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EXECUTIVE SUMMARY

Excavations in a deeply stratified coastal site (AS-13-1) at To'aga, Ofu Island, in the Manu'a group of American Samoa, yielded evidence of human occupation spanning the entire Samoan cultural sequence. The earliest deposits, dated to 3700-3300 BP, may represent a Lapita Period occupation, although the present sample is very limited. An Ancestral Polynesian phase, dated from 2500-1900 BP, is well attested, with abundant Polynesian Plainware ceramics, simple one-piece fishhooks, and other artifacts and associated faunal materials. Aceramic deposits, dated after 1900 BP, are also present. A model for the geomorphological evolution of the site, incorporating sea level change and the effects of human impact on the landscape, is presented. This model will be especially useful in future attempts to locate archaeological deposits dating to the earliest periods of Samoan prehistory.

Site AS-13-1 has been shown to be a highly significant archaeological site for the following reasons: (1) the site is well-stratified, with discrete assemblages dating to various time periods in Samoan prehistory; (2) it is virtually the only site known at present within American Samoa that encapsulates within its stratigraphic sequence virtually the entire prehistory of American Samoa; (3) depositional conditions at the site are conducive to excellent preservation of a range of bone and shell objects

(both artifacts and faunal materials), as well as pottery and stone, thus yielding a very broad array of material culture remains and other evidence upon which the prehistory of American Samoa may be constructed; (4) the site has been shown to yield significant new data bearing on the formative stages of Polynesian culture, and is thus of critical importance not only for local Samoan archaeology and prehistory, but for broader regional issues of Polynesian culture history.

A portion of the Toaga site was destroyed by land-fill operations prior to our initial fieldwork in 1987; since that time there has been no further disturbance, and the site does not appear to be immediately threatened by development activities. However, given the great significance of the site, it is important that its exact horizontal extent be determined, and that it be nominated to the National Register of Historic Places. A further phase of field investigations was carried out in 1989 (under a separate contract from that reported herein) which will permit the preparation such a nomination.

INTRODUCTION

Background to the Project

Extensive archaeological work in the Western Samoan islands of Upolu and Savai'i has shown the prehistory of the archipelago to have a time depth of three millennia, beginning with classic Lapita colonization by about 3000 BP (Green and Davidson 1969, 1974; Jennings et al. 1976; Jennings and Holmer 1980; Davidson 1979; Leach and Green 1989). Within Samoa, the transition from Lapita to distinctive early Polynesian forms of material culture is particularly well attested, especially in ceramics (the sequence from Early Eastern Lapita through Late Eastern Lapita to Polynesian Plain Ware) and stone adzes (Green 1971; 1974). Thus Samoa, along with the Tongan archipelago (including such outliers as Niuatoputapu), forms part of a "homeland region" within which Ancestral Polynesian culture developed out of an older Lapita culture (Green 1981; Kirch and Green 1987). Primarily on linguistic criteria (Green 1966), but also on grounds of most plausible voyaging routes (Finney 1988; Irwin 1989), Samoa has also been identified as the likely point of departure for voyagers who moved eastwards to colonize the archipelagos of Central Eastern Polynesia. Consequently, an understanding of the early or Ancestral Polynesian phase of the Samoan prehistoric

sequence is of critical importance to Polynesian prehistory as a whole.

Ancestral Polynesian culture has been defined as "the social forms and supporting technological base that emerged from the Lapita transition" in the Western Polynesian region by about 2500 BP (Kirch 1984:52), and prior to the later differentiation of distinctive Samoan, Tongan, Futunan, and 'Uvean cultures after about 1700 BP. As Kirch and Green (1987:438) have argued, a detailed knowledge of Ancestral Polynesian culture is essential to an evolutionary understanding of the entire Polynesian region. A summary of current information on Ancestral Polynesian culture, based both on archaeological evidence and on lexical reconstruction, is presented by Kirch (1984:53-67).

Despite the obvious significance of Ancestral Polynesian culture, direct archaeological evidence of this phase of the Samoan sequence, dating from about 2500-1700 BP, has been limited primarily to a few sites on the island of Upolu. These include Sasoa'a (SU-Sa-3) in the Falefa Valley, and the SU-Va-1, and Va-4 sites at Vaialele investigated by the University of Auckland expedition (Green and Davidson 1969, 1974), all of which yielded important pottery and stone adze assemblages. Acidic depositional contexts, however, precluded the preservation of any shell or bone materials at these sites. Subsequent excavations at

two middens (Falemoa, SM17-2, and Potusa, SM17-1) on Manono Islet, and at Jane's Camp (SU-F1-1) on Upolu, by the University of Utah expedition (Jennings et al. 1976; Jennings and Holmer 1980) added further assemblages dating to this period, including the first faunal materials and a few shell artifacts, in addition to the ubiquitous pottery. In American Samoa, Clark and Herdrich (1988:71-85, 173) carried out limited test excavations at a pottery-bearing site (AS-21-5, Locality 2) in the 'Aoa Valley on Tutuila Island. The precise chronology of the 'Aoa deposits remain undetermined, however. A few potsherds were also reported by Best, Leach, and Witter (1989:34-35) at the Tataga-Matau adz quarry site on Tutuila. However, most archeological sites recorded in American Samoa post-date the period of ceramic use (i.e., after about A.D. 300). Surveys of these later, aceramic sites are provided by Clark (1980) and Kikuchi (1963); for a summary of other archaeological work in American Samoa, see Hunt and Kirch (1988:153-154) and Clark and Herdrich (1988:7-9).

The Manu'a Archaeological Project

In 1986 PVK and TLH initiated a long-term archaeological project in the Manu'a Islands, the most easterly group of the Samoan Archipelago (Hunt and Kirch 1988). Among other goals, we anticipated that a sequence of time depth parallel to that already defined for Western

Samoa could be developed for Manu'a, thus providing a more balanced picture of Samoan prehistory. An initial season of intensive reconnaissance on Ta'u, Ofu, and Olosega Islands revealed a variety of prehistoric sites, including evidence at two localities for sub-surface occupation deposits containing Polynesian Plain Ware ceramics. In 1987 we returned to one of these localities, To'aga (site AS-13-1) on Ofu Island, for more intensive subsurface testing and excavation. Since the AS-13-1 site appeared to be the first such archaeological site in American Samoa with well-preserved materials of Ancestral Polynesian age, it was essential that the nature and extent of this site be more clearly defined. Determination of the site's extent, age, stratigraphic nature, and cultural significance are essential if it is to be nominated to the National Register of Historic Places, and thereby offered some measure of protection. As a result of the 1987 investigations, a deep, well-stratified occupation sequence was exposed at AS-13-1, spanning much of the Samoan sequence, and particularly rich in material remains dating to the Ancestral Polynesian phase. A coastal site with calcareous sand deposits, To'aga has excellent preservation not only of ceramics and lithics, but of bone and shell materials as well. In this report we describe the 1987 excavations at the To'aga site, their implications for our understanding of Ancestral Polynesian culture, and the cultural and archaeological significance of the site. (NOTE: Further investigations at AS-13-1 were

undertaken during the summer of 1989, as part of a third phase of the Manu'a Project. The results of these latest investigations are not dealt with here, as they were carried out under the terms of a separate contract, but will be reported in detail in a final report on the 1989 project.)

THE RESEARCH AREA

The To'aga site is situated on Ofu Island (Fig. 1), lying 100 km east of Tutuila Island. Ofu, along with its adjacent twin island Olosega, consists of a Plio-Pleistocene shield volcano with steep slopes rising dramatically to heights of 638 m above sea level. Ofu Island has a total land area of only 3.4 km², inhabited by about 250 Samoans. Less than 9% of the land area has slopes of less than 30%, with most of the surface topography of the island consisting of steep flow slopes of the volcanic cone, or of precipitous cliffs. Consequently, human settlement has always been confined to the very narrow, discontinuous coastal flats, especially on the SW and SE sides of the island. These flats range from about 100-200 m wide, and derive from the accumulation of colluvial materials and calcareous sands. The USDA soil survey of American Samoa (Nakamura 1984) mapped these areas as "Aua very stony clay loam" and "Negedebus mucky sand." The extent of these formations is indicated in Figure 1 with stippling. Today, habitation is confined to Ofu Village, situated along the SW side of the

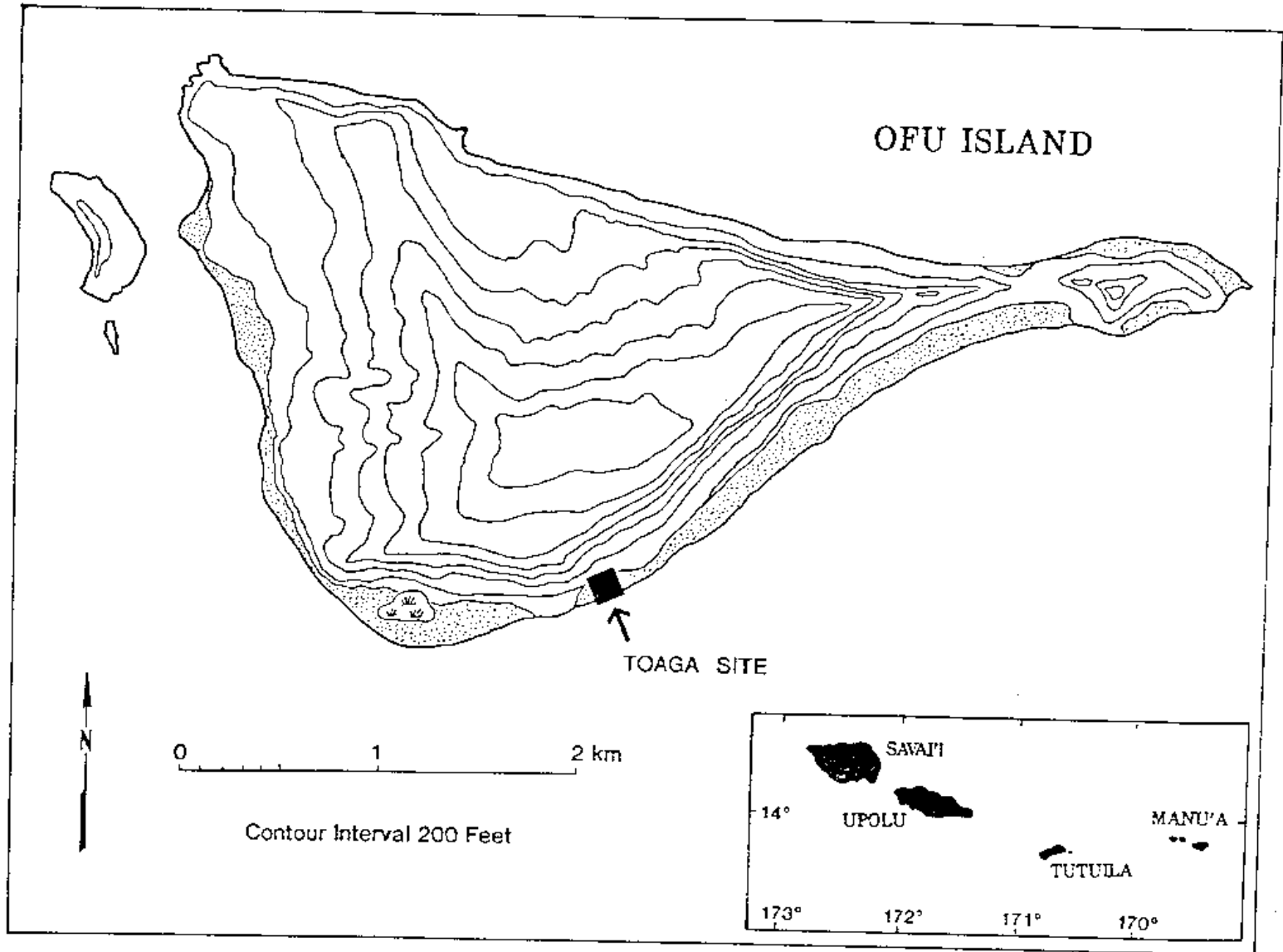


Figure 1. Map of Ofu Island, showing the location of the To'aga site; inset shows the position of the Manu'a group within the Samoan archipelago. The stippled area indicates the distribution of Ngedebus Mucky Sand and Aua Very Stony Silty Clay Loam.

island, with the best access to garden lands on the less steep volcanic slopes.

The To'aga site lies on the narrow SE coastal flat, which varies from 75-175 m wide, and is about 2 km long (Fig. 1). The flat is fronted by a broad fringing reef, and by a continuous sand beach. Exposed 'beach rock' at various points along this shoreline, as well as eroding coconut palms and other trees, indicate that the shoreline is unstable. Inland, the coastal flat abruptly turns into a steep colluvial-talus slope, over which towers a precipitous cliff, rising to heights of up to 400 m (the Le'olo Ridge). This cliff, the result of massive faulting and collapse of the shield volcano, exposes a complex sequence of lava flows with intercalated beds of ash, tuff, and breccia of the Asaga and Tuafanua Formations, of Pliocene age (Stice and McCoy 1968).

The To'aga site thus occupies an "interfacial" geomorphological setting, in which both mass wasting of terrigenous sediments, and accumulation of beach ridge calcareous sediments (by both low and high energy processes) continue to play key roles. A major objective in our excavations has been the interpretation of site stratigraphy in terms of these geomorphic processes, in order to understand not only the sequence of cultural occupation, but of the formation of the coastal plain itself. Given the very

restricted area of flat land on the island, this coastal strip was an extremely significant resource zone to the prehistoric inhabitants, and indeed, continues to be intensively utilized by the contemporary population. Today, the To'aga flat provides an important zone of mixed arboriculture (especially of breadfruit, *Artocarpus altilis*) and swidden cultivation (particularly of bananas and *Alocasia taro*). Abundant feral populations of the cultigen species *Dioscorea bulbifera*, *Tacca leontopetaloides*, *Cordyline fruticosa*, and *Morinda citrifolia* attest to the intensity of cultivation of this zone in the past.

Aside from the value of the To'aga flat for intensive cultivation, prehistoric inhabitants had access to the marine resources of the broad fringing reef, including a variety of molluscs (particularly large *Turbo* gastropods found on the outer reef crest) and sea urchins, and reef fish (such as Scaridae and Labridae which are common just off the reef edge). Other faunal resources in the vicinity of the site include the white-tailed tropic bird (*Phaethon lepturus*) which nests in the overshadowing cliffs, and fruit bats (*Pteropus* sp.) which are frequently seen at dusk.

Although our research objectives were aimed primarily at the buried cultural deposits containing ceramics, the To'aga area also has many surface indications of late prehistoric or early historic Samoan settlement. In the

immediate vicinity of the 1987 excavations, these features include a roughly oval, slightly elevated pavement of waterworn volcanic pebbles ('lili'lili) representing a house floor pavement, and a large talus boulder with several large oval depressions on its flat upper surface, resulting from adz grinding and polishing (Fig. 2). The area also has a number of depressions (ca. 1-2 m diameter) that probably are filled masi or breadfruit fermentation pits, and various crude, low rock alignments or low terraces associated with gardening activities.

THE 1987 TO'AGA SITE EXCAVATIONS

The To'aga site (AS-13-1) was initially discovered during reconnaissance survey in 1986, when examination of a deep bulldozer cut that had been excavated by the Public Works Department for a sanitary landfill disturbed a buried cultural deposit containing Polynesian Plain Ware ceramics (Hunt and Kirch 1988:168). A 1-m² test excavation adjacent to the bulldozed area yielded an uncorrected ¹⁴C age of 2,350 ± 50 BP (Hunt and Kirch 1987) in direct association with the pottery.

Returning to the site in 1987, we turned our attention to the coastal flat immediately NE of the landfill, which had not been disturbed by bulldozing (Fig. 2). As can be seen in the transect profile in Figure 3, this flat is about

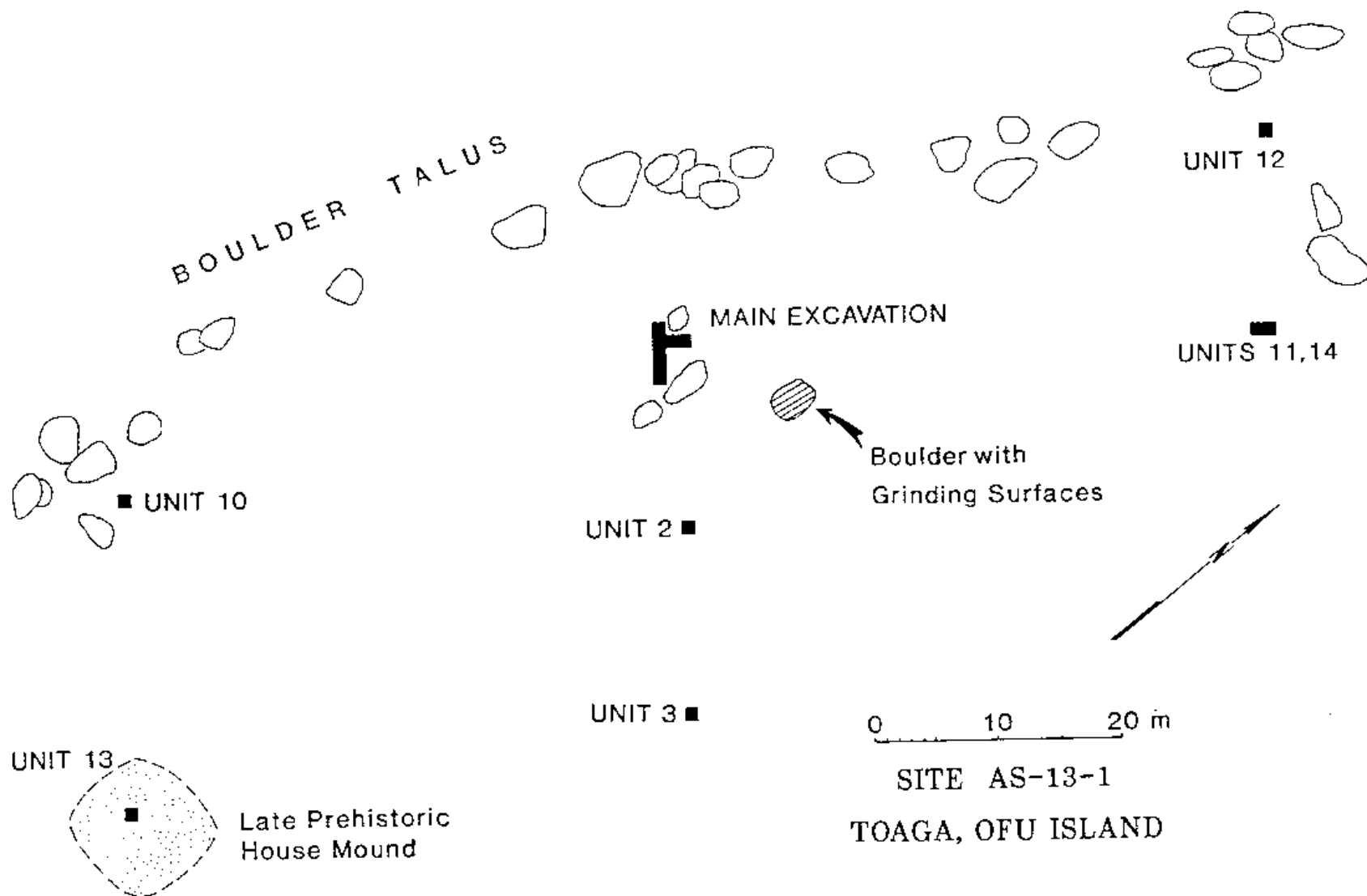


Figure 2. Map of the To'aga site, AS-13-1, showing the locations of excavations carried out in 1987. The Ofu land-fill cut, in which ceramics were first discovered in 1986, lies slightly to the southwest of the mapped area.

