fins all dark brown with small white spots and white margins.

Genus CEPHALOPHOLIS

Cephalopholis Bloch and Schneider 1801. Systema ichth., p. 311. (Type species, Cephalopholis argus Bloch and Schneider).

Cephalopholis argus

Cephalopholis argus Bloch and Schneider 1801. Systema ichth., p. 311, pl. 61. (Type locality, East Indies).

12 specimens. 38 - 209 mm. Onotoa.

1 specimen. 140 mm. Tarawa.

D IX,16; A III,9; P 18; gill rakers 27 and 28 (includes many rudiments). (2 specimens).

Color from 35 mm Kodachrome transparency dark purplish brown with numerous dark-edged bright blue spots on head and body; five vertical pale bands on posterior half of body (not seen in all specimens); basal part of spinous portion of dorsal fin colored like body, ends of membranes orange; remaining fins dark blue with blue spots somewhat obscured; posterior margin of caudal fin whitish.

This was a common species at Onotoa and was seen in many different habitats.

The stomachs of 10 specimens, 95 to 260 mm in standard length, were opened. One contained 3 small fish (very fresh and probably prior victims of the rotenone). Another contained a penaeid shrimp; the rest were empty.

Cephalopholis sonnerati

Serranus sonnerati Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 299. (Type locality, Pondicherry and Ceylon).

1 specimen. 61 mm. Onotoa lagoon.

1 specimen. 223 mm. Tarawa.

D IX,15; A III,9; P 18 or 19; gill rakers 22 and 23. (2 specimens).

Color in life of 61 mm specimen light yellowish brown with 5 or 6 faint dark vertical bars on upper half of body; small brown spots covering head and body (orangish brown on head); faint white spots posteriorly and ventrally on body; dorsal and anal fins brown with whitish margins on soft portions; caudal fin brown with a broad whitish posterior border (broader at ends of upper and lower rays than median rays), the extreme margin reddish; pectoral fin dusky in basal central portion, whitish on outer half; pelvic fins dark brown. The 223 mm specimen is uniform brown in alcohol.

Middle opercular spine nearest lower spine; caudal fin rounded; palatine and vomerine teeth present; 127 vertical scale rows from upper anterior end of gill opening to middle base of caudal fin; depth 2.5 in standard length.

Cephalopholis hemistiktos

Serranus hemistiktos Rüppell 1828. Atlas Reise nörd. Afrika, Fische, rothen Meers, p. 109, pl. 27, fig. 3. (Type locality, Red Sea).

Epinephelus hemistictus Boulenger 1895. Cat. fishes British Mus., p. 190.

1 specimen. 84 mm. Onotoa lagoon.

D IX,14; A III,9; P 18; gill rakers 22.

Color in alcohol very dark brown with small blackish spots on head, body, and median fins (more prominent on head, but difficult to see even here because of dark ground color of the specimen); caudal fin with a distinct white posterior margin (broader at upper and lower part); soft portions of dorsal and anal fins with a very narrow whitish margin; pectoral fin blackish, shading to dusky pale on about outer one-third of rays.

To my knowledge this species has never been recorded from the Pacific. Boulenger (1895:191) lists it from the Red Sea, south coast of Arabia, and Zanzibar. I have compared my specimen with a 138 mm one from the Red Sea. The counts of the latter are D IX,14; A III,9; P 17; gill rakers 21. The Gilbert Islands specimen is more melanistic; there is a large black spot posteriorly on the opercle; the pale band posteriorly on the caudal is broader; the pale outer part of the pectoral is less obvious. The dentition is very similar in both. There is a pair of canines anteriorly in the upper jaw separated by about 3/4 of an eye diameter and a pair anteriorly in the lower jaw separated by about half an eye diameter; the bands of palatine and vomerine teeth are narrow. The snout is slightly shorter in the Gilbert Islands specimen, its length contained 4.7 in the head length; that of the Red Sea specimen is about 4.2 in the head length.

I identify my specimen as hemistiktos with some uncertainty. I believe that the differences noted might be due to the difference in size of the two specimens which were compared and to their great spatial separation. When specimens of Indo-Pacific species of fishes from the Red Sea are compared with ones from Oceania slight differences are often apparent.

Cephalopholis urodelus

Percam urodetam (Forster) Bloch and Schneider 1801. Systema ichth., p. 333. (Type locality, St. Christina, Waitaho).

Serranus urodelus Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 3, pl. 3, fig. A. (Kingsmill Islands).

Cephalopholis urodelus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 175. (Gilbert Islands).

8 specimens. 34 - 69 mm. Onotoa.

D IX,15 or 16; A III,9; P 17 or 18; gill rakers 23. (2 specimens).

Color in alcohol dark brown; a prominent black spot posteriorly on opercle; caudal fin blackish with a broad angular region of the upper and lower corners pale with dusky (bright red in life) center; dorsal and anal fins blackish, the soft portions of each with a narrow dusky margin and a broad pale submarginal band; centro-basal part of pectoral fin blackish, outer part pale; pelvic fins pale with dusky margins.

Schultz (1943) confused C. leopardus with urodelus. The specimens from the Phoenix and Samoa Islands which he identified as leopardus were actually urodelus and vice versa. He corrected this error in U. S. Nat. Mus. Bull. 202 (1953: 366).

Cephalopholis leopardus

Labrus leopardus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 450, 518, pl. 30, fig. 1. (Type locality, "le grande Océan equatorial").

Cephalopholis urodelus Schultz 1943. Bull. U. S. Nat. Mus. 180, p. 109.

33 specimens. 27 - 95 mm. Onotoa.

D IX,14; A III,9; P 17; gill rakers 23 or 24. (2 specimens).

Color from 35 mm Kodachrome transparency of 95 mm specimen: body light grayish pink with 5 indistinct pink vertical bars which contain light grayish pink spots; an elongate black spot (in some specimens 2 spots) mid-dorsally on caudal peduncle; head light purplish gray with numerous faint pinkish spots and a dusky band from eye to upper posterior edge of operculum; dorsal fin color of body except for broad light red margin; anal fin light red; caudal fin light red with a diagonal black band on upper hind corner; pectoral fin orange with a narrow faint reddish margin.

This species was abundant in coral areas of the lagoon and the outer reef.

The stomachs of 6 specimens 80 to 109 mm in standard length were opened. One contained a small fish, and the rest were empty.

Genus ANYPERODON

Anyperodon Günther 1859. Cat. fishes British Mus., vol. 1, p. 95. (Type species, *Serranus leucogrammicus* Cuvier and Valenciennes).

Anyperodon leucogrammicus

Serranus lencogrammicus Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 347. (Type locality, Moluccas and Seychelles).

2 specimens. 160 and 169 mm. Onotoa lagoon.

D XI,15; A III,9; P 16; gill rakers 29. (1 specimen).

Color in life olive green with rust-colored spots on head and body.

Body slender, depth about 3.7 in standard length; no palatine teeth; caudal rounded.

Genus PLECTROPOMUS

Plectropomus Oken 1782. Isis, p. 1782. (Type species, Bodianus maculatus Bloch).

Plectropomus truncatus

Plectropomus truncatus Fowler and Bean 1930. Bull. U. S. Nat. Mus. 100, vol. 10, p. 196, fig. 5. (Type locality, Atulayan Island, Luzon).

2 specimens. 290 and 368 mm. 1 specimen. 32 mm. Onotoa.

D VIII,11; A III,8; P 15 or 16. (2 specimens). gill rakers 11 (all but 3 are rudiments). (1 specimen).

Color from 35 mm Kodachrome transparency of 368 mm specimen dark brown with head, body, and fins covered with numerous small dark-edged metallic blue-green spots.

Caudal fin truncate; depth of body about 3.2 in standard length; a pair of close-set canine teeth anteriorly on each side of upper jaw, each pair separated by about an eye diameter in distance; lower jaw with similar anterior dentition, the pairs being slightly closer together, and two additional well-spaced canines posteriorly. The ends of these long canines fit into sockets on the opposite jaw.

The small specimen was taken with rotenone from the surface of a lagoon coral head in three feet of water. It was brown with dark blue spots. One of the adults was collected from the lagoon side of the west reef in about 5 feet of water and the other from the leeward outer reef in the northern part of the atoll at about the same depth.

Genus VARIOLA

Variola Swainson 1839. Nat. hist. class. fishes, amphibians, ..., vol. 2, p. 202. (Type species, Variola longipinna Swainson).

Variola louti

Perca louti Forskål 1775. Descr. animalium, pp. xi, 40. (Type locality, Red Sea).

2 specimens. 182 and 225 mm. Tarawa.

D IX,14; A III,8; P 19; gill rakers 24 (counting all rudiments) (1 specimen).

Color from 35 mm Kodachrome transparency of a specimen collected at Kwajalein, Marshall Islands: greenish brown, shading to purplish on chin and abdomen, with numerous dark-edged red spots on head, body, and fins (those on body horizontally elongate); pectoral fin yellow, blackish basally; margin of caudal fin orangish.

A pair of elongate canine teeth anteriorly in upper and lower jaws, those on lower jaw more medially located than those on upper jaw; two elongate canines in middle of side of dentary; canine teeth fitting into sockets in the opposite jaw; caudal fin very lunate.

Genus GRAMMISTES

Grammistes Bloch and Schneider 1801. Systema ichth., p. 182. (Type species, Grammistes orientalis Bloch and Schneider = Perca sex-lineata Thünberg.)

Grammistes sexlineatus

Perca sexlineata Thünberg 1792. Kongl. Vet. Akad. Nya Handl., vol. 13, p. 142, pl. 5. (Type locality, East Indies).

Grammistes orientalis Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 10. (Kingsmill Islands).

Genus YPSIGRAMMA

Ypsigramma Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, p. 372. (Type species, Ypsigramma lineata Schultz = Chorististium susumi Jordan and Seale).

Ypsigramma brocki

Ypsigramma brocki Schultz in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, pp. 373, 379, fig. 60. (Type locality, Rongelap Atoll, Marshall Islands).

1 specimen. 58 mm. Onotoa.

D VI-I,12; A III,8; P 14; gill rakers 6-1-13.

Color in life light gray with irregular olive-brown longitudinal lines on the body, three of which carry forward to hind edge of eye; fins pink; snout reddish; iris yellow.

This specimen was designated by Schultz (1953) as a paratype of brocki.

I examined the holotype of Y. susumi (Jordan and Seale 1906:256, fig. 48). The chief basis for Schultz' consideration of Y. lineata as distinct from susumi is the possession by the latter of 10 predorsal scales instead of 12. I counted 12 on susumi. In view of this and the great similarity in color pattern, I place lineata in the synonymy of susumi.

Y. brocki is obviously very closely related to susumi from which it differs slightly in color pattern. The holotype of brocki is 40 mm long. It has only traces of lengthwise lines on the body. The Onotoa paratype, 58 mm in length, is intermediate in color between the holotype of brocki and the holotype of susumi, which measures 66 mm. Probably brocki should also be a synonym of susumi. More specimens are needed to elucidate this problem.

Genus ANTHIAS

Anthias Bloch 1792. Natur. ausländ. Fische, vol. 6, pt. 9, p. 97. (Type species, Labrus anthias Linnaeus).

Anthias squamipinnis

Serranus (Anthias) squamipinnis Peters 1855. Monatsb. Akad. Wiss. Berlin, p. 429. (Type locality, Mozambique).

? Anthias nobilis Franz 1910. Abh. Bayer. Akad. Wiss., vol. 4, p. 38, pl. 4, fig. 44.

1 specimen. 64 mm. Onotoa lagoon.

D X,17; A III,7; P 18; gill rakers 9-1-24.

Color in life brown with an orange band from eye to pectoral fin (faint in preservative); snout and tip of lower jaw orange; rows of longitudinal orange spots on side of body (no longer visible in preservative); a bright red spot on upper distal part of pectoral fin between third and seventh rays (this spot blackish in preservative); caudal fin bright yellow, the upper and lower lobes orange; dorsal fin brown basally, orange distally; anal fin yellowish.

There are 45 to 50 lateral line scales. The specimen was speared and badly damaged in the middle of the body on both sides, hence an accurate count of lateral line scales can not be made; 5 scales between anterior end of lateral line and origin of dorsal fin; two opercular spines; entire head scaled; maxillary scaled; caudal fin deeply forked, the lobes drawn out in filaments; distance from tip of upper lobe to most anterior part of posterior margin of caudal fin contained 4.7 times in standard length; depth of body 3.1 in standard length; eye 3.7 in head length; head 3.6 in standard length; a canine tooth extending antero-laterally from each corner of tip of lower jaw; a second canine tooth, slightly larger, a short distance behind the first and recurved posteriorly; dorsal fin continuous; third dorsal spine not produced to a filament.

According to Fowler and Bean (1939:305) the third dorsal spine of this species is not always elongate.

I examined a specimen from the Philippines identified as squamipinnis by Fowler and Bean. It differed from the one from Onotoa in having the third dorsal spine produced, a less evident blackish spot on the pectoral fin, 40 lateral line scales, and a gill raker count of 10-1-22.

Fowler and Bean considered Anthias nobilis Franz from Japan as a variety of squamipinnis. At least in coloration, the Onotoa specimen more nearly resembles this form.

Genus MIROLABRICHTHYS

Mirolabrichthys Herre 1927. Philippine Jour. Sci., vol. 32, p. 413. (Type species, Mirolabrichthys tuka Herre and Montalban).

Mirolabrichthys tuka

Mirolabrichthys tuka Herre and Montalban 1927. Philippine Jour. Sci., vol. 32, p. 413, pl. 1. (Type locality, Maricaban Island, Philippine Islands).

1 specimen. 85 mm. Onotoa.

D X,16; A III,7; P 18; gill rakers 34.

Color in life rosy lavender shading to light lavender ventrally; an orange line from snout to base of pectoral fin; faint longitudinal lines of orange dots on body; fins bright magenta.

A small fleshy prominence extending ventrally from tip of upper jaw; maxillary broad, maximum depth more than one-half eye diameter; a canine tooth projecting antero-laterally from each side of end of lower jaw; a second canine tooth, its tip curved backward, on each side of mandible posterior to first canine; margin of hind half of orbit papillate; caudal fin deeply forked, the lobes produced to filaments; depth of body about 3 in standard length; eye 4.5 in head length; dorsal fin continuous.

Herre and Montalban described the life color of tuka from the Philippines as brownish red above, the sides roseate, with two longitudinal golden red bands, and golden fins with a violet patch on the soft dorsal. I examined specimens in the United States National Museum from the Philippines and East Indies identified as tuka and found no important differences in the color in preservative or morphology between these and the Onotoa specimen. The counts from a specimen from Borneo are: D X,15; A III,7; P 17; gill rakers 33. I believe that the apparent differences in life color and possible differences in counts are only subspecific, indicative of slight differentiation of the populations in the Philippine-East Indies area and the Gilbert Islands.

At Onotoa this beautiful species was sighted in small schools hovering above the bottom on the outer coralliferous terrace in about 30 feet of water. The gill rakers are very long, suggesting that it might be a plankton feeder. The same is true of Anthias squamipinnis.

One additional specimen was taken at Onotoa from the stomach of an adult Caranx melampygus. It was about half digested and was discarded.

The genus Mirolabrichthys may eventually be placed in the synonymy of Anthias when the Anthiinae is carefully revised, as indeed it should be.

Family PSEUDOCHROMIDAE

I am following Schultz (1953: 388) in placing Pseudochromis, Pseudogramma, Pseudoplesiops, and Plesiops in the one family Pseudochromidae. Although this may be ultimately shown to be an unnatural grouping of these little fishes, it appears to be a suitable classification at the present time.

Genus PSEUDOCHROMIS

Pseudochromis Rüppell 1835. Neue Wirbelth....Fische. p. 8. (Type species, Pseudochromis olivaceus Rüppell).

Pseudochromis tapeinosoma

Pseudochromis tapeinosoma Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol. 4, p. 115. (Type locality, Ambon, East Indies).

4 specimens. 36 - 39 mm. Onotoa.

3 specimens. 38 - 43 mm. Tarawa.

D III,22; A III,13; V I,5; P 18; dorsal lateral line scales plus scale rows to base of caudal fin 36 and 37. (2 specimens).

Color in alcohol brown; fin rays of dorsal and anal fins dark brown, membranes dusky; basal half of caudal fin (scaled) dark brown, outer half and dorsal and ventral margins dusky; paired fins dusky. In life the posterior part of the body was yellowish.

Genus PSEUDOGRAMMA

Pseudogramma Bleeker 1875. Verh. Akad. Amsterdam, vol. 15, p. 24. (Type species, Pseudochromis polyacanthus Bleeker).

Pseudogramma polyacantha

Pseudochromis polyacanthus Bleeker 1856. Nat. Tijdschr. Ned.-Ind., vol. 10, p. 375. (Type locality, Ternate).

7 specimens. 30 - 48 mm. Onotoa.

1 specimen. 34 mm. Tarawa.

D VII,20; A III,16 or 17; V I,5; P 17; scale rows from upper end of gill opening to base of caudal fin 51 and 52. (2 specimens).

Color in alcohol brown with round light brown spots larger than pupil of eye in approximately five rows on body (those ventrally tend to merge); a round dark brown spot larger than pupil of eye on opercle at level of eye; two irregular narrow dark streaks running posteriorly from lower part of eye; median fins dark brown with narrow pale margins; paired fins pale, the pectorals dusky at base.

The Onotoa specimens were collected from the west reef of the atoll at poison station IV. The Tarawa specimen was taken from a surge channel.

Pseudogramma bilinearis

Aporops bilinearis Schultz 1943. Bull. U. S. Nat. Mus. 180, pp. 111, 112, fig. 9. (Type locality, Hull Island, Phoenix Islands).

5 specimens. 26 - 55 mm. Onotoa.

5 specimens. 34 - 60 mm. Tarawa surge channel.

D VII,24; A III,20; V I,5; P 16; scale rows from upper end of gill opening to base of caudal fin 63 and 65. (2 specimens).

Color in alcohol brown with round dark brown spots about the size of the pupil and vertically elongate dark brown spots on body; median fins brown, a little darker on basal scaled portions; paired fins paler than median fins.

Schultz (1943) erected the genus Aporops for this one species of pseudochromid primarily on the basis of an increased number of soft fin rays in the dorsal and anal fins and the lack of a pair of large pores in the interorbital space, such as is seen in Pseudogramma polyacantha. In my opinion these differences do not warrant generic distinction.

Genus PSEUDOPLESIOPS

Pseudoplesiops Bleeker 1858. Nat. Tijdschr. Ned.-Ind., vol. 15, p. 215. (Type species, Pseudoplesiops typus Bleeker).

Pseudoplesiops rosae

Pseudoplesiops rosae Schultz 1943. Bull. U. S. Nat. Mus. 180, pp. 111, 117, fig. 11. (Type locality, Rose Island, Samoa Islands).

1 specimen. 20 mm. Onotoa.

D 22; A 13; V I,3: P 17; scales from upper end of gill opening to base of caudal fin 30.

Color in alcohol light brown.

The single specimen was collected from the west reef of the atoll in poison station number IV.

Genus PLESIOPS

Plesiops Oken 1817. Isis, app. p. 1182a. (Type species, Pharopteryx nigricans Rüppell).

Plesiops nigricans

Pharopteryx nigricans Rüppell 1828. Atlas Reise im nördlichen Afrika, p. 15, pl. 4, fig. 2. (Type locality, Red Sea).

1 specimen. 88 mm. Onotoa.

2 specimens. 85 and 96 mm. Tarawa.

D XII,7; A III,8; P 20; scales from gill opening to base of caudal fin 27 (1 specimen).

Color in life blackish with small light bluish green spots (one per scale) on body and extending out on fins; a prominent dark-edged blue spot on opercle; a blue line at base of dorsal fin; distal end of pectoral fin and membrane between first branchiostegal ray and opercle bright orange-yellow.

The Onotoa specimen was caught by hand by D. W. Strasburg from beneath a rock in a shallow tide pool just shoreward of the "Lithothamnion ridge" at low tide.

According to Rüppell's description and figure, P. nigricans lacks the dark spot on the opercle which is so characteristic of the species in Oceania.

Family APOGONIDAE

This family includes small fishes with relatively large mouths and eyes and two separate dorsal fins. The males of at least some genera incubate the eggs in the mouth. Apogonids are rarely seen underwater as they are nocturnal and are found under rocks or in holes in the coral during the day. There were no Gilbertese names for the species or even for this group of fishes in general.

Lachner in Schultz and collaborators (1953) recorded 22 species of cardinal fishes from the northern Marshall Islands. Sixteen are here listed from the Gilbert Islands, five of which were not reported by Lachner. Undoubtedly more species of this family occur in both areas than have thus far been collected.

Key to the Species of Apogonidae Recorded from the Gilbert Islands

1a. A near-vertical dark brown band from origin of spinous dorsal fin to abdomen between pelvic and anal fins; prominent dark brown spots on head and body; body depth great, about 2 in standard length...Apogon orbicularis

1b. No near-vertical dark brown band on body; no prominent dark brown spots on head and body; body depth not great, about 2.5 to 6 in standard length.............2

2a. Enlarged canine teeth lacking in jaws; body somewhat elevated, its depth contained less than 4 times in standard length; palatine teeth present or absent....3

2b. Enlarged canine teeth, 3 to 6 times longer than remaining villiform teeth, present in jaws; body relatively elongate, its depth contained 4 or more times in standard length; palatine teeth present............13

3a. First dorsal fin composed of 6 spines (the first spine is small and easily overlooked), the second spine the longest; body pale (transparent red in life) with no definite markings; palatine teeth present...........4

3b. First dorsal fin composed of 7 spines, the third spine the longest; body with definite dark markings; palatine teeth present or absent.............................5

4a. Second dorsal spine very long, 3.6 or less in standard length; profile from snout to origin of first dorsal fin almost straight; posterior margin of preopercle very feebly serrated; 12 pectoral rays...Apogon doryssa

4b. Second dorsal spine of moderate length, 4.2 or more in standard length; profile from snout to origin of first dorsal fin definitely curved; posterior margin of preopercle with obvious serrations; 14 pectoral rays. ....<u>Apogon erythrinus</u>

5a. Opercle with a round or elliptical black blotch about two-thirds diameter of eye in width; lateral line incomplete, ending under base of second dorsal fin (though a few pores may be visible posteriorly); no palatine teeth; caudal fin rounded; posterior and anterior margins of preopercle not serrated; posterior end of maxillary extends beyond a vertical through the posterior edge of eye (in young specimens the maxillary may reach only to posterior edge of eye).... 6

5b. Opercle without a round or elliptical black blotch; lateral line complete; palatine teeth present; caudal fin emarginate or forked; posterior margin of preopercle serrated, anterior margin may or may not be serrated; posterior end of maxillary terminates in front of a vertical through posterior edge of eye....7

6a. Somewhat irregular, lengthwise lines of small black spots on body................................<u>Apogon isostigma</u>

6b. No small black spots on body.............<u>Apogon auritus</u>

7a. Body with one or a few longitudinal dark stripes; no dark diagonal streak on cheek running from posteroventral edge of eye to posterior margin of preopercle; anterior margin of preopercle smooth or serrated.....8

7b. Body without longitudinal dark stripes; a dark diagonal streak running from eye to posterior margin of preopercle; anterior margin of preopercle smooth....12

8a. Body with 5 longitudinal dark stripes, the uppermost adjacent to dorsal fins; anterior margin of preopercle smooth; suborbital smooth; a dark spot at base of caudal fin may or may not be present (if present, it is centered on the end of the lateral line)..........9

8b. Body with only 1 longitudinal dark stripe, this stripe passing from snout through eye to caudal peduncle (in a few specimens this stripe is faint, especially posterior to head); anterior margin of preopercle serrated; suborbital strongly serrated; a dark roundish spot on caudal peduncle near end of, and slightly above, lateral line...................................11

9a. Second and fourth body stripes curve to meet middle body stripe at base of caudal fin; upper and lower margins of caudal fin not narrowly dark brown; median body stripe ends at base of caudal fin in a roundish jet black spot (obscured by stripe in melanistic specimens)............................*Apogon nigrofasciatus*

9b. Second and fourth body stripes do not curve to meet middle body stripe at base of caudal fin (if second and fourth stripes join median stripe, they do so well out on caudal fin rays); upper and lower margins of caudal fin narrowly dark brown (faint in *novemfasciatus*); median body stripe may or may not end in a black spot (if a spot is present, it appears more as an elliptical enlargement of end of stripe than a distinct spot).... 10

10a. Second and fourth body stripes end at base of caudal fin (though traces of dark pigment may extend out on caudal fin rays from stripes); median body stripe enlarged slightly to an elliptical-shaped area at base of caudal fin (usually a little darker than stripe)... ....*Apogon robustus*

10b. Second and fourth body stripes extend on caudal fin, converging to join or nearly join median stripe near end of fin; median body stripe not enlarged at base of caudal fin........................*Apogon novemfasciatus*

11a. Body somewhat elongate, its depth contained 3.2 to 3.4 times in standard length; caudal peduncular spot large, 2 to 3.8 in least depth of caudal peduncle; lengthwise body stripe abruptly narrow posterior to head and indistinct on large specimens; pigment on paler regions of body uniform; no dark brown saddle on back beneath second dorsal fin...................*Apogon exostigma*

11b. Body somewhat elevated, its depth contained 2.7 to 2.9 times in standard length; caudal peduncular spot small, 3.4 to 6 in least depth of caudal peduncle; lengthwise body stripe of equal width throughout most of its length; pigment on paler regions of body concentrated on peripheral portions of scales; a dark brown saddle usually on back beneath second dorsal fin............ ....*Apogon snyderi*

12a. Caudal peduncle with a dark saddle dorsally (this saddle reaching midventral line in specimens smaller than approximately 45 mm); a prominent diagonal dark mark on cheek, noticeably broader at edge of eye than at posterior margin of preopercle; a dark band in upper and lower lobes of caudal fin.......*Apogon savayensis*

12b. Caudal peduncle without dark markings or with only a small dark spot located slightly above midlateral line; dark mark on cheek very faint, narrow, and of almost uniform width; no dark band in upper and lower lobes of caudal fin..........................*Apogon nubilus*

13a. Posterior margin of preopercle with a single, stout spine and a membranous ventral flap which projects posteriorly; body pale (transparent, with silvery abdomen in life) without any definite dark markings; each pelvic fin united in its entire length with a membrane to mid-ventral line of body; caudal fin forked........................Gymnapogon philippinus

13b. Preopercle lacking a single stout spine and membranous flap; body with a definite pigment pattern; pelvic fins not united with a membrane to body; caudal fin rounded or forked...14

14a. Lateral line incomplete, ending beneath second dorsal fin; anterior preopercular margin not visible externally; opercular margin with a notch at level of maxillary; caudal fin rounded; scales small, about 55 in lengthwise series; body with about 15 longitudinal lines and with small dark spots superimposed on line pattern and on head; a large round black blotch at base of caudal fin, its center above midline of body; an elongate black flap at posterior edge of anterior nostril.........Pseudamia polystigma

14b. Lateral line complete; anterior preopercular margin evident externally; no notch in opercular margin; caudal fin forked; scales large, 25 in lengthwise series; body with 5 longitudinal dark lines, 3 of these extending past ends of second dorsal and anal fins; a black spot contained in a pale area in midline at base of caudal fin; anterior nostril tubular. 15

15a. Tip of lower jaw without enlarged canine teeth.......... ....Cheilodipterus quinquelineatus

15b. Tip of lower jaw on each side of symphsis with 1 or 2 enlarged canine teeth.........Cheilodipterus isostigma

Genus APOGON

Apogon Lacépède 1802. Hist. nat. poiss., vol. 3, p. 411. (Type species, Apogon ruber Lacépède).

Apogon orbicularis

Apogon orbicularis (Kuhl and Van Hasselt) Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 155. (Fowler, 1928, gives the type locality as Java).

Amia orbicularis Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 154. (Kingsmill Islands).

Apogon doryssa

Amia doryssa Jordan and Seale 1906. Bull. U. S. Bur. Fish., vol. 25, p. 245, fig. 39. (Type locality, Apia, Samoa).

2 specimens. 23 and 36 mm. Onotoa.

D VI-I,9; A II,8; P 12. (2 specimens).

Color in life was probably transparent red, as this species was not distinguished in the field from *Apogon erythrinus* which is this color. The color in alcohol is pale with traces of black pigment anteriorly at base of each dorsal fin and at base of caudal fin.

Apogon doryssa differs from *A. erythrinus* principally in having a stouter and longer second dorsal spine, a straighter profile from the snout to the origin of the dorsal fin, and 12 instead of 14 pectoral rays.

The holotype was examined and compared with the two specimens from the Gilbert Islands.

Apogon doryssa appears to be a rather rare species, in contrast to the usually abundant *Apogon erythrinus*. There may be habitat differences between the two species. The specimens of *erythrinus* were taken from the lagoon or shallow channel between the sea reef and the lagoon. *A. doryssa* was obtained from the sea side of the atoll, though in a well-protected area of numerous small coral heads.

Apogon erythrinus

Apogon erythrinus Snyder 1904. Bull. U. S. Fish. Comm., vol. 22, p. 526, pl. 9, fig. 17. (Type locality, Puako Bay, Hawaii).

9 specimens. 23 - 30 mm. Onotoa.

D VI-I,9; A II,8; P 14; vertical scale rows 22 to 24. (4 specimens).

Color in life transparent red. Color in alcohol pale, usually with a small elongate patch of tiny black specks posteriorly and midlaterally on caudal peduncle. Occasional specimens with tiny specks of dark pigment scattered on the body; often the outer edges of scales appear slightly darker than the central portions. All of the above-mentioned pigmentation is inconspicuous, however, and the general color effect is of a uniformly pale fish.

The type was examined. This and other Hawaiian specimens had more tiny dark spots on the body than the specimens from the Gilbert Islands, and they appear to be of larger average size.

Apogon isostigma

Apogonichthys isostigma Jordan and Seale 1906. Bull. U. S. Bur. Fish., vol. 25, p. 251, fig. 45. (Type locality, Apia, Samoa).

7 specimens. 30 - 58 mm. Onotoa lagoon and sea reef.

D VII-I,9; A II,8; P 14; vertical scale rows 21 to 23. (3 specimens).

Color in alcohol brown with a prominent roundish black spot on opercle and numerous small dark spots in approximate linear series on body; a horizontal dark line above opercular spot; two dark lines extending posteriorly and slightly downward from lower portion of eye (the lower line is narrow and the upper line, which extends to margin of preopercle at level of opercular spot, is broader and more diffuse); area on cheek between these two lines and around the opercular spot paler than rest of head; fins dusky, especially the caudal, which has a pale edge posteriorly (this pale edge narrower in median portion of fin). A 17 mm specimen from the Marshall Islands can be identified as isostigma; however, the lines of spots on the body are not apparent, though scattered small spots occur.

The type was examined.

In contrast to Schultz's statement (1943: 93) that palatine teeth are usually present in this species, none were found in any of the specimens from the Gilbert Islands. Jordan and Seale (1906) utilized the lack of palatine teeth, along with the opercular spot and interrupted lateral line as a basis for including isostigma in Apogonichthys Bleeker.

Apogon auritus

Apogon auritus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 443. (Type locality, Mauritius).

6 specimens. 26 - 38 mm. 2 specimens. 62 and 72 mm. Onotoa.

D VII-I,9; A II,8 or 9 (usually 8); P 14; vertical scale rows 24 or 25. (3 specimens).

Gill rakers of the two large specimens 14 (counting rudiments).

Color in alcohol brown with a prominent round or elliptical black spot on opercle, relatively larger in smaller specimens (in large specimens the anterior portion of the spot is slightly covered by the preopercle); a short horizontal dark line visible above opercular spot (this is rather indistinct in large specimens); two or three dark lines extending posteriorly from eye as in A. isostigma (in the large specimens only the lowermost of these lines is distinct). Small specimens exhibit vertical dusky bars on the body. The 38 mm specimen has traces of these bars and is considered intermediate between the adult and juvenile color pattern. This specimen is a sexually mature female. Color in life orange-brown.

The species was collected from both the lagoon and the outer reef.

Apogon nigrofasciatus

Apogon nigrofasciatus Lachner in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 466, fig. 81. (Type locality, Bikini Atoll, Marshall Islands).

17 specimens. 28 - 64 mm. Onotoa lagoon and outer reef.

D VII-I,9; A II,8; P 14; vertical scale rows 24 or 25.

Color in alcohol pale with 5 longitudinal dusky to black stripes on the body, all converging on the head (the first stripe is located mid-dorsally; the third stripe passes from snout through eye to base of caudal fin; stripes above and below this stripe extend on to caudal peduncle, and all three merge at base of caudal fin). The stripes do not extend on to the caudal fin rays. In specimens in which the stripes are not very dark, a black spot is visible mid-laterally at the base of the caudal fin. An oblique dark streak may be seen basally in the second dorsal and anal fins.

In life the body was reddish and the fins pale red. The stripes on the body varied from golden through dusky yellow to black. This variability in coloration occurred in specimens taken in the same poison station.

Apogon nigrofasciatus appears to be very closely related to Apogon aroubiensis Hombron and Jacquinot. Lachner (1953) separated the two on the basis of slightly different gill raker counts, larger size of nigrofasciatus at maturity, and broader, browner stripes in aroubiensis; however, these two species have not yet been collected from the same island group, aroubiensis being characteristically East Indian and nigrofasciatus from Oceania (Marshall Islands, Mariana Islands, Samoa, and Austral Islands). It is possible that these two forms are merely subspecies of one wide-ranging species. They are however, about as easily separated as other species in the difficult "fasciatus" complex, such as nomemfasciatus, robustus, and angustatus.

Apogon robustus

Amia robusta Smith and Radcliffe 1912. Proc. U. S. Nat. Mus., vol. 41, p. 255, fig. 2. (Type locality, Jolo Reefs, Philippine Islands).

Amia novemfasciata Jordan and Seale (in part) 1906. Bull. U. S. Bur. Fish., vol. 25, p. 242, fig. 37.

1 specimen. 58 mm. Tarawa surge channel.

D VII-I,9; A II,8; P 14; vertical scale rows 24.

This species is colored much like nigrofasciatus. It differs chiefly in the lack of a round black spot at the base of the caudal fin, in the failure of the second, third, and fourth body stripes to merge at the base of the caudal fin, and in the extension of these stripes faintly on to the caudal fin rays. There is a trace of black pigment on the uppermost and lowermost principal rays of the caudal fin. Figure 37 of Jordan and Seale (1906) portrays a Samoan specimen of this species, considered by these authors as a color variety of Apogon novemfasciata. The specimen from the Gilbert Islands appears very much like this figure, but the posterior end of the middle body stripe is not as broad or as dark and there is no slight convergence of the stripes above and below the middle stripe toward the end of the middle one. Such marking seems to be characteristic of specimens from Guam and the Marshall Islands as well as Samoa. The specimen from the Gilbert Islands differs further from Jordan and Seale's figure in lacking the broadening of the stripe on the cheek anterior to the base of the pectoral fin, and thus it possesses a relatively large silvery area on the operculum above the pectoral base. The isthmus, abdomen, and side of the body to the end of the pectoral fin is somewhat silvery in the preserved specimen.

Apogon novemfasciatus

Apogon novemfasciatus Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 154. (Type locality, Timor and Guam).

Apogon fasciatus Günther (in part) 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 19, pl. 20, fig. B. (Kingsmill Islands).

Apogon exostigma

Amia exostigma Jordan and Starks in Jordan and Seale 1906, Bull. U. S. Bur. Fish., vol. 25, p. 238, fig. 31. (Type locality, Apia, Samoa).

Apogon fraenatus Lachner in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 451.

6 specimens. 36 - 61 mm. Onotoa.

D VII-I,9; A II,8. P 13. vertical scale rows 24. (3 specimens).

Color in alcohol light brown with a black stripe extending from snout through eye to middle of base of caudal fin (this stripe narrows abruptly posterior to head; in larger specimens the portion of the stripe on the body is faint); a small black spot posteriorly on caudal peduncle, generally just above lateral line; a faint dark line basally in second dorsal and anal fins; upper and lower margins of caudal fin narrowly dark; body and head finely speckled with dark spots, especially ventrally (these spots are relatively larger and darker in smaller specimens).

This species may be confused with Apogon snyderi Jordan and Evermann or Apogon fraenatus Valenciennes, both of which are characterized by a single median longitudinal stripe and a caudal peduncular spot. Lachner (1953) recorded fraenatus from the Marshall Islands and separated it from exostigma on the basis of the caudal peduncle spot being above the lateral line in the latter species and both above and below in fraenatus. Upon examining the specimens identified as fraenatus from Bikini, I conclude that they are actually exostigma in which some of the spot pigment appears below the lateral line tube. I believe that fraenatus may be a Philippine and East Indian form that does not occur in the rest of Oceania. Specimens of fraenatus from the Philippines display a more prominent and uniform body stripe and a slightly larger and rounder caudal peduncular spot which is centered on the lateral line. Apogon exostigma may be separated from snyderi, as indicated in the key, in its being a more slender and less melanistic fish.

Specimens of exostigma were obtained from both lagoon and outer reef areas.

Apogon snyderi

Apogon snyderi Jordan and Evermann 1903. Bull. U. S. Fish Comm., vol. 22, p. 180. (Type locality, Honolulu).

42 specimens. 41 - 83 mm. Onotoa.

D VII-I,9; A II,8; P 14; vertical scale rows 24 or 25. (4 specimens).

The gill raker counts of 12 specimens were 17 to 19 (mostly 18).

Color in alcohol light brown with a dark brown stripe (in average width about seven-eighths the height of a body scale) running from snout through eye to base of caudal fin (the intensity of this stripe varies considerably from specimen to specimen; in some it is barely visible); a dark brown spot of variable size posteriorly on caudal peduncle (this spot is usually located entirely above the lateral line, but in occasional specimens a small amount of pigment may extend below it); body scales narrowly rimmed in dark brown (in paler specimens this coloration of the scales is most evident on the nape); a narrow dark line basally in the second dorsal and anal fins running parallel with contour of body; anterior portion of first dorsal fin black; upper and lower margins of caudal fin dark brown; first two rays of pelvic fins with some black pigment; most specimens with a marked concentration of dark brown color below the second dorsal fin. In addition to this dark, saddle-like area many specimens are dark along the dorsal aspect of the body, especially posteriorly on the caudal peduncle where the pigment tends to obscure the outline of the spot in this region. In some specimens there is a concentration of dark brown pigment anteriorly on the lateral line. In life the body has a light lavender or pinkish cast, and the pectoral and caudal fins are faintly pink.

The Gilbert Islands specimens were compared with the type from Hawaii, with Samoan specimens, and with specimens from the Marshall Islands. They tend to be more melanistic than the others, especially those from the Marshall Islands, and the anterior preopercular serrations are not so well developed.

Apogon snyderi was abundant at Onotoa, where it was obtained from the lagoon, channel, and outer reef.

This species seems to reach much larger size in Hawaii than the rest of Oceania. In Hawaii it may attain a standard length of about 180 mm, a very large size for an apogonid. Of 369 specimens from the Marshall Islands, the largest was 97 mm.

As far as is known, this species is not recorded from the Philippines, East Indies, or more western waters. Its distribution suggests that it might be a Hawaiian endemic form that has drifted southward and become established in the major island groups of the South and Central Pacific. The closely related Hawaiian species, Apogon menesemus Jenkins, may be exhibiting the same pattern of distribution in an incipient stage; Apogon menesemops Lachner is recorded only from the northern Marshall Islands. Lachner's specimens are probably only subspecifically different from Apogon menesemus.

The stomach contents from 10 specimens of snyderi, which were collected during daylight hours, were examined. One had eaten a small fish which was half digested. Another contained unidentified organic matter with a few small pieces of hard substance which are probably crustacean fragments. The remaining stomachs were empty.

Apogon savayensis

Apogon savayensis Günther 1871. Proc. Zool. Soc., p. 656. (Type locality, Savaii, Samoa).

15 specimens. 34 - 94 mm. Onotoa lagoon and outer reef.

D VII-I,9; A II,8 or 9 (usually 9); P 13; vertical scale rows 23 or 24. (4 specimens).

Color of body in alcohol dark brown dorsally, shading into light brown below lateral line; head and nape dark brown; a dark brown saddle on caudal peduncle (in small specimens this mark extends as a band to midventral line); a prominent diagonal dark line on cheek extending posteriorly and downward from lower rear quadrant of eye. Fins dusky; a dark submarginal band in the upper and lower lobes of the caudal fin. Vertical dusky bars may be seen on the sides of some specimens.

Apogon nubilus

Apogon nubilus Garman 1903. Bull. Mus. Comp. Zoöl., p. 229, pl. 1, fig. 1. (Type locality, Suva, Fiji Islands).

7 specimens. 38 - 84 mm. Onotoa.

D VII-I,9; A II,8; P 13; vertical scale rows 24 or 25. (3 specimens).

Color in alcohol light brownish with body and head very finely and uniformly speckled with tiny black dots. A few specimens show vertical concentrations of these tiny dots to form faint bars on the body. A very faint and narrow diagonal mark is visible on the cheek as in savayensis. Only one specimen has a spot on the caudal peduncle above the lateral line. In all specimens the fins are dusky, especially the first dorsal fin.

Color in life: back brownish, sides silvery with a lavender cast.

All 7 specimens were taken from one Heliopora coral head in shallow water of a sandy channel connecting lagoon and the open ocean. Such a distinctive habitat, if shown to be consistent, may separate this species ecologically from the closely related A. savayensis. Lachner (1951) discussed the

the morphological distinctness of these two species and *A. bandanensis* Bleeker.

Gymnapogon philippinus

Henicichthys philippinus Herre 1939. Copeia, no. 4, p. 200. (Type locality, Dumaguete, Oriental Negros, Philippine Islands).

5 specimens. 11.5 - 24 mm. Onotoa.

D VI-I,9 or 10 (mostly 9); A II,8; P 15. (4 specimens).

Color in alcohol uniform pale yellowish with melanophores forming numerous individual tiny spots over brain and usually with a few in mid-dorsal line posterior to second dorsal fin. In one 13 mm specimen the pelvin fins were dusky. There is in all specimens a criss-crossing of short straight lines of papillae on the head which become whitish when the specimens dry and the papillae are penetrated by air. Color in life transparent with silver on operculum and over abdomen; an orange-red line on body from region of pectoral fin to middle of base of caudal fin; an orange-red line at base of dorsal and anal fins.

