ISSN 2538-1016; 31

NEW ZEALAND OCEANOGRAPHIC INSTITUTE

MEMOIR No. 31

Contributions to the Natural History of Manihiki Atoll, Cook Islands

J. S. BULLIVANT

and

CHARLES MCCANN

1974

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NEW ZEALAND

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

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Price: $2.50

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Bibliographic Reference
(World List of Scientific Periodicals, 4th edn.)
Mem. N.Z. oceanogr. Inst. 31

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MANIHIKI ATOLL SURVEY 1960: GENERAL ACCOUNT AND STATION LIST

BY

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SUMMARY

The survey of Manihiki Atoll produced collections of marine invertebrates for detailed examination, and data on the hydrological environment in the lagoon.

INTRODUCTION

In 1960 the N.Z. Department of Island Territories requested assistance in determining the hydrological characteristics of Manihiki lagoon, so that data of use in pearl shell oyster fisheries investigations might be available.

A party of three from the N.Z. Oceanographic Institute—J. S. Bullivant (Leader), A. Langford, and L. E. Johns—left for the island in May 1960. They were equipped with portable winch, grabs and trawls, reversing water bottles, and thermometers, bathythermographs, thermographs, conductivity meters, tide gauge, aqualungs, and echo-sounding and surveying equipment. The lugger *Louisa Marekino* was used in sampling operations principally in the lagoon.

Manihiki *(figures 1–6)* is a coral atoll in the northern Cook Group centred in latitude 10° 25′ 20″ S, longitude 161° 02′ 46″ W. The lagoon is roughly triangular with the apex, at which the smaller of the two villages on the atoll is situated, to the north. The lagoon is about 5 miles in diameter and is studded with small islets of uplifted coral a few feet above water level. In many places along the inner and outer shores of the atoll well-cemented beach rock occurs. Raised coral and coral sand islands occupy two-thirds of the atoll perimeter. There is a series of lesser gaps at the southern end and a major interval 1½ miles long between islands at the north-western corner.

OBSERVATIONS, AND DATA COLLECTED

As an essential preliminary, an echo-sounding survey was made of that portion of the lagoon not covered by lead-line soundings (Bullivant 1962a). Reference marks on the islets in the lagoon and on the atoll were fixed by triangulation and traverses were made with a portable echo-sounder. Calibration checks were made each day during the survey. Preliminary interpretation of the results in the field allowed more effective siting of hydrological, dredge, and trawl stations.

A "Foxboro" tide gauge was set up, once inside and once outside the lagoon. Temperature and salinity stations were worked with reversing water bottles and thermometers at 22 points, 14 inside the lagoon and 8 outside. Surface water temperature was recorded with a "Negretti and Zambra" thermograph mounted on the boat. Bathythermograph observations were made at the T/S stations and some additional points. Immediate analyses were made for silicate and oxygen of the near-surface and near-bottom water samples at 7 of the T/S stations.

Sediment samples were obtained by Dietz grab from most of the lagoon T/S stations and from near-shore and beach sites. Parts of the T/S station sediment samples were preserved in alcohol for microfaunal analyses. Two short cores and several samples of beach rock were obtained.

At most T/S stations vertical hauls with an N 70 plankton net were made and a standard 20 bucket water sample was taken for phytoplankton extraction. A series of N 50 surface tows was taken.

Collections of benthic animals were made from reef localities and from islets in the lagoon. Grab and trawl samples were secured from stations within the lagoon and a number of bottom photographs taken *(figure 7)*. Underwater observations were made on the breeding and feeding of the pearl shell oyster.

The opportunity was taken to make a fairly comprehensive collection of fish together with colour notes. Miscellaneous terrestrial animals, principally reptiles and insects, were collected.

The survey lasted from 2 June 1960 to 26 August 1960 and more than 100 collecting stations were occupied *(table 1)*.

RESULTS

The sounding information available has been used to construct a bathymetric chart of the lagoon (Bullivant 1962a). Analyses of the tidal and hydrological data are presented elsewhere in this bulletin together with faunal lists of the principal groups of benthic animals. The collected and identified material forms a substantial reference collection of tropical species. Breeding in the blacklip pearl oyster and the thorny oyster *Spondylus* sp. (Bullivant 1962b), and a new species of eel (McCann 1967), have already been described for the Manihiki locality.

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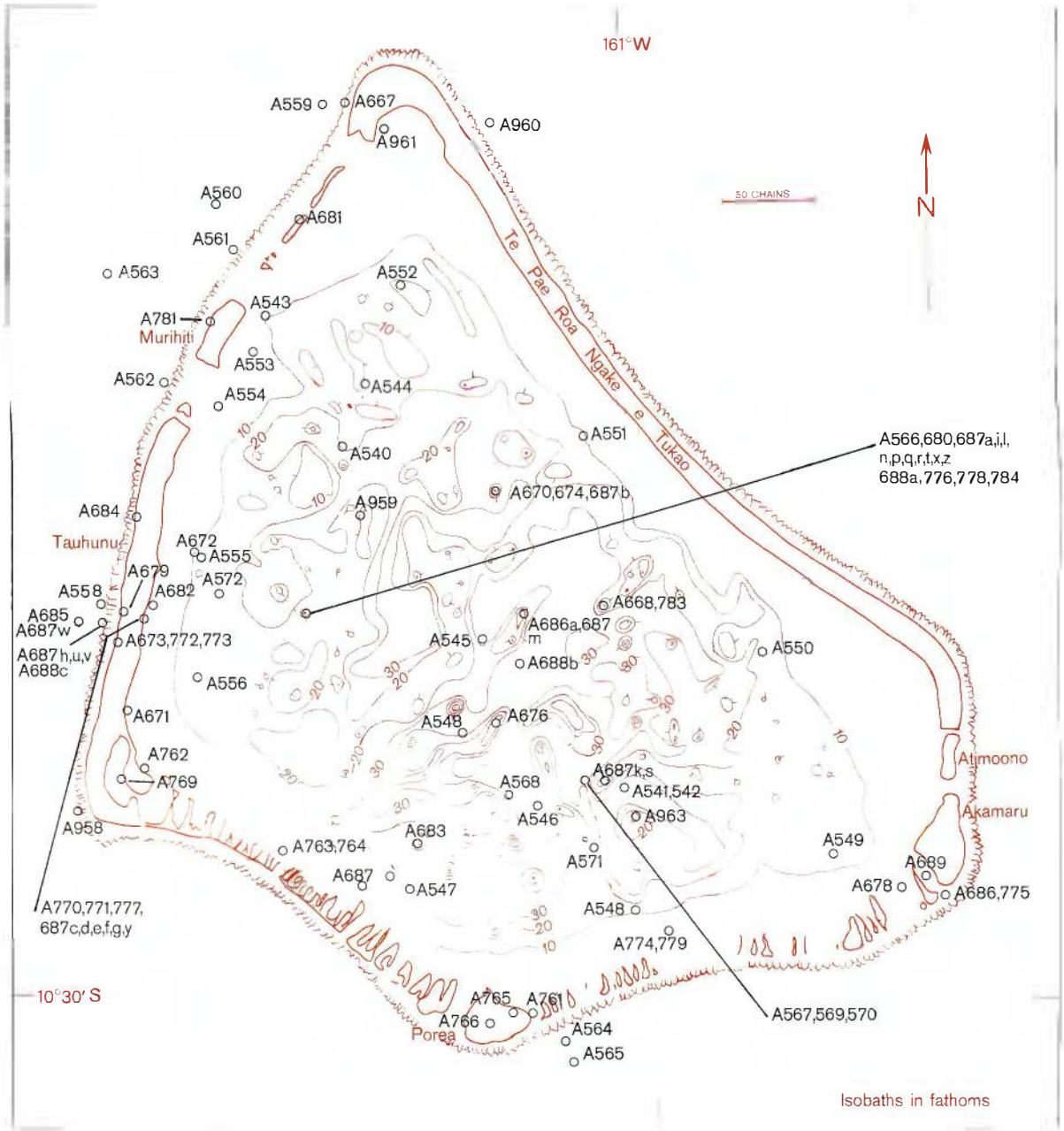

FIGURE 1: Chart showing outline bathymetry of Manihiki lagoon and station positions.

ACKNOWLEDGMENTS

Thanks are due to the Department of Island Territories which arranged transport to Manihiki, and other facilities; to the Resident Agent, Mr Tom Bryant, and many local residents for accommodation, hospitality, and help in collecting specimens; to Messrs Ioapa and Arthur Marsters for their assistance in handling the boat and obtaining samples by diving; to Mr Ron Powell, Fisheries Officer, Cook Islands Department of Agriculture, for invaluable help and guidance and provision of sounding data; to the RNZAF for outward transport from Manihiki.

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FIGURE 2: View south across the lagoon towards Porea at the southern point. Islets and coral sandbanks show as white patches. (*Photo, courtesy RNZAF*)

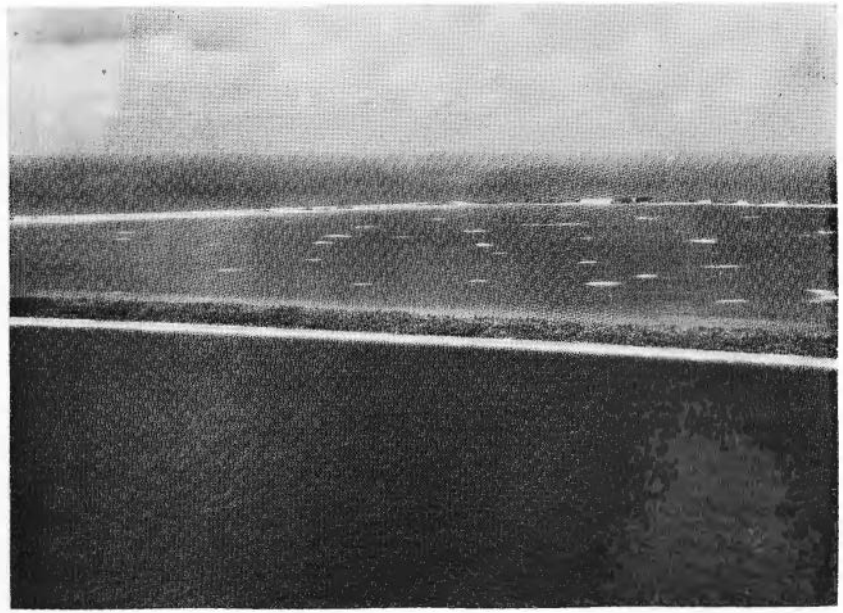

FIGURE 3: View north-east across the lagoon. Murihiti Island in foreground. Tukao village at left. (*Photo, courtesy RNZAF*)

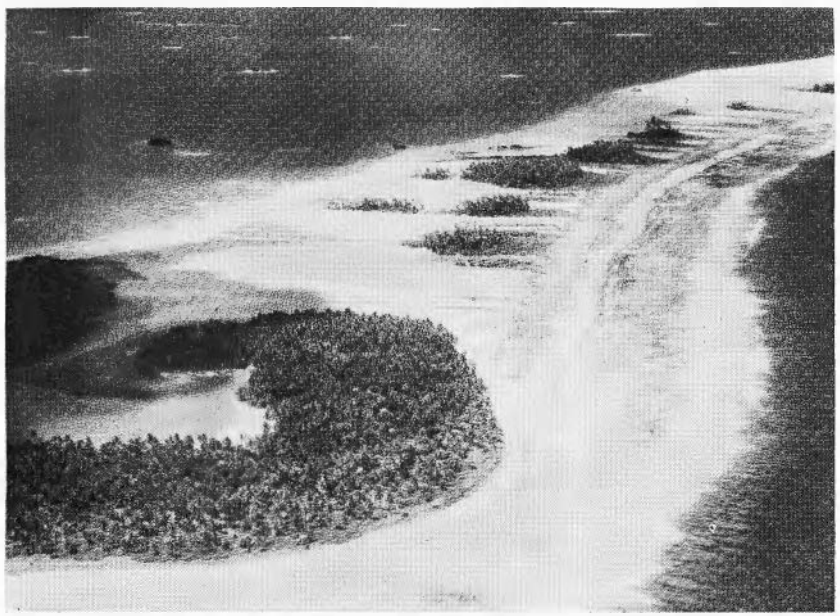

FIGURE 4: View east across south tip of Tauhunu, Te Puka, and brackish pond at south-western extremity. (*Photo, courtesy RNZAF*)

FIGURE 5: View north-east. Tauhunu village at left. (*Photo, courtesy RNZAF*)

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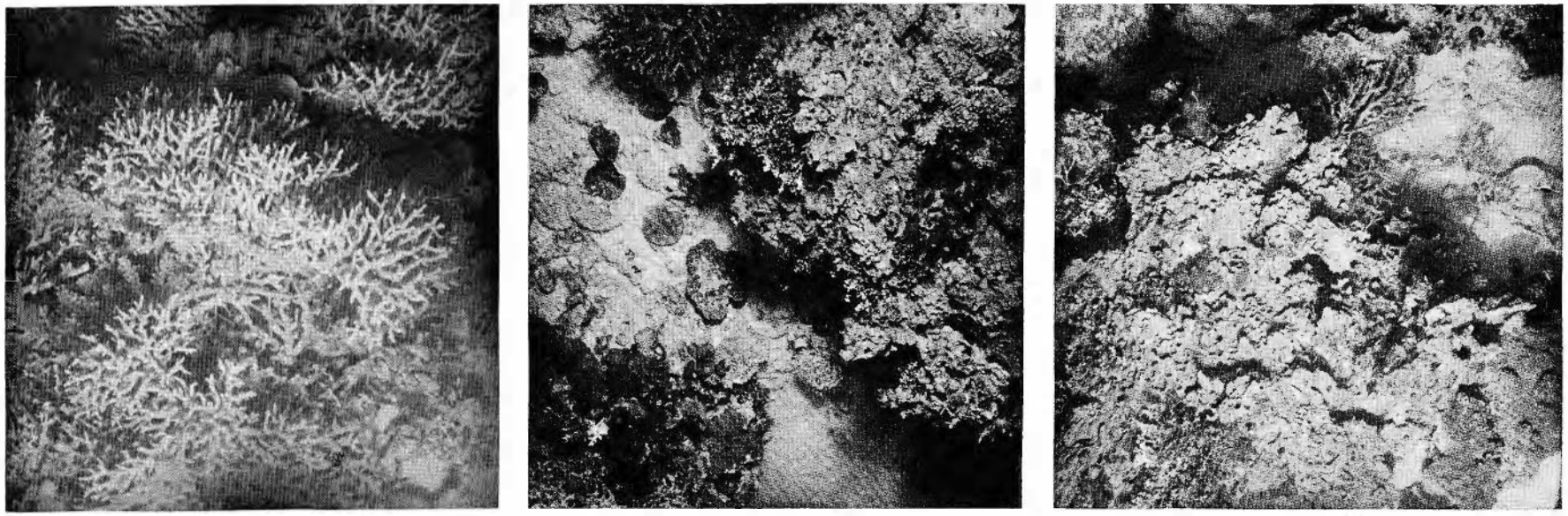

FIGURE 7 a *above left*, b *above centre*, c: Floor of Manihiki lagoon. 3 views, Sta. A566, 40 yd west of Moko islet.

FIGURE 6: Tauhunu village.
(*Photo, courtesy RNZAF*)

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Table 1 Station list

CL	Gravity corer	T/S	Temperature and salinity
N 70	Net with 70mm mesh	DN	Naturalist's Dredge
GTP	Petersen Grab	NP	Plankton net
BT	Beam Trawl	Dietz	Dietz Grab
GOS	Small Orange Peel Grab	B/T	Bathythermograph

Sta. No.	Date 1960	POSITION Lat. S ° ' "	Long. W ° ' "	Time	Depth fm	Depth (m)	Gear	Remarks
A540	Jun 17	10 24 18	161 01 38	1635 - 1645 h	20	(37)	N 70	Debris, possibly dinoflagellates and copepods; appendicularian.
A541	Jun 21	10 26 16	160 59 57		32	(59)	N 70	White debris in sediment ("bathybius").
A542	Jun 24	10 26 16	160 59 57	1658 - 1708 h	32	(59)	N 70	White debris.
A543	Jun 27	10 23 35	161 02 03	1550 - 1650 h	11	(20)	GTP BT T/S N 70	5 grab hauls in calc. sand; worms, few shells. T/S - 3 rev. bottles.
A544	Jun 29	10 23 57	161 01 30	1045 - 1230 h	13-6 (24-11) 6	(11)	DN GOS T/S B/T	Naturalists dredge laid steaming to westward. Hauled at anchor, weak links broken. Few bits coral and sponge. 7 drops: *Fungia*, corals, small amount sand, some algae. 4 bottles: bottom and surface oxygen samples.
A545	Jun 29	10 25 24	161 00 51	1515 - 1645 h	28-23 (51-42) 23 23	(42) (42)	DN GOS T/S BT N 70	Weak links broken. White sandy mud, sulphurous smell, heart urchins. 3 drops: coral, algae, calcareous fragments. 8 bottles: O_2 samples top and bottom. N 70: 10 min.
A546	Jun 30	10 26 24	161 00 30	1500 - 1704 h	35	(64)	DN GOS T/S BT NP N 70	DN lost. 2 grabs: smelly, sticky, shelly, mud. 8 bottles: O_2 and SiO_2 samples top and bottom.
A547	Jul 2	10 26 53	161 01 15	1030 - 1200 h	19	(34)	GOS BT T/S N 70 NP	4 drops of grab: 3-creamy white sand, no smell, dead shell; 1-small amount weed. Touched bottom, SiO_2 and O_2 samples top and bottom. N 70 vertical haul: chaetagnaths. NP: 10 min. tow NNW from station.

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Sta. No.	Date 1960	POSITION Lat. S ° ' "	Long. W ° ' "	Time	Depth fm	Depth (m)	Gear	Remarks
A548	Jul 2	10 27 02	160 59 54	1400 - 1530 h	13	(24)	GOS T/S	5 drops of grab: 2 of seaweed and small bits rock; 2 of large bits rock and sand; 1 of rock and good sample sand, no smell. SiO_2 and O_2 samples top and bottom.
A548a	Jul 2	10 26 02	161 00 58		12 11	(22) (20)	BT N 70 NP	Many small shells. N 70: 10 min. tow NNW from station.
A549	Jul 4	10 26 39	160 58 45	1000 - 1200 h	12 11	(22) (20)	GOS BT T/S N 70 NP	6 drops: white sticky sandy mud, heart urchins, bits of coral. SiO_2 and O_2 samples top and bottom. 20 buckets of water from surface. Vertical lead on bottom.
A550	Jul 4	10 25 30	160 59 12	1230 - 1400 h	17	(31)	GOS T/S BT N 70 NP	Sand and shell, some pieces coral. 6 drops T/S. O_2 samples top and bottom. NP 20 buckets from surface.
A551	Jul 4	10 24 18	161 00 12	1500 - 1630 h	16	(29)	GOS T/S BT N 70 NP	5 drops: weed, sand, pieces of coral. N 70 vertical. NP 20 buckets 10 from each side ship at surface.
A552	Jul 5	10 23 24	161 01 15	1000 - 1130 h	10	(18)	GOS T/S BT N 70 NP	4 grabs: creamy sand and crows feet-like calcareous fragments; 1 with *Acropora* coral only. BT 18m. N 70: 15m - surface. NP surface 20 buckets. SiO_2 and O_2 samples.
A553	Jul 5	10 23 48	161 02 12	1400 - 1515 h	8	(15)	GOS T/S BT N 70 NP	5 drops: each with compact sand, worm tubes and bivalves. BT 14m. N 70 vertical. NP surface 20 buckets. SiO_2 and O_2 samples.
A554	Jul 5	10 24 04	161 02 24	1530 - 1600 h	6	(11)	Dietz N 70 BT NP T/S	*Acropora* coral. N 70: 9m - surface. BT 9m. NP 20 buckets at surface.
A555	Jul 6	10 24 54	161 02 25	0900 - 1030 h	10	(18)	GOS T/S BT NP N 70	4 grabs of assorted corals and urchins etc. O_2 sample. BT: 17m. N 70: 17m. Surface. NP 20 buckets.

A556	Jul 7	10 25 40	161 02 30	0930 - 1100 h	9	(17)	GOS BT NP T/S N 70	3 grabs: cupful mud, bits coral - muddy sand and *Fungia* - 3 large pieces assorted corals. T/S 4 bottles. O_2 sample. N 70: 15m - surface. NP 2 buckets.
A558	Jul 12	10 25 15	161 03 03	1400 - 1530 h	11	(20)	GOS BT NP T/S N 70	3 drops: 1 small shell. BT: 19m. N 70: 15m vertical. NP 10 buckets each side of boat. O_2 sample.
A559	Jul 13	10 22 56	161 01 40	1030 - 1145 h	20	(37)	GOS BT NP T/S N 70	No sample. T/S SiO_2 and O_2 fixed on psn and filtered 10 hrs later. BT: 35m. N 70: 30m. NP 20 buckets.
A 560	Jul 13	10 22 52	161 02 21	1200 h	65	(119)	GOS BT N 70 NP T/S	Small piece coral. N 70 vertical. 20 buckets, 10 each side. O_2 sample.
A561	Jul 13	10 23 12	161 02 14	1500 h	10	(18½)	GOS T/S N 70 BT NP	2 drops no sample. N 70: 5m. BT: 8m. NP 20 buckets.
A562	Jul 14	10 23 56	161 02 40	1400 h	13	(24)	GOS T/S BT NP N 70	No sample. O_2 sample. BT: 22m. N 70: 21m - vertical. NP surface 20 buckets.
A563	Jul 14	10 23 18	161 03 00	1600 h	219	(400)	T/S BT N 70 NP	T/S to 350m. N 70 to 200m vertical. BT: 60m. NP surface 20 buckets. O_2 sample.
A564	Jul 15	10 27 42	161 00 24	1200 h	118	(215)	T/S	50 yards off reef ¼ mile East of Porea. O_2 sample.
A565	Jul 15	10 27 48	161 00 18	1230 h	109	(200)	T/S	170m no bottom, lowest sample 145m. O_2 sample.
A566	Jul 18	10 25 18	161 01 54	1400 - 1600 h	14	(26)	U/W Camera	16m. Trials 6 shots with bulb flash. 40 yards west of Moko.
A567	Jul 19	10 26 18	161 00 12	1130 - 1600 h	38-36 (69-65) 27-21 (50-38)		U/W Camera	6 shots Ektachrome. 60 yards west of Koutu. 6 shots Agfacolour.

