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BIOLOGY OF COOK ISLANDS' BIVALVES, PART I. HETERODONT FAMILIES

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INTRODUCTION

The marine invertebrates of the Cook Islands are rather poorly known. Most of our knowledge of them comes from the following sources: the Manihiki Atoll Survey in 1960 (Bullivant & McCann, 1974), the Eclipse Expedition in 1965 (McKnight, 1972), the Cook Bicentennary Expedition in 1969 (Gibbs, 1972; Gibbs et al., 1971; Stoddart & Gibbs, 1975; Stoddart & Pillai, 1972), the Westward Expedition in 1971 (Devaney, 1972, 1974; Devaney & Randall, 1973; Marsh, 1974; Randall, 1978), the NZOI - Royal Society Cook Islands Expedition (Grange & Singleton, 1985, but no studies on invertebrates yet), and a few additional studies (Banner & Banner, 1967; Paulay, 1984, 1985; Scoffin et al., 1985). Significant contributions to knowledge on the Cook Islands bivalve fauna were made by the Manihiki Atoll Survey (McCann, 1974), the Cook Bicentennary Expedition (Gibbs et al., 1975), and the Morgan shell collection of the Rarotonga Museum, a collection consisting primarily of Cook Islands specimens (uncritically listed by Stoddart & Gibbs, 1975). General scientific studies in the Cook Islands have been summarized by Stoddart (1975A).

Since 1982 I have been studying selected marine invertebrates of the Cook Islands in an attempt to understand some of the effects of Pleistocene sea level fluctuations on the marine fauna of Pacific Islands. Among those studied were heterodont bivalves. I selected the Cook Islands and Niue for my studies because they include several tectonically uplifted islands that in many ways mimic conditions presumed to have existed on most Central Pacific Islands during Pleistocene low sea stands.

The purpose of the present study is to: 1/ list the presently known heterodont bivalve fauna of the Cook Islands, 2/ document the habitat specificity of the species involved in as much detail as possible, and 3/ investigate the correlation between a species' habitat specificity and its distribution among the various islands. While several studies have been done on the molluscan fauna of inner reef environments on Pacific islands (though bivalves are often neglected), there has been little work on the fauna of the outer reef slope. An important part of this study involved documenting the bivalve species living on this slope, and thus a large portion of my survey was carried out there.

The Cook Islands are located between Tonga and the islands of French Polynesia. They are more a political than a geographical entity, consisting of 15 islands that are grouped into a widely scattered Northern Group and a more closely set Southern Group. Seven of the 8 islands of the Northern Group are atolls (Penryhn, Pukapuka, Rakahanga, Manihiki, Suwarrow, Palmerston), and 1 (Nassau) is a sand cay. The Southern Group is much more heterogeneous, consisting of one atoll (Manuae), one almost-atoll (Aitutaki),

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one sand cay (Takutea), 4 makatea islands that have a central volcanic core surrounded by uplifted reef facies (Atiu, Mitiaro, Mauke, Mangaia), and one high island with a fringing reef (Rarotonga).

Aspects of the reefal and lagoonar structures of some of the islands have been described in various detail. The morphology of the reefs of Aitutaki has received the greatest attention due to surveys by both the Eclipse and the Cook Bicentenary Expeditions (Stoddart, 1975b; Stoddart & Pillai, 1972; Summerhayes, 1971). Various components of the reefs of Rarotonga have been studied (Gauss, 1982; Lewis et al., 1980; Stoddart & Pillai, 1972), and those of Manihiki were described briefly by Bullivant (1974). The lagoon of Manuae has been described by Summerhayes (1971). Several publications dealing with the geology of the various Cook Islands cover basic reef structure, the principal ones being Marshall (1927), Stoddart, Spencer & Scoffin (1985) and Sugimura et al. (1986) for Mangaia, Marshall (1930) for Atiu and Rarotonga, and Wood & Hay (1970) for the entire group. The ages of the islands are listed by Turner & Jarrard (1982). Stoddart (1975A) reviews the history of the many additional earlier and smaller studies on Cook Island reefs.

Most of the geological and biological research that has been done in the past on the Cook Islands, as well as my own work, has been on islands in the Southern Group. Thus this paper focuses primarily on those islands. Because most bivalve faunal lists are, unfortunately, based largely on poorly-identified specimens, I have chosen to include here only records of specimens that I was able to examine personally. Those species collected by the Cook Bicentennary Expedition from Aitutaki that were not met with during my own survey are discussed, but the records of the Manihiki Survey are not; in the latter case, most identifications are only to the generic level, and those at the species level are questionable. Records from a small collection of bivalves made by G. McCormack on most of the islands of the Northern Cooks are incorporated where appropriate as are holdings from the US National Museum of Natural History (NMNH). The distributions of the species discussed are presented in tables 1 (Southern Cooks) and 2 (Northern Cooks), and their habitat specificities are summarized in table 3. All individual island records for a species are not necessarily listed in the discussion on that species.

ISLANDS AND REEFS STUDIED

I selected three of the Cook islands for detailed study: Aitutaki, Mauke, and Rarotonga, and did some additional but more limited work on Mangaia and Atiu. A brief description of the reef structure relevant to bivalve habitats is summarized below for these 5 islands.

Aitutaki is a triangular (N/SW/SE) almost-atoll, with a large, exceptionally shallow lagoon (max. depth 10.5m, but 75% of it less than 4.5m) (Stoddart, 1975B). The major volcanic island is at the N/NW part of the lagoon, such that it is bordered by a 1-2km wide fringing reef along 2/3 of its NW coast. There are a large number of motus along the E side, while the S and SW reefs are essentially devoid of islets. A brief analysis of the sediments of the Aitutaki lagoon is presented by Summerhayes (1971). Most of the sediments are calcareous with a limited terrestrial component near the main island, and range from a muddy fine sand to a granular coarse sand; granulometric analyses of the sediments are not yet available. The outer reef slope of Aitutaki is the most variable I have seen in the Cook Islands during my studies. In some places (e.g. E of Maungapu), a rather wide shelf slopes very gently to a steep break at a depth of 25-30m, about 200-400m from the reef crest, while in other places (e.g. at several places off the SW reef and

reportedly off the S reef), a sharper dropoff occurs in 8-15m of water, perhaps 50-100m from the crest.

Mauke has a very simple reef system: the entire island is surrounded by a 50-100m wide reef flat, much of which is intertidal and even supratidal but the rest holds up to 3/4m deep water at l;ow tide. On Mauke more than on any other makatea island in the Cook Islands, the reef flat is dominated by a hard reef rock pavement, so that there are few pockets of mobile sediments and few loose rocks under which organisms can shelter. As a result, the fauna of this reef flat is extremely depauparate. The flat is followed seaward by an outer reef slope that slopes gently to a depth of 8-15m, then becomes considerably steeper and extends without interruption to at least 80m. This outer reef slope is generally without shelves, and thus sand and rubble pockets on it are small and few. In one area observed, around and N of Taunganui Landing, there is limited (50m wide) shelf development between 10 and 30m depths with a corresponding increase in soft bottom habitats.

The reefs of the rest of the makatea islands are very similar to that of Mauke with a few differences. Atiu, unlike the other Cook makatea islands but like Niue, has a large stretch of coastline along the N side of the island that lacks a reef flat, the ocean abutting directly against cliff faces. Mangaia has an outer reef slope that steepens precipitously (as on Mauke) but levels off to a wide terrace at perhaps 30-40m depths.

Rarotonga is a classic high island with a fringing reef. The reef increases in size continuously from the SE corner of the island counterclockwise, such that the widest and narrowest reefs are adjacent at the SE corner. The narrowest reefs are the windward E reefs, 50-100m wide with large intertidal portions and large amounts of accumulated rubble. The widest reefs are those on the S side, over 800m wide with a moat that is mostly <1m deep but occasionally reaches depths of up to 3m. The outer reef slope has a 200-600m wide shelf to depths of 26-31m, and then steepens. Limited sediment analyses as well as nearshore bathymetry are presented by Gauss (1982) and Lewis et al. (1980).

The nature of the outer reef slope of an island plays an important role in determining the nature of the bivalve fauna occurring there. On this slope, sediments available for burrowing are generally limited and rather uniform. Steeper outer reefs have fewer potential places for sediments to accumulate, and thus contain fewer and smaller sediment pockets, than do more gently sloping reefs. Where large terraces develop on the outer reef slope, as on Mangaia (or Niue), large amounts of sediment are trapped and extensive habitats for infaunal organisms are created. The various grooves and channels that are cut into a reef in a radiating direction also trap mobile sediments. Although the smaller grooves often have a diversity of sediments as well as fauna, the larger, more open channels often have very uniform sands and are poor in infaunal organisms. Sediment is generally less abundant and coarser in shallow waters (depths <10m) than in deeper waters, especially on steep outer reefs and contains a depauparate fauna.

For the purposes of this paper I distinguish 4 habitat types (Table 3). Three of these are inner reef habitats, the fourth is the outer reef slope. The inner reef habitats overlap to some extent: reef flats (with large intertidal as well as subtidal parts, usually with a hard rock pavement and with water <0.5m deep), moats (mostly subtidal, mostly 0-1m deep, occasionally up to 3m deep, with much mobile sediments) and lagoons (subtidal, with large areas over 3m deep, with much mobile sediments). In a few cases where it was appropriate an outer reef flat habitat was also distinguished. The fourth habitat distinguished is the outer reef slope.

