MARINE RESOURCE USE AND DISTRIBUTION ON OFU ISLAND, MANU’A, AMERICAN SĀMOA

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
Of Agriculture and Applied Science

By

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In Partial Fulfillment of the Requirements
For the Degree of
MASTER OF ARTS

Major Department:
Sociology and Anthropology

April 2014

Fargo, North Dakota

North Dakota State University
Graduate School

Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University’s regulations and meets the accepted standards for the degree of

MASTER OF ARTS

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ABSTRACT

Marine resources have played a vital role in the lives of the prehistoric populations that settled Oceania. While it is widely accepted that marine resources make up a considerable component of the diet of prehistoric peoples, distinguishing between shell fragments as a result of food procurement or debris from tool manufacture can be a difficult task. This study, in addition to examining the density and distribution of shellfish use by human populations on Ofu Island, examines the various ways these shellfish might have been procured and processed by utilizing archaeological, ethnographic, and experimental methods. By analyzing excavation data from three sites, interviewing locals, taking part in a shellfish gathering trip, and performing test breaks on *Turbo* shells, it has been possible to gain a holistic view of shellfish use since initial human occupation. Findings reflect mobile populations that have exploited abundant marine resources in a resilient marine environment throughout prehistory.

ACKNOWLEDGEMENTS

A number of people greatly contributed to the creation, planning, and implementation of this research that deserve my thanks and recognition. I am incredibly grateful to the people of Ofu and Olosega who were continually willing to help me and other members of the research teams over the years of research on their islands. Without the Malae family at Va'oto Lodge, none of this would have been possible. Carlo Caruso, Tish Peau, Ricky Misaalafua, Alisana Malae, and the rest of the employees at the National Park of American Samoa provided crucial assistance and the use of the National Park Service labs for in-field post processing which helped tremendously. NDSU students and my fellow researchers worked hard both in the field and in the lab, providing much assistance and entertainment throughout the duration of this research. Finally, I must thank my committee, Jeffrey Clark, Thomas Riley, and Donald Schwert (and his Swiss Army knife) for their comments, criticism, advice, and guidance throughout my entire graduate career.

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LIST OF SAMOAN TERMS

‘Āiga………….Family

Ali’i……………Chief

Alili……………*Turbo* spp. or any common shellfish

Lama………….Fishing by torchlight

Matai………….Samoan title holder

Tulāfale……….Talking Chief

Umu……………Earth oven

CHAPTER 1. INTRODUCTION

This research seeks to examine the relationship between humans and the marine environment throughout the first thousand years of human occupation on Ofu Island, Manu'a, American Samoa. A focus on the exploitation of shellfish will serve as a case study for interpreting changing foraging practices of the early inhabitants of this island and hopefully aid in others' interpretations regarding broader archaeological issues such as subsistence systems and settlement patterns.

Volcanic high islands, the Samoan Archipelago is home to coral reefs rich in marine resources. A fringing reef fronts much of the islands of Manu'a, including the island of Ofu. The Ofu portion of the U.S. National Park of American Samoa is the reef at To'aga, which is a short distance away from the study site. The park has become a focal spot for reef researchers owing to the corals' resilience and resistivity to sea temperature changes that might wreak havoc upon other coral reefs. Although the corals within the territory have been relatively resilient, they are increasingly susceptible to coral bleaching, and modern technologies can put these areas at risk of overfishing. One example is SCUBA assisted fishing, which was banned on Tutuila in the mid-1990s after it was found that fish populations were threatened by severe overfishing (Richmond 2002). It is possible that archaeological research on Ofu Island will serve as an example to better understand interactions between humans and the marine environment over time, thus contributing to future applications for coral reef management throughout the territory.

Archaeology as Anthropology

Unlike archaeological traditions in other parts of the world, archaeology in the Unites States tends to be placed within the field of anthropology, as one of four subfields along with cultural anthropology, physical anthropology, and linguistics. Archaeologists are trained in a variety of methods, emphasizing anthropology's holistic approach to studying the human condition. As American archaeologists, we are able to draw from other areas of anthropology in order to glean useful information to fill the gaps left by purely archaeological methods such as excavation and survey. American archaeologists have the ability to apply cultural inferences to hard data, although that is not to say that other archaeologists are robots, but simply that as a subfield of anthropology, our emphasis lies more on the humanistic aspect of the material cultures we study. We are not mere pot-hunters, rifling through discarded possessions but, rather, we yearn to know more of human nature, the mundane details of daily life, in order to make better sense of current events and the path of our own society as revealed by our study of the past. By incorporating social methods into our research, we can enhance our understanding of the cultural relationships with artifacts and other material remains for which we search.