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Sta. No.	Date 1960	POSITION Lat. S ° ' "	Long. W ° ' "	Time	Depth fm (m)	Gear	Remarks
A568	Jul 20	10 26 21	161 00 42	1400 - 1630 h	13-15 (24-27)	U/W Camera	About 12 shots. Koutu; East end Tukao; N. Tearai; Tukao village.
A569	Jul 20	10 26 18	161 00 12	1200 h	30 (55)	CL	60 yards west of Koutu; core 6 in.
A570	Jul 21	10 26 18	161 00 12	1000 h	33 (60)	CL	6 yards west of Koutu; core.
A571	Jul 21	10 26 45	161 00 09	1200 - 1600 h	28 (51)	U/W Camera	19 shots upslope.
A572	Jul 21	10 25 09	161 02 21	1600 - 1700 h	11 (20)	U/W Camera	10 shots Superanscochrome.
A667	Jul 28	10 22 24	161 01 36	1200 h	Shore Collection		Gastropods, coral, algae etc. W. Tukao outer reef inside surf zone.
A668	Aug 2	10 25 15	161 00 10	1100 - 1200 h	2-5 (4-9)		Sponge, ophiuroids, coral etc. Two 2 lb jars. West side Islet Mehau Matie. One 2 lb jar East side.
A669	Aug 19	10 26 48	160 58 12		2 (4)		Various corals from coral head in secondary lagoon ⅓m S. of Akamaru.
A670	Aug 1	10 24 36	161 00 48		2-3 (4-6)		*Spondylus* and other bivalves, dead coral, boring worms, sponges, gastropods, black holothurian.
A671	Aug 16	10 25 52	161 02 50	1600 h	Shore Collection		Abundant *Littorina coccinea*. Lagoon shore between Tauhunu and Te Puka.
A672	Jul 26	10 24 54	161 02 30		10 (18)		Line 1 outer reef edge. Coral, seaweed, small crustacea.
A673	Jun 6	10 25 24	161 02 58		Shore Collection		Many shells with hermit crabs. Picked up above high water Sth Tauhunu.
A674	Aug 1	10 24 36	161 00 48		½ (1)		Coral anthozoa *Linnia*, mollusca; Holothurians. Tengakura west side 0-3 ft.
A675	Jul 27	10 25 00	161 00 00	1200 h	Shore Collection		One 2 lb jar assorted corals. 2 ch. position line 1.
A676	Jul 4	10 25 54	161 00 46		Shore Collection		Molluscs. One 2 lb jar. About Tearai in shallows.
A677	Jul	10 25 00	161 00 00		Shore Collection		Three *Spondylus* no label. *Rocellaria*.

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A678	Aug 18	10 26 54	160 58 22		Shore Collection		One 2 lb jar corals between Porea and Te Puka and sand flat near Motu Akamaru.
A679	Jun 4	10 25 20	161 02 57		Shore Collection		Rock pool 1 lb jar. West shore Tauhunu near jetty by tide gauge.
A680	Aug 16	10 25 18	161 01 52		½ (1)		Sample from *Tridacna* shells. Note *Tridacna* gonad. One 2 lb jar.
A681	Jul 25	10 23 02	161 01 50		Shore Collection		Holothurians, gastropods, 1 ft Reef flat between Murihiti and Tukao.
A682	Aug 7	10 25 16	161 02 44		Shore Collection		One 2 lb jar, Tauhunu Lagoon.
A683	Jun 2	10 26 36	161 01 12		Shore Collection		Waters edge Keturau. One 2 lb jar leeward side west.
A684	Aug 9	10 24 48	161 02 48		Shore Collection		One 1 lb jar long holothurians; gastropods. Seaweed reef flat NW of Tauhunu village.
A685	Jul 13	10 25 20	161 03 09	0100 h	109 (200+)	Hand	Moorings off Tauhunu fishing line.
A686	Aug 19	10 26 54	160 58 06		Shore Collection		Assorted corals, molluscs. Seaward reef ⅓m South of Akamaru.
A686a	Jul 19	10 25 18	161 01 36		Shore Collection		Encrusting organisms of pearl shells Kokiri Tau 1-3 ft.
A687a	Aug 23	10 25 18	161 01 52		Shore Collection		Octopus at surface on Rahiakiaua.
A687b	Jul 5	10 24 36	161 00 48		3-10 (6-18)		Arthropods from inside oysters Tengakura.
A687c	Jun 22	10 25 20	161 02 46		Shore Collection		Shells, Lagoon Tauhunu village.
A687d	Jul 17	10 25 20	161 02 46		Shore Collection		Crabs, Tauhunu village.
A687e	Jul 27	10 25 20	161 02 46		Shore Collection		Large dark brown Gecko taken from haversack.
A687f	Jul 10	10 25 20	161 02 46		Shore Collection		Gecko from wall Resident Agent's house.
A687g	Aug 4	10 25 20	161 02 46		Shore Collection		Male crab. Manihiki, caught by Ioapa Marsters.
A687h	Aug 15	10 25 20	161 03 02		Shore Collection		Shell from water's edge beach outside Tauhunu.

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Sta. No.	Date 1960	POSITION Lat. S ° ' "	Long. W ° ' "	Time	Depth fm	Depth (m)	Gear	Remarks
A687i	Jul 5	10 25 18	161 01 52		12	(22)	Hand	Shells taken from raft near Moko mid-lagoon.
A687j	Aug 19	10 27 40	161 00 40		Shore Collection			Frigate birds and black boobies nesting. On land beneath coconut palm.
A687k	Jul 19	10 26 15	161 00 06		22	(40)	From frame on camera	Seaweeds, off Koutu.
A687l	Jul 5	10 25 18	161 01 52		2	(4)	Hand	Shells. Raft near Moko from chain.
A687m	-	10 25 18	161 00 36		10	(18)	Hand	Lagoon sample of 50 shells collected by Tahake windward side Kokiri Tou.
A687n	Jul 5	10 25 18	161 01 52		Shore Collection			Raft near mid-lagoon.
A687o	Jul 2	10 26 54	161 01 30		Shore Collection			Shell from small island.
A687p	Jul 5	10 25 18	161 01 52		6	(11)		Shells. Raft near mid-lagoon.
A687q	Jul 5	10 25 18	161 01 52		8	(15)		Shells. Raft near mid-lagoon.
A687r	Jun 29	10 25 18	161 01 52		6-7	(11-13)		Attached to shell Moko Motu.
A687s	Jul 27	10 26 15	161 00 06		2	(4)		Samples from stomach of small Hapuku. Kava near Koutu.
A687t	Jun 5	10 25 18	161 01 52		Shore Collection			Moko, northern tip of lagoon, Papaka.
A687u	Aug 16	10 25 20	161 03 02		1-2	(2-4)		Shell. South end Tauhunu water level, seaward reef.
A687v	Aug 11	10 25 20	161 03 02		Shore Collection			Reef shell.
A687w	-	10 25 20	161 03 09		10	(18)		Scales off large fish caught outside reef, Tauhunu, 50-60 lbs, 8'6" long, 2ft deep.
A687x	Jul 6	10 25 18	161 02 52		6	(11)		Shells. Raft near mid-lagoon.
A687y	Jun 23	10 25 20	161 02 46		Shore Collection			Centipede behind cookhouse Resident Agent's house.
A687z	Jul 5	10 25 18	161 01 52		2	(4)		Shells. Raft mid-lagoon.

A688a	Aug 1	10 25 18	161 01 52	Shore Collection		Crabs, land Moko.
A688b	Aug 23	10 25 33	161 00 38	Shore Collection		Stomach contents large fish.
A688c	Aug 12	10 25 20	161 03 22	1½	(3)	Seaweed, Reef Tauhunu; fish trap Papaka.
A761	Aug 9	10 27 36	161 00 36	Shore Collection		Sediment sample.
A762	Aug 10	10 26 12	161 02 46	Shore Collection		Sediment sample.
A763	-	10 26 40	161 02 00	Shore Collection		Sediment sample. Te Puka, Porea.
A764	-	10 26 40	161 02 00	Shore Collection		Sediment sample between Te Puka and Porea.
A765	Aug 12	10 27 36	161 00 40	Shore Collection		Sediment sample, small lagoon Porea.
A766	Aug 12	10 27 40	161 00 48	Shore Collection		Sediment sample. Skinks, crabs. Large lagoon, Porea.
A767	Aug 18	10 25 00	161 00 00	Shore Collection		Sediment sample No. 1.
A768	Aug 18	10 25 00	161 00 00	Shore Collection		Sediment sample No. 2.
A769	Aug 15	10 26 12	161 02 54	Shore Collection		Sediment sample. Lagoon side Te Puka swamp.
A770	Aug 18	10 25 20	161 02 46	1	(2)	Sediment sample. Resident Agent's wharf.
A771	Aug 18	10 25 20	161 02 46	2	(4)	Sediment sample. Resident Agent's wharf.
A772	-	10 25 24	161 02 58	Shore Collection		Sediment sample. South end Tauhunu village.
A773	-	10 25 24	161 02 58	Shore Collection		Sediment sample. South end Tauhunu.
A774	-	10 27 08	160 59 40	Shore Collection		Sediment sample. Lagoon between Porea and Motu Akamaru.
A775	-	10 26 54	160 58 06	Shore Collection		Sediment sample. South of Akamaru.

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Sta. No.	Date 1960	POSITION Lat. S ° ' "	Long. W ° ' "	Time	Depth fm (m)	Gear	Remarks
A776	-	10 25 18	161 01 52		Shore Collection		Sediment sample. Moko West, east of Manihiki.
A777	-	10 25 20	161 02 46		Shore Collection		Sediment sample. Edge Resident Agent's wharf.
A778	Jun 23	10 25 18	161 01 52	1000 h	6-7 (11-13)	Hand	Moko from nylon lines.
A779	Jul 23	10 27 08	160 59 40	Day	] (2)	Hand	Reef lagoon, SSE corner.
A780	-	10 25 00	161 00 00		Shore Collection		Manihiki.
A781	Jul 27	10 23 36	161 02 24	1630 h	Shore Collection		Seaward of Murihiti rockpool.
A782	-	10 25 00	161 00 00		Shore Collection		Manihiki.
A783	Aug 2	10 25 15	161 00 10	1100 - 1200 h	½-3 (1-6)		Mehau Matie, west side.
A784	-	10 25 18	161 01 52		Shore Collection		Manihiki.
A785	-	10 27 40	161 00 48		Shore Collection		Manihiki.
A786	-	10 25 00	161 00 00		Shore Collection		Manihiki.
A958	Aug 10	10 26 25	161 03 06		Shore Collection		Manihiki.
A959	Jun 17	10 24 42	161 03 30		Shore Collection		Pohaturoa.
A960	Jun 23	10 22 27	161 00 50		Shore Collection		Tukao (reef).
A961	Jun 20	10 22 50	161 01 22		Shore Collection		Tukao.
A962	Jun-Aug	10 25 00	161 03 00				This number is used for all external stations around Manihiki not otherwise specified. *Allotaius* fish from photograph.
A963	Jun-Aug	10 25 00	161 00 00				This number is used for all internal, inner and outer reef and lagoon stations not otherwise specified.

LAGOON AND REEF MORPHOLOGY OF MANIHIKI ATOLL

BY

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SUMMARY

Soundings taken in Manihiki lagoon show that its greatest depth is 72 m. The greatest development of coral within the lagoon is at the south-eastern perimeter where waves wash over the reef.

The lagoon islets are at various stages of development: miniature reef flats are developed around some, and a number show evidence of recent uplift.

The outline of the atoll shows concave forms facing the direction of the prevailing winds.

GENERAL DESCRIPTION

Manihiki is roughly triangular in outline with the apex pointing northward. The sides, rather than tending to bow outwards and form the classical circular shape of a coral atoll, tend to bow into the lagoon. Indeed, both raised coral islands and atolls with a lagoon quite commonly have such embayments in their peripheries (see later discussion, p. 20).

The only land of the atoll consists of low lying perimeter islands and islets within the lagoon. The two largest islands, Tukao and Tauhunu, lie on the north-east and north-west sides respectively. On the south side the largest island is Porea. On either side of Porea are islets in the form of numerous narrow strips perpendicular to the fringing reef. Between Tauhunu and Porea an almost continuous strip of level beach rock connects the seaward side of these strips to form a comb-like feature.

The islands are composed of poorly sorted fragments of coral. Where there is vegetation some earth has accumulated and in some places there are larger pockets such as the patch of swamp called Te Puka at the south end of Tauhunu where taro is grown.

The beach above the reef flat on the seaward side of the perimeter islands varies in its steepness, width, and the size of the coral fragments of which it is generally formed. On the seaward side of Tauhunu are patches of sand and coral fragments. Around the southern end of Tauhunu and on the seaward side of Porea, both projecting angles in the periphery, the beach is steep, rising to perhaps 15 ft above sea level, and is composed of coral slabs up to 2 ft in diamenter. The beach seaward of Tukao is only a few feet wide.

On the lagoon sides of the perimeter islands the vegetation usually extends to the water's edge or overhangs a narrow beach of angular coral fragments. There are some sandy beaches on the south side of the lagoon.

None of the islets within the lagoon is large: the number of palm trees growing on them gives an idea of their size, and none supports more than about six trees. Some of the islets are simply exposed banks made up of dead coral fragments. On others the scrubby *Pemphis acidula* has become established and provides nesting sites for fairy terns and white-capped noddys. This plant is probably the most hardy of the atoll flora and is the first noticeable coloniser of exposed banks.

There are brackish ponds at the southern tip of Tauhunu and on Porea. Young of the clupeoid fish *Chanos chanos* as well as the grey mullet *Mugil cephalus* are found in the pond on Tauhunu which communicates with the lagoon. The milk fish *C. chanos* are transplanted from this pond to the enclosed pond on Porea where they grow to a larger size.

The outer reef is typical in appearance, with buttresses and surge channels and deep water close in. Where wave action is vigorous, e.g., on the outside of Tukao and the south end of Tauhunu, the salmon-coloured coralline algae of the outer edge of the reef present smooth, rounded surfaces to the waves. The more sheltered reef edge on the west side of the atoll has a level surface and jagged edge.

The outer reef flat varies in width, being narrowest on the outside of Tukao. Sea water which breaks almost constantly over the reef edge collects in shallow pools on this reef flat and then flows parallel with the beach into the often branching terminations of the surge channels.

These outer reef flats harbour a varied fauna. Small clumps of corals are visible on the surface together with coralline algae. The proportion of living to dead coral varies from place to place. Between Tauhunu and Tukao, where there is some outflow from the lagoon, the dead coral is brittle and undercut by channels and tunnels; living coral grows in the channels. Along the outer shore of Tauhunu and Tukao patches of gravel and boulders of dead coral lie on the compacted dead coral. Very small shallow grooves and pits on this surface are evidence of the grazing activity of parrot fish. The starfish *Linckia* is quite common and lizard fish were found along the shore line. Small moray eels, bristle worms, and a variety of gastropods were found under the coral slabs. The needle-spined sea urchin *Diadema setosum* is common in the small channels; the slate-pencil urchin *Heterocentrotus* sp. was found only on the outer reef of Tukao, very firmly wedged into crevices.

Trigger fish, scorpion fish, surgeon fish, and squirrel fish are among the many brightly coloured fish to be found in deeper channels crossing the reef flat. These fish were seen in particular abundance on the southern

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reef flat, between Porea and Tauhunu, where the greatest development of channels and pools was found.

There are no deep channels connecting the Manihiki lagoon with the open sea. What small exchange of sea water there is between the lagoon and the open sea is due to waves breaking over the reef south of Akamaru and tidal flow backwards and forwards through small channels between Tauhunu and Tukao. These channels are only about 1 m deep and the aggregate width is about 15 m. Drift measurements on 25 July 1960 gave a total flow of 7.30 cu ft per sec. But greater exchange is possible as the reef flat between the lagoon and the ocean is here almost at sea level.

The perimeter islands cap a continuous rampart of consolidated coral fragments which is about 300 ft above the deepest part of the lagoon. Its outer flanks descend steeply to ocean depths of about 3,000 m (Summerhayes 1967). Seismic observations made by Hochstein (1967) indicate a layer of coral only 30 m thick beneath a point about midway along Tukao and about 500 m thick at either end of Tukao. Manihiki, like the other Cook Islands, is based on an extinct volcano. As the greatest depth is 72 m in the lagoon basalt outcrops could be expected, but no igneous rock was seen during the present survey.

The 10 fm contour within the lagoon is peripheral, lying about 500 m from the shore. The 20 fm contour on the other hand runs round a number of ridges which project in an apparently haphazard fashion from the southern and western margins, each usually connecting several of the islets together and filling a fair proportion of the lagoon.

Patches of coral, dead coral fragments, sand, and sandy-mud cover the bottom. Sand and sandy-mud appear to be more common in the northern and eastern corners and in the deeper parts of the lagoon. There is a shallow sand flat interdigitating with the perimeter islands to the south. The edible mantis shrimp is found on this flat. A submerged discontinous belt of coral separates this sand flat from the main lagoon.

The greatest development of coral within the lagoon appears to be within the south-eastern perimeter where wave wash enters the lagoon. Crayfish are often caught in the tunnels in the coral of this area.

Pinnacles of dead and living coral are abundant in the lagoon and some break the surface as sandbanks and small islets.

The islets are surrounded by a miniature fringing reef and on their slopes *Acropora* sp. and mushroom corals *Fungia* sp. were especially abundant (*figure 1*).

FIGURE 1: Floor of the Manihiki Lagoon, Sta. A566, showing staghorn (*Acropora* sp.) corals, seaweed, and a single mushroom coral (*Fungia* sp.). Depth 13 fm.

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FORMATION OF ISLETS

Islets in different stages of development are present in the lagoon. The growth rate of the blacklip pearl shell oyster, *Pinctada margaritifera*, was found to be greater when the oyster was attached to ropes suspended in the open lagoon (Mr R. Powell pers. comm.) than when the oyster was growing on the bottom of the lagoon. In a similar way the islets and ridges provide suitable sloping substrates extending into the more favourable conditions of food and light at the surface. Perhaps a balance may exist between the amount of light and nutrients and the amount of algae and animal life within the lagoon. The topography of islets and ridges provides optimum conditions for the growth of the lagoon reef biocoenoses away from the suspended sediment in the shallow margins of the lagoon. The degree of reef-building and islet-building reflects in turn a balance between the growth of shell-forming and coral-forming organisms and the breakdown and solution of dead coral and shells.

The reduction in nutrients is reflected in the removal of silicate from lagoon waters (see *table 1*, p. 20).

When a pinnacle reaches the surface it becomes truncated and a miniature fringing reef develops which surrounds and protects a small flat surface a few yards in diameter; dead coral fragments accumulate on this flat and may rise above sea level and provide a foothold for plants. The miniature reef flats surrounding these islets are a favoured locality for the Tridacnid clams which with their mantles spread add colour to the reef flat.

The land on either side of Porea has a comb-like topography. The backbone of this comb is a discontinuous bench of dead coral fragments firmly cemented together into "beach rock". The surface of this bench is almost 1 m above sea level. Between Tauhunu and Tukao flat benches of dead coral fragments also occur. The top of a strip about 20 m wide on the reef flat between Murihiti and Tukao was 66 cm above sea level on the lagoon side and 86 cm above sea level on the ocean side. It was composed of slabs of coral up to 30 cm by 30 cm cemented together.

The reef flat behind the seaward reef has a similar surface of cemented coral fragments variously channelled and with scattered living corals. Perhaps the surface of the elevated benches represents an earlier reef flat either at a higher stand of sea level or prior to a slight elevation of the atoll.

However, the compact nature of the bench rock and the absence of burrows of the many boring organisms of the reef suggest it was formed under covering sediment, perhaps under the influence of bacteria and a freshwater lens. The island of Murihiti probably rests on beach rock. If the beach rock is formed beneath such islands, it may be formed at slightly different heights about one atoll. Slabs of beach rock which conform to the slope of the beach may be formed under such a beach or be undermined by sections originally laid down horizontally. The presence of brackish ponds at the southern end of Tauhunu, and on Porea, may be the clue to the type of erosion that has taken place on this southern side of the atoll, i.e., brackish ponds later broken into by more rapid erosion from the lagoon side.

FORMATION OF THE ATOLL

Perhaps the two most significant theories of how coral atolls develop are those of Darwin (1842) and Daly (1910). Darwin proposed that coral atolls were once fringing reefs about islands. Widespread subsidence carried many of the islands below the surface. The reefs by growth maintain themselves at the surface, forming first barrier reefs, and later atolls.

Daly suggested that the atolls derive their ring shape from reefs which have grown up from sea mounts truncated during the low sea levels of glacial periods. The tops of the sea mounts on which some atolls rest are well below these low stands of sea level (Ladd 1961) and such comparatively recent changes of sea level must have played at the most a minor role in formation of the atolls which are known to be formed by shallow water organisms. Cotton (1948) and Kuenen (1947) have combined the two theories. Another theory (MacNeil 1954) explains topographical features of atoll structure as a result of subaerial erosion during periods of lowered sea level.

In recent years certain investigations have confirmed the theory of widespread change in depth of the Pacific Ocean, e.g.:

1. The recovery of shallow water corals and Foraminifera as well as certain pollens and "high island" molluscs shells from boring on Eniwetok (Ladd 1961).

2. The dredging of rounded cobbles and Cretaceous coral reef organisms from guyots (thought to be wave-truncated sea mounts) at 1,000 m.

3. The tops of the guyots are mostly found at depths of about 1,000–2,000 m and are rarely shallower. In agreement with this, seismic studies indicate basalt at a depth of about 1,300 m and 1,750 m respectively below the atolls of Bikini and Eniwetok (Raitt 1957) and drilling found igneous rock at about 1,300 m in Eniwetok.

Change in sea level accounts for the presence of coral atolls formed by shallow water corals and coralline algae standing in deep water.

Some other generalisations may be made about commonly recurring features of the structure of atolls.

The ability of the atoll to survive at all is evidently due to the encrusting coralline algae or "nullipores", commonly *Porolithon onkodes*, which form the characteristic buttresses of the outer reef.

The edge of the outer reef is a position of maximum illumination and aeration, high nutrient concentration, and, on the windward side at least, minimum erosion by suspended sediment. It must also be borne in mind that the outer reef fringe is almost at the surface or even above the surface at low tide, and being exposed to almost continuous, often vigorous, wave action, is subject to grazing by only a few well adapted invertebrates.

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The bowing inwards of the sides of Manihiki, particularly of the island of Tukao, is a feature to be found in many atolls, as will be seen by a glance at charts such as those of the Marshall Islands in Emery, Tracey, and Ladd (1954). Usually attributed to slumping (Summerhayes 1967), such embayments do appear to be oriented more frequently towards the prevailing wind. This is not so surprising when it is remembered that the reef is modified by the strength of the prevailing wind. The stronger the wind the more robust the structure and the more numerous the surge channels. The Marshall Islands (Emery, Tracey, and Ladd 1954), as well as the Tokelau and Cook Islands, reveal this tendency (McLintock 1959). The prevailing surface currents probably assist in sculpturing the outline, greater growth of the corals and algae occurring at corners of the atoll where eddying and turbulence bring more nourishment to the organisms.

Manihiki, Rakahanga, Suwarrow, Nassau, and Puka Puka rise from the Manihiki Plateau (Heezen, Glass, and Menard 1966). The plateau rises to depths of 2,400–300 m from ocean depths of 5,500 m and could represent and unsubsided remnant of the Darwin Rise. The already-noted finding by Hochstein (1967) of basalt extending to near the surface agrees with this hypothesis.

FORMATION OF THE LAGOON

A frequently discussed puzzle of coral atoll geology is the solution of limestone on the reef flat and the probably related problem of the formation of beach rock—the slabs of consolidated sand, shell, and coral fragments which are associated with most coral atolls.

Solution basins, pitting, and intertidal nips are positive and widespread evidence of chemical erosion of the surface of the reef. Despite several studies there is no satisfactory explanation for this chemical solution. Indeed it has been shown that sea water in the tropics is supersaturated with respect to Ca^{++} ions (Revelle and Emery 1957).