Many of the bivalve species discussed here are known primarily from dead specimens. Hence one may question the validity of the habitat interpretations provided, as post-mortem transport can greatly alter observed distributional patterns. Such transport, however, appears to be of rather limited importance in these islands: there are many species whose valves are found, with rare exception, only on the inner reef or only on the outer reef (eg. see discussion under Fragum fragum, Tellina robusta, Macoma dispar, Asaphis violascens, Gafrarium pectinatum) thus no or only occasional valves were found in habitats where they do not live. Species known only from inner reef habitats are much more common among the heterodonts studied here than species known only from outer reef habitats. In part 2 of this study, however, I will demonstrate the outer-reef specificity of the family Pectinidae; most members of which were found exclusively on the outer reef slope in the Cook Islands.

Post-mortem transport does appear to occur occasionally from outer reef slope to reef flat, especially on windward coasts. I have interpreted specimens found on reef flats as originating from the outer reef when all other data for the given species unequivocally indicate that it is an outer reef specialist.

The specimens here discussed will be (or have already been) deposited in the collections of the Division of Mollusks, NMNH, Smithsonian Institution.

THE FAUNA

CHAMIDAE

Chamids are the only cemented sessile heterodonts in the Cook Islands. Their way of life makes them rather susceptible to ecophenotypic variation, complicating their taxonomy. In addition to the 5 species here reported, at least 2 other species occur, each represented by a single specimen. There are no recent reviews of this family for the area. Bernard's (1976) review of the Eastern Pacific fauna does not include any of the species occurring in the Cooks. Lamy (1927) reviewed the family but without presenting keys, illustrations or sufficient descriptions for many species.

Chama limbula Lamarck, 1819

This species is usually referred to by the name of Chama iostoma Conrad, 1837 or Chama imbricata Broderip, 1835. Lamy (1927) pointed out the synonymy of C. iostoma (described from Hawaii) with Chama limbula, but maintained that C. imbricata was a valid species. Rehder (1980) reported the synonymy of C. iostoma and C. imbricata. Individuals of C. limbula are relatively large; C. pacifica is the only other Chama species of this size in the Cook Islands that I know of but is easily distinguished by the orange color and fine crenulations along the entire inner shell margin.

Chama limbula has been recorded from Suez and E Africa (Lamy, 1927) to the Hawaiian Islands (Kay, 1979) and Easter Island (Rehder, 1980).

Chama limbula is very common on all of the Cook Islands studied, and it supports a minor subsistence fishery. Richard (1985) has studied the growth rates of this species. Chama limbula generally inhabits lagoons and reef flats and often displays different phenotypes in different habitats. On Aitutaki, specimens from the lagoon are larger and have smoother upper valve surfaces than do specimens from shallow subtidal or intertidal reef flats. Further, the valves of the former lack the coarse crenulations found on the posterodorsal inner edge of the valves of the latter. Makatea islands, lacking a lagoon,

have only the latter form. Wherever it occurs, C. limbula is unlike most chamids in living exposed rather than hidden under rocks or in crevices.

Chama limbula is occasionally found on the outer reef slope in shallow (0-15m) water, a habitat it has been collected from on Mauke (BMAK-40) as well as on Niue, but it is mainly restricted to inner reef environments. On Aitutaki it is found in all of the inner reef habitats: on windward reef flats (BAIU-8, 91), in moats (BAIU-3, 11, 22, 80), on outer reef flats (BAIU-27, 59) and in the lagoon (BAIU-9, 151). On Rarotonga it is similarly widespread, most common on windward reef flats (BRAR-88, 89). On all of the makatea islands it is very common on reef flats (BMAK-17, 18, 40, BMNG-4, 5, 6, BATI-1).

Chama pacifica Broderip, 1834

On the basis of NMNH collections, this species is known to occur from Australia and Borneo in the W to the Tuamotu Islands in the E. Specimens found on a ship's hull at Pearl Harbor in Hawaii (NMNH collections) indicate that it has been carried to the Hawaiian Islands as well, though it is not recorded as established there (Kay, 1979).

Chama pacifica appears to be restricted to larger lagoonar habitats. Accordingly, it has been found only on Aitutaki among the Southern Cooks; there I have usually collected it in the lagoon (BAIU-43A, 59, 109), but also once in the moat off the NW part of the main island (BAIU-22). A single specimen from Manihiki in the Northern Cooks, from a lagoon-side beach, is in the NMNH (704419). Among the 28 lots of this species from French Polynesia in the NMNH, all for which habitat data were recorded (20) were collected from lagoons on islands with large lagoons (Tubuai, Tahiti, Bora Bora, Tahaa, Maupiti, Raiatea, Scilly, Rangiroa, Vahitahi, Temoe, Anuanuraro, Raroia, Takume, Gambier).

Chama asperella Lamarck, 1819

This small, variable species has many synonyms and is in need of revision. Its distinction from Chama "spinosa" is somewhat problematic (see discussion under that species). It is recorded from Suez and E Africa in the W to the Tuamotu Islands in the E (Lamy, 1927).

Chama asperella is very common throughout Polynesia in a wide variety of habitats. It is almost invariably cryptic, attached to the undersides of rocks or living in reef crevices. It occurs in inner reef habitats as well as on the outer reef slope.

C. asperella is known from all of the Cook Islands that have been adequately sampled, and presumably exists on the other islands as well. I have collected it from reef flats (BMAK-11, 17, 27, BRAR-59), outer reef flats (BAIU-26, BRAR-42), moats (BAIU-3, 11, 22, 149, BRAR-77, 115, 116), lagoons (BAIU-59, 157), and outer reef slopes (BATI-3, BMAK-32, BRAR-96).

Chama "spinosa" Broderip, 1835 sensu Lamy (1906)

This species and Chama asperella may turn out to be conspecific with further study, a possibility already indicated by Lamy (1927) and Bernard (1976). The name here follows Lamy's (1906) usage for a collection of shells from the Tuamotu and Gambier Islands which are certainly of the same species as the specimens discussed below. In his revision of the family, Lamy (1927) synonymised Chama "spinosa" and C. asperella. Though the

two do appear to overlap to some extent in their characters, they are nevertheless fairly distinct and seem to inhabit rather distinct environments. Chama "spinosa" is predominantly a shallow water (<3m) species, being especially common on exposed reef flats, while C. asperella is much more catholic in its choice of habitat (see above). Morphologically the two differ in that C. "spinosa" has a thicker, more purple shell and tends to have a larger horn-like basal valve than C. asperella. Shell characters do overlap somewhat, however.

On the basis of the NMNH collections, this species is recorded from the Tokelau, Line, Cook, Austral, Society, Gambier, Tuamotu, and Pitcairn Islands.

In the Cooks, Chama "spinosa" was found on all of the islands upon which intensive collections were made, and presumably exists on the others as well. With the exception of one lot from a moat (BAIU-3), all are from reef flats (BMNG-6, BMAK-12, 17, 18, 19, 21, NMNH 721459 & 684517: Rarotonga). Among the NMNH collections from the Cook Islands and further E, this species is invariably recorded from shallow water, either from oceanic reef flats (11 lots), or from the lagoon-side sand flats of atolls (9 lots).

Chama sp. 2

I have not been able to identify this very distinctive species; it is possibly new. It is immediately recognizable by the uniform honeycomb-like sculpture on the exterior of its upper valve and by the yellow internal coloration of its valves. As in many other chamid species, the valves' internal margins are finely crenulated. Chama sp. 2 is at present known to me only from the Niue, Cook, Society, Gambier and Pitcairn Islands.

Nowhere is this species common. It is most frequently found on the outer reef slope (BAIU-82, 131, 133, BRAR-66, 95, 105, BMAK-41, 43), but it also occurs on reef flats (BMAK-19, 21, 39). Two specimens from Tahiti are known from deeper lagoons (BTAH-10, NMNH 766603). I have seen only one live specimen of this species from a reef flat on Niue, and presumably it has a cryptic lifestyle.

LUCINIDAE

The Lucinidae are infaunal filter-feeders, often characteristic of marginal habitats (Bretsky, 1976). The last review of lucinids applicable to the Indo-Pacific region is by Lamy (1920), but it lacks illustrations, keys or sufficient descriptions for identification. The 4 Cook Island species, however, are well known and easily recognized.

Codakia punctata (Linné, 1758)

This species is known from E Africa in the W to the Tuamotu Islands in the E (NMNH collections), and from Hawaii (Kay, 1979). It inhabits mobile sediments, mostly in inner reef environments. Occasional specimens are known from outer reef slopes, but these are much less frequent than are specimens from inner reefs.

In the Cook Islands, Codakia punctata is known only from moats (BAIU-3, 11, 22, 80, BRAR-80, 94, 111, 112) and lagoons (BAIU-7), and is not abundant anywhere. It has not been recorded from any of the very limited reef flats of the makatea islands of the Cooks. On Niue, I have on 3 occasions found specimens of C. punctata on a deep, sandy, rubble terrace 15-33m deep on the outer reef slope. Similarly, one specimen from Raivavae (Austral Is.) in the NMNH (732202) is from 14m on the outer reef slope. Other NMNH specimens of C. punctata from Central Pacific Islands are from a wide range of

habitats, including both outer reef benches and inner reef flats of atoll motus (judging primarily from beach specimens) as well as lagoons.

Codakia tigerina (Linné, 1758)

This species is known from E Africa to the Gambier Islands (NMNH collections). It is the rarer of the two large Codakia species in the Cook Islands. Its habits appear to be rather similar to those of Codakia punctata.

In the Cooks Codakia tigerina is known mostly from moats (BRAR-27, 33, 43, 111), but also occurs on the outer reef slope (BRAR-95, and one record from Niue island). Oddly, it has not yet been recorded from anywhere but Rarotonga and Mangaia among the Cook Islands. The Mangaian specimen (NMNH 365552) bears no habitat information and it may have originated from either the reef flat or the outer reef slope. The few additional specimens in the NMNH with habitat localities and the specimens in my Pacific Islands collections are all from inner reef habitats, mostly from lagoons and from beaches facing lagoons.