125 m wide from the base of the steep colluvial-talus slope to the present shoreline. Using the systematic transect strategy effectively developed for sub-surface sampling in similar coastal settings in Niuaotuputapu and Tikopia (Kirch and Yen 1982; Kirch 1988), we laid out a transect baseline extending across the To'aga coastal flat, at a location 60 m NE of the Ofu landfill site. Excavations proceeded by natural stratigraphy, with finer arbitrary subdivisions between natural layers where this was deemed advisable. All excavated earth was screened through 0.25-inch mesh sieves, and 100% of all faunal and artifactual materials retained for laboratory analyses. Detailed plan records were kept for each excavation level, and measured profiles were drawn of all key sections following the completion of excavations. A 35-mm photo record was maintained during excavation. All artifacts and other specimens recovered during the project are presently housed in the Archaeological Research Facility, University of California at Berkeley, pending their final disposition by the American Samoa Government.

The first three units excavated along the systematic transect (at 0, 15, and 45 m from the base of the talus slope) revealed a complex and deep cultural stratigraphy in Unit 1, but only shallow cultural deposits overlying calcareous beach sands in the seaward units 2 and 3. A shovel test at 105 m further along this transect, near the crest of the modern beach ridge, revealed a total absence of

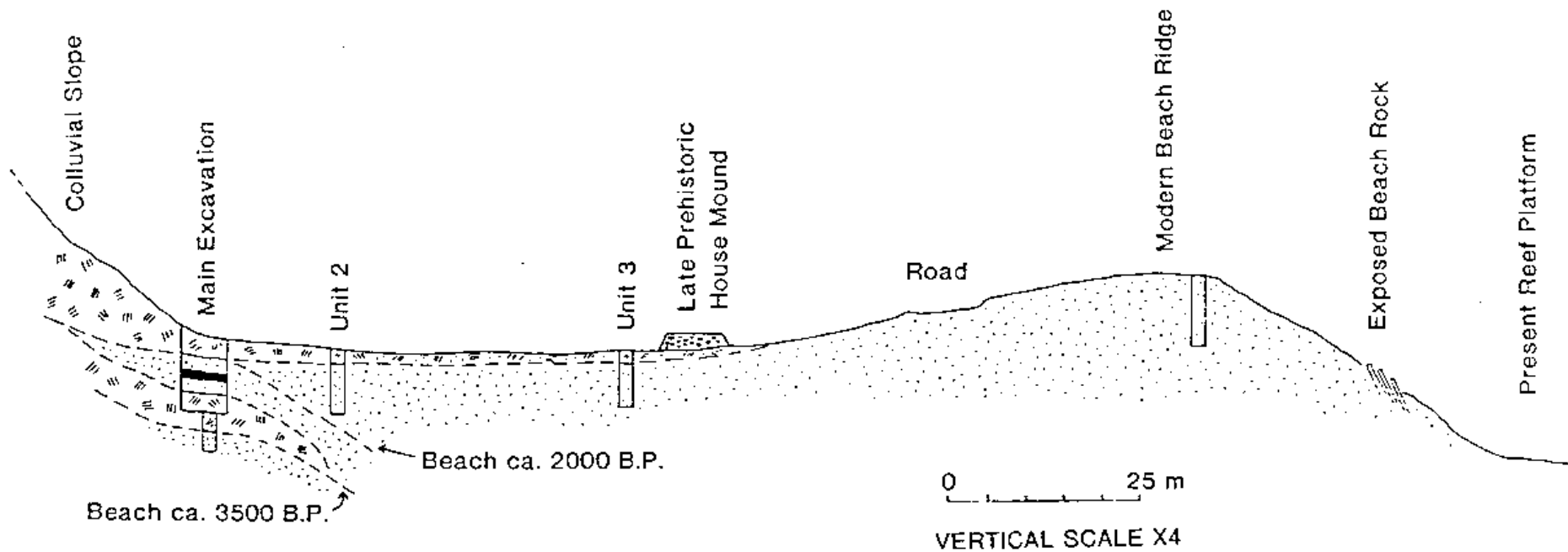


Figure 3. Profile through the To'aga site along the transect connecting excavation units 1, 2, and 3, extending from the base of the colluvial slope to the edge of the reef platform.

cultural deposits, with only calcareous sand. These tests thus demonstrated that the oldest cultural deposits were to be found close to the base of the steep talus and volcanic cliff, and that most of the coastal flat consisted of coral sands and reef detritus, which had been deposited during seaward progradation during the past 2-3000 years.

Following these initial transect tests, Unit 1 was expanded into a larger excavation in order to effectively sample the deep stratigraphic sequence, including in-situ deposits of Polynesian Plain Ware ceramics. Units 4-9 were excavated, joining with Unit 1 to form a T-shaped trench, as shown in Figure 2. All units were dug through the Layer II calcareous sand deposit containing pottery, while Units 1 and 6 were carried deeper, into underlying Layers III and IV (see Stratigraphy below).

The third stage of our excavation strategy was to determine the lateral extent of the early pottery-bearing deposits SW and NE of the main excavation, parallel to the base of the talus. Unit 10 was thus laid out 45 m SW of the baseline transect, as close to the base of the talus as feasible (actually set in among several massive rockfall boulders). This revealed a similar stratigraphy to that in the main trench, including deeply buried cultural deposits with Polynesian Plain Ware, and one fine, thin-ware sherd. Unit 11 was then laid out 45 m NE of Unit 1. In order to get

as close to the base of the talus, another test was laid out 15 m NW of Unit 11, at the very foot of the talus, designated Unit 12. Unit 11 revealed ceramic-bearing deposits, but these were truncated by a large, deep pit (probably a late prehistoric masi or breadfruit-fermentation pit), and so an adjacent square, Unit 14, was opened to clarify the stratigraphy. In Unit 12, a massive deposit of colluvium and large angular boulders had to be penetrated to a depth of 1.8-1.9 m before we were able to reach a thin deposit of calcareous sand containing four thin, fine-tempered potsherds (one rim and four body sherds).

These test units indicated that the early cultural deposits at To'aga extend over a distance of at least 105 m NE of the Ofu landfill, in a narrow zone at the base of the colluvial-talus slope. There is no reason to believe that we have discovered the full extent of these deposits, which may well extend further along the To'aga flat. (NOTE: Additional systematic transects to test this possibility were excavated during the 1989 field season, to be reported in detail in a subsequent report. They revealed that the site does extend for several hundreds of meters along the southern Ofu Island coastline.)

A final test, Unit 13, was opened in the center of a low pavement of waterworn pebbles (*lililili* in Samoan) that apparently marks a later prehistoric house floor. Our

objective in excavating Unit 13 was to obtain a sample of the later prehistoric midden and possibly artifacts to contrast with the older, ceramic-associated assemblage.

STRATIGRAPHY

Although the site stratigraphy varies from unit to unit, the most complete depositional sequence is revealed in the main trench excavations (Units 1, 4-9), and reflected also in Units 10, 11, 12, and 14. Seaward of the main trench, Units 2 and 3 display simpler stratigraphic profiles, resulting from the later progradation of calcareous beach sands.

Stratigraphy of the Main Trench

The western profile of the main trench is shown in Figure 4, in which all of the principal depositional units are represented. Results of laboratory analysis of sediment samples removed from this western trench profile are presented in Table 1. The stratigraphic units are as follows:

Layer IA: this is the upper 15-20 cm portion of the upper colluvial which has been heavily reworked by gardening; various planting pits or depressions are detectable in the section.

Layer IB: a massive deposit of reddish brown colluvium, very

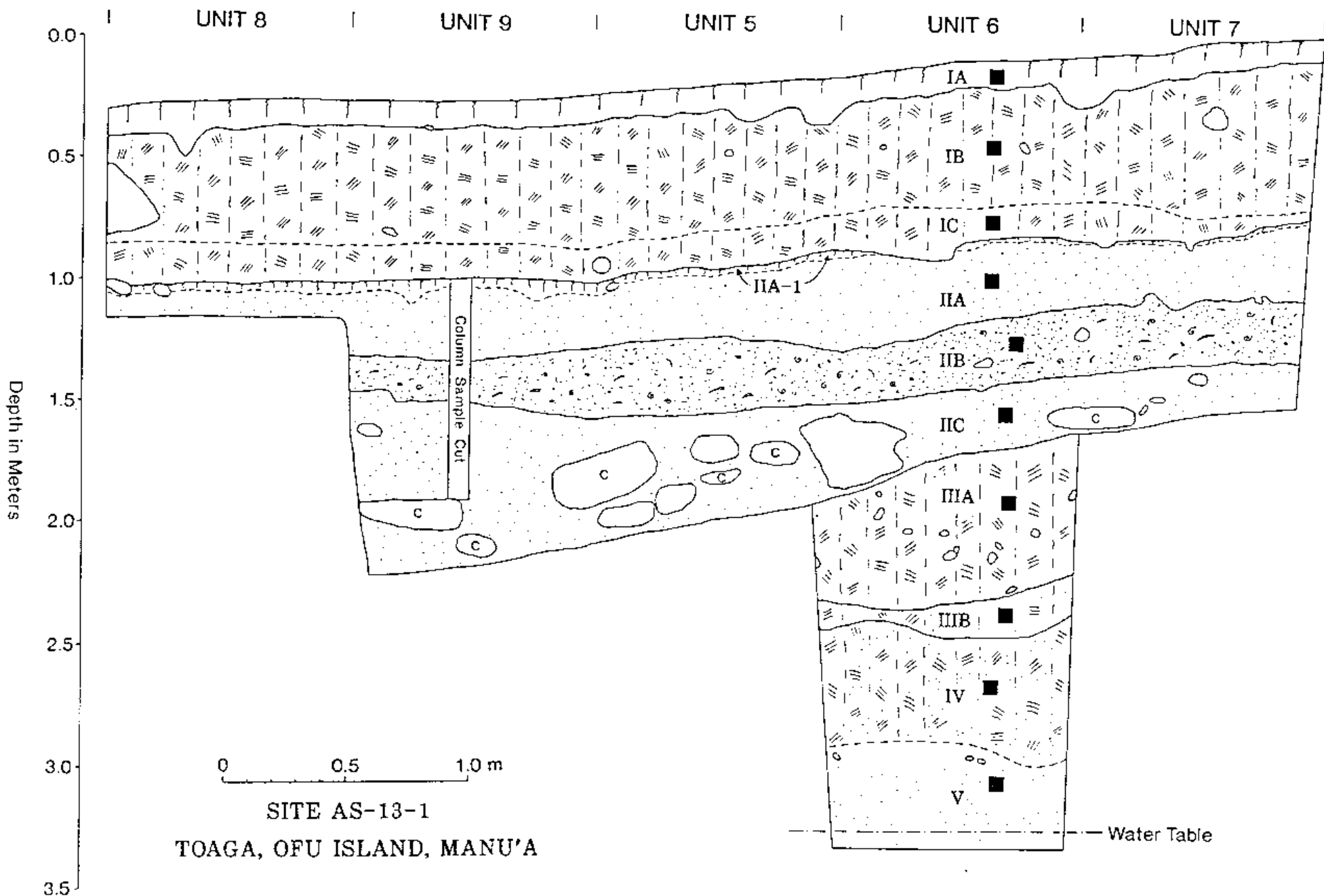


Figure 4. Stratigraphic section of the grid west face of the main excavation trench (Units 5-9). The black squares indicate the locations of sediment samples described in Table 1. Cobbles designated with "C" are of coral; other cobbles are volcanic.

compact, with no internal lensing or bedding evident. No charcoal flecking was observed. The deposit incorporates numerous angular to subangular weathered volcanic lithic fragments in the gravel-to-pebble size range. A small lens-shaped pocket of slightly darker soil containing charcoal flecking was noted within IB (designated Feature 1), and may represent a garden burn feature (this does not appear in the section shown in Figure 4 because Feature 1 was visible only in the east profile.). This would suggest that Layer IB accumulated gradually, and that the land surface was intermittently gardened during its deposition.

Layer IC: this is the basal 15-20 cm the upper colluvium, and is somewhat darker than the overlying IB, containing dispersed flecks and chunks (5-10 mm) of charcoal. The deposit is associated with an earth oven feature in Unit 9 (only in the eastern portion of the unit), and the charcoal (which is concentrated in a zone around the oven) appears to have derived from oven rake outs. Some thick, coarse-tempered pottery was also recovered from this deposit. It does not appear to have been a permanent occupation, however, and may represent a short-term or intermittent occupation such as a field shelter on the former land surface.

Layer II: This unit with its subdivisions represents a period of active deposition of a calcareous beach ridge.

Table 1

Sediment Analysis of Samples from the Toaga Site*

LAYER	% SAND	% SILT	% CLAY	pH	% ORGANIC MATTER	% CaCO ₃	COLOR DRY	COLOR MOIST
IA	69.11	18.28	12.61	6.82	7.26	2.24	10 YR 3/1.5	7.5 YR 3/2
IB	78.26	13.58	8.18	6.71	3.49	1.61	10 YR 3/2	5 YR 3/3
IC	54.00	16.38	29.61	6.92	7.53	2.05	10 YR 2/1	10 YR 2/1
IIA-1	87.79	8.06	4.15	8.34	2.32	85.99	10 YR 5/2	10 YR 4/2
IIA	97.05	2.90	0.05	8.29	2.72	84.10	10 YR 7/2	10 YR 6/2
IIB	90.87	5.00	4.13	8.27	2.79	79.46	7.5 YR 4/2	10 YR 3/2
IIC	99.34	0.66	0.00	8.50	1.51	71.67	10 YR 5/2	10 YR 4/2
IIIA	73.32	20.56	6.12	7.95	4.98	4.21	7.5 YR 3.5/2	7.5 YR 3/3
IIIB	74.48	17.38	8.14	8.31	3.59	67.98	7.5 YR 4/2	7.5 YR 3/4
IV	93.20	4.85	1.95	8.52	2.59	87.65	7.5 YR 5/4	7.5 YR 4/4
V	100.00	0.00	0.00	8.58	2.60	93.29	10 YR 8/2	10 YR 6/3

*All samples from excavation Unit 6; see Figure 4 for location of samples in section wall.

Layer IIA-1: a thin zone at the top of Layer IIA, slightly darker and organically-enriched, containing anthropophilic landsnails, and representing a phase of stabilization and vegetation of the Layer II sandy beach ridge. Some occupation in the vicinity is suggested by the presence of a few thick, coarse-tempered sherds, and a thin scatter of marine shell midden.

Layer IIA: loose, calcareous beach sand, not compacted or cemented, lacking cultural materials. Although most of the sediment consists of calcareous materials, there is a subordinate quantity of basaltic lithic grains, giving the sand a distinct "salt-and-pepper" appearance; this indicates that at the time of deposition the shoreline incorporated exposed volcanic headlands, as the source for the basaltic sand grains.

Layer IIB: this is the principal pottery-bearing deposit, representing a period during which the actively accumulating sandy beach ridge surface was occupied. Lithologically, IIB is similar to IIA and IIC, but with the addition of organic/cultural materials due to occupation, and is both darker and compacted. The deposit contains shell and bone midden, large quantities of small sea urchin spines and test fragments, ceramic sherds (primarily of thick, coarse-tempered ware), and other artifacts (see description of Portable Artifacts, below). It also contains

anthropophilic landsnails. The deposit is non-concentrated, and probably accumulated over a fairly brief time span.

Layer IIC: this basal component of the Layer II beach ridge consists, as with IIA, of a "salt-and-pepper" lithology with dominant calcareous grains and a subordinate quantity of volcanic lithic fragments. Toward the base of this deposit are numerous large coral cobbles and some angular volcanic cobbles, along with branch coral fingers and coral rubble. This material indicates a relatively high energy depositional environment, such as storm activity along an exposed beach front. Thirteen sherds of thin, fine-tempered ware present, although the deposit shows no evidence of being an in-situ occupation locale.

Layer III: massive silty-clay colluvium with some incorporated subangular lithic fragments. Occasional charcoal flecks are present, particularly near the top of the deposit. Nine thin, fine-tempered potsherds were also incorporated in the deposit. It appears to represent a single depositional event, resulting from a combination of mass-wasting and fluvial transport from the colluvial slope above the site. A lower zone, designated Layer IIIB, incorporates some sand mixed from Layer IV, presumably at the time of deposition. The presence of charcoal flecking indicates burning of this slope prior to the deposition of the sediment,

perhaps due to gardening or other human disturbance.