The diurnal fluctuations of O_2, CO_2, and hence pH in surface water due to photosynthesis of plants and respiration of the total biota is well established for the open sea (Park, Hood, and Odum 1958) as well as for intertidal pools and reef flats (Orr and Moorhouse 1933; Emery 1946). Despite the fact that Revelle and Emery found supersaturation of Ca^{++} in shallow reef waters at Bikini and Guam both during the day and at night, they showed at the same time that there were diurnal fluctuations in Ca^{++} ion concentration indicating movement of calcium between the solid and dissolved states.

Table 1 shows the results of 2-hourly observations of oxygen concentrated over a period of 24 hours on 15 August 1960. A minimum was reached just before midnight.

It has already been noted that erosion of the bench of beach rock on the southern margin of the atoll appears to be most rapid on the lagoon side. It was also observed that dead coral fragments in the lagoon were softer than dead coral fragments from the outer reef.

Table 1 Variation in oxygen concentration over a 24-hour period (15–16 August 1960) at a Lagoon Station

Time	*Oxygen* µg atoms/l
0700	0.494
0910	0.556
1100	0.572
1300	0.594
1500	0.600
1700	0.577
1930	0.523
2100	0.503
2300	0.388
0100	0.488
0300	0.490
0455	0.492
0755	0.528

Some writers (e.g., Gardiner 1931) consider that the filamentous algae, which permeate the surface rock, play an important role in dissolving it.

Revelle and Fairbridge (1957) mention the "milky" appearance of lagoon water seen sometimes as it enters the open ocean on an ebb tide and also in one case the clouding of lagoon water presumably owing to the formation of aragonite crystals. Milky waters leaving the lagoon have been observed in the Cook Islands by Mr R. Powell (pers. comm.).

Many authors have mentioned the variety and abundance of animals which rasp the surface or burrow into shell and coral. Fish, molluscs, and echinoderms rasp the surface as they feed on the algae which encrust and permeate it. Molluscs, sipunculids, polychaetes, barnacles, and sponges burrow into the carbonate for protection. A large proportion of the rock is comminuted by these animals and fresh surfaces are continually being exposed. Such mechanical reduction must facilitate solution and when animals such as deposit-feeding holothurians ingest the fine fragments, the acid stomach juices (pH 6.8; Emery, Tracey, and Ladd 1954) no doubt cause further solution.

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Darwin briefly discussed the nature of atoll lagoons and observed that they might be deeper if the rate of subsidence were not slow, as the rate of sedimentation he thought was very slow.

Wiens (1962) discusses the depths of lagoons. After reviewing 56 atolls he states (p. 31): "It may be concluded that generally although the lagoons of small atolls may be deep or shallow, the larger atolls all have relatively deep lagoons"; and further (p. 32): "For greater widths between 15 and 32 miles, the depth appears to be fairly constant at about 45 fathoms."

He also concludes that at least within Micronesia, situation did not influence lagoon depth. Neither did lagoon depth appear to be correlated with the presence of passes into the lagoon; Manihiki lacks passes but is deeper than average.

What then is the reason for the agreement in depth between the lagoons of atolls thousands of miles apart? A uniform rate of subsidence may be ruled out as atolls on the Manihiki Platform appear to be unsubsided. The post-glacial rise in sea level of a few tens of metres during the last 10,000 years is a possible cause. But it seems clear that the lagoon depth is maintained if not caused by a balance between the formation of calcareous skeletons and their breakdown and removal. Coral is destroyed by solution, comminution by animals, and wave action; the products are removed by waves and the outflow of lagoon waters.

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HYDROLOGY OF MANIHIKI LAGOON

BY

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SUMMARY

The water of Manihiki lagoon proved to be less saline than the surrounding sea water, probably because of seepage from the island's freshwater lens. Dissolved-oxygen values obtained show that the lagoon water is generally supersaturated with oxygen.

INTRODUCTION

During the survey of Manihiki lagoon physical properties of the lagoon water were recorded using reversing thermometers mounted in Knudsen water-sampling bottles. A series of nine bathythermograph soundings was obtained. The near-surface water temperature at a selected position within the lagoon was recorded using a mercury-in-steel thermograph. Salinity determinations were made by Th. J. Houtman using a conductivity meter; oxygen determinations were made by J. S. Bullivant, and silica determinations were made at the Chemistry Division, DSIR.

DATA

Fourteen hydrological stations were occupied within the lagoon between 27 June and 7 July 1960 and a further 8 stations were occupied outside the reef between 12 July and 15 July 1960. Their positions and additional the bathythermograph sounding positions are shown in *figure 1.* At each hydrological station temperature and salinity were recorded at each sampling depth, and oxygen and silica determinations of near-surface and bottom samples were generally made (*table 1*).

The thermograph was located on the wharf at Tauhunu village (*figure 1*), and its temperature element was fixed at a depth of 4½ ft. below mean sea level. (The local tidal range is approximately 1 ft.) Continuous temperature records were obtained between 7 June and 23 August 1960 (*table 2*).

Temperature

Surface and bottom temperatures *(figure 2)* were measured at hydrological stations. Surface temperature readings and surface salinities *(figure 3)* were taken at depths of up to 1½ m. The highest near-surface temperature recorded in the lagoon (28.59°C) was at A 549 and the lowest (27.98°C) at A556, a range of 0.61°C. Since the mean diurnal variation in the near-surface temperature over the total period of observations was only 1.3°C *(table 2)*, and since the station temperatures are not synoptic, no significant geographical distribution of temperature can be established.

No thermocline is shown by the bathythermograms which were obtained between 12 July and 15 July 1960 but a weak thermal stratification is indicated by the station data which show that the thermocline is shallower at Sta. A 550 and A 551 near the north-eastern margin of the lagoon than it is at Sta. A 545, A 546, and A 548 just south of the lagoon centre. According to Defant (1961, p. 577) the slope of the internal boundary in a two-layer system is usually opposite to that of the sea surface. If the dynamical situation in Manihiki lagoon is comparable to the model discussed by Defant the observed slope of the thermocline may be explained since the prevailing ESE winds will tend to pile up the lagoon water along the western margin of the reef.

The temperatures recorded during the period of the survey may be typical of those during any month since the seasonal variation in the monthly mean sea and air temperatures does not exceed 1°C around Manihiki (Meteorological Office, London, 1947). However, daily variations could considerably exceed this value.

Salinity

The pattern of salinity revealed by plotting the surface and bottom salinity measurements *(figure 3)* is of lower salinity for the lagoon water than for the surrounding sea water. This could be the result of freshwater entering the lagoon and the most likely source of fresh water is the island freshwater lens as described by Wiens (1962, Ch. 14). Any run-off of this ground water would dilute lagoon water more than ocean water because of their comparative volumes. Mixing along the seaward margin of the reef would be greater than that in the lagoon because of wave action and local currents.

The lagoon salinity would be affected by sea water coming into the lagoon. Sea water enters the lagoon near the south-east corner (J. S. Bullivant pers. comm.) and lagoon water escapes over the reef near the northern point of the atoll *(figure 1)*. These are the only gaps in the circumference of the atoll. The volume of sea water entering the lagoon will depend upon both wind and tide and short-term variations of lagoon salinity will result. Reduced surface salinities on the seaward side of the discharge area appear to be caused by discharge of lagoon water.

Lagoon salinity is also affected by precipitation and evaporation. The mean annual rainfall at Manihiki, aver-

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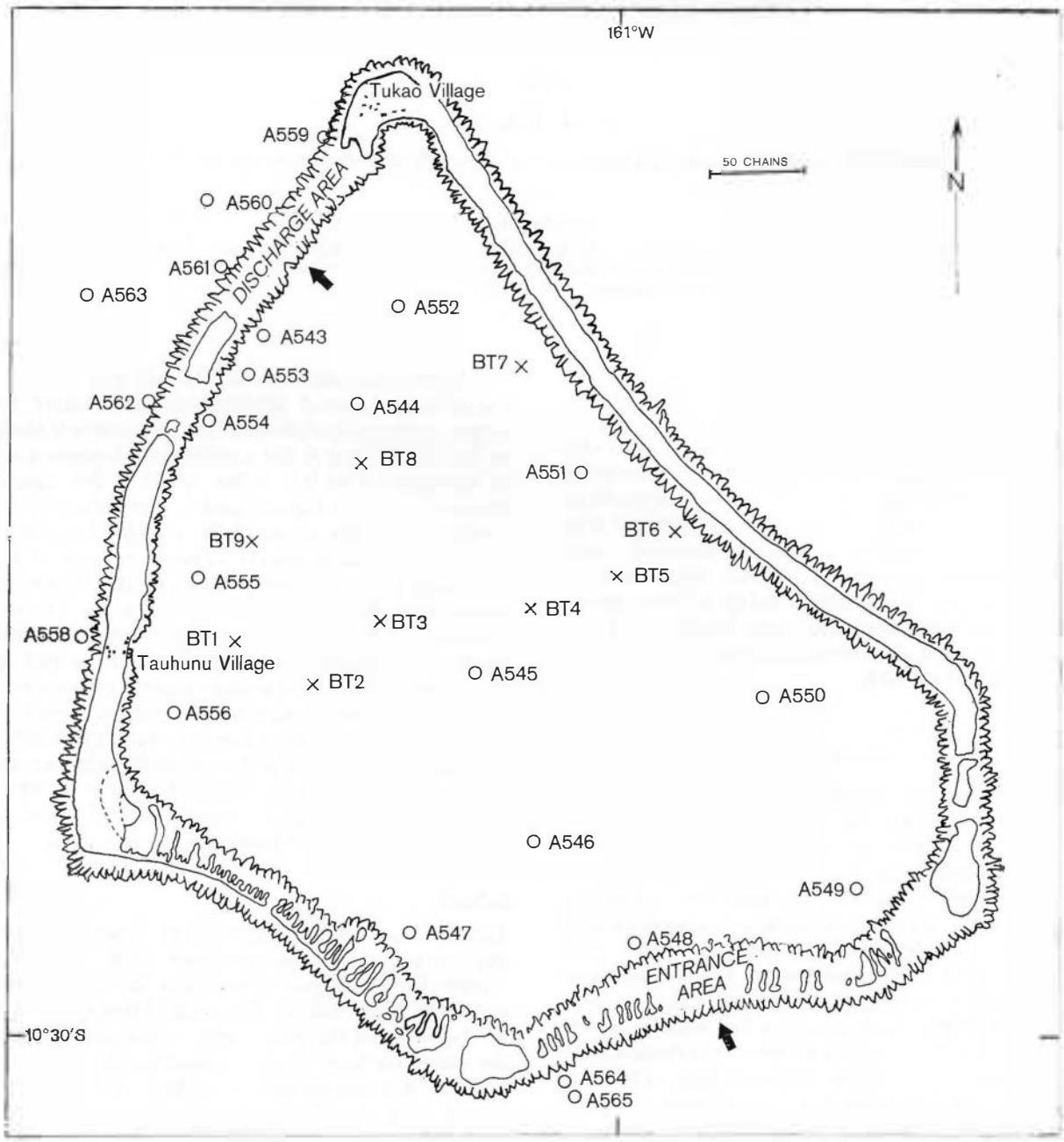

FIGURE 1: Locality map showing serial stations and BT sounding positions. The sea-water entrance and lagoon-water discharge areas are marked.

aged over 14 years, was 94.74 in. (Wiens 1962, p. 471), and although no figures are available it is unlikely that mean annual evaporation will exceed 50–60 percent of the precipitation. Thus, the low salinity of the lagoon water compared with that of the surrounding sea may be the usual condition. There may be some seasonal variation since the summer period from October to March is considerably wetter than the rest of the year (Wiens 1962, p. 155).

Oxygen and Silica

The oxygen values obtained show that the lagoon water is generally supersaturated with oxygen. These high oxygen values are a not unusual feature of coral reef waters since oxygen production in these situations is often high (Wiens 1962, p. 283; Odum *et al.* 1959).

The silica values recorded are similar to those obtained in nearby waters by the "Carnegie" expedition in 1929 (Fleming *et al.* 1945).

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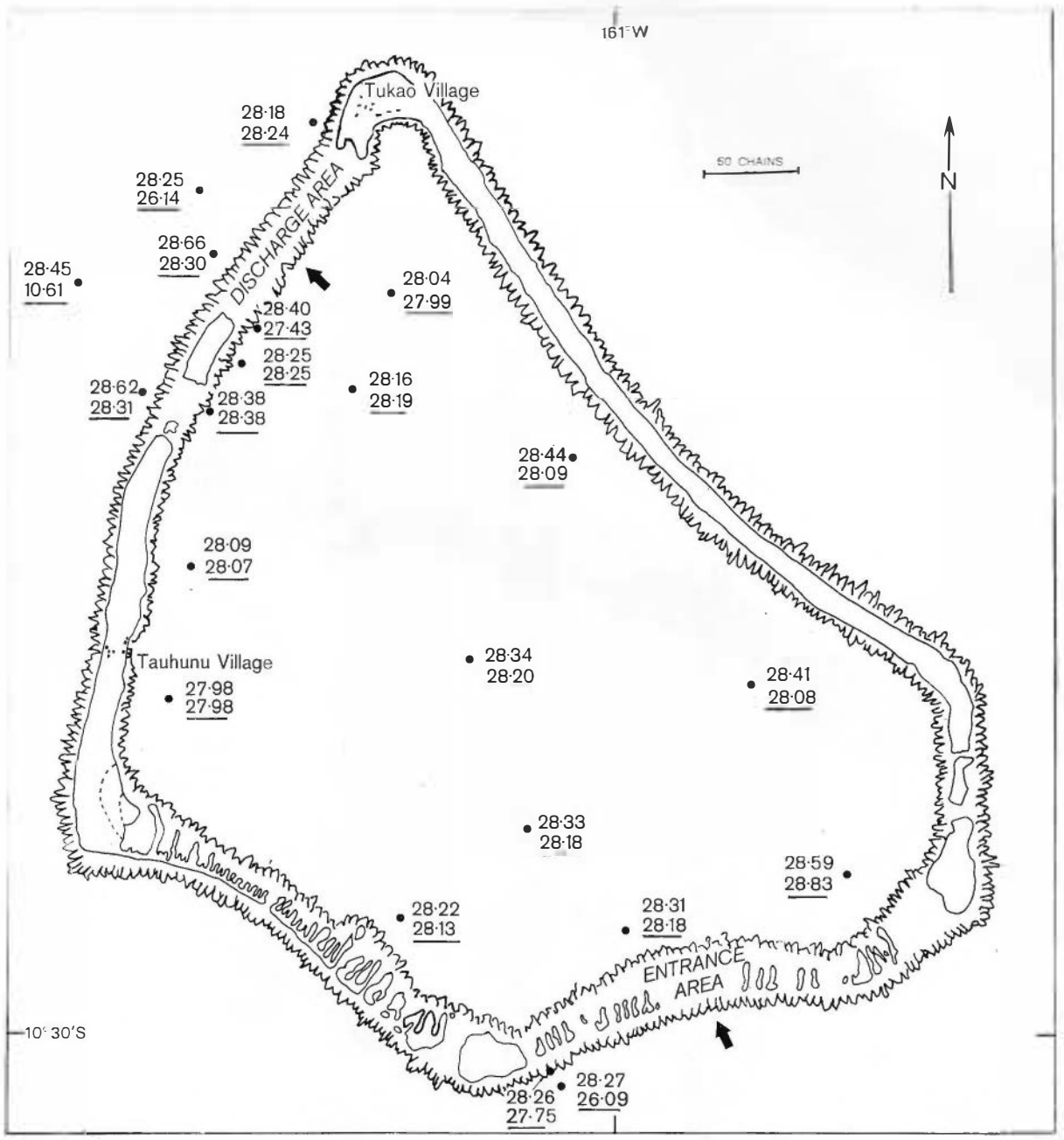

FIGURE 2: Surface and bottom (underlined) temperatures measured at the serial stations.

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Table 1 Serial station data

Station No. and Details	*Depth to Bottom* m	*Sampling Depth* m	*Temperature* °C	*Salinity* ‰	Si µg/l	SiO_2 µg/l	O_2 µg/l
A543	20	2	28.40	35.01	-	-	-
1550-1650 h		9	.42	.07	-	-	-
27/6/60		18	.42	.03	-	-	-
A544	24	1½	28.16	-	-	-	-
1200-1230 h	to	4	.16	34.99	-	-	4.94
29/6/60	11	10	.22	-	-	-	-
		13	.19	34.99	-	-	4.75
A545	51	1	28.34	35.03	-	-	-
1515-1645 h	to	3	.34	.04	-	-	5.11
29/6/60	42	8	.30	.07	-	-	-
		13	.41	.01	-	-	-
		18	.40	.03	-	-	-
		28	.19	.01	-	-	-
		38	.19	.01	-	-	-
		40	.20	.02	-	-	4.60
A546	64	0	28.33	35.08	0.00	0.00	-
1500-1600 h		1	.36	.09	-	-	5.27
30/6/60		6	.30	.08	-	-	-
		16	.19	.08	-	-	-
		31	.19	.11	-	-	-
		46	.17	.12	-	-	-
		57	.19	.12	0.00	0.00	-
		58	.18	.16	-	-	4.58
A547	23	0	28.22	35.11	0.00	0.00	5.41
1030-1100 h		6	.27	.07	-	-	-
2/7/60		13	.17	.08	-	-	-
		23	.12	.41	-	-	-
		33	.13	.08	0.4	0.85	4.58
		34	-	.09	-	-	-
A548	24	0	28.31	35.10	0.00	0.00	4.85
1430-1515 h		3	.28	.09	-	-	-
2/7/60		8	.24	.11	-	-	-
		13	.23	.11	-	-	-
		18	.25	.11	-	-	-
		23	.18	.10	0.00	0.00	5.3[illegible]
A549	22	0	28.59	35.15	0.6	1.28	5.00
1000-1040 h		5	.05	.11	-	-	-
4/7/60		10	27.99	.11	-	-	-
		16	.98	.13	-	-	-
		21	.83	.18	0.3	0.64	5.03
A550	29	1½	28.41	35.10	-	-	5.20
1230-1250 h		6½	.08	.09	-	-	-
4/7/60		11½	.09	.09	-	-	-
		16	.05	.07	-	-	-
		21	.09	.08	-	-	-
		31	.08	.08	-	-	5.28
A551	29	1½	28.44	35.09	-	-	-
1500-1630 h		6½	.28	.05	-	-	-
4/7/60		11½	.19	.06	-	-	-
		16½	.14	.08	-	-	-
		21	.12	.08	-	-	-
		28	.09	.08	-	-	-
A552	15	1½	28.04	35.00	0.1	0.21	5.2[illegible]
1000-1020 h		3½	.05	.00	-	-	-
5/7/60		8½	27.98	34.98	-	-	-
		13	28.05	35.00	-	-	-
		18	27.99	34.99	0.3	0.64	5.25

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Station No. and Details	Depth to Bottom m	Sampling Depth m	Temperature °C	Salinity ‰	Si µg/l	SiO_2 µg/l	O_2 µg/l
A553	15	1½	28.25	35.02	0.2	0.42	5.15
1400-1430 h		5½	.20	34.99	-	-	-
5/7/60		9½	.24	35.04	-	-	-
		14	.25	.01	0.4	0.85	5.25
A554	11	2	28.38	34.99	-	-	-
1530-1555 h		6	.37	35.00	-	-	-
5/7/60		11	.38	.01	-	-	-
A555	19	1½	28.09	34.98	-	-	5.02
0900-1030 h		3½	.09	.99	-	-	-
6/7/60		8½	.04	.98	-	-	-
		13	.09	.98	-	-	-
		18	.07	.98	-	-	5.16
A556	17	0	27.98	35.00	-	-	5.22
0930-1100 h		5	.98	.00	-	-	-
7/7/60		10	28.02	.00	-	-	-
		15	27.98	.01	-	-	5.17
A558	17	0	28.64	35.56	-	-	5.62
1400-1510 h		5	.27	.53	-	-	-
12/7/60		10	.29	.53	-	-	-
		15	.30	.54	-	-	-
		20	.30	.55	-	-	5.35
A559	37	1½	28.18	35.45	0.3	0.64	5.19
1030-1120 h		6½	.20	.47	-	-	-
13/7/60		11½	.18	.50	-	-	-
		21	.24	.49	-	-	-
		31	.24	.49	2.4	5.14	5.33
A560	119	2	28.25	35.51	-	-	4.95
1200-1420 h		7	.20	.49	-	-	-
13/7/60		12	.26	.52	-	-	-
		32	.23	.50	-	-	-
		52	.26	.50	-	-	-
		72	.35	.57	-	-	-
		92	.14	.67	-	-	-
		112	26.14	.52	-	-	4.69
A561	7	½	28.66	35.19	-	-	-
1510-1600 h		13½	.28	.47	-	-	-
13/7/60		18½	.30	.49	-	-	-
A562	15	1	28.62	35.26	-	-	5.59
1400-1455 h		9	.32	.56	-	-	-
14/7/60		14	.30	.58	-	-	-
		19	.34	.57	-	-	-
		24	.31	.50	-	-	5.10
A563	400	0	28.45	35.55	-	-	5.10
1600-1750 h		5	.47	.55	-	-	-
14/7/60		25	.41	.61	-	-	-
		75	.36	.56	-	-	-
		175	23.62	35.05	-	-	-
		275	15.23	36.06	-	-	-
		375	10.61	34.62	-	-	2.60
A564	120	0	28.26	35.59	-	-	4.90
1200-1320 h		115	28.74	.58	-	-	-
15/7/60		215	27.75	.86	-	-	4.92
A565	200	0	28.27	35.54	-	-	4.99
1400-1515 h		45	.32	.62	-	-	-
15/7/60		145	26.09	35.14	-	-	4.43

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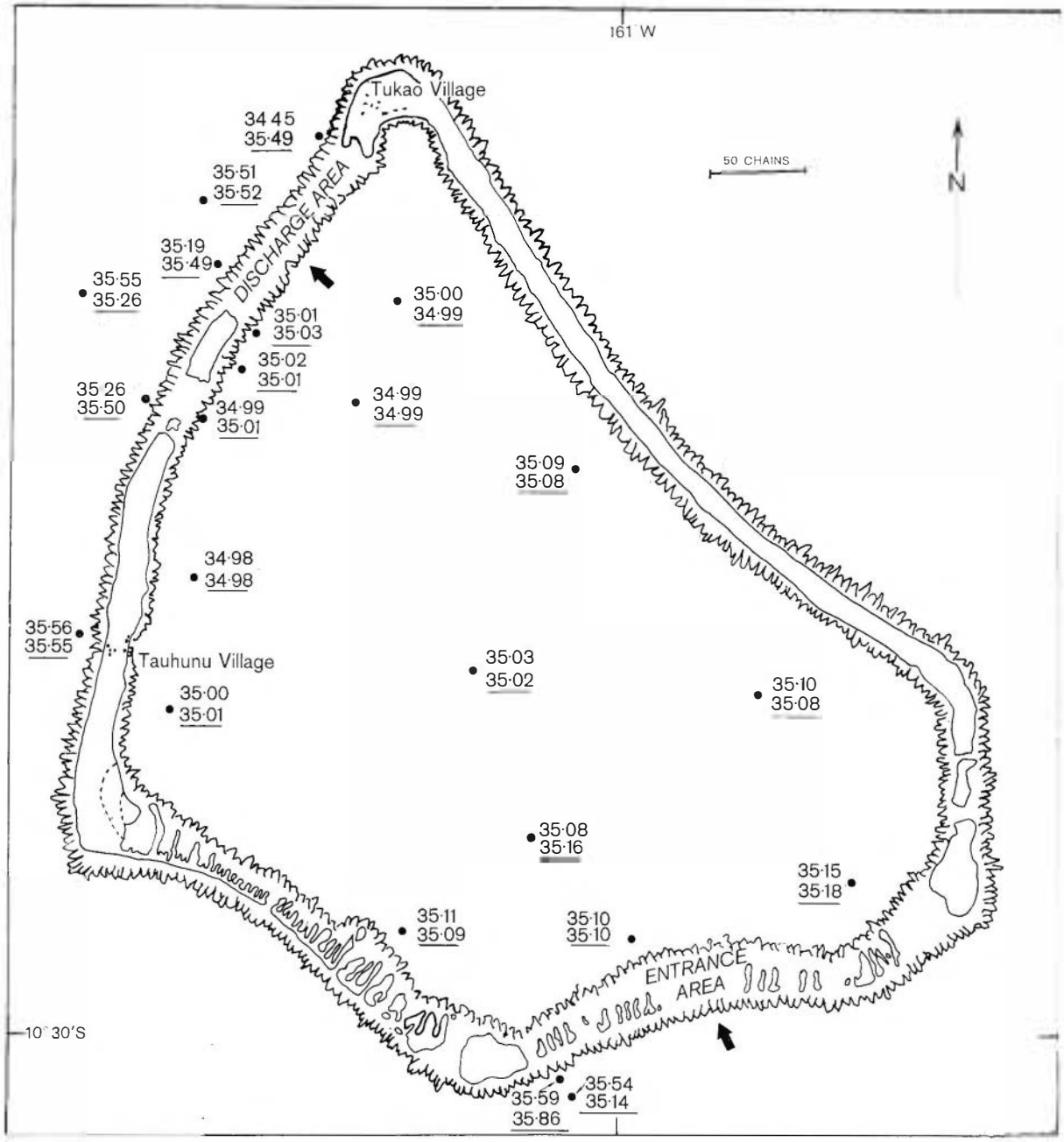

FIGURE 3: Surface and bottom (underlined) salinities (‰) measured at the serial stations.