Codakia bella (Conrad, 1837)

This species is often referred to as Codakia divergens (Philippi, 1850), a synonym. It is fairly variable in shape and sculpture (see illustrations in Kay, 1979). It has been recorded from Suez in the W (Lamy, 1920), to Hawaii (Kay, 1979) and Easter Island (Rehder, 1980) in the E.

Codakia bella is the most abundant and ubiquitous lucinid in Polynesia. It has been collected on all of the Cook Islands that have been intensively sampled, and presumably occurs on the others also. It is known on these islands from reef flats (BAIU-8, 91, 106, BMAK-16, 21, 35, 42, 70, BMNG-6) where it can live in very limited sand pockets, from outer reef flats (BAIU-128), from moats (BAIU-3, 11, 22, 36, 80, BRAR-24, 28, 31, 53, 111, 112), from lagoons (BAIU-7, 43A, 45, 55, 59, 109, 120, 135, 157, 158) and from outer reef slopes (BAIU-133, 147, BRAR-2, 12, 14, 74, 105, BMAK-20, 23, 29, 32, 34) where it has been collected from depths between 3 and 27m. It is similarly widespread and ubiquitous on other Pacific islands, judging from the NMNH collections.

Anodontia edentula (Linné, 1758)

Several nominal species of Anodontia are very similar to this one. As their shells are very thin and featureless, and as considerable intraspecific variation occurs, a thorough review is needed before the various species can be sorted out. Lamy (1920) has synonymised many of the species already.

Anodontia edentula (dependent on identification) ranges from E Africa to the Tuamotu Islands and Hawaii (NMNH collections). In the Southern Cook Islands it is not particularly common, but, like the other 3 lucinids, inhabits a variety of inner reef as well as outer reef slope habitats. These habitats include moats (BAIU-11, BRAR-24, 43, 94) and lagoons (BAIU-7, 45), and outer reef slopes at depths between 14 and 24m (BAIU-111, 133, BRAR-46, BMAK-23). Specimens from the outer reef slope of Niue were found in 9-33m depths. In French Polynesia this species is often common in well-developed barrier reef and atoll lagoons.

LEPTONACEA

There are several species of leptonaceans in the Cook Island fauna, but are not treated here because the systematics of the group, especially for dead-collected specimens, is in a scattered state.

CARDIIDAE

Cockles are generally shallow-burrowing infaunal bivalves. A few species, including most of the Cook Island forms (Fragum fragum, and probably Fragum mundum and Corculum dionaeum), harbor symbiotic zooxanthellae in their mantle tissues and could thus be depth-limited (Kawaguti, 1950, 1983). Several relevant reviews exist for cardiids (Wilson & Stevenson, 1977; Keen, 1980; Fischer-Piette, 1977), but a review of the family in the entire Indo-Pacific region is needed.

Trachycardium orbitum (Broderip & Sowerby, 1833)

The generic placement of this species is questionable and will depend on future revision of the American species of the genera Trachycardium and Acrosterigma. The former genus has priority if the two are synonyms, but the Indo-Pacific species are more like the American species of Acrosterigma than those of Trachycardium (Wilson & Stevenson, 1977). Trachycardium orbitum is particularly similar to and replaced by Trachycardium angulatum (Lamarck, 1819) to the W.

Trachycardium orbitum is known from the Cook, Austral, Society, Pitcairn, Marquesas (from which the nominal species Trachycardium mendanaense Sowerby, 1897 is described) and Hawaiian islands; it is probably a Central Pacific endemic.

In the Southern Cook Islands Trachycardium orbitum appears to be restricted to outer reef slopes; with the exception of a single valve from a moat beach (BAIU-11) all specimens from the 3 Cook Islands surveyed in detail came from outer reef slopes (BAIU-41, 71, 82, 93, 111, 131, BMAK-9, 46, 71, 73, BRAR-46, 118). There the species had a depth range of 12-52m, and was more common in deeper water. On islands with deeper lagoons like Tahiti T. orbitum is also found in the lagoons. While it is fairly common on the outer reef slopes of many islands, T. orbitum is rarely collected because of its deeper-water habits.

Fragum fragum (Linné, 1758)

This is the most common cockle in the Cook Islands. It ranges throughout the Indo-Pacific from East Africa to the Tuamotu Islands. On some islands, e.g. many Tuamotu atolls, it is exceedingly abundant. Richard (1983) studied the productivity of this species in the lagoon of Anaa Atoll (Tuamotu Is.). Kawaguti (1983) showed that this species has symbiotic zooxanthellae, which may explain in part its restriction to mostly shallow water: among over 100 lots of Fragum fragum specimens at the NMNH, one is from18-27m (NMNH 789653: Rangiroa lagoon) and all others are from <18m depths. All of the 39 lots in my collections are from <18m depths.

Fragum fragum is unknown to me from the outer reef slope. Its absence from the outer reef slope of islands on which it is otherwise very abundant is an indication of the relative unimportance of post-mortem transport from inner to outer reef. It is generally absent from reef flats as well as from outer reefs; the only reef flat specimens I know of are one record from Mangaia (NMNH 365553) and 3 from outer motu beaches in the Tuamotu Islands (NMNH 698064, 723199, 723693, compared to many records from inner motu beaches on these islands). Thus F. fragum is very rare or absent on makatea

islands, which have only reef flats and outer reef slopes to offer. It is abundant in moats (BAIU-3, 11, 12, 22, 39, 80, BRAR-24, 30, 31, 40, 52, 111, 112 and many other locations not recorded) and in lagoons (BAIU-7, 43A, 45, 46, 59, 109, 114, 118, 134, 157, 158).

Fragum unedo (Linné, 1758)

This species was recorded from Aitutaki by the Cook Bicentennary Expedition (Gibbs et al., 1975) from 2 localities in the lagoon. Since Fragum unedo is not known E of Samoa and was not collected by me in 1986, one lot of specimens from the Cook Bicentennary Expedition collections at the National Museum of New Zealand (Wellington) was borrowed through the courtesy of B.A. Marshall to ascertain its identity. The 3 specimens in the lot (MF-21699) are all juvenile Fragum fragum, thus there is no evidence for the existence of F. unedo in the Cook Islands at present.

Fragum mundum (Reeve, 1845)

Fragum mundum is a small species, <1cm in size. It is somewhat similar to F. fragum but is easily distinguished by its drawn-out posteroventral angle and its much smaller size. It has a patchy record, partly because it is easily overlooked but also because it is apparently rare over much of its range. On certain islands, however, such as Raroia (Tuamotu Is.), it can be very abundant, contributing substantially to beach sand formation. Fragum mundum was described from S Marutea in the Tuamotus and is known from several islands in the Tuamotus, Cooks, Marshalls, and Samoa (NMNH collections), from Kapingamarangi (NMNH), from Niue (my collections), Hawaii (Kay, 1979), Queensland, and Japan (Fischer-Piette, 1977).

Kay (1979) notes this species to be "common in shallow water, occurring singly nestling in the algal-sand mat of tide pools and shoreward fringing reefs". Considering its shallow habit and close relationship to Fragum fragum and Fragum unedo, both of which are known to harbor zooxanthellae (Kawaguti, 1983), it is possible that Fragum mundum does likewise.

The single record from the Cook Islands is from the shallow lagoon side of a motu on Suwarrow Atoll (NMNH 704506: E side of Anchorage, W side of Pylades Bay, 6. XI. 1973, coll. H.A. Rehder). The abundant NMNH collections (29 lots) from Raroia are all from depths ≤3m; most are from the oceanic reef flat, but some are from the lagoonar sides of motus.

Corculum dionaeum (Broderip & Sowerby, 1828)

The genus Corculum was revised by Bartsch (1947) and includes only this species in Southeastern Polynesia. The range of Corculum dionaeum as recorded by Bartsch (1947) is rather limited: Anaa (Tuamotu Is.), Tuamotu, Mangaia (Cook Is.), and Lifu (Loyalty Is.). Records at the NMNH since Bartsch's paper include ones from Tubuai (Austral Is.) (705443), Tetiaroa (Society Is.) (706004, 705904), Takume (723692), Temoe (671843) Takaroa (790057) and Raroia (720623 and 13 other lots), these last 4 islands are all in the Tuamotus. In addition, Fischer-Piette (1977) records it (as Corculum cardissa, in the synonymy of which he includes all Corculum species) from Gambier. This species is thus known mostly from Southeastern Polynesia, with an isolated record from Lifu in the Loyalty Islands.

Corculum dionaeum appears to live almost exclusively on seaward reef flats, though it may also inhabit shallow lagoonar flats. Corculum cardissa was shown to harbor zooxanthellae by Kawaguti (1950), and it is likely that all species in the genus do so; the form of their shells seems to be adapted specifically toward this end.

My 2 records from the Cook Islands (BAIU-91, BMAK-35) are from beaches behind seaward reef flats. A third record (NMNH 363437: Mangaia) is probably from a similar setting, as Mangaia has only reef flats and outer reefs. All of the lots of Corculum dionaeum specimens at the NMNH are from ocean or lagoon beaches of atolls with 2 exceptions, both of which were dead-collected from lagoons in 0-3m depths.

TRIDACNIDAE

There are 2 indigenous species of giant clams in the Cook Islands. A third species, Tridacna derasa, has been recently introduced by the Cook Islands Fisheries Department to Aitutaki. The tridacnids are a small family of only 7 species. Six species were reviewed by Rosewater (1965), since then an additional species of Hippopus was described (Rosewater, 1982).

Tridacna maxima (Röding, 1798)

Tridacna maxima ranges from E Africa (Rosewater, 1965) to Ducie Atoll (Pitcairn group) (NMNH). It is generally a conspicuous and abundant species on all hard-substrate reef environments where it occurs. Richard (1977) studied its growth and abundance in the Takapoto lagoon (Tuamotu). It is strongly byssate and is generally partly buried in reef material, making it difficult to dislodge.