Layer IV: a mixed deposit of fine-grained calcareous sand and reddish silt-clay, apparently culturally sterile.

Layer V: basal deposit of 'salt-and-pepper' sand with included marine shell and reef detritus; fairly compact, and showing the initial stages of cementation, probably due to frequent ground-water wetting. This deposit represents an active beach ridge depositional environment. It yielded two sherds of thin, fine-tempered ware, which may have derived from a primary occupation locus behind the beach (which would now be buried under at least 10 m of colluvium).

Stratigraphy of Units 2-3

The stratigraphies of Units 2 and 3, seaward of the main excavation, were essentially identical; the section for Unit 3 is typical:

Layer I: An organically-enriched, silty-clay loam, presently under cultivation. Lithologically, the deposit is a mixture of calcareous sand (77%) with the addition of silt and clay sized terrigenous grains, the latter deriving from sheet wash erosion from the colluvial slope. Various planting depressions filled with loose, reworked soil are visible in the section. The deposit also contains fragments of marine shell midden from occupation in the vicinity. An earth oven feature was

exposed in the W face of the unit.

Layer II: Loose, calcareous beach sand; culturally sterile.

This deposit is comprised wholly of calcareous grains, and lacks the 'salt-and-pepper' combination of calcareous and basaltic grains found in the Layer II deposit in the main excavation, indicating that by the time of deposition of Layer II in Unit 3, the coastline had prograded sufficiently to bury the volcanic headlands.

Stratigraphy of Unit 10

The stratigraphy of Unit 10, situated 45 m SW of the baseline transect, could be correlated fairly closely with that described above for the main trench. The main difference between the two sections is that the deep layers IV and V in the main trench are represented in Unit 10 only by a single deposit, Layer IV. The stratigraphy recorded for Unit 10 is as follows (depths recorded at the NE corner of the unit):

Layer IA: 0-5 cm. Upper portion of massive colluvial deposit; presented gardened, and thus loose and reworked. Silty-clay loam with angular lithic gravel included. Landsnails (zonitids, *Subulina* sp.) were noted in this deposit. The contact with Layer IB is diffuse over a 2-3 cm zone.

Layer IB: 5-32 cm. Very compact deposit of clayey colluvium

with subangular lithic fragments. Very occasional charcoal fragments. There is no evidence to suggest that this deposit was ever reworked by gardening, and it appears to represent a single depositional event.

Layer IC: 32-43 cm. Basal portion of the upper colluvium.

The contact with IB is diffuse over a 2-3 cm zone, while the contact with Layer II is distinct. Layer IC is very similar to IA, and appears to represent material that was reworked by an earlier gardening phase. It is less compact than the overlying IB deposit, and contains some landsnail shells (*Lamellaxis* sp.?). Several narrow, conical-shaped depressions penetrate from Layer IC into the underlying Layer II, and may be digging-stick impressions.

Layer IIA-1: 43-44 cm. A thin, discontinuous deposit of calcareous sand stained gray and enriched with organic matter. Landsnail shells present (species not determined). This thin deposit represents a poorly developed paleosol horizon (A₁) that formed after stabilization of the underlying Layer II beach ridge system.

Layer IIA: 44-67 cm. A sterile deposit of dominantly calcareous sand with some included volcanic lithic fragments (hence having a "salt-and-pepper" appearance), indicating that the beach producing this sediment included an immediate source of volcanic materials (evidence that the shoreline had not yet

prograded to its present position). The sand deposit is not compacted, and appears to have been deposited fairly rapidly following abandonment of the ceramic-period occupation represented by Layer IIB.

Layer IIB: 67-88 cm. Primary ceramic-phase occupation deposit. Parent lithology is essentially the same as Layer IIA, and the deposit represents a phase of occupation on the old beach ridge while the ridge was continuing to build through aeolian deposition of calcareous sediments. The deposit is stained gray with finely-dispersed organic materials, but actual macroscopic midden is sparse, and not nearly so concentrated as in the main trench. This suggests that Unit 10 may be near the periphery of the occupation represented by Layer IIB.

Layer IIC: 88-109 cm. A mixed deposit of calcareous dune sand with fine reddish clay, culturally sterile. The clay is evidently the result of hydraulic transport from the steep colluvial slope north of the site. The contact with Layer III is sharp but irregular.

Layer III: 109-150 cm. Compact deposit of reddish-brown silty clay. The mode deposition appears to have been fluvial rather than due to mass wasting. No charcoal flecking was observed. The contact with Layer IV is diffuse, with some mixing. Culturally sterile.

Layer IV: 150-200 cm (base of excavation). Beach sand of mixed calcareous-volcanic lithic fragment lithology,

and incorporating some larger coral cobbles, branch-coral fingers, etc., indicative of high-energy transport. This layer appears to represent a high energy beach ridge depositional environment.

Stratigraphy of Units 11, 14

Units 11 and 14 form a 1x2 m trench situated 45 m NE of the main trench. The stratigraphy of these units was somewhat obscured by the presence of a large pit (diameter greater than 1 m, depth approximately 140 cm) that occupied most of the excavation area. This pit, which was filled with dense shell midden, was very likely originally dug for use as a *lua masi*, or underground silo for the semi-anaerobic fermentation of breadfruit (see Kirch 1984). To the extent that they were visible in the peripheral portions of Units 11 and 14 not occupied by the large pit, the primary depositional layers in this part of the site consist of: I, massive colluvium; II, calcareous beach ridge sediments; III, colluvium. Some potsherds were found in the Layer II deposit.

Stratigraphy of Unit 12

As described above, Unit 12 was excavated to the east of the main trench, in an effort to get as close to the base of the steeply sloping talus as possible. The stratigraphy

of the east face was as follows:

Layer I: 0-180 cm. Massive deposit of silty-clay colluvium with inclusions of large, angular to subangular talus boulders. Excavation of this deposit was exceedingly difficult due to the compaction of the silty-clay, and the presence of the large boulders, many of which had to be prized out of position with steel crowbars. The deposit is culturally sterile.

Layer II: 180-200 cm. Thin deposit of calcareous dune sand, stained reddish with fine clay inclusions. This layer contained a few sherds of thin, fine-tempered ceramic ware, including a notched rimsherd. A sample of dispersed charcoal flecks was taken for ^{14}C age determination, which unfortunately proved to be too small for dating after pretreatment. This deposit appears to represent an inland "pinching-out" of the beach ridge deposit containing the primary ceramic period occupation (represented by Layer IIB in the main trench sequence).

Layer III: 200-250 cm (base of excavation). Massive deposit of silty-clay and boulder colluvium; similar to Layer II.

Stratigraphy of Unit 13

Unit 13 was excavated in the middle of a pavement of lililili gravel presumed to represent a late prehistoric

(aceramic phase) house floor, as is typical throughout the Samoan archipelago. The stratigraphy was the western face of the 1-m test unit was as follows:

Layer I: 0-28 cm. Concentrated deposit of water-worn branch coral fragments and coral gravel, in a 'greasy' textured, black (7.5 YR 2/0) sandy matrix, containing shell and bone midden.

Layer II: 28-45 cm. Coral gravel as in Layer I, but somewhat less concentrated, in a matrix of sand and ash (brown 10 YR 2/1).

Layer III: 45-70 cm (base of excavation). Sterile, white (10 YR 8/2) calcareous sand with unworn branch coral.

RADIOCARBON DATING AND CHRONOLOGY

Eight samples of charcoal and shell from the To'aga site provide the basis for a radiocarbon chronology. One sample was obtained from the 1986 test pit adjacent to the Ofu landfill dump (Hunt and Kirch 1987), and the remaining seven samples were selected to represent the main stratigraphic units exposed during the 1987 excavations. The 1987 dates have been reported in full by Kirch, Hunt, and Tyler (1989), which is included with this report as Appendix 2. All eight ^{14}C dates from AS-13-1 are listed in Table 2, giving the conventional ^{14}C age (after Stuiver and Polach 1977), and the calibrated age ranges at one standard

Table 2

RADIOCARBON AGE DETERMINATIONS FROM THE TOAGA SITE

LAB NO	UNIT	LAYER	MATERIAL	AGE B.P.*	CALIB AGE**
19742	TP	---	Shell	2350 \pm 50	1977-1842 BP
25033	6	IIA-1	Shell (<u>Turbo</u>)	2640 \pm 80	2311-2094 BP
25034	6	IIB	Shell (<u>Turbo</u>)	2570 \pm 80	2244-2007 BP
25035	6	V	Shell (<u>Asaphis</u> , <u>Lunella</u>)	3820 \pm 70	3714-3549 BP
25673	1	V	Shell (<u>Phalium</u>)	3620 \pm 80	3475-3326 BP
26463	3	II-4	Shell (<u>Turbo</u>)	1910 \pm 50	1389-1287 BP
26464	10	IIB	Charcoal	2620 \pm 140	2916-2403 BP
26465	13	III-3	Shell (<u>Turbo</u>)	1600 \pm 70	1122-950 BP

* Conventional ^{14}C age BP (^{13}C corrected).

** Calibrated age range at one standard deviation.

deviation. Calibrations were made using the CALIB microcomputer program of Stuiver and Reimer (1986); for marine samples we have used a Delta-R correction factor of 100 ± 24 (Kirch, Hunt, and Tyler 1989:9).

The oldest dates are those for samples Beta-25035 and -25673, both from Layer V of the main trench, the basal calcareous beach sand which yielded two thin, fine-tempered sherds. Both dating samples consisted of unweathered marine shell which, although not culturally-deposited food refuse, can be inferred to have been deposited at approximately the same time as the sherds (details of these samples are provided in Kirch, Hunt, and Tyler 1989:11-12). The samples yielded ages overlapping at two standard deviations, and indicate a calibrated time range of between 3700-3300 BP for the deposition of this beach sand containing the thin, fine tempered-ware pottery sherds. While this age range is very early for human occupation in Western Polynesia, it is not out-of-line with the earliest known dates for Lapita sites in the region (Kirch and Hunt 1988).

Four samples are in direct association with the Polynesian Plain Ware assemblage. Three samples (Beta-25034, -26464, and -25033) derive from the Layer II occupation in the main trench and from its correlated deposit in Unit 10. The fourth sample (Beta-19742) derives from the 1986 test pit. All four samples agree well, and indicate a calibrated

time range of between 2500-1900 BP for the main Polynesian Plain Ware occupation at To'aga.

A terminus post quem for the use of ceramics at the To'aga site is provided by Beta-26463, which derives from the base of an aceramic occupation deposit which stratigraphically postdates Layer II in the main trench. This sample yielded a calibrated age of 1389-1287 BP.

The final sample (Beta-26465) was obtained from the base of the aceramic house mound tested by Unit 13, and yielded a calibrated age of 1122-950 BP. Since the platform is constructed on the present land surface, it is evident that the sequence of coastal progradation and of colluvial deposition in the vicinity of the main excavation had stabilized by the beginning of the second millennium A.D.

DEPOSITIONAL SEQUENCE

The depositional sequence at To'aga can be summarized as a series of stages, as follows:

Stage 1 (3700-3300 BP): Formation of the calcareous sand beach represented by Layer V of the main trench, at a time when the shoreline was close to the base of the talus slope, with volcanic headlands exposed to active wave erosion (thus yield mixed calcareous-basaltic lithology sands). Human occupation in the vicinity of

the beach (presumably now buried under a considerable depth of colluvium and talus) is suggested by the presence of thin, fine-tempered ware sherds.

Stage 2 (> 2500 BP): Burial of the older beach ridge by terrigenous silt-clay from upslope, with erosion initiated in part due to human clearance of the vegetation with fire (indicated by charcoal flecking in the erosional deposit).

Stage 3a (ca. 2500 BP): Renewed accumulation of the calcareous beach ridge, with the shoreline still close to the talus slope (indicated again by mixed calcareous-basaltic grain suites). Exposure to the active shoreline is indicated by the large coral cobbles and reef detritus, representing one or more storm events.

Stage 3b (2500-1900 BP): Human habitation directly on the active beach ridge surface (Layer IIB of the main trench), resulting in the deposition of ceramics and midden.

Stage 4 (2500-1900 BP): Abandonment of the beach ridge as an occupation locus, and continued accumulation of the ridge (Layer IIA).

Stage 5 (ca. 1900 BP): Stabilization of the old beach ridge surface, indicated by the formation of an A horizon, and deposition of anthropophilic garden snails (Layer IIA-1 of the main trench). This stabilization resulted from seaward progradation of the shoreline, thus

removing the immediate source of calcareous sediment. It is at roughly this time that the basal sands represented by Layer II in Units 2 and 3 were deposited.

Stage 6 (< 1900 BP): Additional erosion and deposition of terrigenous sediments from up-slope in the area of the main trench. A brief occupation event is indicated by the presence of ceramics and an earth oven.

Stage 7: Continued progradation of the shoreline to its present position about 125 m seaward of the main excavation locus. Gradual deposition of fine-grained terrigenous sediments over the surface of the newly-formed coastal flat, and reworking of these through gardening activities.

Stage 8 (ca. 1000-100 B.P.): Dispersed habitation on the expanded coastal flat, represented by the pebble pavement tested by Unit 13, and by other surface cultural features.

In sum, the depositional sequence at To'aga begins in the late second millennium B.C. with a coastal flat only a few tens of meters wide, and a substantially wider reef platform than at present. This geomorphic situation fits well with recent geological evidence for a 1-m higher stand of the sea in this part of the Pacific at ca. 3,000 BP (Pirazzoli and Montaggioni 1986, 1988; Yonekura et al. 1988). By about 1900 BP the shoreline had begun to rapidly

prograde, probably associated with a drop in sea level to its present stand, with exposure of the reef crest leading to a high rate of calcareous sediment production. The development of a coastal plain more than 100 m wide was accompanied by the addition of fine terrigenous sediments due to erosion and sheet-wash of the higher colluvial slopes, forming a highly productive zone for intensive cultivation and habitation.

THE CERAMIC ASSEMBLAGE

The To'aga excavations yielded a collection of 1,464 ceramic sherds, all of them plain ware; of these 66 (5%) are rims. The assemblage can be sub-divided into two wares, with differential representation stratigraphically in the site. These are: (1) a thin, fine-tempered ware present in low frequencies in the deeper stratigraphic units (a total of 32 sherds); and (2) a thick, coarse-tempered ware found primarily in the main Layer IIB occupation, and in the Layer IC occupation.

Thin, Fine-Tempered Ware

The thin ware has vessel walls ranging from 4.2-7.7 mm in thickness. Surface color of the paste ranges from dark reddish gray (5 YR 4/2-3) to reddish brown (5 YR 4/4) to yellowish-red (5 YR 5/6). The sherd interiors have been

thoroughly oxidized, and do not have carbon cores. The five rim sherds recovered (Fig. 5) include direct rims with flat lips, and direct or slightly incurved rims with thickened or expanded lips. A single rim from Layer II of Unit 12 has slight depressions along the lip formed by pinching with the fingers; this is the only sherd from the entire assemblage that could be classed as 'decorated.' Reconstruction of vessel diameters is hindered by the small size of rim sherds, but vessels in the < 20 cm diameter range are indicated.

The thin ware is characterized by the presence of relatively fine-grained non-plastic inclusions or temper (grain size generally < 1 mm). We have not yet undertaken detailed petrographic examination of this fine-grained temper, although feldspars, olivine, and lithic fragments have been noted in examination of sherd breaks under low-power magnification. These non-plastic inclusions were most likely natural constituents of the clay body. However, in some of the thin ware sherds, rounded calcareous sand grains are present, apparently representing manually-added temper. Calcareous grains were observed in the thin-ware sherds from Unit 12, as well in some sherds from Layer III of Unit 6 in the main excavation. In Western Polynesia and Fiji, calcareous sand temper is generally associated with early ceramic assemblages, particularly Early Eastern Lapita (Kirch 1981:137; 1988:184). In Samoa, only the relatively

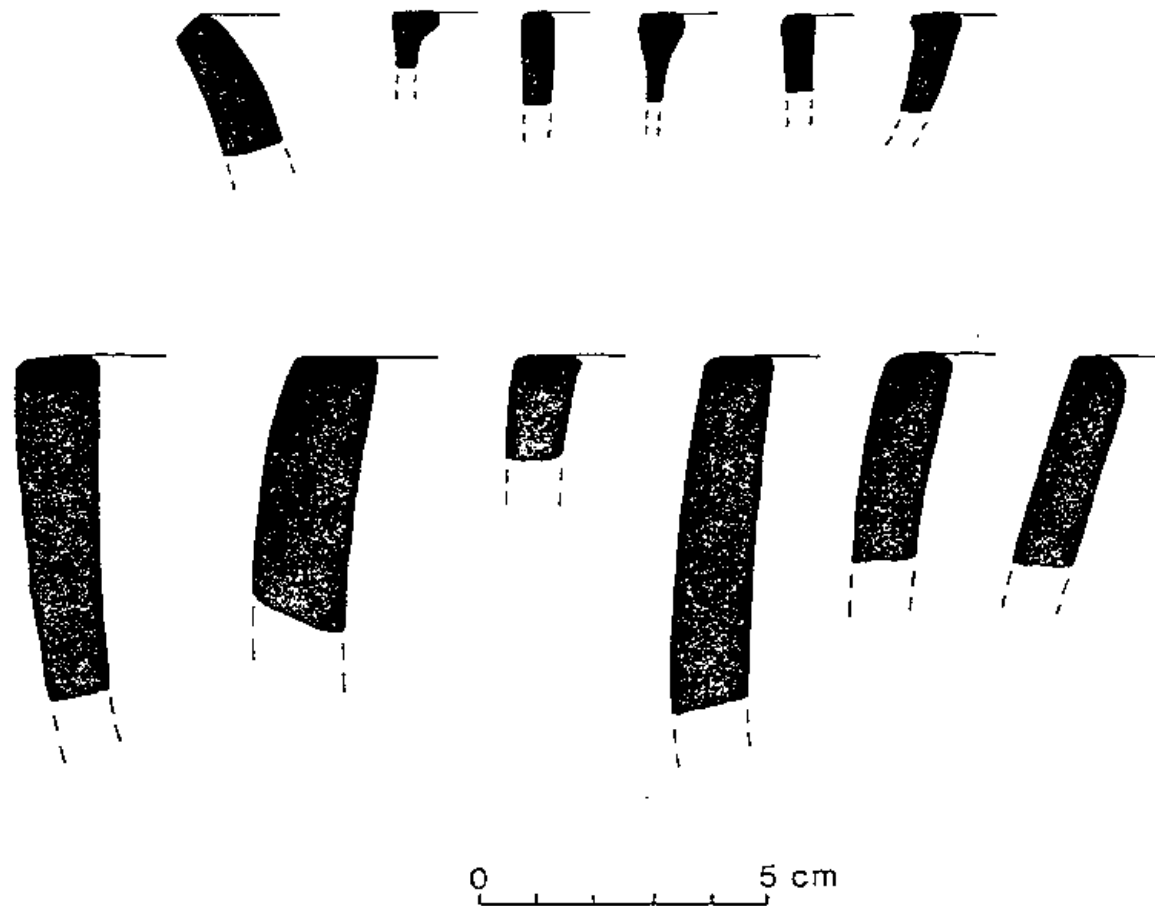


Figure 5. Rim profiles of ceramics from the To'aga site. Top row (l to r): everted rim of thick, coarse-tempered ware, and rims of thin, fine-tempered ware; bottom row: bowl rims of thick, coarse-tempered ware.

early Faleai'u Fine Ware, and the Mulifanua Lapita Ware described by Holmer (1980:111-112) are known to also contain calcareous sand temper.