Table 2 Summary of near-surface temperatures recorded with thermograph located at Tauhunu village

Temperatures given in degrees Celsius

Month	*Average Daily Maximum Temperature*	*Average Daily Minimum Temperature*	*Average Daily Range*	*Maximum Temperature Recorded*	*Minimum Temperature Recorded*	*Maximum Daily Variation Recorded*	*Minimum Daily Variation Recorded*
June	29.5	28.4	1.1	30.3	27.1	2.4	0.1
July	29.2	28.0	1.2	29.9	26.8	2.0	0.3
August	29.2	28.0	1.6	30.7	26.7	2.2	0.9

Average daily variation in near-surface temperature over total period of observations : 1.3°C

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TIDAL MEASUREMENTS AT MANIHIKI ATOLL

BY

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SUMMARY

Tide records obtained by a "Foxboro" liquid level recorder showed that the tidal range at Manihiki is quite small, normally less than 1 ft, and in the lagoon, less than half of that.

DATA

During the Manihiki Lagoon Survey 1960, a number of tide records were obtained by a "Foxboro" liquid level recorder. Tides in the ocean were recorded at a site (latitude 10° 23.7′ S, longitude 161° 03′ W) approximately 100 yd north of the Tauhunu landing between 5 June and 10 August. The underwater pressure unit was placed in shallow water over the reef and connected by a pressure line to the recorder situated on the beach (*figure 1*). The bench mark chosen was the Tauhunu flagpole and the base point on it is near ground level at the corner nearest the tide gauge (in plan *figure 2*; in section *figure 3*).

Sea levels inside the lagoon were recorded as close as possible to the site of tide observations in the ocean (*figure 2*), from 15 to 21 August 1960.

Records of ocean tides throughout the month of July were analysed by a semi-graphic method (Admiralty Hydrographic Department 1959). Throughout the analysis the data were expressed in terms of GMT. Harmonic constants of the five major constituents are given in *table 1*.

The tidal range on Manihiki Island is quite small, normally less than 1 ft. The tides are predominantly lunar semi-diurnal with the amplitude ratio $F = (K_1 + O_1)/(M_2 + S_2) = 0.2$.

A noteworthy feature is the relatively large magnitude of the N_2 constituent (*table 1*) which indicates the

FIGURE 1: Photograph of the recorder site and position of the underwater pressure unit (marked by the staff).

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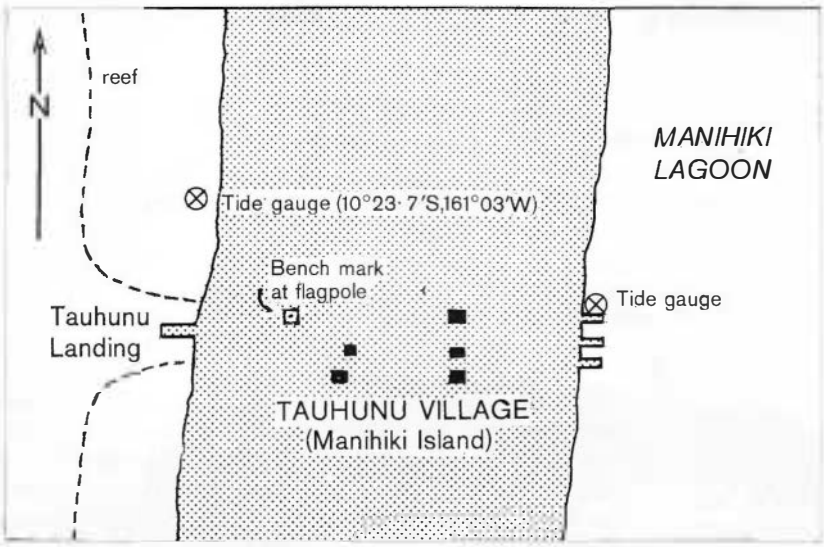

FIGURE 2: Sketch map showing the positions of the tide gauge in the ocean and lagoon, and the bench mark to which mean sea level is referred (see also the photograph, *figure 6*, p. 8).

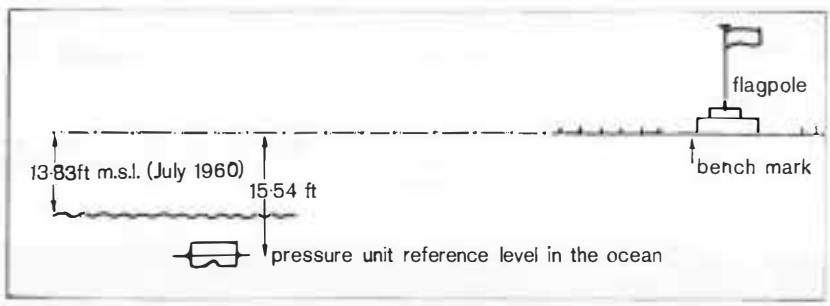

FIGURE 3: Diagram showing the mean sea level (m.s.l.) in the ocean, with reference to the bench mark

Table 1 Harmonic constants (with respect to GMT)

Constituent	H *feet*	g *degrees*
M_2	0.34	156
S_2	0.08	97
N_2	0.10	150
K_1	0.05	157
O_1	0.03	107

extent to which the amplitude of the lunar semi-diurnal tide varies with the distance between the earth and moon.

Mean sea level in the ocean during July 1960 was 13.83 ft below the bench mark *(figure 3)*.

Tidal variations of level in the lagoon were quite small; about half those in the ocean. The phase of the lagoon tides lagged slightly behind the ocean tides.

REFERENCE

ADMIRALTY HYDROGRAPHIC DEPARTMENT, 1959: "The Admiralty semi-graphic method of tidal analysis". *Admty Tidal Handb. 1:* H.D. 505

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SCLERACTINIAN CORALS FROM MANIHIKI ATOLL

BY

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SUMMARY

Eleven families, 18 genera, and 30 species of scleractinian corals were collected from Manihiki.

INTRODUCTION

Identifications of the scleractinian corals collected from Manihiki Atoll are given.

The classification is that of Vaughan and Wells (1943).

The collection represents 11 families, 18 genera, and 30 species. In addition to Anthozoan corals, two or three species of the calcareous coralline algal genus *Lithothamnia* are present.

CHECKLIST OF GENERA

FAMILY	GENUS	NO. OF SPECIES
Seriatoporidae	*Pocillopora*	1
Acroporidae	*Acropora*	6
	Montipora	2
Fungiidae	*Fungia*	2
Poritidae	*Goniopora*	1
	Porites	1
Faviidae		
Subfamily: Faviinae	*Favites*	1
	Goniastrea	2
	Hydnophora	3
Subfamily: Montastreinae	*Montastrea*	1
	Leptastrea	1
Merulinidae	*Merulina*	1
Mussidae	*Acanthastrea*	1
Pectiniidae	*Mycedium*	1
Caryophylliinae	*Caryophyllia*	1
Flabellidae	*Flabellum*	1
Dendrophyllidae	*Dendrophyllia*	1
	Turbinaria	3

MATERIAL EXAMINED

SERIATOPORIDAE Milne-Edwards and Haime, 1849

Genus *Pocillopora* Lamarck, 1816

P. eydouxi Milne-Edwards and Haime, 1849. Vaughan and Wells, 1943: 106, pl. 7, fig. 3. A667, A672, A675.

ACROPORIDAE Verrill, 1902

Genus *Acropora* Oken, 1815

A. digitifera (Dana) 1846. Crossland, 1952: 207, pl. XXXV, fig. 2. A669.

A. haimei Milne-Edwards and Haime, 1860. Crossland, 1952: 207, pls. XXXIII, fig. 1; XXXV, fig. 1. A669.

A. surculosa (Dana) 1848. Crossland, 1952: 214, pl. XXXVIII, figs 2–5. A669.

A. cancellata (Brook) 1893. Crossland, 1952: 225, pl. XLI, figs 3, 4. A552, A554, A555, A556, A668, A669.

A. otteri Crossland, 1952: V (3), 229, pls. 43, 44. A668, A669, A672, A674, A686, A774.

A. glochiclaclos (Brook) 1893. Crossland, 1952: 213, pl. XXXIX, figs 1, 2. A678.

Genus *Montipora* de Blainville, 1830

M. composita Crossland, 1952: pls. XXVIII, figs 1, 5; XXIX, figs 1, 2, 4. A672.

M. erythraea Marenzeller, 1906. Crossland, 1952: 193, pls. XXIV, figs 2–4; XXVII, figs 1, 2. A672, A675.

FUNGIIDAE Dana, 1848

Genus *Fungia* Lamarck 1801

F. echinata (Pallas) 1766. Crossland, 1952: 152. A544, A552, A556, A668, A669, A670.

F. scutaria Lamarck, 1816. Crossland, 1952: 152. A544, A556, A670, A674, A678, A683, A686. A774.

PORITIDAE Gray, 1942

Genus *Goniopora* de Blainville, 1830

G. minor Crossland, 1952: 233, pl. XLVIII, figs 1, 3. A675, A685, A686.

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Genus *Porites* Link, 1807
P. stephensoni Crossland, 1952: 238, pl. L, fi4s 3, 4. A668, A672, A672, A678.

FAVIIDAE Gregory, 1900

FAVIINAE Vaughan and Wells, 1943

Genus *Favites* Link, 1807
F. abdita (Ellis and Solander) 1786. Crossland, 1952: 129. A543, A668, A674, A680.

Genus *Goniastrea* Milne-Edwards and Haime, 1848
G. benhami Vaughan, 1917. Crossland, 1952: 136, pl. VIII, fig. 2. A669.
G. mantonae Crossland, 1952: 136, pl. VII, figs 1, 2. A669, A672.

Genus *Hydnophora** Fischer de Waldheim, 1807
H. exesa Dana, 1846. Crossland, 1952: 165, pls. XVI, figs 2, 3; XVII, fig. 4. A669, A686, A774.
H. microconos Lamarck, 1816. Crossland, 1952: 151. A672.
H. contigua Esper, 1797. Crossland, 1952: 165, pls. XV, figs 4, 5; XVII, fig. 3. A686.

MONTASTREINAE Vaughan and Wells, 1943

Genus *Montastrea* de Blainville, 1830
M. vacua† (Crossland) 1952: 124, pls. II, figs 1, 4; III, fig. 2. A672, A686.

Genus *Leptastrea*‡ Milne-Edwards and Haime, 1949
L. purpurea Dana, 1848. Crossland, 1952: 115. A548, A550, A669.

MERULINIDAE Verrill, 1866

Genus *Merulina* Ehrenberg, 1834
M. ampliata (Ellis and Solander) 1786. Crossland, 1952: 151. A683, A774.

*Crossland (1952) assigns the species of this genus to the family Thamnastreidae and genus *Psammocora.*

†Crossland (1952) names this species *Orcibella vacua;* but Vaughan and Wells (1943) (footnote p. 173) point out that de Blainville's *Montastrea* (1830) precedes *Orcibella* Dana (1848).

‡Crossland (1952) places this genus in a family Astraeidae.

MUSSIDAE Ortmann, 1890

Genus *Acanthastrea* Milne-Edwards and Haime, 1848
A. echinata Dana, 1848. Crossland, 1952: 141, pls. VIII, figs. 1, 3; IX, figs, 1, 2. A548, A669, A670, A678, A683, A774.

PECTINIIDAE Vaughan and Wells, 1943

Genus *Mycedium* Oken, 1815
M. elephantotus Pallas, 1766. Vaughan and Wells, 1943: 198. A548.

CARYOPHYLLIINAE Milne-Edwards and Haime, 1857

Genus *Caryophyllia* Lamarck, 1801
Caryophyllia sp. Alcock, 1902: 7. A683.

FLABELLIDAE Bourne, 1905

Genus *Flabellum* Lesson, 1831
Flabellum sp. Alcock, 1902: 29. A552.

DENDROPHYLLIDAE Gray, 1847

Genus *Dendrophyllia* de Blainville, 1830
Dendrophyllia sp. Crossland, 1952: 169. A668.

Genus *Turbinaria* Oken, 1815
T. peltata Esper, 1797. Crossland, 1952: 174. A669.
T. stephensoni Crossland, 1952: 178. A668, A669, A670, A774.
T. frondeus (Dana). Crossland, 1952: 176. A677.

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CROSSLAND, C. 1952: Madreporaria, Hydrocorallinae, *Heliopora,* and *Tubepora. Scient. Rep Gt Barrier Reef Exped. VI(3):* 86–257. LVI pl.

VAUGHAN, T. W.; WELLS, J. W. 1943: Revision of suborders, families, and genera of the Scleractinia. *Spec. Pap. geol. Soc. Am. 44.* 10 + 363 pp., 51 pl.

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SIPUNCULIDS FROM MANIHIKI

BY

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SUMMARY

Two species of sipunculid were collected from Manihiki Atoll, Cook Islands, from the genera *Phascolosoma* and *Paraspidosiphon*.

INTRODUCTION

A number of sipunculids were collected at Manihiki Atoll from the lagoons and outer coral reef in July and August 1960 by members of the New Zealand Oceanographic Institute. These proved to belong to at least two species.

SYSTEMATICS

Phascolosoma sp.

Specimens of *Phascolosoma* were taken at three stations but were unidentifiable to species level because of their small size or poor condition.

MATERIAL EXAMINED: A550, 1 specimen, damaged introvert; A544, 1 specimen; A672, 2 specimens, very small.

Paraspidosiphon klunzingeri (Selenka, de Man, and Bülow, 1883)

Thirty-four specimens and three fragments of this species were obtained. The size of trunk varied from 6–32 mm long and 1.5–3.0 mm wide. *(figures 1, 2).*

MATERIAL EXAMINED: A544, 12 specimens, 2 fragments; A548, 2 specimens; A550, 9 specimens; A551, 1 specimen; A556, 6 specimens; A627, 1 specimen; A672, 2 specimens; A677, 1 specimen; A686, 1 fragment.

REFERENCE

SELENKA, E.; MAN, J. G. DE; BÜLOW, C. 1883: Die Sipunculiden. *In* Semper, C. C. "Reisen im Archipel Philippinen, etc. Zweiter Theil. Wissenschaftliche Resultate". *4(1):* i-xxxii, 1–131, 14 pl. Leipzig and Wiesbaden

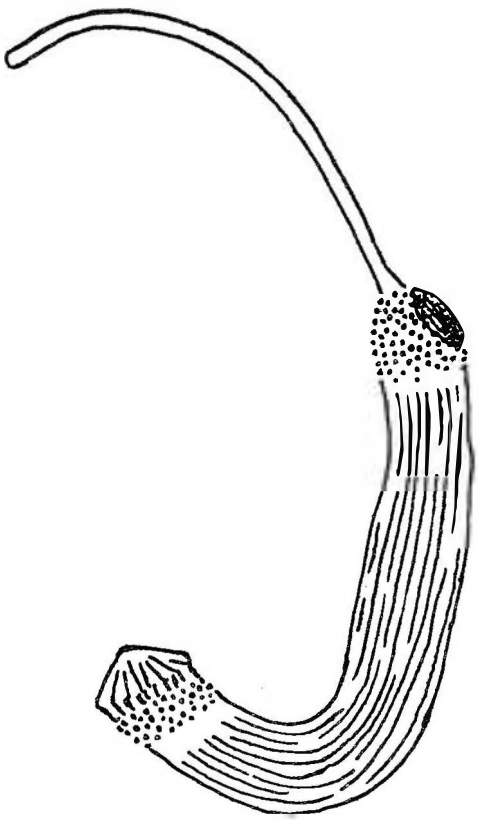

FIGURE 1: *Paraspidosiphon klunzingeri*, entire animal.

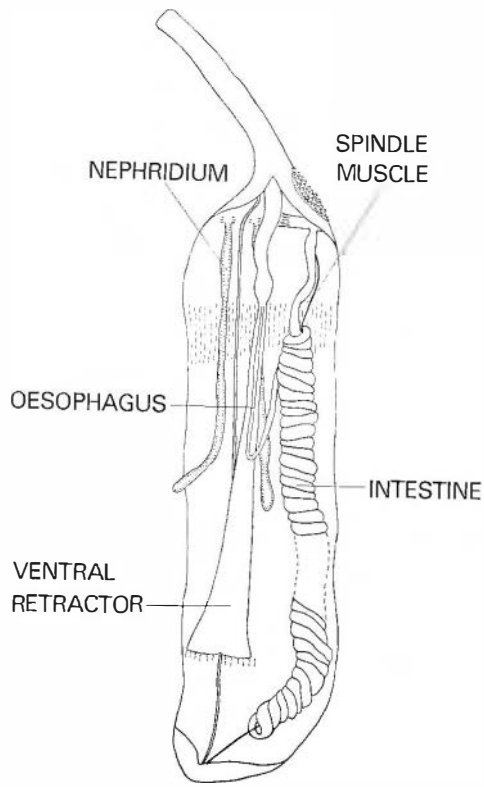

FIGURE 2: *Paraspidosiphon klunzingeri*, dissected specimen.

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MOLLUSCA FROM MANIHIKI ATOLL

BY

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New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington

SUMMARY

Thirty-five families and 49 genera of Gastropoda, and 19 families and 33 genera of Bivalvia constitute the major part of the collection of Mollusca from Manihiki. Some Cephalopoda, but no Amphineura or Scaphopoda, were obtained.

INTRODUCTION

The Manihiki Atoll molluscs, obtained by means of hand collection along the shore and reefs through to the use of grabs and deep dredges, are well represented by the Gastropoda and Bivalvia. Many of the gastropod shells were tenanted by hermit crabs (Paguridae). The Cephalopoda are represented by only two species of different genera. One specimen was found under a coconut tree, possibly regurgitated by a sea bird. Amphineura and Scaphopoda are not represented at all.

The systematic arrangement follows that of Abbott (1959).

The Gastropoda are represented by 35 families and 49 genera; the Bivalvia by 19 families and 33 genera. With few exceptions, most of the families are represented by single genera with one or more species.

CHECKLIST OF FAMILIES: Gastropoda

FAMILY	NO. OF GENERA	NO. OF SPECIES
Fissurellidae	1	1
Patellidae	1	1
Acmaeidae	1	1
Trochidae	2	2
Cyclostrematidae	1	1
Turbinidae	1	1
Neritopsidae	1	1
Neritidae	1	5
Littorinidae	1	1
Truncatellidae	1	1
Turritellidae	1	1
Vermetidae	1	1
Planaxidae	1	1
Cerithiidae	3	9
Triphoridae	1	1
Calyptraeidae	1	1
Strombidae	1	1
Cypraeidae	1	5
Naticidae	3	3
Cymatiidae	1	1
Bursidae	1	4
Magilidae	2	2
Muricidae	2	8
Columbellidae	1	1
Nassariidae	1	1
Fasciolariidae	1	1
Mitridae	4	5
Turridae	2	2
Conidae	1	4
Terebridae	1	1
Acteonidae	2	2
Atyidae	2	2
Retusidae	1	1
Pyramidellidae	1	1
Ellobiidae	1	1
Siphonariidae	1	1

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MATERIAL EXAMINED: Gastropoda

(Superfamily names are shown in SPACED CAPITALS; family names in CAPITALS.)

Subclass **PROSOBRANCHIA**

Order ARCHAEOGASTROPODA

PLEUROTOMARIACEA

FISSURELLIDAE

Genus *Diodora* Gray, 1821
Diodora sp. A556, A672

PATELLACEA

PATELLIDAE

Genus *Cellana* H. Adams, 1869
Cellana sp. A686 (C. McCann det.)