These 5 specimens were compared with a 28 mm paratype of *Henicichthys philippinus* Herre. The following differences were discernible: small black spots on tip of jaws in the latter, different pattern of papillae, and a lavender-silver sheen on the preopercle. Color in life, as described by Herre, was translucent rose with a bluish pearly lustre. Regards body form, fin ray counts, and especially dentition (the characteristics which Lachner *in* Schultz and collaborators (1953) has set down in tabular form for the known species of *Gymnapogon*) the Gilbert Island and Philippime specimens were identical. It is therefore believed that the differences mentioned above may be only subspecific.

The specimens were obtained from the first 175 feet of a transect of the outer reef flat at Onotoa at low tide. They were in small, shallow tide pools which contained sparse algal growth and in which the temperature during the day sometimes reached or exceeded 40° C.

Gymnapogon has been classified in various families, and its affinities with the Apogonidae often questioned. Lachner (1953) has discussed the genus in detail and prefers to include it within the Apogonidae, though as a distinct subfamily. I do not believe that this is advisable in view of the characters of the monotypic genus *Pseudamia* which serve to connect *Gymnapogon* with more typical genera of the family. *Gymnapogon* is naked whereas other apogonid genera have large, well-formed scales; *Pseudamia* has small thin scales which tend to fuse on the body. Gymnapogon possesses a single spine at the angle of the preopercle; small Pseudamia have several small spines at this location; the pattern of the lines of pores on the head of Pseudamia is very similar to the lines of papillae on Gymnapogon. Total gill raker counts (including rudiments) of Gymnapogon 11 to 12; of Pseudamia, 14.*

Genus PSEUDAMIA

Pseudamia Bleeker 1865. Ned. Tijdschr. Dierk., vol. 2, p. 284. (Type species, Cheilodipterus polystigma Bleeker).

Pseudamia polystigma

Cheilodipterus polystigma Bleeker 1859-1860. Nat. Tijdschr. Ned.-Ind., vol. 20, p. 454. (Type locality, Singapore).

Pseudamia polystigma Weber and de Beaufort 1929. Fishes Indo-Austral. Arch., vol. 5, p. 370, fig. 90.

2 specimens. 47 and 70 mm. Onotoa.

1 specimen. 25 mm. Abemama.

D VI-I,9; A II,9. P 15; vertical scale rows about 50. (2 specimens).

Color of 70 mm specimen in alcohol light brown with numerous small dark spots on head and body; narrow, somewhat irregular, longitudinal dark lines on body: a large round dark blotch posteriorly on caudal peduncle, displaced slightly above mid-lateral point of body; a black spot in middle of upper 5 or 6 caudal fin rays; a black elongate flap posteriorly on the anterior nostrils; median fins dusky, especially the caudal, with outer margins pale; paired fins pale or faintly dusky. Color in life bluish silver with brown lines and spots; dorsal fins and anal fin purplish brown, edged in white; caudal peduncular spot and caudal fin dark blue to purple.

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*After the above was written, a paper by J.L.B. Smith entitled "Apogonid fishes of the subfamily Pseudamiinae from south-east Africa" appeared in the Annals and Magazine of Natural History, ser. 12, vol. 7, pp. 775-795, October, 1954. Smith arrived at the same conclusion regarding the close affinity of Pseudamia and Gymnapogon; however I question his consideration of these two genera and the new genus Pseudamiops as a subfamily within the Apogonidae. I believe this subfamily should be re-evaluated in terms of the characteristics of the genus Cheilodipterus Lacépède.

The 25 mm specimen, which was collected by Catala at Abemama Atoll, has no dark spot on the caudal peduncle, but only the one on the upper part of the caudal fin; there are no dark lines on the body; the dorsal and anal fins are hyaline. The 47 mm specimen, however, is intermediate in color to the 25 and 70 mm specimens.

The small specimen has several indistinct spines at the angle of the preopercle, and criss-crossed on the head are prominent short rows of pores (these pores are present on the larger specimens but are not distinct).

Pseudamia polystigma serves as a link between the bizarre *Gymnapogon* and more typical apogonids. See further discussion under *Gymnapogon*.

The 47 mm specimen was taken from a shallow water area of the lagoon where there was considerable turtle grass (*Thalassia*) and occasional coral rocks. The large specimen was taken from a poorly defined surge channel region on the lee side of the atoll where the bottom was mostly coral-covered.

Genus CHEILODIPTERUS

Cheilodipterus Lacépède 1802. Hist. nat. poiss., vol. 3, p. 539. (Type species, *Cheilodipterus lineatus* Lacépède, as restricted by Cuvier and Valenciennes).

Paramia Bleeker 1863. Ned. Tijdschr. Dierk., vol. 1, p. 233.

Cheilodipterops Schultz 1940. Proc. U. S. Nat. Mus., vol. 88, p. 413.

Cheilodipterus quinquelineatus

Cheilodipterus quinquelineatus Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 167. (Type locality, Bora Bora, Society Islands).

Paramia quinquelineata Bleeker 1865. Ned. Tijdschr. Dierk., vol. 2, p. 147.

Cheilodipterus quinquelineatus Weber and de Beaufort 1929. Fishes Indo-Austral. Arch., vol. 5, p. 361.

Jadamga quinquelineata Schultz 1940. Proc. U. S. Nat. Mus., vol. 88, p. 416. (Corrected to *Paramia quinquelineata* by Schultz, 1940, Copeia, no. 3, p. 203.).

Paramia quinquelineata Lachner 1951. Proc. U. S. Nat. Mus., vol. 101, p. 606.

1 specimen. 35 mm. Onotoa channel.

Color in alcohol very light brown with five longitudinal dark brown lines on the head and body, the pale interspaces between the stripes being two to three times as broad as the stripes themselves; a round black spot centered on lateral line at base of caudal fin, this spot surrounded by an unpigmented area (yellow in life). The first body stripe lies in mid-dorsal line, beginning in the interorbital space and bifurcating to surround base of the two dorsal fins; the second stripe runs from snout through top of eye, ending at edge of pale area on caudal peduncle; the third stripe runs down middle of body from snout to caudal peduncle; the fourth extends from the chin through lower edge of eye to caudal peduncle; the fifth stripe is double on chin, triple in pelvic region, double around anal fin, and a single mid-ventral line on caudal peduncle.

I am in agreement with Weber and de Beaufort (1929) in not separating this species into another genus, _Paramia_.

Cheilodipterus isostigma

Cheilodipterops isostigma Schultz 1940. Proc. U. S. Nat. Mus., vol. 88, p. 413. (Type locality, New Guinea).

1 specimen. 40 mm. Onotoa lagoon.

Color as in _Cheilodipterus quinquelineatus_, except the stripes on the chin and abdomen, which are less distinct.

C. isostigma is very difficult to distinguish from _C. quinquelineata_ without examination of the teeth at the tip of the lower jaw where the presence of one or two canines in _isostigma_ affords a consistent means of separation. Since both species possess canines, I do not believe that their presence or absence in one place in the jaws constitutes a generic difference as indicated by Schultz (1940).

Family KUHLIIDAE

Genus KUHLIA

Kuhlia Gill 1861. Proc. Acad. Nat. Sci. Phila., p. 48. (Type species, _Perca ciliata_ Cuvier).

Kuhlia marginata

Dules marginatus Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 116, pl. 52. (Type locality, Java).

1 specimen. 154 mm. Nukunau.

D X,11; A III,11; P 14; lateral line scales 56 (last 4 posterior to base of caudal fin); median predorsal scales 12.

The gill arches have been removed; therefore no gill raker counts are given. The specimen appears to have been dried before preservation. No distinctive color markings (such as black margin to caudal fin) are apparent.

Kuhlia taeniura

Dules taeniurus Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 114. (Type locality, Java).

Dules argenteus Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 25, pl. 19, fig. C. (Kingsmill Islands).

Kuhlia taeniura Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 171. (Abaiang, Gilbert Islands).

Moronopsis taeniurus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 292. (Ocean Island).

1 specimen. 62 mm. Tarawa.

D X,10; A III,11; P 14; lateral line scales 56 (last 5 posterior to base of caudal fin); median predorsal scales 11; gill rakers 10-1-23.

Color in alcohol: back blackish, remainder of body tan; caudal fin with 5 black bands, 1 median and 2 on each lobe; spinous dorsal with attenuated ends of membranes black; soft dorsal with broad black band in outer part of fin.

Family PRIACANTHIDAE

Genus PRIACANTHUS

Priacanthus Oken 1817. Isis, p. 1183. (Type species, Anthias macrophthalmus Bloch).

Priacanthus cruentatus

Labrus cruentatus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 452, 522. (Type locality, Martinique).

11 specimens. 85 - 220 mm. Onotoa.

D X,13; A III,14; P 17 or 18 (usually 18). (7 specimens). lateral line scales 63 and 69; gill rakers 23. (2 specimens).

Color in life red, blotched with silver; median fins reddish with small reddish brown spots; paired fins pale reddish.

The specimens were taken in coral areas of the lagoon and protected outer reef.

Family SCOMBRIDAE

Genus NEOTHUNNUS

Neothunnus Kishinouye 1923. Jour. College Agric. Tokyo Univ., vol. 8, p. 445. (Type species, _Thynnus macropterus_ Temminck and Schlegel).

Neothunnus macropterus

Thynnus macropterus Temminck and Schlegel 1844. Fauna Japonica, Poissons, p. 98, pl. 51. (Type locality, Nagasaki).

1 specimen. 720 mm (only dorsal and anal fins saved). Onotoa.

Genus EUTHYNNUS

Euthynnus Lütken _in_ Jordan and Gilbert 1882. Bull. U. S. Nat. Mus. 16, p. 429. (Type species, _Thynnus thunnina_ Cuvier and Valenciennes).

Euthynnus yaito

Euthynnus yaito Kishinouye 1915. Suisan Gakkwai Ho (Proc. Sci. Fish. Assoc.), vol. 1, p. 22, pl. 1, fig. 15. (Type locality, Japan).

2 specimens. 265 and 340 mm. Onotoa.

1 specimen. 120 mm. Tarawa.

Genus ACANTHOCYBIUM

Acanthocybium Gill 1862. Proc. Acad. Nat. Sci. Phila., vol. 14, p. 125. (Type species, _Cybium sara_ Bennett).

Acanthocybium solandri

Cybium solandri Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 8, p. 192. (Type locality, open seas).

1 specimen (only head saved). Length of head about 250 mm. Onotoa.

Family HISTIOPHORIDAE

Genus HISTIOPHORUS

Istiophorus Lacépède 1803. Hist. nat. poiss., vol. 3, p. 274. (spelling corrected to *Histiophorus* by Cuvier and Valenciennes 1831: 291) (Type species, *Istiophorus gladifer* Lacépède).

Histiophorus gladius

Scomber gladius Broussonet 1786. Mém. Acad. Sci., p. 454.

1 specimen. 1500 mm (not retained for collection). Onotoa, offshore.

D XLVII-6; A XI-7.

Color from 35 mm Kodachrome transparency dark blue on back, shading to light blue on side and silvery white ventrally; fins dark blue.

Distance from tip of sword to eye 3.9 in fork length; longest dorsal spine about 3 in fork length; second dorsal fin follows first by a distance less than twice the least depth of the caudal peduncle; paired keels at base of caudal fin; length of pectoral fin slightly greater than body depth; pelvic fins with one spine and one ray prolonged to 420 mm.

I identify this species as *H. gladius* from the key, descriptions, and photograph of *H. orientalis* in the work of de Beaufort and Chapman (1951: 240-242).

Genus MAKAIRA

Makaira Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 688, 689. (Type species, *Makaira nigricans* Lacépède).

Makaira sp.

The sword from a large marlin was obtained from a Gilbertese fisherman who stated that he had caught the specimen at Onotoa. The specimen was not seen by me.

Family GEMPYLIDAE

Genus PROMETHICHTHYS

Promethichthys Gill 1893. Mem. Nat. Ac. Sci., vol. 6, pp. 115, 123. (Type species, *Prometheus atlanticus* Lowe).

Promethichthys prometheus

Gempylus prometheus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 8, p. 213. (Type locality, St. Helena).

Promethichthys prometheus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 293. (Ocean Island).

Genus RUVETTUS

Ruvettus Cocco 1833. Giorn. Sci. Sicilia, vol. 42, p. 2. (Type species, *Ruvettus pretiosus* Cocco).

Ruvettus tydemani

Ruvettus Tydemani Weber 1913. Siboga Exp. Fische, p. 401. (Type locality, Binongka Island).

Ruvettus tydemani Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 293. (Ocean Island and Nauru).

Fowler (1928: 135) maintains that *Ruvettus tydemani* Weber is not different from the Atlantic *Ruvettus pretiosus* Cocco.

Family CARANGIDAE

The jacks represent one of the dominant families of fishes in the Gilbert Islands, as elsewhere in tropical marine waters. Fast swimming and mainly piscivorous, fishes of this group fill the niche of "roving carnivore" on the reef more than those of any other group.

The most important family characteristic is the presence of two isolated anal spines anterior to the anal fin proper.

Genus ELAGATIS

Elagatis Bennett 1840. Narrative of a whaling voyage around the globe, vol. 2, p. 283. (Type species, Seriola bipinnulata Quoy and Gaimard).

Elagatis bipinnulatus

Seriola bipinnulata Quoy and Gaimard 1824. Voyage autour du monde..."Uranie"...Zool., p. 363, pl. 61, fig. 3. (Type locality, "Iles des Papous").

1 specimen (only the head saved). 580 mm. Onotoa.

D VI-I,24-2; A II-I,17-2.

The specimen was caught by Gilbertese fishermen by trolling off the edge of the west reef of the atoll. Dorsal and anal fin ray counts were made and the head was purchased.

Genus SCOMBEROIDES

Scomberoides Lacépède 1802. Hist. nat. poiss., vol. 3, p. 50. (Type species, Scomberoides commersonianus Lacépède).

Scomberoides sanctipetri

Chorinemus Sancti Petri Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 8, p. 379, pl. 236. (Type locality, coast of Malabar).

Chorinemus sanctipetri Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 292. (Nauru).

2 specimens. 340 and 390 mm. Onotoa.

2 specimens. 251 and 318 mm. Tarawa.

D VI or VII-I,20; A II-I,18 or 19; P 17 or 18; gill rakers 25 or 26 plus 2 tiny rudiments. (2 specimens).

Color from 35 mm Kodachrome transparency light silvery blue on back shading to silvery white on sides and ventrally; a row of faint dusky roundish blotches on side of body just above lateral line; 3 or 4 similar blotches mid-laterally on body below lateral line in a row just posterior to tip of pectoral; a large black spot on the dorsal fin between the first and sixth soft rays (this spot covers all but the basal part of this section of the fin); anal fin pale with a blackish spot anteriorly; caudal fin purplish; pectoral fin dusky; pelvic fins white.

Eye 4.6 in head; maxillary reaches slightly posterior to vertical from hind edge of eye; depth of body 4.4 in standard length; length of pectoral fin 1.5 in head length; first 6 or 7 dorsal spines and first 2 anal spines isolated; posterior rays of dorsal and anal occur as separate finlets; course of lateral line, especially anteriorly, irregular.

The two Onotoa specimens were taken with rotenone on the lagoon side of the west reef. When first brought from the water they had a yellowish cast ventrally. The largest Tarawa specimen was speared from a boat anchored in the lagoon after it was attracted by night lighting.

Kendall and Goldsborough (1911: 267) and Fowler (1928: 140) recorded Scomberoides tolooparah (Cuvier) from the Gilbert Islands. The former authors suggested that tolooparah might be the young of S. sanctipetri.

Genus DECAPTERUS

Decapterus Bleeker 1851. Nat. Tijdschr. Ned.-Ind., vol. 1, p. 352. (Type species, Caranx kurra Cuvier and Valenciennes).

Decapterus muroadsi

Caranx muroadsi Temminck and Schlegel 1844. Fauna Japonica, p. 108, pl. 58, fig. 1. (Type locality, Japan).

1 specimen. 220 mm. Tarawa.

D VIII-I,34-1; A II-I,28-1; P 23; gill rakers 49.

Color in alcohol brown with a black spot on margin of opercle above the posterior projection of the opercular membrane at level of upper edge of base of pectoral.

Depth of body 5.3 in standard length; body almost cylindrical, body width 1.2 in body depth; no teeth in jaws, on vomer, or palatines; adipose eyelid well developed, maximum width of the open slit over pupil contained more than 3 times in diameter of eye.

Many of the scales and scutes were missing; hence no scale or scute counts were made.

Genus TRACHUROPS

Trachurops Gill 1862. Proc. Acad. Nat. Sci. Phila., p. 238. (Type species, Scomber plumieri Bloch = Scomber crumenopththalmus Bloch).

Trachurops crumenophthalmus

Scomber crumenophthalmus Bloch 1793. Natur. ausländ. Fische, vol. 7, pt. 10, p. 77, pl. 343. (Type locality, Acara Bay, West Africa).

1 specimen. 128 mm. Tarawa.

1 specimen. 148 mm. Nukunau.

D VIII-I,27; A II-I,22; P 21; gill rakers 37. (1 specimen).

Color in alcohol: upper half of body brown, lower half light brown; tips of jaws slightly blackish.

Depth of body 3.7 in standard length; maximum width of body 1.8 in depth; small teeth in jaws, on vomer, palatines, and tongue; adipose eyelid well developed, maximum width of open slit over pupil contained about 3 times in diameter of eye.

The specimens are in poor condition and scale and scute counts could not be made.

Genus CARANX

Caranx Lacépède 1802. Hist. nat. poiss., vol. 3, p. 57. (Type species, Scomber carangus Bloch = Scomber hippos Linnaeus).

Caranx melampygus

Caranx melampygus Cuvier and Valenciennes 1833. Hist. nat. poiss., vol. 9, p. 116. (Type locality, Waigiu, Rawak, Baru, Vanicolo, and Mauritius).

Caranx ascensionis Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 145. (Abaiang, Gilbert Islands).

2 specimens. 345 and 400 mm. 8 specimens. 79 - 127 mm. Onotoa.

5 specimens. 76 - 245 mm. Tarawa.

D VIII-I,22 or 23; A II-I,18 or 19; P 20 or 21; scutes 36 to 41; gill rakers 26 to 27. (4 specimens).

Color from 35 mm Kodachrome transparency of a 600 mm specimen (not saved): upper half of body brownish blue with scattered small black spots; lower half of body white (no sharp demarcation, however, between the upper and lower halves in color); head dark grayish, brownish dorsally and whitish ventrally; median fins bluish; dorsal fin with a bright blue band at base; pectoral fin dusky.

Color in life of 102 mm specimen: back greenish blue, sides and belly silvery white; dorsal and caudal fins bluish; anal fin yellowish, tipped with bluish; upper half of pectoral yellow.

Caranx melampygus was the most abundant species of the genus at Onotoa. It appears to be a roving predator on other reef fishes. Adults were often seen singly or in groups of two to five, constantly on the move and generally in one direction, on the coralliferous terrace of the outer reef. Schools of juveniles were observed in shallow lagoon areas.

The stomach contents of four adult specimens from 250 to 450 mm in standard length were examined. Two of the specimens were taken with rotenone. They had eaten a great many small fish which were undoubtedly earlier results of the poison than the *Caranx* themselves. The two other specimens were speared. The stomach of one contained nothing; the stomach of the other contained two fish, one of which was not identifiable and the other was *Mirolabrichthys tuka*. There was also a mass of fish scales.

Caranx (*hippos?*)

?*Scomber hippos* Linnaeus 1766. Syst. nat., ed. 12, p. 494. (Type locality, Carolina).

Caranx sexfasciatus Quoy and Gaimard 1824. Voyage autour du monde..."Uranie"...Zool., p. 358, pl. 65, fig. 4. (Type locality, "Îles des Papous").

Caranx sexfasciatus Fowler 1928. Bull. B. P. Bishop Mus., vol. 10, p. 149. (Abaiang, Gilbert Islands).

Caranx forsteri Kendall and Goldsborough 1911. Mem. Mus. Comp. Zool., vol. 26, p. 268. (Butaritari, Gilbert Islands).

2 specimens. 59 and 61 mm. Onotoa lagoon.

2 specimens. 85 and 109 mm. Tarawa.

2 specimens. 149 and 176 mm. Butaritari. (*C. forsteri* of Kendall and Goldsborough).

D VIII-I,20 or 21; A II-I,16 or 17; P 20 or 21; scutes 30 to 33; gill rakers 22 to 25. (4 specimens).

Color in alcohol of 59 mm specimen light brown with 6 broad dusky bars extending from mid-dorsal line to about mid-lateral line of body. The 149 and 176 mm specimens no longer show such bars.

I compared the specimens from the Gilbert Islands with Caranx hippos of comparable size from Florida. The meristic data on the few specimens counted are identical. There are a few slight morphological and color differences; however I believe these are only subspecific in magnitude (providing hippos is confined to the Atlantic and sexfasciatus occurs only in the Indo-Pacific region as is apparently the case). The Florida hippos have a prominent blackish spot on the margin of the operculum at the level of the lower part of the eye; in some Gilberts specimens a dusky area may be seen at this same level on the operculum but anterior to the margin. In addition there is a small blackish spot at the upper end of the gill opening. There were minor differences in shape of scutes, pattern of squamation on the cheek, and in dentition. I believe that further study of this problem is advisable.

J. T. Nichols (1910: 159) reported on his examination of the type of Caranx forsteri Cuvier and Valenciennes. From his description it appears to be the same as C. sexfasciatus Quoy and Gaimard of which he made no mention. Nichols considered Caranx marginatus Gill, Caranx rhabdotus (Jenkins), and Caranx elecate (Jordan and Evermann) as synonyms of C. forsteri.

On several occasions at Onotoa I encountered one or two huge individuals of Caranx, probably this species, in surge channels. They appeared to be 4 to 5 feet in length.

Caranx lugubris

Caranx lugubris Poey 1861. Mem. Hist. Nat. Cuba, vol. 2, p. 222. (Type locality, Cuba).

Caranx lessonii Hiyama 1943. Poisonous fishes S. Seas, p. 36, pl. 4, figs. 11 and 12.

3 specimens. 237 - 450 mm. Onotoa.

D VIII-I,22; A II-I,17 to 19; P 22; scutes 28 to 30; gill rakers 26 to 27. (3 specimens).

Color from 35 mm Kodachrome transparency silvery gray; head blackish except cheek and opercle which are silvery gray in areas; fins blackish; scutes, except for central, elevated portions, black.

All three specimens were speared from the coralliferous terrace of the outer reef. This species appeared quite inquisitive and approached a swimmer closely.

The stomachs of two of the specimens were opened. One contained nothing and the other a half-digested fish.

Caranx ignobilis

Scomber ignobilis Forskål 1775. Descr. animalium, pp. xii, 55. (Type locality, Djedda, Red Sea).

Caranx ignobilis Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 292. (Nauru and Ocean Island).

Caranx ferdau

Scomber ferdau Forskål 1775. Descr. animalium, pp. xii, 55. (Type locality, Djedda, Red Sea).

1 specimen. 260 mm. Onotoa.

D ---- I,31; P 24; scutes 30; gill rakers 32.

Color in life light irridescent green above, silvery on sides and below; 7 or 8 small elliptical bright yellow spots scattered in a group on side of body (on the left side these are in the middle of the body and just below the lateral line; on the right side they are slightly posterior to the middle of the body and some above and the rest below the lateral line); elongated anterior part of dorsal and anal fins blue; remainder of these fins and caudal fin bluish gray; pectoral fin faintly yellowish; iris of eye yellowish. Faint vertical dark bars were visible on the fish before it was speared and for a short time thereafter.

The specimen was taken on the coralliferous terrace of the outer reef. It is lacking the spinous dorsal fin: there is evidence of injury to the usual site of this fin in the specimen. The spear damaged the anal fin such that counts of fin rays could not be made.

Caranx speciosus

Scomber speciosus Forskål 1775. Descr. animalium, p. 12. (Type locality, Arabia).

Two individuals of what is tentatively identified as this species were observed underwater off the Island of Aunteuma in the northern part of Onotoa. They were about 2 feet in length and had vertical dark bars on the body as figured for this species by Fowler (1928: pl. 11, fig. C). One was speared but was not captured.

Caranx ciliaris

Zeus ciliaris Bloch 1787. Nat. ausländ. Fische, pt. 3, p. 36, pl. 191. (Type locality, East Indies and Suratte).

Caranx ciliaris Günther 1876. Jour. Mus. Godeffroy, vol. 4, pt. 11, p. 135, pl. 89. (Kingsmill Islands).

Family LUTJANIDAE

Along with the groupers, the snappers are the most important group of carnivorous fishes in the Gilbert Islands. The species are numerous and the individuals of several are abundant.

As will be noted, I have followed Schultz et al (1953) in classifying such genera as Lethrinus, Aphareus, Caesio, Aprion, Gnathodentex, and Monotaxis in the Lutjanidae.

Genus LUTJANUS

Lutjanus Bloch 1790. Natur. ausländ. Fische, vol. 4, pt. 7, p. 105. (Type species, Lutjanus lutjanus Bloch).

Lutjanus vaigiensis

Diacope vaigiensis Quoy and Gaimard 1824. Voyage autour du monde...L'Uranie...Zool., p. 307. (Type locality, Waigiou).

Lutjanus marginatus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 292. (Nauru).

6 specimens. 61 - 228 mm. Onotoa lagoon.

3 specimens. 141 - 169 mm. Tarawa surge channel.

D X,13 or 14; A III,8; P 16; scale rows from upper end of gill opening to base of caudal fin 47. (2 specimens).

Color in life of a 125 mm specimen: light yellowish gray dorsally shading to yellowish white ventrally; chin, gill membranes, and thorax pure white; spinous portion of dorsal fin light gray with dark red band distally except tips of spines which are white; a line of large orange spots on gray part of spinous portion of dorsal fin; soft part of dorsal fin dusky on basal third and black on upper two-thirds with a narrow dark red band down the middle and a very narrow white margin; caudal fin nearly black with a narrow white margin and a reddish black submarginal area; anal, pectoral, and pelvic fins yellow; upper half of maxillary orange; a small yellow area immediately dorsal and posterior to eye. A 62 mm specimen was colored similarly. It differed in having eight longitudinal yellow lines on the body and hyaline pectoral fins.

The stomachs of six surplus specimens from a Tarawa surge channel (155 to 180 mm in standard length) were opened. Two were empty and two contained small fresh specimens of Thalassoma umbrostygma which had probably been killed by rotenone; one fish had eaten a small holothurian, and the last had made a meal of a small brachyuran crab. The stomachs of two Onotoa specimens, 75 and 95 mm in length, were empty.

Lutjanus monostigmus

Mesoprion monostigma Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 446. (Type locality, Seychelles).

Lutianus monostigma Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl., vol. 26, p. 287. (Butaritari, Gilbert Islands).

2 specimens. 80 mm. 1 specimen. 29 mm. Onotoa.

3 specimens. 53 - 117 mm. Tarawa.

D X,13; A III,8; P 16; vertical scale rows from upper end of gill opening to base of caudal fin about 54. (2 specimens).

Color in life very similar to the plate of the species in Hiyama (Poisonous Fishes of the South Seas, 1943: pl. 6, fig. 16) (misidentified as Lutjanus fulviflamma). The lateral line of the Onotoa specimens bissects the black spot on the side. The spot is centered below the base of the second soft ray of the dorsal fin.

The 80 mm Onotoa specimens were taken by Gilbertese from the outer reef flat at night while torchfishing. The 29 mm juvenile was caught in a tide pool of the outer reef flat. A 290 mm adult was obtained near the end of our stay at Onotoa with rotenone from the lagoon side of the west reef, but could not be preserved due to lack of formaldehyde.

Lutjanus bohar

Sciaena bohar Forskål 1775. Descr. animalium, pp. xi, 46. (Type locality, Arabia).

1 specimen. 250 mm. Onotoa.

1 specimen. 285 mm. Tarawa.

D X,14; A III,8; P 17; vertical scale rows from upper end of gill opening to base of caudal fin about 51. (1 specimen).

Color from 35 mm Kodachrome transparency gray dorsally shading to dull red on sides and ventrally with a whitish spot basally on each scale; a prominent white spot, larger than pupil of eye on back adjacent to posterior part of soft dorsal fin; median fins red (except spinous dorsal which is dark reddish gray) with broad dark margins; upper half of pectoral fin dark orange-red, lower half hyaline orange-red; iris golden.

The Onotoa specimen taken was speared from beneath a coral ledge on the coralliferous terrace of the outer reef by a Gilbertese native in an estimated 25 feet of water. Solitary individuals were often seen in this area, some 2 feet or more in length. They were readily identified underwater by the saddle-like white spot on the posterior part of the body. Some individuals displayed a second white spot below the spinous dorsal fin.

The gut of the Onotoa specimen was empty.

Lutjanus gibbus

Sciaena gibba Forskål 1775. Descr. animalium, pp. xi, 46. (Type locality, Arabia).

1 specimen. 200 mm. 28 specimens. 35 - 60 mm. Onotoa lagoon.

1 specimen. 163 mm. Tarawa.

D X,14; A III,8; P 17; vertical scale rows from upper end of gill opening to base of caudal fin about 65. (2 specimens).

Profile of head of adults concave, the upper part ascending steeply to origin of dorsal fin; lobes of caudal fin rounded. Profile of head of young straight; ends of caudal lobes pointed.

Color from 35 mm Kodachrome transparency of 200 mm specimen: red, the centers of the scales on the body and operculum whitish; spinous portion of dorsal fin red; soft portion of dorsal fin, anal fin, and caudal fin reddish black with narrow white margins; pectoral fins red with a golden spot in region from upper part of base to gill opening at level of opercular spine; pelvic fins reddish; a small golden patch posterior to knob on interopercle; iris yellow except for a narrow red rim around pupil.

Color in life of juveniles 35 to 60 mm in length: blue-green on back, pale below; borders of scales black, resulting in an oblique lined effect on the body due to the ascending scale rows; a large black area on caudal peduncle and base of caudal fin; rest of caudal fin bright yellow; dorsal grayish with a pale margin and a dark sub-marginal band.

The adult specimen which was retained for the collection was poisoned with rotenone at station VI at Onotoa. The site of this station consisted of a large truncated coral head which reached to within 3 feet of the surface of the lagoon. The juvenile specimens were taken from the Thalassia flat region of station V.

The species was observed only in shallow lagoon waters around coral heads. In the northern Marshall Islands, however, Schultz (1953) reports taking it only from moderately deep water.

The stomach contents of three Onotoa specimens, 250 to 290 mm in standard length, were examined. These fishes were collected with the use of rotenone. They had eaten small fishes which were probably prior victims to the poison than the lutianids themselves.

Lutjanus kasmira

Sciaena kasmira Forskål 1775. Descr. animalium, pp. xi, 46. (Type locality, Arabia).

20 specimens. 30 - 120 mm. Onotoa.

2 specimens. 37 and 45 mm. Tarawa.

D X,15; A III,8; P 16; vertical scale rows from upper end of gill opening to base of caudal fin about 65. (2 specimens).

Color from a 35 mm Kodachrome transparency of a 90 mm specimen: yellow dorsally, shading to white ventrally, with four longitudinal light blue bands on head and upper two-thirds of body; fins yellow.

No large adults of the species were taken. Most of the Onotoa specimens were collected from around coral heads in shallow areas of the lagoon.

Lutjanus rivulatus

Diacope rivulata Cuvier and Valenciennes 1828. Hist. nat. poiss., vol. 2, p. 312, pl. 38. (Type locality, Coromandel, Java, Red Sea, and Malabar).

Lutjanus rivulatus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 202. (Abaiang, Gilbert Islands).

Genus APRION

Aprion Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 543. (Type species, *Aprion virescens* Cuvier and Valenciennes).

Aprion virescens

Aprion virescens Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 544. (Type locality, Seychelles).

1 specimen (head only). length of head 164 mm. Tarawa.

Genus APHAREUS

Aphareus Cuvier and Valenciennes. 1830. Hist. nat. poiss., vol. 6, p. 485. (Type species, *Aphareus caerulescens* Cuvier).

Aphareus furcatus

Labrus furcatus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 429, 477, pl. 21, fig. 1. (Type locality, le grand Océan).

4 specimens. 120 - 235 mm. Onotoa.

D X,11; A III,8; P 15; lateral line scales 76 and 77; gill rakers 26 (the last 5 of the 10 on the upper limb of the arch are tiny rudiments). (2 specimens).

Color in life of a 230 mm specimen: blue-green above, shading to pale blue below, with anterior third of the exposed part of each scale dark brownish gray, giving an overall bluish gray effect to the fish; a broad bright yellow band from tip of chin across mouth to interorbital space, narrowing beyond this point as it extends to origin of dorsal fin (posterior to interorbital space the yellow is suffused with brownish gray on the edges of the scales); dorsal and anal fins orange-yellow; caudal fin yellowish brown basally, shading to brownish red distally; pectoral fins light yellow on upper half, clear reddish brown below; pelvic fins yellow, red medially; iris of eye orange next to pupil, light blue in outer half. The other three specimens were colored similarly except they lacked the bright yellow band medially on the head. The fish with the yellow band is a ripe female.

As has been pointed out by Fowler (1928: 195), specimens of *A. furcatus* with the yellow frontal band (*A. flavivultus* Jenkins) do not seem to differ in any other way from those lacking this yellow coloration.

This species was always seen as solitary individuals actively swimming several feet off the bottom in coral-rich areas such as the coralliferous terrace of the outer reef. The stomachs of all four specimens were opened. Two were empty, one contained an unidentified fish, and the last had eaten what appears to be a specimen of *Priacanthus*.

Genus CAESIO

Caesio Lacépède 1802. Hist. nat. poiss., vol. 3, p. 85. (Type species, *Caesio coerulaureus* Lacépède).

Caesio coerulaureus

Caesio coerulaureus Lacépède 1802. Hist. nat. poiss., vol. 3, p. 85. (Type locality, Moluccas).

1 specimen. 240 mm. Onotoa.

D X,15; A III,11; P 22; lateral line scales 69; scales from lateral line to base of spinous dorsal fin 7½; gill rakers 41.

A single bony process on premaxillary besides the median process; teeth on premaxillary in one row (one or two tiny teeth were found medial to this row); no palatine or vomerine teeth visible; depth of body 3.7 in standard length.

Color from a 35 mm Kodachrome transparency dark blue dorsally, shading to light blue on side and white ventrally; a greenish yellow longitudinal band from upper edge of gill opening to upper base of caudal fin; median part of lobes of caudal fin broadly black; a triangular black mark on upper half of base of pectoral fin; dorsal fin gray; anal fin reddish; pectoral fin light yellowish; iris pale yellow.

The specimen was speared from a school of about 12 individuals swimming at a depth of about 30 feet on the coralliferous terrace of the outer reef.

Caesio xanthonotus

Caesio xanthonotus Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol. 4, p. 466. (Type locality, Batavia).

7 specimens. 125 - 185 mm. Onotoa.

D X,15; A III,12; P 21; lateral line scales 59 and 62 (these extend half way out on caudal fin); scales from lateral line to base of spinous portion of dorsal fin 6; gill rakers 34 and 35. (2 specimens).

A single elongate process extending dorsally from side of premaxillary (in addition to median process); two rows of teeth on premaxillary, the outer row short and conical, the inner row minute and villiform; no teeth on palatines; vomer essentially toothless (under high power of a binocular microscope several tiny teeth were found after probing in the palate lining); depth of body 3.6 to 3.7 in standard length; pectoral fin longer than head, 2.9 to 3.1 in standard length.

Color in life: posterior half of body above lateral line, caudal peduncle, and caudal fin bright yellow; lower third of head and body white; rest of head and body between the yellow dorsal and ventral white regions bright blue (blackish in preservative); black on tip of chin, axil of pectoral fin, and base of pectoral fin (broader at upper part of base of fin than lower); dorsal fin gray on basal scaled portion, yellowish distally except for a narrow black margin; anal fin reddish basally, shading to yellow and finally whitish distally; paired fins hyaline; inner part of iris red. After death the brilliance of the sharply defined yellow region on the back changes to dull yellowish green and reddish areas appear on the white ventral region.

This species was commonly seen in aggregations of about 50 or more individuals in mid-water on the coralliferous terrace of the outer reef; sometimes the school was dispersed nearly from the surface to the bottom in about 30 or more feet of water and tended to remain in approximately the same location. The individuals of the school were surprisingly unafraid of an approaching swimmer and could be speared with ease. All seven specimens were taken in this manner.

The stomach contents of two of the specimens was examined. As the elongate gill rakers and the swimming position well off the bottom suggest, these individuals proved to be plankton feeders. The bulk of the food material consisted of pelagic copepods. Other typical planktonic constituents such as mollusk larvae, larval stages of shrimp, and fish eggs were found.

Genus PTEROCAESIO

Pterocaesio Bleeker 1875. Versl. Akad. Amsterdam, ser. 2, vol. 9, p. 153. (Type species, Caesio multiradiatus Steindachner = Caesio tile Cuvier and Valenciennes).

Pterocaesio tile

Caesio tile Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 428. (Type locality, Caroline Archipelago).

1 specimen. 140 mm. 23 specimens. 70 - 90 mm. Onotoa.

D XI or XII, 20 or 21; A III, 13 or 14; P 22 or 23; lateral line scales 79 or 80 (last lateral line scale is nearly half way out on caudal fin); scales from lateral line to base of spinous portion of dorsal fin 6½; gill rakers 35 and 36. (3 specimens).

Two elongate processes on the side of the premaxillary in addition to the median process; teeth on premaxillary in a single row; no teeth on palatines or vomer; depth of body 3.9 in standard length of 140 mm specimen, about 4.6 in the small specimens; length of pectoral fin about 4.5 in standard length.

Color in life of 140 mm specimen: dark blue dorsally (dark by virtue of each scale being rimmed in black) down to a narrow longitudinal black band which extends from the upper part of eye out into upper lobe of caudal fin; below this black band to middle of fish irridescent light blue; lower half of body and head white (this became reddish shortly after the fish was speared); a black longitudinal band in lower lobe of caudal fin medial to lowermost two principal caudal rays (like band in upper lobe except that it does not extend on to body); fins faintly reddish; a triangular black spot at upper base of pectoral fin.

Specimens of about 140 mm in length were observed in loose aggregations in mid-water on the coralliferous terrace of the outer reef. All of the small specimens were obtained over coral heads in the lagoon. During our stay at Onotoa, the young of *C. tile* appeared in the lagoon in great numbers, a phenomenon which I was told occurs once in about every ten years. The Gilbertese hold these small fish in high esteem and employ a special fishing method to catch them (see Randall *in* Banner and Randall, 1952: 52-53).

Genus PENTAPUS

Pentapus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 258. (Type species, *Pentapus iris* Cuvier and Valenciennes).

Pentapus caninus

Scolopsides caninus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 5, p. 266. (Type locality, New Guinea).

Heterognathodon caninus Günther 1874. Jour. Mus. Godeffroy, vol. 2-3, pt. 5-6, p. 32. (Abemama, Gilbert Islands).

Genus SCOLOPSIS

Scolopsis Cuvier 1814. Bull. Soc. Philom. Paris, p. 90. (Type species, *Scolopsides kurite* Cuvier = *Anthias vosmeri* Bloch).

Scolopsis cancellatus

Scolopsides cancellatus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 5, p. 351. (Type locality, Hawaii, Waigiou, Rawak, New Guinea, Vanicolo, and Ulea).

Scolopsis cancellatus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 208. (Paanopa = Ocean Island).

Genus GNATHODENTEX

Gnathodentex Bleeker 1873. Versl. Akad. Amsterdam, ser. 2, vol. 7, p. 41. (Type species, *Pentapus aurilineatus* Bleeker).

Gnathodentex aureolineatus

Sparus aureolineatus Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 42, 132.

Pentapus aurolineatus Günther 1874. Jour. Mus. Godeffroy, vols. 2-3, pts. 5-6, p. 33, pl. 25 B. (Kingsmill Islands).

18 specimens. 53 - 185 mm. Onotoa.

D X,10; A III,9; P 15; lateral line scales 71 and 77. (2 specimens).

A strongly serrate longitudinal ridge on maxillary.

Color in life of a 185 mm specimen: silvery brown with a prominent yellow blotch at base of soft dorsal fin and longitudinal yellow lines of about a scale's width on side of body; fins reddish.

Adults were most commonly observed swimming in groups of about eight or ten close to the bottom on the inshore part of the coralliferous terrace of the outer reef. The young were taken from shallow lagoon and channel areas.

Genus MONOTAXIS

Monotaxis Bennett 1830. Memoir...Sir Stamford Raffles, p. 688. (Type species, Monotaxis indica Bennett = Sciaena grandoculis Forskål).

Monotaxis grandoculis

Sciaena grandoculis Forskål 1775. Descr. animalium, pp. xii, 53. (Type locality, Djedda, Red Sea).

24 specimens. 34 - 169 mm. Onotoa.

D X,10; A III,9; P 14; lateral line scales 47. (3 specimens).

Jaws with canine teeth anteriorly, large truncate molariform teeth posteriorly. Specimens up to 39 mm in standard length show no indication of molariform teeth. The last tooth in the lower jaw of a 40 mm juvenile is slightly enlarged. In a 49 mm specimen this last lower tooth is further enlarged and apically rounded, and teeth in front of this tooth are enlarging. The small specimens display a distinct ridge on the maxillary with about 10 to 12 pointed denticulations along the top as seen in Gnathodentex. In the large specimens of Monotaxis this ridge is flattened and inconspicuous and the denticulations rounded and variously fused.

The color in life is variable, some specimens being more melanistic than others and some displaying broad vertical black bars dorsally on the body which are completely absent in others. The color of a 158 mm specimen from my field notes is as follows: greenish purple dorsally, shading to silvery on the sides and ventrally; a large black area above pectoral fin; interorbital yellowish; snout, lips, and chin blackish; dorsal, anal, and pectoral fins light red; caudal fin light red except proximal half of upper and lower lobes which are yellowish orange; pelvic fins hyaline; axil of pectoral fin black.