The thin, fine-tempered ware was represented by two sherds from the basal Layer V deposit in the main trench, by 8 body sherds and 1 rim from the Layer III clay deposit, by 12 body sherds and 1 rim from Layer IIC, and by 2 body sherds and 1 rim from Layer IIB. Layer II in Unit 12 also yielded 3 body sherds and 1 rim of thin, fine-tempered ware; Unit 10 produced a single body sherd.

Thick, Coarse-Tempered Ware

The thick, coarse-tempered ware has vessel walls ranging from 11.7-17.0 mm thick. Both exterior and interior surfaces have been wiped (fine striations visible under low power magnification), and paste colors range from brown (7.5 YR 5/4) to reddish brown (5 YR 4-5/3-4). Fire-clouding on exterior surfaces, especially near the rim, is common (color dark reddish gray 5 YR 3-4/2 or dark reddish brown 5 YR 2.5-3/2). The sherds are very crumbly, break easily, and contain a high quantity of coarse-grained non-plastic inclusions. Fresh sherd breaks frequently reveal incompletely oxidized (carbon) cores.

In all but a single case, the rims are either vertical

(direct) or slightly incurved, from relatively open-mouthed bowls (Fig. 5). Lips are flat or very slightly beveled. Vessel diameter is difficult to reconstruct because of the small sherd size, but fairly large bowls are indicated, with diameters in the range of 36-40 cm.

The thick ware is characterized by an abundance of coarse non-plastic inclusions or temper, with individual grains frequently in the size range of 1-3 mm. Grains are sharply angular and unweathered, and thus are not from stream or beach environments. Rather, they were probably components of very young colluvial clay deposits, in which case these non-plastic inclusions are not manual additions to the potting clay (i.e., the clays were 'self-tempered'). Such colluvial clay deposits were noted in the vicinity of the To'aga site, immediately up-slope.

There is some variation in the lithology and mineralogy of these non-plastic inclusions in the To'aga thick coarse-tempered ware. The most common variant is dominated by large (1-3 mm) angular lithic fragments of what appear to be multicrystalline andesite or trachyte. These latter frequently overlap with tabular feldspar crystals, and individual feldspars are also common. This temper variant appears to closely match the "Feldspathic Trachytic Temper" described by Dickinson (1969:272-273) from the Va-1 and Sa-3 ceramic sites on Upolu, although we have not yet carried out

petrographic studies to confirm this similarity. Another, less common variant in the To'aga assemblage consists of a roughly equal mixture of angular pale-green crystals (olivine ?) and black, glassy, frequently isotropically-fractured grains.

The presence of at least two main temper variants indicates that the thick, coarse-tempered ware was manufactured with self-tempered clays from at least two separate localities. It is possible that these clay sources are present in the general To'aga area, given the range of young volcanic rocks exposed in the cliff section above the coastal plain. However, the possibility that ceramics were being transported between individual islands in the Samoan archipelago cannot be ruled out, and the apparent similarity between the To'aga ceramics and Dickinson's Feldspathic Trachytic Temper (1969) is of note. We plan to explore these possibilities through a combination of petrographic and SEM-EDS elemental analyses (see Hunt 1989).

OTHER PORTABLE ARTIFACTS

The excavations yielded a small but significant collection of other portable artifacts that expand our knowledge of Ancestral Polynesian material culture. Most derived from the primary occupation in Layer IIB of the main trench, with a few specimens from Layers IIA-1 and IIC.

Artifacts recovered during the 1986 test excavation at AS-13-1 have been described and illustrated by Hunt and Kirch (1988:169-176); these include a shell adz, basalt adz, and fishhook fragments.

Stone Adzes

From Layer IIA-1 in Unit 9 we excavated a finely ground and polished, complete adz of Samoan Type V (Green and Davidson 1969:24-26). The adz is of a very fine-grained basalt or andesite, and most of the original flaking scars have been removed by extensive polishing. The bevel is curved, and the poll shows distinct battering, as if it were used as a hammer while hafted. The adz is 136.8 mm long, 54 mm wide, and 35.2 mm thick at the mid-point. Type V adzes are commonly associated with plain ware ceramics, both in Samoa (Green 1974) and in other early Western Polynesian contexts (Kirch 1988:192, 203).

From Unit 3, in an aceramic depositional context, we recovered a mid-section of a fine-grained basalt or andesite adz with trapezoidal cross-section, probably of Samoan type IV (Green and Davidson 1969:24).

Hammerstones

Two hammerstones, both from Layer IIA-1 of Unit 9 in

the main trench, were excavated. One is an ovoid cobble of porphyritic igneous stone (abundant feldspars) (diameter 93-105 mm, 30 mm thick) with flat sides, and distinct pecking or damage along the margins. One face appears to be ground smooth, perhaps during use as an abrading or polishing stone. The second specimen is an elongate basalt or andesite cobble, beach-worn, with pecking damage on the broader end. The cobble measures 147 mm long (max. width 70 mm), and the damaged surface has an area of 17.1 by 26.9 mm.

Fishhooks

Samoaan archaeological sites have been notoriously poor in the preservation of bone or shell artifacts, and only a few specimens of fishing gear have ever been excavated (Green and Davidson 1969, Pl. 23; Janetski 1980). The same has also been true of other Western Polynesian sites, in Tonga and Futuna (Kirch and Dye 1979). In our 1986 test excavation at To'aga, two fragments of small Turbo-shell one-piece fishhooks were recovered (Hunt and Kirch 1988:175, fig. 8, b-c). In 1987 the expanded excavations yielded four nearly complete hooks, and 14 fragments, the largest assemblage of prehistoric fishing gear yet recovered from Samoa, and a major addition to our knowledge of early Polynesian fishing (Fig. 6).

The To'aga fishhook assemblage is remarkably uniform in

size and morphology, with only minor variations. The hooks are all manufactured from the body whorls of *Turbo setosus*, a gastropod common on the reef edge of Ofu Island. The Layer IIB midden contained large quantities of *T. setosus* shell, some of which was probably manufacture debris. Three pieces could be clearly identified as unfinished hooks. One worked fragment, probably an unfinished hook tab, was of the larger and less commonly occurring species, *Turbo marmoratus*.

The hooks are enumerated, with measurements (as defined by Emory, Bonk, and Sinoto 1959, fig. 7), in Table 3, and illustrated in Figure 6. The hooks are small, and rather delicate, and must have been used to take smaller reef fish. The complete hooks have shank heights ranging from 13.1 to 20.4 mm. Hook width ranges from 10.1 to 15.6 mm. Most appear to have been rotating in form, although one hook is technically of the jabbing variety. The bends have an O or U shape. One hook has a distinctive in-curved shank, reminiscent of some early Marquesan hooks (Suggs 1961:81, fig. 26). Two specimens have an inner shank knob, presumably to assist in line attachment. Several other shanks have very small notches or grooves on the outer shank face.

Coral Abrader

From Layer III of Unit 11 we recovered a tabular shaped abrader of *Porites* sp. coral. The abraded facet has a

Table 3
FISHHOOKS FROM THE TOAGA SITE*

CAT NO	DESCRIPTION	S HT	P HT	WD	TH	REMARKS
1-7-1	Point fragment				3.7	
1-8-1	Complete hook	13.1	7.2	10.1	2.0	Jabbing. Notched
5-7-1,2	Bend fragments				3.7	
6-7-1	Shank fragment				2.1	
7-5-2	Bend and point		12.5+	15.1	2.7	
7-7-1	Shank fragment				3.2	Notched
9-2-3	Complete hook	19.2	11.5+	11.4	2.5	Rotating
9-3-1	Complete hook	16.1		10.2	2.4	Rotating
9-6-2	Bend fragment					
9-12-1	Complete hook	17.1	10.5	11.4	2.2	Rotating, incurved
10-4-1	Shank fragment				3.2	Notched
11-5-1	Bend and point		10.9	15.6	4.4	
11-7-21	Shank and bend				4.1	
11-7-22	Shank and bend				3.1	
11-12-1	Shank fragment	20.4			3.6	

*All catalog numbers preceded by AS-13-1. S HT, shank height, P HT, point height, WD, hook width, TH, thickness of shank.

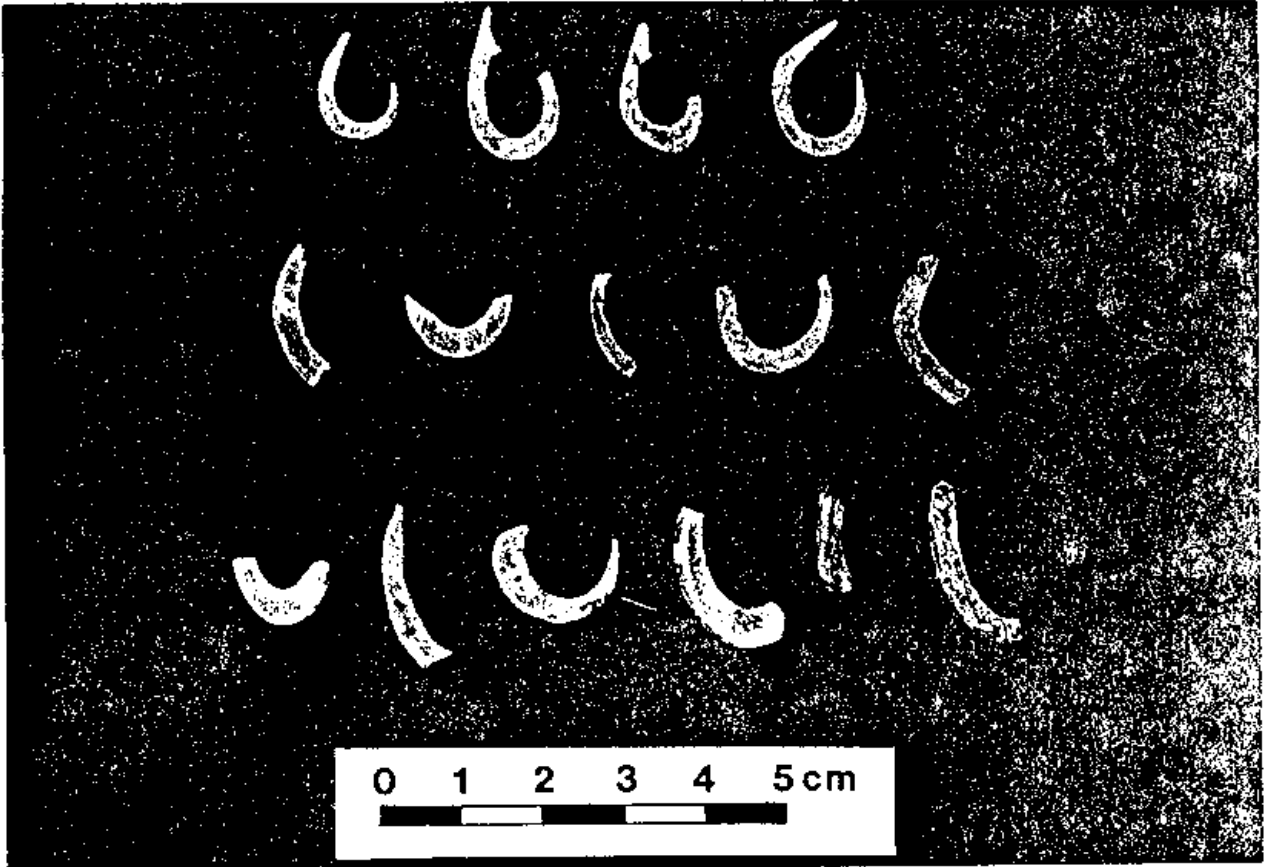


Figure 6. One-piece fishhooks of Turbo shell from the To'aga site.

surface area measuring 50 x 60 mm.

Echinoid-Spine Abraders

Two abraders of slate-pencil sea urchin spines (*Heterocentrotus mammillatus*) were excavated, both from Layer IIA-1 in the main trench (Fig. 7). Both have distally abraded facets at an angle to the longitudinal axis, as do the abraders reported by Janetski (1980, fig. 43, g-i) from the early Falemoa site in Western Samoa. These abraders were likely used to manufacture the Turbo hooks and other artifacts of shell.

Shell Ornaments

Several classes of shell ornament were recovered (Fig. 7). From Layer IIB in the main trench are two delicate beads of *Conus* sp., very well ground, with diameters of 5.6 and 5.9 mm, and thicknesses of 1.9 and 2.1 mm. Layer IIB also produced two fragments of larger *Conus* sp. rings, very well ground, with original diameters of about 50 mm. One fragment had been sharpened to a point after breaking. Also found in this stratigraphic context were two *Nerita* sp. shells with artificial perforations in the basal whorl, perhaps for stringing as beads. Layer II in Unit 11 produced a fragment of a large shell ring or armband, made either of a large species of *Conus*, or possibly of *Tridacna*. The ring fragment

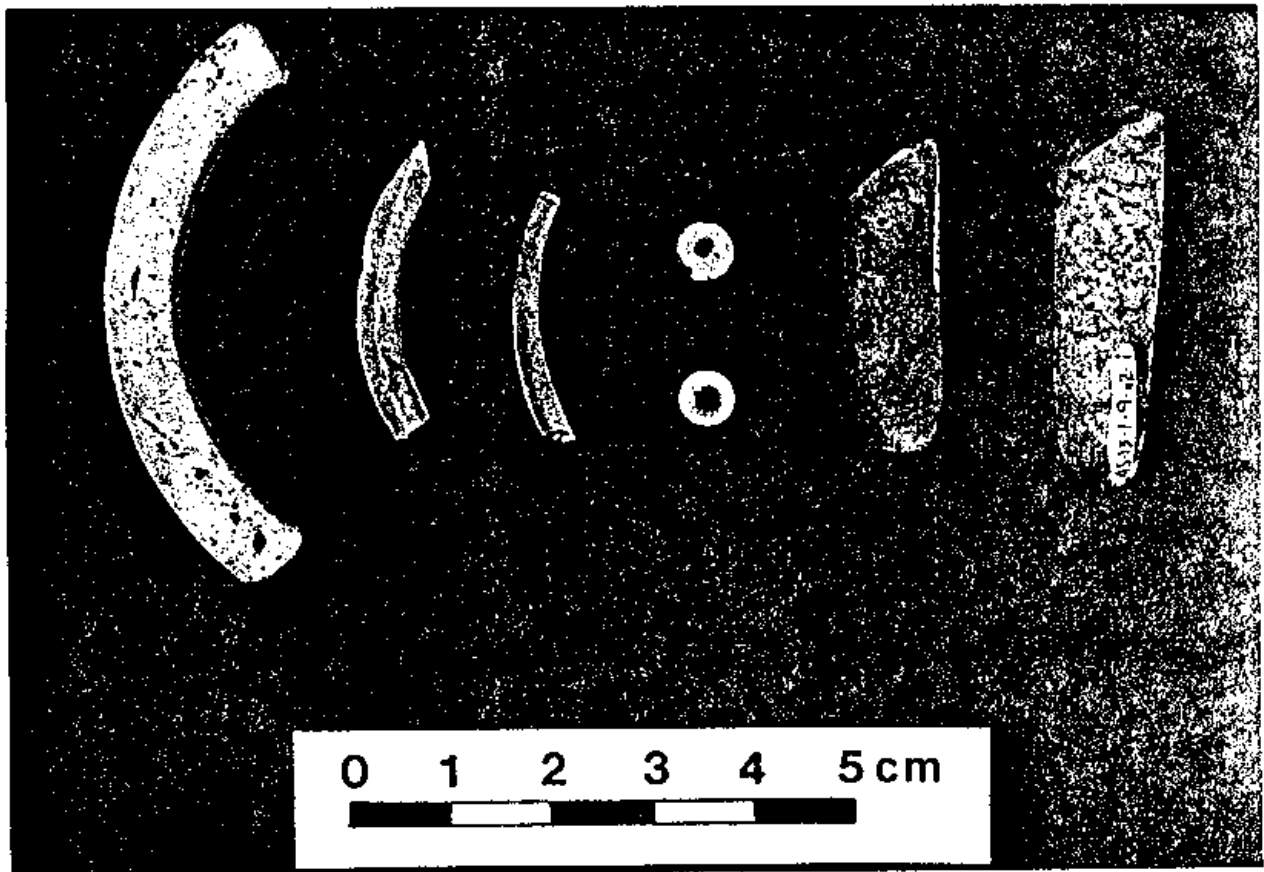


Figure 7. Shell and sea-urchin spine artifacts from the To'aga site. L to R: armband fragment of Tridacna shell; two Conus-shell ring fragments; two beads of Conus shell; and, two abraders of slate-pencil sea-urchin spines.

is 7.3 by 11.6 mm in thickness, and has a reconstructed diameter of about 70 mm. A similar armband fragment from the Falemoa site is illustrated by Janetski (1980: fig. 45, b).