ACMAEIDAE

Genus *Acmaea* Eschscholtz *in* Kotzebue, 1830
Acmaea sp. A686

TROCHACEA

TROCHIDAE

Genus *Stomatia* Hebling, 1779
S. Sanguinea A. Adams, 1850 A686

Genus *Astraea* Roeding, 1798
A. rhodostoma Lamarck, 1799 A670, A673
Astraea sp. A550 (operculum only)

CYCLOSTREMATIDAE (syn. VITRINELLIDAE)

Genus *Cyclostremiscus* Marryat, 1818
C. (Ponocyclas) novemcarinatus (Melvill)* A545, A549, A556

TURBINIDAE

Genus *Turbo* Linnaeus, 1758
T. argyrostomus Linnaeus, 1758 A669, A673, A674, A676, A683
Turbo sp. A556

NERITACEA

NERITOPSIDAE

Genus *Neritopsis* Grateloup, 1832
N. radula (Linnaeus, 1758) A671

NERITIDAE

Genus *Nerita* Linnaeus, 1758
N. plicata Linnaeus, 1758 A667, A671, A67[illegible] A679, A683
N. undata Linnaeus, 1758 A674
N. polita Linnaeus, 1758 A676
N. cf. *maxima* Gmelin, 1791 A668, A671
N. chamaelon Linnaeus, 1758 A671
Nerita sp. A668

**Cyclostremiscus (Ponocyclas) novemcarinatus* (Melvill) is not dated.

Order MESOGASTROPODA

LITTORINACEA

LITTORINIDAE

Genus *Littorina* Ferussac, 1822
L. coccinea (Gmelin, 1791) A667, A671, A673, A686

RISSOACEA

TRUNCATELLIDAE

Genus *Truncatella* Risso, 1826
Truncatella sp. (terrestrial) A671

CERITHIACEA

TURRITELLIDAE

Genus *Turritella* Lamarck, 1799
Turritella sp. A545, A550, A552, A556, A785

VERMETIDAE

Genus *Vermetus* Daudin, 1800
Vermetus sp. A556

PLANAXIDAE

Genus *Planaxis* Lamarck, 1822
P. lineatus (da Costa, 1778) A667, A668, A671, A686

CERITHIIDAE

Genus *Cerithium* Bruguière, 1789
C. adansoni Bruguière, 1792 A667
C. atromarginatum Dautzenberg & Bouge, 1933 A667
C. breve Quoy & Gaimard, 1832 A667, A668, A674, A682, A683
C. columna Sowerby, 1824 A544, A545, A550, A552, A556, A570, A673, A683, A686
C. ianthinum Gould, 1851 A667, A667
C. nesioticum Pilsbry & Vanatta, 1905 A671
C. sinense (Gmelin, 1791) A674
Cerithium sp. A543, A544, A544 (fragments), A553, A556 (fragments), A667, A668, A674, A678, A679, A682, A687 (broken), A782, A784, A785, A786

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Genus *Bittium* Gray, 1847
Bittium sp. A549, A672 (juv.), A686

Genus *Diala* A. Adams, 1861
D. lanta A. Adams, 1861 A550, A552, A544, A556, A670, A672, A674, A683
Diala sp. A543, A544 (fragments), A668, A683, A686, A785

TRIPHORIDAE

Genus *Triphora* Deshayes, 1832 (= *Triphoria*)
Triphora sp. A552

CALYPTRAEACEA

CALYPTRAEIDAE

Genus *Calyptraea* Lamarck, 1799
C. turcica (Roeding, 1798) A550, A556, A785
Calyptraea sp. A550 (C. McCann det.)

STROMBACEA

STROMBIDAE

Genus *Strombus* Linnaeus, 1758
S. mutabilis Swainson, 1821 A556, A558, A670, A671, A673, A674, A677, A683

CYPRAEACEA

CYPRAEIDAE

Genus *Cypraea* Linnaeus, 1758
C. caputserpentis Linnaeus, 1758 A688
C. depressa Gray, 1821 A667
C. fimbriata Gmelin, 1790 Manihiki (J. S. Bullivant, det.)
C. isabella Linnaeus, 1758 A686
C. moneta Linnaeus, 1758 A668, A670, A671, A673, A674, A683, A688, A786

NATICACEA

NATICIDAE

Genus *Polinices* Montfort, 1810
Polinices sp. A552 (young)

Genus *Natica* Scopoli, 1777
N. chemnitzi Pfeiffer, 1840 A673
Natica sp. A667

Genus *Eunaticina* Fischer, 1885
E. papillosa (Gmelin, 1791)
Eunaticina sp. A544

TONNACEA

CYMATIIDAE

Genus *Cymatium* Roeding, 1798
C. tuberosum (Lamarck, 1785) A673
Cymatium sp. A552 (young)

BURSIDAE

Genus *Bursa* Roeding, 1798
B. affinis Roeding, 1798 A673
B. bufonia (Gmelin, 1791) A681
B. granularis Roeding, 1798 A673, A686
B. siphonata (Reeve, 1846)A 673

Order NEOGASTROPODA

MAGILIDAE

Genus *Coralliobia* H. & A. Adams, 1853
C. violacea (Kiener)* A556, A673 (C. McCann det.)
Coralliobia sp. (C. McCann det.)

Genus *Quoyula* Iredale, 1912
Q. madreporarum Sowerby, 1832 A672

MURICIDAE

Genus *Drupa* Roeding, 1798

Subgenus *Drupa* s. str.
D. (D.) ricina (Linnaeus, 1758) A667, A683, A686

Subgenus *Morula* Schumacker 1817
D. (M.) cariosa (Wood, 1828) A667
D. (M.) cornus (Roeding 1798) A680
D. (M.) granulata (Duclos, 1832) A667
D. (M.) grossularia Roeding, 1798 A667, A686
D. (M.) morum Roeding, 1798 A667, A673
D. (M.) uva Roeding, 1798 A674, A679

Genus *Thais* Roeding, 1798
T. hippocastanum Linnaeus, 1758 A667, A684, A781

BUCCINACEA

COLUMBELLIDAE

Genus *Columbella* Lamarck, 1799
C. cf. *varians* Sowerby, 1832 A672

NASSARIIDAE

Genus *Nassarius* Dumérii, 1805
Nassarius sp. A556 (fragments)

FASCIOLARIIDAE

Genus *Latirus* Montfort, 1810
L. nodatus (Gmelin, 1791) A673, A684

**Coralliobia violacea* (Kiener) is not dated.

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VOLUTACEA

MITRIDAE

Genus *Mitra* Roeding, 1798
M. nodosa Swainson, 1840 A673 (C. McCann det.)

Genus *Vexillium* Bolten, 1798 (C. McCann det.)
Vexillium sp. A669 (C. McCann det.)

Genus *Strigatella* Swainson, 1840
S. litterata (Lamarck, 1822) A667, A679, A686
S. virgata Reeve, 1846 A667

Genus *Pusia* Swainson, 1840
P. tuberculata (Kiener, 1839)* A671 (worn by crab)

CONACEA

TURRIDAE

Genus *Mangelia* Risso, 1826
Mangelia sp. A553

Genus *Eucithara* Fischer, 1883
E. coronata (Hinds, 1843) A550

CONIDAE

Genus *Conus* Linnaeus, 1758
C. catus Hwass, 1792 A667, A668 (specimens retained by Dr R. Tucker Abbott, Academy of Natural Sciences of Philadelphia.)
C. ebraeus Linnaeus, 1758 A686
C. leopardus Roeding, 1798 Manihiki (J. S. Bullivant det.)
C. sponsalis Hwass, 1792 A667

TEREBRIDAE

Genus *Terebra* Bruguière, 1792
T. crenata Linnaeus, 1758 A673, A684

Subclass **OPISTHOBRANCHIA**

Order TECTIBRANCHIA

BULLACEA

ACTEONIDAE

Genus *Acteocina* Gray, 1847
Acteocina sp. A543, A549, A784, A785

Genus *Bulla* Linnaeus, 1758
B. monodonta (A. Adams, 1850) A544, A550, A552, A556, A785

ATYIDAE

Genus *Atys* Montfort, 1810
A. cyclindrica Helbling, 1779 A552, A668
Atys sp. A556

Genus *Haminoea* Turton & Kingston, 1830
Haminoea sp. A784, A785

RETUSIDAE

Genus *Retusa* Brown, 1827
Retusa sp. A553, A556

PYRAMIDELLACEA

PYRAMIDELLIDAE

Genus *Otopleura* Fischer, 1885
O. mitralis (A. Adams, 1854) A671

Subclass **PULMONATA**

Order BASOMMATOPHORA

ELLOBIACEA

ELLOBIIDAE

Genus *Melampus* Montfort, 1810
M. flavus Bruguière, 1789 A671
Melampus sp. A671

SIPHONARIACEA

SIPHONARIIDAE

Genus *Siphonaria* Sowerby, 1824
Siphonaria sp. A667

MATERIAL EXAMINED: Pelecypoda

(Superfamily names are shown in SPACED CAPITALS; family names in CAPITALS.)

Order FILIBRANCHIA

Suborder TAXODONTA

ARCACEA

ARCIDAE

Genus *Acar* Gray, 1857
A. plicata (Dillwyn, 1817) A546, A550, A674

Genus *Barbatia* Gray, 1840
B. decussata (Sowerby, 1824) A544, A785

Genus *Arca* Linnaeus, 1758
A. ventricosa (Lamarck, 1819)

**Pusia tuberculata* (Kiener) is not dated.

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Suborder ANISOMYARIA

PTERIACEA

ISOGNOMONIDAE

Genus *Isognomon* Solander, 1786 = *Perna* Bruguière, 1792
I. isognomon (Linnaeus, 1758) A544, A556, A670, A672, A687
I. perua (Linnaeus, 1758) A667, A672, A676, A687
Isognomon sp. A550, A672 (fragments)

PINNIDAE

Genus *Pinna* Linnaeus, 1758
P. muricata Linnaeus, 1758 A668, A670, A782

PTERIIDAE

Genus *Vulsella* Roeding, 1798
V. vulsella Linnaeus, 1758 A543, A556, A670 (young)
Vulsella sp. A550

Genus *Pinctada* Roeding, 1798
P. margaritifera (Linnaeus, 1758) A668
P. radiata (Leach)* A544, A556, A668, A669, A670, A670 (young) A674, A678, A680, A683, A687, A783, A784, Manihiki
Pinctada sp. A544, A548, A552, A671, A674, A683

CHECKLIST OF FAMILIES: Pelecypoda

FAMILY	NO. OF GENERA	NO. OF SPECIES
Arcidae	3	3
Isognomonidae	1	2
Pinnidae	1	1
Pteriidae	2	5
Mytilidae	2	3
Spondylidae	1	1
Anomiidae	1	1
Ostreidae	2	4
Carditidae	1	1
Trapeziidae	1	2
Diplodontidae	1	1
Lucinidae	2	3
Erycinidae	1	1
Chamidae	2	4
Tridacnidae	1	3
Veneridae	3	3
Sanguinolariidae	1	1
Tellinidae	6	8
Gastrochaenidae	1	2

MYTILACEA

MYTILIDAE

Genus *Modiolus* Lamarck, 1799
M. moduloides Roeding, 1798 A544, A556, A683

Genus *Lithophaga* Roeding, 1798
L. masuta Philippi, 1846
Lithophaga sp. A544, A545, A550, A552, A784

PECTINACEA

SPONDYLIDAE

Genus *Spondylus* Lamarck, 1809
Spondylus sp. Manihiki (C. McCann det.)

ANOMIACEA

ANOMIIDAE

Genus *Anomia* Linnaeus, 1758
Anomia sp. A674, A687

OSTREACEA

OSTREIDAE

Genus *Ostrea* Linnaeus, 1758
O. frons Linnaeus, 1758 A544, A680
Ostrea sp. A543, A552, A670, A680, A686, A687, A785

Genus *Pycnodonta* Sowerby, 1824
P. hyotis (Linnaeus, 1758) A545, A550, A552 (young?), A556, A556 (young), A668, A668 (spat), A670, A674, A676, A683, A782, A784
Pycnodonta sp. A544, A668, A687 (fragments)

Order EULAMELLIBRANCHIA

Suborder SCHIZODONTA

CARDITACEA

CARDITIDAE

Genus *Fragum* Roeding, 1798
F. fragum (Linnaeus, 1758) A543, A553, A671, A673, A682, A783

ARCTICACEA

TRAPEZIIDAE

Genus *Trapezium* Meyerle von Mühlfeld, 1811
T. oblongatum (Linnaeus, 1758) A686
Trapezium sp. A550

**Pinctada radiata* (Leach) is not dated.

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LUCINACEA

DIPLODONTIDAE

Genus *Diplodonta* Brown, 1831
Diplodonta sp. A556

LUCINIDAE

Genus *Codakia* Scopoli, 1777
C. divergens Philippi, 1846 A544, A550, A552, A556, A668, A670, A671, A682, A683, A686, A687, A784, A785
C. punctata (Linnaeus, 1758) A668, A682

Genus *Ctena* Moerch, 1861
Ctena sp. A549

ERYCINACEA

ERYCINIDAE (Leptonidae)

Genus *Erycina* Lamarck, 1804
Erycina sp. A550

CHAMACEA

CHAMIDAE

Genus *Chama* Bruguière, 1789
C. limbula Lamarck, 1798 A556, A668, A670, A671, A674, A677, A780, A786
C. squamuligera (Pilsbry & Lowe, 1932)* A550 (28) (C. McCann det.)
Chama sp. A544, A545, A550 (fragments) A552, A556, A687 (worm, fragments), A785 (C. McCann det.)

Genus *Echinochama* Fischer, 1887
Echinochama sp. A761 (C. McCann det.)

CARDIACEA

TRIDACNIDAE

Genus *Tridacna* Bruguière, 1797
T. elongata (Roeding, 1798) A670, A674, A680 (C. McCann det.)
T. maxima Roeding, 1798 A668, A669, A671
Tridacna sp. A671 (fragments) (C. McCann det.)

VENERACEA

VENERIDAE

Genus *Lioconcha* Moerch, 1853
L. hieroglyphica (Conrad), 1837 A543, A545, A550, A552, A553, A785

Genus *Periglypta* Jukes-Browne, 1914
Periglypta fischeri (Reeve, 1846) A574, A786

Genus *Gafrarium* Bolten, 1798
G. pectinatum (Linnaeus, 1758) A668, A671, A671 (fragments), A673, A682, A683

Venerid sp. A549, A785

**Chama squamuligera* (Pilsbry & Lowe) is not dated.

TELLINACEA

SANGUINOLARIIDAE (Asaphidae)

Genus *Asaphis* Modeer, 1793
A. deflorata (Linnaeus, 1758) A682, A686

TELLINIDAE

Genus *Arcopagia* Brown, 1827
A. rugosa (Born, 1778) A671, A673, A682, A683

Genus *Cadella* Dall, Bartsch, & Rehder, 1938
C. semitorta (Sowerby, 1824) A556
Cadella sp. A543, A544, A549, A687

Genus *Fabulina* Gray, 1851
Fabulina sp. A556

Genus *Pinguitellina* Iredale, 1927
Pinguitellina sp. A553

Genus *Scutarcopagia* Pilsbry, 1918
S. liguafelis (Linnaeus, 1758) A550, A556
S. scotinata (Linnaeus, 1758) Manihiki (J. S. Bullivant det.)

Genus *Tellina* Linnaeus, 1758
Tellina sp. A543, A544, A549, A556, A784
Tellina, sp. indeterminate A552, A553, A553 (fragments)

GASTROCHAENIDAE

Genus *Rocellaria* Spengler, 1793
R. cuneiformis Spengler, 1793 A543, A546, A550, A556, A669, A670, A677
Rocellaria sp. A550, A687

MATERIAL EXAMINED: Cephalopoda

Order DECAPODA

OMMASTREPHIDAE

Genus *Nototodarus* Pfeffer, 1912
N. gouldi (McCoy, 1888) A688 (C. McCann det.)

Order OCTOPODA

OCTOPODIDAE

Genus *Octopus* Lamarck, 1798
O. pallidus Hoyle, 1885 A688 (C. McCann det.)

ACKNOWLEDGMENTS

The bulk of the collection was sent to Dr R. Tucker Abbott, Academy of Natural Sciences of Philadelphia, for identification, and we are most grateful for his determinations which form the body of the list, except for a few additional specimens identified by C. McCann and by J. S. Bullivant.

REFERENCE

ABBOTT, R. T. (ed.) 1959: "Indo-Pacific Mollusca", *1* (partly published). Academy of Natural Sciences of Philadelphia, Philadelphia, Penn., U.S.A.

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CRABS FROM MANIHIKI

BY

J. S. Bullivant

New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington

SUMMARY

Twenty-nine identified species of crabs and about 10 unidentified species (mostly small xanthids) were collected from Manihiki.

INTRODUCTION

The following list of crabs collected at Manihiki Atoll in 1960 from the land, the reef, and the lagoon probably includes only a part of the total crab fauna as no special efforts were made to collect this group. Twenty-nine accurately identified species are listed. However, there are also about 10 species, mostly small xanthids, which are unlisted and await specialist examination.

The Manihiki crab fauna closely resembles that of Tahiti and Tuamotu (Forest and Guinot 1961) (*table 1, page* 43).

LIST OF CRABS COLLECTED

DECAPODA, BRACHYURA
OXYSTOMATA

Family CALAPPIDAE

Calappa hepatica (Linnaeus)
Boone, 1934
Barnard, 1950
Sta. A682, damaged specimen; Sta. A689, 2 males; Sta. A693e, male.

BRACHYGNATHA BRACHYRHYNCHA

Family GRAPSIDAE

Cyclograpsus integer H. Milne-Edwards
Rathbun, 1918
Forest and Guinot, 1961
A667, 2 males.

Geograpsus lividus (H. Milne-Edwards)
Rathbun, 1918
Edmondson, 1959
A671, male; A687d, female; A688, female.

Grapsus grapsus tenuicrustatus (Herbst)
Edmondson, 1959
A671, exoskeleton; A673, exoskeleton; A688a, 2 females; A963d, male.

G. longitarsus Dana
Edmondson, 1959
Forest and Guinot, 1961
A667, 2 males.

G. strigosus (Herbst)
Edmondson, 1959
A766, female.

Family GECARCINIDAE

Cardisoma carnifex (Herbst)
Rathbun, 1907
Boone, 1934
Barnard, 1950
A765, juvenile male; A963h, male and female; A963i, male.

C. hirtipes Dana
Edmondson, 1962
A766, juvenile male.

Family OCYPODIDAE

Uca annulipes (Latreille)
Boone, 1934
Barnard, 1950
Forest and Guinot, 1961
A686, damaged male; A765, female.

Family XANTHIDAE

Chlorodiella cythera (Dana)
Forest and Guinot, 1961
A683, male.

C. nigra (Forskal)
Boone, 1934
Forest and Guinot, 1961
A554, 6 small specimens and female in berry; A545, 2 specimens; A550, 2 specimens; A555, 5 small specimens; A556, 10 specimens; A668, 2 small specimens; A670, 1 small specimen; A672, 1 small specimen; A680, male.

Eriphia sebana Shaw and Nodder
Boone, 1934
Forest and Guinot, 1961
A667, female.

Etisodes electra (Herbst)
Barnard, 1950
Forest and Guinot, 1961
A544, male.

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Etisus dentatus Herbst
Boone, 1934
A963a, male.

Euxanthus melissa (Herbst)
Boone, 1934
A963g, male.

Lydia annulipes (H. Milne-Edwards)
Forest and Guinot, 1961
Edmondson, 1962
A667, male; A963c, female.

Medaeus noelensis Ward
Forest and Guinot, 1961
A674, male.

Pilodius scabriculus Dana
Forest and Guinot, 1961
A672, small damaged male; A674, female in berry; A675, female; A683, male and female; A686, male and female.

Tetralia heterodactyla Heller
Serene, 1959
A675, male and female.

Trapezia speciosa Dana
Serene, 1959
Forest and Guinot, 1961
A672, male and female.

Xanthias lamarckii (H. Milne-Edwards)
Barnard, 1950
Forest and Guinot, 1961
A683, damaged male and a female.

Xantho (Leptodius) hydrophilus Herbst
Boone, 1934 (= *Leptodius exavatus*);
Barnard, 1950
A668, juvenile male.

Zosimus aeneus Linnaeus
Boone, 1934
Barnard, 1950
A688, female.

Zozymodes biunguis (Rathbun)
Forest and Guinot, 1961
Edmondson, 1962
A667, 2 males, 3 females.

Family PORTUNIDAE

Thalamita coerulipes Jacquinot and Lucus
Boone, 1934
Stephenson and Hudson, 1957
A963b, male from fish gut.

T. invicta Thallwitz
Stephenson and Hudson, 1957 (p. 317)
A544, damaged specimen.

T. quadrilobata Miers
Stephenson and Hudson, 1957
A544, 1 male.

Thalamitoides quadridens H. Milne-Edwards
Edmondson, 1954
A676, female in berry; A963d, 3 males, 2 females.

The following species was observed but not collected

DECAPODA, ANOMURA

Family PAGURIDAE

Birgus latro Linnaeus
Coconut crab.

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Table 1 Occurrence of crabs collected at Manihiki in collections from some other Pacific islands and from South Africa

	South Africa	Marianas	Marshall and Wake	Gilbert	Manihiki	Tuamotu and Tahiti	Hawaii
Calappa hepatica	*		*	*	*	*	
Cyclograpsus integer					*	*	
Geograpsus lividus	*		*		*		*
Grapsus grapsus tenuicrustatus	*				*	*	*
G. longitarsis			*	*	*	*	*
G. strigosus	*				*		*
Cardisoma carnifex	*			*	*	*	
C. hirtipes					*		
Uca annulipes	*				*	*	
Chlorodiella cythera		*		*	*		
C. nigra				*	*	*	
Eriphia sebana	*		*	*	*	*	
Etisus dentatus	*		*	*	*	*	*
Euxanthus melissa					*		
Lydia annulipes			*		*	*	*
Medaeus noelensis					*	*	
Pilodius scabriculus					*	*	
Tetralia heterodactyla					*		
Trapezia speciosa					*	*	
Xanthias lamarckii	*				*	*	*
Xantho hydrophilus	*				*		
Zosimus aeneus	*		*		*	*	*
Zozymodes biunguis					*	*	*
Thalamita coerulipes				*	*	*	*
T. invicta					*		
T. quadrilobata				*	*		
Thalamitoides quadridens				*	*		
Birgus latro			*	*	*	*	

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ECHINODERMS FROM MANIHIKI LAGOON

BY

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SUMMARY

The collection of echinoderms from Manihiki comprises 25 species, of which over half are Indo-Pacific forms, and most of the rest are widespread throughout the Pacific.

INTRODUCTION

The majority of the Manihiki echinoderms were initially identified by J. S. Bullivant and re-examined by the author. Some of the holothurians were identified by Dr D. L. Pawson and the author.

The collections contain 25 species. Crinoids are not represented and further members of other groups were probably present but not collected. Two of the three species of holothurians preserved in formalin are only tentatively classified as to genera, while one small asteroid is identified, with some reservation, as *Asterina anomala* H. L. Clark. Two species of echinoids and one ophiuroid are possibly undescribed, but comparative material is unavailable yet.

Over half the species listed are widely ranging Indo-Pacific forms, and most of the remainder appear to be quite widely distributed in the Pacific.

The systematic classification follows that in Moore (1966).

MATERIAL EXAMINED

(Family names are shown in CAPITALS; subfamily names in SMALL CAPITALS)

Class **HOLOTHUROIDEA**

Order DENDROCHIROTIDA

CUCUMARIIDAE

Genus ?*Pentacta* sp.
A686 (7 specimens).

Order ASPIDOCHIROTIDA

HOLOTHURIIDAE

Holothuria atra Jaeger. Clark, 1946: 427.
A667 (2 specimens), A668 (1 specimen), A669 (1 specimen), A674 (1 specimen), A675 (1 specimen), A683 (1 specimen).

H. impatiens (Forskål). Clark, 1946: 434.
A545 (1 specimen), A548 (4 specimens,) A668 (5 specimens), A674 (3 specimens).

H. macroperona H. L. Clark, Clark. 1946: 435.
A668 (5 specimens), A674 (9 specimens).

?*Actinopyga* sp.
A667 (1 specimen).