A striking color change in the young is apparent from my series of juvenile specimens. Specimens from 32 to 37 mm are pale (light greenish dorsally in life) with two lengthwise dark lines, the first running from slightly above center of eye to upper base of caudal fin, and the second from lower base of pectoral fin to lower base of caudal fin; there is a region of black pigment distally in the dorsal fin between the second and sixth dorsal spines. A 40 mm specimen is light brown with four broad black bars on upper half of body, the second and third of which extend up into dorsal fin; a short vertical blackish line extends ventrally from the middle of the lower edge of the eye. A 39 mm specimen exhibits intermediate coloration.

The juvenile specimens with the two lengthwise dark lines were all collected from around small coral heads in sandy, shallow lagoon and channel areas. Adults were taken from coralline areas of both the lagoon and outer reef. Adults were common on the coralliferous terrace of the outer reef. Individuals several times larger than the largest specimen taken were observed. Most species of reef fishes either seek refuge in holes in the coral or flee a considerable distance when alarmed by an approaching swimmer. Monotaxis, however, usually moves away from an intruder very slowly in the direction of deeper water.

The gut contents of two specimens, 158 and 160 mm in standard length, were examined. These consisted mainly of the crushed shells of small mollusks along with the remains of small sea urchins. Considerable bottom debris was present, as would be expected.

Genus LETHRINUS

Lethrinus Cuvier 1829. Règne animal, ed. 2, vol. 2, p. 184. (Type species, Sparus choerorhynchus Bloch and Schneider).

Lethrinus variegatus

Lethrinus variegatus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 287. (Type locality, Massuah and Suez).

1 specimen. 345 mm. Onotoa.

1 specimen. 245 mm. Tarawa.

D X,9; A III,8; P 13; lateral line scales 48; scales from lateral line to middle of spinous portion of dorsal fin $4\frac{1}{2}$. (1 specimen).

Snout 1.7 in head length; depth of body 3.4 in standard length; eye 2.7 in head length.

Color from 35 mm Kodachrome transparency of a large adult: light gray, edges of scales rimmed in dark gray (especially dorsally), with a small orange-red spot at upper base of pectoral fin; axil of pectoral fin orange-red; dorsal and anal fins gray; caudal fin brownish gray; pectoral fin rays faintly orangish; iris pale yellow.

The stomachs of two large specimens collected with rotenone were filled with small fishes which had undoubtedly been prior victims of the poison.

The Onotoa specimen retained for the collection was collected at station VII on the lagoon side of the west reef of the atoll.

Lethrinus nebulosus

Sciaena nebulosus Forskål 1775. Descr. animalium, pp. xii, 52. (Type locality, Arabia).

1 specimen. 225 mm. 2 specimens. 95 mm. Onotoa.

D X,9; A III,8; P 13; lateral line scales 48; scales from lateral line to base of middle part of spinous dorsal fin 5 (5½ in small specimens). (3 specimens).

Length of snout 1.8 in head length; depth of body 2.7 in standard length; head 2.9 in standard length; least depth of caudal peduncle 1.5 in snout; eye 2.3 in head length; third anal spine as long as eye (proportional measurements based on 225 mm specimen).

Color in life: light greenish on back; scales narrowly rimmed with dark brown; faint longitudinal stripes of bluish and of orange; a moderately prominent orange longitudinal band at level of pectoral fin; head light greenish yellow with brownish mottlings; dorsal, anal, and caudal rays with dark annulations.

The 225 mm specimen was taken in poison station VII; the two small specimens were seined from the pond-like body of water nearly enclosed in the northern part of the most northern of the two principal islands of the atoll.

Lethrinus rhodopterus

Lethrinus rhodopterus Bleeker 1852. Nat. Tijdschr. Ned.-Ind., vol. 3, p. 65. (Type locality, Singapore).

13 specimens. 50 - 158 mm. Onotoa lagoon.

1 specimen. 112 mm. Tarawa.

D X,9; A III,8; P 13; lateral line scales 47 or 48; scales from lateral line to middle of base of spinous dorsal fin 5. (2 specimens).

Length of snout 2 in head length; depth of body 2.6 in standard length; length of head 3.2 in standard length.

Color in life of a 158 mm specimen which was speared in about 7 feet of water over sand near a lagoon coral head: light gray, each scale center a whitish spot; a large blackish spot just below lateral line, nearly centered on tip of outstretched pectoral; fins reddish, especially the caudal on the posterior half of which there is a broad irregular reddish band which contains pale areas. Immediately upon being speared, the entire posterior half of the fish became dark.

The stomach of the above specimen contained a small, unidentified fish. The stomach contents of 10 specimens from poison station V which measured 75 to 134 mm in standard length were examined. One fish was empty, and the others contained small fishes which were probably eaten following their being killed or nearly so by the rotenone. In addition to fishes one individual had previously eaten an unidentified crustacean.

Lethrinus reticulatus

Lethrinus reticulatus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 298. (Type locality, New Guinea).

Lethrinus moensii Günther 1874. Jour. Mus. Godeffroy, vols. 2-3, pts. 5-6, p. 64, pl. 46, fig. A. (Kingsmill Islands).

Lethrinus ramak

Sciaena ramak Forskål 1775. Descr. animalium, p. 52. (Type locality, Red Sea).

Lethrinus ramak Kendall and Goldsborough 1911. Mem. Mus. Comp. Zool., vol. 26, p. 289. (Butaritari, Gilbert Islands).

This species may not be distinct from *Lethrinus nebulosus* Forskål.

Family LEIOGNATHIDAE

Genus GERRES

Gerres Quoy and Gaimard 1824. Voyage autour du monde... "Uranie", Zool., p. 292. (Type species, *Gerres vaigiensis* Quoy and Gaimard).

Gerres oblongus

Gerres oblongus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 6, p. 479. (Type locality, Ceylon).

1 specimen. 243 mm. Onotoa lagoon.

1 specimen. 187 mm. Tarawa.

D IX,10; A III,7; P 16; lateral line scales to base of caudal fin 45 or 46; scales from origin of dorsal fin to lateral line 7; gill rakers 5 or 6-1-7. (2 specimens).

Color in life silvery with 5 or 6 vertical lines of faint orange spots in middle of side of body.

Depth of body contained 2.6 to 2.7 in standard length; eye 3.6 in head length (with mouth not produced).

Gerres argyreus

Cichla argyrea Bloch and Schneider 1801. Systema ichth., p. 344. (Type locality, Tanna Island and Pacific Island).

Gerres kapas Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 225 (Abaiang, Kingsmill Islands).

2 specimens. 97 and 99 mm. Tarawa.

D IX,10; A III,7; P 16; lateral line scales to base of caudal fin 41; scales from origin of dorsal fin to lateral line 4 or 5; gill rakers 5-1-7.

Color in alcohol dusky dorsally shading to light tan on sides and ventrally; margin of spinous dorsal dusky.

Depth of body contained 2.7 to 2.8 times in standard length; eye 2.7 in head length (with mouth not produced).

Family MULLIDAE

The goatfishes are readily distinguished by their elongate bodies and pair of long barbels that originate on the chin. These fishes are bottom-dwellers and are usually found over sandy areas. The barbels are normally directed backward, but when searching for food they are extended anteriorly and downward into the sand and kept in rapid, almost vibratory, motion as the fish swim forward.

The goatfishes were most commonly seen in the lagoon at Onotoa. The Gilbertese give each species a different name, a fact which reflects the value of these fishes as food.

Identification of the Gilbert Island mullids was made with the assistance of Dr. Ernest A. Lachner.

Genus UPENEUS

Upeneus Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 448. (Type species, Mullus vittatus Forskål).

Upeneus arge

Upeneus arge Jordan and Evermann 1903. Bull. U. S. Fish Comm., vol. 22, p. 187. (Type locality, Honolulu).

Upeneus arge Lachner 1954. Proc. U. S. Nat. Mus., vol. 103, p. 518, pl. 14, fig. A.

2 specimens. 235 and 270 mm. Onotoa.

1 specimen. 225 mm. Tarawa.

D VIII-I,9; A I,6; P 14; lateral line scales 40 or 41. (2 specimens).

Color in life: body light greenish dorsally, silvery white on sides and ventrally, with 2 lengthwise orange-yellow lines from back of head to base of caudal fin (uppermost of these two lines begins at level of eye and is broader than the lower one which starts at axil of pectoral); 5 narrow lengthwise orange lines on back above the 2 principal lines which break up into spots in linear series anteriorly on body; head with numerous short irregular orange lines dorsally, a prominent horizontal orange line anterior to eye, and irregular orange-red blotches ventral to eye and on operculum; first dorsal fin with faint orange bands; second dorsal fin with 4 horizontal orange bands; upper lobe of caudal fin with 7 dusky orange to black horizontal bands; lower lobe of caudal fin with 5 such bands.

The two specimens were speared from a small school of about six rapidly-swimming individuals in the lagoon in about 5 feet of water over sand.

The stomach of the largest specimen was opened and found to be empty.

Genus PARUPENEUS

Parupeneus Bleeker 1863. Ned. Tijdschr. Dierk., vol. 1, p. 242. (Type species, Mullus trifasciatus Lacépède).

Parupeneus trifasciatus

Mullus trifasciatus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 383, 404, pl. 15, fig. 1.

Upeneus multifasciatus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 228. (Kingsmill Islands).

17 specimens. 53 - 120 mm. Onotoa.

D VIII-9; A 7; P 16; lateral line scales 29. (2 specimens).

Color from a 35 mm Kodachrome transparency white with a vertical black bar extending ventrally from anterior part of second dorsal fin, and another black bar on caudal peduncle; a narrow dusky vertical bar between first and second dorsal fins and a broad dusky vertical bar beneath first dorsal fin; a short blackish band extending posteriorly and slightly dorsally from just below middle of eye; snout, lips, and barbels pink; iris red; first dorsal fin pale pink; remaining fins faintly yellowish.

This is the most omnipresent goatfish at Onotoa.

The stomach contents of three small specimens (54 to 55 mm) were examined. The fish had eaten amphipods, copepods, other small unidentified crustacea, and unidentified eggs. Surprisingly, there was no inorganic sediment present.

Parupeneus barberinus

Mullus barberinus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 283, 406, pl. 13, fig. 3. (Type locality, near Moluccas).

10 specimens. 59 - 280 mm. Onotoa.

1 specimen. 168 mm. Tarawa.

D VIII-9; A 7; P 17; lateral line scales 30. (2 specimens).

Color from 35 mm Kodachrome transparency of a 280 mm specimen: a black band running from just above upper lip through eye along back to beneath rear base of second dorsal fin; body above this band bright yellow, below white with occasional small yellow spots; a large round black spot on posterior part of caudal peduncle centered slightly above midline; black band on head bordered with blue; a reddish violet patch on opercle; short irregular yellow lines on head below black band; lips and lower part of head orange; dorsal fins pale grayish lavender; caudal fin lavender; anal fin whitish; pectoral fins light dusky yellow; pelvic fins light orange; iris yellow except a narrow ring next to pupil which is orange.

This species was found in sandy areas of both the lagoon and outer reef.

Parupeneus chryserydros

Mullus chryserydros Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 384, 406.

5 specimens. 60 - 130 mm. Onotoa.

D VIII-9; A 7; P 17; lateral line scales 17. (2 specimens).

Color in life of all of the Onotoa specimens entirely bright yellow. E. A. Lachner (MS) is unable to separate this yellow form meristically or otherwise from the usual P. chryserydros and therefore considers it a color phase.

Because of its yellow color, this species was easily spotted underwater. It was seen in both lagoon and outer reef areas; however it was not common.

Parupeneus pleurostigma

Upeneus pleurostigma Bennett 1831. Proc. Zool. Soc. London, vol. 1, p. 59. (Type locality, Mauritius).

Upeneus pleurostigma Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 231. (Abemama, Gilbert Islands).

Genus MULLOIDICHTHYS

Mulloidichthys Whitley 1929. Rec. Australian Mus., vol. 17, p. 122. (Type species, Mullus flaveolineatus Lacépède).

Mulloidichthys samoensis

Mulloides samoensis Günther 1874. Jour. Mus. Godeffroy, vols. 2-3, pts. 5-6, p. 57, pl. 43, fig. B. (Type locality, Apia, Samoa).

8 specimens. 80 - 145 mm. Onotoa.

3 specimens. 90 - 193 mm. Tarawa.

2 specimens. 70 and 71 mm. Nukunau.

D VII-9; A 7; P 17; lateral line scales 37; gill rakers 27 and 28. (2 specimens).

Color in alcohol light brown, the edges of the scales slightly darker, with a blackish spot, about half the size of the eye, on side of body at level of the first dorsal fin just below the lateral line; peritoneum black; a dusky spot on inside of opercle.

All of the Onotoa specimens were obtained from relatively shallow sandy areas of the lagoon. The species is abundant.

Mulloidichthys (auriflamma?)

Mullus auriflamma Forskål 1775. Descr. animalium, pp. 10, 30. (Type locality, Red Sea).

1 specimen. 78 mm. Onotoa.

Color in life: a bright yellow band from eye to upper base of caudal fin, bordered above and below by narrower blue bands; upper blue band ends below posterior part of anal fin; region below lower blue band yellowish, shading to white ventrally; dorsal fins dusky yellow; anal, caudal, and pelvic fins bright yellow; pectoral fins light yellow; no black spot was visible on the side.

This small specimen has been given to Dr. Lachner who is still not certain of the identification. He counted 30 gill rakers.

The specimen was speared in a Thalassia flat area of the lagoon.

Family PEMPHERIDAE

Genus PEMPHERIS

Pempheris Cuvier 1829. Règne animal, ed. 2, vol, 2, p. 195. (Type species, Pempheris touea Cuvier = Sparus? compressus Shaw).

Pempheris oualensis

Pempheris oualensis Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 299. (Type locality, Oualan).

Pempheris mangula Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 102, pl. 59, fig. B. (Kingsmill Islands).

4 specimens. 115 - 153 mm. Onotoa.

1 specimen. 150 mm. Tarawa.

D VI,9; A III,40 to 43; P 17; lateral line scales 65 or 66; gill rakers 29. (3 specimens).

Color from 35 mm Kodachrome transparency brownish silver; a black spot at base of pectoral fin; dorsal fin yellowish brown with anterior edge broadly black; anal fin yellowish brown, black anteriorly and at base; caudal fin base and upper and lower lobes dark brown, rest of fin yellowish brown.

This species was taken in surge channels and outer reef terrace near the entrance to surge channels. It is very secretive, being seen only in recesses in the reef during the day. I suspect that it may be a nocturnal fish. The large eye supports this contention.

Family POMACENTRIDAE

The damsel fishes are usually small and often vividly colored. As a group they are characterized chiefly by having a single nostril on each side of the snout. They were well represented at Onotoa, both in number of species and abundance of individuals. Most species exhibit distinctive habitat preferences; they usually take cover in interstices in coral or holes in the reef (or, in the well-known case of Amphiprion, in sea anenomes) upon approaching danger. The Gilbertese general name for pomacentrids is te reibu.

Key to the Species of Pomacentridae Recorded from the Gilbert Islands

1a. Dorsal spines X or XI; scales small, about 50 scale rows from upper edge of gill opening to base of caudal fin; body with 2 or 3 vertical pale bars (light blue in life)..2

1b. Dorsal spines XII or XIII; scales not small, 30 or fewer scale rows from upper edge of gill opening to base of caudal fin; body without 2 or 3 vertical pale bars...3

2a. Body, at least in adults, with 2 vertical pale bars, one on head running from nape behind eye to subopercle and interopercle and the other, noticeably narrower (covering 2 to 4.5 lateral line scales), located in middle of body, and lacking an upper portion extending obliquely backward on unscaled part of the dorsal fin; next to last dorsal spine contained 1.2 to 1.4 times in longest dorsal spine; caudal fin uniformly pale..............................Amphiprion bicinctus

2b. Body (at least in Gilbert Islands specimens) with 3 vertical pale bars, one on the head as in 2a, the second, nearly as broad (covering 6.5 lateral line scales), located in middle of body and extending obliquely backward to outer edge of dorsal fin, and the third on caudal peduncle; next to last dorsal spine contained nearly 3 times in the length of the longest dorsal spine; caudal fin with a large, circular centro-posterior dusky area.......Amphiprion sebae

3a. Teeth in front part of jaws conical, usually well-separated...4

3b. Teeth in front part of jaws not conical, at least somewhat compressed, and usually close-set..............10

4a. Body deep, the greatest depth contained 1.5 to 1.7 times in standard length; suborbital evident externally and serrated; preopercle serrated..............5

4b. Body not deep, the greatest depth contained more than 2 times in standard length; suborbital not evident externally or poorly-defined and lacking serration; preopercle not serrated (except in C. lepidolepis)...6

5a. Body pale with 3 broad vertical black bars; caudal fin forked...............................Dascyllus aruanus

5b. Body dark, without vertical bars, and with a pale spot in middle just above lateral line (more evident in young); caudal fin truncate or slightly emarginate... ....Dascyllus trimaculatus

6a. Each body scale with 1 to 3 small, basal, auxiliary scales; edge of preopercle serrated; region from nostril to upper lip scaled........Chromis lepidolepis

6b. No basal auxiliary scales present; edge of preopercle smooth; narrow region from nostril to upper lip naked...7

7a. Body more or less uniform brown in color (blue-green in life) without sharply-contrasting markings; second dorsal spine the longest; dorsal and anal soft rays 9 or 10...........................Chromis caeruleus

7b. Body not uniform light brown and with distinctive dark and light contrasting markings; middle dorsal spines the longest; dorsal and anal soft rays 11 or 12......8

8a. Upper and lower lobes of caudal fin dark brown; scales on anterior 1/3 of interorbital space and dorsally on snout very small, about 1/8 the size of those in the mid-interorbital region; basal third of pectoral fin pale (yellow in life), outer portion of fin with rays dusky, membranes clear.........Chromis xanthochir

8b. Upper and lower lobes of caudal fin pale like rest of fin or very slightly dusky; scales on anterior 1/3 of interorbital space and dorsally on snout not markedly smaller than more posterior scales; basal third of pectoral fin not paler than remainder of fin.........9

9a. Posterior part of body abruptly pale (white in life and in sharp contrast to remainder of body which is dark brown) in a vertical demarcation at the level of base of 7th dorsal soft ray; a large round black spot at base of pectoral fin; preopercular aperture not margined with dark brown; gill opening without a dark brown edge; pectoral rays 16 or 17...*Chromis dimidiatus*

9b. Posterior part of body paler than rest of body (with sharp contrast only in large adults) at a level posterior to base of last dorsal and anal rays; a narrow curved black or dark brown line at the base of the pectoral fin; preopercular aperture margined with dark brown; gill opening (especially dorsally in small specimens) edged in dark brown; pectoral rays 18 or 19.....................*Chromis opercularis*

10a. Margin of preopercle smooth; suborbital smooth........11

10b. Margin of preopercle serrated; suborbital usually serrated...23

11a. 5 or 6 vertical dark bars on body; dorsal spines XIII; size often greater than 130 mm in standard length (except *Abudefduf curacao* which probably does not exceed 100 mm).......................................12

11b. 5 or 6 vertical dark bars not present on body; dorsal spines XII or XIII; size rarely exceeding 80 mm in standard length...15

12a. Dorsal soft rays 15 or 16; anal soft rays 14 or 15; a black saddle dorsally on caudal peduncle in adults...*Abudefduf sordidus*

12b. Dorsal soft rays 12 or 13; no black saddle dorsally on caudal peduncle in adults (upper part of caudal peduncle bar no darker than lower part).............13

13a. 6 vertical dark bars on body; forehead scaled to least interorbital space; caudal fin moderately forked, horizontal distance from ends of middle caudal fin rays to tips of upper rays contained more than 2 times in head length.........*Abudefduf septemfasciatus*

13b. 5 vertical dark bars on body; forehead scaled to nostrils; caudal fin deeply forked, horizontal distance from ends of middle caudal fin rays to tips of upper rays contained less than 2 times in head length.....14

14a. Preorbital naked; body depth contained 1.65 to 1.8 times in standard length; vertical scale rows 26 to 28...................................*Abudefduf saxatilis*

14b. Preorbital scaled; body depth contained 1.75 to 1.9 in standard length; vertical scale rows 24 or 25...*Abudefduf curacao*

15a. Dorsal fin rays XII, 15 to 18; anal soft rays 13 to 15...16

15b. Dorsal fin rays XIII, 12 or 13; anal soft rays 12 or 13...19

16a. Body and fins yellowish white with no distinctive pigmented markings (except anterior 2/3 of eye which is blackish)....................*Abudefduf imparipennis*

16b. Body brown or dark brown with distinctive pigmented markings...17

17a. 4 vertical pale (pink in life) bars on body (a 5th is present at base of caudal fin but is not readily visible due to caudal being pale); a broad black bar on caudal peduncle..............*Abudefduf phoenixensis*

17b. No vertical pale bars on body; caudal peduncle paler than rest of body and without a black bar...........18

18a. Body light brown with a broad vertical black bar on side at level of 2nd to 6th dorsal soft rays; no spots on body; dorsal soft rays 17 or 18...*Abudefduf dicki*

18b. Body very dark brown with no vertical black bar; small, pale (blue in life) spots widely scattered on body; dorsal soft rays 15 to 17 (usually 15 or 16)..*Abudefduf lacrymatus*

19a. A round black spot at upper edge of base of caudal fin; a bluish (bright blue in life) line passing from snout through upper edge of eye and widening to a band along back adjacent to spinous dorsal fin; a large black spot at base of last 2 dorsal spines...*Abudefduf leucopomus*

19b. No black spot at upper edge of base of caudal fin; no blue line from snout through eye to base of spinous dorsal (except young of *A. glaucus* and possibly also *biocellatus*); a black spot may or may not be present at base of last two dorsal spines.................20

20a. Body light brown or gray (bluish gray in life); margin of anus black and contrasting with light color of body...................................*Abudefduf glaucus*

20b. Body brown or dark brown; anus not black (if dark, not contrasting with rest of body).....................21

21a. A large white elliptical spot on operculum; basal 1/3 of caudal fin black and contrasting with caudal peduncle and outer part of caudal fin which are pale; a vertical pale bar usually present in middle of body; dorsal and anal soft rays 12....*Abudefduf amabilis*

21b. No white spot on operculum; basal 1/3 of caudal fin not black; a vertical pale bar may or may not be present on side of body; dorsal and anal soft rays 13 (rarely 12)..22

22a. A black spot at base of last 2 dorsal spines; a second, smaller, black spot at base of last 2 or 3 dorsal soft rays; a vertical pale bar usually not present on side of body..................<u>Abudefduf biocellatus</u>

22b. No black spot at base of last 2 dorsal spines; no black spot at base of last few dorsal soft rays; a vertical pale bar usually present on side of body...<u>Abudefduf zonatus</u>

23a. Dorsal spines XII; one row of teeth in each jaw.......24

23b. Dorsal spines XIII; two rows of teeth in each jaw, the inner closely applied to the outer (each inner tooth shorter and narrower with tip in interspace between 2 outer teeth)..28

24a. Preorbital large, its width measured from eye toward rictus about equal to eye diameter; no black spot at base of last few dorsal rays or dorsally on caudal peduncle; no dark brown or black spot at upper base of pectoral fin....................<u>Pomacentrus lividus</u>

24b. Preorbital not large, its width measured from eye toward rictus contained about 2 times in diameter of eye; a black spot at base of last few dorsal rays or dorsally on caudal peduncle; a dark brown or black spot at upper base of pectoral fin...........................25

25a. A black spot mid-dorsally on caudal peduncle, not touching dorsal fin rays; rest of body and fins pale (bright yellow in life) except for a small black spot at extreme upper edge of pectoral fin and black anus.......................<u>Pomacentrus aureus</u>

25b. No black spot mid-dorsally on caudal peduncle (a spot, if present, at base of last few dorsal rays and extending only narrowly on caudal peduncle); body and fins brown to dark brown (except pale phase of <u>nigricans</u>, in which case, anus not black)...........26

26a. Anal soft rays 12; dorsal soft rays 14 or 15; lobes of caudal fin pointed; snout scaled to level of nostrils.....................<u>Pomacentrus albofasciatus</u>

26b. Anal soft rays 12 to 14 (rarely 12); dorsal soft rays 15 to 17; lobes of caudal fin pointed or rounded; snout scaled slightly beyond level of nostrils......28

27a. Black spot at axil of soft dorsal fin preceded by a prominent pale area; anal soft rays 12 or 13 (rarely 13); pectoral rays 20 to 21 (usually 20); lobes of caudal fin pointed.............. Pomacentrus eclipticus

27b. Black spot at axil of soft dorsal fin not preceded by a pale area; anal soft rays 13 or 14; pectoral rays 18 to 20 (rarely 20); lobes of caudal fin rounded..... .... Pomacentrus nigricans

28a. Body slim, depth contained 2.5 to 2.8 in standard length; dorsal soft rays 13 or 14....................29

28b. Body not slim, depth contained 1.8 to 2.1 in standard length; dorsal soft rays 14 to 17 (rarely 14).......30

29a. Anal soft rays 13 (rarely 14); body light brown (blue in life), only slightly darker dorsally than ventrally; a prominent black spot on opercle, as large or larger than pupil; depth of body 2.5 to 2.6 in standard length................................ Pomacentrus pavo

29b. Anal soft rays 15; body very dark brown (bright blue in life) except caudal peduncle and ventrally near anal fin which is abruptly pale (bright yellow in life); a small black spot on opercle, smaller than pupil (difficult to see because of dark color of body); depth of body 2.6 to 2.8 in standard length........... .... Pomacentrus coelistis

30a. A large black ocellated spot at base of 7th to 11th dorsal soft rays; body light brown (blue in life) with small dark brown spots on scales forming dotted lines on head and body; a hook-like ventral projection anteriorly on suborbital; anal soft rays 15 or 16; pectoral rays 17 or 18.............. Pomacentrus vaiuli

30b. No large black ocellated spot in soft dorsal fin; body dark brown with lower half of each scale margin still darker, resulting in near-vertical lines on body; no hook-like projection on suborbital; anal soft rays 12 to 14; pectoral rays 20 or 21.. Pomacentrus jenkinsi

Genus AMPHIPRION

Amphiprion Block and Schneider 1801. Systema ichth., p. 200. (Type species, Lutjanus ephippium Bloch).

Amphiprion bicinctus

Amphiprion bicinctus Rüppell 1828. Atlas Reise nörd. Afrika, Fische des Rothen Meeres, p. 139, pl. 35, fig. 1. (Type locality, Red Sea).

2 specimens. 76 and 85 mm. Onotoa.

1 specimen. 67 mm. Butaritari.

Color from 35 mm Kodachrome transparency: body dark brown, orange-yellow ventrally on chest and abdomen; head anterior to eye and all fins orange-yellow; a broad, near-vertical, light blue, dark-edged band running from nape on to posterior part of the head behind eye to subopercle and interopercle; a similar but narrower vertical band from base of last 2 dorsal spines almost to anus; all fins except pectoral very narrowly margined with black.

Considerable difference was seen in the two Onotoa specimens. In one the second vertical bar is very narrow, only 2 lateral line scales in width, and, except at the ends, of about uniform width; the caudal peduncle is dark brown; the soft dorsal rays number 15; the preopercular margin is serrate. In the other the second vertical bar is broader (4 lateral line scales in width) and narrower ventrally; the caudal peduncle is largely pale, especially ventrally; the dorsal soft rays number 17; the margin of the preopercle is smooth. One would suspect these differences to be of a specific level were it not for the specimen from Butaritari which is intermediate in all of these characters except the second pale blue vertical bar which is 4½ lateral line scales in width and gradually narrows as it proceeds ventrally.

The largest specimen was speared in from 35 to 40 feet of water on the outer sea reef bench just as it was entering a large sea anenome. The other Onotoa specimen was brought in by a Gilbertese boy with no data as to locality. The specimen from Butaritari was speared in quiet water of about 9 feet in depth on the sea reef on the lee side of the atoll.

<u>Amphiprion sebae</u>.

<u>Amphiprion sebae</u> Bleeker 1853. Nat. Tijdschr. Ned.-Indië, vol. 4, p. 478; 1877, Atlas ichth., vol. 9, pl. 400, fig. 9. (Type locality, Batavia, Java).

1 specimen. 51 mm. Onotoa.

Color in life dark yellow-brown shading to yellow-orange on head anterior to eye and ventrally on chest and abdomen; body with 3 vertical light purplish-blue bars edged in black (the first extending from nape to operculum as in <u>A. bicinctus</u>; the second, 6½ lateral line scales in width and narrower ventrally, in middle of body and on dorsal fin from 9th dorsal spine to first dorsal soft ray; the third reaching 2/3 the way down on caudal peduncle); caudal fin yellow-orange with a large round dusky patch in centro-posterior part of fin; dorsal fin yellow-orange except posterior part of soft dorsal which is dusky orange; pectoral, pelvic, and anal fins yellow-orange; all fins except pectoral with a very narrow black margin.

The specimen was secured with rotenone in the Onotoa lagoon in a sandy region with occasional patches of coral rubble at a depth of 5 feet. Before being poisoned it was observed to be in close association with a sea anenome of about 5 inches in diameter (when expanded).

There is a specimen of this species in the Bishop Museum, Honolulu, bearing the label, Apiang, Gilbert Islands.

Genus DASCYLLUS

Dascyllus Cuvier 1829. Règne animal, vol. 2, p. 179. (Type species, Chaetodon aruanus Linnaeus).

Dascyllus aruanus

Chaetodon aruanus Linnaeus 1758. Syst. nat., ed. 10, p. 275. (Type locality, Indies).

23 specimens. 10 - 45 mm. Onotoa.

2 specimens. 38 and 46 mm. Tarawa.

Color in life white with 3 broad near-vertical black bars, one running from nape through eye to chin, the second from region of 5th to just beyond 8th dorsal spines passing downward under pectoral fin, and the third from base of 12th dorsal spine and remainder of dorsal fin (except distal ends of last few soft dorsal rays) vertically downward to anal fin (the last 2 bars interconnect distally in the spinous dorsal fin); pectoral and caudal fins white; pelvic and anal fins (except extreme tips of last anal rays) black.

All of the Onotoa specimens were obtained from coral areas of the lagoon. Many were collected merely by breaking off small coral heads, removing the coral from water, and picking the little fish out with forceps.

Dascyllus trimaculatus

Pomacentrus trimaculatus Rüppell 1828. Atlas Reise im nörd. Afrika, Fische des Rothen Meeres, p. 39, pl. 88, fig. 3. (Type locality, Massaua, Red Sea).

1 specimen. 106 mm. Onotoa.

Color in life dark purplish brown becoming orangish in extreme ventral region, with centers of scales whitish; a white spot on side just above lateral line at the level of the 8th dorsal spine, this spot fading upon death of the specimen; spinous portion of dorsal fin purplish brown with a row of yellow spots, one per interradial membrane; basal half of soft dorsal fin purplish brown, outer half with membranes clear, rays brown; anal, pelvic, and caudal fins dusky orange, narrowly dark brown at margins; pectoral fin hyaline.

The single specimen seen was speared on the coralliferous terrace of the outer reef at an estimated depth of 35 feet.

Genus CHROMIS

Chromis Cuvier 1815. Mém. Mus. Hist. Nat. Paris, vol. 1, p. 393. (Type species, Sparus chromis Linnaeus).

Chromis lepidolepis

Chromis lepidolepis Bleeker 1877. Versl. Akad. Amsterdam, vol. 10, p. 389;--Atlas ichth., vol. 9, pl. 403, fig. 2. (Type locality, Timor, East Indies).

Dascyllus pomacentroides Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl., vol. 26, p. 298, pl. 5, fig. 1. (Butaritari).

2 specimens. 41 and 44 mm. Onotoa.

Color after 3 days in formalin: dark brown dorsally, lighter brown on sides and ventrally; scales with narrow dark brown margins; dorsal and anal fins dark brown, pale posteriorly; a very dark brown lengthwise band in each lobe of caudal fin.

The 2 specimens were obtained in the Onotoa lagoon very close to the west reef in an area containing numerous coral heads.

Chromis caeruleus

Heliases caeruleus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 5, p. 497. (Type locality, New Guinea and Ulea).

Heliastes lepidurus Günther 1881. Jour. Mus. Godeffroy, vol. 7, pt. 15, p. 238, pl. 128, figs. C & D. (Kingsmill Islands).

Chromis caeruleus Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl., vol. 26, p. 299. (Butaritari).

12 specimens. 27 - 64 mm. Onotoa.

3 specimens. 32 - 57 mm. Tarawa.

Color from 35 mm Kodachrome transparency: dorsal half of body light blue-green, shading to white on ventral half; dorsal and anal fins bluish; baso-central portion of caudal fin blue-green, grading to dark blue on upper and lower lobes; posterior third of caudal fin pale.

All Onotoa specimens were obtained in the lagoon where they were always seen close to coral heads in which they sought refuge.

Chromis xanthochir

Heliases xanthochir Bleeker 1851. Nat. Tijdschr. Ned.-Indië, vol. 2, p. 248;--1877, Atlas ichth., vol. 9, pl. 402, fig. 5. (Type locality, Banda Islands).

Pomacentrus anabatoides Bean and Weed (not of Bleeker) 1912. Proc. U.S. Nat. Mus., vol. 42, p. 608.

Chromis weberi Fowler and Bean 1928. Bull. U.S. Nat. Mus. 100, vol. 7, p. 41, pl. 1.

Chromis reticulatus Fowler and Bean 1928. Bull. U. S. Nat. Mus. 100, vol. 7, p. 40.

Chromis scotochilopterus Fowler 1918. Proc. Acad. Nat. Sci. Phila., vol. 70, p. 61, fig. 24.

1 specimen. 65 mm. Onotoa.

Color in life dark brown dorsally, grading to dark olive green on sides; spinous dorsal dusky yellow with large brown blotches posteriorly on basal 2/3 of fin membranes, leaving a narrow band of yellow anterior to brown region on each interspinous membrane; soft dorsal and anal fins dark brown with dusky yellow on posterior portion, especially on soft dorsal where the upper posterior half of the fin is dusky yellow; pectoral fin dusky with a large dark yellow spot basally on rays; outer edges of the upper and lower lobes of the widely-forked caudal fin dark brown, medial portions and central part of caudal fin clear; pelvic fins dusky.

The single specimen taken was speared from a small school of this species seen in a poorly-defined surge channel on the lee side of the most northern island of the atoll in about 5 feet of water. All of the fish in the aggregation were of about the same size.

The type of C. reticulatus Fowler and Bean from Bouro Island was examined. The dark edges of the scales are not a unique feature, for they appear in Bleeker's plate of C. xanthochir and were seen in some of the types of C. weberi. The Onotoa specimen is very melanistic, but the dark edges to the scales are visible in it as well. Although the type of C. scotochilopterus was not seen, specimens from the Albatrose collections in the U. S. National Museum which were identified by Fowler as scotochilopterus appear to be C. xanthochir. C. ternatensis (Bleeker) is distinct on the basis of 12 dorsal spines and a deeper body.

Chromis dimidiatus

Heliastes dimidiatus Klunzinger 1871. Verk. zool. bot. Ges. Wien, vol. 21, p. 529. (Type locality, Red Sea).

Chromis leucurus Gilbert 1905. Bull. U. S. Fish Comm. 23, pt. 2, p. 620, pl. 77, fig. 2.

22 specimens. 36 - 50 mm. Onotoa.

Color in life dark chocolate brown with portion of body and fins posterior to a vertical level at base of the 7th soft dorsal ray abruptly white; a large round black spot at base of pectoral fin.

With the exception of C. caeruleus, this species of Chromis was the most abundant at Onotoa. All specimens were secured with rotenone on either the lagoon or sea side of the west or lee reef of the atoll.

Males of the species have larger teeth than the females.

In Hawaii C. leucurus Gilbert has been considered distinct by some authors. The demarcation between the anterior dark and posterior pale parts of the body occurs just behind the base of the last dorsal and anal rays; and the body color in general is lighter (though variable). Counts of the soft dorsal rays are 13 and those of the anal usually 13; pectoral rays are 17 or 18. The distinction, therefore, is very minor, and the species in Hawaii should perhaps be considered only a variety or subspecies of dimidiatus. C. iomelas Jordan and Seale from Samoa may, however, be a valid species with the division of the dark and light parts of the body occurring at the level of the 6th or 7th dorsal spines and the fin ray counts, as given by Jordan and Seale, being 11 for the soft dorsal and 12 for the anal fins.

Chromis opercularis

Heliastes opercularis Günther in Playfair and Günther 1866. Fishes of Zanzibar, p. 84, pl. 11, fig. 2.

5 specimens. 45 - 88 mm. Onotoa.

Color in life brown, with edges of scales slightly darker than centers; a vertical, very dark brown line at preopercular aperture; another line, equally broad and dark, running from upper edge of gill opening to dorsal edge of base of pectoral fin and continuous with dark axil of pectoral fin and a curved dark line at the lateral base of the fin; dorsal and anal fins dark brown except posterior rays which are abruptly pale; caudal peduncle and caudal fin paler than rest of body. The caudal region is markedly and abruptly pale in the three large specimens (over 77 mm long) and suggestive of C. dimidiatus coloration.

All of the specimens of the species were taken in one locality at Onotoa, the lagoon side of the west reef in an estimated 10 feet of water.

The Onotoa specimens differ from Günther's figure and description in lacking any dark spot on the caudal fin rays. C. opercularis is very closely related to C. xanthurus Bleeker which apparently lacks the dark lines on the edge of the preopercle and opercle.

Genus ABUDEFDUF

Abu-defduf Forskål 1775. Descr. animalium, p. 59. (Type species, Chaetodon sordidus Forskål).

Abudefduf sordidus

Chaetodon sordidus Forskål 1775. Descr. animalium, p. 62. (Type locality, Djedda, Red Sea).

2 specimens. 130 and 140 mm. Onotoa.

Color from 35 mm Kodachrome transparency light brownish gray with 6 vertical blackish brown bars on body, the first just posterior to head and the last on caudal peduncle; centers of scales paler than edges; upper part of vertical bar on caudal peduncle black; fins dusky, the basal half of caudal, soft dorsal, and anal fins darker than outer half; eye bluish.

The two specimens of Abudefduf sordidus were collected from a surge channel on the outer reef, one with the use of rotenone and the other by a Gilbertese man who caught it with hook and line using hermit crab for bait.

The stomach contents of one adult specimen consisted primarily of green algae.

Abudefduf septemfasciatus

Glyphisodon septemfasciatus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 5, p. 463. (Type locality, Mauritius).

Abudefduf septemfasciatus Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl. vol. 26, p. 295. (Butaritari).

3 specimens. 120 - 134 mm. 2 specimens. 15 and 17 mm. Onotoa.

1 specimen. 132 mm. Tarawa.

Color in life of adult specimens dusky white with a faint yellowish cast; 6 vertical brownish bars on body similar to those of sordidus, but no spot on dorsal part of caudal peduncle (the upper part of the third and fourth vertical bars is a little darker, however, appearing as indistinct dark spots); median fins dusky, light yellowish brown distally except ends of caudal lobes which are faintly blackish; pectoral rays light dusky yellow. The juvenile specimens have a jet black saddle dorsally on the caudal peduncle and a large black spot in the front part of the dorsal fin.

The 15 and 17 mm specimens were taken from an inshore tide pool on the outer reef flat. One adult was collected from a surge channel, another from a Heliopora flat in a shallow channel, and the last was seined by Gilbertese from the back ridge trough.

The stomach contents of two adult specimens from Onotoa were examined. They were entirely algal, primarily the fine coralline red, Jania.

Abudefduf saxatilis

Chaetodon saxatilis Linnaeus 1758. Syst. nat., ed. 10, p. 276. (Type locality, India).

2 specimens. 102 and 110 mm. Onotoa.

Color in life blue-green with 5 vertical bluish black bars on the body, the first from origin of dorsal to axil of pectoral fin, the fourth from posterior part of dorsal fin almost to posterior part of anal fin, and the last, a narrower bar, at end of caudal peduncle; all fins except pectoral blackish; pectoral hyaline, rays slightly dusky.

Abudefduf saxatilis was seen in only one location at Onotoa, the coralliferous terrace of the outer reef usually near the entrance to surge channels. It was not abundant. The two specimens were speared with difficulty due to wariness of individual fish.

The closely-related A. abdominalis of the Hawaiian Islands invades many habitats and is much more common. It differs from saxatilis in having 13 or 14 dorsal and anal soft rays, the fourth dark bar on the body originating at the base of the first few dorsal soft rays (instead of last few), and in developing in adults a large blackish spot basally at the posterior part of the dorsal and anal fins (and concommitant loss of the fifth vertical black bar).

Another similar species is A. sexfasciatus. Although not seen in the Gilbert Islands, I would expect it to occur there. This species can be distinguished by the dark upper and lower lobes of the caudal fin and 29 vertical scale rows.

Abudefduf curacao

Chaetodon curacao Bloch 1787. Natur. ausländ. Fische, pt. 3, p. 106, pl. 212, fig. 1. (Type locality, Curacao Island, off Venezuela, possibly an error).

Abudefduf curacao Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 318, fig. 55. (Kingsmill Islands).

Abudefduf imparipennis

Glyphisodon imparipennis Vaillant and Sauvage 1875. Rev. Mag. Zool., ser. 3, vol. 3, p. 279. (Type locality, Honolulu).

Although no specimens of this species were collected, it was commonly seen in the shallow water of the outer part of the seaward reef flat. It was never observed in tidepools.

Abudefduf phoenixensis

Abudefduf phoenixensis Schultz 1943. Bull. U. S. Nat. Mus. 180, p. 190, fig. 15. (Type locality, Enderbury Island, Phoenix Islands).

?Abudefduf xanthozona Fowler (not of Bleeker) 1928. Mem. B. P. Bishop Mus., vol. 10, p. 325 (Kingsmills).

2 specimens. 45 and 50 mm. Onotoa.

Color in alcohol brown with 5 vertical pale bars on body and caudal peduncle (these bars recalled as pinkish in life), the first running from nape on to opercle, the second originating at base of 5th dorsal spine, the third at base of last dorsal spine and first dorsal soft ray (the second and third bars extend a short distance into dorsal fin, paralleling direction of fin rays), the fourth and fifth adjacent to a broad vertical black bar on caudal peduncle; base and axil of pectoral fin dark brown; dorsal and anal fins dark brown; an indistinct blackish spot at upper, posterior part of soft dorsal fin; caudal fin pale yellowish; pectoral fin hyaline; pelvics blackish.