Worked Shell

Various small pieces of worked shell were recovered throughout the excavations. Most of these are of *Turbo* sp., but one specimen from Unit 11 is of pearl shell (*Pinctada* sp.).

FAUNAL MATERIALS

One of the most important characteristics of the To'aga site is the excellent preservation of both vertebrate and invertebrate faunal remains in the Layer II occupations. This is the first site in Samoa with such a well preserved faunal assemblage dating to the Ancestral Polynesian phase.

Vertebrate Fauna

The vertebrate fauna is dominated by fishbone, but also includes lesser frequencies of marine turtle, bird, rat, human, and a range of various sized mammals, as yet unidentified. Some of this latter may include pig and/or dog. The marine turtle is most likely *Chelonia mydas*. The rat bones all appear to be *Rattus exulans*, the widely-

dispersed Polynesian Rat (Tate 1951).

The 75 excavated bird bones, most of which were directly associated with the Layer II ceramic-bearing occupation, are of particular interest. These were identified by D. Steadman of the New York State Museum, whose report follows as Appendix 1. The majority of identifiable bones consist of procellariids, including *Puffinus pacificus*, *P. griseus*, and *Pterodroma rostrata*. Also present are a *Fregata* sp., a *Sterninae* sp., and the domestic fowl, *Gallus gallus*. The fairly abundant material of *Puffinus griseus* (Sooty Shearwater) is notable, as this species is not known to occur in the Samoan archipelago today.

Identifications to family level were made of fish dentaries and premaxillaries, as well as of certain distinctive skutes, spines, and caudal tangs; these are summarized in Table 4. The most prevalent taxon is Diodontidae, almost certainly deriving from the species *Diodon hystrix*, the spiny puffer. High frequencies of *D. hystrix* bones have been noted in other early Pacific sites, such as Tikopia (Kirch and Yen 1982:292), which is curious in light of their poisonous flesh, and the fact they are often avoided by islanders today. Also represented in the To'aga assemblage are a range of other inshore taxa, in the families Labridae, Scaridae, Lutjanidae, Lethrinidae,

Table 4

FISHBONE FROM THE TOAGA SITE, MAIN EXCAVATION*

FAMILY	IDENTIFIED ELEMENT	IIA-1	IIA	IIB	IIC
Lutjanidae	Dentary	2			
Serranidae	Premaxillary	1	1	8	1
	Dentary		2	1	3
Holocentridae	Dentary	1			
Diodontidae	Dentary				1
	Spine	4	25	137	46
Carangidae	Premaxillary				1
	Skute		2	1	
Acanthuridae	Dentary				1
	Caudal Tang	2	1	2	1
Lethrinidae	Premaxillary			2	
	Tooth				2
Scaridae	Premaxillary	1		4	
	Dentary			4	
Balistidae	Premaxillary				2
	Spine	1		5	
Muraenidae	Dentary		1	4	4
	Vomer		2		
Belonidae	Premaxillary		1		
Labridae	Premaxillary		12		
Elasmobranch	Vertebrae		1		
Shark	Tooth				1

*Units 5, 6, 7, 8, 9.

Serranidae, Balistidae, Carangidae, Belonidae, Acanthuridae, Holocentridae, and Muraenidae. Some vertebrae of elasmobranchs (sharks and rays) were present, as well as one shark tooth. While many of the smaller serranids, holocentrids, and probably carangids could probably have been taken on the one-piece Turbo shell fishhooks found in the site, other taxa are unlikely to have been taken by angling (Kirch and Dye 1979). Rather, the diversity of taxa represented in the site suggests that a broad range of fishing strategies was practiced by the site's inhabitants, including netting and spearing.

The deposits also contain large quantities of shellfish midden, including gastropod and bivalve molluscs, sea urchins (spines and test fragments), and crustacea. It has not yet been possible to identify the sea urchins or crustacea to specific taxa, but the molluscs have been fully identified. The invertebrate assemblage from Unit 9 in the main excavation, which is typical from that from other units as well, is reported in Table 5, by stratigraphic unit. The most commonly represented gastropods are *Turbo crassus* and *T. setosus*, along with their opercula. Among the bivalves, the most important species is *Tridacna maxima*. The molluscan suite represents both sandy bottom and rocky substrate dwelling species, but is dominated by taxa that prefer the surge-zone habitat of the reef crest (such as *Turbo*, *Trochus*, *Drupa*, *Nerita*). These molluscs may be readily

Table 5

INVERTEBRATE FAUNAL REMAINS FROM UNIT 9, TOAGA*

TAXON	IIA-1	IIA	IIB	IIC
<u>Turbo crassus</u>	49.66	83.62	175.36	175.54
<u>Turbo setosus</u>	115.06	139.20	467.49	552.99
<u>Operculae (Turbo)</u>	65.04	51.85	51.32	441.99
<u>Trochus maculatus</u>	11.91	53.14	130.96	120.33
<u>Strombus spp.</u>	1.18		2.24	1.39
<u>Cymatium spp.</u>	5.87	1.12	12.76	
<u>Cypraea spp.</u>	16.20	10.35	23.44	64.56
<u>Drupa spp.</u>	3.94	2.65	12.43	1.72
<u>Thais spp.</u>	0.86	13.73	48.81	3.93
<u>Nerita spp.</u>	0.25	3.61	5.89	14.85
<u>Bursa sp.</u>		10.24	19.54	16.05
<u>Tonna sp.</u>		1.53	4.16	2.15
<u>Cerithium nodulosum</u>				31.47
<u>Conidae spp.</u>	1.49	0.51	8.67	55.45
Other Gastropods	13.96	11.47	18.60	102.14
<u>Tridacna maxima</u>		4.41	4.22	225.46
<u>Quidnipagus palatam</u>		1.94	10.31	13.19
<u>Scutarcopagia scobinata</u>	0.81		4.07	10.94
<u>Periglypta reticulata</u>				0.58
<u>Codakia divergens</u>				0.87
<u>Asaphis violaceus</u>	1.12			0.86
<u>Arca sp.</u>				6.00
<u>Chama sp.</u>				1.08
<u>Isognomon sp.</u>				0.67
TOTAL MOLLUSCS				
Sea Urchins	13.15	25.23	15.84	51.16
Crustacea	1.28	1.22	24.42	0.73
TOTAL INVERTEBRATE	301.78	415.82	1040.53	1896.10

*Weights in grams.

obtained on the broad fringing reef fronting the To'aga site, which would have been even wider prior to the later prehistoric progradation of the shoreline demonstrated by our excavations.

Detailed tabulations of identified molluscan assemblages from the various excavation units are provided in Appendix 3 to this report.

In sum, the faunal assemblage associated with the plain ware ceramics in the To'aga site, and dating to the Ancestral Polynesian phase, indicates broad spectrum exploitation of a range of natural resources, from marine, littoral, and terrestrial habitats. These included shellfish, inshore reef fish, marine turtles, and seabirds; the latter presumably nesting in fairly large numbers on the island prior to prolonged exploitation by humans. The domestic fowl was also definitely present; the presence of dog or pig remains to be confirmed by further study of the skeletal elements.

The Unit 13 test in a later prehistoric (aceramic) house mound provided a small faunal assemblage which can be compared with the earlier materials from the main excavation. This later assemblage is not appreciably different, containing a similar array of shellfish (again dominated by Turbo), and inshore fish bones (Serrandiae,

Holcentridae, Muraenidae). However, no bird bones were present.

CONCLUSIONS

The To'aga Cultural Sequence

The To'aga site encapsulates virtually the whole of the Samoan cultural sequence. The earliest materials are as yet poorly sampled, only two excavation units of the main trench having penetrated Layer V, where the presence of habitation in the vicinity of the beach is suggested by two thin, fine-tempered sherds. (Other thin, fine-tempered sherds are found in Layers III and IIC underlying the later Polynesian Plainware deposit in Layer IIB.) Until a larger sample of ceramics and other cultural materials is obtained, it would be premature to label this earliest phase "Lapita." However, the two ^{14}C dates from unweathered shell in Layer IV agree closely with known ages of Lapita settlements, not only at Mulifanua in Western Samoa but in Tonga and Fiji as well (Kirch 1988:244, table 48; Kirch and Hunt 1988).

The To'aga site contains a major Polynesian Plain Ware occupation phase, with ^{14}C determinations bracketing this phase between 2500-1900 B. P. (calibrated). The deposits of

this phase (especially Layers IIB and IIA-1 of the main trench) have yielded a well preserved sample of artifacts and faunal materials referable to Ancestral Polynesian culture.

Deposits and features relating to the last 2,000 years of the Samoan sequence occur in the upper stratigraphic levels, particularly seaward of the main trench (Units 2 and 3), and as discrete features such as the Lili'ili paved house mound tested by Unit 13. Radiocarbon ages indicate that manufacture and use of ceramics on Ofu had ceased by at least 1300 BP (calibrated), while historical accounts and oral traditions reveal that To'aga continued to be occupied into the early part of this century.

Ancestral Polynesian Culture

Unlike other first-millennium BC Samoan sites in which acidic conditions thwarted preservation of organic materials, To'aga yielded shell artifacts, and shell and bone faunal materials, in addition to the ubiquitous ceramics. The site thus extends our information base for the reconstruction of Ancestral Polynesian culture.

The To'aga sequence spans a period during which ceramics were changing from a dominant thin, fine-tempered ware, to a thick, coarse-tempered ware. This ceramic change

thus closely matches the sequence defined by Green (1974:245-250) for Western Samoa based on the Vaialele and Sasoa'a assemblages. Even though the eastern Samoan islands, and especially Manu'a, are geographically isolated from Upolu and Savai'i, continuous cultural contact between populations throughout the archipelago is implied by these parallel developments. A further common item of the material culture repertoire throughout Samoa is the Type V, plano-convex sectioned adz.

The To'aga site produced the first substantial assemblage of one-piece shell fishhooks from any early Western Polynesian context, thus filling a lacuna in the archaeological record for Ancestral Polynesian culture, particularly given the importance of one-piece hooks in early East Polynesian sites. The To'aga hooks might well be regarded as the kind of assemblage from which early East Polynesian fishhook complexes were derived. Indeed, the simple Turbo-shell hooks reported by Rappaport et al. (1967:187-192, fig. 19) from Mo'orea in the Society Islands are strikingly similar in many features to the To'aga assemblage. Certain Marquesan forms, such as the Curved Shank, Rotating Hook, and Obtuse Recurved Point forms described by Suggs (1961:78-82, fig. 26) could also have been developed from prototypes like those from To'aga. The prior dearth of fishhooks in Western Polynesian sites has evidently been more a function of sampling error (and lack

of suitable depositional contexts) than a true reflection of the role of angling in Ancestral Polynesian fishing strategies.

The To'aga collection also adds several other artifact classes to the Ancestral Polynesian inventory including echinoid-spine and block coral abraders, hammerstones, small *Conus*-shell beads, *Conus*-shell rings, and larger *Tridacna* rings, and shell adzes.

The To'aga site provides the first sizeable sample from Samoa of invertebrate and vertebrate fauna associated with an Ancestral Polynesian occupation. While this faunal assemblage might be interpreted as evidence for an economy dominated by marine exploitation and bird-hunting (cf. Groube 1971), we believe that such an interpretation would be incorrect, ignoring a wealth of direct and indirect evidence supporting a model of Lapita and later Ancestral Polynesian peoples as horticulturalists (Green 1979; Hunt 1981; Kirch 1984, 1988). At To'aga such evidence is admittedly slim, but does include the presence of in Layer II of anthropophilic garden snails, especially *Lamellaxis gracilis* (Christensen and Kirch 1981), and the charcoal flecking in terrigenous erosional deposits suggestive of up-slope firing of vegetation.

Landscape Change

The narrow, discontinuous coastal plain of Ofu Island comprises one of the most important resource zones for the human population, providing the only suitable terrain for habitation structures, and being a major zone of arboriculture and swidden cultivation. Our excavations provide a geomorphological sequence and chronology for the formation of this coastal plain. At 3500 BP the fringing reef platform extended nearly to the base of the steep talus, with only a narrow beach ridge upon which human settlement could establish a tenuous foothold. This older beach ridge, represented by the Layer V-II sequence in the main excavation, may well be associated with a putative +1 m higher stand of the sea in the central Pacific at between 4-2,000 BP. (The extent to which subsidence of the Samoan archipelago may have complicated eustatic sea-level change at To'aga is a matter requiring further investigation.) In any event, rapid progradation of the beach ridge occurred sometime between about 1900 and 1000 BP, leading to the deposition of the calcareous sand plain extending along Ofu's southeastern coast.

While the process of coastal progradation of the calcareous beach ridge is doubtless linked to sea-level fluctuations (whether eustatic, tectonic, or both in origin), the productivity of the newly-created coastal plain

owes much to human activity. In particular, the deposition of terrigenous sediments onto the calcareous beach terrace, resulting in the formation of organically-enriched soils, was aided by forest clearance and cultivation of the higher colluvial and talus slopes. Habitation of the coastal flat also resulted in the incorporation of midden and other organic refuse into the soil horizon. Thus, by about 1000 BP, the coastal flat was rapidly becoming a zone of organically-enriched, well-drained soils, planted in tree crops and intensively occupied. This sequence of landscape change at To'aga thus adds another instance of anthropogenic landscape modification in island ecosystems, paralleled by such cases as Tikopia (Kirch and Yen 1982), Aneityum (Spriggs 1986), and Niuatoputapu (Kirch 1988). The late prehistoric economic landscape of Ofu Island was substantially different from that which had greeted the first colonists, and to a large degree reflected the impacts from generations of human land use.

Cultural Resource Management Implications

The 1987 systematic test excavations at Site AS-13-1, and subsequent dating and analysis of specimens, described in full above, clearly demonstrate that this site is one of the most important archeological resources yet to be identified in American Samoa. The significance of the To'aga site is indicated by the following points: (1) Site AS-13-1

is very well stratified, with discrete assemblages and features dating to various time periods in Samoan prehistory; (2) It is the only site within American Samoa known at present which encapsulates within its stratigraphic sequence virtually the entire prehistoric sequence of Samoa; (3) Depositional conditions within the site are conducive to excellent preservation of bone and shell materials, as well as ceramic and stone artifacts, thus yielding a broad array of evidence upon which the prehistory of Manu'a and American Samoa may be constructed; and (4) The site has already yielded important new data bearing on the formative stages of Ancestral Polynesian culture. Thus, Site AS-13-1 is of archaeological significance not only for Manu'a and American Samoa, but for the Polynesian region as a whole.

While our 1987 investigations, reported herein, have been sufficient to demonstrate the age, nature, and significance of the To'aga site, we were unable to determine its full horizontal extent. It is clear that the subsurface deposits at AS-13-1 occupy a fairly narrow band parallel to the modern beach, beginning about 20-40 m inland of the coast road, and running inland (N) under the steeply sloping colluvium. How far to the W and E of the 1987 excavation area these deposits extend could not be determined with the time and funds allotted in 1987. Therefore, an expanded phase of subsurface testing is proposed for 1989. (NOTE: This fieldwork was effectively accomplished, and the lateral

boundaries of the subsurface deposits have now been determined. These results will be presented in a separate report detailing the results of the 1989 contract.) Once the full extent of subsurface deposits at AS-13-1 have been adequately determined, it will be feasible to prepare a nomination of this important site to the National Register of Historic Places.

While a small portion of the site was destroyed by government land-fill operations prior to 1986 (originally leading to the discovery of the site), there has not been any subsequent disturbance to the area. Landowners have been fully apprised of the significance of the site, and we were assured that no earth-moving activities that might affect the integrity of the subsurface deposits were planned for the To'aga area.

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PVK and TLH co-directed the To'aga excavations. JT assisted in fieldwork and analyzed sediment samples in the

Burke Museum laboratory. LN analyzed the molluscan and vertebrate faunal assemblages. The report was authored by PVK.

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APPENDICES

1. Archaeological Bird Bones from Ofu, Manu'a, American Samoa: Extirpation of Shearwaters and Petrels, by David W. Steadman, New York State Museum
2. A radiocarbon sequence from the Toaga site, Ofu island, American Samoa, by P. V. Kirch, T. L. Hunt, and J. Tyler. Extracted from Radiocarbon, Volume 31, No. 1, Pages 7-13, 1989.
3. Quantitative Analyses of Molluscan Faunal Assemblages from Site AS-13-1 Excavation Units.

Appendix 1. Archaeological Bird Bones from Ofu, Manu'a,
American Samoa: Extirpation of Shearwaters and Petrels

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The 1987 excavations at the Toaga site (AS-13-1) on Ofu Island yielded 23 identifiable and 52 undiagnostic bird bones (Table 1), providing the first prehistoric bird bone assemblage to be studied from either American or Western Samoa. The archaeology of the Toaga site has been described by Hunt and Kirch (1988), Kirch et al. (1989, this volume). The only previous record of bird bones from Toaga is that of "medium bird (possibly Gallus gallus)" in Hunt and Kirch (1988:177).

The identifiable bird bones from Toaga have been catalogued in the University of Washington Burke Museum (UWBM) Fossil Bird Collection. All but four of these bones are of procellariids (petrels and shearwaters). Compared with avian assemblages from other Polynesian archaeological sites, the dominance of procellariids would characterize a fairly early site, i.e., one that dates to within the first thousand years of human occupation. On the other hand, when compared with sites that seem to represent the initial human

occupation of an island, such as the Hane site (Ua Huka, Marquesas; Steadman 1989a) or Tongoleleka site (Lifuka, Tonga; Steadman 1989b), the lack of native landbirds from the Toaga site suggests that it probably does not represent the first 500 years of human occupation of Ofu. These ideas will be tested by obtaining a larger sample of bird bones from the site.

No species of petrels or shearwaters nest on Ofu today (Amerson et al. 1982a:90). The archaeological bird bones suggest that at least three such species nested there prehistorically. Of these, the Wedge-tailed Shearwater and Tahiti Petrel still nest on Ta'u Island of the Manu'a Group. The bones of Sooty Shearwater represent the first specimen record of this species from anywhere in Samoa.