Class **ECHINOIDEA**

Subclass **EUECHINOIDA**

Order DIADEMATOIDA

DIADEMATIDAE

Echinothrix diadema (Linnaeus). Mortensen, 1940: 290–5, pls, 43 (1–2), 44 (1), 45 (1–8), 46 (2–4), 47 (4, 6–7), 48 (4), 71 (1, 3).
A681 (1 specimen).

Order ECHINOIDA

ECHINOMETRIDAE

Echinometra mathaei (de Blainville). Mortensen, 1943: 381–93, pls. 42 (1–10), 47 (1–4), 65 (16–26).
A667.

Heterocentrotus trigonarius (Lamarck). Mortensen, 1943: 420–5, pls. 50 (3–6), 52 (4–5), 56 (1–6, 8).
A667 (2 specimens), A686

PARASALENIIDAE

Parasalenia gratiosa A. Agassiz. Mortensen, 1943: 269–70, pls. 29 (5–11), 30 (1), 31 (3–5, 7–13), 57 (4–10, 17).
A544 (1 specimen), A545, A546, A548 (2 specimens), A549, A550, A552, A555 (8 specimens), A556 (8 specimens), A566, A668 (3 specimens), A670, A674 (2 specimens), A680, A685, A687i (1 specimen), A963 (fragments and spines).

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CHECKLIST OF GENERA

ORDER	FAMILY	GENUS	NO. OF SPECIES
	CLASS : Holothuroidea		
Dendrochirotida	Cucumariidae	?*Pentacta* ¶	1
Aspidochirotida	Holothuriidae	*Holothuria*	3
		?*Actinopyga*	1
	CLASS : Echinoidea		
	SUBCLASS : Euechinoidea		
Diadematoida	Diadematidae	*Echinothrix*	1
Echinoida	Echinometridae	*Echinometra*	1
		Heterocentrotus	1
	Parasaleniidae	*Parasalenia*	1
Holectypoida	Echinoneidae	*Echinoneus*	1
Spatangoida	Schizasteridae	*Paraster*	1
	Brissidae	*Metalia*	2
	Spatangidae	*Maretia*	1
	SUBCLASS : Asteroidea		
Valvatida	Ophidiasteridae	*Linckia*	2
Spinulosida	Asterinidae	?*Asterina*	1
	Acanthasteridae	*Acanthaster*	1
	SUBCLASS : Ophiuroidea		
Ophiurida	Ophiuridae		
	Subfamily : Ophiolepidinae	*Ophiocypris*	1
	Ophiocomidae	*Ophiocoma*	1
		Ophiocomella	1
		Ophiomastix	1
	Ophiodermatidae	*Distichophis*	1
	Ophiactidae	*Ophiactis*	1
	Amphiuridae	*Amphioplus*	1
		Ophiocnida	1

¶ A question mark before a generic name means the genus (and species, if given) is (are) in doubt because the specimen is incomplete or badly preserved.

Order HOLECTYPOIDA

ECHINONEIDAE

Echinoneus cyclostomus Leske. Mortensen, 1948: 75–80, pls. 1 (14, 26), 12 (21, 23).
A686 (1 test, 1 fragment).

Order SPATANGOIDA

SCHIZASTERIDAE

Paraster sp.
A545 (fragments), A550 (1 specimen), A556 (1 specimen, live fragments).

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BRISSIDAE

Metalia dicrana H. L. Clark. Mortensen, 1951: 546, pls. 37 (1–3), 64 (6, 12).
A671 (1 specimen).
Metalia sp.
A963 (5 specimens).

SPATANGIDAE

Maretia carinata Bolau. Mortensen, 1951: 39–41, pls. 1 (5–7), 44 (8, 14–16).
A544 (1 specimen), A545 (20 specimens), A549 (6 specimens).

Subclass **ASTEROIDEA**

Order VALVATIDA

OPHIDIASTERIDAE

Linckia guildingii Gray. Ely, 1942: 18–19, pl. 1.
A674 (1 specimen), A681 (1 specimen).
L. multiflora (Lamarck). Ely, 1942: 19–20, pls. 2, 3.
A544 (1 specimen), A668 (2 specimens), A669 (1 specimen), A674 (2 specimens), A678 (1 specimen), A683 (5 specimens), A684 (1 specimen), A686 (2 specimens).

Order SPINULOSIDA

ASTERINIDAE

?*Asterina anomala* H. L. Clark. Ely, 1942: 25–6, pl. 7 (B).
A963 (1 specimen).

ACANTHASTERIDAE

Acanthaster planci (Linnaeus). Ely, 1942: 28–9, pl. 9 (A).
A693—Ngaere, 10 ft (1 specimen).

Subclass **OPHIUROIDEA**

Order OPHIURIDA

OPHIURIDAE

OPHIOLEPIDINAE

One unidentified species.
A672 (2 specimens).
This species falls near the genus *Ophiocypris* Koelhler, but differs in that the oral shield is not transversely divided, and in the oral papillae.

OPHIOCOMIDAE

Ophiocoma erinaceus Müller and Troschel. Ely, 1942: 52–4; text-figs. 4, 5, 14 (a, b); pl. 12 (a).
A675 (1 specimen), A963 (1 specimen).
Ophiocomella parva (H. L. Clark). Ely, 1942: 60, text-fig. 18 (a, b).
A672 (1 specimen).
Ophiomastix bispinosa (H. L. Clark). Clark, 1917: 442, pl. 2 (1, 2).
A550 (1 specimen), A555 (2 specimens), A556 (1 specimen), A687 (2 specimens), A963 (2 specimens).

OPHIODERMATIDAE

Distichophis clarki Ely. Ely, 1942: 47–8, text-fig. 12 (a, b).
A675 (1 specimen), A687k (1 specimen).

OPHIACTIDAE

Ophiactis savignyi (Müller and Troschel). Ely, 1942: 42–4; text-fig. 10 (a, b); pl. 10 (B).
A544 (18 specimens), A545 (15 specimens), A546 (11 specimens), A548 (2 specimens), A550 (8 specimens), A551 (1 specimen), A555 (*ca.* 100 specimens), A556 (20 specimens), A668 (*ca.* 100 specimens, A669 (4 specimens), A670 (50 specimens), A676 (2 specimens), A674 (6 specimens), A680 (2 specimens), A687 (34 specimens), A687i (29 specimens), A783 (1 specimen), A963 (4 specimens).

AMPHIURIDAE

Amphioplus caelatus Ely. Ely, 1942: 39–40, text-fig. 8 (a, b).
A544, A556 (6 specimens).
Ophiocnida sp. (juvenile).
A550 (2 specimens), A672 (1 specimen).

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MORTENSEN, TH. 1940: "A Monograph of the Echinoidea". III (1). "Aulodonta (with additions to Vol. II)". (2 pts.). C. A. Reityet, Copenhagen. 370 + 22 pp, 77 pls.
——— 1943: Ibid. III (3). "Camarodonta" II. (2 pts.). C. A. Reityet, Copenhagen. 446 + 23 pp., 66 pls.
——— 1948: Ibid. IV (1). "Holectypoida, Cassiduloida". C. A. Reityet, Copenhagen. 363 pp., 14 pls.
——— 1951: Ibid. V (2). "Spatangoida". II. (2 pts.). C. A. Reityet, Copenhagen. 593 + 30 pp., 64 pls.

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FISHES FROM MANIHIKI ATOLL

BY

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SUMMARY

Thirty-seven families, 61 genera, and 103 species of fishes were collected from Manihiki; reef-hunting species were well represented.

INTRODUCTION

During the investigations carried out on Manihiki Atoll in 1960, every opportunity was taken to secure a representative collection of fishes. Lack of space and preservative restricted the size of individual specimens and the number of them collected. Lines; nets and poison in restricted pools; and aqualung equipment were used in collecting. The collection represents 37 families, comprising 61 genera and 103 species. As might be expected, reef-haunting species are well represented.

The classification is that of Schultz *et al.* (1953, 1960, 1966).

A new species of small eel of the genus *Moringua* is described elsewhere (McCann 1967).

CHECKLIST OF FAMILIES

ORDER	FAMILY	NO. OF GENERA	NO. OF SPECIES
Lamnida	Carcharhinidae	1	1
Isopondylida	Dussumieridae	1	1
	Chanidae	1	1
Anguillida	Ophichthidae	1	1
	Moringuidae	1	1
	Muraenidae	2	5
Synentognathida	Belonidae	1	1
	Hemiramphidae	1	3
	Exocoetidae	2	2
Berycomorphida	Holocentridae	2	8
Syngnathida	Fistulariidae	1	1
Percomorphida	Sphyraenidae	1	1
	Atherinidae	1	1
	Mugilidae	1	2
	Kuhlidae	1	3
	Serranidae	3	6
	Pseudochromidae	1	1
	Priacanthidae	1	1
	Carangidae	2	2
	Lutjanidae	4	5
	Pempheridae	1	1
	Chaetodontidae	1	3
	Zanclidae	1	2
	Acanthuridae	3	5
	Mullidae	3	8
	Pomacentridae	2	6
	Labridae	3	5
	Scaridae	2	6
	Cirrhitidae	3	4
	Blennidae	3	6
	Scombridae	1	1
	Gemphylidae	1	1
	Gobiidae	1	1
	Scorpaenidae	2	2
	Balistidae	3	4
Plectognathida	Tetraodontidae	1	2
Heterosomata	Bothidae	1	1

MATERIAL EXAMINED

(Family names are shown in CAPITALS)

Class **CHONDRICHTHYES**

Order LAMNIDA

CARCHARHINIDAE

Genus *Carcharhinus* de Blainville, 1816

C. melanopterus (Quoy & Gaimard) 1824. Schultz *et al.*, 1953: 13, pl. 3A. Type loc.: Waigu, Marianas.

A761 (1 specimen)

Class **OSTEICHTHYES**

Order ISOPONDYLIDA

DUSSUMIERIDAE

Genus *Spratelloides* Bleeker, 1851

S. delicatulus (Bennett) 1831. Schultz *et al.*, 1953: 26. Type loc.: Mauritius.

A959 (1 specimen).

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CHANIDAE

Genus *Chanos* (Forskål) 1775
C. Chanos (Forskål) 1775. Smith 1961: 88. Type loc.: Djedda, Red Sea.
A765 (1 specimen), A769 (8).

Order ANGUILLIDA

OPHICHTHIDAE

Genus *Leiuranus* Bleeker, 1853
L. semicinctus (Lay and Bennett) 1839. Schultz *et al.*, 1953: 57; fig. 11 b, c, pl. 8D, E. Type loc.: Oahu, Hawaii.
A770 (1 specimen).

MORINGUIDAE

Genus *Moringua* Gray, 1831
M. semperviridens McCann. McCann, 1967: 211. Type loc.: Tauhunu, Manihiki.
A958 (1 specimen).

MURAENIDAE

Genus *Echidna* Forster, 1777
E. leucotaenia Schultz, 1943. Schultz *et al.*, 1953: 105. Type loc.: Phoenix and Samoa Islands.
A958 (2 specimens).

Genus *Gymnothorax* Bloch, 1794
G. pictus (Ahl) 1789. Schultz *et al.*, 1953: 123; fig. 23g; pl. 13C. Type loc.: East India.
A667 (1 specimen). Manihiki name—*puhi.*
G. schismatorhynchus (Bleeker) 1853. Schultz *et al.*, 1953: 111. Type loc.: Sumatra.
A958 (9 specimens).

G. petelli (Bleeker) 1856. Schultz *et al.*, 1953: 133. Type loc.: Java.
A958 (1 specimen).
G. magaritophorus (Bleeker) 1864. Schultz *et al*, 1953: 113. Type loc.: Amboina, Indonesia.
A958 (1 specimen).

Order: SYNENTOGNATHIDA

BELONIDAE

Genus *Belone* Cuvier, 1817
B. platyura Bennett, 1831. Schultz *et al*, 1953: 160. Type loc.: Mauritius.
A685 (2 specimens). Manihiki name—*miro.*

HEMIRAMPHIDAE

Genus *Hyporamphus* Gill, 1859
H. actus (Guenther) 1871. Schultz *et al.*, 1953: 174, fig. 34c. Type loc.: Rarotonga, Cook Islands.
A685 (2 specimens). Manihiki name—*ihi.*
H. dussumieri (Valenciennes) 1846. Schultz *et al.*, 1953: 172. fig. 346. Type loc.: Seychelles.
A685 (2 specimens).
Hyporamphus sp. Schultz *et al.*, 1953: 168.
A685 (2 specimens).

EXOCOETIDAE

Genus *Parexocoetus* Bleeker, 1866
Parexocoetus sp. Schultz *et al.*, 1953: 176. FIGURE 1
A685 (1 specimen). Manihiki name—*maroro.*

Genus *Cypselurus* Swainson, 1838
C. spilonotopterus (Bleeker) 1866. Schultz *et al.*, 1953: 179. Type loc.: Padang, Sumatra.
A685 (1 specimen).

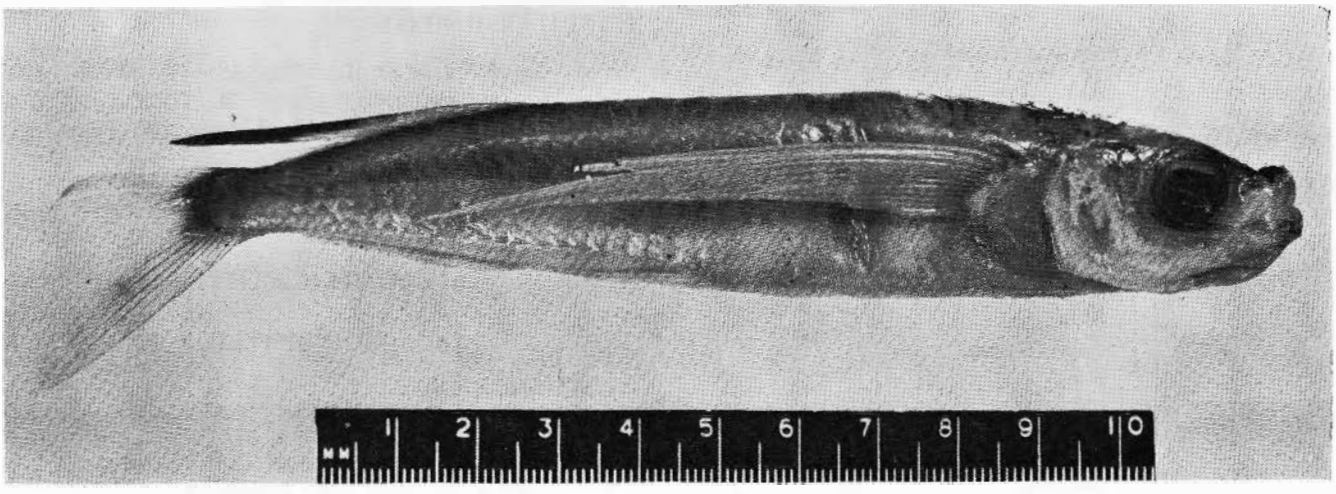

FIGURE 1: *Parexocoetus* A685

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Order BERYCOMORPHIDA

HOLOCENTRIDAE

Genus *Myripristis* Cuvier, 1829

M. microphthalmus Bleeker, 1852. Schultz *et al.*, 1953: 195. Type loc.: Amboina, Indonesia.
A676 (1 specimen), A761 (1), A781 (1), A959 (1), A963 (1). Manihiki name—*pahataroa.*

M. argyromus Jordan and Evermann, 1902. Schultz *et al.*, 1953: 205; pl. 18C. Type loc.: Hilo, Hawaii.
A685 (2 specimens).

Myripristis sp.
A685 (1 specimen).

Genus *Holocentrus* Scopoli, 1777

H. laevis Guenther, 1859. Schultz *et al.*, 1953: 214. Type loc.: Louisiade Archipelago, Guadalcanal, Solomon Islands; Amboina, Indonesia.
A770 (1 specimen).

H. microstomus Guenther, 1859. Schultz *et al.*, 1953: 223, pl. 21A. Type loc.: Amboina.
A762 (1 specimen), A958 (3). Manihiki name—*kihi.*

H. sammara (Forskål) 1775. Schultz *et al.*, 1953: 210, pl. 19A. Type loc.: Djedda, Red Sea.
A679 (5 specimens). Manihiki name—*kuku.*

H. spiniferus (Forskål) 1775. Schultz *et al.*, 1953: 218. Type loc.: Djedda, Red Sea.
A781 (1 specimen).

H. tiere Cuvier and Valenciennes, 1829. Schultz *et al.*, 1953: 221. Type loc.: Tahiti.
A685 (1 specimen).

Order SYNGNATHIDA

FISTULARIIDAE

Genus *Fistularia* Linnaeus, 1758

F. petimba Lacépède, 1803. Schultz ***et al.***, 1953: 228. Type loc.: New Britain, Union Island.
FIGURE 2
A685 (1 specimen).

Order PERCOMORPHIDA

SPHYRAENIDAE

Genus *Sphyraena* Walbaum, 1792

S. belleri Jenkins, 1899. Schultz *et al.*, 1953: 287. Type loc.: Honolulu.
A685 (1 specimen). Manihiki name—*tetu.*

ATHERINIDAE

Genus *Pranesus* Whitley, 1930.

P. insularum (Jordan and Evermann) 1903. Schultz *et al.*, 1953: 307. Type loc.: Honolulu.
A686 (1 specimen).

MUGILIDAE

Genus *Chelon* Roese, 1793

C. engeli (Bleeker) 1858. Schultz *et al.*, 1953: 319. Type loc.: Batavia, Java.
A687 (1 specimen), A769 (1), A781 (24).

C. vaigiensis (Quoy and Gaimard) 1835. Schultz *et al.*, 1953: 318. Type loc.: Waigiou.
A770 (1 specimen).

KUHLIDAE

Genus *Kuhlia* Gill, 1861

K. taeniura (Cuvier and Valenciennes) 1829. Schultz *et al.*, 1953: 326. Type loc.: Java.
A685 (1 specimen).

K. marginata (Cuvier and Valenciennes) 1829. Schultz *et al.*, 1953: 327. Type loc.: Java.
A781 (6 specimens). Manihiki name—*aore.*

K. sandvicensis (Steindachner). Schultz *et al.*, 1953: 325.
A558 (1 specimen).

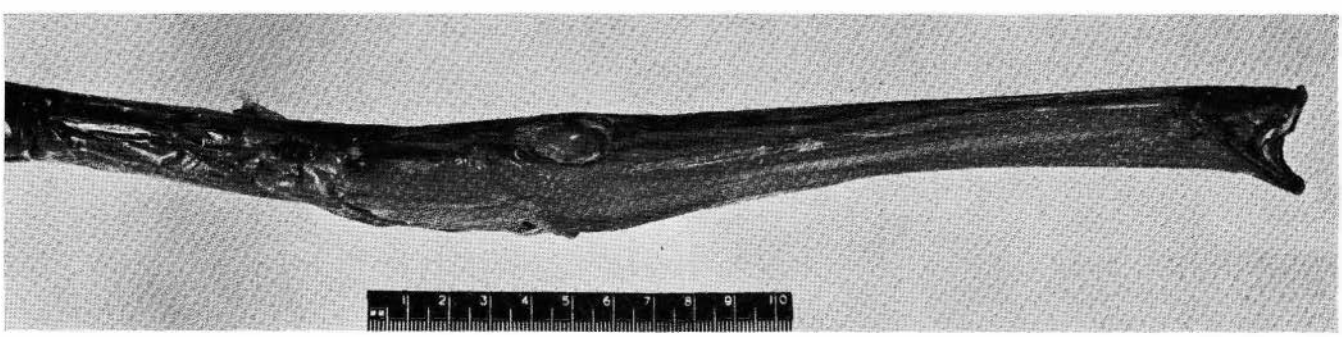

FIGURE 2: *Fistularia petimba* A685

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SERRANIDAE

Genus *Epinephelus* Bloch, 1793

E. fuscoguttatus (Forskål) 1775. Schultz *et al.*, 1953: 351. Type loc.: Suerens, Djedda.
A763 (1 specimen), A770 (3). Manihiki name—*hapuku.*

E. hexagonatus (Bloch and Schneider) 1801. Schultz *et al.*, 1953: 355. Type loc.: Tahiti.
A685 (1 specimen), A958 (4).

E. socialis (Guenther) 1873. Schultz *et al.*, 1953: 339. Type loc.: Paumotu, Kingsmill, Hervey Is. and Samoan Is.
A958 (1 specimen).

Genus *Plectropomus* Oken, 1782

P. leopardus (Lacépède) 1802. Schultz *et al.*, 1953: 364. No type locality.
A770 (1 specimen).

Genus *Cephalopholis* Bloch and Schneider, 1801

C. argus Bloch and Schneider, 1801. Schultz *et al.*, 1953: 367. Type loc., East Indies.
A958 (2 specimens), A963 (2). Manihiki name—*tarao.*

C. urodelus Bloch and Schneider, 1801. Schultz *et al.*, 1953: 368. Type loc.: St. Christina, Waitaho.
A685 (1 specimen).

PSEUDOCHROMIDAE

Genus *Aporops* Schultz, 1943

A. bilinearis Schultz, 1943. Schultz *et al.*, 1953: 396. Type loc.: Hull Island, Phoenix Group.
A958 (1 specimen).

PRIACANTHIDAE

Genus *Priacanthus* Oken, 1817

P. cruentatus (Lacépède) 1800. Schultz *et al.*, 1953: 501. Type loc.: Martinique, Windward Islands.
A685 (1 specimen).

CARANGIDAE

Genus *Trachurops* Gill, 1862

T. crumenophthalmus (Bloch) 1793. Schultz *et al.*, 1953: 508. Type loc.: Acara Bay, West Africa.
A685 (1 specimen).

Genus *Caranx* Lacépède, 1802

C. speciosus (Forskål) 1775. Ogilby, 1915: 67, pl. XXII. Type loc.: Arabia. FIGURE 3.
A685 (1 specimen). Manihiki name—*kanoveru.*

LUTJANIDAE

Genus *Lutjanus* Bloch, 1790

L. monstigmus Cuvier and Valenciennes, 1828. Schultz *et al.*, 1953: 531. Type loc.: Seychelles.
A679 (4 specimens). Manihiki name—*taumotu.*

L. vaigiensis (Quoy and Gaimard) 1824. Schultz *et al.*, 1953: 532. Type loc.: Waigiou.
A687h (1 specimen), A770 (1). Manihiki name—*tangu.*

Genus *Aphareus* Cuvier and Valenciennes, 1830

A. furcatus (Lacépède) 1802. Schultz *et al.*, 1953: 539. Type loc.: The Great Ocean, Mauritius.
A685 (1 specimen).

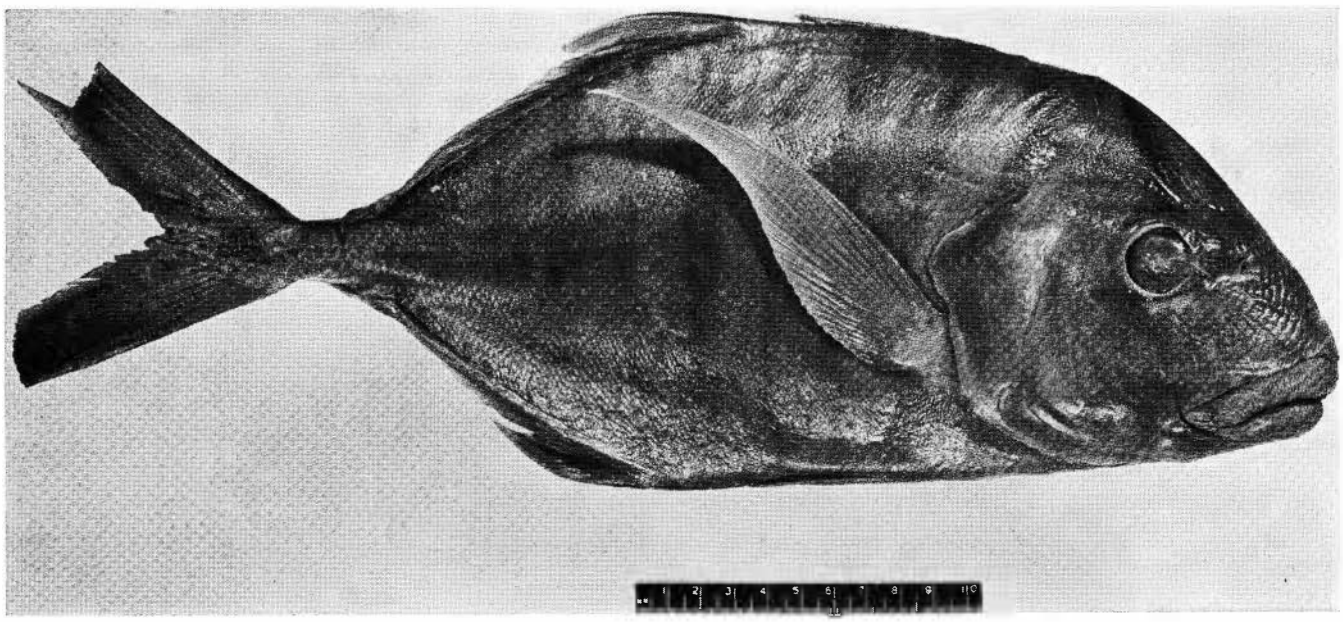

FIGURE 3: *Caranx speciosus* A685

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Genus *Allotaius* Whitley, 1937

A. spariformis (Ogilby) 1916. Whitley, 1937: 139.

A962 (1 specimen).