A. phoenixensis appears to be restricted to the outer reef flat near surge channels. It was only occasionally seen.

Abudefduf dicki

Glyphisodon dickii Liénard 1839. Dixième Rapp. Soc. Hist. Nat. Maurice, p. 35. (Type locality, Mauritius).

6 specimens. 28 - 60 mm. Onotoa.

This species is readily distinguished by its color pattern. There is a black vertical bar on the body at the level of the 2nd to 6th dorsal soft rays. Anterior to this bar the head and body is cinnamon brown, the body scales with outer edges dark brown; posterior to the bar the body and caudal fin is whitish.

The species was taken on both the lagoon and sea side of the west or lee reef of the atoll.

Abudefduf lacrymatus

Glyphisodon lacrymatus Quoy and Gaimard 1824. Voyage autour du monde..."Uranie"...Zool., p. 388, pl. 62, fig. 7. (Type locality, Guam).

11 specimens. 23 - 63 mm. Onotoa.

1 specimen. 64 mm. Butaritari.

Color in life dark brown with small, widely-scattered, pale blue spots on upper two-thirds of body, head, and dorsal fin; posterior part of dorsal and anal fins, caudal peduncle, and caudal fin pale yellowish.

A. lacrymatus was taken in the same coral-rich areas as A. dicki.

Quoy and Gaimard's figure is of a juvenile specimen in which the pale blue spots occur ventrally and posteriorly on the body and are of relatively larger size than on adults.

A West Indian pomacentrid, Microspathodon chrysyrus (Cuvier and Valenciennes), has a similar sequence of color pattern in life. The young are brown with bright blue spots; with age the spots are reduced and a yellow tail develops.

Abudefduf leucopomus

Glyphisodon leucopomus Lesson 1830. Voyage autour du monde... "Coquille",...Zool., p. 189. (Type locality, Oualan).

2 specimens. 38 and 48 mm. Onotoa.

The salient color character in life is the broad blue band at the base of the spinous dorsal fin which narrows as it extends forward through upper edge of eye and circles snout. There is a prominent black spot enclosed within the posterior part of the blue band; another diagnostic mark is the black spot at the upper edge of the base of the caudal fin; there are faint yellow longitudinal lines on the body and about 14 irregular rows of obscure pale blue spots; all fins slightly yellowish.

The two specimens were secured with rotenone in a well-protected area with numerous small coral heads at the extreme northern part of the atoll.

Abudefduf glaucus

Glyphisodon glaucus Cuvier and Valenciennes 1830. Hist. nat. poiss., vol. 5, p. 475. (Type locality, Guam).

2 specimens. 28 and 43 mm. Onotoa.

1 specimen. 71 mm. Tarawa.

Color in life of 43 mm specimen bluish gray, paler ventrally; back with small blue spots and narrow short lines; a narrow blue line through upper part of eye; median fins pale yellowish with faint narrow black margin; pectoral fins hyaline; pelvic fins dusky yellow. In smaller specimens the blue line through the eye is relatively broader and extends to tip of snout.

Abudefduf glaucus is a very common species of the outer reef flat. Younger specimens were frequently observed isolated in shallow tide pools at low tide; adults tended to stay farther out on the reef flat.

Abudefduf amabilis

Glyphisodon amabilis De Vis 1884. Proc. Linn. Soc. N. S. Wales, vol. 8, p. 452. (Type locality, South Seas islands).

8 specimens. 29 - 53 mm. Onotoa.

2 specimens. 37 and 48 mm. Tarawa.

Color in alcohol chestnut brown, centers of scales whitish; an elliptical white spot vertically aligned on opercle; extreme edge of opercle with a short dark brown band; a large black spot on basal third of caudal fin, contrasting with rest of caudal fin and with caudal peduncle which are pale; a vertical white bar, which angles slightly backward as it passes ventrally, may be present on middle of body (in 4 of 18 Onotoa specimens of the field collection this bar was absent or indistinct); dorsal, anal, and pelvic fins blackish, pectoral fin hyaline, base dark brown.

A common species on the seaward reef flat in the outer rough zone near the surge channels.

Abudefduf biocellatus

Glyphisodon biocellatus Quoy and Gaimard. 1824. Voyage autour du monde..."Uranie"....Zool., p. 389. (Type locality, Guam).

Glyphisodon biocellutus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 298. (Nauru).

3 specimens. 34 - 62 mm. Onotoa.

5 specimens. 34 - 70 mm. Tarawa.

Color in alcohol brown with 2 lightly-ocellated black spots at base of dorsal fin, one at base of last 2 dorsal spines and the other at axil of soft dorsal; a broad whitish vertical bar may be present on middle of body; caudal fin pale yellowish; dorsal fin pale to dusky with a narrow blackish margin; anal and pelvic fins dusky; pectoral fins pale.

See further discussion of this species under zonatus below.

Abudefduf zonatus

Glyphisodon zonatus Cuvier and Valenciennes. 1830. Hist. nat. poiss., vol. 5, p. 483. (Type locality, New Guinea and Vanicolo Island).

4 specimens. 65 - 70 mm. Onotoa.

Color similar to biocellatus though darker and without the two black spots (at least in adults).

Herre (1936) and others have regarded biocellatus and zonatus as varieties of the same species. Schultz (1943) could not find intergradation of color pattern and considered the two as separate species. I am unable to separate them on any other basis than color, although I have too few specimens for a detailed study of meristic data. A large number of gill raker counts might show a difference. Total gill raker counts (including rudiments) of three biocellatus were 23, 23, and 24; of three zonatus 23, 25, 25.

I prefer to regard the two as distinct species because of their different habitats as observed at Onotoa. A. zonatus was always seen in relatively shallow, somewhat turbid water of the eastern shore of the lagoon where the bottom was sandy with intermittent piles of coral rubble. A. biocellatus was taken only in outer reef areas where living coral was abundant.

Genus POMACENTRUS

Pomacentrus Lacépède 1802. Hist. nat. poiss., vol. 4, p. 505. (Type species, Chaetodon pavo Bloch).

Pomacentrus lividus

Chaetodon lividus (Forster) Bloch and Schneider 1801. Systema ichth., p. 235. (Type locality, Pacific Ocean).

Eupomacentrus lividus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 298. (Nauru).

Pomacentrus aureus

Pomacentrus aureus Fowler 1927. Bull. B. P. Bishop Mus. 38, p. 22, fig. 3. (Type locality, Howland Island).

2 specimens. 67 and 70 mm. Onotoa.

Color in life bright yellow with a small black saddle dorsally on caudal peduncle, a small black spot at upper base of pectoral fin, a black anus, and slightly blackish lips. One of the two specimens in preservative has brownish outer edges on the body scales.

This species was rare at Onotoa; it was seen on only two occasions. One specimen was speared in about 20 feet of water on the coralliferous terrace of the outer reef and the other in 4 feet on the lagoon side of the west reef.

Pomacentrus albofasciatus

Pomacentrus albofasciatus Schlegel and Müller 1839-44. Verh. Nat. Gesch. Zool. Leiden, vol. 2, p. 21. (Type locality, Celebes).

Pomacentrus albofasciatus albofasciatus Schultz 1943. Bull. U. S. Nat. Mus. 180, p. 185.

1 specimen. 63 mm. Onotoa.

Color in life dark brownish gray with a broad vertical gray and white bar (gray anteriorly, white posteriorly) in middle of body; a longitudinal gray band running from snout to the gray and white bar.

The single specimen collected was speared by D. W. Strasburg in a Heliopora flat of a channel of about 3 foot depth. He provided the above color note. All of the gray and white coloration disappeared when the fish was speared. Some examples of the species seen underwater lacked the white part of the vertical bar; most did not show the longitudinal gray band.

Pomacentrus eclipticus

Pomacentrus eclipticus Jordan and Seale 1906. Bull. U. S. Bur. Fish., vol. 25, p. 282, fig. 50. (Type locality, Apia, Samoa).

Pomacentrus albofasciatus eclipticus Schultz 1943. Bull. U. S. Nat. Mus. 180, p. 185.

10 specimens. 30 - 54 mm. Onotoa.

Color in alcohol brown with a black spot at base of about last 5 rays of the dorsal fin and narrowly on adjacent portion of caudal peduncle; a pale area, slightly over half the width of the black spot, preceding and adjacent to this spot; a black spot at base of pectoral fin and in axil of pectoral, more intense above; median and pelvic fins dark brown, pectorals hyaline.

Two small specimens (30 mm in standard length) had a black area anteriorly in the dorsal fin which contained a small blue spot. The pale area in front of the black spot in the axil of the soft dorsal was pale blue instead of white, and there was a tiny yellow spot posteriorly within the blue area. There was a faint light blue area behind the black axil spot.

Specimens were seen and taken only from the outer reef, though in two distinctly different areas. One was a broad region at the northern part of the atoll where there was much live coral and fairly quiet water. The other was a rough (both with respect to turbulence of water and nature of substrate) zone on the reef flat just shoreward of the Jania zone and the back ridge trough. It is not uncovered at a low tide.

Pomacentrus nigricans

Holocentrus nigricans Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 332, 367.

48 specimens. 27 - 82 mm. Onotoa.

In life nigricans is usually dark gray to nearly black in color. There is a black spot at the axil of the soft dorsal end one at the upper part of the base of the pectoral fin, but these are difficult to see on dark specimens. The iris is yellowish and there may be small purple dots basally at the front of the anal fin. Occasional specimens had a decided yellowish cast to the body, especially posteriorly and on fins, and in these the black spots are very apparent. There were intermediates connecting the palest specimens with the darkest.

A very abundant species, nigricans was observed in nearly all habitats.

Pomacentrus pavo

Chaetodon pavo Bloch 1787. Natur. ausland. Fische, pt. 3, p. 6, pl. 198. (Type locality, East Indies).

Pomacentrus pavo Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl., vol. 26, p. 295. (Butaritari).

9 specimens. 19 - 65 mm. Onotoa.

1 specimen. 48 mm. Tarawa.

4 specimens. 16 - 25 mm. Abemama.

Color in life blue with vertical paler blue lines on scales; chest and abdomen whitish; outer half of caudal fin pale yellow, the lobes brighter yellow than centro-posterior part of fin; margin and posterior part of anal fin pale yellow; outer portion of last few rays of soft dorsal fin yellow; a dark blue spot at upper edge of opercle (black in preservative); head with small pale blue spots.

Pomacentrus pavo was observed only around coral heads in the lagoon.

Pomacentrus coelestis

Pomacentrus coelistis Jordan and Starks 1901. Proc. Calif. Acad. Sci., zool. ser. 3, vol. 2, p. 383, pl. 21. (Type locality Wakanoura, Kii, Japan).

4 specimens. 43 - 53 mm. Onotoa.

A brilliantly colored species in life, the body was bright blue with caudal peduncle, caudal fin, anal fin and adjacent part of body forward to just before anus, and posterior part of soft dorsal fin bright yellow; pelvic fins yellowish;

pectoral fins hyaline. In preservative a small black spot is apparent on the opercle at the upper edge of the gill opening, the base of the pectoral fin is dark, and the centers of the scales a little paler than edges.

The species was collected in two localities on the lagoon side of the west reef in from 7 to 11 feet of water.

The holotype at the Stanford Natural History Museum was examined and compared with my specimens.

Pomacentrus vaiuli

Pomacentrus vaiuli Jordan and Seale 1906. Bull. U. S. Bur. Fish., vol. 25, p. 280, pl. 40, fig. 2. (Type locality, Samoa).

35 specimens. 16 - 62 mm. Onotoa.

Color in life: light brown on head and nape, shading into blue on body to caudal peduncle; head and body with dark blue spots in linear series; a large black spot in soft dorsal, ringed in light blue; a dark blue spot on opercle, larger than other spots on head, at upper end of gill opening; caudal peduncle, caudal fin, and posterior part of dorsal fin yellowish; pectoral fin light yellow.

This species was fairly common in quiet water with living coral in both outer reef and lagoon areas.

Pomacentrus jenkinsi

Pomacentrus jenkinsi Jordan and Evermann 1903. Bull. U. S. Fish Comm., vol. 22, p. 189. (Type locality, Honolulu).

Pomacentrus inornatus Schultz (not of De Vis) 1943. Bull. U. S. Nat. Mus. 180, p. 184.

20 specimens. 50 - 76 mm. Onotoa.

4 specimens. 72 - 80 mm. Tarawa.

Like nigricans, P. jenkinsi is a drab species. It is dark brown with axil and extreme upper edge of pectoral fin black. It is easily confused with nigricans in the field. Without resorting to counting dorsal spines, the best means of separation is the presence on jenkinsi of vertical dark lines on the body (due to lower outer edges of scales being darker).

A common species, it was taken both on the outer reef and in the lagoon.

Table 4 Counts Made on the Pomacentridae Collected in the Gilbert Islands

Dorsal fin

	spines			soft rays									
	XI	XII	XIII	9	10	11	12	13	14	15	16	17	18
Am. bicinctus	3									1	1	1	
Am. sebae	1										1		
D. aruanus		10					10						
D. trimaculatus		1								1			
C. lepidolepis		2					2						
C. caeruleus		12		1	11								
C. xanthochir			1			1							
C. dimidiatus		22					22						
C. opercularis			5		1	4							
Ab. sordidus			2						1	1			
Ab. septemfasciatus			5				3	2					
Ab. saxatilis			2				2						
Ab. phoenixensis		2										2	
Ab. dicki		6										4	2
Ab. lacrymatus		10								3	6	1	
Ab. leucopomus			2				2						
Ab. glaucus			3				3						
Ab. amabilis			9				9						
Ab. biocellatus			4					4					
Ab. zonatus			4					4					
P. aureus		2									2		
P. albofasciatus		1							1				
P. eclipticus		10								8	2		
P. nigricans		17								6	9	2	
P. pavo			9					8	1				
P. coelestis			4						4				
P. vaiuli			12						1	6	5		
P. jenkinsi			12							2	9	1	

Table 4 (Cont.) Anal fin

	spines	soft rays							
	II	9	10	11	12	13	14	15	16
Am. bicinctus	3					2	1		
Am. sebae	1					1			
D. aruanus	10				9	1			
D. trimaculatus	1						1		
C. lepidolepis	2			2					
C. caeruleus	12	2	10						
C. xanthochir	1			1					
C. dimidiatus	22			1	20	1			
C. opercularis	5			5					
Ab. sordidus	2						1	1	
Ab. septemfasciatus	5				5				
Ab. saxatilis	2				2				
Ab. phoenixensis	2					1	1		
Ab. dicki	6						3	3	
Ab. lacrymatus	10					8	2		
Ab. leucopomus	2				2				
Ab. glaucus	3				3				
Ab. amabilis	9				9				
Ab. biocellatus	4				1	3			
Ab. zonatus	4					4			
P. aureus	2				2				
P. albofasciatus	1				1				
P. eclipticus	10				9	1			
P. nigricans	17					14	3		
P. pavo	9					8	1		
P. coelestis	4							4	
P. vaiuli	12							4	8
P. jenkinsi	12				1	7	4		

Table 4 (Cont.)

		Pectoral rays**						Vertical scale rows*						
		16	17	18	19	20	21	25	26	27	28	29	50	51
Am.	bicinctus					2	1						2	1
Am.	sebae					1							1	
D.	aruanus		1	5						5				
D.	trimaculatus				1					1				
C.	lepidolepis			2						2				
C.	caeruleus		2	8	2			3	3					
C.	xanthochir				1						1			
C.	dimidiatus	2	20					1	4					
C.	opercularis			1	4					2	3			
Ab.	sordidus			1	1					2				
Ab.	septemfasciatus			3					1	2				
Ab.	saxatilis			1	1				1	1				
Ab.	phoenixensis						2	1	1					
Ab.	dicki			1	4	1			2	2	2			
Ab.	lacrymatus				5	5		4	1					
Ab.	leucopomus			1	1			2						
Ab.	glaucus		1	2					1	1				
Ab.	amabilis			3	5	1		1	1	1				
Ab.	biocellatus			4				2	2					
Ab.	zonatus			4				1	3					
P.	aureus				1	1				1	1			
P.	albofasciatus				1					1				
P.	eclipticus					9	1	1	4					
P.	nigricans			4	12	1		1	6					
P.	pavo	6	3					1	2	1				
P.	coelestis		2	2						2	2			
P.	vaiuli		6	6				4	1					
P.	jenkinsi					9	3			2	3	1		

* All elements of pectoral fin counted.

** Vertical scale rows counted from upper edge of gill opening to end of hypural plate (generally the last large scale is at this location).

Family MALACANTHIDAE

Genus MALACANTHUS

Malacanthus Cuvier 1829. Règne animal, ed. 2, p. 264. (Type species, *Coryphaena plumieri* Bloch).

Malacanthus hoedti

Malacanthus hoedti Bleeker 1859. Act. Soc. Sci. Indo-Neerl. vol. 6, p. 18. (Type locality, New Guinea).

Malacanthus hoedti Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 292. (Nauru).

Family LABRIDAE

More species of wrasses were taken in the Gilbert Islands than any other family of fishes; however, there are still many as yet unrecorded which must occur there. Most were very highly colored and had the characteristic projecting teeth anteriorly in the jaws. The Gilbertese did not distinguish the smaller species with different names, the single name *Tearinai* being applied to nearly all of them.

Genus THALASSOMA

Thalassoma Swainson 1839. Nat. hist. class. fishes, amphibians,...vol. 2, pp. 172, 224. (Type species, *Scarus purpureus* Forskål).

Thalassoma purpureum

Scarus purpureus Forskål 1775. Descr. animalium, pp. x, 27. (Type locality, Djedda, Red Sea).

Thalassoma quadricolor Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 298. (Nauru).

1 specimen. 260 mm. Tarawa.

D VIII,13; A III,11; P 16; gill rakers 24.

Color in alcohol: head and an irregular band dorsally on body purplish gray; body light brown; a pale reddish irregular band running from eye diagonally across operculum, forking posteriorly; two lengthwise pale reddish bands on side of body; upper axil of pectoral blackish; outer part of pectoral fin faintly blackish; a blackish spot anteriorly in dorsal fin.

Thalassoma trilobatum

Labrus trilobatus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 454, 526. (Type locality, "le grand Océan équatorial").

Labrus fuscus Lacépède 1802 (not of Gmelin, 1788). Hist. nat. poiss., vol. 3, pp. 437, 493.

Thalassoma fuscum Jordan and Evermann 1905. Bull. U. S. Fish Comm., vol. 23, pt. 1, pp. 295, 299, pl. 34 (erroneously labelled *purpureum*).

2 specimens. 116 and 132 mm. Onotoa.

D VIII,13; A III,11; P 16; lateral line scales 27; gill rakers 20 (2 specimens).

Color from 35 mm Kodachrome transparency: head and anterior part of body orangish yellow; posterior part salmon orange; two broad longitudinal bands of more-or-less rectangular blue-green blotches on side of body (4 or 5 of these blotches in the upper band extend to base of dorsal fin); a vertical blue line posteriorly on opercle; a short blue line above and one below eye; caudal fin yellow with horizontal blue lines, especially posteriorly; dorsal fin orange with green blotches along base, a blue line distally and a black spot on first interspinous membrane; anal fin orange on basal half, bright blue on distal half; pectoral hyaline with a blue line at base ending at upper edge in a blackish spot; pelvics light blue.

This species was seen only on the outer sea reef, especially in the surge channel zone.

The stomach contents of one of the specimens consisted of fragments of a good-sized brachyuran crab. The test of the crab was orange-red with white nodules.

Thalassoma umbrostygma

Julis umbrostygma Rüppell 1835. Neue Wirbelth. Fische, p. 11, pl. 3, fig. 2. (Type locality, Red Sea).

Julis umbrostigma Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 294, pl. 59, fig. B. (Kingsmill Islands).

2 specimens. 106 and 121 mm. Onotoa.

2 specimens. 122 and 128 mm. Tarawa.

D VIII,13; A III,11; P 16; lateral line scales 27; gill rakers 20 or 21. (2 specimens).

Color from 35 mm Kodachrome transparency dusky red dorsally, shading to salmon pink on side, and white ventrally; 2 longitudinal broad bands of more-or-less rectangular green blotches on side of body (upper part of each green blotch of upper band extends irregularly to base of dorsal fin; broad green lines radiating from eye; dorsal fin deep orange-yellow with a green band, and a prominent black spot on first interspinous membrane; anal fin salmon colored with 2 green bands; caudal fin deep orange-yellow with traces of green especially posteriorly on upper and lower lobes; pectoral fins hyaline-yellowish; pelvic fins white.

This species was also seen only in outer reef areas where the water was turbulent.

The stomach contents of the large Onotoa specimen were examined. This labrid had eaten the same kind of crab as the specimen of T. trilobatum.

Thalassoma quinquevittatum

Scarus quinquevittatus Lay and Bennett 1839. Zool. Capt. Beechey's voyage, p. 66, pl. 19, fig. 3. (Type locality, Loo Choo Islands).

24 specimens. 39 - 125 mm. Onotoa.

2 specimens. 89 and 108 mm. Tarawa.

D VIII,13; A II,11; P 16; lateral line scales 27; gill rakers 23. (2 specimens).

Color from 35 mm Kodachrome transparency of 125 mm specimen: body except abdomen green with a very broad rose pink band on the back and side containing a band of connected green blotches which shade to blue on caudal peduncle (this blue connects at base of caudal fin with a similar blue band on caudal peduncle at margin of the broad rose pink band; abdomen purplish with 3 diagonal blue bands separated by rose pink; head greenish (reddish on upper part of opercle and on region from chin to eye,) with blue bands radiating from eye; a blue line under chin; dorsal fin rose pink, green on margin; a black spot on first two interspinous membranes of dorsal fin; caudal fin bright orange except upper and lower lobes which are rose pink; anal and pectoral fins hyaline; a black spot at upper edge of base of pectoral fin; pelvic fins light purplish.

Smaller specimens have a row of black spots on the back along the base of the dorsal fin, the most prominent one being at the axil of the dorsal, and a black spot basally on the membrane between the second and third dorsal soft rays.

This colorful species was the most abundant of the genus at Onotoa and was seen in many different habitats.

The stomachs of two adult specimens were opened. One contained a small pelecypod, and the other a crangonid shrimp.

Thalassoma hardwickei

Sparus hardwicke Bennett 1828. Fish. Ceylon, pl. 12. (Type locality, Ceylon).

Julis dorsalis Quoy and Gaimard 1834. Voyage "Astrolabe", Zool., vol. 3, p. 713, pl. 15, fig. 5.

Thalassoma dorsale Jordan and Seale 1906. Bull. U. S. Bur. Fish., vol. 25, p. 306.

8 specimens. 25 - 103 mm. Onotoa.

D VIII,13; A II,10 or 11; P 16; lateral line scales 27; gill rakers 22 or 23. (2 specimens).

Color from 35 mm Kodachrome transparency of an 88 mm specimen: body light blue dorsally and on side and white ventrally with 5 broad dark purple bars on back, the first extending from origin of dorsal to axil of pectoral fin and the last from base of last few dorsal rays to lateral line; head light violet dorsally, white ventrally, with light red lines radiating from eye; a black spot (2 black spots on some specimens) in a small dark purple area dorsally on caudal peduncle; a black spot anteriorly in dorsal fin; a black spot at upper edge of base of pectoral fin.

In the 103 mm specimen the region from base of caudal fin to gill opening is black, and there is a black line basally in the dorsal fin. The 25 mm specimen shows the same saddle-like bars on the body as in adults. There is a black spot in the middle of the dorsal fin as well as anteriorly.

Thalassoma melanochir

Julis melanochir Bleeker 1857. Act. Soc. Sci. Indo-Neerl., vol. 2, p. 77. (Type locality, Ambon, East Indies).

Thalassoma marnae Schultz 1943. Bull. U. S. Nat. Mus. 180, p. 203, fig. 17.

2 specimens. 84 and 90 mm. 8 specimens. 43 - 67 mm. Onotoa.

D VIII,13; A II,11; P 15; lateral line scales 27; gill rakers 14 to 17. (7 specimens).

Color in life of 84 mm specimen: dark green on back shading to light purplish ventrally with vertical red lines on scales (these more pronounced in middle of body); a broad region from nape to about mid-point of spinous portion of dorsal fin yellow-green (more green dorsally, more yellow ventrally) (no evidence of this color in preserved specimen); head bluish purple with a green area antero-ventral to eye; a narrow dark purple-bordered gold band from snout through lower third of eye nearly to end of operculum; a similar band from corner of mouth to postero-ventral portion of operculum; dorsal fin red with oblique dusky streaks, a narrow clear margin, and a thin submarginal black line; caudal fin hyaline except for reddish brown on upper and lower lobes; pectoral yellow, black at base, with a large black area in outer part of fin.

The 2 large specimens were speared next to a large coral head in the lagoon.

The smaller specimens fit the description of Thalassoma marnae Schultz. The largest is losing the black band down the middle of the body; all but the smallest specimen display faint vertical dark lines on the scales. The gill rakers of the two large specimens number 14 and 16. Those of 5 of the smaller specimens range from 15 to 17. The type of marnae has 16 gill rakers.

Thalassoma lunare

Labrus lunaris Linnaeus 1758. Syst. nat., ed. 10, p. 283. (Type locality, India).

2 specimens. 120 and 125 mm. Onotoa.

D VIII,13; A II,11; P 15 or 16; lateral line scales 27; gill rakers 16 and 19. (2 specimens).

Color in life; body forest green with narrow vertical purplish red lines on scales; head green with violet stripes; central and posterior part of caudal fin bright yellow, bordered with blue; elongate upper and lower lobes of caudal fin orange with narrow blue margins; basal part of dorsal fin green, outer part orange; pectoral fin blue with second to sixth rays orange except for basal and extreme distal portions (this orange color preserves as an elongate blackish area). Not noted in the field but readily apparent in both specimens in alcohol are 4 dark bands on the abdomen, the two median ones extending to anal fin.

The specimens were speared in the lagoon where the maximum depth of the water was 20 feet, but numerous coral heads reached to 5 feet of the surface.

The species of *Thalassoma* in Oceania which develop a black area in the pectoral fin include *melanochir* (Bleeker), *lunare* (Linnaeus), *lutescens* (Lay and Bennett), *aneitensis* (Günther), *duperreyi* (Quoy and Gaimard), and *neanis* Jordan and Evermann (*in* Jordan and Snyder, 1907). The latter two species are apparently restricted to the Hawaiian Islands. In addition to color, gill raker and pectoral fin ray counts are useful in separating the species of this group, *T. lutescens* and *T. neanis* have a total of 16 rays in the pectoral, the others (*aneitensis* not seen) generally 15. *T. melanochir* has 14 to 17 gill rakers; *lunare* counts in the Gilbert Islands were 16 and 19 (three from the Philippines had 18 to 20); three examples of *lutescens* from the Marshall Islands had 22 or 23 rakers, three *duperreyi* from Midway Island and 21 or 22; the type of *neanis* has 17.

Fowler (1928: 354) has placed *neanis* in the synonymy of *lutescens*. Admittedly these two are closely related; if the life color as given by Jordan and Evermann (p. 214, and pl. 12, fig. 2) is correct (especially with respect to the lack of vertical lines on the scales), I believe they are distinct species. Adult *lutescens* in the Marshall Islands are yellow with orange stripes on the head and abdomen; there is a lengthwise orange band down the middle of the dorsal fin, a black spot centered on the second dorsal spine, an orange band at the base of the anal fin, orange upper and lower lobes of caudal fin, and orange vertical lines on body scales; there is a black spot at the upper edge of the base of the pectoral and a blackish area in the outer part of the fin.

No specimens of *lutescens* were seen in the Gilbert Islands. The species was common in the Marshall Islands. I have not seen the specimen from Honolulu identified by Jordan and Evermann (*Bull. U. S. Fish. Comm.*, vol. 23, 1905: 303) as *Thalassoma lunaris* and later by Jordan and Snyder (*Bull. U. S. Bur. Fish.*, vol. 26, 1907: 214) as *lutescens*.

Julis aneitensis Günther (1862) may be a synonym of *lutescens*. I have examined no specimens of the former. The specimen collected by Berndt and identified by Jordan and Evermann (1905: 304, pl. 41) as *Thalassoma aneitense* is probably *neanis*. The white spots on the scales as described and figured seem to be some sort of deposit on the underside of the scales and may be an artifact of preservation.

Genus HALICHOERES

Halichoeres Rüppell 1835. Neue Wirbelth., Fische, p. 14. (Type species, *Halichoeres bimaculatus* Rüppell).

Halichoeres centriquadrus

Labrus centriquadrus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 437, 493. (Type locality, Madagascar, Mauritius, and Réunion)

Labrus hortulanus ibid, pp. 449, 518.

Halichöres eximius Rüppell 1835. Neue Wirbelth., Fische, p. 16, pl. 5, fig. 1.

8 specimens. 68 - 140 mm. 3 specimens. 25 - 43 mm. Onotoa.

2 specimens. 126 and 128 mm. Tarawa.

D IX,11; A II,11; P 14; lateral line scales 28. (3 specimens).

Color from 35 mm Kodachrome transparency of 135 mm specimen: body light gray dorsally, white on sides and abdomen, with an elongate black spot at the base of each scale; two prominent yellow spots on back adjacent to dorsal fin, the first at base of fourth to fifth dorsal spines and followed by a blackish area, and the second at the base of the fifth to sixth dorsal soft rays; head light gray (snout greenish) with irregular short pink bands; dorsal orangish with numerous yellow spots (more evident basally); caudal fin bright orange-yellow; anal fin light yellow; pectoral fin hyaline with a black spot at upper edge of base; pelvic fins white.

The two smallest specimens (25 and 38 mm) have a different color pattern from the larger specimens, as is so often true of the Labridae. There is a large black spot on the nape, a large black ocellated spot in the middle of the dorsal fin, and a large black spot basally at the anterior part of the anal fin; lesser black spots are present on dorsal and ventral edges of the caudal peduncle, mid-centrally at base of caudal fin, and on body at base of last few anal rays. In the middle of the body running from dorsal to anal and pelvic fins and on the caudal peduncle there is a network of scales with dark edges (this pattern on the scales of the body is similar to that of H. margaritaceus; in the latter species the dark edged scales are restricted mostly to the dorsal half of the body). A 42 mm specimen has lost most of the black spots except the dorsal ocellus; a 68 mm specimen still has a vestige of the dorsal ocellus.

Rüppell's plate of H. eximius from the Red Sea shows some differences in color from the Gilbert Islands specimens. Notable are the blue-green ground color, three instead of two yellow spots on the back; lack of a black spot behind the first yellow spot, and presence of a small black spot at upper base of caudal fin. These differences are perhaps of sufficient magnitude to recognize them by applying subspecific names. I definitely do not regard them as distinct species, however.

This species of Halichoeres was common. It did not seem to prefer any specific habitat, but was seen in nearly all areas.

The stomach contents of two adult specimens were examined. They consisted mostly of small gastropods and pelecypods. In both stomachs the remains of a single unidentified crustacean were found.

Halichoeres trimaculatus

Julis trimaculata Quoy and Gaimard 1834. Voyage "Astrolabe", Zool., vol. 3, p. 705, pl. 20, fig. 2. (Vanikolo).

Platyglossus vicinus Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 267, pl. 142, fig. C. (Kingsmill Islands).

23 specimens. 29 - 95 mm. Onotoa.

D IX,11; A II,11; P 14; lateral line scales 27. (4 specimens).

Color in life of 95 mm specimen: back greenish, shading to light tan below; outer edges of scales darker on upper two-thirds of body; head green, the upper half from snout to just behind eye irridescent light green, with bright orange-rose bands which are narrowly dark bordered; roundish and elliptical spots of orange-rose on head behind eye, on nape, and anteriorly on body to pectoral region; a long orange band from axil of pectoral obliquely downward and backward almost to mid-pelvic region (this band shaded outwardly with blue); a dark purple spot above lateral line on caudal peduncle broadly bordered with bright green; dorsal fin with 2 orange-pink bands in spinous portion and 3 in soft portion; anal fin greenish in proximal half with a rosy lengthwise band in middle of fin; caudal fin orange.

Many specimens were very pale and had little bright color; these were connected with intermediates to the darker, more colorful form as depicted above.

This species is abundant; it appears to be primarily a lagoon form. It was seen in outer reef areas only where the water was quiet and the bottom predominately sandy.

Halichoeres margaritaceus

Julis margaritaceus Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 13, p. 484. (Type locality, Vanicolo).

Julis kawarin Bleeker 1852. Nat. Tijdschr. Ned.-Ind., vol. 3, p. 172.

Halichoeres kawarin Bleeker 1862. Atlas ichth., vol. 1, p. 121, pl. 41, fig. 4.

Platyglossus kawarin Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 266, pl. 142, fig. B. (Kingsmill Islands).

3 specimens. 40 - 71 mm. Onotoa.

2 specimens. 54 and 55 mm. Nukunau.

D IX, 11; A II,11; P 13 or 14; lateral line scales 27 or 28. (3 specimens).

Color in alcohol light tan with edges of most of scales dark brown on dorsal two-thirds of body (groups of scales within this region without dark pigment, giving an overall mottled effect) (in the 71 mm specimen the scales are more broadly darkened); head with dark stripes running through eye (faint in small specimens); a vertical black mark just behind eye; a blackish spot on opercular membrane (much more evident on large specimen); a black ocellus in outer part of dorsal fin between second and third soft rays (nonocellated in 71 mm specimen); rest of dorsal fin with faint irregular lines which outline pale spots; remaining fins pale.

Halichoeres marginatus

Halichöres marginatus Rüppell 1835. Neue Wirbelth., Fische, p. 16. (Type locality, Red Sea).

Julis notopsis Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 13, p. 485.

Platyglossus marginatus Bleeker 1862. Atlas ichth., vol. 1, p. 109, pl. 41, fig. 3.

Platyglossus notopsis Bleeker 1862. Atlas ichth., vol. 1, p. 111, pl. 41, figs. 1, 2.

Halichoeres marginatus Schultz 1943. Bull. U. S. Nat. Mus. 180, pp. 208, 210.

Halichoeres notopsis Schultz ibid.

3 specimens. 81 - 104 mm. 4 specimens. 26 - 63 mm. Onotoa.

D IX,13; A II,12; P 14; lateral line scales 28. (4 specimens).

Color in life of the 81 mm specimen: body green except antero-dorsal portion which is blue; 4 lengthwise lines of bright red spots beneath pectoral fin; head blue with orange stripes, these becoming golden on nape; dorsal and anal fins dark purplish blue with a narrow green margin and a light blue submarginal line; caudal fin green with a large light blue-edged, dark blue crescent-shaped blotch, the upper and lower edges of which reach the upper and lower margins of the fin (concave side of crescent faces anteriorly); pectoral membranes hyaline.

In the field I identified the four smaller specimens as notopsis. Upon closer examination I am convinced that notopsis is the young of marginatus. The 26 mm specimen is pale with 5 dark brown bands running the entire length of the body from snout to base of caudal fin (these bands about as wide as alternating pale interspaces). There is a prominate ocellated black spot in the dorsal fin between the second and fifth soft rays. In a 39 mm specimen the dark bands are twice as broad as the pale. In a 60 mm specimen they are no longer apparent. A dusky area can be seen in the caudal fins of the 60 and 63 mm specimens which presages the formation of the dark crescent-shaped blotch so typical of marginatus. The ocellus is still evident in the dorsal fin in these specimens, though the dorsal fin has become darker. The 81 mm specimen has the adult coloration of the species. In this and even the 104 mm specimen the ocellus can be faintly made out if the dorsal fin is elevated with a bright light behind it. Small pale spots develop in the fin and invade the ocellus and the intensity of the black spot diminishes. The last remnant of the ocellus is the pale ring. A pale margin develops on the dorsal and anal fins during this same period of alteration in color.

Two of the specimens were collected from protected waters of the outer reef and the rest in the lagoon.

Genus MACROPHARYNGODON

Macropharyngodon Bleeker 1861. Proc. Zool. Soc. London, p. 412. (Type species, Julis geoffroyi Quoy and Gaimard).

Macropharyngodon geoffroyi

Julis Geoffroy Quoy and Gaimard 1824. Voyage autour du monde ..."Uranie", Zool., p. 270, pl. 56, fig. 3. (Type locality, Hawaiian Islands).

Julis meleagris Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 13, p. 481. (Type locality, Ulea = Woleai, Caroline Islands).

2 specimens. 72 and 76 mm. Onotoa lagoon.

D IX,11; A II,11; P 12; lateral line scales 28; gill rakers 17 (2 specimens).

Color in alcohol blackish with a slightly paler spot in the center of each scale; 2 black spots, one above the other, just posterior to upper end of gill opening; a black spot anteriorly on isthmus; head with pale dark-edged bands radiating from eye or running diagonally below eye and with pale dark-edged spots ventrally; median fins light dusky with irregular pale bands and spots; a blackish area anteriorly in dorsal fin; paired fins hyaline.

Some authors have considered the species in Hawaii distinct from that in the rest of the Indo-Pacific, giving the latter the name of meleagris (Cuvier and Valenciennes). I compared two specimens from the Hawaiian Islands with the two from the Gilbert Islands. Counts of fin rays, lateral line scales, and gill rakers of the Hawaiian specimens were identical with counts of the ones from the Gilberts. I can find only slight color differences as follows: the Hawaiian specimens lack the black spots just behind the upper end of the gill opening and the spot on the isthmus, and the bands on the head are narrower. In my opinion these differences are not specific.

Macropharyngodon pardalis

Leptojulis pardalis Kner 1867. Sitz. Akad. Wiss. Wien., vol. 56, p. 728. (Type locality, Fiji Islands).

3 specimens. 58 - 67 mm. Onotoa lagoon.

D IX,11; A II,11; P 12; lateral line scales 28. (2 specimens).

Color in life white, light greenish on back, with numerous large irregular black spots on body and most of head; dusky orange lines on snout and interorbital space; dorsal and caudal fins with small brownish orange spots (these form vertical lines on caudal); anal fin yellow with a row of black spots basally and small orange spots distally;

pectoral clear; iris of eye yellow with a green ring and 4 short radiating red-orange lines.

Genus LABRICHTHYS

Labrichthys Bleeker 1854. Nat. Tijdschr. Ned.-Ind., vol. 6, p. 331. (Type species, Labrichthys cyanotaenia Bleeker).

Labrichthys cyanotaenia

Labrichthys cyanotaenia Bleeker 1854. Nat. Tijdschr. Ned.-Ind., vol. 6, p. 331. (Type locality, Larantuka, Flores).

1 specimen. 30 mm. Onotoa.

D IX,11; A III,10; P 14; lateral line scales 27.

Color in alcohol dark brown with a pale line from snout through lower part of eye to middle of caudal fin; a second pale longitudinal line, less distinct than the first, runs from chin, beneath base of pectoral, to lower part of caudal peduncle; margins of median fins hyaline; pectoral pale, the extreme basal part of the rays whitish; pelvic fins pale with dusky centers.

The coloration as described above is based on the single 30 mm specimen taken. This is different from the usual color pattern of numerous faint longitudinal pale lines, but I believe my specimen exhibits the juvenile color pattern for the species. It has the well-developed fleshy tubular lips and peculiar dentition of the genus.

Genus LABROIDES

Labroides Bleeker. 1851. Nat. Tijdschr. Ned.-Ind., vol. 2, p. 249. (Type species, Labroides paradiseus Bleeker = dimidiatus Cuvier and Valenciennes).

Labroides dimidiatus

Cossyphus dimidiatus Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 13, p. 136. (Type locality, Mauritius).

4 specimens. 50 - 82 mm. Onotoa.

D IX,11; A III,10; P 13; lateral line scales 52 or 53. (3 specimens).

Color in life bright light blue with a black band running from snout through eye along upper part of body to end of caudal fin, this band becoming progressively broader as it passes posteriorly; a black line at base of anal fin which connects narrowly with a hook-like ventral extension from end of broad black band on caudal fin; a vertically-elongate small black spot below axil of pectoral; dorsal fin black basally, pale distally; paired fins pale.

This species was seen only in quiet outer reef areas or in the lagoon. It often exhibited an unusual mode of swimming by oscillating the posterior part of the body up and down as if to attract attention. It was seen to dance around other fishes in this manner and to intermittently pick at their bodies. The fishes receiving such attention often slowed their swimming or came to a stop. It was thought at the time that the Labroides were picking off external parasites from these fishes. The gut contents of two specimens from the Gilbert Islands and three from the Marshall Islands consisted of calagoid copepods and a few fish scales. The two remaining Gilbert Islands specimens had eaten tiny isopods along with several fish scales.

Barnard (1927: 749) noted the great resemblance of Labroides dimidiatus to the petroscirtian blenny, Aspidontus taeniatus, and suggested that the phenomenon of mimicry might be involved. He offered no explanation of such mimicry beyond a statement that one of the two species might have poisonous qualities. The similarity in color pattern of these two phylogenetically dissimilar species is certainly striking, and mimicry might well be operative. If so, it is my belief that the blenny is mimicking the labrid. Labroides dimidiatus may escape predation by virtue of its parasite-feeding habit. A blenny of comparable size and the same color pattern might gain the same protection.

Labroides bicolor

Labroides bicolor Fowler and Bean 1928. Bull. U. S. Nat. Mus. 100, vol. 7, p. 224. (Type locality, Port Maricaban, Philippine Islands).

1 specimen. 81 mm. Onotoa.

D IX,12; A III,10; P 13; lateral line scales 25.

Color from 35 mm Kodachrome transparency: head and anterior part of body black; posterior part of body and caudal peduncle bright yellow (this yellow region rounded anteriorly); caudal fin green anteriorly and centrally, this area outlined posteriorly by a black crescent; region of caudal fin posterior to the crescent light blue; margin of soft portion of dorsal fin and anal fin light bluish; pectoral fins pale; pelvic fins black.

This rare species was sighted only twice, both times on the coralliferous terrace of the windward reef. The single specimen taken was obtained with a spear.

Genus STETHOJULIS

Stethojulis Günther 1862. Cat. Fishes British Mus., vol. 4, p. 140. (Type species, Julis strigiventer Bennett).

Stethojulis strigiventer

Julis strigiventer Bennett 1832. Proc. Comm. Zool. Soc. London, p. 184. (Type locality, Mauritius).

Julis (Halichoeres) Renardi Bleeker 1851. Nat. Tijdschr. Ned.-Ind., vol. 2, p. 253.

Stethojulis strigiventer Bleeker 1862. Atlas ichth., pl. 43, fig. 1.