In the species accounts that follow, "Unit" refers to meter square excavations (designated with arabic numerals). Roman numerals refer to stratigraphic layers. See Kirch et al. (this volume) for details of the stratigraphy.

Species Accounts

Order Procellariiformes

Family Procellariidae

Puffinus pacificus (Wedge-tailed Shearwater)

MATERIAL. 3 ulnae (UWBM 1244, 1251, 1256), Unit 9, IIB; Unit 5, IIC; Unit 14, IIIa-4. 2 pedal phalanges (UWBM 1246, 1248), Unit 4, IIB; Unit 1, IIB.

REMARKS. As mentioned above, this widespread tropical

shearwater breeds today on nearby Ta'u, but not on Ofu.

Puffinus griseus (Sooty Shearwater)

MATERIAL. Scapula (UWBM 1245), Unit 9, IIB. 2 ulnae (UWBM 1240, 1241), Unit 11, II-8. Carpometacarpus (UWBM 1259), Unit 7, IIA. Manus digit (UWBM 1260), Unit 7, IIA. 2 tibiotarsi (UWBM 1252, 1253), Unit 6, IIA.

REMARKS. These specimens are larger than in any species of shearwater that resides today anywhere in tropical Polynesia. They agree in all osteological details with bones of Puffinus griseus, a species that probably migrates through the Samoan region today (Harrison 1983:260, 420; Pratt et al. 1987:55), although there are no records from American Samoa. The Sooty Shearwater nests only on temperate islands off New Zealand, southern Australia, and extreme southern South America (Harrison 1983:260, 420).

Three possible explanations for the unexpected presence of P. griseus on Ofu are: 1) the bones represent migrant birds taken at sea by fishermen; 2) this species once resided on Ofu and, like other procellariids, were taken from their nesting burrows; 3) the bones represent an extinct, resident shearwater that differs specifically or subspecifically from modern P. griseus but is osteologically very similar.

Concerning item 1, I am aware of no ethnographic accounts that Polynesians capture seabirds while fishing. For item 2, the oceanographic conditions near Ofu are much warmer than at the cool, temperate areas where P. griseus nests today. That

this large shearwater, or a very closely related extinct relative, was once resident rather than migrant on Ofu is supported, however, by how common its bones are (seven of 23 identifiable bones) and also that it is represented among the very few bird bones from a Lapita site on Niuatoputapu, southwest of American Samoa (pers. obs.). Proof of residency on Ofu or elsewhere in tropical Polynesia will require the discovery of bones of juveniles.

Pterodroma rostrata (Tahiti Petrel)

MATERIAL. Mandible (UWBM 1250), Unit 4, IIB. Ulna (UWBM 1242), Unit 5, IIA. Tarsometatarsus (UWBM 1247), Unit 4, IIB.

REMARKS. This very large petrel nests today only in the Marquesas Islands, Tahiti, New Caledonia, and American Samoa, the latter based upon a colony of about 500 individuals discovered in 1976 high in the mountains of Ta'u (Amerson et al. 1982a:49, 53, 90-92; 1982b:56). Elsewhere in Polynesia, I have identified bones of P. rostrata from archaeological sites in the Marquesas (Ua Huka, Tahuata), Society Islands (Huahine), and Tonga (Lifuka, 'Eua).

Procellariidae sp. (unknown petrel/shearwater)

MATERIAL. Ulna (UWBM 1243, 1258), Unit 9, IIB; Unit 5, IIB. Radius (UWBM 1249), Unit 4, IIB. Carpometacarpus (UWBM 1239), Unit 9, IIB.

REMARKS. These three very fragmentary bones cannot be

identified beyond the family level.

Order Pelecaniformes

Family Fregatidae

Fregata sp. (unknown frigatebird)

MATERIAL. Humerus (UWBM 1254), Unit 14, IIIa-4.

REMARKS. This very fragmentary specimen cannot be distinguished from the humeri of Fregata minor or F. ariel, both of which occur on Ofu today (Amerson et al. 1982a:90).

Order Charadriiformes

Family Laridae

Sterninae sp. (unknown tern)

MATERIAL. Ulna (UWBM 1257), Unit 14, IIIb-5.

REMARKS. This eroded, fragmentary specimen represents a small tern approximately the size of Sterna sumatrana or Anous minutus, both of which occur today in American Samoa, although only the latter nests on Ofu (Amerson et al. 1982a:90).

Order Galliformes

Family Phasianidae

Gallus gallus (Chicken)

MATERIAL. Sternum (UWBM 1261), Unit 11, II-12. Ulna (UWBM 1255), Unit 14, IIIa-4.

REMARKS. This non-native species has been found virtually throughout Polynesia in archaeological sites of all ages.

Order Unknown, Family Unknown

Unidentifiable birds

MATERIAL. 52 uncatalogued bone fragments.

REMARKS. These specimens are wholly undiagnostic.

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APPENDIX 2

[RADIOCARBON, VOL. 31, NO. 1, 1989, P 7-13]

A RADIOCARBON SEQUENCE FROM THE TOAGA SITE, OFU ISLAND, AMERICAN SAMOA

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The Samoan Archipelago occupies a critical position for understanding the dispersal of early Austronesian-speaking peoples into the southwestern Pacific, including the initial colonization by humans of the Polynesian triangle. To date, the most easterly reported site of the Lapita cultural complex (Green, 1979; Kirch, 1984; Kirch & Hunt, 1988) is the Mulifanua site on Upolu Island, Western Samoa (Green & Davidson, 1974). Lapita colonists settled the larger, western Samoan Islands by the end of the second millennium BC. Archaeologic and linguistic evidence also suggest that the islands of Eastern Polynesia (eg. Marquesas, Society and Cook Islands) were settled, at least in part, from Samoa. However, the timing of this movement into Eastern Polynesia has not yet been dated to earlier than ca 150 BC on the basis of radiocarbon dating of cultural materials from the Marquesas Islands (Kirch, 1986; Ottino, 1985). This has raised the issue of whether there was a "long pause" between the settlement of Samoa (and the other islands of Western Polynesia, such as Tonga, Futuna, and 'Uvea) and that of Eastern Polynesia (Irwin, 1981; Kirch, 1986; Terrell, 1986).

Until recently, the remote Manu'a Islands at the eastern end of the Samoan Archipelago had not been well explored archaeologically, even though, on a geographic basis, they would have provided the most likely point of departure for early voyaging canoes bound on eastward courses of discovery and colonization (Finney, 1985, 1988). In 1986 and 1987, the authors initiated a long-term archaeological project in the Manu'a group (Hunt & Kirch, 1988), leading to the discovery of several early sites containing pottery assemblages. The Toaga site (AS-13-1) on Ofu Island, in particular, contains a deeply-stratified sequence of cultural occupations. In this paper, we report a sequence of seven ¹⁴C age determinations from the Toaga site, providing the first radiometric framework for eastern Samoan prehistory. Following a brief summary of the Toaga site, and the radiocarbon dates, the implications of this sequence for Polynesian prehistory are discussed.

THE TOAGA SITE

The Toaga site (AS-13-1) is located on the southeastern coast of Ofu Island (14° 10' 55" S, 169° 39' 0" E), a very steep remnant shield volcano of Pleistocene age. The site is situated within the geomorphologic context of a narrow coastal plain constructed primarily of unconsolidated marine calcareous sands, with alternating terrigenous colluvial deposits at the base of the steep volcanic slope. A geomorphologic analysis of the site stratigraphy, to be presented in detail elsewhere (Kirch, Hunt & Tyler, ms in preparation), indicates that this coastal plain has prograded substantially within the late Holocene. At ca 4000 BP, immediately prior to initial human settle-

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ment, the shoreline was much closer to the volcanic cliffs than at present, and occupation was confined to the formerly narrow beach ridge.

The site was discovered during reconnaissance survey in 1986, when inspection of a bulldozed landfill operation revealed Polynesian Plainware ceramics in a buried occupation horizon (Hunt & Kirch, 1988). A test pit was excavated, and a sample of marine shell midden dated to 2350 ± 50 (Beta-19742) (Hunt & Kirch, 1987). In 1986, expanded excavations were undertaken at the site in undisturbed areas of the coastal plain east of the landfill. A total of 13m^2 was excavated, 7m^2 in a main stratigraphic trench, and 6 test excavation units. The main trench revealed a deep stratigraphic sequence (total excavation depth 3.5m), with the following principal stratigraphic units: Layer I, massive deposit of colluvium; Layer II, calcareous sand representing dune-beach ridge depositional environment prior to coastal progradation, and incorporating Layer IIB, an occupation horizon with Polynesian Plainware ceramics; Layer III, massive deposit of silty-clay colluvium; Layer IV, mixed calcareous sand with reddish colluvial clay; Layer V, basal calcareous beach deposit, containing isolated sherds of thin, fine ceramic ware.

Layer IIB of the Toaga site yielded one of the largest samples of Polynesian Plainware ceramics and associated cultural materials (fishhooks, ornaments, other artifacts, as well as vertebrate and molluscan faunal remains) from the Samoan Archipelago. Thus, it is of substantial significance for our understanding of Western Polynesian prehistory. The small thin-ware sherds from Layer V represent an earlier ceramic phase of uncertain, but probable Lapita, affinity. The site also incorporates later aceramic prehistoric occupations in Layer I, overlying the main Polynesian Plainware phase (Layer IIB). In short, the Toaga site encapsulates within its sequence virtually the entire span of Samoan prehistory.

THE RADIOCARBON SEQUENCE FROM TOAGA

The seven ^{14}C samples from the Toaga site were selected from key stratigraphic contexts so as to provide a chronologic framework for the site from initial human occupation up through late prehistory. Six samples consist of marine shell, naturally deposited but in direct association with ceramic sherds (Beta-25035 and -25673), and culturally-modified food remains (Beta-25034, -25033, -26463 and -26465). Sample Beta-26464 consisted of wood charcoal fragments in association with Polynesian Plainware pottery.

^{14}C measurements were performed by Beta Analytic, Inc. Shell samples were pretreated by etching away the outer layers with dilute acid. The samples were then attacked with further acid to produce carbon dioxide, which was used as the carbon source (M Tamers, pers commun, 21 July 1988). The charcoal sample was picked for rootlets, and then given an acid, alkali and acid series of soakings. Benzene syntheses and counting of all samples proceeded normally. Charcoal sample, Beta-26464, which consisted of only 0.2g of final carbon after pretreatment, was given extended counting time (four times the normal amount) to reduce statistical error as much as prac-

ticable. The $^{13}\text{C}/^{14}\text{C}$ ratios were measured for all samples to establish ^{13}C adjusted, "conventional ^{14}C ages" (Stuiver & Polach, 1977). These conventional age determinations, ^{13}C values, and details of all samples are presented at the end of this paper.

Corrections for specific ^{14}C activity, and for the marine reservoir effect taking into account regional ocean variation (ΔR estimate), as well as calibration for secular effects, were made following the recent work of Stuiver, Pearson and Braziunas (1986) for the marine shell samples, and of Stuiver and Becker (1986) for the terrestrial charcoal sample. For calibration of the marine shell samples, we used a ΔR value of 100 ± 24 , a weighted average of empirically determined ΔR values from Eniwetok, Hawaii and Society Islands (Stuiver, Pearson and Braziunas, 1986, Table 1). As in the case of ^{14}C samples from Lapita sites in the Mussau Islands (Kirch & Hunt, 1988, p 162), we feel that this pooled value best represents a ΔR value for the tropical central Pacific. Calibrations and probability estimates were made using the Rev. 2.0 version of Stuiver and Reimer's FORTRAN microcomputer program (Stuiver & Reimer, 1986).

Figure 1 displays the calibrated BP age ranges (1σ) for the seven samples from the Toaga site, in stratigraphic order. The samples are internally consistent with each other and with the stratigraphic sequence, with no significant inversions or anomalies.

Beta-25035 and -25673, which overlap at 2σ , indicate an age between 3700–3300 BP for the deposition of the calcareous sand beach deposit represented by Layer V in the main excavation. The isolated thin-ware ceramic sherds contained within this beach deposit are inferred to date to this same approximate time span. This age range is consistent with ^{14}C dates for initial Lapita occupation sites elsewhere in the southwest Pacific, including Tonga and Fiji (Kirch & Hunt, 1988, Fig 2).

Beta-25034, -26464 and -25033 are in direct association with the prin-

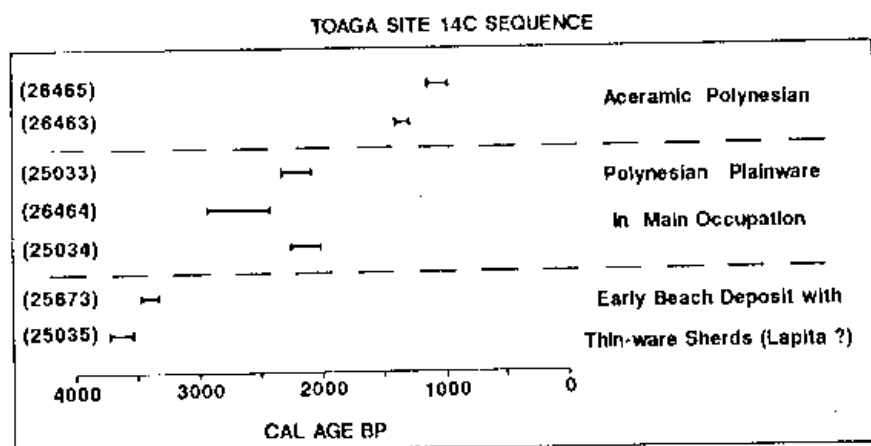


Fig 1. Calibrated BP age ranges (1σ) of ^{14}C samples from the Toaga site, Ofu Island, in stratigraphic order, with major cultural associations noted

cipal occupation deposit in Layer II of the main excavation, and with its correlated stratigraphic deposit in test excavation Unit 10. A fourth sample in association with ceramics was obtained in 1986 during the excavation of a test unit near the land-fill operation, and yielded a ^{14}C age of 2350 ± 50 (Hunt & Kirch, 1987, p 418). Together, all four samples in association with Polynesian Plainware ceramics, fishhooks and other cultural artifacts indicate a time span of ca 2500–1900 BP for this main occupation phase.

Beta-26463 was obtained from the base of an aceramic occupation deposit seaward of the main excavation trench, and overlying a calcareous beach deposit stratigraphically capping the Polynesian Plainware occupation in the main trench. Its age range of 1389–1287 BP indicates that the inhabitants of Ofu Island had ceased manufacturing or using pottery by the mid-first millennium AD.

Beta-26465 dates the base of an aceramic habitation platform constructed essentially on the present ground surface (and thus, overlying the midden from which Beta-26463 was obtained). The age of 1122–950 BP indicates that the alternating marine-terrestrial (beach ridge-colluvial slope) depositional sequence of the Toaga site had been completed by this time period, with the construction of permanent habitation features on the modern landscape.

CONCLUSIONS

The suite of 8 ^{14}C age determinations from the Toaga site (7 reported herein, plus 1 additional date obtained in 1986 (Hunt & Kirch, 1987)) provide a stratigraphically consistent chronologic sequence for human occupation of Ofu Island, spanning the period from ca 3700–3300 BP up to the modern era. This sequence has the following significant implications for Polynesian prehistory:

- 1) Although only a few small thin-ware sherds were recovered from the basal Layer V beach deposit, their stratigraphic context is secure, sealed under the massive colluvial deposit of Layer III. We believe that the sherds represent the periphery of a primary occupation area lying further inland of the main excavation trench, and now buried under as much as 5–15m of colluvium. The sample of sherds is too small to determine, on stylistic criteria, whether they represent Lapita pottery, but the associated ^{14}C ages of Beta-25035 and -25673 are wholly consistent with other ^{14}C dates from Lapita sites in Tonga and Fiji (Kirch & Hunt, 1988). Pending further excavations at Toaga to obtain a larger sample of this early thin-ware pottery (planned for 1989), we believe it is reasonable to tentatively conclude that the human colonization of Ofu Island was effected by a Lapita population in the mid-third millennium BC. This extends the known eastern boundary of the Lapita cultural complex from Western Samoa to the Manu'a group, and reinforces the emerging picture of the Lapita dispersal as a very rapid phenomenon. It further suggests that the true eastern boundary of the Lapita distribution may not yet be archaeologically attested.

- 2) Four ^{14}C dates in direct association with Polynesian Plainware ceramics and other artifacts indicate that this phase of Samoan prehistory

extended from ca 2500–1900 BP. These dates from Toaga are in close agreement with other ¹⁴C ages from Plainware sites in Western Samoa (Green & Davidson, 1974; Jennings & Holmer, 1980). Thus, the phase of Plainware production and use was contemporaneous throughout both western and eastern parts of the archipelago.

3) Two ¹⁴C dates (Beta-26463 and -26465) from aceramic cultural contexts indicate that the production and use of pottery on Ofu Island had ceased sometime between ca 1900 and 1300 BP. These dates are consistent with the interpretation of Green and Davidson (1974) that pottery use in Western Samoa ended by ca AD 300.

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ARCHAEOLOGIC SAMPLES

Ofu Island series

Beta-25033. Toaga 2640 ± 80
δ¹³C = +2.3‰

Marine shell (*Turbo setosus*, 71g) from Unit 6, Layer IIA-1. *Comment:* specimen represents culturally-deposited food remains (midden) assoc with earth oven feature and small quantities of Polynesian Plainware ceramics. Cal BC 362 (244) 145 at 1σ; cal BP 2311 (2193) 2094 at 1σ.

Beta-25034. Toaga 2570 ± 80
δ¹³C = +2.5‰

Marine shell (*Turbo setosus*, 70g) from Unit 6, Layer IIB. *Comment:* specimen represents culturally-deposited food remains (midden) in primary occupation deposit containing Polynesian Plainware ceramics, shell fishhooks and other artifacts. Cal BC 295 (161) 58 at 1σ; cal BP 2244 (2110) 2007 at 1σ.