In the Cook Islands, it is common on reef flats (BAIU-8, 91, 106, BMAK-12, 17, 18), moats (BAIU-3, 11, 22, 80, BRAR-111, 112), outer reef flats (BAIU-24), lagoons (BAIU-59, 109) and outer reef slopes (BAIU-131). The small number of records presented here reflects only the small number of collections; this species is in fact found very commonly in all of these habitats. It is hard to judge which habitats it favors most because it suffers from very heavy fishing pressure; the species forms the basis of an important local subsistance fishery, especially on Aitutaki. The largest concentrations of it are on various patch reefs in the Aitutaki lagoon today. It is not common on the outer reef slope, a habitat which, due to its depth, is not heavily fished.Tridacna maxima is widespread on all of the islands I sampled, but it is more abundant on islands with larger inner reefs, especially Aitutaki.

Tridacna squamosa Lamarck, 1819

Until now Tridacna squamosa was known only from E Africa to Samoa and Tonga (Rosewater, 1965). It is in fact widespread in the Cook Islands, though not common, and recently I found it in abundance on the outer reef slope of Ducie Atoll (Pitcairn Islands), thus extending the geographic range toward the E as far as that of Tridacna maxima.

Tridacna squamosa is unattached or weakly attached by byssus as an adult and nestles in rubble or in reef pockets. All specimens found in the Cook Islands were from the outer reef slope (BAIU-82, BMAK-74, BRAR-62, 119) where it is occasionally encountered to depths of at least 30m.

TELLINIDAE

Tellinids are the most diverse group of heterodonts in the Cook Islands. They are mostly infaunal deposit feeders and several species appear to be restricted to inner reef or lagoonar environments. There are no recent reviews of the Indo-Pacific fauna, but Boss' (1969) treatment of the South African Tellininae covers some widespread Indo-Pacific species, and Afshar (1969) reviewed the generic and subgeneric classification of the family.

Tellina (Tellinella) virgata Linné, 1758

Boss (1969) presents a thorough discussion of Tellinella species, including Tellina virgata. Tellina virgata ranges from S. Africa in the W (Boss, 1969) to the Tuamotu Islands in the E (NMNH collections). Boss (1969) describes it as a "common shallow water species that prefers sandy substrates".

In Southeastern Polynesia, Tellina virgata appears to be strictly an inhabitant of inner reef environments, especially lagoons. It is known only from islands with well-developed barrier reefs and from atolls: Aitutaki, Tahiti, Moorea, Bora Bora, Tikahau (Tuamotu Is.), Rangiroa (Tuamotu Is.), and Gambier (NMNH and personal records). Among the Southern Cook Islands it has been recorded, as might be expected considering its habitat requirements, only from Aitutaki. There it has been collected from the moat (BAIU-3) and from the lagoon (BAIU-43A, 45, 109), but it is uncommon.

All of the 7 lots of specimens from the Society and Tuamotu Islands with habitat information in the NMNH were dredged from lagoons at 9-29m depths; the single Gambier collection is a beach specimen. Three of the 4 lots that I collected in the Society Islands are from 0-2m depths on sand flats, and one is from 15-18m in a lagoonar bay.

Tellina (Tellinella) staurella Lamarck, 1818

This species was recorded from Aitutaki by the Cook Bicentennary Expedition (Gibbs, Vevers, & Stoddart, 1975) from 7 stations in the lagoon, making it the second most common bivalve collected by the expedition. Considering that Tellina staurella is not known E of Samoa, that I did not find the species on Aitutaki (an unusual circumstance if it indeed was so abundant only 17 years ago), and that there are no records of it at the NMNH, it is likely that the specimens collected by the expedition were misidentified. There is no material with this identification in the holdings of the National Museum of New Zealand where the mollusc collections of the Cook Bicentennary Expeditions were supposed to have been deposited (B.A. Marshall, personal communication). I hypothesize that the specimens originally identified as T. staurella were actually Loxoglypta rhomboides, the only tellinid species resembling T. staurella that occurs in such abundance in Aitutaki's lagoon. Accordingly, L. rhomboides was not recorded by the Expedition. The other 2 Tellinella species, Tellina virgata and Tellina crucigera, are both uncommon in Aitutaki.

Tellina (Tellinella) crucigera Lamarck, 1818

Tellina tithonia Gould is synonymous with Tellina crucigera. This species is widespread from E Africa to Hawaii (Kay, 1979) and to the Tuamotu and Gambier Islands (NMNH collections). It can be distinguished from the related Tellina virgata and Tellina staurella by its dorsoventrally shallower shell, a more posterior umbo, and the absence or very poor development of the ventral process of the posterior adductor muscle scar.

Some specimens are only tentatively included under this identification (BAIU-130, 133), as they appear to be intermediate between Tellina crucigera and Tellina rastellum: they have the shape and size of the former, but the localized rasplike sculpture that is characteristic of the latter. I know of 4 lots of specimens of this morph: 1 from Niue, 1 from Temoe, Tuamotus (NMNH 731473), and the 2 from Aitutaki. All are very similar and all are from the outer reef slope.

Kay (1979) notes this species to be most common in depths of 8-100m. In Southeastern Polynesia it appears to inhabit both inner and outer reef environments. In the Cook Islands it is known from moats (BAIU-3, 22, BRAR-86), from a deep passage through a fringing reef (BRAR-93), and from the outer reef slope (BAIU-79; and the specimens with rasplike sculpture BAIU-130, 133). I have collected 3 specimens of this species from the outer reef slope of Niue, one with the rasplike shell sculpture discussed. The limited collections at the NMNH from Southeastern Polynesia are mostly beach specimens, but 6 lots are from lagoons and the single specimen with rasplike sculpture referred to above (731473) is from the outer reef slope. The depth range of these specimens is 18-27m in lagoonar areas (NMNH 789634: Rangiroa, Tuamotu Is.), and up to 41m on the outer reef slope (NMNH 731473: Temoe, Tuamotu Is.).

Tellina (Quidnipagus) palatam (Iredale, 1929)

This species is the only one in the subgenus Quidnipagus and it is readily recognizable. It ranges from Africa to the Tuamotu and Hawaiian Islands (Boss, 1969).

Boss (1969) notes that Tellina palatam "lives in rather shallow water in coarse substrates", while Kay (1979) writes that "these bivalves are found in silty sand inshore on fringing reefs and at depths of 2 to 3m." Except for a few dead specimens collected at depths to 10-15m (Tahiti, my collections), this species was found exclusively in very shallow water. It has a patchy distribution, but can be locally abundant. For example, on Rarotonga, a particularly large assemblage of dead shells was found at <0.5m depth on a small landward embayment of Oneroa Motu.

In the Cook Islands Tellina palatam is widespread and is most often found on moats (BAIU-3, 11, 22, BRAR-24, 27, 94, 111, 112), and in shallow lagoons (BAIU-7, 43A, 109). The single Mangaian specimen (NMNH 613405) is the only one from a makatea island; it is without habitat data, but is presumably from the reef flat. No records exist for this species from any other makatea island nor from any outer reef slopes. All NMNH habitat records (21 lots) of this species from Southeastern Polynesia are from shallow inner reef environments.

Tellina (Arcopagia) scobinata Linné, 1758

The genus/subgenus of this readily recognizeable species is often referred to as Scutarcopagia or as various combinations of Tellina, Arcopagia, and Scutarcopagia. The present generic/subgeneric assignment follows Boss (1969). The species ranges from E Africa to the Tuamotu Islands and to Henderson Island in the Pitcairn group (NMNH collections); in Hawaii it is replaced by the dubiously distinct Tellina elizabethae Pilsbry, its only close relative (Kay, 1979).

Tellina scobinata is a very common species, probably found on most if not all islands in the Cooks and in the rest of Polynesia. It occurs in a variety of habitats, usually burrowing in coarse substrates and sometimes nestling partly exposed in rubble. It has been collected on reef flats (BAIU-8, 91, BRAR-71, 90, BMNG-6), outer reef flats

(BAIU-24, 152), moats (BAIU-3, 11, 22, 80, BRAR-24, 31, 111, 112), lagoons (BAIU-7, 43A, 59, 109, 158) and on the outer reef slope (BAIU-41, 71, 79, 82, 130, 131, 133, 147, BRAR-2, 21, 46, 105, BMAK-9, 31, 36) at depths between 10 and 30m.

Tellina (Arcopagia) robusta Hanley, 1844

The genus of the species group to which Tellina robusta belongs is sometimes referred to as Arcopagia (Pinguitellina) or as other combinations of Tellina, Arcopagia, and Pinguitellina. The present classification follows Boss (1969). Tellina robusta has many close relatives and in the Society Islands a related species, Tellina ?nux Hanley also occurs commonly. Tellina robusta ranges from E Africa to Hawaii (Kay, 1979) and to the Tuamotu Islands (NMNH collections).

Tellina robusta is a strictly inner reef species, occuring only in moats and lagoons. Accordingly it is not known from any makatea islands. It is very common in moats and lagoons, and it was this bivalve species that was recovered from the largest number of lagoon stations on Aitutaki by the Cook Bicentennary Expedition. My records for T. robusta include moats (BAIU-3, 4, 11, 12, 22, BRAR-31, 33, 111), outer reef flats (BAIU-29) and lagoons (BAIU-7, 43A, 45, 59, 109, 114, 118, 120, 121, 124, 134, 135, 157, 158). The NMNH records for this species from Southeastern Polynesia are also entirely inner reef, from barrier reef islands or atolls in the Society, Austral and Tuamotu groups. Among the NMNH collections, the greatest depth recorded for the species is 23-29m, from the lagoon of Bora Bora (Society Is.) (NMNH 629920).