Stethojulis Renardi Bleeker, ibid., fig. 2.

10 specimens. 52 - 75 mm. Onotoa lagoon.

D IX,11; A III,11; P 14 or 15 (mostly 15); lateral line scales 27; gill rakers 24 to 26. (5 specimens).

Color in alcohol of a 65 mm female specimen: light brown except upper part of head and nape above lower edge of eye which is dark brown; narrow lengthwise white lines on lower half of body; a small black spot (a pair of spots on some specimens) at base of caudal fin just above last lateral line scale.

Five of my specimens were identified in the field as S. renardi. These ranged from 72 to 75 mm in standard length and were more colorful than the smaller strigiventer. The lower half of the body was whiter with only traces of brownish longitudinal lines; on the upper half of the head and body were 4 dark-edged red lines as figured for renardi in Bleeker; the area between the two lowermost red lines was blue.

I sexed these five specimens and found that all were males. The five specimens of strigiventer (52 to 69 mm) were either males or females.

I then examined a large series of specimens of both species in the United States National Museum which were collected at Guam. There were 18 specimens of renardi, ranging from 62 to 81 mm, and all were males. 42 specimens larger than 34 mm were labelled strigiventer; of these 14 were females from 63 to 68 mm. The remaining 28 consisted of 16 females and 12 males. Three specimens, 61 to 62 mm in standard length, were intermediate in color pattern to typical renardi and strigiventer. I therefore conclude that renardi is the large adult male of strigiventer.

The male apparently reaches a larger size than the female. The largest female specimen was 68 mm; 10 males were longer than 70 mm.

In addition to the small caudal spot, the smaller specimens had a tiny black spot on the next to last dorsal ray near the base and another on the next to last anal ray. The anal spot disappears at a size of about 50 mm in standard length and the dorsal spot at a length of about 64 mm.

Stethojulis axillaris

Julis axillaris Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 272. (Type locality, Hawaiian Islands).

10 specimens. 38 - 80 mm. Onotoa.

D IX,11; A II,11; P 14; lateral line scales 27. (4 specimens).

Color in alcohol of a 64 mm specimen: dorsal half of head and body dark grayish brown, lower half light brown, these two areas separated by a light brown band (smaller specimens with a second pale band from above eye to top of caudal peduncle); 1 to 3 small black spots in mid-line at base of caudal fin; all fins pale. Small specimens with a small black spot on anal fin near base of last 2 anal rays.

In life there was an orange area at upper axil of pectoral fin and a yellow band from snout to lower edge of eye continuing as a light gray band to base of caudal.

This species is apparently abundant throughout all of Oceania. It was taken in several different habitats at Onotoa from shallow lagoon to outer reef.

Stethojulis sp.

Stethojulis casturi Günther 1909 (not of Bleeker). Jour. Mus. Godeffroy, vol. 6, pt. 16, pl. 141, fig. A.

Stethojulis albovittata Fowler 1928 (in part). Mem. B. P. Bishop Mus., vol. 10, p. 335. (Kingsmill Islands).

Stethojulis casturi Schultz 1943. Bull. U. S. Nat. Mus. 180, pp. 213, 214.

3 specimens. 74 - 82 mm. Onotoa.

D IX,11; A II (III?),11; P 14 or 15; lateral line scales 27. (2 specimens).

Color in life like the plate of S. casturi in Günther (1909) and the key to casturi in Schultz (1943: 213).

This species will be described as new by Schultz in volume 2 of the Fishes of the Marshall and Marianas Islands. The species first described as casturi (Bleeker, 1852) is now recognized as trilineata (Bloch and Schneider).

De Beaufort (1940: 161) has discussed the problem of whether to consider Stethojulis albovittata (Bonnaterre) (pl. 141, fig. B in Günther, 1909) a distinct species or just a color variety of the form known in recent times as casturi (pl. 141, fig. A in Günther, 1909).

Genus CORIS

Coris Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 96, 97. (Type species, Coris aygula Lacépède).

Coris gaimardi

Julis gaimard Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 265, pl. 54, fig. 1. (Type locality, Maui, Hawaiian Islands).

No specimens of this colorful species were collected in the Gilbert Islands. D. W. Strasburg sighted one when swimming underwater at Onotoa.

Genus NOVACULICHTHYS

Novaculichthys Bleeker 1861. Proc. Zool. Soc., p. 414. (Type species, Labrus taeniourus Lacépède).

Novaculichthys taeniourus

Novaculichthys taeniourus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 363, pl. 41, fig. A. (Kingsmill Islands).

Genus ANAMPSES

Anampses Quoy and Gaimard 1824. Voyage autour du monde... "Uranie", Zool., p. 276. (Type species Anampses cuvieri Quoy and Gaimard).

Anampses caeruleopunctatus

Anampses caeruleopunctatus Rüppell 1828. Atlas Reise nördlichen Afrika. Fische, p. 42, pl. 10, fig. 1. (Type locality, Red Sea).

No specimens were collected in the Gilbert Islands. I observed the species on several occasions on Onotoa reefs.

Genus GOMPHOSUS

Gomphosus Lacépède 1802. Hist. nat. poiss., vol. 3, p. 100. (Type species, Gomphosus caeruleus Lacépède).

Gomphosus tricolor

Gomphosus tricolor Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 280, pl. 55, fig. 2. (Type locality, Hawaiian Islands).

3 specimens. 125 - 230 mm. Onotoa.

D VIII,13; A II,11; P 16; lateral line scales 27. (2 specimens). Gill rakers 23 (1 specimen).

Color from 35 mm Kodachrome transparency of 230 mm specimen: head purplish black, body bluish green with a light apple green band from nape to pectoral fin base; dorsal and anal fins and a large crescent-shaped area posteriorly in caudal fin turquoise blue; pectoral fin blackish with outer edge broadly purple, and a black spot at upper edge of base.

The stomach contents of two specimens, 220 and 230 mm in standard length, were examined by A. H. Banner. The fish had eaten stomatopods and crangonid shrimps.

Gomphosus varius

Gomphosus varius Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 100, 104. (Type locality, Tahiti).

4 specimens. 42 - 89 mm. Onotoa.

D VIII,13; A II,11; P 16; lateral line scales 27; gill rakers 24 and 25. (2 specimens).

Color in alcohol of 89 mm specimen: head and anterior half of body light tan with a single black spot on outer edge of each scale of nape and body (except abdomen) and a horizontal black line through eye; posterior half of body blackish, the scales with similar black spots which, however, are visible only in the anterior part of black portion of body where pigmentation is not so intense; dorsal fin blackish with a narrow pale margin on soft portion; anal fin black with a pale margin and a pale spot on each interradial membrane; caudal fin black with a broad pale posterior margin; paired fins pale.

Color in life of 42 mm specimen: two narrow black bands running entire length of body, the first from snout through eye to upper base of caudal fin, the second from chin to lower base of caudal fin (the two bands connect irregularly at base of caudal fin); body dorsal to first band green, ventrally white.

Both species of Gomphosus were seen in the lagoon and outer reef areas, but never where wave action was strong.

Genus HEMIGYMNUS

Hemigymnus Günther 1861. Ann. Mag. Nat. Hist., London, vol. 8, p. 386. (Type species, Mullus fasciatus Thunberg = Labrus fasciatus Bloch).

Hemigymnus fasciatus

Labrus fasciatus Bloch 1792. Natur. ausländ. Fische, vol. 6, p. 6, pl. 290. (Type locality, Japan).

1 specimen. 205 mm. Onotoa.

D IX,11; A II,11; P 14; lateral line scales 28.

Color from 35 mm Kodachrome transparency: body black (except for chest anterior to origin of pelvic fins which is white) with 4 vertical white bars, the first running from anterior part of spinous portion of dorsal fin to mid-abdomen, the last crossing caudal peduncle; dorsal part of head and nape black; head below level of eye light yellow-green with broad, irregular, blue-edged, rose-colored bands; median and pelvic fins black; pectoral fin with rays black, membranes hyaline.

The one specimen seen was speared at a depth of about 30 feet on the coralliferous terrace of the outer reef.

Hemigymnus melapterus

Labrus melapterus Bloch 1791. Natur. ausländ. Fische, vol. 5, p. 137, pl. 285. (Type locality, Japan).

2 specimens. 100 and 119 mm. 1 specimen. 330 mm. Onotoa.

D IX,11; A II,11; P 14; lateral line scales 28. (2 specimens).

Color of 330 mm specimen after one day in formalin: dark green with a purplish cast; slightly curved vertical narrow blue lines on scales of body; head with tortuous rose bands except for a broad block of this color under eye; eye rimmed with irridescent green.

Color in life of 100 mm specimen: body anterior to a diagonal line of demarcation from second dorsal spine nearly to end of pelvic fins white; body posterior to this line to caudal peduncle black; caudal peduncle and caudal fin yellow; 3 black spots in a vertical line at base of caudal fin on one side of fish and a single spot at this location on the other side; head dorsal to lower edge of eye black, ventrally whitish; pale blue spots, one per scale, located posteriorly on black portion of body; dorsal fin black with a reddish marginal band; anal fin black with a narrow reddish margin and a blue submarginal band of about equal width.

Genus PSEUDOCHEILINUS

Pseudocheilinus Bleeker 1861. Proc. Zool. Soc. London, p. 409. (Type species, Cheilinus hexataenia Bleeker).

8 specimens. 38 - 49 mm. Onotoa.

Pseudocheilinus hexataenia

Cheilinus hexataenia Bleeker 1857, Act. Soc. Sci. Ind. Neerl., vol. 2, p. 4. (Type locality, Ambon, East Indies).

D IX, 11, A III,9; P 15 or 16; lateral line scales 23 (anterior part 18, peduncle part 5). (3 specimens).

Color from 35 mm Kodachrome transparency: body dark bluish (reddish on abdomen) with 6 lengthwise bright orange lines; a small black spot at upper edge of base of caudal fin; dorsal and anal fins orange, dusky blue at base; caudal fin green, outer part yellow; head bluish dorsally, shading to buff on snout and cheeks.

All specimens were secured with rotenone in the lagoon or protected outer reef waters.

Genus CHEILINUS

Cheilinus Lacépède 1802. Hist. nat. poiss., vol. 3, p. 529. (Type species, Cheilinus trilobatus Lacépède).

Cheilinus trilobatus

Cheilinus trilobatus Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 529, 537. (Type locality, Madagascar, Mauritius, and Réunion).

9 specimens. 50 - 220 mm. 1 specimen. 17 mm. Onotoa.

D IX,10; A III,8; P 12; lateral line scales 25 (anterior part 16, peduncular part 9). (5 specimens).

Color in life of 173 mm specimen olive brown with a vertical orange-red line in the middle of each body scale; numerous orange-red spots and short lines on head, the 4 longest lines radiating anteriorly from eye; chest and abdomen with large orange spots, the largest in mid-ventral line; soft dorsal and anal fins reddish with greenish rays; anal fin, in addition, blotched with brown; spinous portion of dorsal fin orange distally with a wavy green submarginal line, then a narrower orange line, and blotched orange and green at the base.

Smaller specimens usually had broad vertical dark and light areas on the side of the body and a series of about 5 dark spots midlaterally, the more posterior spots being more conspicuous. The 17 mm specimen is provisionally identified as trilobatus. It was green in life and had the 5 median spots on the body from behind gill opening to base of caudal fin.

The 220 mm specimen has a pronounced tri-lobed caudal fin.

The species was most commonly taken in the lagoon.

Cheilinus undulatus

Cheilinus undulatus Rüppell 1835. Neue Wirbelth. Fische, p. 20, pl. 6, fig. 2. (Type locality, Red Sea).

1 specimen 370 mm. 2 specimens 77 and 78 mm. Onotoa.

D IX,10; A III,8; P 12; lateral line scales 25 (anterior part 16, peduncular part 9). (2 specimens).

Color in life of 675 mm specimen (discarded in field due to large size): olive green with broad vertical dark brown lines on body scales (these lines anterior to tip of pectoral orange-brown); head reticulated with alternating orange and gray lines; 2 black lines extending posteriorly from orbit, the lowermost the longest; median fins narrowly barred with olive-green and brown; pectoral fins olive; pelvic fins dusky.

77 and 78 mm specimens with broad vertical dark bars on body due to a vertically elongate blackish spot on outer edge of each body scale in these areas and absence of this spot on most of the scales in intervening pale areas; two black lines extending diagonally and posteriorly from orbit and meeting just anterior to upper edge of gill opening; a

similar pair of dark lines extending anteriorly from eye toward mouth (these lines faint in 370 mm specimen).

The two small specimens were taken in a sandy-bottomed pond-like body of water narrowly confluent with the lagoon proper. The large specimens were taken from deeper water in outer reef areas. Individual fish of this species of very large size (estimated to 6 feet or more in length) with a large hump on the forehead were seen on many occasions at the extreme edge of the outer reef in about 50 feet of water. They were often almost motionless in the water or swam very slowly.

Cheilinus diagrammus

Labrus diagramma Lacépède 1802. Hist. nat. poiss., vol. 3, pp. 448, 518. (Type locality, "le grand Océan équatorial").

Cheilinus radiatus Bleeker 1862. Atlas ichth., p. 68, pl. 26, fig. 1.

2 specimens. 147 and 170 mm. Onotoa lagoon.

D IX,10; A III,8; P 12; lateral line scales 25 (anterior part 16, posterior part 9). (2 specimens).

Color in life: head and upper half of body greenish brown grading into dull orange on ventral half of body; a large vertical oblong red spot antero-centrally on each body scale; a series of about 5 orange-red lines on upper part of head parallel with upper profile of head; perpendicular to these on cheek another series of about 8 such lines which start out orange-red and shade into dark purple ventrally; base of caudal and upper and lower lobes dark purplish; outer, central part of caudal fin green; dorsal, anal, and pelvic fins reddish; pectoral fin light orange.

Cheilinus fasciatus

Sparus fasciatus Bloch 1791. Natur. ausländ. Fische, vol. 5, p. 18, pl. 257. (Type locality, Japan).

Cheilinus fasciatus, Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 360. (Kingsmill Islands).

Cheilinus chlorourus

Sparus chlorourus Bloch 1791. Natur. ausländ. Fische, vol. 5, p. 24, pl. 260 (Type locality, Japan and St. Domingo).

Cheilinus chlorurus, Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 362. (Kingsmill Islands).

Genus EPIBULIS

Epibulis Cuvier 1817. Règne animal, p. 264. (Type species Sparus insidiator Pallas).

Epibulis insidiator

Sparus insidiator Pallas 1770. Spicil. Zool., vol. 8, p. 41, pl. 5, fig. 1. (Type locality, Java).

4 specimens. 87 - 220 mm. Onotoa lagoon.

D IX,10; A III,8; P 12; lateral line scales 21 to 23 (anterior part 12 or 14, peduncular part 9 or 10). (3 specimens).

Color in life of 220 mm specimen dark yellowish brown with forest green edges to scales in middle of body; iris orange; fins dark brown except pectoral which is dusky orange.

No specimens in the yellow color phase were sighted.

Family SCARIDAE

The parrotfishes were one of the dominant families of fishes in the Gilbert Islands, as elsewhere in tropical marine waters. Taxonomically, they are a very difficult group; therefore much time was devoted to collecting them (mostly by spearing), making color notes, and taking color photographs. All of the specimens, field notes, and color pictures were made available to Dr. Leonard P. Schultz of the United States National Museum who is monographing the family. The Onotoa and Tarawa records listed below represent his identifications.

Genus SCARUS

Scarus Forskål 1775. Descr. animalium. p. 25. (Type species, Scarus psittacus).

Scarus sordidus

Scarus sordidus Forskål 1775. Descr. animalium, pp. x, 30. (Type locality, Red Sea).

Pseudoscarus abacurus Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 329, pl. 162). (Kingsmill Islands)

38 specimens. 38 - 200 mm. Onotoa.

2 specimens. 147 and 197 mm. Tarawa..

Scarus microrhinos

Scarus microrhinos Bleeker 1854. Nat. Tijdschr. Ned.-Indië, vol. 6, p. 200. (Type locality, Batavia, Java).

1 specimen. 285 mm. Onotoa.

Scarus harid

Scarus harid Forskål 1775. Descr. animalium, pp. x, 30. (Type locality, Red Sea).

3 specimens. 150 - 320 mm. Onotoa.

Scarus javanicus

Scarus javanicus Bleeker 1854. Nat. Tijdschr. Ned. Indië, vol. 6, p. 198. (Type locality, Java).

No specimens were taken. Large parrot-fish were seen on the outer coralliferous terrace which may have been this species. They appeared gray underwater, with the posterior half of the body abruptly paler than the anterior half.

Scarus formosus

Scarus formosus Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 283. (Type locality, Hawaiian Islands).

1 specimen. 160 mm. Butaritari.

Scarus schlegeli

Pseudoscarus schlegeli Bleeker 1861. Verslag. Akad. Wet. Amsterdam, vol. 12, p. 242. (Type locality, Celebes).

1 specimen. 180 mm. Onotoa.

Scarus forsteri

Scarus forsteri Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 275. (Type locality, Tahiti).

1 specimen. 96 mm. Onotoa.

Scarus globiceps

Scarus globiceps Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 242. (Type locality, Tahiti).

1 specimen. 170 mm. Onotoa.

1 specimen. 240 mm. Butaritari.

Scarus brevifilis

Pseudoscarus brevifilis Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 327, pl. 161. (Type locality, Tahiti and Abemama, Gilbert Islands).

7 specimens. 23 - 225 mm. Onotoa.

Scarus lepidus

Scarus lepidus Jenyns 1842. Zool. voyage "Beagle", pt. 4, Fish, p. 108. (Type locality, Tahiti).

Callyodon laxtoni Whitley. 1948. Rec. Australian Mus., vol. 22, p. 94. (Ocean Island).

Scarus vermiculatus

Callyodon vermiculatus Fowler and Bean 1928. Bull. U. S. Nat. Mus. 100, vol. 7, p. 472, pl. 49. (Type locality, Philippine Islands).

2 specimens. 65 and 240 mm. Onotoa.

Scarus chlorodon

Scarus chlorodon Jenyns 1842. Zool. voyage "Beagle", pt. 4, Fish, p. 105, pl. 21. (Type locality, Keeling Island, Indian Ocean).

Pseudoscarus altipinnis Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 326, pl. 160. (Kingsmill Islands).

3 specimens. 150 - 205 mm. Onotoa.

1 specimen. 260 mm. Butaritari.

Scarus oviceps

Scarus oviceps Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 244. (Type locality, Tahiti).

4 specimens. 128 - 220 mm. Onotoa.

Scarus niger

Scarus niger Forskål 1775. Descr. animalium, pp. x, 28. (Type locality, Red Sea).

3 specimens. 135 - 200 mm. Onotoa.

Scarus aeruginosus

Scarus aeruginosus Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 257. (Type locality, Red Sea).

2 specimens. 129 and 134 mm. Onotoa.

Scarus pectoralis

Scarus pectoralis Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 269. (Type locality, Djedda, Red Sea).

2 specimens. 150 and 230 mm. Onotoa.

1 specimen. 160 mm. Butaritari.

Scarus dussumieri

Scarus dussumieri Cuvier and Valenciennes 1839. Hist. nat. poiss., vol. 14, p. 252. (Type locality, Seychelles).

2 specimens. 250 and 300 mm. Onotoa.

Scarus taeniurus

Scarus taeniurus Cuvier and Valenciennes. 1839. Hist. nat. poiss., vol. 14, p. 257. (Type locality, Mauritius).

2 specimens. 78 and 87 mm. Onotoa.

Scarus ghobban

Scarus ghobban Forskål 1775. Descr. animalium, p. 28. (Type locality, Red Sea).

Pseudoscarus garretti Günther 1909. Jour. Mus. Godeffroy, vol. 6, pt. 16, p. 306, pl. 153, fig. C. (Type locality, Kingsmill Islands).

4 specimens. 160 - 190 mm. Onotoa.

Scarus sp.

This is a reddish brown parrot-fish with longitudinal lines on the body, red fins, and a pale caudal peduncle which will be described as new by L. P. Schultz.

Genus CHLORURUS

Chlorurus Swainson 1839. Nat. hist. class. fishes, amphibians,..., vol. 2, p. 227. (Type species, *Scarus gibbus*).

Chlorurus gibbus

Scarus gibbus Rüppell 1828. Atlas Reise nördlichen Afrika, p. 81, pl. 20, fig. 2. (Type locality, Red Sea).

A school of over 20 very large parrot-fishes with tremendously swollen foreheads was observed at the west reef at Onotoa. From my description Dr. Schultz believes that these were *gibbus*.

Chlorurus bicolor

Chlorurus bicolor Rüppell 1828. Atlas Reise nördlichen Afrika, p. 82, pl. 21. (Type locality, Djedda, Red Sea).

Although this species was seen on numerous occasions, no specimens were taken. A close-range spearing attempt resulted in the securing of a single scale from a large adult.

Family KYPHOSIDAE

No kyphosids were collected in the Gilbert Islands by the author; however, unidentified individuals of the genus *Kyphosus* were occasionally seen underwater.

I follow Fowler (1928: 221) in considering *Pachymetopon squamosum* Alleyne and Macleay as a synonym of *Kyphosus cinerascens* Forskål.

Genus KYPHOSUS

Kyphosus Lacépède 1802. Hist. nat. poiss., vol. 3, p. 114. (Type species, *Kyphosus bigibbus* Lacépède = *Xyster fuscus* Lacépède).

Kyphosus cinerascens

Sciaena cinerascens Forskål 1775. Descr. animalium, pp. xii, 53. (Type locality, Arabia).

Opisthistius squamosus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 293. (Nauru).

Family CHAETODONTIDAE

The butterfly and angel fishes need no introduction. With their striking color patterns and high compressed bodies, they are well known to all. They were very conspicuous on Gilbert Islands reefs, especially the species with bright yellow color. One wonders at the survival value of such color which so attracts the eye. To my knowledge it does not advertise poisonous spines or distasteful qualities (at least to man). Some authors such as Norman (1931: 212) have stressed the role of disruptive coloration in the black bands and spots that are so often present in *Chaetodon*. These markings may be operative in this way for some marine predators, but I have never found myself nearly overlooking a chaetodont on this basis. I believe that the bright color and distinctive markings function more for species recognition, not just in chaetodonts, but in reef fishes of tropic seas in general. This I infer from the great multiplicity of species and from the clear water which enhances the use of visual stimuli in species recognition. Also, fishes of the reef areas are provided with excellent cover in the many interstices in the coral, and the need for blending with the surroundings to escape notice of roving predators is not such a keen one. Under such circumstances selection against bright color pattern is lessened.

Some species of butterfly fishes such as *Chaetodon auriga* employ a mode of swimming by which they may avoid detection. They angle their bodies toward a potential danger, displaying them in narrow dorsal aspect.

The high body and array of stout dorsal and anal spines of these fishes is probably of considerable importance in their escaping predation.

At Onotoa the Gilbertese referred to nearly all the species of *Chaetodon* by the one name *Teibaba*.

Subfamily CHAETODONTINAE

Included in this grouping are the butterfly fishes, distinguished from the angel fishes primarily by lacking the long stout spine near the angle of the preopercle.

Although observed in nearly all habitats, the butterfly fishes were no where abundant. They were usually seen singly or in pairs.

Genus CHAETODON

Chaetodon Linnaeus 1758. Syst. nat., ed. 10, vol. 1, p. 272. (Type species, Chaetodon capistratus Linnaeus).

Chaetodon auriga

Chaetodon auriga Forskål 1775. Descr. animalium, pp. xiii, 60. (Type locality, Red Sea).

Chaetodon setifer Kendall and Goldsborough 1911. Mem. Mus. Comp. Zoöl., vol. 26, p. 306. (Butaritari).

2 specimens. 90 and 125 mm. 12 specimens. 22 - 25 mm. Onotoa.

D XIII, 22 to 24; A III, 19 or 20; P 16. (2 specimens)

Color in life white, yellow-orange posteriorly and on soft dorsal and anal fins; a broad vertical black bar through eye; a large black spot in outer part of soft dorsal fin adjacent to ray which extends as a filament; 5 diagonal black lines running from opercle toward spinous dorsal; about 9 similar parallel lines perpendicular to the first set and running across chest and side of body to base of anal fin; a brownish region dorsally between yellow and white coloration of body in which there are yellow lines paralleling both sets of black lines as described.

This was the most abundant species in the Onotoa lagoon.

Chaetodon ephippium

Chaetodon ephippium Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 80, pl. 174. (Type locality, Moluccas and Society Islands).

1 specimen. 135 mm. 3 specimens. 19 - 36 mm. Onotoa.

D XIII, 23; A III, 20; P 16. (1 specimen).

Color from 35 mm Kodachrome transparency light gray with a large purplish black area on back and dorsal fin posterior to 6th dorsal spine, this area broadly bordered ventrally in white; tip of snout and a broad region ventrally on chest to origin of pelvic fins orange; about 6 lengthwise purplish lines on lower half of side of body; caudal fin purplish hyaline with upper and lower lobes narrowly yellow and base reddish orange; a band of yellow and red-orange in outer part of soft dorsal fin running from base of filament to axil of soft dorsal; anal fin white with a broad yellow marginal and a reddish submarginal band; pelvics yellow.

This species was seen only in the lagoon at Onotoa.

Chaetodon lineolatus

Chaetodon lineolatus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 40. (Type locality, Mauritius).

Chaetodon lineolatus Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 45; pl. 34, fig. A. (Kingsmill Islands).

Chaetodon vagabundus

Chaetodon vagabundus Linnaeus 1758. Syst. nat., ed. 10, p. 276. (Type locality, Indies).

3 specimens. 105 - 115 mm. 4 specimens. 22 - 25 mm. Onotoa.

2 specimens. 97 and 107 mm. Tarawa.

D XIII, 24 or 25; A III, 19 or 20; P 16. (3 specimens).

Color from 35 mm Kodachrome transparency white, dusky white posteriorly, with a vertical black bar extending from nape through eye to isthmus; a black line at base of spinous dorsal, broadening into a band at base of soft dorsal, and continuing across base of caudal fin on to anal fin; 6 diagonal narrow black lines running from upper part of head toward spinous dorsal fin; 12 similar lines perpendicular to first set running across body toward anal fin and base of caudal fin; soft dorsal fin yellow with a broad black margin; anal fin yellow with a pale margin and a black submarginal line; caudal fin yellow (except narrow margin which is hyaline) with 2 vertical black bars, the outer one narrow and submarginal to hyaline outer part of fin.

C. vagabundus was taken only in the lagoon. It was more characteristic of areas of rich coral growth than auriga or ephippium which seem to prefer sandy regions with little coral.

Chaetodon ornatissimus

Chaetodon ornatissimus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 22. (Type locality, Tahiti).

1 specimen. 115 mm. Onotoa.

1 specimen. 145 mm. Tarawa.

D XII, 25; A III, 21; P 17. (1 specimen).

Color from 35 mm Kodachrome transparency white with 6 prominent diagonal orange bands crossing body, the most ventral nearly parallel with base of anal fin; head and nape yellow; a vertical black band through eye; a vertical black line just behind eye extending as a submarginal line into the dorsal fin, meeting at its terminus the fourth orange body band; a vertical black line on snout; lower lip black; a dusky orange vertical line on operculum; caudal fin with basal half white, then a black band, a broad yellowish area, and a black margin.

The species was only sighted on two occasions, each time on the coralliferous terrace of the outer reef.

Chaetodon meyeri

Chaetodon meyeri Bloch and Schneider 1801. Systema ichth., p. 233. (Type locality, Moluccas).

6 specimens. 32 - 130 mm. Onotoa.

D XII, 24 or 25; A III, 20 or 21; P 17. (4 specimens).

Color from 35 mm Kodachrome transparency white with long curving black bands as follows: one beginning as a submarginal band near end of soft dorsal fin, leaving fin at level of 4th dorsal spine and sweeping across operculum and chest to base of anal fin; a second beginning dorsally near base of caudal fin, extending to base of pectoral fin, up to spinous dorsal, and curving back to pectoral base; third and fourth beginning beneath pectoral fin, running diagonally back to soft dorsal, and curving forward on this fin; a yellow-margined, vertical, black bar through eye; all fins yellow, median fins with black bands; a row of orange dots in soft dorsal, several rows dorso-anteriorly on body, and 2 narrow, vertical, orange lines in caudal fin.

This striking species was taken both in the lagoon and in outer reef areas, but always in regions of high coral cover.

Chaetodon falcula

Chaetodon falcula Bloch 1793. Natur. ausländ. Fische, pt. 7, p. 102, pl. 325, fig. 2.

3 specimens. 103 - 111 mm. 1 specimen. 38 mm. Onotoa.

D XII, 24; A III, 20; P 15 or 16. (3 specimens).

Color from 35 mm Kodachrome transparency dusky white, yellow posteriorly, with 2 large vertical blackish areas on side and extending on to dorsal fin, the first just behind head, the second adjacent to yellow color of posterior part of body; about 17 vertical black lines on body, more apparent in whitish area between the two blackish areas; a vertical black band crossing head and passing through eye; a black spot at base of caudal fin; median fins yellow, caudal with edge hyaline and a submarginal black line; indistinct submarginal black lines in dorsal and anal; pelvic fins white; pectorals hyaline.

All of the specimens were collected in the lagoon around coral heads.

Chaetodon kleini

Chaetodon kleinii Bloch 1790. Natur. ausländ. Fische, pt. 4, p. 7, pl. 218, fig. 2. (Type locality, East Indies).

4 specimens. 36 - 80 mm. Onotoa.

D XIII, 21 or 22; A III, 19; P 15. (4 specimens).

Color in life of 80 mm specimen dusky yellowish on anterior half of body, dull orange posteriorly and on dorsal and anal fins; a vertical black band running from nape across head through eye and curving across chest to pelvic fins which are dark; 2 indistinct broad vertical brown areas, the first just behind head, the second at front of posterior orange part of body; caudal fin yellow with a white band at base, outer one-fourth hyaline; posterior part of soft dorsal and soft anal fins with narrow hyaline margin and a narrow black submarginal line; tip of snout black.

A rare species, C. kleini was taken in only two localities, one in the lagoon in 18 feet of water near a large coral head and the other on the outer reef on the lee side.

Chaetodon bennenti

Chaetodon Bennetti Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 84. (Type locality, Sumatra).

5 specimens. 79 - 120 mm. Onotoa.

D XIV, 17 or 18; A III, 16; P 16 or 17 (mostly 16). (5 specimens).

Color from 35 mm Kodachrome transparency yellow with a large round black spot rimmed in blue on the back just posterior to midpoint of body; area around this black spot dusky; two bright blue bands originating on opercle and passing posteriorly and ventrally on body; a blackish blue-bordered band running from nape across head through eye.

Chaetodon bennenti was found in all major regions of the atoll, but was not common in any.

Chaetodon quadrimaculatus

Chaetodon quadrimaculatus Gray 1833. Zool. Misc., p. 33. (Type locality, Hawaiian Islands).

1 specimen. 38 mm. Onotoa.

D XIV, 21; A III, 16; P 16.

Color in alcohol: body dark brown on dorsal half, pale yellowish (yellow in life) ventrally; a round pale (white in life) spot on middle of back just above lateral line; a second pale area (also white in life on back, half way from pale spot to base of caudal fin (this area confluent with pale yellowish of lower half of body); head pale with a black bordered band (recalled as orange in life) running from origin of dorsal through eye to lower edge of operculum; caudal fin and posterior parts of soft dorsal and anal fins pale; pelvic fins pale; pectoral fins hyaline.

The single small specimen was the only one seen at Onotoa. It was speared close inshore off the small island of Aunteuma in the northern part of the atoll.

Chaetodon lunula

Pomacentrus lunula Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 507, 511, 513.

2 specimens. 62 and 129 mm. 7 specimens. 19 - 22 mm. Onotoa.

D XII, 24 or 25; A III, 18; P 16. (2 specimens).

Color from 35 mm Kodachrome transparency of 62 mm specimen: dorsal half of body and base of dorsal fin blackish purple; ventral half of body dirty yellow; head pale with a vertical black band through eye; adjacent and posterior to this, a broad white band; a broad black band bordered with yellow narrowing as it passes to middle of base of spinous dorsal fin; a large black area on caudal peduncle edged in bright yellow; a black spot in middle base of soft dorsal fin with a yellow line running from its base to yellow area at front of black area on caudal peduncle; basal half of caudal fin yellow, outer half clear, these two regions separated by a narrow black band; dorsal fin with a distinct black marginal band, yellow submarginally; anal fin yellow with a narrow black margin; pelvics yellowish; pectorals yellowish-hyaline; faint diagonal lines on body.

This well-known species was seen in many atoll environments, but most commonly in the lagoon.

Chaetodon trifasciatus

Chaetodon trifasciatus Mungo Park 1797. Trans. Linn. Soc. London, vol. 3, p. 34. (Type locality, Sumatra).

10 specimens. 22 - 97 mm. Onotoa.

D XIII, 21 or 22 (mostly 21); A III, 19 or 20; P 15. (5 specimens).

Color from 35 mm Kodachrome transparency tan dorsally shading to orange-yellow ventrally with about 14 narrow, slightly curved, lengthwise, purplish lines on side of body; a black bar, edged in bright orange-yellow, on head passing through eye; posterior and adjacent to this a narrow white and a narrow black band; end of snout black; basal part of spinous dorsal with many narrow lines such as appear on body; outer membranes of spinous dorsal whitish; soft dorsal with 4 lengthwise bands of about equal width, a light dusky outer band, a white band narrowly edged in black, a yellowish band, and a black basal band (broader posteriorly and edged in yellow); base of anal soft fin bluish, then a broad white line, a black band, a narrow bright yellow line, a broad blackish area, and a narrow whitish margin; anal spines dusky orange; caudal peduncle bluish with a black spot dorsally (in line with black band at base of soft dorsal); caudal fin white on base, followed by a vertical black band, a narrow yellowish line, and outer one-third hyaline; pelvic fins yellow; pectorals hyaline.

A very omnipresent chaetodont, this species was probably the most abundant generally at Onotoa.

The stomach contents of 7 adult specimens were examined. They consisted primarily of green algae.

Chaetodon reticulatus

Chaetodon reticulatus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 32, pl. 171. (Type locality, Tahiti, and Ulea = Woleai, Caroline Islands).

This distinctive species was seen at Onotoa, but no specimens were taken.

Genus MEGAPROTODON

Megaprotodon Guichenot 1848. Rev. Zool., vol. 11, p. 12. (Type species, Chaetodon bifasciatus Cuvier and Valenciennes).

Megaprotodon strigangulus

Chaetodon strigangulus Gmelin 1788. Syst. nat., ed. 13, p. 1269.

2 specimens. 54 and 140 mm. Onotoa lagoon.

D XIV, 15; A IV 14 or 15; P 15. (2 specimens).

Color from 35 mm Kodachrome of large specimen white with about 14 "V"-shaped lines on side of body, the bottom of each V pointing forward about in mid-line of body (posteriorly there are more dorsal limbs of the V's than ventral); a black band, bordered in yellow, running from nape through eye to isthmus; caudal fin black with upper and lower margins narrowly yellow, a black posterior margin, and a yellow submarginal band; dorsal fin orange-yellow with a very narrow black margin posteriorly; anal fin pale yellowish with a narrow black margin over ends of soft rays; pelvic fins white; pectoral fins hyaline with a yellowish spot at upper edge of base.

The 54 mm specimen has a large black crescent-shaped area (preceded by a pale band) on hind part of body, posterior part of dorsal and anal fins, and base of caudal fin; posterior to this in the caudal fin is a pale triangular area with a black line at its base which is submarginal to outer hyaline part of fin.

Genus HENIOCHUS

Heniochus Cuvier 1817. Règne animal, ed. 1, vol. 2, p. 335. (Type species, Chaetodon macrolepidotus Bloch).

Heniochus permutatus

Heniochus permutatus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 77, p. 99.

2 specimens. 118 and 127 mm. 6 specimens. 36 - 42 mm. Onotoa.

D XIII, 22 or 23; A III, 17 or 18; P 15. (4 specimens).

Color of 42 mm juvenile specimen from 35 mm Kodachrome transparency white with 3 diagonal black bands on body, the first running from nape across head to pelvic region, the second from the 3rd to 9th dorsal spines (and extending out on long filament of 4th dorsal spine) to the soft anal fin, and the third (a narrower band) at base of soft dorsal; a pale-rimmed, black spot in soft anal fin; caudal fin hyaline with a black spot at base of upper rays; pelvic fins black; pectoral fins hyaline; snout yellow.

The young were taken from tidepools on the outer reef flat and in shallow lagoon or channel waters. The two adults were poisoned with rotenone from a protected outer reef area with numerous coral heads.

Heniochus acuminatus

Chaetodon acuminatus Linnaeus 1758. Syst. nat., ed. 10, p. 272. (Type locality, Indies).

24 specimens. 25 - 46 mm. Onotoa.

D XI, 25 or 26; A III, 18 or 19; P 17 or 18. (5 specimens).

Color in alcohol white with 2 broad diagonal black bands on body, the first from anterior part of dorsal fin to pelvic fins (and including them), the second from 5th to 11th dorsal spines to posterior half of anal fin. The membraneous filament of the 4th dorsal spine of this species (not well developed in the smaller specimens) is white.

Only juveniles were collected, all from shallow-water lagoon areas.

Heniochus varius

Taurichthys varius Cuvier 1829. Règne animal, ed. 2, vol. 2, p. 192. (Type locality, East Indies).

3 specimens. 33 - 42 mm. Onotoa.

D XI, 23 or 24; A III, 17 or 18; P 15. (3 specimens).

Color of 42 mm specimen from 35 mm Kodachrome transparency dark brown with a white band running from origin of dorsal fin across posterior part of head to chest and another one running diagonally from posterior part of spinous dorsal to caudal peduncle; outer portion of soft dorsal fin and all of caudal fin and pectoral fins hyaline; pelvic and anal fins dark brown; numerous, pale, lengthwise lines faintly visible on body.

All specimens were taken from around coral heads in the lagoon. One was speared by D. W. Strasburg.

Subfamily POMACANTHINAE

Genus POMACANTHUS

Pomacanthus Lacépède 1802. Hist. nat. poiss., vol. 4, p. 517. (Type species, Chaetodon arcuatus Linnaeus, as restricted by Cuvier).

Pomacanthus imperator

Chaetodon imperator Bloch 1787. Natur. ausländ. Fische, vol. 3, p. 51, pl. 174. (Type locality, Japan).

Pomacanthoides imperator Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 293. (Nauru).

Genus CENTROPYGE

Centropyge Kaup 1860. Arch. Naturg., vol. 26, pt. 1, p. 140 (Type species, Centropyge tibicen Kaup).

Centropyge flavissimus

Holocanthus flavissimus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 197. (Type locality, Ulea = Woleai, Caroline Islands).

3 specimens. 74 - 100 mm. Onotoa.

D XIV, 15 or 16; A III, 16; P 16 or 17. (3 specimens).

Color from 35 mm Kodachrome transparency bright yellow with a blue ring around the eye; edge of opercle light blue with extreme margin above base of pectoral black; spines at corner and lower limb of preopercle light blue; soft dorsal, soft anal, and caudal fins with a narrow pale blue margin and a thin black submarginal line.

The species was taken on the outer reef or in the lagoon where coral was abundant. It is the most common angel fish at Onotoa.

Centropyge bicolor

Chaetodon bicolor Bloch 1787. Nat. ausländ. Fische, pt. 3, p. 94, pl. 206, fig. 1. (Type locality, East Indies).

Holacanthus bicolor Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 261. (Kingsmill Islands).

A small, bright yellow angel fish with broad blue bars was sighted at a depth of about 25 feet in the Onotoa lagoon near a coral knoll. It was probably this species.

Genus PYGOPLITES

Pygoplites Fraser-Brunner 1933. Proc. Zool. Soc. London, p. 587. (Type species, Chaetodon diacanthus Boddaert).

Pygoplites diacanthus

Chaetodon diacanthus Boddaert 1772. Epistola...de Chaetodonte diacantho descripto, p. 19. (Type locality, Ambon, East Indies).

1 specimen. 140 mm. Onotoa.

1 specimen. 131 mm. Tarawa.

D XIV, 19; A III, 19; P 16. (1 specimen).

Color from 35 mm Kodachrome transparency: body with alternate bars of blue and orange (the blue dark with pale centers) which extend on to and curve backwards on dorsal and anal fins; caudal fin bright yellow; head and chest purplish; 2 vertical blue lines running from nape to eye; margin of opercle and margin of preopercle with a blue line; spine at corner of preopercle blue; mouth orange-yellow; pelvic fins orange; pectoral fins hyaline-yellow.

The Onotoa specimen was speared near a coral head in the lagoon.

Family EPHIPPIDAE

Genus PLATAX

Platax Cuvier 1817. Règne animal, ed. 1, vol. 2, p. 334. (Type species, Chaetodon tiera Bloch)

Platax orbicularis

Chaetodon orbicularis Forskål 1775. Descr. animalium, p. 59. (Type locality, Red Sea).

1 specimen. 88 mm. Tarawa.

D V, 35; A III, 25; P 18.

Teeth as in Fig. 49 b and body shape as in Fig. 51 (left) of Weber and de Beaufort (1936).

Family ZANCLIDAE

Genus ZANCLUS

Zanclus Cuvier and Valenciennes 1831. Hist. nat. poiss., vol. 7, p. 102. (Type species, Chaetodon cornutus Linnaeus).

Zanclus cornutus

Chaetodon cornutus Linnaeus 1758. Syst. nat., ed. 10, p. 273. (Type locality, Indies).

Chaetodon canescens Linnaeus 1758. Syst. nat., ed. 10, p. 215.

Zanclus cornutus Günther 1876. Jour. Mus. Godeffroy, vol. 5, pt. 11, p. 142, pl. 92.

Zanclus canescens Herre 1927. Philip. Jour. Sci., vol. 34, p. 472, pl. 8.

Zanclus cornutus Herre, ibid, p. 473, pls. 9, 10.

Zanclus cornutus Weber and de Beaufort 1936. Fishes Indo-Austral. Arch., vol. 7, p. 170, fig. 44.

Zanclus canescens Weber and de Beaufort, ibid, p. 172, fig. 45.

Zanclus cornutus Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, p. 610, pl. 50, A.

Zanclus canescens Woods, ibid, p. 612, pl. 60.

4 specimens. 57 - 130 mm. Onotoa.