Beta-25035. Toaga 3820 ± 70
δ¹³C = +2.4‰

Marine shell (*Asaphis violascens*, *Lucella cinerea*, 48g) from Unit 6, Layer V, 314cm below surface. *Comment:* specimens consist of naturally-deposited marine shell in a beach deposit also containing isolated thin-ware ceramic sherds. Marine shell retained surface coloration, and was not water-rolled, indicating deposition soon after death. Cal BC 1765 (1682) 1600 at 1σ; cal BP 3714 (3631) 3549 at 1σ.

Beta-25673. Toaga

3620 ± 80

 $\delta^{13}C = +2.2\text{‰}$

Marine shell (*Phatium* sp, 45g) from Unit 1, Layer V, 290cm below surface. *Comment:* specimen consists of a single whole shell, not waterworn and with original coloration, naturally deposited in beach deposit also containing isolated thin-ware ceramic sherds. Cal BC 1526 (1441) 1377 at 1 σ ; cal BP 3475 (3390) 3326 at 1 σ .

Beta-26463. Toaga

1910 ± 50

 $\delta^{13}C = +2.5\text{‰}$

Marine shell (*Turbo setosus*, 72g) from Unit 3, Layer II-4, 40-70cm below surface. *Comment:* specimen consisted of a single large shell, with apertural margin displaying chipping, due to cultural removal of operculum. Represents basal contact of cultural, aceramic midden deposit with underlying sterile beach sand. Cal AD 561 (620) 663 at 1 σ ; cal BP 1389 (1330) 1287 at 1 σ .

Beta-26464. Toaga

2620 ± 140

 $\delta^{13}C = -27.8\text{‰}$

Charcoal flecks (coln weight ca 1g, yielding 0.2g final carbon after pretreatment) from Unit 10, Layer IIB occupation, 70-80cm below surface. *Comment:* assoc with Polynesian Plainware ceramics. Sample was given extended counting time. Cal BC 967 (801) 454 at 1 σ ; cal BP 2916 (2750) 2403 at 1 σ .

Beta-26465. Toaga

1600 ± 70

 $\delta^{13}C = +2.0\text{‰}$

Marine shell (*Turbo setosus*, 66.4g) from Unit 13, Layer III-3, 35-45cm below surface. *Comment:* sample consisted of 1 nearly complete shell and 2 smaller fragmentary shells, all displaying culturally-induced fractures and chipping. Exterior of all shells were stained light-gray from inclusion in cultural midden deposit. Specimens assoc with aceramic cultural midden near base of pebble-paved house platform. Cal AD 828 (914) 1000 at 1 σ ; cal BP 1122 (1036) 950 at 1 σ .

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APPENDIX 3
RESULTS OF QUANTITATIVE ANALYSIS OF
MOLLUSCAN MIDDEN SAMPLES FROM SITE AS-13-1

NOTE: The following tables present the results of quantitative analysis of molluscan midden samples from the site AS-13-1 excavations. All weights expressed in the tables are in grams.

The provenience designations given along the top row of each table are field labels, which indicate the provisional (field) layer designations (roman numerals), followed by the arbitrary excavation level (arabic numerals). For the main trench units, the following concordance between field layer designations, and the final stratigraphic designations used in the above report should be consulted:

Field Designation	Final Designation
I	IA, IB
II	IC
IIA	IIA-1
III	IIA
IV	IIB
V	IIC
VI	III
V	IV

TAXONOMIC LISTING OF IDENTIFIED SPECIES

Turbinidae

Turbo crassus Wood
Turbo setosus Gmelin
Astrea stellare Gmelin
Lunella cinereus Born
 Turbo spp.

Neritidae

Nerita picea Recluz
Nerita plicata Linne
Nerita polita Linne
 Nerita spp.

Haliotidae

Haliotis ovina Gmelin

Patellidae

Patella sp.
 Cellana sp.

Trochidae

Trochus maculatus Linne
Trochus niloticus Linne
Tectus fenestrus Gmelin
 Trochus spp.

Cerithiidae

Cerithium nodulosum Bruguiere
 Cerithium sp.

Strombidae

Strombus maculatus
Strombus mutabilis Swainson
 Strombus sp.

Cypraeidae

Cypraea annulus Linne
Cypraea arabica Linne
Cypraea caputserpentis Linne
Cypraea mappa Linne
Cypraea moneta Linne
Cypraea tigris Linne
 Cypraea spp.

Tonnidae

Tonna sp.

Cymatium

Cymatium nicobarium Roding
 Cymatium sp.

Thaididae

Thais armigera Link
 Thais sp.
Drupa ricina Linne
Drupa grossularia Roding
Drupa rubusidaeus Roding
 Drupa sp.
Morula uva Roding
 Nassa sp.

Buccinidae

Cantharus undosa Linne

Vasidae

Vasum ceramicum Linne

Muricidae

Naticidae
 Policines sp.
 Bursidae
 Bursa granularis Roding
 Bursa sp.
 Conidae
 Conus ebraeus Linne
 Conus eburneus Hwass
 Conus sp.
 Terebridae
 Terebra sp.
 Bullidae
 Bulla sp.
 Alys cylidricus Helbing
 Melampidae
 Melampus fasciatus Deshayes
 Pythia scarabeus Linne
 Nassaridae
 Nassarius sp.
 Hipponicidae
 Hipponix conicus Schumacher
 Arcaidae
 Arca sp.
 Mytilidae
 Pteriidae
 Isognomon sp.
 Lucinidae
 Codakia divergens
 Codakia sp.
 Veneridae
 Periglypta reticulata Linne
 Gafrarium sp.
 Tridacnidae
 Tridacna maxima Roding
 Hippopus hippopus Linne
 Tellinidae
 Quidnipagus palatam Iredale
 Scutarcopegia scobinata Linne
 Chamiidae
 Chama sp.

TP-1	II	III-3	IV-4	IV-5	IV-6
Turbo crassus	20.00	150.00	2.98	503.39	68.41
Turbo setosus	60.00	150.00	179.17	503.39	258.85
Turbo spp.					
Operculae					
Astrea stellare					
Trochus maculatus					
Trochus spp.	5.00	20.00	5.00	20.00	40.00
Cypraea spp.	1.00	10.00		20.00	15.00
Nerita polita					
Nerita spp.				13.00	5.00
Strombus cf. maculatus				10.00	
Hipponix conicus					5.00
Muricidae				10.00	
Cymatiidae					5.00
Melampidae					5.00
Cerithiidae					
Conidae					
Mytilidae	2.00	10.00	3.00	5.00	5.00
Tridacna maxima				279.67	370.00
Scutarcopagia scobinata			3.00		5.00
Periglypta reticulata			59.17		
Asaphis violaceus					
Gafrarium			60.00		
Lucinidae		3.00			
Urchin		*	*	0.23	0.28
Crustacea	*				

TP-1	V-7	V-8	VI-9
Turbo crassus		30.00	0.54
Turbo setosus	331.26	281.13	
Turbo spp.			
Operculae			
Astrea stellare		12.44	
Trochus maculatus		3.47	1.28
Trochus spp.	28.00	40.00	1.00
Cypraea spp.	25.00	15.00	
Nerita polita			0.97
Nerita spp.	5.00		1.00
Strombus cf. maculatus	30.00		
Hipponix conicus			
Muricidae	15.00		
Cymatiidae			
Melampidae			
Cerithiidae	25.00		
Conidae		10.00	
Mytilidae	5.00	5.00	1.00
Tridacna maxima	81.52		
Scutarcopagia scobinata	10.00	15.00	2.29
Periglypta reticulata			
Asaphis violaceus			0.27
Gafrarium			
Lucinidae			
Urchin	*	*	
Crustacea			

TP-2	II-5	II-6	II-7	II-8	II-9	II-10
Turbo crassus						1.00
Turbo setosus	354.03	158.28	3.43	15.00	9.92	5.97
Trochus maculatus						4.72
Trochus niloticus	99.91					
Trochus spp.			2.00	2.00		2.00
Nerita picea					1.05	0.26
Nerita plicata					0.88	
Nerita polita					2.65	5.53
Nerita spp.	2.00			5.00	10.00	5.00
Cypraea annulus			0.35		5.03	3.87
Cypraea moneta			1.65		1.61	1.10
Cypraea spp.	10.00	3.00	3.16	10.00	14.26	12.21
Cymatium nicobarium					0.60	2.96
Drupa ricina						3.68
Morula sp.						0.40
Muricidae				10.00		2.00
Cantharus undosus					4.74	3.18
Bulla verrucosa					0.36	
Melampus fasciatus					1.08	1.29
Melampidae					5.00	1.00
Strombus cf. maculatus		5.00		3.00	1.11	1.00
Strombus cf. mutabilis						1.00
Conidae			2.24	2.00	13.76	1.00
Cerithiidae	3.34	5.00			1.07	
Hipponix conicus			1.00		17.77	2.00
Cellana sp.			0.16		0.12	0.54
Mytilidae	2.00					0.40
Tridacna maxima	61.86	40.17				
Scutarcopagia scobinata				10.00		
Arca sp.						1.09
Codakia sp.						0.73
Urchin	*					
Crustacea					0.15	0.16

TP-3	I-1	I-2	I-3	II-3	II-4	Basal
Turbo crassus	16.28					
Turbo setosus	111.07	499.78	300.80	270.00	207.18	22.35
Astrea stellare					7.17	
Trochus maculatus	1.20					1.24
Trochus spp.		30.00	10.00	55.00	10.00	18.58
Drupa sp.					0.53	0.75
Thais armigera	1.84					
Thais sp.						0.95
Vasum ceramicum	3.88					
Muricidae		3.00	5.00	40.00	10.00	
Strombus cf. maculatus		10.00		2.00	5.00	
Strombus cf. mutabilis					1.78	
Strombus sp.						0.63
Cantharus undosus					10.53	
Bursa granularis						0.60
Cerithiidae					10.79	1.22
Cypraea annulus					0.54	
Cypraeidae	35.33	10.00	40.00	20.00	21.33	13.19
Cymatium nicobarium					3.20	5.74
Conus	11.96		5.00			10.13
Nerita plicata					4.13	0.32
Nerita polita					3.66	2.20
Neritidae		10.00		5.00	10.00	
Alys naucum						0.09
Melampus fasciatus						4.42
Mytilidae				2.00	3.00	0.43
Cellana sp.					1.11	0.12
Tridacna maxima					0.20	82.00
Scutarcopagia scobinata					5.00	
Urchin				*		0.20
Crustacea						0.83

Unit 4	III	IV-3	IV-4	IV-5
Turbo crassus	40.01	70.73	165.00	8.40
Turbo setosus	174.66	283.17	598.01	125.12
Turbo spp.	40.00	15.00	70.00	3.00
Astrea stellare				7.61
Strombus cf. maculatus	2.00			
Nerita polita			2.40	
Neritidae	1.00	5.00	10.00	
Cerithiidae	2.00		15.00	
Cymatidae			10.00	
Cypraeidae	2.00	5.00	50.00	10.00
Vasum ceramicum	9.33			
Muricidae	50.00	15.00	20.00	
Melampidae	5.00	3.00		
Conidae	2.00		10.00	
Hipponix conicus	2.00			
Mytilidae	5.00	5.00	10.00	1.00
Tridacna maxima			15.00	
Scutarcopagia scobinata	2.00	5.00	5.00	
Anadara sp.		1.00		
Gafrarium			5.00	
Lucinidae		2.00		5.00
Urchin	1.06	1.17	1.51	*
Crustacea	1.00	1.12	0.44	

Unit 5	IIa-2	III-3	IV-4	IV-5	V-6
Turbo crassus	55.16	34.98	12.00	20.00	182.18
Turbo setosus	514.37	219.63	965.51	402.30	312.20
Turbo spp.	50.00	90.00	60.00	30.00	15.00
Lunella cinereus	2.74				
Trochus maculatus	6.97		6.40		7.07
Strombus cf. maculatus	15.00		10.00	30.00	20.00
Vasum ceramicum			64.42		
Muricidae	20.00	10.00	98.00	5.00	30.00
Nerita polita					3.33
Neritidae	10.00		7.00	10.00	12.00
Cypraeidae	10.00	10.00	25.00	35.00	10.00
Cerithium nodulosum					
Cerithiidae			5.00	10.00	
Cymatium nicobarium					6.84
Cymatiidae	10.00				
Melampidae	10.00		2.00	3.00	
Conidae	10.00		20.00		
Hipponix conicus			2.34		
Mytilidae	20.00	10.00	2.00	2.00	2.00
Hippopus hippopus					60.00
Tridacna maxima	60.00	17.90		291.11	29.00
Scutarcopagia scobinata	3.00	5.00	5.00	8.00	3.00
Chama spp.				30.00	
Urchin	5.78	1.32	3.24	1.95	*
Crustacea		0.39	0.27	0.39	

Unit 5	V-7	V-8	V-9
Turbo crassus	105.00	65.00	
Turbo setosus	195.00	308.99	107.37
Turbo spp.	50.00	50.00	10.00
Lunella cinereus			
Trochus maculatus			5.99
Strombus cf. maculatus		10.00	
Vasum ceramicum			
Muricidae		25.00	
Nerita polita			
Neritidae		10.00	
Cypraeidae	25.00	40.00	2.00
Cerithium nodulosum		135.00	
Cerithiidae			
Cymatium nicobarium			
Cymatiidae			
Melampidae	5.00	10.00	5.00
Conidae		5.00	5.00
Hipponix conicus	2.34	5.00	
Mytilidae	5.00		
Hippopus hippopus			155.00
Tridacna maxima	447.84	15.00	
Scutarcopagia scobinata	10.00	15.00	5.00
Chama spp.			
Urchin		*	0.29
Crustacea			0.16

Unit 6	IIa-2	III-3	III-4	IV-5	IV-6
Turbo crassus	160.00	30.00	2.00	9.50	214.23
Turbo setosus	866.18	164.56	31.88	112.28	310.47
Turbo spp.	95.00	80.00	5.00	11.59	70.00
Lunella cinereus					
Astrea rhodostoma					
Trochus maculatus		9.08		1.10	
Strombus cf. maculatus		5.00			10.00
Strombus cf. mutabilis					
Muricidae	30.00	5.00			20.00
Nerita plicata				0.40	
Nerita polita					
Neritidae	10.00	1.00			10.40
Cerithium nodulosum					20.00
Cerithiidae		1.00			
Cypraea mappa					
Cypraea moneta					
Cypraeidae	20.00	20.00	10.00	10.00	40.00
Cymatium nicobarium					
Cymatiidae	15.00				
Bursidae					
Conidae		5.00			5.00
Policines spp.					5.00
Bulla sp.					0.39
Tonnidae					
Melampus fasciatus					
Pythia scarabeus					
Melampidae	5.00	1.00		5.00	5.00
Hipponix conicus	10.00			1.00	5.00
Patella sp					
Mytilidae	15.00	20.00	2.00		2.00
Hippopus hippopus				121.40	
Tridacna maxima	160.00			70.00	15.00
Asaphis violaceus					
Scutarcopagia scobinata	5.00			13.40	10.00
Tellinidae					1.00
Urchin	*	4.34	0.31	0.40	1.57
Crustacea		1.21	1.00	0.38	0.07

Unit 6	V-7	VI-8	VI-10
Turbo crassus	90.00	44.38	4.58
Turbo setosus	447.66	84.83	100.92
Turbo spp.		32.00	8.08
Lunella cinereus			8.66
Astrea rhodostoma	5.00		
Trochus maculatus		19.20	
Strombus cf. maculatus	5.00		
Strombus cf. mutabilis		2.42	
Muricidae	90.00		
Nerita plicata			14.85
Nerita polita			
Neritidae	10.00	0.32	
Cerithium nodulosum			
Cerithiidae			
Cypraea mappa		24.25	
Cypraea moneta		9.72	
Cypraeidae	85.00	0.73	3.89
Cymatium nicobarium		2.02	
Cymatiidae			
Bursidae		13.17	
Conidae	5.00	4.78	
Policines spp.			
Bulla sp.			
Tonnidae	15.00		
Melampus fasciatus		0.89	
Pythia scarabeus			1.47
Melampidae	15.00		
Hipponix conicus	5.00		
Patella sp		1.09	
Mytilidae	15.00		
Hippopus hippopus			
Tridacna maxima	760.00	40.67	
Asaphis violaceus		1.12	
Scutarcopagia scobinata	15.00	3.28	
Tellinidae			
Urchin	0.66	17.86	
Crustacea		0.32	5.28

Unit 7	IIa-2	III-3	III-4	IV-5	IV-6	V-7
Turbo crassus	95.00	10.00	32.52	14.46	10.00	20.00
Turbo setosus	384.78	20.00	73.50	240.68	199.85	313.89
Turbo sp	65.00	10.00	10.00	20.00	31.89	20.00
Astrea stellare			4.25			
Trochus maculatus			4.62		6.92	
Strombus cf. maculatus		2.00				
Cypraea arabica				25.63		
Cypraeidae	5.00	10.00	2.00	40.00	2.56	30.00
Vasum ceramicum						58.97
Muricidae	15.00	5.00			15.00	125.00
Nerita polita			1.39		0.07	
Neritidae		5.00	2.00	2.00	3.04	5.00
Cerithidae		3.00	2.68	2.00	1.00	
Melampidae		5.00		2.00	5.00	2.00
Bursa sp.		5.00				
Conidae		3.00		5.00		2.00
Hipponix conicus			1.00		2.00	2.00
Mytilidae	25.02	10.00	7.40			
Tridacna maxima	38.53			65.38	210.00	140.00
Tridacna spp.	45.00					
Scutarcopagia scobinata			3.00		5.00	2.00
Urchin	0.37		0.49	0.58	0.75	0.03
Crustacea	0.20		0.25	1.23		1.02

Unit 8

IIa-2

Turbo crassus	138.13
Turbo setosus	191.81
Turbo spp.	5.16
Trochus maculatus	17.83
Nerita polita	6.65
Bulla sp.	1.08
Thais armigera	14.22
Cantharus undosus	0.95
Melampus fasciatus	0.54
Cypraea annulus	1.77
Cypraea caputserpentis	2.64
Cypraea cf. tigris	0.37
Cypraeidae	12.95
Cerithidae	1.05
Cymatium	0.17
Mytilidae	4.39
Asaphis violaceus	1.95
Quidnipagus palatam	0.27
Scutarcopagia scobinata	2.50
Urchin	2.20
Crustacea	3.29