In order to bridge gaps left by archaeology alone, I have employed both ethnographic and experimental research. While on Ofu Island, I conducted a series of interviews with local residents regarding their knowledge of marine shellfish, specifically as a food resource. I also took part in a shellfish-gathering trip or, *lama alili*, in order to get a better idea of the time and energy expended in this activity as well as a general idea of how this might have been accomplished in the distant past. Experimental research also helped to shed light on the potential nature of shell materials recovered in midden deposits throughout our excavations at sites on Ofu that can be attributed to either food extraction, shell fishhook manufacture, or natural wear. Through performing experimental breakage of these shells, I attempted to test the hypothesis that breakage resulting from food extraction can produce pieces similar to the early stages of fishhook manufacture. By studying these breakage patterns, I was also able to make several inferences about the potential use of some of the broken shell types that have been recovered in excavations on Ofu.

Environmental Setting

The Samoan Archipelago lies in the Pacific Ocean in a cultural area known as Polynesia, and more specifically, West Polynesia. It is located roughly halfway between Hawai'i and New Zealand, on the Pacific Plate about 120 km north of the Tonga-Kermadec Trench. Though considered to be a single cultural group, the peoples of the archipelago are divided into an independent nation and an unincorporated territory of the United States. The Independent State of Samoa (formerly Western Samoa) comprises the largest islands in the archipelago, 'Upolu and Savai'i, as well as Manono and Apolima. The Territory of American Samoa includes the islands of Tutuila, Aunu'u, and the Manu'a group, which consists of Ta'u, Ofu, and Olosega; also included are the uninhabited Rose Atoll and Swains Island.