D VII,40 to 42; A III,34 or 35; P 18 or 19. (3 specimens).

Color from 35 mm Kodachrome transparency of 130 mm specimen: body white and yellow with a very broad black region from origin of dorsal and nape, enclosing eye and base of pectoral fin, and broadening ventrally on chest and abdomen; a broad black band on posterior part of body extending into soft dorsal and soft anal fins (this area followed by a narrow white and a narrow black line); caudal peduncle and posterior part of soft dorsal and anal fins yellow; caudal fin black with a white margin and a white diagonal line at base; snout white with a black-edged, orange saddle-like mark dorsally; lower lip and outer half of chin black; pectoral fins hyaline with dusky rays; pelvic fins black.

Specimens were taken from both the lagoon and outer reef. The stomach contents of two adult specimens were examined and found to be mostly algal. A small amount of bottom sediment had also been ingested.

There has been a long-standing controversy as to whether Zanclus canescens Linnaeus is the young of Zanclus cornutus Linnaeus or whether the two are valid species. The consensus of recent works favors the latter opinion. Weber and de Beaufort (1936: 173) have reviewed the problem in detail. Although these authors admit that canescens is probably of a more pelagic habit and no specimens above 80 mm in length (apparently total length) are known, they prefer to recognize both species.

I have examined Zanclus in the collections of the United States National Museum, Stanford Natural History Museum, California Academy of Sciences, Bishop Museum, and University of Hawaii. All of the large specimens are cornutus. Those specimens with a prominent preorbital spine just above and slightly posterior to the rictus (canescens of some authors) were all small, the largest being 63 mm in standard length. Some specimens of typical cornutus were as small as 52 mm. In my opinion canescens is the late post larval stage of cornutus, and the size at transformation from the canescens form to the juvenile cornutus is variable as has been demonstrated for various species of surgeon fishes (Breder, Copeia, 1949: 296) (Randall, MS).

Although specimens were found which were variously intermediate in color between the pale (probably transparent in life) canescens with silvery abdomen and the black-banded cornutus, none were seen with the preorbital spine undergoing gradual resorption as was expected. Two specimens at the California Academy of Sciences (No. 7162), 52 and 54 mm in standard length, provide a possible answer to this enigma. Although traces of silvery color are still present on the abdomen of these specimens, and the broad vertical bars are not intensely black, the spine on each side of both is completely gone. At its site is a slightly depressed area of exposed preorbital bone about the size of the base of the spine. The epidermis at the margin of this area is free and jagged. This suggests that the preorbital spine may be shed as a unit during transformation. It seems unlikely that the spine on both sides of the two specimens would have been torn off during or subsequent to their capture. Confirmation of the hypothesis that the spine is shed could be most convincingly obtained by placing a live canescens in an aquarium and observing the postulated transformation into cornutus.

I examined the 63 mm specimen reported by Woods in Schultz and collaborators (1953: 612, pl. 60) as Z. canescens. It was taken at the entrance to a channel to Bikini Atoll by night lighting, and it still shows the silver coloration over the abdomen. On recounting the fin rays, I find that there are 33 soft rays in the anal fin instead of 32. The 57 mm specimen from Onotoa is a late canescens form with the preorbital spine. Its fin ray counts are D VII,42; A III,35, well within the range given by Woods for cornutus; thus the apparent separation of canescens and cornutus by fin ray counts as tabulated by this author is probably not valid. It resulted from his two specimens of canescens being, by chance, ones with low counts.

To my knowledge, Günther (1876: 142) was the first to indicate that Z. canescens is the young of Z. cornutus. He used only the name cornutus; therefore this name is preferred in spite of the page priority of canescens.

The pair of supraorbital horns that are deemed characteristic of cornutus were not seen on any small examples of Zanclus. Some specimens as large as 120 mm in standard length lacked these bony prominences; others as small as about 90 mm had them at least partly formed. Good-sized adult specimens generally showed either well-developed horns or short nubbins. Fifteen such specimens were sexed. Seven had large horns and were all males; the remaining eight had short horns and were females. A 128 mm male from the Philippines had horns which exceeded in length the diameter of the pupil of the eye. The horn length (measured from tip to base where head squamation appears) of a 130 mm female taken in the Gilbert Islands was contained about 4 times in the diameter of the pupil.

It is suspected that the variability in length of fish at which horns develop is also a manifestation of sexual differences, the males forming their horns sooner. This could not be demonstrated because of the difficulty in determining the sex of subadult specimens that have been in preservative for many years.

Family ACANTHURIDAE

The surgeon fishes are well known for their herbivorous food habits and the possession of defensive apparatus in the form of a single folding spine or a pair of fixed, keel-like spines on each side of the caudal peduncle. At Onotoa they were the most abundant family of fishes of their size on the reefs. Some species such as Acanthurus mata, A. bleekeri, A. pyroferus (= celebicus) and certain of the Naso were not seen or taken in the Gilbert Islands but probably occur there. Fowler (1928: 270) recorded Acanthurus dussumieri (as Hepatus bariene) from the Kingsmill Islands. In view of the known distribution of this species (Randall, in press), this record should be checked.

An intersting zonation of different species of acanthurids was observed on the outer sea reef at Onotoa. In inshore reef areas, exposed as tide pools at low tide, the young of Acanthurus triostegus were very abundant. Farther seaward but still on the reef flat the adults of A. triostegus were the dominant surgeon fishes. In the surge channels three species of Acanthurus were commonly seen. A. guttatus was observed in small schools in the highly turbulent water toward the apices of the surge channels. A. achilles was occasionally seen in the same area but seemed to prefer less turbulent surge channel water to seaward. The colorful A. lineatus occurred throughout the surge channels but predominated in the broad outer parts as they opened on to the coralliferous terrace. A. glaucopareius and Ctenochaetus striatus were especially abundant in the latter zone.

Key to the Species of Acanthuridae Recorded from the Gilbert Islands

1a. Caudal peduncle armed on each side either with 2 sharp, laterally-projecting, fixed spines or a pair of small bony protuberances; dorsal spines V to VII (usually VI or VII) anal spines II; pelvic fin rays I,3; teeth conical or almost so, without denticulations or with very slight marginal serration; least depth of caudal peduncle contained 3.5 to 6 times in head length; a prominent bump or horn often present on forehead.....2

1b. Caudal peduncle armed on each side with a single, sharp, folding spine, fitting into a horizontal groove in side of body; dorsal spines IV, V, VIII, or IX; anal spines III; pelvic fin rays I,3 or I,5; teeth flattened, always with prominent marginal denticulations; least depth of caudal peduncle contained 2.1 - 3.5 in head length; a prominent bump or horn never present on forehead...6

2a. Caudal peduncle spines and broad area surrounding each spine pale (orange in life) and in sharp contrast to dark brown color of rest of body; no horn or bony prominence present on forehead; a distinct pale (yellow in life) line running dorsally from rictus and curving posteriorly to eye; margin of preopercle pale.............................Naso lituratus

2b. Caudal peduncle spines or protuberances and surrounding area not distinctly paler than rest of body; a conspicuous horn or rounded bony eminance present on forehead of adults; color not as in 2a............3

3a. A horn-like protuberance on forehead of adults.........4

3b. A prominent hump on forehead of adults.................5

4a. Base of rostral horn posterior to rictus; body (except in acronurus or keris stage which is spotted) without spots or vertical lines; caudal spines surrounded by blackish areas (blue in life); teeth without small denticulations (though teeth at sides of jaw may show faint marginal serration); pectoral rays 17 or 18 (all elements counted)..................*Naso unicornis*

4b. Base of rostral horn anterior to rictus; body faintly marked with indistinct vertical dark lines, ventrally with spots; no blackish areas around caudal spines; margins of teeth with small denticulations; pectoral rays 15 or 16 (all elements counted)...*Naso brevirostris*

5a. Side of body without numerous long vertical dark lines; head, dorsal 2/3 of body, and caudal fin with many small black spots; dorsal and anal fins not elevated, length of last dorsal spine contained more than 2 times in length of snout; caudal spines (at least in specimens as large as 250 mm in standard length) not long and blade-like with tips curved forward; caudal fin without long narrow filaments..*Naso tuberosus*

5b. Side of body with numerous long vertical dark lines; back, head, chest, and abdomen with small dark spots; dorsal and anal fins elevated, length of last dorsal spine about equal to length of snout; caudal spines of adults long and blade-like with tips curved forward (similar to *lituratus* and *unicornis*); caudal fin may have long, narrow, posterior filaments, one from the upper and one from the lower lobe..*Naso vlamingi*

6a. Pelvic fin rays I, 3; soft dorsal rays 18 to 20; scales on head broad and tuberculated; a broad black area on back enclosing an oval grayish (blue in life) region at tip of pectoral fin; a long yellowish triangle (yellow in life) with apex anterior to caudal spine and base formed by truncate posterior margin of caudal fin; upper and lower lobes of caudal fin black, this color continuous with black on back; rest of body grayish (blue in life)...*Paracanthurus hepatus*

6b. Pelvic fin rays I, 5; soft dorsal rays 22 to 33; scales on head not broad and tuberculated; color not as in 6a...7

7a. Dorsal spines IV or V; dorsal and anal fins elevated, the first soft ray of the dorsal fin contained 2.0 to 3.7 times in the standard length; snout markedly produced...8

7b. Dorsal spines VIII or IX; dorsal and anal fins not elevated, the first soft ray of dorsal fin contained 4.5 to 7.5 in standard length; snout not markedly produced...9

8a. Dorsal soft rays 30 to 33; anal soft rays 24 to 26; dorsal and anal fins extremely elevated, the first soft ray of dorsal fin 2.0 to 2.3 in standard length (1.8 in a 25 mm juvenile specimen); body with alternating pale and dark vertical bands...Zebrasoma veliferum

8b. Dorsal soft rays 23 to 25; anal soft rays 19 to 21; dorsal and anal fins moderately elevated, the first soft ray of dorsal fin 2.7 to 3.7 in standard length (2.2 in a 32 mm juvenile specimen); body of adults brown with faint, pale, narrow, longitudinal lines (juveniles with narrow vertical pale lines and small spots)....................Zebrasoma scopas

9a. Teeth very elongate, freely-movable, and numerous (varying from 20 in the upper jaw of a 37 mm specimen of C. striatus to 42 in a 130 mm specimen), the tips expanded, incurved, and bearing lateral denticulations; dorsal spines VIII.........................22

9b. Teeth not very elongate, not movable, and not numerous (not exceeding 22 in upper jaw of largest adults), flattened, and denticulated on entire margin; dorsal spines IX (rarely VIII)...............................10

10a. Body light gray with 6 vertical black bars (1 on head passing through eye, 4 on body, and 1 on caudal peduncle); anal soft rays 19 to 21; caudal peduncle spine very small, its greatest length contained about 3 to 4 times in greatest diameter of eye...Acanthurus triostegus

10b. Body not light gray with vertical black bars; anal soft rays 22 or more; caudal peduncle spine not very small, its length contained 1.5 times or less in greatest diameter of eye.............................11

11a. Posterior half of body and dorsal and anal fins with numerous white spots on a dark brown background; body with 3 broad vertical pale bands; body very deep, greatest depth contained 1.5 - 1.6 times in standard length...................Acanthurus guttatus

11b. Posterior half of body and dorsal and anal fins without white spots; body without 3 broad vertical pale bands; body not very deep, greatest depth contained 1.7 - 2.2 times in standard length.........................12

12a. Upper 3/4 of body lined with about 10 black bands, each containing a median pale line (blue in life), running nearly horizontally (many of these bands continue on to head and converge on eye); spaces between bands pale (yellow in life); caudal spine very long, about 1.9 to 2 in head length............Acanthurus lineatus

12b. Upper 3/4 of body not lined with about 10 nearly horizontal black bands containing median pale lines; caudal spine not very long, about 2.5 to 8 in head length..13

13a. Body very dark brown or black with a white line under chin and a pale line or band at the base of the dorsal and anal fins; mouth very small, its width from rictus to rictus contained 5 to 6 times in length of head; maximum number of upper or lower teeth 12; body depth relatively great, about 1.7 to 1.8 in standard length; dorsal soft rays 28 to 33; anal soft rays 26 to 29....................................14

13b. Body not very dark brown or black with a white line under chin and a pale band at base of dorsal and anal fins; mouth not very small, its width from rictus to rictus contained 3.2 to 4.8 in length of head; number of teeth in upper or lower jaw 14 to 24 (in specimens over 50 mm long); body depth not great, 1.8 to 2.4 in standard length; dorsal soft rays 23 to 28; anal soft rays 22 to 26..............15

14a. Body with a large elliptical pale yellowish (orange in life) spot posteriorly, enclosing caudal peduncle spine (this pale area absent in specimens of about 65 mm or less in standard length); an elongate white spot at edge of opercle; no pale area under eye; pale line on chin not extending above rictus; caudal fin lunate; dorsal soft rays 29 to 33 (mostly 30 to 32)................................<u>Acanthurus achilles</u>

14b. Body without a large elliptical pale spot posteriorly; no elongate white spot at corner of opercle; a pale area under eye; pale line on chin extending well above rictus; caudal fin emarginate to moderately concave; dorsal soft rays 28 to 31 (mostly 29 to 30)..........................<u>Acanthurus glaucopareius</u>

15a. Snout very short, its length contained 7.9 to 8.2 times in standard length; teeth very small (greatest length of undetached upper teeth .7 mm in 135 mm specimen); a dark brown spot extending slightly below axil of pectoral fin; entire caudal fin paler than body....... ....<u>Acanthurus thompsoni</u>

15b. Snout not very short, its length contained 3.9 to 5.3 in standard length; teeth not very small; no dark brown spot extending below axil of pectoral fin; entire caudal fin not paler than body...............16

16a. A black spot at base of last few dorsal and anal rays... 17

16b. No black spot at base of last few dorsal and anal rays.. 18

17a. Caudal fin lunate, caudal concavity (horizontal distance from tip of upper lobe of caudal fin to most anterior portion of hind edge of fin) contained 4.5 to 6 times in standard length; a definite black margin around caudal peduncle spine groove; black spot at axil of soft dorsal fin large, its greatest width contained less than 2 times in greatest diameter of eye; a definite white margin to posterior edge of caudal fin; shape of ends of medial upper teeth (ignoring denticulations) pointed...Acanthurus nigrofuscus

17b. Caudal fin not lunate, caudal concavity contained 6.7 - 12 times in standard length; no black margin around caudal peduncle spine groove; black spot at axil of soft dorsal fin small, its greatest width contained more than 2 times in greatest diameter of eye; white margin to posterior edge of caudal fin barely discernible; shape of ends of medial upper teeth rounded...............................Acanthurus nigroris

18a. A horizontal pigmented bar on shoulder, either entirely black or pale yellowish with dark margins (this bar not present in juveniles)..............................19

18b. No horizontal pigmented bar on shoulder...............21

19a. Shoulder bar pale yellowish (orange in life) edged in black (in specimens below about 80 mm the black border is not present; in specimens below about 45 mm there is no trace of a bar at all); a broad, white, crescent-shaped region in postero-central part of caudal fin; body uniform brown (pale in juveniles which are yellow in life) without longitudinal lines; dorsal soft rays 23 to 25 (usually 24); anal soft rays 22 to 24 (usually 23).......Acanthurus olivaceus

19b. Shoulder bar black; no broad, white, crescent-shaped region in postero-central part of caudal fin (though a white terminal margin is present on the caudal fin of A. gahhm); body dark brown, with or without faint, narrow, irregular, pale, longitudinal lines; dorsal soft rays 24 to 28; anal soft rays 22 to 26........20

20a. Posterior edge of caudal fin with a distinct white margin; a long, black, lancet-like line extending forward from anterior end of caudal peduncle spine; no longitudinal bands or lines in dorsal or anal fins; no narrow, irregular, pale, longitudinal lines on body; no yellow spots on head in life; dorsal soft rays 25 to 28 (usually 26 or 27); anal soft rays 24 to 26...............................Acanthurus gahhm

20b. Posterior edge of caudal fin without a distinct white margin; no long black line extending forward from caudal peduncle spine; dorsal fin with longitudinal dark brown bands (about 8 in soft dorsal), alternating with pale bands (yellowish in life) of about the same width; numerous irregular pale (yellowish in life) longitudinal lines on body (faint or absent in preserved specimens); yellow spots on head in life; dorsal soft rays 24 to 26 (usually 25); anal soft rays 22 to 24 (usually 23)..Acanthurus maculiceps

21a. Outer 1/3 of pectoral fin pale (yellowish in life) and contrasting with darker basal 2/3 of fin (in specimens over about 120 mm in standard length); dorsal fin with about 4 broad lengthwise bands; caudal fin very lunate, caudal concavity about 4.5 to 7 in standard length; caudal spine usually small, about 4.5 to 5.5 in length of head; dark margin around socket of caudal spine usually narrow and indistinct; anterior gill rakers 16 to 22; posterior gill rakers 17 to 22. (Indo-Pacific)...Acanthurus xanthopterus

21b. Pectoral fin uniform brown; dorsal fin (at least in Hawaiian specimens) with about 8 narrow lengthwise bands; caudal fin not very lunate, caudal concavity about 6 to 10 in standard length; caudal spine usually not small, about 3 to 4.2 in length of head; a definite dark brown or black margin around socket of caudal spine forming an area about twice as high as maximum width of spine; white band at base of caudal fin usually distinct; anterior gill rakers 21 to 25; posterior gill rakers 23 to 25. (Indo-West-Pacific)...?.Acanthurus mata (not yet known from Gilbert Islands)

22a. Body with numerous pale longitudinal stripes (may be faint in preserved specimens); interradial membranes of pectoral fin hyaline; margin of lower lip smooth; teeth of upper jaw with 5 to 7 (usually 6) denticulations on expanded ends........Ctenochaetus striatus

22b. Body with stripes, when alive speckled with numerous bright blue spots which may or may not persist in preserved specimens; interradial membranes of pectoral fin dark brown; margin of lower lip papillate; teeth of upper jaw with 4 denticulations (counting the tip) on expanded ends.............Ctenochaetus sp.

Genus NASO

Naso Lacépède 1802. Hist. nat. poiss., vol. 3, p. 105. (Type species, Naso fronticornis Lacépède = Chaetodon unicornis Forskål.

Naso lituratus

Acanthurus lituratus Bloch and Schneider 1801. Systema ichth., pp. xxxviii, 216.

This unmistakable species was sighted occasionally underwater at Onotoa and also at Butaritari; however, no specimens were secured.

Naso unicornis

Chaetodon unicornis Forskål 1775. Descr. animalium, p. xiii, 63. (Type locality, Djedda, Red Sea).

Naseus unicornis Günther 1873. Jour. Mus. Godeffroy, vol. 1, pp. 118-121, pl. 78.

Naso unicornis Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 297. (Nauru).

Naso brevirostris

Naseus brevirostris Cuvier and Valenciennes 1835. Hist. nat. poiss., vol. 10, p. 277. (Type locality, Moluccas, Mauritius, New Guinea, and Indian Ocean).

Naseus brevirostris Günther 1873. Jour. Mus. Godeffroy, vol. 1, p. 121, pl. 79, fig. A. (Kingsmill Islands).

Naso tuberosus

Naso tuberosus Lacépède 1802. Hist. nat. poiss., vol. 3, p. 111, pl. 7, fig. 3.

Naseus tuberosus Günther 1873. Jour. Mus. Godeffroy, vol. 1, p. 123, pl. 80.

Naso tuberosus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 276. (Gilbert Islands).

Naso vlamingi

Naseus vlamingii Cuvier and Valenciennes 1835. Hist. nat. poiss., vol. 10, p. 293. (Type locality, Moluccas).

Although this species was consistently seen at the seaward edge of the outer reef at Onotoa in about 40 feet of water, no specimens were taken. It appeared almost black underwater. One specimen, when speared at Arno Atoll in the Marshall Islands, suddenly altered its dark color to pale, thus making evident the characteristic vertical blue lines and small blue spots on the body.

Naso sp.

A 37 mm specimen of *Naso* in the keris stage was obtained with rotenone in a tide pool 160 feet from shore on the sea reef flat at Onotoa. It is pale (transparent in life) with silver over abdomen and posterior part of head. There are 6 near-vertical rows of indistinct blackish spots on the dorsal half of the body, scattered tiny blackish flecks on posterior half of body, and a dusky band at the base of the caudal fin. The dorsal rays are VI, 27 and the anal rays II, 28. There are 16 pectoral rays. I am unable to identify the specimen to species; however I suspect that it may be *brevirostris*. It is definitely not *unicornis*, for this species has 17 or 18 pectoral rays and reaches a larger size in the keris stage (over 50 mm in standard length).

Genus PARACANTHURUS

Paracanthurus Bleeker 1863. Ned. Tijdschr. Dierk., vol. 1, p. 252. (Type species, *Teuthis hepatus* Linnaeus, in part).

Paracanthurus hepatus

Teuthis hepatus Linnaeus 1766. (in part). Syst. nat., ed. 12, p. 507.

Acanthurus theuthis Lacépède 1802. Hist. nat. poiss., vol. 4, pp. 547, 549.

Acanthurus hepatus Günther 1873. Journ. Mus. Godeffroy, vol. 1, p. 115, pl. 75. (Kingsmill Islands).

Genus ZEBRASOMA

Zebrasoma Swainson 1839. Nat. hist. and class. fishes, amphibians,..., vol. 2, p. 256. (Type species, *Acanthurus velifer* Bloch).

Zebrasoma veliferum

Acanthurus velifer Bloch 1795. Natur. ausländ. Fische, pt. 9, p. 106, pl. 427, fig. 1. (Type locality, East Indies).

2 specimens. 175 and 193 mm. 8 specimens. 20 - 25 mm. Onotoa.

Color of adult from 35 mm Kodachrome transparency purplish black with 6 vertical yellowish bands about 1/3 width of dark interspaces (except dark interspace through eye which is of comparable width) on head and body; narrow dark lines visible within the pale yellowish bands and narrow orangish vertical lines in the dark interspaces; snout purplish, densely covered with small greenish-yellow spots; fins purplish black; base of caudal fin with a whitish vertical band. Color of 20 mm juvenile pale yellow with vertical black bands, the 2 anterior ones (through eye and at edge of operculum) much blacker and more distinct; snout and base of caudal fin bright orange.

Adults were seen on both sea reef and deeper sections of the lagoon with moderate coral growth; the small juveniles were all taken in shallow-water lagoon area.

Zebrasoma scopas

Acanthurus scopas Cuvier 1829. Règne animal, ed. 2, vol. 2, p. 224. (Type locality, Neira, Province of Banda).

Zebrasoma flavescens Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 297. (Nauru).

1 specimen. 88 mm. 2 specimens. 32 and 34 mm. Onotoa.

Color in life of 88 mm specimen dark brown with numerous, narrow, wavy, light blue, longitudinal lines on body (anteriorly on the body these lines become dotted; on the head the linear pattern is lost and discrete blue dots occur); anterior median portion of the body yellow-brown; all fins except the pectoral dark brown; pectoral fin clear with dusky orange rays and a narrow black upper edge; caudal peduncle spine sheath white. Color of juvenile from 35 mm Kodachrome transparency: anterior fourth of body brownish yellow, posterior three-fourths dark brown; snout and inter-orbital space brown, remainder of head brownish yellow; body with numerous vertical lines; head and chest with many tiny pale yellow spots.

At Onotoa adults were seen only in the lagoon, hiding in the recesses in a mass of dead staghorn coral. They were observed on the sea reef at Butaritari on the lee side of the atoll. At Onotoa the young were taken from the environs of small isolated coral heads in a shallow-water section of the lagoon. No yellow Zebrasoma were seen by me in the Gilbert Islands.

Genus ACANTHURUS

Acanthurus Forskål 1775. Descr. animalium, p. 59. (Type species, Chaetodon sohal Forskål as designated by Jordan, 1917) (The genus Teuthis Linnaeus was restricted to the siganids by Opinion 93 of the International Commission on Zoological Nomenclature.)

Acanthurus triostegus

Chaetodon triostegus Linnaeus 1758. Syst. nat., ed. 10, p. 463. (Type locality, Indies).

Teuthis troughtoni Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 294, text fig. 3. (Nauru).

118 specimens. 21 to 114 mm. Onotoa.

1 specimen. 112 mm. Tarawa.

Color in life: light greenish gray, becoming abruptly white ventrally, with 4 narrow vertical black bars on body, 1 near-vertical bar through eye, and a short bar dorsally on caudal peduncle; a median black line on forehead; a small black spot ventrally on caudal peduncle; a small black spot, 2 spots, or a short bar at the base of the pectoral fin.

A. triostegus was a very common species on both inshore sea reef and sandy shallow-water lagoon areas. In the first 175 feet of a 50 foot wide transect of the outer reef flat at Onotoa, 29 juvenile specimens were taken with rotenone ranging in size from 23 to 35 mm. In the next 120 feet (approximately 95% covered with water at low tide when the inshore 175 feet is about half covered), 81 specimens were obtained of sizes 21 to 52 mm. In the next 120 feet only 2 small specimens were taken. Adults appeared in the Jania zone still farther from shore and in the so called back ridge trough. No quantitative data were secured from the deeper areas of the outer reef.

Acanthurus guttatus

Acanthurus guttatus Bloch and Schneider 1801. Systema ichth., pp. xxxviii, 215. (Type locality, Tahiti).

Teuthis guttatus Kendall and Goldsborough 1911. Mem. Mus. Comp. Zool., vol. 26, p. 310. (Butaritari, Gilbert Islands).

Teuthis fuliginosus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 294, pl. 14, fig. 4. (Nauru).

3 specimens. 33 - 165 mm. Onotoa.

1 specimen. 160 mm. Tarawa.

Color from 35 mm Kodachrome transparency brown with posterior half of body covered with small white spots; a vertical white band from origin of dorsal to edge of opercle; another broader white band from the base of the 3rd to 5th dorsal spines to region of anus; a third, narrow, white band from the 3rd dorsal soft ray to the 3rd anal soft ray; region of chest white; pelvic fins bright yellow with narrow dark brown margins; caudal fin brown, whitish at base, and dark brown terminally.

This species was observed only in the surge channels of the outer reef where it swam rapidly about in small schools in the roughest, milky-white water of this habitat.

The stomach contents of 10 specimens were examined; the bulk of the material was algal, though there was some fine calcareous sand. Many kinds of algae were present, but _Jania_ probably predominated. Presence of the blue-green _Calothrix_ indicates a cropping close to the substrate.

Acanthurus lineatus

Chaetodon lineatus Linnaeus 1758. Syst. nat., ed. 10, p. 274. (Type locality, Indies).

10 specimens. 35 - 170 mm. Onotoa.

2 specimens. 163 and 170 mm. Tarawa.

Color from 35 mm Kodachrome transparency: upper 3/4 of body yellow with 10 black lengthwise stripes, each stripe containing a bright blue center (these stripes continue on to head where they are narrower and tend to converge on eye); lower fourth of head and body bluish white; pelvic fins orange with dark lateral margin; caudal fin black with a large crescent-shaped dusky yellowish area narrowly margined in blue in the posterior median part of the fin; pectoral pale; dorsal fin yellowish, lined with blue; anal fin yellowish.

Juveniles about 40 mm in length displayed, in addition to colors like adults, red coloration on dorsal and anal fins (especially posteriorly).

This species was abundant in or near surge channels of the outer reef at Onotoa and was also very common in relatively shallow quiet water of protected reef areas such as the lagoon side of the west reef of the atoll.

The gut contents of 10 specimens, 120 to 160 mm in length, consists primarily of finely divided red algae.

Acanthurus achilles

Acanthurus achilles Shaw 1803. General zoology, vol. 4, pt. 2, p. 383.

3 specimens. 108 - 119 mm. Onotoa.

1 specimen. 129 mm. Tarawa.

Color from 35 mm Kodachrome transparency black with a large bright orange elliptical spot enclosing caudal peduncle spine; dorsal and anal fins black with narrow dual-colored (outer half orange, inner half bluish white) lines basally in posterior parts of these fins; anal fin with a narrow blue margin; a white patch at edge of opercle; a light blue line under chin; iris blue; pelvic fins black with lateral blue margin; caudal fin with a narrow white margin, a narrow black submarginal line and then a broad bright orange zone; basal half of fin black.

This species was seen only in the surge channels at Onotoa. Its abundance varied in different parts of the atoll in spite of apparent similarity of the surge channels in the different areas.

Acanthurus glaucopareius

Acanthurus glauco-pareius Cuvier 1829. Règne animal, ed. 2, vol. 2, p. 224. (Type locality as indicated by Günther 1861, Tahiti).

Acanthurus aliala Lesson 1830. Voyage autour du monde... "Coquille",...vol. 2, pt. 1, p. 150.

Teuthis glaucopareius Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 297. (Nauru).

11 specimens. 50 - 107 mm. Onotoa.

1 specimen. 155 mm. Tarawa.

Color from 35 mm Kodachrome transparency purplish black; dorsal and anal fins with a yellow band basally which broadens posteriorly; anal fin with narrow blue margin; a prominent white patch under eye; a white line on chin adjacent to lower lip extending well above corner of mouth and running adjacent to upper lip; caudal spine yellow; caudal fin light bluish gray with a submarginal yellow band; pelvic fins black with a blue lateral edge; membranes of pectoral fins clear, the rays blackish. In three specimens 52 to 55 mm in length the submarginal band in the caudal fin was red instead of yellow.

This was a very abundant species on the coralliferous terrace of the outer reef at Onotoa and in coral areas in the lagoon. It was also observed at Butaritari.

The gut of six specimens, 70 to 145 mm in standard length, was filled with algae, mostly filamentous reds.

Acanthurus thompsoni

Hepatus thompsoni Fowler 1923. Occ. Pap. B. P. Bishop Mus., vol. 7, p. 386. (Type locality, Honolulu).

Acanthurus philippinus Herre 1927. Philip. Jour. Sci., vol. 34, p. 434, pl. 5, fig. 1.

Acanthurus philippinus Schultz and Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 637.

1 specimen. 138 mm. Onotoa.

Color from 35 mm Kodachrome transparency: uniform brown with a dusky white caudal fin; iris blue; dorsal and anal fins dark brown with still darker longitudinal bands barely discernible. In life the most conspicuous feature of this species was its pure white caudal fin; this faded to dusky white after death.

Only two specimens were seen at Onotoa. Both of these occurred as solitary individuals at the extreme seaward edge of the coralliferous terrace of the outer reef. One was speared from 35 feet of water.

Acanthurus nigrofuscus

Chaetodon nigro-fuscus Forskål 1775. Descr. animalium, pp. xiii, 64. (Type locality, Red Sea).

Acanthurus elongatus Schultz and Woods in Schultz and collaborators (in part) 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 634, pl. 62, fig. D.

3 specimens. 38 - 93 mm. Onotoa.

No life color notes taken for adults. Color in life of 38 mm juvenile: body brown with a prominent black spot at the base of the last few rays of the dorsal fin; dorsal and anal fins with a thin pale blue margin and a narrow black submarginal line; remainder of these fins with faint alternating red and blue bands; caudal fin brown with upper and lower margins reddish.

Specimens were obtained from both the sea reef and from the lagoon near the west reef.

Acanthurus nigroris

Acanthurus nigroris Cuvier and Valenciennes 1835. Hist. nat. poiss., vol. 10, p. 208. (Type locality, Hawaii).

Acanthurus lineolatus Günther 1873. Jour. Mus. Godeffroy, vol. 1, p. 112, pl. 73, fig. A.

Teuthis atrimentatus Jordan and Evermann 1905. Bull. U. S. Fish Comm. vol. 22, p. 198.

Acanthurus elongatus Schultz and Woods in Schultz and collaborators (in part) 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 634, pl. 62, fig. C.

2 specimens. 57 and 93 mm. Onotoa.

1 specimen. 143 mm. Tarawa.

Onotoa specimens were taken with rotenone from the outer sea reef.

Acanthurus olivaceus

Acanthurus nigricans var. olivaceus Bloch and Schneider 1801. Systema ichth., pp. xxxviii, 214.

No specimens were obtained. D. W. Strasburg observed a bright yellow colored juvenile in shallow water of the Onotoa lagoon.

Acanthurus gahhm

Chaetodon nigro-fuscus var. gahhm Forskål 1775. Descr. animalium, pp. xiii, 64. (Type locality, Red Sea).

Acanthurus nigricans Schultz and Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 633, pl. 68.

27 specimens. 23 - 188 mm. Onotoa.

Color from 35 mm Kodachrome transparency of a 165 mm specimen: dark brown with an elongate, nearly horizontal black bar originating just anterior to upper end of gill opening and extending posteriorly to level of the 6th dorsal spine; caudal peduncle spine socket narrowly margined with black, this color extending anteriorly in a horizontal, lancet-like mark greater in length than the length of the caudal spine; pectoral fin with basal two-thirds dark brown, outer one-third yellow, especially in upper part; dorsal fin uniform dark brown; anal fin dark brown with a narrow bright blue margin; caudal fin dark brown with a distinct white margin, broader in central part of fin and gradually disappearing on the greatly extended upper and lower lobes of the fin. The shoulder bar is absent in juveniles. It can be seen just forming in a specimen 57 mm long. The black lancet-like line extending forward from caudal peduncle spine is also an adult feature; it is just beginning to form in an 82 mm specimen. Small juvenile specimens were chocolate brown in color with the caudal fin abruptly white basally, dusky white distally. Specimens were obtained transforming from the Acronurus stage at a length of 23 to 26 mm.

This species was very abundant at Onotoa and was seen at Butaritari. It was found around the base of isolated coral heads in sandy lagoon areas and was never seen on the ocean side of the atoll. The very small juveniles were common in tidal flats and shallow tide pools in the lagoon, but were never taken from sea reef tide pools. This suggests that the majority of the species either completes the life cycle in the lagoon or that the pelagic young avoid outer reef areas and pass through channels to reside in the shallow quiet waters of the lagoon. A third, but unlikely possibility is that the young experience heavy mortality in sea reef tidepools. The young of Acanthurus triostegus, however, do not appear to undergo any serious mortality in this habitat.

The gut of a 160 mm specimen was filled with fine yellowish grit such as can be found in the gut of scarids.

Acanthurus maculiceps

Hepatus maculiceps Ahl 1923. Mitt. Zool. Mus. Berlin., vol. 11, pt. 1, p. 36, fig. 4. (Type locality, Talassia, New Britain).

1 specimen. 194 mm. Onotoa.

1 specimen. 203 mm. Tarawa.

Color in life dark brown with numerous, narrow, pale yellowish, longitudinal lines on body; a short horizontal black bar on shoulder (19 mm in length in the 194 mm specimen), its forward end located slightly posterior to upper end of gill opening; head brown with numerous prominent cream-colored spots; pectoral fin blackish with a large yellow spot on the distal third of the upper 6 rays; caudal fin brown with a bright white band at base which quickly faded upon death of the specimen.

The Onotoa specimen was speared in about 20 feet of water on the coralliferous terrace of the outer reef.

This constitutes the first record of this species in Oceania.

Acanthurus xanthopterus

Acanthurus xanthopterus Cuvier and Valenciennes 1835. p. 215. (Type locality, Seychelles).

Acanthurus blochii Günther 1873. Jour. Mus. Godeffroy, vol. 1, p. 109, pl. 69, fig. B.

Acanthurus matoides de Beaufort 1951. Fishes Indo-Austral. Arch., vol. 9, p. 156.

Acanthurus fuliginosus Schultz and Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, vol. 1, p. 637.

2 specimens. 47 and 200 mm. Tarawa.

The 200 mm specimen was speared at a depth of 39 feet in the Tarawa lagoon. While still alive the following color note was made: the color changed back and forth from a uniform purplish gray to a phase where highly irregular dark gray lines alternated with light blue-gray lines, all of these lines about 2 scales in width; base of caudal fin and adjacent portion of caudal peduncle very light gray; ventral two-thirds of eye edged in yellow; a region of dull yellow extending anteriorly from eye a distance equal to about 1 eye diameter; a lesser posterior extension of yellow from lower corner of eye; dorsal and anal fins yellowish (especially distally) with a bluish gray line at the base and 4 longitudinal blue bands; outer margins of dorsal and anal fins very narrowly black; basal two-thirds of pectoral fins dusky, then a region of yellow, then clear; pelvic rays purplish, the membranes dusky yellow; caudal fin, except basally as noted, purplish gray.

The gut of this specimen was filled with yellowish particulate calcium carbonate like the specimen of A. gahhm.

Genus CTENOCHAETUS

Ctenochaetus Gill 1885. Proc. U. S. Nat. Mus., vol. 7, p. 279. (Type species, Acanthurus strigosus Bennett).

Ctenochaetus striatus

Acanthurus striatus Quoy and Gaimard 1824. Voyage autour de monde..."Uranie", Zool., vol. 2. p. 373; Atlas, pl. 63, fig. 3. (Type locality, Guam).

Ctenochaetus ctenodon Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 294. (Nauru).

36 specimens. 32 - 130 mm. Onotoa.

Color in life of adults dark olive brown with numerous narrow lengthwise bluish lines on the body; head finely spotted with orange; dorsal and anal fins olive brown with about 5 lengthwise blue bands. Specimens about 40 mm in length presented a different coloration. On the body were narrow, red, lengthwise lines which inclined slightly downward as they ran posteriorly. The brown interspaces between were about 2 to 3 times the width of the red lines, and centrally within these brown areas, bluish lines were beginning to appear. The tips of the caudal fin were red.

Of the fishes collected at Onotoa, this species was the dominant one on a weight basis. At most of the poison stations the take of Ctenochaetus striatus exceeded that of any other species, and the number of specimens was frequently the highest. It was abundant in almost all habitats.

The gut contents of seven specimens, 110 to 135 mm in standard length appears to consist only of fine particles of yellowish calcium carbonate.

Ctenochaetus sp.

Ctenochaetus sp. Randall (in press, Zoologica)

Ctenochaetus sp. Hiyama 1943. Rep. of an invest. of poisonous fishes of the South Seas, p. 93, pl. 19, fig. 53.

Ctenochaetus strigosus Schultz (in part) 1943, Bull. U. S. Nat. Mus. 180, p. 161.

2 specimens. 170 and 175 mm. Onotoa.

Color in life: head and body brown, covered with small bright blue spots; dorsal and anal fins dark brown with 9 to 10 lengthwise bluish bands; pectoral dark brown with blue spots; caudal and pelvic fins dark brown.

Both specimens were speared from a poorly-defined surge channel region just beyond the surf zone in the northwest corner of the atoll in about 5 feet of water. The species was observed only in small schools in turbulent water.

Ctenochaetus sp.

I am unable to identify a 35 mm specimen of *Ctenochaetus* which was collected from the Onotoa lagoon. It had a bright yellow caudal fin in life. Later examination of the specimen in alcohol revealed the last few rays of the soft dorsal and anal fins to be colorless except for a small black spot at the base of these rays; small brown spots could be perceived on the head and anteriorly on the body. The counts are: D VIII, 27; A III, 25; P 15; anterior gill rakers 27; posterior gill rakers 27. There are 22 upper and 22 lower teeth. The upper teeth bear 6 or 7 (usually 7) denticulations and the lower teeth 3 or 4 (mostly 4). This may be the young of *Ctenochaetus* sp. Randall (in press, *Zoologica*), reported only from the Philippine Islands and East Indies.

Table 5. Fin Ray Counts of the Acanthuridae Collected in the Gilbert Islands

Dorsal fin

	Spines				Soft rays*											
	IV	V	VII	IX	22	23	24	25	26	27	28	29	30	31	32	33
Z. veliferum	10													4	4	2
Z. scopas		3				3										
A. triostegus				33	9	22	2									
A. guttatus				4						2	2					
A. lineatus				8						5	3					
A. achilles				4										4		
A. glaucopareius				12							1	7	3	1		
A. thompsoni				1				1								
A. xanthopterus				2					1	1						
A. gahhm				12				1	7	4						
A. maculiceps				2			1	1								
A. nigrofuscus				3			2		1							
A. nigroris				3			2	1								
C. cyanoguttatus			2							2						
C. striatus			28							1	9	13	4	1		

*Each fin ray with a distinct base was counted, regardless of how close adjacent rays might be. At times dissection was necessary to determine whether the last two rays of the dorsal and anal fins shared the same basal element or not.

Table 5 (Cont.) Anal fin

	Spines	Soft rays									
	III	19	20	21	22	23	24	25	26	27	28
Z. veliferum	10						4	5	1		
Z. scopas	3	3									
A. triostegus	33	3	19	11							
A. guttatus	4						2	2			
A. lineatus	8								2	4	2
A. achilles	4									1	3
A. glaucopareius	12								5	6	1
A. thompsoni	1						1				
A. xanthopterus	2						2				
A. gahhm	12						4	7	1		
A. maculiceps	2				1	1					
A. nigrofuscus	3				1	1	1				
A. nigroris	3				2	1					
C. cyanoguttatus	2							2			
C. striatus	28						1	5	21	1	

Family TEUTHIDIDAE (= Siganidae of authors)

Genus TEUTHIS

Teuthis Linnaeus 1766. Syst. nat., ed. 12, p. 507. (Type species, Teuthis javus) (Designated in Opinion 93 of the International Commission on Zoological Nomenclature).

Siganus Forskål 1775. Descr. animalium, pp. x, 25.

Teuthis rostrata

Amphacanthus rostratus Cuvier and Valenciennes 1835. Hist. nat. poiss., vol. 10, p. 158. (Type locality, Massuah, Red Sea).

Siganus argenteus Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, pp. 649, 651.

Siganus rostratus Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, pp. 650, 654, pl. 74.

3 specimens. 160 - 220 mm. 12 specimens. 50 - 62 mm. Onotoa.

D XIII,10; A VII,9; P 18; V I,3,I. (4 specimens).

Color in life dark olivaceous blue with numerous indistinct pale orangish spots; spinous dorsal, posterior part of caudal, spinous anal, and pectoral fins olive-yellow; soft dorsal and soft anal fins with rays olive, membranes hyaline.

Color in alcohol of 62 mm specimen brown, paler over abdomen and cheek, with a dense stippling of tiny black dots on dorsal two-thirds of body; about 10 or 12 small brownish blotches on posterior part of body; upper and lower margins of caudal fin with a row of small brown spots; membranes of spinous dorsal dusky, especially basally and distally. This color pattern is quite intermediate to subadult rostratus and smaller specimens identified by Woods as argenteus, and I believe that the former represent the late postlarval stage of the latter, as suspected by Woods. His specimens of argenteus were pelagic and came to a light at night.