Unit 9	IIa-2	III-3	IV-4	IV-5	V-6
Turbo crassus	49.66	83.62	121.85	53.51	61.22
Turbo setosus	115.06	139.20	273.83	193.66	82.35
Turbo spp.			1.62		7.07
Astrea stellare					
Lunella cinereus	0.46				
Trochus maculatus	11.91	53.14	75.34	55.62	19.44
Trochus sp.					
Strombus cf. mutabilis	1.18				
Strombus sp.			2.24		
Cymatium nicobarium	5.87	1.12	3.68		
Cymatium				9.08	
Cypraea annulus	9.77	0.48			
Cypraea caputserpentis		4.12			3.25
Cypraea moneta	1.03				3.12
Cypraea spp.	5.40	5.75	18.39	5.05	3.64
Drupa grossolaria					
Drupa ricina	2.32			6.53	
Drupa spp.	1.62	2.65	5.90		
Thais armigera		13.73	48.81		
Thais sp.	0.86				
Vasum ceramicum					5.02
Bulla sp.		1.37	7.22	1.89	1.18
Cantharus undosus	0.61	0.47			
Nerita plicata	0.25	0.71	0.54		
Nerita polita		2.90	2.79	2.56	1.52
Nerita sp.					
Melampus fasciatus				0.24	
Bursa sp.		10.24	19.54		
Tonna sp.		1.53	3.83	0.33	
Nassa sp.				1.43	
Cerithium nodulosum					31.47
Cerithium	0.85	0.51		1.89	2.30
Conidae	1.49	4.54		8.67	1.46
Nassarius sp.					6.37
Haliotis ovina					
Hipponix conicus	1.04				
Cellana sp.					0.57
Mytilidae	11.00	5.09	2.98	0.47	0.42
Tridacna maxima		4.41	4.22		85.28
Quidripagus palatam		1.94		10.31	3.16
Scutarcopagia scobinata	0.81		1.24	2.83	1.76
Periglypta reticulata					
Codakia divergens					
Asaphis violaceus	1.12			0.86	
Arca sp.					1.75
Chama sp.					1.08
Isognomon sp.					
Urchin	13.15	25.23		15.84	2.96
Crustacea	1.28	1.22	24.42		

Unit 9	V-7	V-8	V-9	V-10	V-11	V-12
Turbo crassus	4.37	18.14	26.28	10.53	21.10	33.90
Turbo setosus	72.54	79.77	44.57	54.05	78.86	140.85
Turbo spp.	1.45	12.99	7.78	7.96	1.88	5.34
Astrea stellare		0.52				
Lunella cinereus						1.08
Trochus maculatus	16.92	11.06	9.11	22.63	12.76	28.41
Trochus sp.	2.22	1.06				
Strombus cf. mutabilis	1.39					
Strombus sp.						
Cymatium nicobarium						
Cymatium						
Cypraea annulus	2.02	2.43	0.32	1.90	0.95	0.74
Cypraea caputserpentis		0.01				
Cypraea moneta	1.61	2.08		10.65	11.14	2.96
Cypraea spp.	2.53	0.92	0.41	0.22	9.06	6.52
Drupa grossularia		1.72				
Drupa ricina						
Drupa spp.						
Thais armigera		2.18				
Thais sp.		1.75				
Vasum ceramicum				0.83	3.20	
Bulla sp.						
Cantharus undosus	1.28	3.46				0.72
Nerita plicata						
Nerita polita	1.37		2.43	1.68		6.48
Nerita sp.		1.37				
Melampus fasciatus	0.63			0.23		0.34
Bursa sp.					16.05	
Tonna sp.		1.00		0.42		0.72
Nassa sp.						
Cerithium nodulosum						
Cerithium						0.41
Conidae			0.74	1.11	1.85	50.29
Nassarius sp.						
Haliotis ovina		13.87				
Hipponix conicus				0.73		0.90
Cellana sp.	1.37			0.06		
Mytilidae	0.01	4.47	0.77	0.29	0.72	1.48
Tridacna maxima	12.33			109.08	11.42	7.35
Quidnipagus palatam		4.58	2.46	1.23	1.76	
Scutarcopagia scobinata	0.88	1.68		4.64	1.15	0.83
Periglypta reticulata		0.58				
Codakia divergens		0.53				0.34
Asaphis violaceus						
Arca sp.	4.25					
Chama sp.						
Isognomon sp.		0.67				
Urchin	4.21	3.04	7.07	17.38	5.07	11.43
Crustacea			0.23			0.50

Unit 10	I-1	II-2	II-3	III-4	IV-5	IV-6
<i>Turbo crassus</i>		2.51	6.79	7.94	4.25	20.47
<i>Turbo setosus</i>	86.82	104.02	90.76	99.85	48.33	66.34
<i>Lunella cinereus</i>					5.52	9.03
<i>Turbo</i> spp.						16.80
<i>Trochus maculatus</i>				9.71	8.98	10.40
<i>Strombus</i> cf. <i>mutabilis</i>	0.32					
<i>Strombus</i> sp.				0.54	0.45	
<i>Cypraea moneta</i>		1.36				
<i>Cypraea</i> spp.			6.65	5.99	6.06	2.79
<i>Nerita plicata</i>			1.26		1.80	
<i>Nerita polita</i>			3.71		6.39	8.89
<i>Nerita</i> spp.				11.87		2.65
<i>Drupa</i> sp.			0.60	1.01	0.76	
<i>Thais armigera</i>					4.41	
<i>Thais</i> sp.				9.41	2.32	
<i>Cantharus undosus</i>		0.84	0.48			
<i>Pythia scarabeus</i>					4.66	7.44
<i>Melampus fasciatus</i>			0.35	1.75	1.05	
<i>Harpa amuretta</i>					13.79	
<i>Bulla</i> sp.				0.46	0.23	1.54
<i>Tonna</i> sp.		0.64		0.18		
<i>Cerithium nodulosum</i>				1.18		
<i>Cerithium</i>			0.30	1.03		0.68
<i>Cymatium</i> sp.			0.83		2.77	
<i>Nassarius</i> sp.			0.65			
<i>Terebra</i> sp.				0.89		
<i>Conus</i> spp.		2.49	2.21	5.89	0.95	1.44
<i>Hipponix conicus</i>				0.40		
Mytilidae			1.18	0.73	0.15	1.26
<i>Tridacna maxima</i>	9.33		19.38			
<i>Quidnipagus palatam</i>			0.45	1.16		0.96
<i>Scutarcopagia scobinata</i>		3.94				
<i>Asaphis violaceus</i>			2.48	0.77		
<i>Chama</i> spp.		1.56			13.02	1.49
<i>Isognomon</i> sp.		0.43				
Urchin			7.08	29.51	0.52	
Crustacea			0.38	1.77	0.59	4.85

Unit 11	I-2	II-3	II-4	II-5	II-6	II-7
Turbo crassus	74.20	373.65	283.25	207.59	234.97	200.21
Turbo setosus	222.80	242.20	718.46	1004.87	295.64	724.19
Astrea stellare	0.89	9.09		6.51		
Lunella cinereus						
Turbo spp.	30.50	23.02	53.48	44.06	22.41	32.65
Trochus maculatus	8.48	28.40	67.12	74.91	56.90	90.08
Trochus niloticus				4.36		
Tectus pyramis		49.28				
Strombus cf. mutabilis		2.84		5.75	2.53	
Strombus spp.						0.35
Drupa ricina	15.23	1.24	9.14	22.62		
Drupa rubusidaceus						16.73
Drupa sp.					13.03	0.54
Morula cf. uva						
Thais armigera	19.00	5.47	25.32	49.56	0.40	31.21
Thais sp.						19.17
Vasum ceramicum	10.52	66.45	110.36	123.67	22.25	
Cypraea annulus		0.23		2.17		0.18
Cypraea arabica						21.31
Cypraea caputserpentis		15.18	23.94	10.19		21.69
Cypraea cf. ebraeus						
Cypraea mappa				3.05		
Cypraea moneta		7.53	2.93			
Cypraea spp.	15.56	33.37	49.46	36.37	19.53	19.24
Nerita picea			0.48	0.97	0.79	
Nerita plicata		0.76		0.68		0.36
Nerita polita		1.29	6.06		0.67	5.26
Cerithium nodulosum		19.13				6.99
Cerithium spp.			5.30			1.03
Cantharus undosus						
Bursa sp.						39.29
Nassa sp.	3.17			3.18		2.87
Cymatium sp.	0.17		0.99		1.66	4.20
Conus spp.	4.77	19.56	65.30	62.36	50.47	65.02
Terebra sp.		8.17				
Tonna sp.			4.24			
Bulla sp.					0.43	
Melampus fasciatus					1.17	0.01
Pythia scarabeus		0.45			1.15	
Hipponix conicus	0.45	2.69	0.65	1.60	0.60	0.21
Mytilidae	0.13				0.24	0.54
Hippopus hippopus						14.48
Tridacna maxima	52.09	84.87	74.48	81.31	15.61	50.40
Scutarcopagia scobinata			4.69	1.07		1.14
Asaphis violaceus				1.08		
Isognomon sp.						
Urchin		5.89	2.74	10.91	2.01	14.10
Crustacea						0.34

Unit 11	II-8	II-9	II-10	II-11	II-12	III-13
Turbo crassus	247.78	77.68	170.25	11.65	91.05	3.55
Turbo setosus	815.43	438.48	409.48	433.27	469.47	75.23
Astrea stellare	4.36	12.65				
Lunella cinereus	0.90	0.60	3.11			
Turbo spp.	48.19	35.62	36.54	33.53	4.99	9.48
Trochus maculatus	72.33	78.74	73.02	45.75	36.67	
Trochus niloticus	2.39			2.74		
Tectus pyramis						
Strombus cf. mutabilis	3.60	2.37				
Strombus spp.						
Drupa ricina			7.97	4.46	1.73	
Drupa rubusidaceus						
Drupa sp.	6.88					
Morula cf. uva	0.47					
Thais armigera	15.36	13.59	34.34	67.18		
Thais sp.	21.55					
Vasum ceramicum		23.79	11.04	30.36		
Cypraea annulus	1.19	1.28				
Cypraea arabica	5.02					
Cypraea caputserpentis	20.67	14.65	14.00	1.76		
Cypraea cf. ebraeus	2.38					
Cypraea mappa						
Cypraea moneta						
Cypraea spp.	55.43	48.75	15.31	17.53	14.11	0.85
Nerita picea						
Nerita plicata	1.27	0.77				
Nerita polita	2.54	1.15	6.87	4.16	3.15	3.59
Cerithium nodulosum	33.42		45.04			
Cerithium spp.	1.43	1.50		2.29		
Cantharus undosus			1.26			
Bursa sp.				3.71		
Nassa sp.						
Cymatium sp.	7.14		2.04	2.27		
Conus spp.	34.92	13.88	43.33	1.18	1.86	2.34
Terebra sp.						
Tonna sp.	0.44					
Bulla sp.						
Melampus fasciatus						
Pythia scarabeus					1.60	
Hipponix conicus	1.69		0.36			0.51
Mytilidae	0.34	0.29	0.89		0.53	
Hippopus hippopus						
Tridacna maxima	24.24	11.43	3.29	36.37	1.42	
Scutarcopagia scobinata		0.78	0.54		1.27	
Asaphis violaceus	1.10				1.78	
Isognomon sp.						
Urchin	22.78	11.39	5.12	11.34	10.49	0.36
Crustacea	0.28		47.99	16.13	10.94	1.30

Unit 11

III/IV-14

Turbo crassus	
Turbo setosus	32.89
Astrea stellare	
Lunella cinereus	4.74
Turbo spp.	
Trochus maculatus	
Trochus niloticus	
Tectus pyramis	
Strombus cf. mutabilis	
Strombus spp.	0.69
Drupa ricina	
Drupa rubusidaceus	
Drupa sp.	0.73
Morula cf. uva	
Thais armigera	
Thais sp.	
Vasum ceramicum	
Cypraea annulus	
Cypraea arabica	
Cypraea caputserpentis	
Cypraea cf. ebraeus	
Cypraea mappa	
Cypraea moneta	
Cypraea spp.	4.65
Nerita picea	
Nerita plicata	3.77
Nerita polita	3.70
Cerithium nodulosum	
Cerithium spp.	
Cantharus undosus	3.90
Bursa sp.	
Nassa sp.	
Cymatium sp.	
Conus spp.	2.17
Terebra sp.	
Tonna sp.	0.79
Bulla sp.	2.26
Melampus fasciatus	
Pythia scarabeus	
Hipponix conicus	
Mytilidae	
Hippopus hippopus	
Tridacna maxima	
Scutarcopagia scobinata	
Asaphis violaceus	
Isognomon sp.	0.23
Urchin	
Crustacea	3.73

Unit 12	I-1	II-3	II-4	III-5	III-6
Turbo setosus		28.42	13.88	11.64	
Astrea stellare			3.42	14.83	
Turbo spp.		2.66	69.72		8.32
Trochus maculatus			11.54	2.69	2.37
Trochus spp.		1.82			
Nerita polita	1.25				
Thais armigera			20.15		
Cypraea spp.			11.51		
Cymatium sp.			7.91		
Conus spp.		2.66	4.05		
Mytilidae			0.92		
Hippopus hippopus			8.39		
Quidnipagus palatam			0.28		0.75
Scutarcopagia scobinata			0.29		
Urchin		0.50	6.21		
Crustacea			0.22		

Unit 13	I-1	II-2	III-3	IV-4
<i>Turbo crassus</i>	23.65	43.82	73.98	
<i>Turbo setosus</i>	124.77	249.98	265.06	99.21
<i>Astrea stellare</i>			4.23	2.01
<i>Turbo</i> spp.	16.60	20.11	24.01	
<i>Trochus maculatus</i>	29.98	38.84	36.51	8.78
<i>Trochus niloticus</i>	8.84	6.38		
<i>Trochus</i> sp.	1.44			
<i>Nerita picea</i>		2.64		
<i>Nerita plicata</i>	6.49	1.79		
<i>Nerita polita</i>	6.43	7.86	3.39	2.09
<i>Nerita</i> sp.	2.68			
<i>Cypraea annulus</i>	4.05	9.69	5.64	1.47
<i>Cypraea arabica</i>	6.71	0.65		0.81
<i>Cypraea caputserpentis</i>		2.66	7.58	0.85
<i>Cypraea cf. tigris</i>		1.98		
<i>Cypraea moneta</i>	4.54	4.18	2.51	0.79
<i>Cypraea</i> spp.	33.76	50.75	24.19	6.64
<i>Strombus cf. mutabilis</i>	1.52	4.43	7.52	4.23
<i>Drupa ricina</i>		2.46	6.98	1.43
<i>Drupa</i> sp.	0.34	2.97	1.17	
<i>Thais armigera</i>		25.28	23.07	5.62
<i>Vasum ceramicum</i>		5.43	3.00	
<i>Cantharus undosus</i>		0.71	2.17	2.84
<i>Melampus fasciatus</i>	0.50		0.53	
<i>Cymatium</i> sp.	2.85			
<i>Cymatium nicobarium</i>		2.30		
<i>Conus cf. ebraeus</i>			2.63	
<i>Conus cf. eburneus</i>			3.98	
<i>Conus</i> spp.	47.54	21.41	17.21	0.83
<i>Tonna</i> sp.	1.23	0.54		0.82
<i>Nassa</i> sp.				0.45
<i>Hipponix conicus</i>	2.42	5.17	0.56	0.56
Mytilidae		5.48	3.37	
<i>Tridacna maxima</i>	47.64	26.78	19.17	7.66
<i>Quidnipagus palatam</i>				1.32
<i>Scutareopagia scobinata</i>	0.75	2.72	0.85	
<i>Periglypta reticulata</i>	6.26		8.10	
<i>Asaphis violaceus</i>		0.73		
<i>Chama</i> spp.	10.86			
Urchin		5.74	11.17	1.72

Unit 14	III-3	IIa-4	IIIb-5	IV-6
<i>Turbo crassus</i>		403.54	128.07	76.97
<i>Turbo setosus</i>		916.50	128.07	142.72
<i>Astrea stellare</i>			2.81	
<i>Lunella cinereus</i>			5.56	
<i>Turbo spp.</i>		13.80	24.22	10.11
<i>Trochus maculatus</i>		228.22	82.60	4.36
<i>Trochus niloticus</i>		35.32		
<i>Tectus pyramis</i>		4.46	26.19	
<i>Trochus spp.</i>			7.62	
<i>Drupa ricina</i>		4.90	3.70	
<i>Thais armigera</i>		143.78	103.87	
<i>Vasum ceramicum</i>		130.10	2.06	
<i>Nerita polita</i>		4.23	3.25	2.42
<i>Cypraea annulus</i>			1.32	
<i>Cypraea caputserpentis</i>			4.20	
<i>Cypraea cf. mappa</i>			2.24	
<i>Cypraea spp.</i>		16.65	8.14	
<i>Strombus cf. mutabilis</i>			3.81	
<i>Strombus sp.</i>			0.29	
<i>Melampus fasciatus</i>				0.24
<i>Bulla sp.</i>		1.65	0.26	
<i>Bursa sp.</i>		72.99	11.93	
<i>Cerithium sp.</i>		0.70	0.26	
<i>Conus spp.</i>	1.35	10.82	58.94	11.02
<i>Hipponix conicus</i>		0.70	1.63	
<i>Mytilidae</i>		4.88		
<i>Tridacna maxima</i>		274.52	26.27	
<i>Quidnipagus palatam</i>			3.60	1.00
<i>Scutarcopagia scobinata</i>			2.97	2.10
<i>Asaphis violaceus</i>		0.52	2.32	1.53
Urchin	1.34	5.38	8.35	103.45
TOTAL (in grams)	2.69	2273.67	654.55	355.92