Tellina (Cadella) semen Hanley, 1844

This small species ranges from Africa (Boss, 1969) to the Tuamotu and Gambier Islands (NMNH collections); in Hawaii it is replaced by the similar and probably synonymous Tellina oahuana (Dall, Bartsch & Rehder). Tellina mauia (Dall, Bartsch & Rehder) is synonymised under T. oahuana by Kay (1979) and Burch & Burch (1981) demonstrated that the 2 forms in Hawaii intergrade completely. Rehder (1980) recorded T. mauia from Easter Island and noted T. oahuana proper to be the French Polynesian species.

Boss (1969) writes: "Tellina semen lives in offshore waters, usually in relatively coarse substrates..... Maes (1967) noted that this species was abundant at Cocos-Keeling in fine, soft sand in shallow water. It was not an intertidal or beach species and rapidly buried itself in the substrate if disturbed." Tellina oahuana was found from 10 to 75 fathoms and noted to be one of the most abundant bivalves in Hawaii by Burch & Burch (1981). The present collections indicate that this species lives both in outer reef and inner reef habitats.

There are only 3 records of the species in the Cook Islands at present: 1 from a moat (BAIU-39) and 2 from the outer reef slope (BRAR-105, BMAK-69). An additional outer reef slope specimen is known from Niue. There are 12 lots at the NMNH from Raroia (Tuamotu Is.), all from the lagoon, from beaches to 17m depths. The 5 NMNH lots from the Society Islands are also from lagoons, from beaches to 15m depths, and the single Gambier lot is from a lagoon beach. I found this species to be common (6 lots) in Paopao Bay as well as elsewhere in the lagoon on Moorea (Society Is.), at 1-18m depths.

Jactellina obliquaria (Deshayes, 1854)

This small, yellow, scissulate species, described from "the Pacific Ocean", is widespread in the Pacific, with specimens from the Marshall, Gilbert, Fiji, Niue, Cook, Society, Tuamotu, and Gambier Islands in the NMNH and my collections.

Jactellina obliquaria is known in the Cook Islands from reef flats (NMNH 697320, 697291: both from Aitutaki, ocean-side beach of Akaiami motu), outer reef flats (BAIU-128), moats (BRAR-43), lagoons (BAIU-59) and outer reef slopes (BAIU-130), but nowhere is it abundant. It is known from the outer reef slope of Niue (2 records). The combined depth range of the outer reef records (1 from the Cook Islands and 2 from Niue) is 12-19m. This species is common in inner reef environments in the Society Islands, most often in shallow water (0-2m), but also at depths to 16-18m in lagoons (personal observation).

Loxoglypta rhomboides (Quoy & Gaimard, 1834)

This species is sometimes referred to as Tellina rhomboides, but it belongs to the Macominae, not to the Tellininae. It extends from E Africa (Boss, 1969) to Oeno Atoll (Pitcairn Group) (NMNH collections). The similar, and possibly synonymous Loxoglypta obliquilineata (Conrad, 1837) is known from Hawaii.

Loxoglypta rhomboides is a very abundant and ubiquitous species, occurring in a variety of habitats but especially abundant in inner reef environments. In the Cook Islands it is known from moats (BAIU-3, 4, 11, 22, 51, BRAR-24, 31, 43, 86, 111), lagoons (BAIU-7, 43A, 109, 114, 120, 125, 135, 157, 158), and outer reef slopes (BAIU-130, 133, BRAR-46, 105, BMAK-34, 38). Among these habitats, it is most common in lagoons and least common on the outer reef slope. Accordingly, among the Southern Cook islands this species is most abundant on Aitutaki and least abundant on the makatea islands (only 4 individuals are known from Mauke). In the Society and Tuamotu Islands L. rhomboides is very common in the various inner reef environments (over 50 lots at NMNH). Two presumably outer reef slope records exist for Anaa (NMNH 775883, 775884: Tuamotu Is., off NE Pt. diving, 60 feet). Probably due to its diverse habits, L. rhomboides is known from all islands within its range that have been intensively sampled, and it is probably present on the others as well. Presumably the specimens identified as Tellina staurella in the Cook Bicentenary Expedition collections were of this species (See discussion under T. staurella).

Macoma (Scissulina) dispar (Conrad, 1837)

This species, again of the Macominae, is often referred to as Tellina dispar. Boss (1969) treats it extensively. It ranges from Africa to Hawaii (Boss, 1969) and to the Tuamotu Islands (NMNH collections).

Boss (1969) notes that Macoma dispar lives "from below the low tide zone to depths of up to 10 fathoms", especially in "calcareous sandy bottoms with a relatively coarse texture." In Southeastern Polynesia it is known only from islands with barrier reefs and from atolls, and it appears to be almost entirely restricted to lagoons.

In the Cook Islands it is known from Aitutaki and Rakahanga. With the exception of 1 specimen from an outer reef flat (BAIU-29), it was found only in the lagoon on Aitutaki (BAIU-7, 43A, 109, 114, 125, 157, 158), where it was very common. The 20 records I know of (NMNH and my collections) from French Polynesia are all from lagoons or shallow inner sand flats, with the exception of a single valve from the oceanside beach and inner reef flat of Tetiaroa Atoll (NMNH 705716). Again, the absence of specimens of

this species from the outer reef slope in spite of its abundance in the lagoon is an indication of minimal post-mortem transport from inner to outer reef.

PSAMMOBIIDAE

Gari gari (Linné, 1758)

This species was recorded from 3 lagoon stations by the Cook Bicentennary Expedition in Aitutaki. Gari gari is a nomen nudum (Dodge, 1952). I have not found any Gari species in the Cook Islands, though Gari ?pennata (Deshayes) is known from Tahiti and Niue. There are no specimens with this identification deposited in the National Museum of New Zealand, where the molluscan collections of the Cook Bicentennary Expedition were supposed to have been deposited (B.A. Marshall, personal; communication). The identity of this species thus remains unresolved.

Asaphis violascens (Forsskål, 1775)

The only species of its genus in the Pacific, Asaphis violascens ranges from E Africa to the Tuamotu-Gambier Islands and is considered conspecific by some authors with the Atlantic Asaphis deflorata (Linné, 1758) which, in that case, has priority. In several publications dealing with Polynesian shells the erroneous spelling A. violaceus appears. In the Cook Islands the species is the basis of a minor subsistence fishery on Rarotonga and Aitutaki at least.

Asaphis violascens is a deeply burrowing, strictly very shallow water, mostly intertidal species. Kira (1962) notes that it is "very common on muddy and gravelly bottoms near the low tide mark." Among the over 60 lots from Southeastern Polynesia at the NMNH, the greatest depth from which this species is recorded is 2m (dead). Asaphis violascens is least common on makatea islands, presumably due to the rarity of low intertidal mobile sediments on these islands.

Most records of the species are from moat and lagoon shores (BAIU-3, 7, 8, 11, 22, 43A, 80, 91, 109, BMAK-19, 39, BRAR-111, 112) with only a few specimens (all dead) from moats (BRAR-27, 31) and one from the outer reef slope in front of the principal harbor of Rarotonga (BRAR-27, dead). Within its shoreside habitat, Asaphis violascens is patchily distributed. On Aitutaki, the S ends (channel side) of at least 2 of the E side motus (Akaiami and Papau) have large populations of these clams in poorly sorted rubbly sediments.

SEMELIDAE

Semelids are infaunal deposit feeders, and while they are not abundant numerically in the Cook Islands, at least 5 species occur there (one of which is represented only by a small fragment and is not included here).

Semele australis (Sowerby, 1832)

Described from S Marutea (Tuamotu Is.), Semele australis ranges at least to Hawaii (Kay, 1979), Easter Island (Rehder, 1980), Loyalty Islands (NMNH collections) and Ryukyu Islands (Habe, 1964). It appears to frequent shallow inner reef environments as well as deeper outer reef waters. Kay notes that in Hawaii it inhabits shallow waters.

It was found on all of the Cook Islands intensively surveyed and probably inhabits the others as well. Records are from outer reef flats (BAIU-24), reef flats (BAIU-91, BMAK-19, 39, 42), moats (BAIU-4, BRAR-111, 114), lagoons (BAIU-45, 59), and outer reef slopes (BAIU-131, 133, BRAR-105). Among the NMNH collections from Southeastern Polynesia most specimens come from beach drift or shallow depths (<2m). Occasional specimens, all from the reef-poor Marquesas and Rapa Islands, come from greater depths (3 lots: 3-18m, 1 lot: a single valve from 108-121m). There are no records of this species from the lagoonar dredging surveys in the Society and Tuamotu Islands, though I have found valves at 15-18m in the lagoonar Paopao Bay of Moorea. The greatest depth at which this species was collected in the Cook Islands is 19-21m (BAIU-133).

Abra seurati (Lamy, 1906)

Described from Anaa (Tuamotu), Abra seurati is known from the Fiji, Niue, Cook, Austral, Society, Tuamotu and Gambier Islands (NMNH and personal collections), from a total of only 23 lots of specimens. The largest number of specimens (9 lots) are from Aitutaki, where it was usually encountered singly. It appears to occupy a variety of reef environments.

In the Cook Islands it is known only from Aitutaki and Rarotonga, from the following habitats: moats (BAIU-44A, 51), lagoons (BAIU-43A, 59, 125, 135, 158), outer reef flats (BAIU-106), and outer reef slopes (BAIU-131, BRAR-105). There is one record of Abra seurati from the outer reef slope of Niue, 2 records from 2-9m on shoreside lagoonar sandy bottoms in Fiji, 1 record from 15-18m in the lagoonar Paopao Bay of Moorea, 1 record from just behind a barrier reef crest on Tahiti, and 2 records from lagoons (1 from 17m) in the Tuamotus. All remaining records of the species are beach specimens from islands surrounded by barrier reef lagoons.