One 60 mm specimen was speared near a rock jetty in the lagoon by D. W. Strasburg. Subsequently 11 others of comparable size were taken with rotenone in the same area. No adults were seen in the lagoon, but were occasionally observed in outer reef areas. The 160 mm specimen was speared from a slow swimming dense school on the outer coralliferous terrace at a depth of about 20 feet. There was no scattering of individual fish of the school at my approach nor any increase in rate of swimming. I had the misfortune to be spined by the speared specimen. A stinging pain followed almost immediately and lasted for about a half an hour.

Teuthis punctata

Amphacanthus punctatus Bloch and Schneider 1801. Systema Ichth., p. 210. (Type locality, Pacific Ocean).

Siganus punctatus Woods in Schultz and collaborators 1953. Bull. U. S. Nat. Mus. 202, pp. 650, 657.

1 specimen. 85 mm. Onotoa.

D XIII,10; A VII,9; P 16; V I,3,I.

Color in life dark brown with numerous, close-set, prominent dusky orange spots on head and body.

The specimen was taken in the lagoon in about 5 feet of water near a large expanse of Thalassia.

Teuthis puella

Amphacanthus puellus Schlegel 1852. Bijdr. Dierk., vol. 1, p. 39, fig. 1. (Type locality, East Indies).

Teuthis puella Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 91. (Abemama, Gilbert Islands).

Family CIRRHITIDAE

The hawk fishes have, as their most characteristic feature, the lower 6 or 7 pectoral rays swollen and unbranched. These carnivorous fishes are sedentary, and though less camouflaged than the scorpaenids which have the same habit, they are usually not seen until they move from one part of the reef to another.

In the discussions below under Cirrhitichthys and Paracirrhites, clarification of some of the problems in the generic classification as concerns the Gilbert Islands species is attempted.

Key to the Species of Cirrhitidae Recorded from the Gilbert Islands

1a. Tiny indistinct scales on cheek; 40 or 41 transverse scale rows from upper end of gill opening to base of caudal fin; brown spots on dorsal, anal, and caudal fins; black blotches on back adjacent to dorsal fin and dorsally on caudal peduncle...Cirrhitus pinnulatus

1b. 4 to 6 rows of large scales on cheek; 43 to 51 transverse scale rows from upper end of gill opening to base of caudal fin; no brown spots on dorsal, anal, and caudal fins (except faintly in P. polystictus); no black blotches on back adjacent to dorsal fin and dorsally on caudal peduncle (blotches, if present in this location, light brown)..................2

2a. Preopercular margin strongly serrated; dorsal spines long, length of 4th dorsal spine less than 2 in head length (measured from snout to most posterior extension of opercular membrane); interorbital narrow, bony interorbital width contained about 2 times in eye; dorsal soft rays 12; annulations plainly visible in lower pectoral rays; dorsal half of body with large roundish blotches (as large or larger than eye)...............Cirrhitichthys aprinus

2b. Preopercular margin finely serrated (in part, smooth); dorsal spines not long, length of 4th dorsal spine about 3 in head length; interorbital not narrow, bony interorbital width contained 1.5 or less times in eye; dorsal soft rays 11; annulations not plainly visible in lower pectoral rays; dorsal half of body without large roundish blotches (spots, if present, distinctly smaller than eye)........................3

3a. A diagonal "U" shaped mark behind eye, the ends confluent with eye; no dark spots on head or body; body moderately compressed, its maximum width just posterior to gill opening contained 2.1 to 2.5 in head length...........................Paracirrhites arcatus

3b. No "U" shaped mark behind eye; dark spots on head or body; body not moderately compressed, its maximum width just posterior to gill opening contained 1.7 to 2.1 times in head length...........................4

4a. Black spots on head and anterior part of body; transverse scale rows 46 to 49; median fins pink in life..........................Paracirrhites forsteri

4b. No black spots on head (numerous on body); transverse scale rows 49 to 51; median fins not pink in life....5

5a. Color dark brown (head reddish in life) with a white spot nearly as large as eye just above mid-line of body below 8th and 9th dorsal spines; black spots on body present ventrally as well as dorsally; no median pale line on side of body..................... ....Paracirrhites polystictus

5b. Color brown on back, tan ventrally, with no white spot on side of body; no black spots on lower third of body; a median pale (pinkish white in life) line on side of body...*Paracirrhites hemistictus*

Genus CIRRHITUS

Cirrhitus Lacépède 1803. Hist. nat. poiss., vol. 5, p. 2. (Type species, *Cirrhitus maculatus* Lacépède = *Labrus pinnulatus* Bloch and Schneider).

Cirrhitus pinnulatus

Labrus pinnulatus Bloch and Schneider 1801. Systema ichth., p. 264. (Type locality, Tahiti).

Cirrhitus pinnulatus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 293. (Nauru).

4 specimens. 53 - 123 mm. Onotoa.

1 specimen. 119 mm. Tarawa.

Color from 35 mm Kodachrome transparency white with large irregular brown blotches and small reddish spots on body and irregular yellowish brown lines on head; 5 large blackish blotches on back adjacent to dorsal fin and dorsally on caudal peduncle; median fins with brown spots; pectoral fin light reddish.

This species was collected only from surge channels of the outer reef.

The stomach of one adult specimen contained the chelae and gastric mill of a brachyuran crab. Another was empty.

Genus CIRRHITICHTHYS

Cirrhitichthys Bleeker 1857. Act. Soc. Sci. Indo-Neerl., vol. 2, p. 39. (Type species, *Cirrhites graphidopterus* Bleeker = *Cirrhites aprinus* Cuvier and Valenciennes).

Cirrhitoidea Jenkins 1903. Bull. U. S. Fish Comm., vol. 22, p. 489. (Type species, *Cirrhitoidea bimacula* Jenkins).

Acanthocirrhitus Fowler 1938. Proc. U. S. Nat. Mus., vol. 85, p. 50. (Type species, *Cirrhites oxycephalus* Bleeker).

Paracirrhites Schultz (not of Bleeker) 1943. Bull. U. S. Nat. Mus. 180, p. 134.

Jenkins erected Cirrhitoidea for the single species bimacula, apparently unaware of Cirrhitichthys Bleeker, a genus into which bimacula fits very nicely. Jenkins is mistaken in stating that there are no palatine teeth on bimacula. I examined the holotype and found teeth present at this location. Paracirrhites cinctus Jenkins (= Cirrhites fasciatus Bennett, 1828) and Cirrhites oxycephalus Bleeker also belong in the genus Cirrhitichthys.

Schultz (1943) listed aprinus in the genus Cirrhitichthys, but placed bimacula in Paracirrhites.

Cirrhitichthys aprinus

Cirrhites aprinus Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 76. (Type locality, Timor).

3 specimens. 34 - 49 mm. Onotoa lagoon.

Color in alcohol tan with large brown blotches on dorsal half of body, largest and most prominent adjacent to dorsal fin (the upper part of the latter spots extending on to basal parts of dorsal fin rays); a black spot at base of first 2 or 3 dorsal spines; head with scattered small brown spots.

Genus PARACIRRHITES

Paracirrhites Bleeker 1874. Poiss. Madagascar et Réunion, p. 93. (Type species, Grammistes forsteri Bloch and Schneider).

Amblycirrhitus Schultz (not of Gill) 1943. Bull. U. S. Nat. Mus., 180, p. 132.

Gymnocirrhites Smith 1951. Ann. Mag. Nat. Hist., ser. 12, vol. 4, pp. 627, 638. (Type species, Cirrhites arcatus Cuvier and Valenciennes).

The type species of the genus Amblycirrhitus Gill is Cirrhites fasciatus Cuvier and Valenciennes (1829: 76, pl. 47). Fowler (1938: 49), noting that this name was preoccupied by Cirrhites fasciatus Bennett (1828: 39), proposed Amblycirrhitus indicus to replace it. This species, according to the plate of Cuvier and Valenciennes, is a deep-bodied form with the fin membranes of the spinous dorsal fin attached to anterior edges of the spines about one-third to one-half the length of the spines from their base. Schultz' (1943) use of Amblycirrhitus for the species arcatus, hemistictus, and polystictus does not seem advisable, for these species do not resemble Amblycirrhitus indicus but appear to be closely related to Paracirrhites forsteri. For the same reason, the erection of the new genus

Gymnocirrhites for these three species by Smith (1951) is also not well founded.

Paracirrhites arcatus

Cirrhites arcatus Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 3, p. 74. (Type locality, Mauritius and Tahiti).

7 specimens. 49 - 85 mm. Onotoa.

Color in alcohol brown, darker on dorsal half of body, with a broad pale band running on back from base of caudal fin to a point beneath the 7th dorsal spine (the lateral line runs through the ventral part of this pale band); a "U" shaped pale line (red in life) edged in black, extending diagonally upward from hind part of eye; 2 or 3 diagonal pale dark-edged lines on opercle at level of base of pectoral fin.

There is variability in color in this species as shown in pl. 49, figs. B and C of Günther (1873).

P. arcatus was always seen in association with live coral. With the possible exception of P. forsteri it was the most abundant cirrhitid at Onotoa.

Paracirrhites forsteri

Grammistes forsteri Bloch and Schneider 1801. Systema ichth., p. 191. (Type locality, St. Christine or Waitaho, Marquesas Islands).

11 specimens. 64 - 120 mm. Onotoa.

2 specimens. 98 and 126 mm. Tarawa.

Color from 35 mm Kodachrome transparency: back and head dorsal to level of eye dark purple; below this a broad band of pale yellow; head and anterior part of body with small dark reddish brown spots; median fins pink; pelvic fins light yellow-orange; pectoral fins pale pinkish.

This species was common in coral regions of the lagoon and outer reef.

The stomachs of four specimens, 82 to 112 mm in standard length, were opened. Three were empty, and one contained a small shrimp.

Paracirrhites polystictus

Cirrhites polystictus Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 70, pl. 50, fig. A. (Type locality, Society Islands and Kingsmill Islands).

3 specimens. 147 - 190 mm. Onotoa.

1 specimen. 146 mm. Tarawa.

Color from 35 mm Kodachrome transparency dark brown, head brownish red, with a bright pinkish white spot almost as large as eye just above mid-line of body below 8th and 9th dorsal spines; rows of dark brown or black spots on side of body (ventrally on body these fuse to form lengthwise lines); median fins dark brown with still darker spots faintly visible; pelvic fins dark brown; pectoral fins orange.

The stomach of one specimen contained a small pomacentrid fish.

Paracirrhites hemistictus

Cirrhites hemistictus Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 69, pl. 50, fig. B. (Type locality, Kingsmill Islands and Society Islands).

1 specimen. 110 mm. Onotoa.

1 specimen. 168 mm. Tarawa.

Color from 35 mm Kodachrome transparency of 185 mm specimen collected by me at Arno, Marshall Islands: upper half of body dark greenish, lower half light greenish, these two regions separated by a pinkish white band; dark greenish part of body densely spotted with black; light greenish ventral region with brownish yellow spots or brownish yellow dotted lengthwise lines; head gray; dorsal fin dusky yellow; caudal and anal fins yellow; paired fins yellow-orange.

Marshall (1950: 183, pl. 18, lowermost figure) described a form from Cocos-Keeling Islands which he believed intermediate to polystictus and hemistictus, and placed polystictus in the synonymy of hemistictus. I believe that these two are valid species, and the intermediate specimen should be re-examined on the possibility of its being a hybrid.

Table 3 Counts Made on the Cirrhitidae Collected in the Gilbert Islands

	Dorsal fin spines	Dorsal fin rays		Anal fin spines	Anal fin rays	Pectoral fin rays
	X	11	12	III	6	14
C. pinnulatus	5	5		5	5	5
C. aprinus	3		3	3	3	3
P. arcatus	7	7		7	7	7
P. forsteri	11	11		11	11	11
P. polystictus	3	3		3	3	3
P. hemistictus	2	2		2	2	2

	Transverse scale rows											
	40	41	42	43	44	45	46	47	48	49	50	51
C. pinnulatus	2	3										
C. aprinus				2	1							
P. arcatus						1	2	4				
P. forsteri							2	5	3	1		
P. polystictus										1	1	1
P. hemistictus										1	1	

Family SCORPAENIDAE

Only six species of scorpion fishes were collected at Onotoa. Two small juvenile specimens, however, were not identified to species. Fowler (1928) reported a specimen collected by Garrett from the Gilbert Islands as *Dendrochirus zebra*. Whitley and Colefax (1938) listed *Pterois volitans* from Nauru. This is less than half the number of scorpaenids which I would expect to occur in the Gilbert Islands.

Synancea was not seen but is probably present throughout the Gilberts. I was told that a British girl at Tarawa was spined by a stone fish and suffered several days until a Gilbertese volunteered his services and stopped the pain. He would not divulge the secret of his cure; this was supposedly passed on from father to son, and by virtue of it, the possessor maintained a lofty position in the community.

Genus SCORPAENA

Scorpaena Linnaeus 1758. Syst. nat., ed. 10, p. 266. (Type species, *Scorpaena porcus* Linnaeus).

Scorpaena albobrunnea

Scorpaena albo-brunnea Günther 1873. Jour. Mus. Godeffroy, vol. 2, pt. 3, p. 77. (Type locality, Palau Islands).

8 specimens. 26 - 64 mm. Onotoa.

D XII,9; A III,5; P 15 or 16; transverse scale rows from upper end of gill opening to mid-base of caudal fin 49 to 51. (3 specimens).

Color from 35 mm Kodachrome transparency brown with large blotches of chartreuse; pectoral fin yellow.

The specimens were collected in coralliferous areas of the lagoon, outer reef, and a shallow channel.

Genus SCORPAENODES

Scorpaenodes Bleeker 1857. Nat. Tijdschr. Ned.-Ind., vol. 13, p. 371. (Type species, Scorpaena polylepis Bleeker).

Scorpaenodes kelloggi

Sebastopsis kelloggi Jenkins 1903. Bull. U. S. Bur. Fish., vol. 22, p. 492, fig. 37. (Type locality, Honolulu).

2 specimens. 23 and 24 mm. Onotoa lagoon.

D XIII,8; A III,5; P 18; transverse scale rows from upper end of gill opening to mid-base of caudal fin 30. (1 specimen).

Color in alcohol: head brown, body with 4 broad vertical brown bars, the intervening areas light brown dorsally and pale tan ventrally except on caudal peduncle where entire area is pale; dusky areas basally in dorsal fin above each brown bar; a dusky brown area at base of anal fin; caudal fin hyaline with small brown spots; pectoral fins hyaline with dusky area basally on rays; pelvic fins dusky.

Scorpaenodes parvipinnis

Scorpaena parvipinnis Garrett 1863. Proc. Calif. Acad. Sci., p. 105. (Type locality, Hawaiian Islands).

3 specimens. 62 - 80 mm. Onotoa.

D XIII,10; A III,5; P 17 or 18; transverse scale rows from upper end of gill opening to mid-base of caudal fin 47 or 48 (2 specimens).

Color in alcohol light brown with 5 irregular broad brown bars on upper one-half to two-thirds of body which extend up into dorsal fin; head and lips with irregular brown spots: all fins with small blackish spots. A color note from life: mottled orange.

The specimens were taken in two diverse habitats, a surge channel and a coral head in the lagoon.

Genus SCORPAENOPSIS

Scorpaenopsis Heckel 1839. Ann. Wiener Mus., vol. 2, p. 158. (Type species, Scorpaena nesogallica Cuvier and Valenciennes).

Scorpaenopsis gibbosa

Scorpaena gibbosa Bloch and Schneider 1801. Systema ichth., p. 192, pl. 44. (Type locality, America).

2 specimens. 93 and 95 mm. Onotoa.

D XII,9; A III,5; P 18; transverse scale rows from upper end of gill opening to mid-base of caudal fin 43. (1 specimen).

Color from 35 mm Kodachrome transparency: head and body irregularly mottled with white, brown, and red (except abdomen which is white); caudal fin white with a broad reddish submarginal band spotted with brown and a blackish band at the base.

Both specimens were collected from the same locality, a poorly-defined surge channel zone on the leeward side of the atoll.

Genus BRACHYRUS

Brachyrus Swainson 1839. Nat. hist. and class. fishes, amphibians,..., vol. 2, p. 264. (Type species, Pterois zebra Quoy and Gaimard).

Brachyrus zebra

Pterois zebra Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 329. (Type locality, Coupang Bay, Timor).

Dendrochirus zebra Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 294. (Gilbert Islands).

Genus PTEROIS

Pterois Oken 1817. Isis, p. 1782. (Type species, Gasterosteus volitans Linnaeus).

Pterois volitans

Pterois volitans Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299. (Nauru).

Pterois radiata

Pterois radiata Cuvier and Valenciennes 1829. Hist. nat. poiss., vol. 4, p. 369. (Type locality, Society Islands).

8 specimens. 50 - 130 mm. Onotoa.

2 specimens. 100 and 124 mm. Tarawa.

D XII,11; A III,6; P 16; transverse scale rows from upper end of gill opening to mid-base of caudal fin 50 to 51. (2 specimens).

Color from 35 mm Kodachrome transparency light brownish red with broad reddish brown, white-edged bands on head and body (all of these bands are more-or-less vertical except one on caudal peduncle which is horizontal and one on head running diagonally from eye toward lower base of pectoral fin); fins hyaline with the long rays light red or white; supraorbital tentacle not dark and white banded.

All of the specimens from Onotoa were collected from around isolated coral heads in calm lagoon or channel waters.

Genus TAENIANOTUS

Taenianotus Lacépède 1802. Hist. nat. poiss., vol. 4, p. 303. (Type species, Taenianotus triacanthus Lacépède).

Taenianotus triacanthus

Taenianotus triacanthus Lacépède 1802. Hist. nat. poiss., vol. 4, p. 303.

1 specimen. 35 mm. Onotoa channel.

D XII,11; A III,6; P 14.

Color in alcohol dark brown mottled with white.

Family PLATYCEPHALIDAE

Genus THYSANOPHRYS

Thysanophrys Ogilby 1898. Proc. Linn. Soc. N. S. Wales, vol. 23, p. 40. (Type species, *Platycephalus cirronasus* Richardson).

Thysanophrys sp.

2 specimens. 62 and 100 mm. Onotoa lagoon.

D VIII-11; A 12; P 20; scale rows from gill opening to base of caudal fin 55 (1 specimen).

Color from 35 mm Kodachrome transparency in dorsal view light reddish brown, spotted and mottled with white; 3 faint broad reddish brown bands across body, the first from back of head to posterior end of spinous dorsal, the second, narrower, across middle of soft dorsal, and the third, still narrower, on caudal peduncle; a transverse band across head at level of eyes, this band about 1/3 greatest eye diameter; fins with small dark brown blotches.

Interorbital width 2.2 in greatest diameter of eye; margins of lips papillate.

This species will be described as new by Schultz in vol. 2 of *Fishes of the Marshall and Marianas Islands*.

Family CARACANTHIDAE

Genus CARACANTHUS

Caracanthus Kroyer 1845. Natur. Tidsskr., vol. 1, p. 267. (Type species, *Caracanthus typicus* Kroyer = *Micropus maculatus* Gray).

Caracanthus maculatus

Micropus maculatus Gray 1831. Zool. Misc., p. 20. (Type locality, seas of Owaihi and Hao).

1 specimen. 40 mm. Onotoa.

D VIII, 12; A II, 11; P 14.

Color in alcohol brown with black dots on head and body, especially dorsally; 8th dorsal spine about half as long as 3rd dorsal spine; a single knob-like projection on ventro-anterior edge of preorbital spine.

This specimen was secured with rotenone from a poorly-defined surge channel region in the northern part of the atoll.

Caracanthus unipinnus

Micropus unipinnus Gray 1831. Zool. Misc., p. 20. (Type locality, Pacific Ocean).

2 specimens. 12 and 22 mm. Onotoa.

D VIII, 12; A II, 11 or 12; P 12 or 13.

Color in alcohol brown with no spots; 8th dorsal spine only slightly shorter than 3rd dorsal spine; two knob-like projections on ventro-anterior edge of preorbital spine.

Taken at the same poison station as Caracanthus maculatus.

Family BOTHIDAE

Genus BOTHUS

Bothus Rafinesque 1810. Caratteri di alcuni nuovi generi e nuove specie di animali e piante della Sicilia, p. 23. (Type species, Bothus rumulo Rafinesque).

Bothus mancus

Pleuronectes mancus Broussonet 1782. Ichthyologia...,(no pagination), pl. (Type locality, Tahiti).

2 specimens. 43 and 47 mm. Onotoa.

1 specimen. 150 mm. Tarawa.

D 99 to 101; A 77 to 78; scale rows 82 to 84. (3 specimens).

Color in alcohol tan with 3 large black spots widely separated along lateral line, the one in the mid region of the body being the largest and darkest; body and fins covered with small black spots.

Both Onotoa specimens were collected with rotenone from the lagoon over a sandy bottom, one from 11 feet and the other from 6 feet of water.

Bothus pantherinus

Rhombus pantherinus Rüppell 1828. Atlas zu der Reise im nördlichen Afrika, Fische, p. 121, pl. 3, fig. 1. (Type locality, Red Sea).

Bothus pantherinus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 297. (Nauru).

1 specimen. 102 mm. Onotoa.

1 specimen. 57 mm. Tarawa.

D 89 to 92; A 71 to 72; scale rows 84 (last 4 small). (2 specimens).

Color very similar to Bothus mancus. The usual way to separate these two bothids is to count dorsal and anal fin rays. Schultz (1943) has shown that gill raker counts will effect a separation. A more convenient method lies in the nature of the squamation of the interorbital space. In B. pantherinus this space is entirely scaled except for regions close to the eyes; in B. mancus the anterior half is naked.

The single Onotoa specimen was speared by D. W. Strasburg in a sandy lagoon area of about 5 feet in depth.

Family PLEURONECTIDAE

Genus SAMARISCUS

Samariscus Gilbert 1905. Bull. U. S. Fish Comm., vol. 23, pt. 2, p. 682. (Type species, Samariscus corallinus Gilbert).

Samariscus sp.

1 specimen. 32 mm. Onotoa.

D 64; A 52; P 5; V 5; lateral line scales 70.

Color in alcohol tan with faint, irregular, brown blotches; 3 conspicuous dark brown circles in the midline of the body, the first lying on the lateral line at the level of the end of the pectoral fin, the second just below the lateral line at the level of the 45th dorsal ray, and the last touching the lateral line with the upper rim of the circle at the level of the posterior ends of the soft dorsal and anal fins; dorsal, anal, and caudal fins pale with scattered small dark brown spots; outer half of pectoral fin rays black.

The one small specimen was taken with rotenone in the lagoon over sand in 11 feet of water.

This species will be described by Woods in vol. 2 of *Fishes of the Marshall and Marianas Islands*.

Family ECHENEIDAE

Genus ECHENEIS

Echeneis Linnaeus 1758. Syst. nat., ed. 10, p. 260. (Type species, *Echeneis naucrates* Linnaeus).

Echeneis naucrates

Echeneis naucrates Linnaeus 1758. Syst. nat., ed. 10, p. 260. (Type locality, Pelago Indico).

Leptecheneis naucrates Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299. (Nauru).

Family GOBIIDAE

An estimated 11 species of gobies were collected by the author in the Gilbert Islands. These have been turned over to Dr. Ernest A. Lachner of the United States National Museum who will include them in his write-up of the Gobiidae for volume 2 of *Fishes of the Marshall and Marianas Islands*. Among the field identifications were the following: *Bathygobius fuscus*, *Mucogobius slateri*, *Amblygobius phalaena*, *Gnatholepis knighti*, *Fusigobius neophytus*, and *Gobiodon citrinus*.

Family ELEOTRIDAE

An estimated five species of eleotrids were turned over to Dr. Ernest A. Lachner of the United States National Museum in order that they might be incorporated with Bikini material for volume 2 of *Fishes of the Marshall and Marianas Islands*. Field identifications of two of the species are *Valenciennea strigata* (= *Eleotriodes strigatus*) and *Valenciennea violifera* (= *Eleotriodes sexguttatus*).

Family BROTULIDAE

Genus BROTULA

Brotula Cuvier 1829. Règne animal, ed. 2, vol. 2, p. 335. (Type species, *Enchelyopus barbatus* Bloch and Schneider).

Brotula multibarbata

Brotula multibarbata Temminck and Schlegel 1846. Fauna Japonica. Pisces, p. 251, pl. 111, fig. 2. (Type locality, Simabara Bay, Japan).

6 specimens. 143 - 200 mm. Onotoa.

D 128 to 130; A 104 to 106; P 25; V 2; barbels on snout 6; barbels on chin 6 (2 specimens).

Color in alcohol grayish brown with very faint narrow lengthwise dark lines on body; outer half of dorsal and anal fins black, margin white.

Posterior part of body ends in a gradually tapering point, and dorsal and anal fin rays are not separable from caudal rays (dorsal and anal fin rays were counted to posterior tip of body); eye about 4 in head length; depth of body 5 to 6 in total length.

No specimens of *Brotula townsendi* Fowler were taken.

Genus DINEMATICHTHYS

Dinematichthys Bleeker 1855. Nat. Tijdschr. Ned.-Ind., vol. 8, pp. 306, 319. (Type species, *Dinematichthys iluocoeteoides*).

Dinematichthys iluocoeteoides

Dinematichthys iluocoeteoides Bleeker 1855. Nat. Tijdschr. Ned.-Ind., vol. 8, p. 319. (Type locality, Batu Archipelago).

22 specimens. 35 - 79 mm. 1 specimen. 130 mm. Onotoa.

7 specimens. 43 - 65 mm. Tarawa.

D 72 to 83; A 59 to 65; P 21 to 24; V 2. (6 specimens).

Color in alcohol light grayish to yellowish brown with 3 narrow yellowish longitudinal stripes faintly visible on side of body. Color in life variable, either orange, yellow, or gray.

Specimens were taken from numerous shallow water habitats.

There was no tendency for grouping fin ray counts among the 6 specimens checked, and it is assumed that all specimens except possibly the 130 mm one represent one highly variable species. The 130 mm specimen, bright yellow with reddish fins in life, and 7 smaller specimens were sent to Boyd W. Walker of the University of California at Los Angeles who is working on this group of fishes.

Family PARAPERCIDAE

Genus PARAPERCIS

Parapercis Bleeker. 1863. Ned. Tijdschr. Dierk., vol. 1, p. 236. (Type species, *Sciaena cylindrica* Bloch = *Percis cylindrica* Cuvier and Valenciennes).

Parapercis cephalopunctatus

Percis cephalopunctatus Seale 1901. Occ. Pap. B. P. Bishop Mus., vol. 1, p. 124. (Type locality, Guam).

10 specimens. 87 - 122 mm. Onotoa.

D IV,21; A I,17; P 17; scale rows from upper end of gill opening to base of caudal fin 60 or 61; gill rakers 14 and 16. (2 specimens).

Color from 35 mm Kodachrome transparency white with 9 vertical reddish brown bars on the side of the body, each broadest below lateral line, and all connected by reddish brown region on back and by a narrow blackish line below lateral line; a blackish spot at lower base of pectoral fin; a large blackish area centro-basally in caudal fin; 5 brownish spots in a horizontal line from tip of lower jaw to cheek; dorsal and caudal fins with small blackish spots.

Most of the specimens were taken in sandy areas of the lagoon.

Family BLENNIIDAE

The blennies are here considered in two subfamilies, the Petroscirtinae and the Salariinae. Species of the former group are generally longer bodied, have gill membranes broadly attached to the isthmus, a somewhat pointed snout and ventral mouth, and an exceedingly large canine tooth posteriorly on each side of the lower jaw. The salarian blennies are usually more robust in form (though many are quite elongate), have gill membranes free from the isthmus, a blunt snout, and lack the large canine teeth. This group, along with the gobies, dominated the tide pools of the reef flat at Onotoa and were common in other environments as well.

The identifications and counts on all of the Onotoa Blenniidae and Tripterygiidae were made by D. W. Strasburg, now of Duke University. His able help in this regard was greatly appreciated. All of the blennies listed below without specific names may represent undescribed forms; these have been sent to Strasburg.

Subfamily PETROSCIRTINAE

Genus RUNULA

Runula Jordan and Bollman 1890. Proc. U. S. Nat. Mus., vol. 12, p. 171. (Type species, Runula azalea Jordan and Bollman).

Runula tapeinosoma

Petroskirtes tapeinosoma Bleeker 1857. Act. Soc. Sci. Indo-Neerl., vol. 2, p. 64. (Type locality, Ambon, East Indies).

5 specimens. 49 - 61 mm. Onotoa.

D VIII, 35 or 36; A II, 30. (5 specimens).

Color in life: a broad black band from snout through eye to base of caudal fin and narrowing out on caudal fin rays, this band broken up into blotches on about anterior two-thirds of body; body greenish above this band, whitish below: a small yellow spot at base of caudal fin just above median dark band; dorsal fin with a narrow pale margin and a black submarginal band; anal fin dusky with narrow pale margin.

This slender little fish often made its presence known by direct attack on a swimmer. The bite was usually barely perceptible for the teeth could not normally be inserted; nevertheless this behavior was distinctly annoying.

Genus ASPIDONTUS

Aspidontus Quoy and Gaimard 1834. Voyage "Astrolabe", Zool., vol. 3, p. 719. (Type species, Aspidontus taeniatus Quoy and Gaimard).

Aspidontus taeniatus

Aspidontus taeniatus Quoy and Gaimard 1834. Voyage "Astrolabe", Zool., vol. 3, p. 719, pl. 19, fig. 4. (Type locality, Guam and northern New Guinea).

2 specimens. 54 and 57 mm. Onotoa.

D XI, 27 or 28; A II,26; P 14. (2 specimens).

Color in life bright blue with a black band running from snout through eye down middle of side of body to end of caudal fin, this band becoming broader posteriorly such that the caudal fin is entirely black except upper and lower lobes which are narrowly blue.

See further remarks on this species under the labrid species Labroides dimidiatus.

Genus MEIACANTHUS

Meiacanthus Norman 1943. Ann. Mag. Nat. Hist. ser. 11, vol. 10, p. 805. (Type species, Petroscirtes oualensis Günther).

Meicanthus atrodorsalis

Petroscirtes atrodorsalis Günther 1877. Jour. Mus. Godeffroy, vol. 4, pt. 13, p. 198, pl. 115, fig. B. (Type locality, Samoa).

2 specimens. 36 and 46 mm. Onotoa lagoon.

D IV, 26 or 27; A II, 16 or 17; P 14. (2 specimens).

Color in life brilliant dark blue-green with caudal peduncle, caudal fin, and caudal filaments bright yellow; a black band at base of dorsal fin.

Genus PETROSCIRTES

Petroscirtes Rüppell 1828. Atlas Reise nördlichen Afrika, vol. 4, p. 110. (Type species, Petroscirtes mitratus Rüppell).

Petroscirtes sp.

2 specimens. 37 and 42 mm. Onotoa lagoon.

D IX, 28; A II, 22 or 23; 7 or 8 chin barbels. (2 specimens).

Color in life: anterior half of body blue dorsally shading to purple ventrally; posterior half bright yellow.

This species is tentatively placed in the genus Petroscirtes. It could not properly be included in any of the genera of the subfamily as defined by Norman (1943). It has a body depth about 6 in standard length; the gill opening is small and just above base of pectoral; the dorsal profile of the head is steep and uniformly convex; the interorbital is slightly wider than eye diameter; the anterior edge of the lower jaw is transversely truncate.

Subfamily SALARIINAE

Genus CIRRIPECTUS

Cirripectus Swainson 1839. Nat. hist. and class. fishes, amphibians,... vol. 2, pp. 79, 80 (Cirripectes on pp. 182, 275). (Type species, Salarias variolosus Cuvier and Valenciennes).

Cirripectus variolosus

Salarias variolosus Cuvier and Valenciennes 1836. Hist. nat. poiss., vol. 11, p. 317. (Type locality, Guam).

3 specimens. 57 - 59 mm. Onotoa.

D XII,14; A II,15. (3 specimens).

Color in alcohol reddish brown with a few tiny pale spots anteriorly on head; fins dusky except anterior part of dorsal, outer upper part of caudal, and pectoral membranes.

Cirripectus sebae

Salarias sebae Cuvier and Valenciennes 1836. Hist. nat. poiss., vol. 11, p. 323.

8 specimens. 30 - 48 mm. Onotoa.

3 specimens. 22 - 38 mm. Tarawa surge channel.

D XII, 14; A II, 14. (2 specimens).

Color in alcohol brown with vertical dark brown bars; head with a faint reticulated pattern of whitish lines. One small specimen has a lengthwise black band along side of body from upper edge of gill opening to caudal fin. In another specimen with a similar band, vertical bars are forming ventrally from the band.

Cirripectus quagga

Rupiscartes quagga Fowler and Ball 1924. Proc. Acad. Nat. Sci. Phila., vol. 76, p. 273. (Type locality, Wake Island).

6 specimens. 47 - 59 mm. Onotoa.

D XII, 15; A II, 16. (2 specimens).

Color in alcohol brown with vertical dark brown bars on side of body; some specimens with numerous small pale spots; head with irregular dark lines and pale spots.

Cirripectus jenningsi

Cirripectes jenningsi Schultz 1943. Bull. U. S. Nat. Mus. 180, pp. 273, 274, fig. 27. (Type locality, Swains Island).

1 specimen. 76 mm. Onotoa.

D XII, 15; A II, 16.

Color in alcohol: anterior half of body tan with 2 vertical dark brown bars running from dorsal fin toward abdomen; posterior half of body dark brown; body covered with small whitish spots (more evident on dark brown portions); head with small dark spots (also faintly evident on anterior half of body).

Cirripectus fuscoguttatus

Cirripectus fuscoguttatus Strasburg and Schultz 1953. Jour. Washington Acad. Sci., vol. 43, pp. 129, 130, fig. 1. (Type locality, Rongerik Atoll, Marshall Islands).

2 specimens. 60 and 79 mm. Onotoa.

D XII, 14; A II, 15.

The two specimens were used as paratypes by Strasburg and Schultz.

Cirripectus stigmaticus

Cirripectus stigmaticus Strasburg and Schultz 1953. Jour. Washington Acad. Sci., vol. 43, pp. 130, 132, fig. 2. (Type locality, Rongerik Atoll, Marshall Islands).

16 specimens. 36 - 76 mm. Onotoa.

D XII, 15; A II, 16.

These specimens were used as paratypes by Strasburg and Schultz.

Cirripectus sp.

4 specimens. 30 - 66 mm. Onotoa.

D XII, 14; A II, 15 or 16. (4 specimens).

Color in alcohol: body and fins uniform dark brown.

This species is distinctive in lacking a notch in the dorsal fin between the spinous and soft portions.

Genus RHAEDOBLENNIUS

Rhabdoblennius Whitley 1930. Mem. Queensland Mus., vol. 10, p. 20. (Type species, Blennius rhabdotrachelus Fowler and Ball).

Rhabdoblennius snowi

Blennius snowi Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 431, fig. 71. (Type locality, Strong's Island, Caroline Islands).

Nixiblennius snowi Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 298 (Nauru reef flat).

20 specimens. 14 - 42 mm. Onotoa.

D XII, 19; A II, 19. (2 specimens).

Color in alcohol light tan with 7 white marks in linear series on side of body, the anterior 4 or 5 each in the form of the letter "H"; most specimens with irregular dark brown blotches especially anteriorly on body; head with widely-scattered small white spots.

All of the specimens were collected from the highest tide pools of the outer reef flat which are normally covered by high tide.

Rhabdoblennius sp.

2 specimens. 22 and 23 mm. Onotoa.

D XII, 15 or 16; A II, 17 or 18.

Color in alcohol light brown with 2 lengthwise rows of about 12 brownish spots down the side of the body (these spots tend to be arranged in groups of 4); 2 irregular oblique dark brown lines on head behind eye which join below eye and continue on to chin; a dark brown spot ventrally on gill membranes just anterior to base of pelvic fin; anterior part of head and upper lip with a concentration of dark pigment spots.

Body elongate, its depth contained about 6.5 times in standard length; one broad simple nuchal cirrus on each side; anterior nostril with a tubular rim, one edge of which is produced into a broad, simple flap; a median cephalic crest with a dark brown spot in its center (and an anterior and posterior spot as well in the larger specimen).

The two specimens were collected by use of rotenone on the outer reef in an area of the northern part of the atoll with numerous small heads of coral reaching to within a foot of the surface; maximum depth of the water was 7 feet.

Genus ISTIBLENNIUS

Istiblennius Whitley 1943. Australian Zool., vol. 10, p. 185. (Type species, Salarias mülleri Klunzinger).

Istiblennius edentulus

Blennius edentulus Bloch and Schneider 1801. Systema ichth., p. 172. (Type locality, Huahine Island, Society Islands).

Salarias edentulus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 298. (Nauru).

5 specimens. 35 - 81 mm. Onotoa.

5 specimens. 51 - 92 mm. Tarawa.

1 specimen. 53 mm. Nukunau.

D XIII, 19 to 21; A II, 21 or 22. (4 specimens).

Color in alcohol brown with pairs of vertical dark brown bars on the side of body; median fins darker than body.

All specimens from tide pools of outer reef flat.

Istiblennius lineatus

Salarias lineatus Cuvier and Valenciennes 1836. Hist. nat. poiss., vol. 11, p. 314. (Type locality, Java).

8 specimens. 31 - 108 mm. Onotoa.

D XIII, 22 to 24; A II, 22 to 24. (8 specimens).

Color in alcohol light brown with pairs of brown spots on back adjacent to dorsal fin and in line with these on the side brown bars which follow myotome contours; about 10 or 12 small dark brown spots on side of caudal peduncle; fins light brown.

The specimens were collected from tide pools on the outer reef flat.

Istiblennius paulus

Salarias paulus Bryan and Herre 1903. Occ. Pap. B. P. Bishop Mus., vol. 2, p. 136. (Type locality, Marcus Island).

Salarias periophthalmus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299. (Nauru).

12 specimens. 18 - 69 mm. Onotoa.

D XIII, 19 or 20; A II, 20 or 21. (5 specimens).

Color in alcohol tan with about 7 brownish "H" shaped marks in linear series on side of body, the upper part of the "H" less distinct; two tiny elliptical dark-edged white spots, one above the other, within each "H" shaped mark; soft dorsal fin with basal half dusky, outer half pale; anal fin with outer one-third dusky, inner two-thirds pale; lower portion of caudal fin dusky (orangish in life), upper half pale.

This species was taken both from tide pools of the outer reef flat and in deeper water (about 5 feet) of the outer reef and lagoon.

Istiblennius gibbifrons

Salarias gibbifrons Quoy and Gaimard 1824. Voyage autour du monde..."Uranie"...Zool., p. 253. (Type locality, Hawaiian Islands).

3 specimens. 35 - 57 mm. Onotoa.

D XIII, 18 or 19; A II, 19 or 20. (3 specimens).

Color of female specimen in alcohol light tan with very faint irregular vertical dark markings on side of body; a jet black spot on fin membrane between first 2 dorsal rays; dorsal and caudal fins pale with small black spots forming irregular lines.

The specimens were collected from tide pools and water up to 7 feet in depth on the outer reef.

Family TRIPTERYGIIDAE

Genus TRIPTERYGION

Tripterygion Risso 1826. Hist. Nat. Eur. Merid., vol. 3, p. 241. (Type species, *Tripterygion nasus* Risso).

Tripterygion minutus

Tripterygium minutum Günther 1877. Jour. Mus. Godeffroy, vol. 4, pt. 13, p. 211. (Type locality, Apia, Samoa).

5 specimens. 15 - 18 mm. Onotoa.

D III-XI-9; anterior lateral line pores 13 or 14. (5 specimens).

Color in alcohol pale with tiny small black spots (melanophores) on body and fins, most concentrated on edges of body scales, caudal fin, anal fin, and ventral half of head and chest.

This small species was taken in tidepools on the outer reef flat about 200 feet from shore.

Genus HELCOGRAMMA

Helcogramma McCulloch and Waite 1918. Rec. South Australian Mus., vol. 1, p. 57. (Type species, *Helcogramma decurrens* McCulloch and Waite).

Helcogramma sp.

4 specimens. 30 - 31 mm. Onotoa.

D III-XIII or XIV-11 or 12; A I, 20 or 21; P 16. (4 specimens); anterior lateral line scales 25. (2 specimens); posterior scales 14; oblique scale rows 39. (1 specimen).

Color in life light brown with 7 pairs of vertical red lines on each side of body extending from mid-dorsal line about four-fifths the body depth (the members of each pair of lines tend to meet ventrally); head blackish due to numerous black dots (except occipital region which is bright red); eyes red.

The species was taken in two different localities at the atoll; one was in the lagoon near the west reef with considerable coral and in 11 feet of water; the other was a similar region though on the outer reef, the depth being 8 feet.

These specimens have been sent to D. W. Strasburg at Duke University who believes they may represent an undescribed species.

Family CARAPIDAE

Genus CARAPUS

Carapus Rafinesque 1810. Indice d'ittiologia sicilana...pp. 37, 57. (Type species, *Gymnotus acus* Linnaeus).

Carapus homei

Oxybeles homei Richardson 1846. Ichthyology voyage "Erebus" and "Terror", p. 74, pl. 44, figs. 7 - 19. (Type locality, seas of Australia? and Timor).

7 specimens. 70 - 127 mm. Onotoa.

Color in alcohol uniform pale yellowish. Pectoral rays counted as 17. 3 elongate gill rakers on upper part of first arch, remaining rakers rudimentary. 3 stout teeth in midline on vomer with small teeth in a single row on either side; 2 rows of teeth on palatine; teeth in jaws in 2 rows, those near symphysis about 2 or 3 times longer than remaining teeth.

Six of the specimens were brought to me by Gilbertese children; when queried as to how the fish were collected, they replied that they were taken from sea cucumbers in the lagoon.

One specimen of this species, 90 mm in length, was inadvertently collected by P. E. Cloud at Onotoa. He picked up a sea urchin with long banded spines (either Diadema or Echinothrix) and placed it in a face plate. Later the little pearl fish was discovered in the same face plate. Because of the habits of these fishes, it was at first assumed that this individual fish had been inside the test of the urchin when it was picked up. In view of the difficulty in visualizing a means of exit from an echinoid, especially one small enough to fit into a face plate, I now believe the fish might have hidden among the spines of the urchin when it was collected. Dr. Cloud, however, still suspects that the fish may have been within the urchin and somehow managed to extricate itself.