Genus *Apsilus*

A. fuscus Valenciennes 1830. Smith, 1961: 253. FIGURE 4

A685 (1 specimen). Identified from a photograph.

PEMPHERIDAE

Genus *Pempheris* Cuvier, 1829

P. oualensis Cuvier and Valenciennes, 1831. Schultz *et al.*, 1953: 559. Type loc.: Oualan.

A685 (1 specimen).

CHAETODONTIDAE

Genus *Chaetodon* Linnaeus, 1758

C. auriga Forskål, 1775. Schultz *et al.*, 1953: 591. Type loc.: Djidda, Lohaja, Arabia, Red Sea. FIGURE 5

A687h (1 specimen), A770 (2), A958 (1). Manihiki name—*taputapu*.

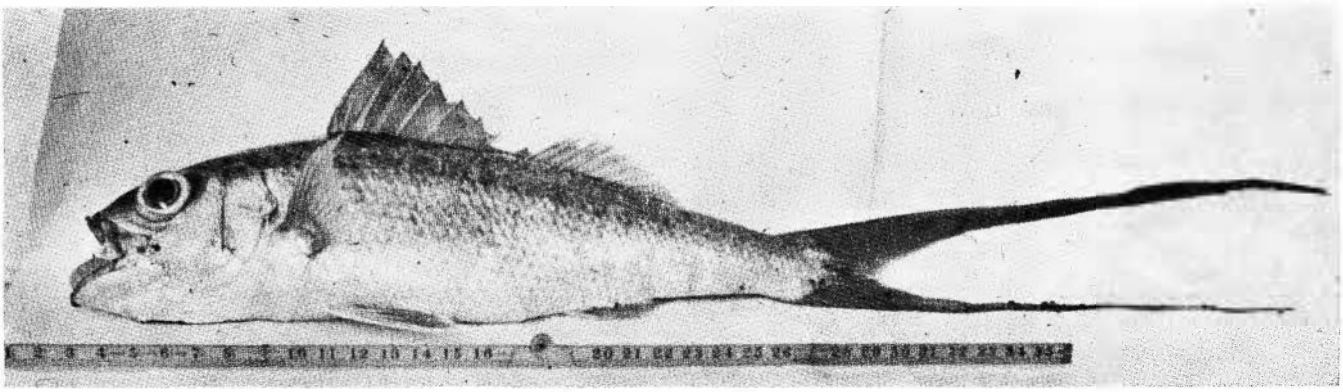

FIGURE 4: *Apsilus fuscus* A685

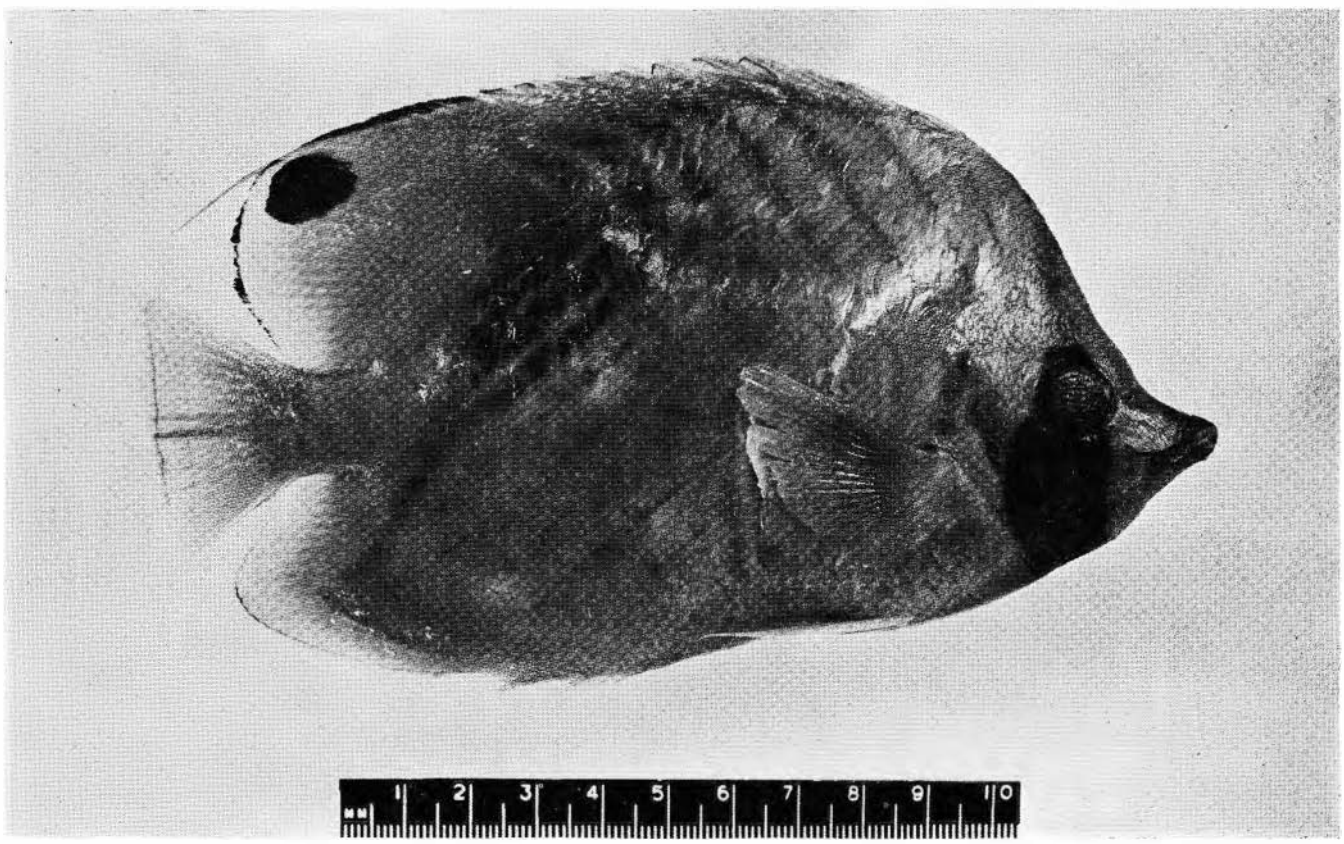

FIGURE 5: *Chaetodon auriga* A770

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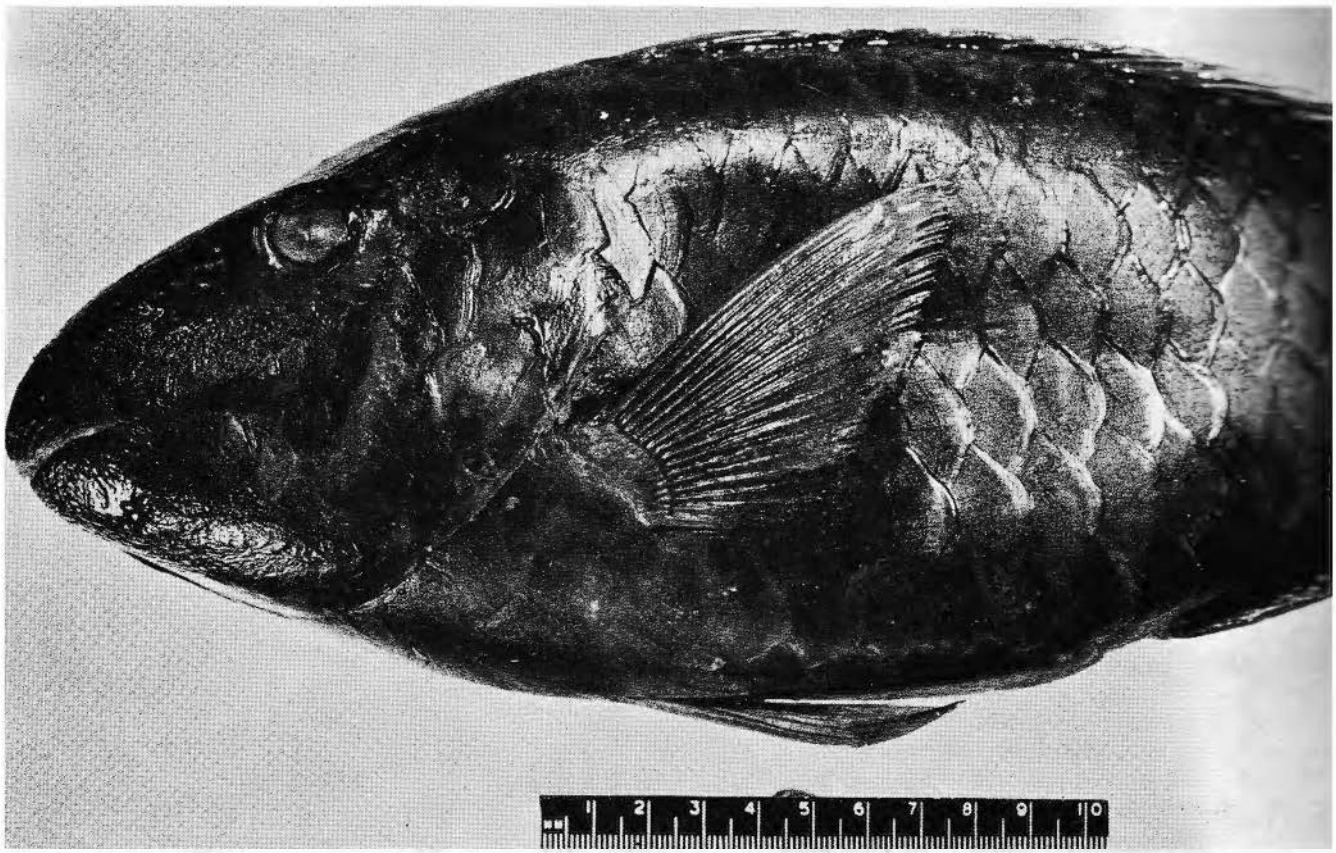

FIGURE 7: *Scarus harid* A687

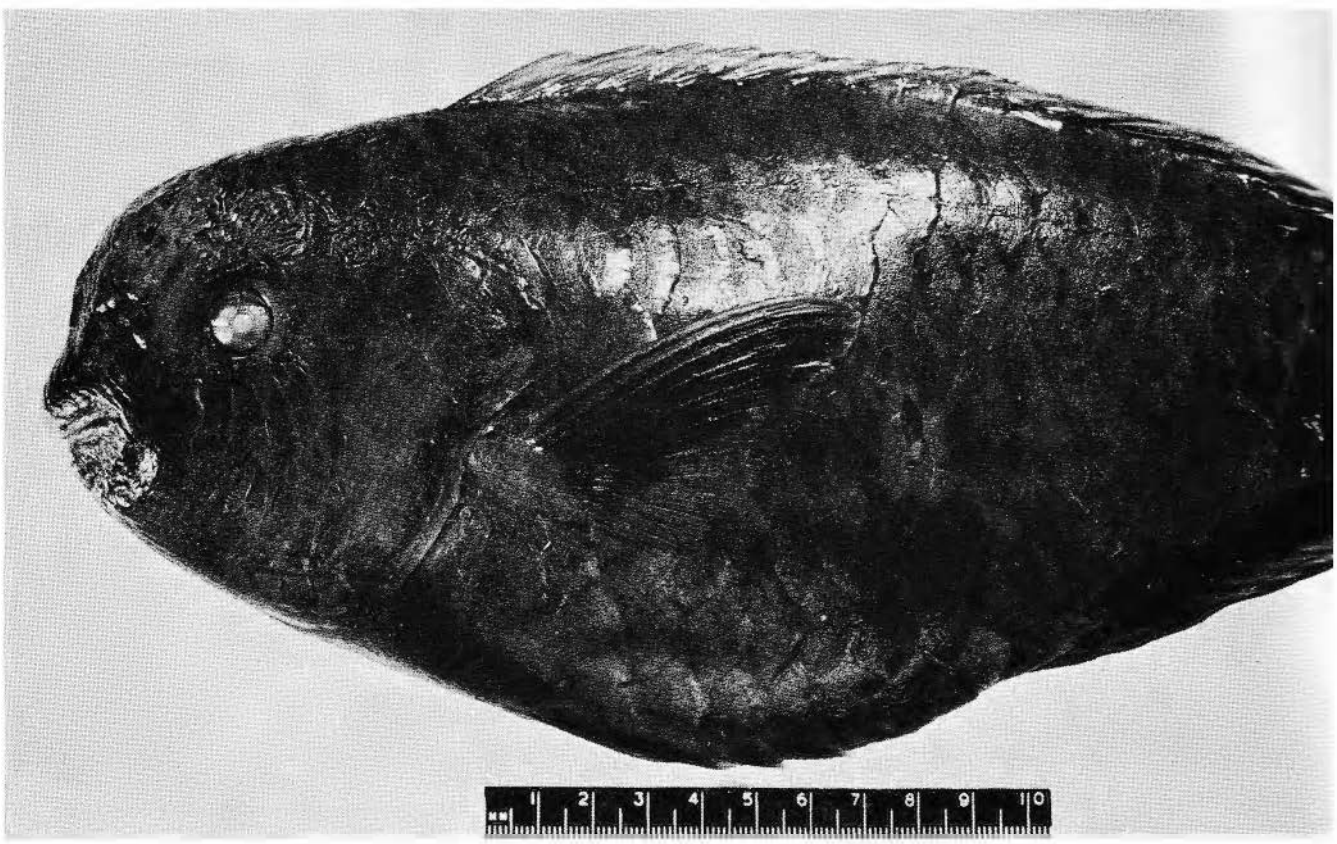

FIGURE 8: *Scarus lunula* A685

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Genus *Entomacrodus* Gill, 1859

E. incisolabiatus Schultz, 1960. Schultz *et al.*, 1960: 322. Type loc.: Bikini Atoll and Enyu I.
A958 (2 specimens).

E. plurifilis Schultz. Schultz *et al.*, 1960: 341. Type loc.: Tau I., Samoa.
A958 (35 specimens).

Genus *Istiblennius* Whitley, 1943

I. endentulus (Bloch and Schneider) 1801. Schultz *et al.*, 1960: 346. Type loc.: Huahine Is., Society Group.
A781 (4 specimens), A958 (37), Manihiki name—*pae*.

I. lineatus (Cuvier and Valenciennes) 1836. Schultz *et al.*, 1960: 345. Type loc.: Java.
A684 (6 specimens), A781 (3), A958 (1).

I. paulus (Bryan and Herre) 1903. Schultz *et al.*, 1960: 349. Type loc.: Marcus I.
A781 (10 specimens), A958 (10).

SCOMBRIDAE

Genus *Neothunnus* Kishinouye, 1923

N. albacora (Lowe) 1839. Schultz *et al.*, 1960: 414.
A963 (1 specimen).

GEMPHYLIDAE

Genus *Ruvettus* Cocco, 1833

R. prometheus Cuvier and Valenciennes, 1831. McCann, 1953: 15. FIGURE 10
A685 (1 specimen).

GOBIIDAE

Genus *Gobiodon* Bleeker

G. quinquestrigatus Cuvier and Valenciennes, 1837 Weber, 1913: 454.
A959 (2 specimens).

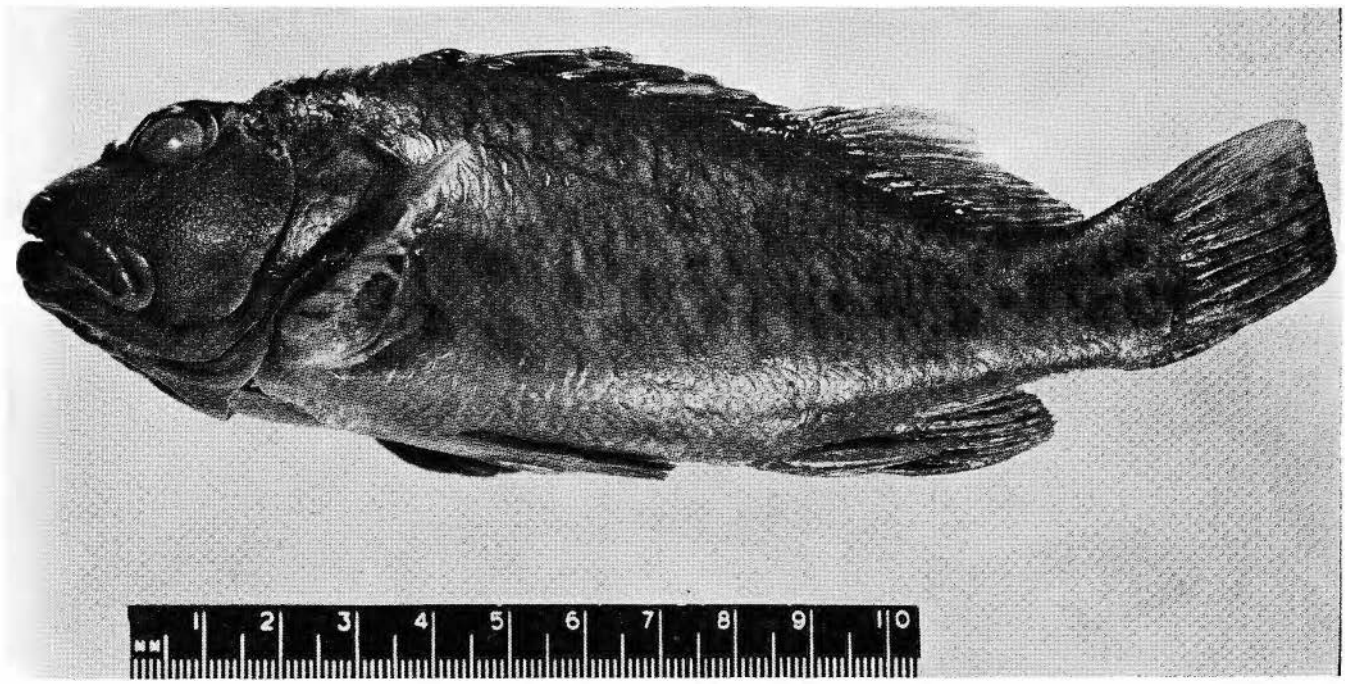

FIGURE 9: *Cirrhitus alternatus* A685

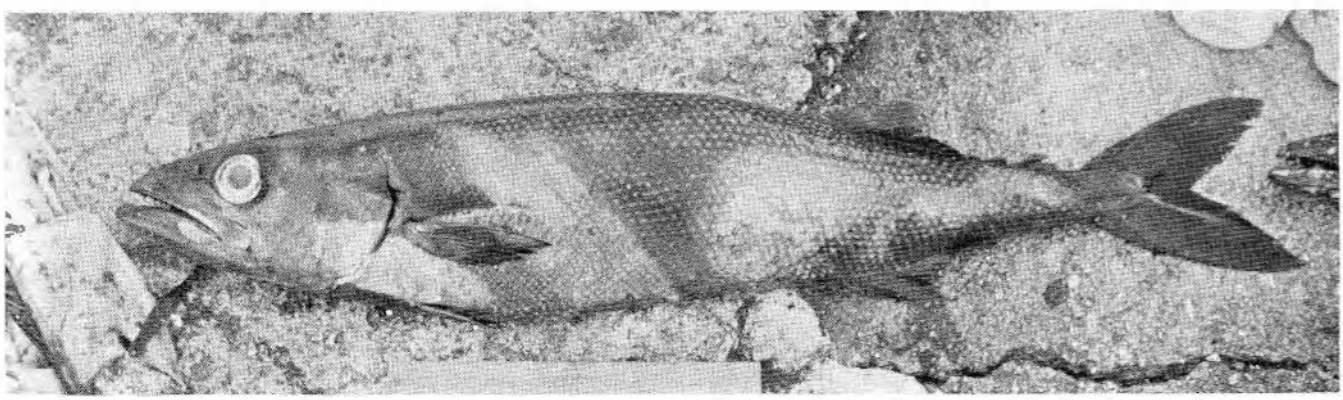

FIGURE 10: *Ruvettus prometheus* A685

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SCORPAENIDAE

Genus *Scorpaena* Linnaeus, 1758. Smith, 1961: 370.
Scorpaena sp.
A958 (1 specimen).

Genus *Denrochirus* Swainson, 1839
D. zebra (Quoy and Gaimard) 1825. Munro, 1955: 245.
A958 (1 specimen).

Order PLECTOGNATHIDA

BALISTIDAE*

Genus *Rhinecanthus* Swainson, 1839
R. aculeatus (Linnaeus) 1758. Munro, 1955: 272. Type loc.: India. FIGURE 11
A668 (1 specimen), A961 (1). Manihiki name—*koriri.*
R. rectangulus (Schneider) 1801. Smith, 1961: 410. FIGURE 12
A685 (1 specimen), A687h (1). Manihiki name—*koriri.*

Genus *Balistapus* Tilesius, 1820
B. undulatus (Mungo Park) 1797. Munro, 1955: 272. Type loc.: Sumata. FIGURE 13
A685 (1 specimen). Manihiki name—*kokiri; kokiri manu.*

Genus *Melichthys* Swainson, 1839
M. vidua (Solander) 1844. Smith, 1961: 408. Type loc.: Tahiti.