Lonoa hawaiiensis Dall, Bartsch & Rehder, 1938

To date Lonoa hawaiiensis was known only from Hawaii (Kay, 1979). I collected single specimens of it from 3 additional localities: Tahiti, Aitutaki (BAIU-74), and Niue. All 3 specimens are from the outer reef slope at 8-27m depths, and all were found dead. The Niue specimen (complete with both valves) was found nestled within the reef framework, which may be the habit of this species in life; such habits would account for the slightly deformed shape of these small bivalves and for their apparent rarity. Kay notes that in Hawaii they have been found only in drift, and suggests a nestling habit based on their shape.

Semelangulus sp. cf. crebrimaculatus (Sowerby, 1867)

Three lots of small semelids from Rarotonga resemble the highly variable Semelangulus crebrimaculatus. All 3 are very similar and are at the edge of the range of morphological variability expressed by S. crebrimaculatus elsewhere. They probably represent a distinct species, as they exhibit the following differences from the standard S. crebrimaculatus stock: less pointed umbones, a thinner internal ligament, and stronger external concentric lyrations. Superficially the specimens resemble Tellina semen. They were collected from a reef flat, nestled among rubble (BRAR-71), and from the outer reef slope (BRAR-58, 95). Semelangulus crebrimaculatus s.s. was described from S. Marutea (Tuamotu) and also occurs in Hawaii (Kay, 1979), Fiji, Society and Tuamotu Islands (NMNH and my collections). It is known to me from 14 lots, all from inner reefs at 0.5-20m depths. Kay (1979) notes a depth range of 1-16m in Hawaii.

TRAPEZIIDAE

Solem (1954) revised the family and summarized the available ecological information on its members.

Trapezium oblongum (Linné, 1758)

Trapezium oblongum ranges from Madagascar to Hawaii (Solem, 1954) and to Henderson Island (NMNH). Solem (1954) noted that it "evidently lives in large crevices and underneath coral blocks in reefs and lagoons." I have found live specimens nestled in crevices, under rocks, and exposed on coral rubble.

It is a common species throughout the Cook Islands in most reef habitats. It has been collected on reef flats (BAIU-91, BMAK-13, 17,. 18, 19, 21, 35, 39, 42), in moats (BAIU-51, BRAR-33, 51, 111), in lagoons (BAIU-10, 45, 59, 158), and on outer reef slopes (BAIU-71, 82, 111, 130, 131, 133, 147, BRAR-46, 58, 105, BMAK-22, 24, 31, 44, 68) to a maximum depth of 27-30m. It is similarly common elsewhere in Southeastern Polynesia in similar habitats (NMNH collections).

Trapezium obesum (Reeve, 1843)

At the time of Solem's (1954) review, this species was known only from 4 lots,from the Mauritius, Borneo, and the Ryukyu Islands. Since then it has been recorded from Kenya (Crame, 1986). Here I add the Society Islands and Fiji (my collectionss), Ailuk Atoll (Marshall Is.) (NMNH 615297), and the Cook Islands (G. McCormack, collector) to the species' range.

In the Cooks, Trazium obesum has been recorded only from the Northern Group (habitat unknown). In the Society Islands (5 lots) and in Fiji (3 lots) it is not uncommon in 10-20m deep lagoons. All of the specimens I collected were from sandy bottoms. Although all were dead the habitat in which they were found and the lack of deformities (unlike Trapezium oblongum) indicates an infaunal lifestyle.

VENERIDAE

Venus toreuma Gould, 1850

This species ranges from E Africa to Hawaii (Fischer-Piette, 1975) and to Pitcairn Island (NMNH collections). Oddly it has not yet been found in the Southern Cook Islands, though it is known from Niue and from the Society and Austral Islands. The single Cook Island record comes from a beach on Suwarrow Atoll in the Northern Group, collected by and in the collection of G. McCormack.

Venus toreuma is known abundantly from the outer reef slope of Niue (11 lots, from 8-33m depths) as well as from the barrier reef, lagoon and outer reef slope of the Society Islands. Kay (1979) gives a depth range of 10-500m for the species in Hawaii.

Periglypta reticulata (Linné, 1758)

This species is distributed from E Africa to the Tuamotu Islands (Fischer-Piette, 1975) and Hawaii (Kay, 1979). Kay (1979) noted that it is common in shallow water in

Hawaii. The records at the NMNH and in my own collections indicate a primarily shallow water, inner-reef dwelling species.

In the Cook Islands, the habits of Periglypta reticulata range from shallowly infaunal to crevice-dwelling. Live specimens were encountered in shallow (<2m) water under rocks, generally only partly buried in coarse sand or coral rubble. I have seen one specimen nestled in a barren reef crevice at 3m on the outer reef slope. Records from the Cooks are from reef flats (BAIU-8, 91, BMNG-2, BMAK-19, 21, BRAR-61), outer reef flats (BAIU-24, 25, 29), moats (BAIU-3, 11, 22, 80, 150, BRAR-24, 25, 101, 111, 112, 117), outer lagoons near the outer reef flats (BAIU-7, 56, 59), and outer reef slopes, at 3-20m depths (BAIU-131, BMAK-20, BRAR-16, 21, 105). Periglypta reticulata is very common in shallow inner reef environments, much more so than the collection records indicate. It is rare, however, on the outer reef slope, and the records noted represent all specimens that I have encountered in that habitat. The NMNH holds 2 lots from the outer reef slope, from 14m on Raivavae (Austral Is.) (732190) and from 9-18m on Fatu Hiva (Marquesas Is., 732636). The rest of the over 70 records of the species from Polynesia are all from <3m depths in inner reefs.

Periglypta ?crispata (Deshayes, 1854)

Periglypta crispata refers to different species in different publications, and here I follow Reeve's usage of the name. The identity of this species, as well as that of Periglypta fischeri (Reeve) and of Periglypta chemnitzi (Hanley) (the 3 of which have been involved in various synonymies), needs to be established before the present species can be correctly named. Fischer-Piette (1975) has synomynized P. crispata as well as many other species incorrectly under Periglypta puerpera (Linné).

The range of the species here discussed includes Mauritius, Marshall, Society, Tuamotu, and Gambier Islands (all based on NMNH collections), Fiji (my collections), and the Cook Islands (coll. G. McCormack).

The sole record of the species in the Cooks is from Manihiki in the Northern Group. All records of the species are from islands with well-developed, deep, barrier reef or atoll lagoons. There are 7 lots of specimens from Polynesia that are not from drift; all of these are from lagoons at 2-18m depths. Thus the absence of the species from the Southern Cook Islands may be real and due to the meager development of lagoons there. As the species is found in the Gambier Islands, a latitudinal restriction seems unlikely.

Lioconcha ornata (Dillwyn, 1817)

The genus Lioconcha is in much need of revision. This species ranges from Mauritius and the Gulf of Suez to the Society Islands (NMNH collections). Within the Cook Islands it is known only from Aitutaki (my collections) and Puka Puka (G. McCormack's collections).

In Aitutaki, Lioconcha ornata is strictly an inner reef species, known from the moat (BAIU-3, 11, 22) and especially the lagoon (BAIU-7, 43A, 109, 114, 118, 120, 121, 124, 157) where it is commonly found alive buried in the sand. In the Cook Islands I have never found it on the outer reef slope. In the Society Islands it has similar habits, found commonly in lagoons at 3-16m depths. On Niue, a sparse population of this species occurs on the outer reef slope on a sandy/rubbly reef terrace at 21-33m (my collections). Similarly, off several islands in the Marquesas, 4 lots of this species were dredged in 40-72m depths.

Pitar prora (Conrad, 1837)

Pitar like Lioconcha is in much need of revision. Pitar prora, however, is a fairly obvious species; it is very similar to Pitar obliquata (Hanley), but the latter does not occur in Southeastern Polynesia. All NMNH specimens of P. prora are from Pacific Islands, ranging from the Mariana and Marshall Islands to the Tuamotu and Gambier Islands.

Pitar prora appears to be a strictly inner reef species, known only from moats and lagoons. Accordingly among the Southern Cook Islands it is known only from Rarotonga and Aitutaki. It has been collected in moats (BAIU-3, 11, 22, BRAR-112) and in lagoons (BAIU-43A, 454, 109) but is nowhere abundant. NMNH records of the species in Southeastern Polynesia are from a variety of islands, all with well-developed barrier-reef or atoll lagoons, in the Austral, Society, Tuamotu, and Gambier Isands. All of these records (21 lots) are from moats or lagoons (or their shores), from depths up to 23-25m (NMNH 629987: Fauni Bay, Bora Bora, Society Is.).

Gafrarium pectinatum (Linné, 1758)

This is a variable species ranging from E Africa to the Tuamotu and Gambier Islands (NMNH collections). In the Centyral Pacific it appears to be strictly an inhabitant of inner reefs, preferring shallow, muddy environments such as shallow bays.

In the Cook Islands Gafrarium pectinatum known from Rarotonga, Aitutaki, Palmerston, Puka Puka, Manihiki, Rakahanga and Penhryn, probably existing on all other islands with well-developed reefs as well but being conspicuously absent from the makatea islands. It is abundant and ubiquitous on moats (BAIU-3, 4, 11, 22, 51, 80, BRAR-24, 33, 111, 112) and lagoons (BAIU-7, 43A, 45, 56, 59, 109, 120, 135, 157, 158), and occasionally occurs on reef flat beaches (BAIU-91 and 2 lots in the NMNH). It is extremely abundant in certain shallow bays, e.g. on the muddy sand flats that surround the main island of Aitutaki along its SW, S, E and especially NE sides. The extensive collections of this species from Southeastern Polynesia in the NMNH (over 75 lots) are all from inner reefs, from depths ≤5m. I have, however, on 3 occasions collected dead shells from 10-18m depths in Paopao Bay on Moorea.

GASTROCHAENIDAE

Gastrochaenid sp.