Family BALISTIDAE

The trigger fishes, with their unusual structure, bright color, and peculiar mode of swimming by undulation of the soft dorsal and anal fins, proved to be a prominent group of fishes on Gilbert Island reefs. They were always seen as solitary individuals and were usually wary of an observer. The natives referred to species in this family as te bubu. Most are readily caught with hook and line.

At Onotoa Rhinecanthus aculeatus was the most abundant in typical lagoon areas while Balistapus undulatus generally predominated elsewhere. The distinctive Rhinecanthus rectangulus was commonly seen on the outer reef, seeking refuge in very small holes in the reef when approached.

Only six species were taken at Onotoa. Another, Melichthys vidua, was often seen underwater at this atoll. It was previously collected by Andrew Garrett at Abaiang and reported by Günther (1910). Also collected by Garrett from the Kingsmill Islands were Pseudobalistes fuscus and Sufflamen chrysoptera.

Odonus niger, Balistoides niger (= B. conspicillum), Pseudobalistes flavimarginatus, and Sufflamen bursa were not seen nor are they recorded from the Gilbert Islands, but these species, and possibly others, may occur there.

Key to the Species of Balistidae
Recorded from the Gilbert Islands

1a. A short groove running forward below the nostrils from the most anterior part of eye........................2

1b. No groove running forward from eye......................8

2a. Third dorsal spine not visible in elevated fin; ventral profile from mouth to pelvic spine prominently convex...3

2b. Third dorsal spine readily visible in elevated fin; ventral profile from mouth to pelvic spine straight or only slightly convex..............................5

3a. A series of 5 long oblique grooves on cheek, the 3 central ones most prominent; body depth not great, 2.5 in standard length; color of body in alcohol light brown with a single round brown spot on each scale..........................Xanthichthys ringens

3b. No series of long grooves on cheek; body depth great, about 2 in standard length; color of body very dark brown to black.....................................4

4a. A series of 8 to 10 conspicuous lengthwise ridges on posterior third of body; caudal fin lunate; all fins dark except a narrow pale (light blue in life) line at the base of the soft dorsal and anal fins.......... ....Melichthys buniva

4b. No series of conspicuous lengthwise ridges on posterior third of body; caudal fin double emarginate to truncate; pectoral fin pale (light yellow in life), soft dorsal and anal fins white with narrow black margins, caudal fin pale (in life with basal third white and distal two-thirds bright salmon-pink)....... ....Melichthys vidua

5a. No rows of spines on caudal peduncle; head naked anteriorly, scaled posteriorly; 4 short horizontal grooves on cheek; soft dorsal and anal fins markedly elevated anteriorly; caudal fin with prolonged pointed upper and lower lobes; margins of pectoral, soft dorsal, anal, and caudal fins abruptly pale..Pseudobalistes fuscus

5b. Rows of small forward-projecting spines on caudal peduncle; head completely scaled; no horizontal shallow grooves on cheek; soft dorsal and anal fins not markedly elevated anteriorly; margins of pectoral, soft dorsal, anal, and caudal fins not abruptly pale..6

6a. Dorsal profile of head from mouth to origin of spinous dorsal fin slightly convex; body with dorsal saddle-like black areas extending midlaterally; eye large, contained about 4 times (3 in young) in distance from snout to upper end of gill opening; caudal fin markedly rounded...............Balistoides viridescens

6b. Dorsal profile of head almost straight; dorsal part of body without any saddle-like black areas; eye relatively small, contained about 5 to 5.5 times in the distance from the snout to the upper end of the gill opening; caudal fin slightly rounded or slightly emarginate...7

7a. Caudal fin slightly rounded; caudal fin uniform brown in color; membrane of spinous dorsal fin extends to tip of first dorsal spine, the free edge of this membrane being almost straight....Sufflamen capistrata

7b. Caudal fin slightly emarginate; caudal fin very dark brown with broad white crescentic marginal area posteriorly and narrower white marginal areas dorsally and ventrally; membrane of the spinous dorsal fin does not extend to extreme tip of first dorsal spine, and the free edge of this membrane is distinctly concave............................Sufflamen chrysoptera

8a. Third dorsal spine large, that seen above dorsal body profile contained .4 to .8 times in greatest diameter of eye; spines on caudal peduncle large, irregularly arranged in 2 short rows, and contained in a large round black area; body dark brown with numerous narrow sweeping pale (orange in life) lines...Balistapus undulatus

8b. Third dorsal spine minute, not visible or only barely visible above dorsal body profile; spines on caudal peduncle small, linearly arranged in 3 to 4 rows, and not contained in a round black area; body pale to light brown with distinctive black markings.......9

9a. Spines on caudal peduncle in 4 horizontal rows, the upper row about half the length of the lower 3; spines on caudal peduncle contained in a triangular black area, the anterior point of which terminates at about the level of the 8th dorsal ray...*Rhinecanthus rectangulus*

9b. Spines on caudal peduncle in 3 horizontal rows, the lowermost of which is less than half the length of the upper 2; spines on caudal peduncle not contained in a triangular black area......*Rhinecanthus aculeatus*

Genus XANTHICHTHYS

Xanthichthys (*ex* Kaup) Richardson 1856. Encycl. Brit., ed. 8, vol. 12, p. 313. (Type species, *Balistes curassavicus* Gmelin 1788 = *Balistes ringens* Linnaeus 1758).

Xanthichthys ringens

Balistes ringens Linnaeus 1758. Syst. nat., ed. 10, vol. 1, p. 329. (Type locality, Ascension Island).

Xanthichthys ringens Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299. (Nauru).

Genus MELICHTHYS

Melichthys Swainson 1839. The nat. hist. and class. fishes, amphibians,...,vol. 2, pp. 194, 325. (Type species, *Balistes ringens* Bloch = *Balistes buniva* Lacépède 1803).

Melichthys buniva

Balistes buniva Lacépède 1803. Hist nat. poiss., vol. 5, pp. 668, 669, pl. 21, fig. 1.

Balistes radula Solander, *in* Richardson 1848. Zool. "Samarang", p. 22.

3 specimens. 106 - 215 mm. Onotoa.

Color in life dark blue-green with black longitudinal lines; a narrow bright light blue line at base of the soft dorsal and anal fins, this line being slightly broader posteriorly. Blue lines radiate dorsally and anteriorly from the eye. Just visible in the dark caudal fin is a somewhat darker submarginal vertical line, faintly edged in light blue, which curves posteriorly to extend to the ends of the somewhat prolonged upper and lower lobes of the caudal fin. Immediately upon death the fish takes on a uniform greenish black hue, thus obliterating the longitudinal lines on the body; the blue lines radiating from the eye disappear. The most conspicuous color, the light blue line at the base of the soft dorsal and anal fins, remains, ultimately fading to white in preserved specimens.

All specimens were speared on the coralliferous terrace of the outer reef, the only habitat where they were seen. They were often observed well above the coral-covered bottom. Rapid swimmers for balistids, they usually moved swiftly away from an area intruded by a swimmer.

There has been considerable confusion with respect to the correct name for this circumtropical species. Three specific names have been in common use, buniva, radula, and ringens. The ringens of Linnaeus (1758) is clearly not this species, for he mentioned the three grooves on the cheek such as we see in the Atlantic Xanthichthys, and these are not present in Melichthys. The name buniva Lacépède predates radula Solander.

Melichthys vidua

Balistes vidua Solander, in Richardson 1844. Zool. "Sulphur", Fishes, p. 128, pl. 59, figs. 9, 10. (Type locality, Tahiti).

Melichthys vidua Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299. (Nauru).

An elusive species at Onotoa, it was frequently seen on the coralliferous terrace of the outer reef near the entrance to surge channels. It avoided capture by retiring to deep recesses in the reef. A specimen procured in the Marshall Islands provided the following color description: body purplish black; basal third of caudal fin snow white, distal two-thirds bright salmon pink; pectoral fin clear yellow; soft dorsal and anal fins edged in black; within the black margins fin rays white, membranes hyaline; spinous dorsal fin black; lips faintly reddish; iris yellow.

Genus PSEUDOBALISTES

Pseudobalistes Bleeker 1866. Ned. Tijdschr. Dierk., vol. 3, p. 11. (Type species, Balistes flavimarginatus Rüppell).

Pseudobalistes fuscus

Balistes fuscus Bloch and Schneider 1801. Systema ichth., p. 471 (on Le Baliste grande-tache Lacépède 1799).

Balistes chrysospilus Bleeker 1865. Atlas ichth., vol. 5, p. 111, pl. 225, fig. 3.

Balistes fuscus Günther 1910. Jour. Mus. Godeffroy, vol. 9, pt. 17, p. 442, pl. 168. (Kingsmill Islands).

Genus BALISTOIDES

Balistoides Fraser-Brunner 1935. Ann. Mag. Nat. Hist., ser. 10, vol. 15, p. 662. (Type species, Balistes viridescens Bloch).

Balistoides viridescens

Balistes viridescens Bloch and Schneider 1801. Systema ichth., p. 477 (on Le Baliste verdatre Lacépède 1799). (Type locality, Mauritius).

6 specimens. 23 - 29 mm. Onotoa.

Color of juveniles in life light golden with scattered dark brown spots on head and body. A faint dark area occurs beneath the soft dorsal fin; a similar blotch can be seen adjacent to the base of the spinous dorsal fin; dorsal, anal, and pectoral fins unspotted except in the largest specimen which possesses 3 faint spots in the soft dorsal fin; caudal fin dusky with small blotches centrally.

These small specimens were identified as viridescens on the basis of fin ray counts which were consistent with those of specimens from the Philippines, East Indies, Samoa, and the Marshall Islands and by comparison with progressively larger specimens from these areas which gradually assume typical adult coloration. An 80 mm specimen from the Philippines displayed the characteristic broad dark band extending and narrowing posteriorly from the upper lip and containing a thin pale line. Bleeker has portrayed this species in color as Figure 2 of Plate 131 in Volume 5 of his Atlas Ichthyologique (1865).

5 specimens (22-23 mm) were collected by hand in a sandy channel region where the water was only a few inches deep. The 29 mm specimen was secured with rotenone from a depth of about 5 feet in the Onotoa lagoon.

Adults are stated by Günther (1910) to reach a length of 2 feet. A specimen of nearly this size from the Line Islands, erroneously identified as fuscus, is present in the Bernice P. Bishop Museum, Honolulu. The adults were not infrequently seen in the Onotoa lagoon well out of spearing range. It is possible, however, that they might be confused at this distance with P. fuscus or P. flavimarginatus which also reach large size.

Genus SUFFLAMEN

Sufflamen Jordan 1916. Copeia, no. 29, p. 27. (New name for Pachynathus Swainson 1839, preoccupied). (Type species, Balistes capistratus Shaw).

Sufflamen capistrata

Balistes capistratus Shaw 1804. General Zoology, vol. 5, pt. 2, p. 417 (on Le Baliste bride Lacépède 1799). (Type locality, Indian Ocean).

Sufflamen fraenatus Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299. (Nauru).

1 specimen. 135 mm. Onotoa.

Color from 35 mm Kodachrome transparency brownish gray; proximal half of lower lip bright yellow; remainder of this lip and upper lip bluish; a pale line on chin extending upwards almost to rictus; spinous dorsal and caudal fins dark brown, the former fin with a black spot distally in the fin membrane; pectoral, soft dorsal, and anal fins brownish, becoming yellowish distally.

A second line under the chin and a prominent line extending from the rictus almost to the base of the pectoral fin were not present in the Onotoa specimen. Such markings are shown in Lacépède's plate and are included in Shaw's description. The absence of such markings, however, is considered within the variability of this species by Fowler (1928).

Sufflamen chrysoptera

Balistes chrysopterus Bloch and Schneider 1801, Systema ichth., p. 466 (on Le Baliste armé Lacépède 1799). (Type locality, Indian Ocean).

Balistes niger Günther, 1910, Jour. Mus. Godeffroy, vol. 9, pt. 17, p. 439. (Kingsmill Islands).

Genus BALISTAPUS

Balistapus Tilesius 1820. Mem. Acad. Imp. Sci. St. Petersburg, vol. 7, p. 306. (Type species, Balistapus capistratus Tilesius 1820 = Balistes undulatus Mungo Park 1797).

Balistapus undulatus

Balistapus undulatus Mungo Park 1797. Trans. Linn. Soc. London, vol. 3, p. 37. (Type locality, Sumatra).

6 specimens. 32 - 153 mm. Onotoa.

Color from 35 mm Kodachrome transparency metallic bluish brown with about 20 narrow bright orange lines, occasionally broken, running somewhat irregularly in a diagonal fashion across body antero-dorsally to postero-ventrally; a broad orange line extending from above upper lip diagonally across chest to pelvic spine (this line is joined at about the level of the eye with a similar orange line which circles the chin); a third and narrower orange line runs above and just parallel to the first; lower lip with a broad orange line; a round, jet black area surrounding caudal peduncle spines; spinous dorsal fin dusky with a prominent black spot distally in the membrane between the first and second dorsal spines, and a lesser black spot in the next interspinous membrane; rays of soft dorsal and anal fins orange, membranes clear; caudal fin rays dark brown; membranes of caudal fin orange in dorsal and ventral part of the fin, yellowish centrally. Some variability in color pattern, especially of the orange lines on the body, was apparent from specimen to specimen.

The 32 mm specimen, displaying the juvenile balistid feature of a relatively long first dorsal spine, has a color pattern very similar to that of adult fish. Instead of about 20 oblique orange lines on the body, however, it has 8.

B. undulatus was probably the most abundant balistid at Onotoa and was taken from outer reef, lagoon, and channel areas.

The stomach and intestinal contents of 8 adult specimens from Onotoa were examined. Only one contained a fish, this being in the forepart of the stomach and probably a prior victim to rotenone than the balistid itself. Three specimens had eaten largely green algae; one of these had a good-sized brachyuran crab, another a number of small Acropora fragments, and posteriorly in the intestine of the third were the broken spines and test of a sea urchin. Included also in the green algae were several small sponges, tunicate fragments, an egg mass, a few small foraminifera, and considerable bottom debris. Three other specimens contained mostly the coralline red alga Jania, one of these having in the posterior part of the stomach a mass of coral fragments. One specimen contained only a little bottom debris and an isopod. The last had made a meal of what appears to be a large polychaete.

It seems, therefore, that this species does not have specialized food habits, but is a rather general bottom feeder. By virtue of its rugged dentition it is able to cope with such unusual food items as coral and sea urchins. In spite of the preponderance of algae in some specimens it is doubtful if algae constitutes important food to the species, for the gut is very short.

Genus RHINECANTHUS

Rhinecanthus Swainson 1839. Nat. hist. and class. fishes, amphibians,..., vol. 2, pp. 194, 325. (Type species, Balistes aculeatus Linnaeus).

Rhinecanthus rectangulus

Balistes rectangulus Bloch and Schneider 1801. Systema ichth., p. 465 (on Le Baliste écharpe Lacépède 1799). (Type locality, Indian Ocean).

3 specimens. 26 - 86 mm. Onotoa.

2 specimens. 97 and 114 mm. Tarawa.

Color from 35 mm Kodachrome transparency light brown, shading to white ventrally on head, chest, and abdomen; a black band extending diagonally from eye, becoming broader just before reaching pectoral fin, and angling more sharply backward at this location to end in midventral line at anterior two-thirds of anal fin and a short distance before this fin; a broad blue band across interorbital space containing 3 black lines; three blue lines extend diagonally downward from eye to pectoral region, 2 of these serving as margins to the previously mentioned black band at this location; a blue line over upper lip; a large triangular black area on caudal peduncle margined with golden lines; slightly removed from, but in alignment with the anterior pointed portion of this black area is a second golden line, the lower limb of which lies adjacent to the upper edge of the broad diagonal black band which extends from pectoral region to anal fin area; red line at base of pectoral fin rays; pectoral, soft dorsal, and anal fins pale, spinous dorsal and caudal fins dusky.

The 26 mm specimen has typical adult coloration.

This species was observed and taken only in the outer reef area.

Rhinecanthus aculeatus

Balistes aculeatus Linnaeus 1758. Syst. nat., ed. 10, p. 328. (Type locality, India).

5 specimens. 28 - 145 mm. Onotoa.

Color from 35 mm Kodachrome transparency: ground color of body light tan above, grading to white ventrally; a black band bordered by blue lines extending from eye to base of pectoral fin; a separate blue line starting from just in front of eye parallels the blue-bordered band and curves to join it at pectoral base; interorbital space blue with 3 black lines running from eye to eye; a large dusky black area centrally on body sending an orangish black band upward to origin of soft dorsal fin and a second dusky branch to posterior part of soft dorsal fin; ventrally the central dusky area is dissected by 4 light blue bands running diagonally back to the anal fin; a 5th band is marginal, running to region of anus; immediate circumanal region black; caudal peduncle spines black and contained within a light blue area; lips bright orange, this color extending broadly from lips to lower base of pectoral fin, narrowing as it approaches this location and displaying a slight hook at the end; a blue line occurs within the orange yellow area just above the upper lip; pectoral, soft dorsal, and anal fins pale; spinous dorsal almost black, caudal fin dusky.

The 28 mm specimen has typical adult coloration.

This species was observed only in sandy lagoon areas around small coral heads.

Table 6 Counts Made on the Balistidae Collected in the Gilbert Islands

Soft rays of the dorsal fin*

	23	24	25	26	27	28	29	30	31	32	33
M. buniva										1	1
B. viridescens				3							
S. capistrata						1					
B. undulatus			3	2							
R. rectangulus	2	2									
R. aculeatus		2	2								

Anal fin rays*

	21	22	23	24	25	26	27	28	29	30
M. buniva									1	1
B. viridescens				3						
S. capistrata					1					
B. undulatus		2	3							
R. rectangulus	4									
R. aculeatus	2	2								

	Scale rows**
M. miniva	54 - 55
S. capistrata	47
B. undulatus	35 - 38
R. rectangulus	33 - 36
R. aculeatus	33 - 36

*All elements of soft dorsal and anal fins, whether articulated or not, were counted as rays.

**Scale rows were counted from the upper end of the gill opening to the end of the hypural plate. No scale counts could be made for B. viridescens, for they were not completely formed in the juvenile specimens which were collected.

Family MONACANTHIDAE

The file fishes were not abundant at Onotoa, with only nine specimens of four species being taken. Garrett collected Aleutera scripta at Abemama. The general Gilbertese name for the monacanthids at Onotoa was te bubuawai.

Key to the Species of Monacanthidae
Recorded from the Gilbert Islands

1a. Caudal fin very large, its length contained about 2.5 times in standard length; dorsal spine small and feeble, contained more than 5 times in standard length; body gray or brown in life with black spots and short curved blue lines..........Aleutera scripta

1b. Caudal fin not very large, its length contained 4 to 4.5 times in standard length; dorsal spine not small and feeble, contained 3 to 5 times in standard length; color not as in 1a..........................2

2a. Snout long and tubular; mouth very small and directed sharply upwards; gill opening small (less than half an eye diameter in length), vertical, and posterior to eye; body light brown (blue-green in life) and covered with numerous roundish pale (orange in life) spots......................Oxymonacanthus longirostris

2b. Snout not long and tubular; mouth not very small and directed only slightly upwards; gill opening not small (1.8 to 2 eye diameters in length), oblique, and not posterior to eye...............................3

3a. Dorsal spine with a lateral series of 8 to 12 prominent downward-curved spines; pelvic spine long, with 2 outer articulated portions bearing stout spines; gill opening relatively short (about .8 eye diameters) and contained in a black area; body scales (in specimens over 50 mm) with a vertical series of 3 to 5 large spinules (the central one being about twice as long as adjacent 2), these spinules becoming conspicuously longer on caudal peduncle, giving it a marked brush-like texture................................Pervagor melanocephalus

3b. Dorsal spine without prominent series of spines; pelvic spine short, without outer articulated portions; gill opening relatively large, 1.2 to 2 eye diameters in length, and not contained in a black area; spinules on body scales small and not as in 3a...............4

4a. 4 prominent (at least in adults) anteriorly curved spines in 2 rows on caudal peduncle; caudal fin orange in life.........................Amanses carolae

4b. No spines on caudal peduncle; caudal fin grayish-brown in life...................Amanses sandwichiensis

Genus ALEUTERA

Aleutera Oken 1817. Isis, p. 1183. (Type species, Balistes monoceros Linnaeus).

Aleutera scripta

Balistes scriptus Osbeck 1765. Reise nach Ostindien und China..., p. 145. (Type locality, China Sea).

Monacanthus scriptus Günther 1910. Jour. Mus. Godeffroy, vol. 9, pt. 17, p. 452. (Abemama).

Osbeckia scripta Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 300. (Nauru).

Genus OXYMONACANTHUS

Oxymonacanthus Bleeker 1866. Nat. Tijdschr. Dierk. Amst., vol. 3, p. 13. (Type species, Oxymonacanthus chrysospilus Bleeker = Balistes longirostris Bloch).

Oxymonacanthus longirostris

Balistes hispidus var. longirostris Bloch and Schneider 1801. Systema ichth. p. 464.

1 specimen. 60 mm. Onotoa.

Color in alcohol light brown with 7 series of prominent roundish pale spots on body; short longitudinal pale lines on head; tip of snout pale, this pale area with a black posterior margin; pelvic spine and adjacent area of body black with small pale spots; membrane connecting pelvic spine to body pale; dorsal and anal fins pale; caudal fin pale with 2 vertical dusky bands; central region of posterior caudal dusky band black. Brief color note from life: body bright blue-green with brilliant orange spots.

The single specimen was obtained with rotenone over the west reef of the atoll on the lagoon side in 11 feet of water. It was occasionally sighted in similar areas hovering just over coral knolls.

Genus PERVAGOR

Pervagor Whitley 1930. Australian Zool., vol. 6, p. 120. (Type species, Monacanthus alternans Ogilby).

Pervagor melanocephalus

Monacanthus melanocephalus Bleeker 1853. Nat. Tijdschr. Ned.-Ind., vol. 5, p. 95. (Type locality, Lawajong, Solor).

4 specimens. 45 - 68 mm. Onotoa.

Color in alcohol dark brown with faint evidence of narrow longitudinal lines; gill opening surrounded by a black blotch which extends upward to level of eye; region of body between anus and pelvic spine black; soft dorsal and anal fins with numerous, slightly irregular, narrow black lines; caudal fin with numerous, slightly wavy, black lines which parallel the rounded posterior edge of the fin, these lines being absent in central part of fin where a pale crescent-shaped area is visible (this pale area is very indistinct and more anterior in location in the 45 mm specimen, suggesting that it might be absent in smaller specimens). There is definitely no broad submarginal black band in the caudal fin of any specimen. This feature, plus the presence of the black area around the gill opening suggests that these specimens are Pervagor melanocephalus melanocephalus. Schultz and Woods will include a discussion of subspecies of P. melanocephalus in vol. 2 of Fishes of the Marshall and Marianas Islands.

The specimens were obtained with rotenone from lagoon and protected outer reef areas.

Genus AMANSES

Amanses Gray 1832-35. Ill. Indian Zool., vol. 2, pl. 98. (Type species, Monacanthus (Amanses) hystrix Gray = Monacanthus scopas Cuvier).

Amanses carolae

Cantherines carolae Jordan and McGregor in Jordan and Evermann 1899. Rep. U. S. Fish Comm. for 1898. p. 281, pl. 6. (Type locality, Socono Island).

1 specimen. 245 mm. Onotoa.

1 specimen. 192 mm. Tarawa.

Color in life grayish brown with slight yellowish cast ventrally; posterior two-thirds of body with about 12 faint vertical dark brown bands; lips flesh colored, darker on distal margins; bony protuberances bearing caudal peduncle spines orange; dorsal, anal, and pectoral fins pale yellowish, caudal fin orange with dusky rays; iris orange-yellow.

The Onotoa specimen was speared in a recess in coral in about 20 feet of water on the coralliferous terrace of the outer reef.

Amanses sandwichiensis

Balistes sandwichiensis Quoy and Gaimard 1824. Voyage autour du monde..."Uranie", Zool., p. 214. (Type locality, Hawaiian Islands).

Cantherines pardalis Whitley and Colefax 1938. Proc. Linn. Soc. N. S. Wales, vol. 63, p. 299.

3 specimens. 48 - 95 mm. Onotoa.

Color from 35 mm Kodachrome transparency light gray with a faint reticulation of light blue on body and narrow lines on head; a prominent white spot (disappearing in preserved specimens) dorsally on the caudal peduncle at posterior end of the dorsal fin; pectoral, dorsal, and anal fins faintly yellowish; caudal fin dark gray.

The specimens were taken with rotenone on west reef of atoll.

Table 7 Fin Ray Counts of the Monacanthidae Collected in the Gilbert Islands

	Dorsal fin						Anal fin				
	31	32	33	34	35	36	28	29	30	31	32
O. longirostris		1						1			
P. melanocephalus	2	1					2	1			
A. carolae					1	1				1	1
A. sandwichiensis					3					3	

	Pectoral fin (both sides counted)				
	11	12	13	14	15
O. longirostris	2				
P. melanocephalus		4	2		
A. carolae				1	3
A. sandwichiensis		2	4		

Family OSTRACIONIDAE

Genus OSTRARION

Ostracion Linnaeus 1758. Syst. nat., ed. 10, p. 330. (Type species, Ostracion cubicus Linnaeus).

Ostracion cubicus

Ostracion cubicus Linnaeus 1758. Syst. nat., ed. 10, p. 332. (Type locality, India).

Ostracion cubicus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 461. (Abaiang, Kingsmill Islands).

No specimens were collected by me in the Gilbert Islands. Color from 35 mm Kodachrome transparency of a 132 mm specimen which I speared at Arno Atoll in the Marshall Islands: carapace dull yellow with scattered small black spots, more numerous anteriorly; caudal peduncle, fins, and lips bright yellow.

Ostracion meleagris

Ostracion meleagris Shaw 1796. Nat. Misc., vol. 7, pl. 253. (Type locality, Southern Ocean).

Ostracion sebae Günther 1910. Jour. Mus. Godeffroy, vol. 6, pt. 17, p. 454. (Kingsmill Islands).

1 specimen. 83 mm. Onotoa.

D 10; A 10; P 10.

Color from 35 mm Kodachrome transparency dark purplish blue with numerous white dots on carapace, caudal peduncle, and tail; spots on head smaller and less distinct than those on body; dorsal, anal, and pectoral fins hyaline with blackish rays.

This was the only trunk fish taken at Onotoa, and no others were seen.

According to Fraser-Brunner (1940: 391) Ostracion sebae Bleeker is the male form of O. lentiginosus (= meleagris). I am unable to sex my specimen for the gonad is very small, but I believe it is a female. The gut is three times as long as the standard length and its contents largely algal (possibly Dictyosphaeria) with bits of bottom sediment. The peritoneum is transparent with scattered small black dots.

Family CANTHIGASTERIDAE

Genus CANTHIGASTER

Canthigaster Swainson 1839. Nat. hist. and class. fishes, amphibians,... vol. 2, p. 194. (Type species, Tetraodon rostratus Bloch).

Canthigaster solandri

Tetrodon solandri Richardson 1845. Zool. voyage "Sulphur", Fishes, p. 125, pl. 57, figs. 4 to 6. (Type locality, Polynesia).

18 specimens. 16 - 62 mm. Onotoa.

1 specimen. 47 mm. Tarawa

D 9; A 9; P 16 or 17 (mostly 17); (8 specimens).

Color from 35 mm Kodachrome transparency reddish tan with numerous small bright blue spots on head and body; blue lines radiating from eye; a black, blue-edged spot beneath dorsal fin; caudal fin orange with bright blue spots arranged in vertical rows; other fins hyaline; throat orange, mid-portion without blue spots.

This was the most abundant sharp-nosed puffer at Onotoa. It was taken in relatively shallow water of lagoon, channel, and outer reef.

Canthigaster jactator

Tropidichthys jactator Jenkins 1901. Bull. U. S. Fish Comm., vol. 19, p. 399, fig. 11. (Type locality, Honolulu).

2 specimens. 52 and 55 mm. Onotoa lagoon.

D 9; A 9; P 17. (2 specimens).

Color in alcohol grayish brown with numerous close-set pale spots on body, somewhat larger and closer together ventrally; dark brown lines radiating from eye and two short diagonal dark lines just beneath dorsal fin; all fins pale without spots.

Canthigaster amboinensis

Psilonotus amboinensis Bleeker 1865. Ned. Tijdschr. Dierk., vol. 2, p. 180. (Type locality, Ambon, East Indies).

5 specimens. 39 - 83 mm. Onotoa.

D 11 or 12 (mostly 12); A 11; P 16 or 17 (mostly 17). (5 specimens).

Color in life dark olive, shading to orange-brown ventrally with small light blue spots and a few brown spots on side of body; light blue lines extending dorsally from eye; dark blue lines ventro-anteriorly from base of pectoral fin; anus and base of anal fin brilliant sapphire blue.

The specimens were collected from rich coral areas of the lagoon near the west reef and from a similar area of the outer reef in the northern part of the atoll.

Family TETRAODONTIDAE

Puffers were infrequently seen in the Gilbert Islands and only four species were collected. The Gilbertese called them all by the name *Tebuni*. They were well aware of the poisonous nature of tetraodont gonads.

Genus AROTHRON

Arothron Müller 1841. Abh. preuss. Akad. Wiss., p. 252. (Type species, *Arothron testudinarius* Müller = *Tetrodon stellatus* Bloch and Schneider).

Arothron hispidus

Tetraodon hispidus Linnaeus 1758. Syst. nat., ed. 10, p. 333. (Type locality, India).

3 specimens. 105 - 199 mm. Onotoa.

1 specimen. 108 mm. Tarawa.

Color from 35 mm Kodachrome transparency grayish brown dorsally with white spots about size of pupil, white ventrally with faint lengthwise yellowish brown lines below pectoral; area around base of pectoral fin and gill opening blackish, with circular white lines; dorsal, anal, and pectoral fins pale yellowish; caudal fin grayish brown with small white spots on basal two-thirds; iris bright orange-yellow.

All of the Onotoa specimens were collected by spearing in a *Thalassia* area of the lagoon of about 5 feet in depth.

Arothron immaculatus

Tetrodon immaculatus Bloch and Schneider 1801. Systema ichth., p. 507.

Tetrodon immaculatus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 469. (Kingsmill Islands).

1 specimen. 70 mm. Tarawa.

Color in alcohol grayish brown dorsally shading to light brown ventrally with lengthwise black lines on head and body (two of these lines are confluent in front of gill opening); dorsal, anal, and pectoral fins pale; caudal fin dusky with upper and lower margins dark. Caudal fin long, its length contained 3 times in standard length.

Arothron stellatus

Tetrodon lagocephalus var. *stellatus* Bloch and Schneider 1801. Systema ichth., p. 503. (Type locality, Mauritius).

Tetrodon stellatus Fowler 1928. Mem. B. P. Bishop Mus., vol. 10, p. 469. (Abaiang, Kingsmill Islands).

Arothron meleagris

Tetrodon meleagris Lacépède 1798. Hist. nat. poiss., vol. 1, p. 505. (Type locality, seas of Asia).

Ovoides meleagris Whitley and Colefax 1938. Proc. Linn. Soc. N. W. Wales, vol. 63, p. 300. (Nauru).

3 specimens. 125 - 160 mm. Onotoa.

Color in life of 125 mm specimen: uniform dark brown with numerous small white spots on head, body, and median fins. A 130 mm specimen was grayish with many small dull yellow spots on dorsal part of body and head and on chin, buff-colored ventrally, with scattered jet black spots on head and body. Color from 35 mm Kodachrome transparency of the 160 mm specimen: bright orange-yellow, whitish ventrally, with an irregular patch of dark brown containing white spots on the right side between dorsal and pectoral fins; dorsal, anal, and pectoral fins with outer one-third whitish, inner two-thirds yellow with rays brownish toward distal part of yellow region; caudal fin yellowish basally, shading to dusky purple over most of fin, and pale distally.

Specimens from both the Gilbert and Marshall Islands, whether yellow, grayish, or brown, have occasional widely-scattered black spots on the head and body, similar to *Arothron nigropunctatus*. The anus is not black, though it may be dusky.

The yellow color phase of *meleagris*, once in preservative with the yellow color faded, can easily be confused with *A. nigropunctatus* which is gray, paler ventrally, with scattered black spots. The two may be separated on fin ray counts (see tabulated counts at end of Tetraodontidae section) and by the coloration of the anus. The anus of *nigropunctatus* is contained within a prominent jet black area.

D. W. Strasburg, in a mimeographed report on the fishes of the southern Marshall Islands submitted to the Office of Naval Research, 1953, should be credited with noticing the higher fin ray counts of *meleagris*. Although he included a specimen of *meleagris* in the yellow color phase under the designation *nigropunctatus*, he suspected that it was a different species because of the higher fin ray counts and pale anus. His yellow specimen lacked the tell-tale patch of *meleagris* coloration which is present on one side of the Onotoa specimen. Another yellow specimen with a small area of *meleagris* coloration was located in the collections of the United States National Museum. It was taken in the northern Marshall Islands. On it the patch of brown with white spots is restricted to the middle of the back.

The 130 mm gray specimen with yellow spots from Onotoa is intermediate in color to the yellow and the brown, white-spotted forms.

Arothron nigropunctatus

Tetrodon nigropunctatus Bloch and Schneider 1801. Systema ichth., p. 507. (Type locality, Tranquebar).

3 specimens. 90 - 169 mm. Onotoa.

Color from 35 mm Kodachrome transparency of 90 mm specimen: dark purplish gray on back, shading to light bluish gray ventrally, with occasional widely-separated black spots of variable size on head and body; dorsal and anal fin rays brownish yellow, membranes hyaline; caudal fin color of body; pectoral fins hyaline; anus jet black.

The gut contents of two of the specimens were examined. They consisted largely of bite-sized pieces of fresh coral.

Table 8 Fin Ray Counts of the Tetraodontidae

	Dorsal fin rays				Anal fin rays			
	9	10	11	12	9	10	11	12
A. hispidus								
Gilbert Is.		3				2	1	
A. immaculatus								
Gilbert Is.		1			1			
A. meleagris								
Gilbert Is.			3				1	2
Marshall Is.			6	1			3	4
A. nigropunctatus								
Gilbert Is.		3				2	1	
Marshall Is.		6	1			4	3	

	Pectoral fin rays		
	17	18	19
A. hispidus			
Gilbert Is.	2	1	
A. immaculatus			
Gilbert Is.	1		
A. meleagris			
Gilbert Is.		1	2
Marshall Is.		1	6
A. nigropunctatus			
Gilbert Is.		1	2
Marshall Is.	1	4	1

Family ANTENNARIIDAE

Only two specimens of frog fishes were collected by the author at Onotoa. These and one specimen collected at Tarawa by Catala were turned over to Leonard P. Schultz of the United States National Museum, who is monographing the group. The identifications provided by Dr. Schultz are as follows: *Antennarius nummifer* (a 20 mm specimen collected from a tide pool on the outer reef flat at Onotoa), *Antennarius coccineus* (Onotoa specimen), and *Antennarius altipinnis* (Tarawa specimen).

Fowler (1928: 478-479) recorded *Antennarius leprosus* from Abaiang, Kingsmill Islands.

Gilbertese Names of Fishes at Onotoa

Abudefduf amabilis	Tereibu
Abudefduf lacrymatus	Tereibu
Abudefduf septemfasciatus	Tebukibuki
Abudefduf zonatus	Tereibu
Acanthocybium solandri	Tebara
Acanthurus achilles	Teribataukarawa
Acanthurus gahhm	Teribaroro
Acanthurus glaucopareius	Teribabui
Acanthurus guttatus	Tebaba
Acanthurus lineatus	Teribanti
Acanthurus nigroris	Tereiba
Acanthurus triostegus	Tekoinawa
Amanses sandwichiensis	Tebubuawai
Amphiprion sebae	Tenikatang
Anyperodon leucogrammicus	Tekuaurari
Aphareus furcatus	Teikakoa
Arothron hispidus	Tebuni
Arothron meleagris	Tebuni
Arothron nigropunctatus	Tebuni
Balistapus undulatus	Tebubutakataka
Bathygobius fuscus	Teuringabo
Belone platyura	Temake
Bothus mancus	Tebaibai
Bothus pantherinus	Tebaibai
Caesio xanthonotus	Tebukimaka
Canthigaster solandri	Tebatua
Caranx lugubris	Teaongo
Caranx melampygus	Tekuaua
Carcharhinus melanopterus	Tebakua
Cephalopholis argus	Tenimanang
Cephalopholis leopardus	Tenimako
Cephalopholis sonnerati	Tentabokai
Chaetodon auriga	Teibaba
Chaetodon bennetti	Teibaba
Chaetodon ephippium	Teibaba
Chaetodon falcula	Teibabataranga
Chaetodon lunula	Teibaba
Chaetodon ornatissimus	Teibaba
Chaetodon trifasciatus	Teibabataranga
Chaetodon vagabundus	Teibaba
Cheilinus trilobatus	Tetanai
Cheilinus undulatus	Tekaron
Chromis dimidiatus	Tereibu
Chromis lepidolepis	Tereibu
Chromis opercularis	Tereibu
Cirrhitus pinnulatus	Tereiati
Cirripectus spp.	Tentaremauri
Corythoichthys flavofasciatus	Tekoekoerikaki
Crenimugil crenilabis	Teaua
Ctenochaetus cyanoguttatus	Tekatawa

Ctenochaetus striatus	Teribaroro
Cypselurus spp.	Teonauti
Dascyllus aruanus	Tenikatang
Dascyllus trimaculatus	Tebukibuki
Dinematichthys iluocoeteoides	Teuringabo
Echidna zebra	Terabonotekabanga
Elagatis bipinnulatus	Tekama
Epibulus insidiator	Teuianau
Epinephelus flavocaeruleus	Tekuamamaninga
Epinephelus fuscoguttatus	Temaneku
Epinephelus merra	Tekuau
Euthynnus yaito	Tetawatawa
Fistularia petimba	Tekoekoerikaki
Gerres oblongus	Tenibongbong
Ginglymostoma ferrugineum	Tebakoa
Gnathodentex aureolineatus	Teneia
Gomphosus tricolor	Tekimoa
Gomphosus varius	Tenareau
Gymnothorax bikiniensis	Tekaibiki
Gymnothorax buroensis	Terabono
Gymnothorax flavimarginata	Terabono
Gymnothorax monostigma	Tebukimeri
Gymnothorax petelli	Teimone
Halichoeres centriquadrus	Tenewekabane
Halichoeres marginatus	Tentabokai
Halichoeres trimaculatus	Tearinai
Hemigymnus fasciatus	Tenei
Heniochus permutatus	Tereiati
Holocentrus diadema	Tekubeibeti
Holocentrus lacteoguttatus	Teku
Holocentrus laevis	Teku
Holocentrus microstomus	Tekubeibeti
Holocentrus tiere	Tebureunawa
Holocentrus violaceus	Teku
Hyporhamphus dussumieri	Tekabubu
Hyporhamphus laticeps	Tekabubu
Istiblennius gibbifrons	Tentarema
Istiblennius lineatus	Tentarema
Istiblennius paulus	Tentarema
Labroides dimidiatus	Teberu
Lethrinus rhodopterus	Teokaoka
Lutjanus bohar	Tekananingo
Lutjanus gibbus	Teikanibong
Lutjanus kasmira	Tetakabe
Lutjanus monostigmus	Tebabeina
Lutjanus vaigiensis	Tebukirabaraba or Tebawe
Macropharyngodon meleagris	Tearinaimawa
Monotaxis grandoculis	Temoto
Mulloidichthys samoensis	Tebaweina
Myripristis adustus	Tekungkung
Myripristis murdjan	Temon
Myripristis pralinius	Temon
Neothunnus macropterus	Teingamea
Ostracion meleagris	Tetoaua
Oxymonacanthus longirostris	Tebubuawai

Paracirrhites arcatus	Tereiawawa
Parapercis cephalopunctatus	Teuringabo
Parupeneus barberinus	Temaebo
Parupeneus chryserydros	Tekaitewe
Parupeneus trifasciatus	Temawa
Pempheris oualensis	Tebarere
Plesiops nigricans	Tentabokai
Pomacentrus aureus	Tereibu
Pomacentrus coelestis	Tereibu
Pomacentrus jenkinsi	Tereibu
Pomacentrus nigricans	Tereibu
Pomacentrus vaiuli	Tenikatang
Pseudocheilinus hextaenia	Tenimawawa
Pseudochromis tapeinosoma	Tenikatang
Pseudogramma bilinearis	Tentarema
Priacanthus cruentatus	Teikauea
Pterocaesio tile	Tekawariki
Pterois radiata	Teikauea
Pypoplites diacanthus	Teikabingao
Rhinecanthus aculeatus	Tebubunabanaba
Rhinecanthus rectangulus	Tebubu
Samariscus sp.	Tebaibai
Saurida gracilis	Tenunua
Scarus brevifilis	Tewibubura
Scarus ghobban	Teouru
Scarus globiceps	Tenimawawa
Scarus harid	Teinai
Scarus niger	Teikabata
Scarus pectoralis	Teikamawa
Scarus sordidus (female)	Teikabata
Scarus sordidus (male)	Tenimaerere
Scorpaena albobrunnea	Tenouika
Scorpaenodes kelloggi	Tekuau
Scorpaenodes parvipinnis	Tenou
Scorpaenopsis gibbosus	Tenou
Sphyraena forsteri	Tenunua
Synodus variegatus	Teuringabo
Teuthis rostratus	Tenimunai
Thalassoma hardwicke	Tearinai
Thalassoma lunare	Tearinaimawa
Thalassoma melanochir	Tearinaimawa
Thalassoma quinquevittatum	Tearinaimawa
Thalassoma trilobata	Tenewekekabane
Uropterygius spp.	Terabono
Zanclus cornutus	Tentibetibei
Zebrasoma veliferum	Teibabataranga

Index to Species of Gilbert Islands Fishes, the Stomach Contents of Which Were Examined

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*No mention is made of fishes from the Gilbert Islands in this work. It is included here because it is cited in the text and because it was found to be the most useful work at the time of the expedition for the identification of fishes in Oceania.