TETRAODONTIDAE

Genus *Arothron* Mueller, 1841
A. reticularis (Bloch) 1801. Munro, 1955: 284.
A769 (2 specimens).
A. meleagris Lacépède, 1798. Schultz *et al.*, 1966: 128. Type loc.: Seas of Asia. FIGURE 14
A762 (1 specimen), A769 (1), A770 (1), A958 (1).

Order HETEROSOMATA

BOTHIDAE

Genus *Bothus* Raffinesque, 1810
B. pantherinus Rueppel, 1828. Munro, 1955: 261. Type loc.: Red Sea.
A781 (1 specimen).

*NOTE: sequence of genera of Balistidae in Schultz is *Melichthys, Balistapus, Rhinecanthus.*

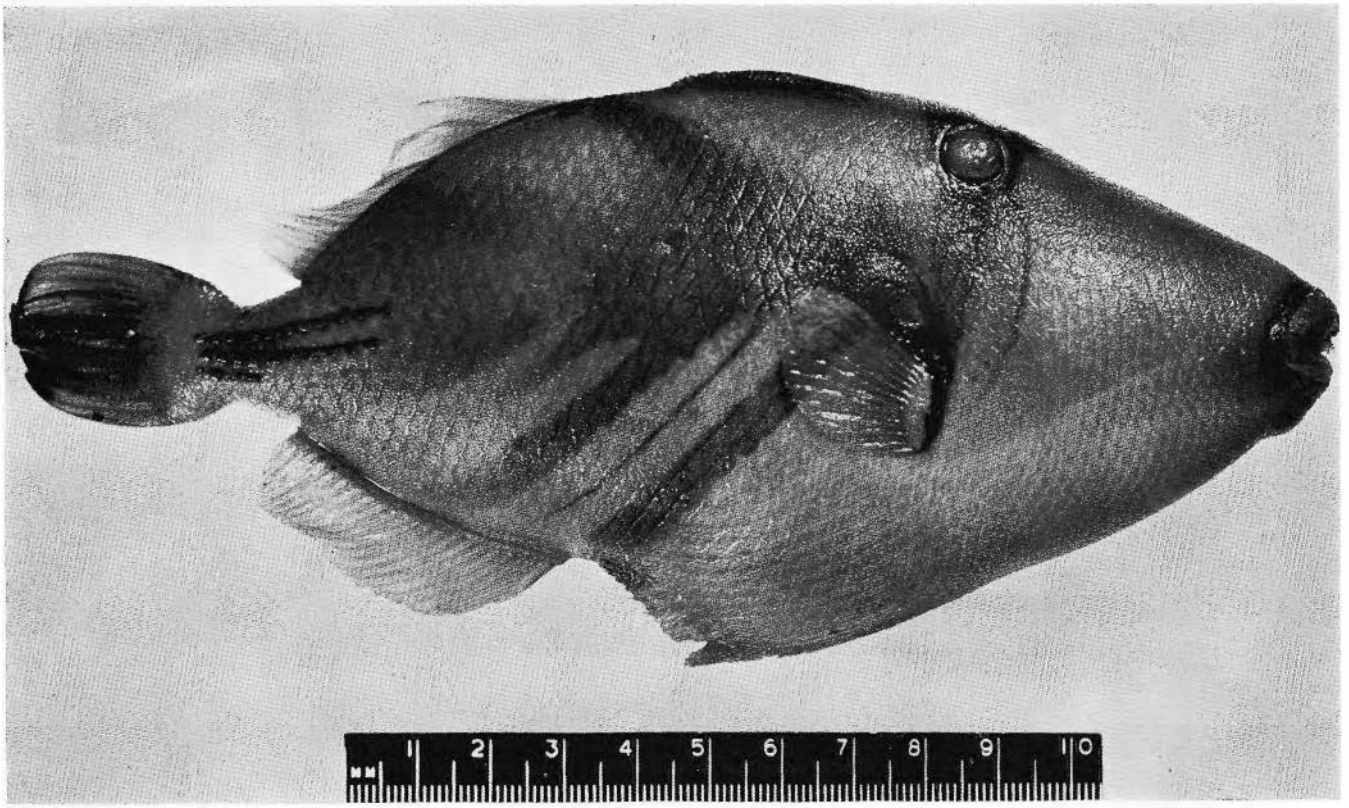

FIGURE 11: *Rhinecanthus aculeatus* A668

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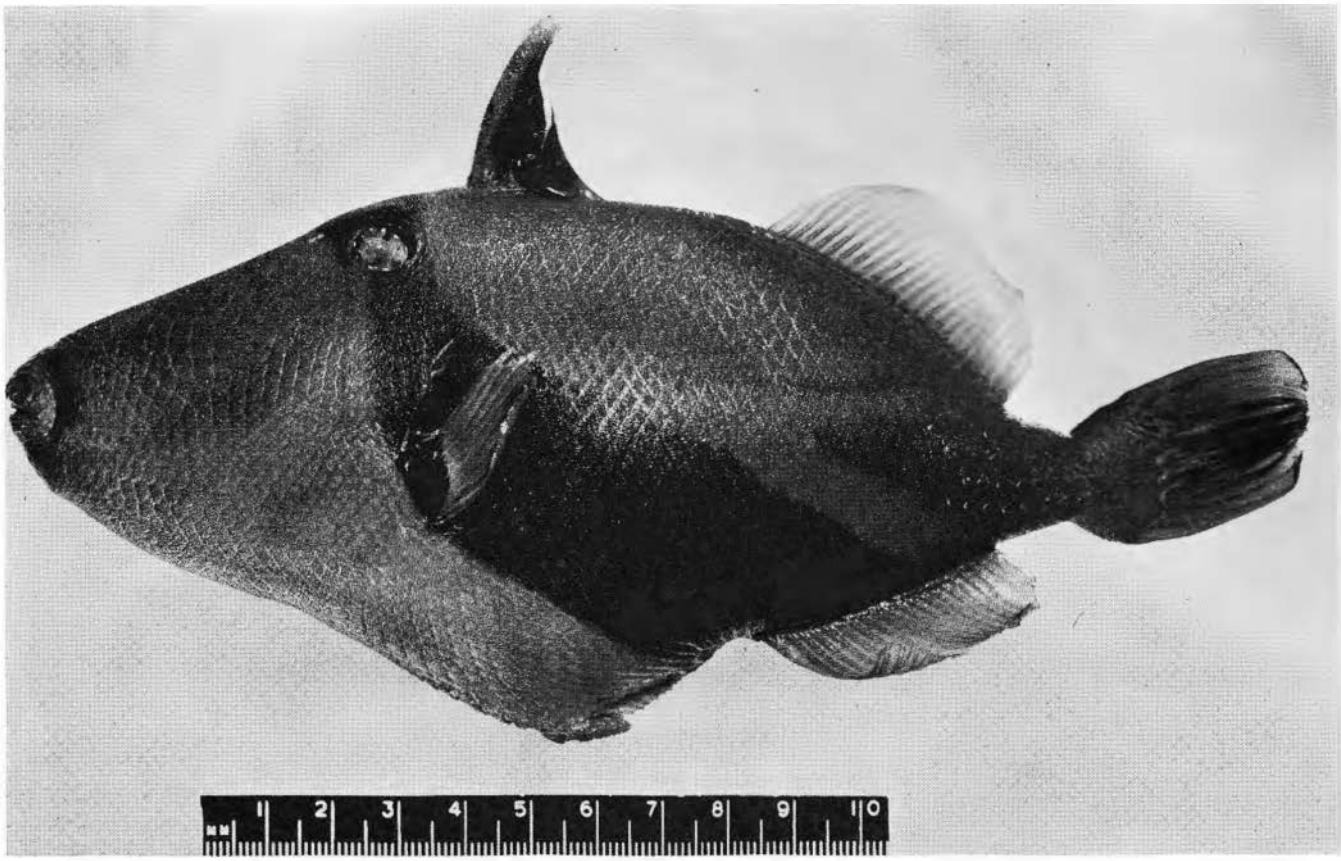

FIGURE 12: *Rhinecanthus rectangulus* A685

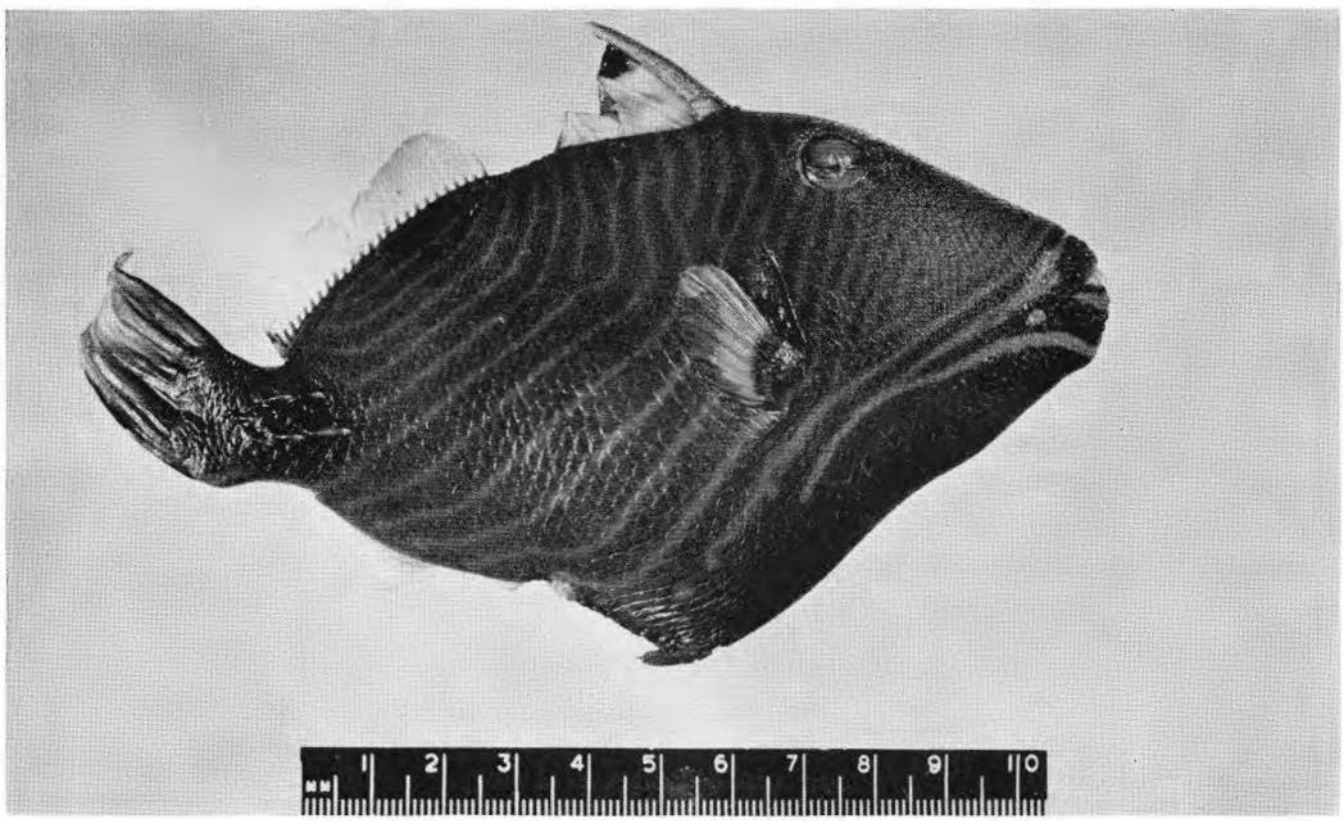

FIGURE 13: *Balistapus undulatus* A685

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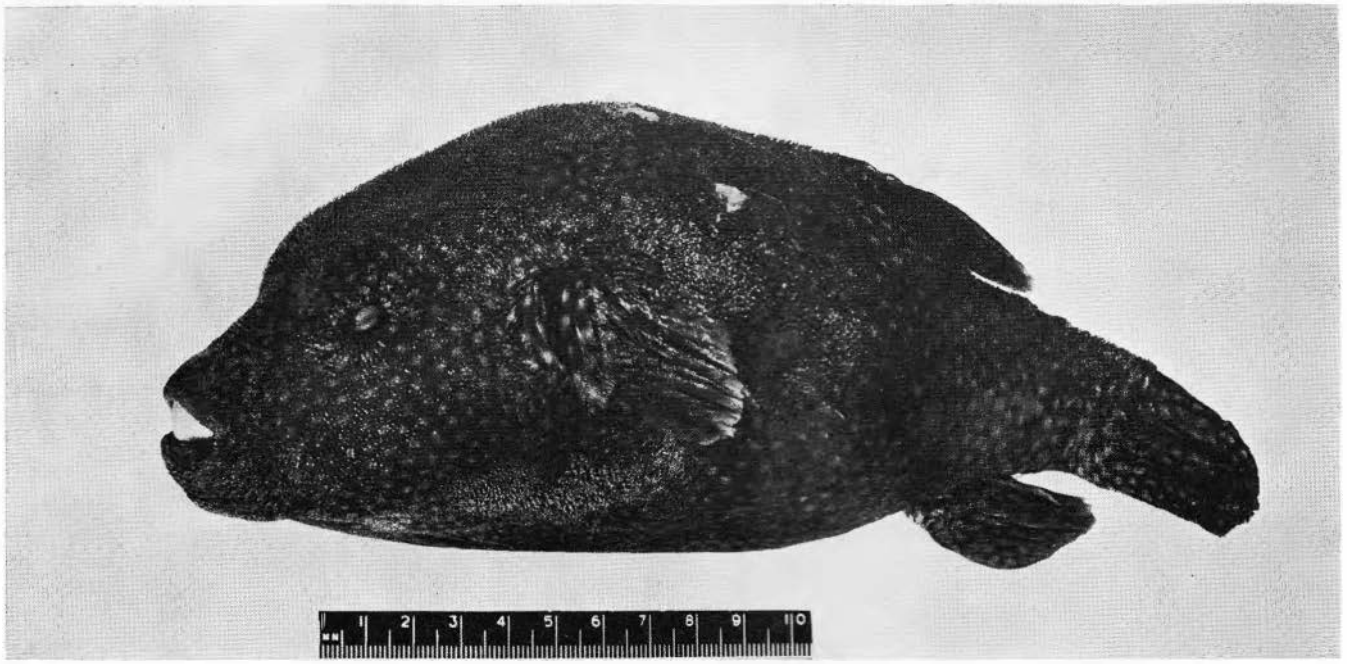

FIGURE 14: *Arothron meleagris* A770

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REPTILES FROM MANIHIKI ATOLL

BY

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New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington

SUMMARY

Specimens of two genera and three species of geckos which appear on many tropical and sub-tropical Pacific islands were found at Manihiki.

Three specimens of one genus of skink were also collected.

INTRODUCTION

Manihiki Atoll is periodically visited by marine turtles but during the visit by members of the New Zealand Oceanographic Institute no specimens were collected. Two or more species are reported to appear in the area and at least one breeds there, for local residents not only eat the turtles they catch (presumably the green turtle *Chelonia mydas*), but also collect the eggs and rear the young until they are large enough to be eaten. (Mr A. Langford, pers. comm). In addition to the well-known green turtle the hawksbill turtle (*Eretmochelys imbricata*) and the luth or leatherback turtle (*Dermochelys coreacea*) probably occur here. Of the sea snakes two likely visitors are almost cosmopolitan species; the yellow-bellied sea snake (*Pelamis platurus*) and the black-bellied sea-snake (*Laticauda colubrina*).

Specimens of the two most widely distributed families of all lizards, the Gekkonidae and Scincidae, were collected. The geckos are represented by three species belonging to two widely distributed genera; *Gehyra oceanica* (Lesson) 1830; *G. mutilata* (Wiegm.) 1935 and *Lepidodactylus lugubris* (Dum. and Bibr.) 1836. These three appear on many of the tropical and sub-tropical Pacific islands and are frequently commensal with man, living on both the inner and outer walls of human habitations. They reach the various islands by way of inter-island trade, hidden in general cargo or in consignments of fruit. All three species are egg-laying. The eggs are commonly agglutinated to the surface they are laid on (usually in some small niche) and so are readily transported.

In addition, three specimens of a small skink of the genus *Ablepharus* were obtained. The skink is not uncommon on the atoll and is frequently associated with the White Tern *(Gygis alba)* (A. Langford, pers. comm.). The association probably stems from the habit of the lizard of feeding on food regurgitated by the birds or on the flies attracted to the nest, or both. A similar habit has been observed in other skinks on isolated islands.

MATERIAL EXAMINED

(Family names are shown in CAPITALS)

Order TESTUDINES

CHELONIIDAE

Genus *Chelonia* Brongniart 1800

C. mydas (Linnaeus) 1758. McCann, 1966: 206.
Identified from photograph.
Captured for food by the islanders *(fide* A. Langford).

Order SQUAMATA

Suborder SAURIA

GEKKONIDAE

Genus *Gehyra* Gray (part) 1834

G. oceanica (Lesson) 1830. McCann, 1955: 20, pl. 1, figs. 1–6. A687e (1 specimen).
This is the largest of the three species of *Gehyra*. It is readily recognised by its large digital pads from the centres of which arise the free digital extremities.

G. mutilata (Weigmann) 1835. McCann, 1955: 22, pl. I, figs. 7–11. A687 (1 specimen).

Genus *Lepidodactylus* Fitzinger 1843

L. lugubris Duméril and Bibron 1836. McCann, 1955: 25, pl. II, figs. 1–7. A687 (1 specimen).
This species is readily recognised by its pale colouring and the arrangement of the spots along its back.

SCINCIDAE

Genus *Ablepharus* Fitzinger 1824

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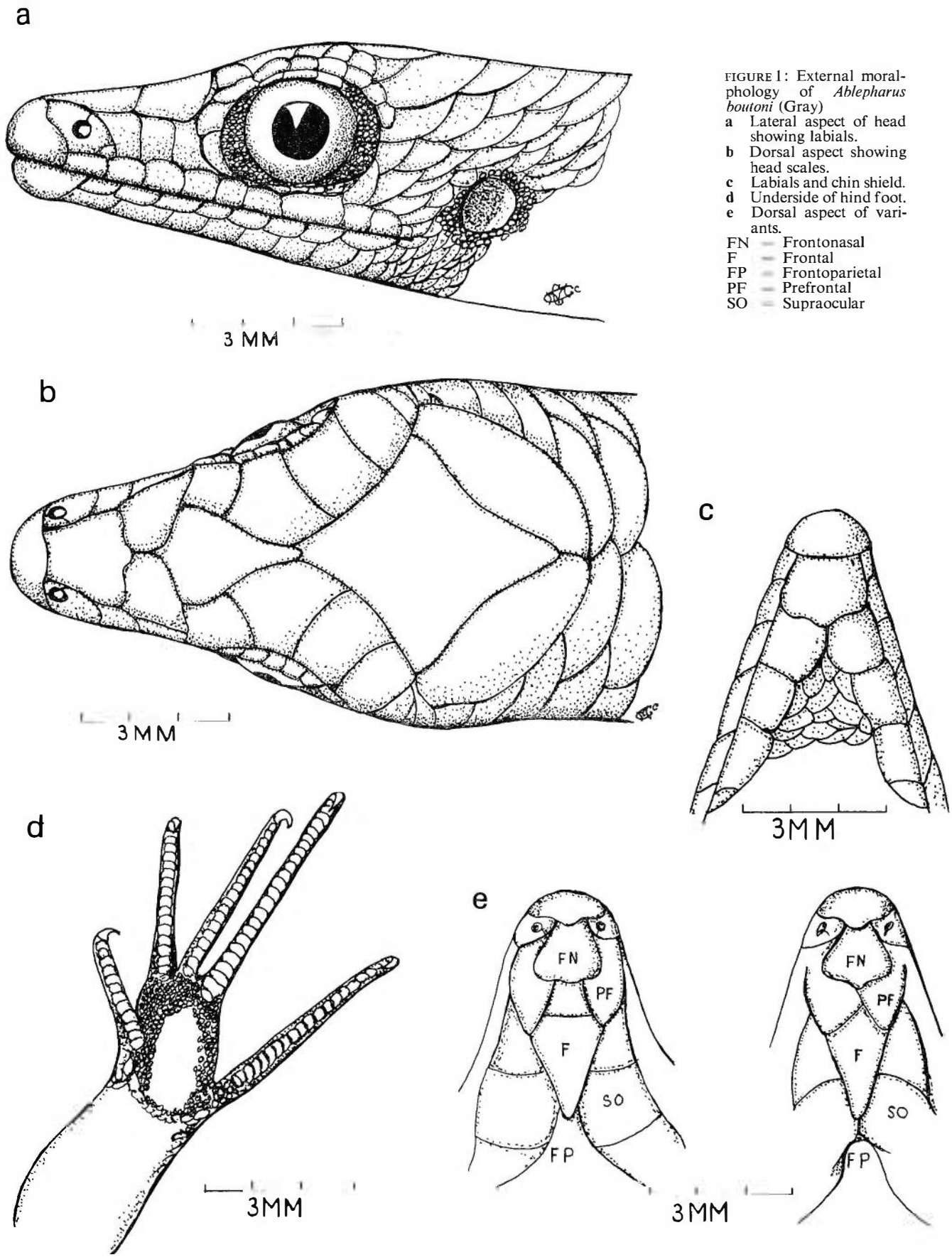

FIGURE 1: External moralphology of *Ablepharus boutoni* (Gray)
a Lateral aspect of head showing labials.
b Dorsal aspect showing head scales.
c Labials and chin shield.
d Underside of hind foot.
e Dorsal aspect of variants.
FN — Frontonasal
F — Frontal
FP — Frontoparietal
PF — Prefrontal
SO — Supraocular

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Table 1 Measurements of three specimens of *Ablepharus boutoni* from Manihiki

Measurements in mm

Head	Snout to Vent	Vent to Tail	Hind Limb	4th Toe	Axilla to Groin	Upper Labial	No. Body Scales
11 × 6	44.5	50	18	6	23	9 (7th under eye)	28
11 × 6	48	26++	21	6.5	27	8 (9) (4-5th under eye)	28
11 × 6	42	15++	21	6.5	22	7 (8) (5th under eye)	28

A. boutoni (Gray) 1845
sub-species *poecilopleurus* Weigmann; Boulenger, 1887. A766 (2 specimens), A783 (1).

Ablepharus boutoni (Gray) is evidently very variable and widely distributed, for Boulenger (1887, pp. 346, 348) described no less than seven varieties or races, which range throughout temperate and tropical islands and coastal regions of the north and south Pacific Oceans, and can occur west of some of the islands and as far east as the African coastal strips bordering the Indian Ocean.

Even on this small atoll a variability in this last species is shown. Although the three specimens *(figure 1 a-d)* have the same midbody scale count (28), they differ in the number and position of the upper labials and in the number of scales under the centre of the eye; they differ also *inter se* in the cranial lepidosis.

In the specimen from Mehau Matie the head scales are more evenly distributed dorsally than in the two from Porea. In one of the two Porea specimens *(figure 1e)* the frontal is divided anteriorly transversely, and the anterior division appears as an additional scale separating the prefrontals from one another and the frontonasal from the frontal.

In the second specimen the frontal is entire but separated from the frontonasal by the meeting of the prefrontals between them; in this specimen the frontal and frontoparietal are separated by the meeting of the two second supraoculars.

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