The only gastrochaenids I have seen from the Cook Islands are specimens from Manihiki (in the collection of G. McCormack) which I have not identified. McCann (1974) reports Rocellaria cuneiformis Spengler, 1793 from Manihiki. I seldom searched rocks for endolithic bivalves and they may well occur on the islands I studied.

PHOLADIDAE

Martesia ?striata (Linné, 1758)

A single broken valve of what appears to be this cosmopolitan wood-borer was collected in drift on Mauke (BMAK-18).

CONCLUSIONS

Thirty-four species of heterodont bivalves are recorded here from the Southern Cook Islands (table 1) and 27 are recorded from the Northern Cook Islands (table 2), yielding a total diversity of 39 species for the entire group. A biogeographical analysis of the 12 species that are known at present from the Southern and not the Northern Group would be inappropriate, as the latter has been poorly sampled. Among the 5 species that are known only from the Northern Cooks, 2, Fragum mundum and the gastrochaenid species, may have been simply overlooked in the south because they are small and have cryptic habits. Two others, Trapezium obesum and Periglypta crispata, are known only from deep lagoons and thus their absence from the Southern Cooks may be real, reflecting a lack of suitable habitats. The absence of the fifth species, Venus toreuma, is more difficult to explain because it lives in a variety of reef environments.

Within the Southern Cooks there is a marked decrease in bivalve diversity from Aitutaki to Rarotonga to Mauke, probably in part reflecting a decrease in the size and complexity of the reef systems, especially of inner reef habitats. A lagoon is present only on Aitutaki among the islands of the Southern Group, and 4 of the 5 species known only from Aitutaki in the Southern group are also known only from lagoon and moat habitats. The fifth species, Lonoa hawaiiensis, is known in the Cook Islands from a single specimen.

The Cook Islands' heterodont bivalve fauna does not appear to contain any endemic elements, and no species reach their eastern distributional limit in the Cooks. All of the species encountered are also found in the Society Islands, with the unlikely exception of Tridacna squamosa which at present is known further E only from Ducie. This trend contrasts greatly with that exhibited by scleractinian corals, which are much more diverse in the Cook Islands than in the Society Islands (Paulay, 1985).

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TABLE 1: HETERODONT BIVALVES OF THE SOUTHERN COOK ISLANDS

+ = recorded from island; - = not recorded from island

CHAMIDAE	Aitutaki	Rarotonga	Mauke	Mitiaro	Atiu	Mangaia	Manuae
Chama limbula	+	+	+	-	+	+	+
C. pacifica	+	-	-	-	-	-	-
C. asperella	+	+	+	-	+	+	-
C. "spinosa"	+	+	+	-	-	+	+
C. sp. 2	+	+	+	+	-	-	-
LUCINIDAE							
Codakia punctata	+	+	-	-	-	-	+
C. tigerina	-	+	-	-	-	+	-
C. bella	+	+	+	-	-	+	+
Anodontia edentula	+	+	+	-	-	-	-
CARDIIDAE							
Trachycardium orbitum	+	+	+	-	-	-	-
Fragum fragum	+	+	-	-	-	+	+
Corculum dionaeum	+	-	+	-	-	+	-
TRIDACNIDAE							
Tridacna maxima	+	+	+	-	-	+	-
T. squamosa	+	+	+	-	-	-	-
TELLINIDAE							
Tellina virgata	+	-	-	-	-	-	-
T. crucigera	+	+	-	-	-	-	+
T. palatam	+	+	-	-	-	+	-
T. scobinata	+	+	+	-	-	+	-
T. robusta	+	+	-	-	-	-	-
T. semen	+	+	+	-	-	-	-
Jactellina obliquaria	+	+	-	-	-	-	-
Loxoglypta rhomboides	+	+	+	-	-	+	-
Macoma dispar	+	-	-	-	-	-	-
PSAMMOBIIDAE							
Asaphis violascens	+	+	+	-	-	+	+
SEMELIDAE							
Semele australis	+	+	+	+	-	-	+
Abra seurati	+	+	-	-	-	-	-
Lonoa hawaiiensis	+	-	-	-	-	-	-
Semelangulus sp.	-	+	-	-	-	-	-
TRAPEZIIDAE							
Trapezium oblongum	+	+	+	+	-	+	+
VENERIDAE							
Periglypta reticulata	+	+	+	-	-	+	+
Lioconcha ornata	+	-	-	-	-	-	-
Pitar prora	+	+	-	-	-	-	-
Gafrarium pectinatum	+	+	-	-	-	-	-
PHOLADIDAE							
Martesia ?striata	-	-	+	-	-	-	-

TABLE 2: HETERODONT BIVALVES OF THE NORTHERN COOK ISLANDS

1= NMNH collections; 2 = G. McCormack collections; * = not recorded from Southern Cooks

CHAMIDAE	Palmerston	Suwarrow	Nassau	Pukapuka	Manihiki	Rakahanga	Penhryn
Chama limbula	1	1	-	-	-	-	-
C. pacifica	-	-	-	-	1	-	-
C. asperella	1	-	-	-	1	1	-
C. "spinosa"	-	1	-	-	-	-	-
LUCINIDAE							
Codakia punctata	1	-	-	-	-	-	-
C. tigerina	-	2	-	-	-	-	-
C. bella	1,2	1,2	2	-	2	2	-
Anodontia edentula	1	-	-	-	2	-	-
CARDIIDAE							
Trachycardium ?orbitum	-	2	-	-	-	-	-
Fragum fragum	1,2	2	-	-	1,2	1,2	2
*F. mundum	-	1	-	-	-	-	-
TRIDACNIDAE							
Tridacna maxima	2	2	-	-	2	-	-
TELLINIDAE							
Tellina crucigera	1	-	-	-	-	-	-
T. palatam	1	-	-	2	1,2	-	-
T. scobinata	1,2	2	-	-	-	2	-
Jactellina obliquaria	1	-	-	-	-	-	-
Macoma dispar	-	-	-	-	-	2	-
PSAMMOBIIDAE							
Asaphis violascens	1,2	1	-	1	2	-	-
SEMELIDAE							
Semele australis	1	-	2	-	-	-	-
TRAPEZIIDAE							
Trapezium oblongum	1	1,2	2	1	-	1,2	-
*Trapezium obesum							
VENERIDAE							
*Venus toreuma	-	2	-	-	-	-	-
Periglypta reticulata	1	-	-	-	-	2	-
*Periglypta crispata	-	-	-	-	2	-	-
Lioconcha cf. ornata	-	-	-	2	-	-	-
Gafrarium pectinatum	1	-	-	2	2	2	2
GASTROCHAENIDAE							
*Gastrochaenid sp.	-	-	-	-	2	-	-

TABLE 3: HABITAT SPECIFICITY OF COOK ISLANDS' HETERODONT BIVALVES

For this table, moats and lagoons were separated artificially by a 3m boundary.
++ = common; + = rare; - = absent.

CHAMIDAE	Outer reef slope	Reef flat	Moat	Lagoon
Chama limbula	+	++	++	++
C. pacifica	-	-	+	++
C. asperella	++	++	++	++
C. "spinosa"	?	++	+	-
C. sp. 2	++	?	-	+
LUCINIDAE				
Codakia punctata	+	-	++	++
C. tigerina	+	-	++	++
C. bella	++	++	++	++
Anodontia edentula	++	-	++	++
CARDIIDAE				
Trachycardium orbitum	++	-	-?	++ (deep)
Fragum fragum	-	+	++	++
F. mundum	-	++	++	-
Corculum dionaeum	-	++	++	-
TRIDACNIDAE				
Tridacna maxima	++	++	++	++
T. squamosa	++	-	-	?
TELLINIDAE				
Tellina virgata	-	-	++	++
T. crucigera	++	-	++	++
T. palatam	-	+	++	++ (shallow)
T. scobinata	++	++	++	++
T. robusta	-	-	++	++
T. semen	++	-	++	++
Jactellina obliquaria	++	++	++	++
Loxoglypta rhomboides	++	-	++	++
Macoma dispar	-	-	+	++
PSAMMOBIIDAE				
Asaphis violascens	-	++	++	-
SEMELIDAE				
Semele australis	++	++	++	++
Abra seurati	++	-	++	++
Lonoa hawaiiensis	++	-	-	-
Semelangulus sp.	+	+	?	?
TRAPEZIIDAE				
Trapezium oblongum	++	++	++	++
Trapezium obesum	-	-	-	++
VENERIDAE				
Venus toreuma	++	-	++	++
Periglypta reticulata	+	++	++	-
P. crispata	-	-	-	++
Lioconcha ornata	+	-	++	++
Pitar prora	-	-	++	++
Gafrarium pectinatum	-	+	++	++

APPENDIX: Collection data for specimens cited.

Specimens are from the following islands: BAIU = Aitutaki; BMAK = Mauke; BRAR = Rarotonga; BATI = Atiu; BMNG = Mangaia. All specimens were collected by me, except on Aitutaki: collections also by B. Holthuis and on Mauke: collections also by K. and G. McCormack

BAIU-3: Beach Rapae & N, main I
BAIU-4: Loc.208-209, moat off Rapae, 0.5-1.5m
BAIU-7: Loc. 211, Tapuaetai Motu beach
BAIU-8: E beach, main island
BAIU-9: Loc. 210, S lagoon, 0.5m, on patch reef, live
BAIU-10: Loc. 210, S lagoon, 0-4m, dead
BAIU-11: Loc. 248, Ureia beach
BAIU-12: Loc. 249, moat at Ureia, live in sand
BAIU-22: N Ureia beach
BAIU-24: Loc. 251, outer reef flat, Ureia, 0.5m, dead
BAIU-25: Loc. 251, outer reef flat, Ureia, 0.5m, live, under rock on sand
BAIU-26: Loc. 251, outer reef flat, Ureia, live, attached to underside of rock
BAIU-27: Loc. 251, outer reef flat, Ureia, live, exposed
BAIU-29: N Ureia, outer reef flat, dead
BAIU-36: N Ureia, moat, live in sand
BAIU-39: Loc. 253, near beach on reef flat, N Ureia, dead
BAIU-41: Loc. 255, W outer reef slope, 21-24m, dead
BAIU-43A: Loc. 256, beach and muddy bay, dead
BAIU-44A: Loc. 257, inner moat NW main I, 0.5-1m, dead
BAIU-45: Loc. 260, SW main lagoon, 1-2.5m, dead
BAIU-46: Loc. 260, SW main lagoon, live, in muddy sand
BAIU-50: Loc. 259, SW shore, main island, 5cm, on mud, near shore, live
BAIU-51: Loc. 261, W/NW outer moat, 0.5-1m
BAIU-55: Loc. 262, outer lagoon at mid S reef, 1.5m, live, buried in sand
BAIU-56: Loc. 262, outer lagoon at mid S reef, live, in sand under rock
BAIU-59: Loc. 262, outer lagoon at mid S reef, 0.5-1.5m, dead
BAIU-71: Loc. 264, NW outer reef slope, 24-27m, dead
BAIU-74: Loc. 268, W/SW outer reef slope, 15-18m, dead
BAIU-79: Loc. 269, E outer reef slope, 12-19m, dead
BAIU-80: N beach
BAIU-82: Loc. 268, SW/W outer reef slope, 24-30m, dead
BAIU-91: Loc. 271, Akaiami motu, seaside beach
BAIU-93: Loc. 273, SW/W outer reef slope, 33-36m, dead
BAIU-106: Loc. 271, Akaiami motu, outer reef flat, dead
BAIU-109: Beach & lagoon dredgings at Tautu wharf
BAIU-111: Loc. 274, NW/W outer reef slope, 20-23 m, dead
BAIU-114: Loc. 271, lagoon adjacent to Akaiami motu, 1-3m, dead
BAIU-118: Loc. 277, mid lagoon, 5-6m, live in sand
BAIU-120: Loc. 277, mid lagoon, 5-6m, dead
BAIU-121: Loc. 278, mid lagoon, 5-6m, live, in sand
BAIU-124: Loc. 275, mid lagoon, 4-6m, live, in sand
BAIU-125: Loc. 275, mid lagoon, 4-6m, dead
BAIU-128: Loc. 276, SW lagoon: outer reef flat, dead

BAIU-130: Loc. 280, NE outer reef slope, 12-19m, dead
BAIU-131: Loc. 280, NE outer reef slope, 14-18m, dead
BAIU-133: Loc. 282, N/NW outer reef slope, 19-21 m, dead
BAIU-134: Loc. 279, SW lagoon, 4-7m, live in sand
BAIU-135: Loc. 279, S lagoon, 4-7m, dead
BAIU-147: Loc. 284, N outer reef slope, 26-27m, dead
BAIU-149: Loc. 283, moat NE main I, live underside of rock
BAIU-150: Loc. 283, NE main island moat, 0.5m, live, half buried under rock
BAIU-151: Loc. 277/8, W big lagoon, patch reefs, live, exposed
BAIU-152: NW outer moat, 0.5m, exposed on rubble, live
BAIU-157: Loc. 278, midW big lagoon, 2-5m, dead
BAIU-158: Middle big lagoon, 1-6m, dead

BRAR-2: Loc. 15, Avatiu outer reef slope, 15-25m, dead
BRAR-12: Loc. 19, Avatiu harbor entrance outer reef slope, 9-15m, dead
BRAR-14: Loc. 20, Matavera outer reef slope, 3-7m, dead
BRAR-16: Loc. 20, Matavera outer reef slope, 3m, live, in crevice on reef
BRAR-21: Matavera outer reef slope, 10-20m
BRAR-24: In dredged fine shelly sand from Avatiu harbor
BRAR-25: Arorangi fringing reef, dead
BRAR-27: Loc. 23, Ngatangiia fringing reef, dead
BRAR-28: Loc. 23, Ngatangiia sand flat landward of motu, live, on surface
BRAR-30: Loc. 24, moat at the Rarotongan, 0.2-1m, live in sand
BRAR-31: Loc. 24, moat at the Rarotongan, 0.2-1m, dead
BRAR-33: Arorangi beach
BRAR-40: Loc. 26, reef flat W of Avaavaroa, 0.5m, live in sand
BRAR-42: Loc. 26, reef flat W of Avaavaroa, live underside of rocks
BRAR-43: Loc. 26, reef flat W of Avaavaroa channel, 0.1-0.7m, dead
BRAR-46: Loc. 27, Avarua outer reef slope, 14-17m, dead
BRAR-51: Loc. 30, Titikaveka moat, 0.2-1m, live nestled in dead Lobophyllia head
BRAR-52: Loc. 30, Titikaveka moat, 0.2-1.5m, dead
BRAR-53: Loc. 30, Titikaveka lagoon, 1.5m, live in rubble/sand
BRAR-58: Loc. 32, Avarua outer reef slope, 15-18m, dead
BRAR-59: Loc. 33, N Matavera fringing reef, 0-0.3m, live on undersides of rock
BRAR-61: Loc. 33, N Matavera reef flat, 0-0.3m, dead
BRAR-62: Outer reef slope, 5-25m, live, coll. D. Simms
BRAR-66: Matavera outer reef slope, 15-20m, dead
BRAR-71: Loc. 33, N Matavera fringing reef, nestled among rubble, live
BRAR-74: Tupapa outer reef slope, 10-20m, dead
BRAR-77: Loc. 42, Nikao fringing reef, attached to rock, live
BRAR-80: Arorangi beach
BRAR-86: Near Avaavaroa passage, on fringing reef, dead
BRAR-88: N Matavera reef flat, live, underside of rock, intertidal
BRAR-89: N Matavera reef flat, live, attached to rock, intertidal
BRAR-90: N Matavera fringing reef, nestled among rubble, live
BRAR-93: In Rutaki passage, 12-18m, dead
BRAR-94: Ngatangiia sand flats, dead
BRAR-95: Avarua outer reef slope, 8-13m, dead
BRAR-96: Avarua outer reef slope, 11m, live, hidden in dead coral
BRAR-101: Nikao, mid fringing reef, on rubble under rock, live

BRAR-105: Loc. 156, Avarua outer reef slope, 12-15m, dead
BRAR-111: Nikao beach
BRAR-112: Loc. 213, reef &beach at Motu Toa, dead
BRAR-114: Loc. 214, Nikao, moat, dead
BRAR-115: Loc. 214, Nikao moat, live underside of rock
BRAR-116: Loc.215, Tupapa moat, live attached underside of rock
BRAR-117: Loc. 214, Nikao moat, half-buried in sand, live
BRAR-118: Outer reef slope, live, coll. D. Simms
BRAR-119: Outer reef slope, dead

BMAK-9: Loc. 65, S Taunganui Landing, outer reef slope, 12-22m, dead
BMAK-11: E beaches
BMAK-12: Misc. beaches
BMAK-13: N beaches
BMAK-16: Loc. 91, near Anaio, moat, buried in sand/rubble
BMAK-17: E & SE beaches
BMAK-18: E beaches
BMAK-19: E to SW beaches
BMAK-20: Loc. 94, Kimiangatau outer reef slope, 20-24m, dead in rubble channel
BMAK-21: E to SE beaches
BMAK-22: Loc. 86, Taunganui outer reef slope, 14-18m, live under rocks
BMAK-23: Loc. 95, Kimiangatau outer reef slope, 18-24m, dead
BMAK-24: Loc. 84, Tukume Landing outer reef slope, 18-21m, dead
BMAK-27: Misc. beaches
BMAK-28: Loc. 94, Kimiangatau outer reef slope, 18-24m, live on underside of rock
BMAK-29: Loc. 66-67, nr. Taunganui Landing, outer reef slope, 14-24m, dead
BMAK-31: Taunganui Landing outer reef slope, 15-18m, dead in sand/rubble channel
BMAK-32: Nr. Taunganui Landing, 12-20m, dead on sand
BMAK-34: Taunganui outer reef slope, 18-24m, dead on/in sand
BMAK-35: NE beaches
BMAK-36: Loc. 86, Taunganui Landing outer reef slope, 14-18m, dead
BMAK-38: Near Taunganui outer reef slope, 20-25m, dead in sand
BMAK-39: E beaches
BMAK-40: Near Anaputa, outer reef slope, 3-7m, live
BMAK-41: Loc. 66, nr. Taunganui Landing, outer reef slope, 14-18m, dead
BMAK-42: E beaches
BMAK-43: Loc. 70, nr. Taunganui Landing, outer reef slope, 12-18m, dead
BMAK-44: Loc. 64, Nr. Taunganui Landing outer reef slope, 6-15m, dead
BMAK-68: Loc. 84, outer reef slope, 18-21m, live, exposed on coral rubble
BMAK-69: Near Taunganui landing, outer reef slope, 18-21m, live in sand
BMAK-70: Loc. 93, Uriaata Landing, reef flat, buried live in sand
BMAK-71: Loc. 78, Kimiangatau, outer reef slope, 50-52m, dead
BMAK-73: Loc. 85, Anaio Landing, outer reef slope, 24-27m, dead
BMAK-74: Loc. 83, outer reef slope off Po'oki Landing, 6m, live, attached to bare reef

BATI-1: Reef flat SE of Tanganui landing, dead
BATI-3: Outer reef slope, 2-12m, live, attached to Leptoria

BMNG-2: Beach nr. Oneroa landing

BMNG-4: Ivirua beach
BMNG-5: Reef flat at & N of Oneroa, live
BMNG-6: Reef flat at & N of Oneroa, dead

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