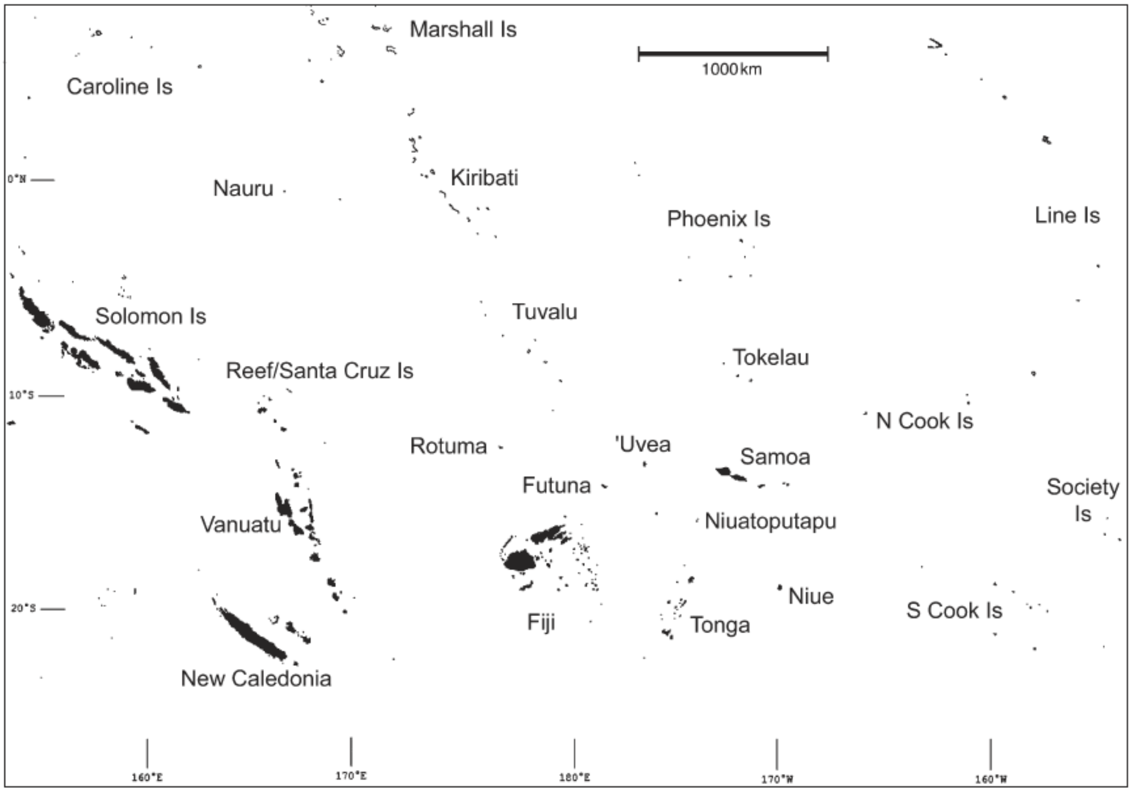


Figure 1: Map of Oceania adapted from Addison & Sand 2008, pg. 98.

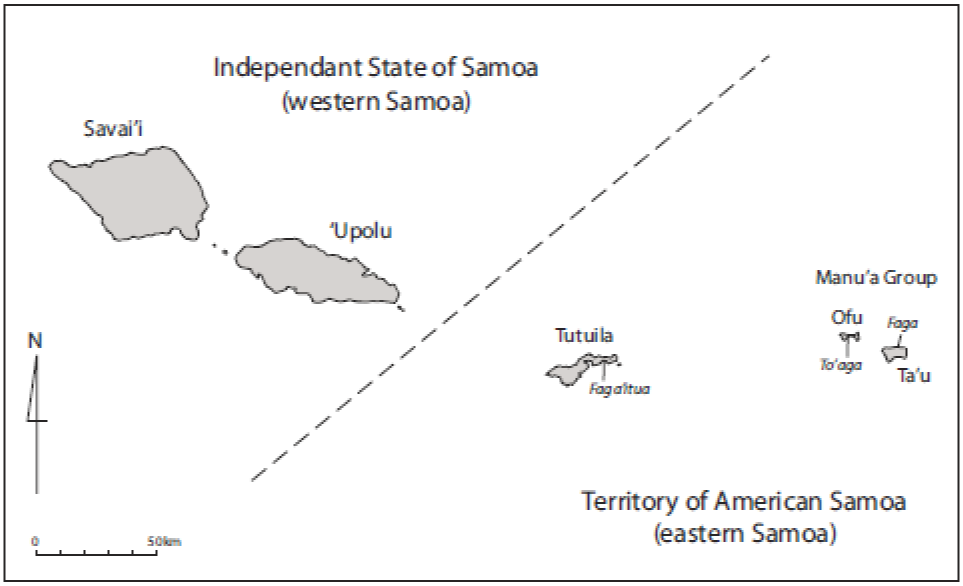


Figure 2: Map of Samoa Archipelago adapted from Petchey & Addison 2008, pg. 80.

The nine main islands of the chain were formed as a result of hot-spot activity on the moving Pacific Plate resulting in basaltic volcanoes that formed the islands (Duncan 1985). The islands of Manu'a are made up of shield volcanoes from the Pliocene and Pleistocene age (Hunt and Kirch 1988). Ofu and Olosega comprise a complex of at least six volcanic cones along the Samoan Ridge that developed as shields (Stice & McCoy 1968). Stice and McCoy (1968) identified four volcanic centers for Manu'a: Muli seamount to the west, Ofu-Olosega, Ta'u, and an active, shallow submarine volcano, Vailulu'u east of Ta'u. These shields later collapsed, producing two calderas, one on Ofu and another on Olosega. The caldera on Ofu was partially filled by ponding of olivine basalt, hawaiite, and ankaramite lava flows (Stice &McCoy 1968). The most recent volcanic eruption was reported in 1868 between Olosega and Ta'u (Stice & McCoy 1968).

The islands of Manu’a are home to fringing coral reefs and calcareous beach deposits, the high cliffs a result of marine erosion (Stice & McCoy 1968). The landscape of the islands, including sea-level and geomorphology, have been found to exhibit extensive changes both naturally and as a result of human actions (Kirch and Hunt 1993; Kirch 2000; Clark and Michlovic 1996).

Figure 3: Map of Ofu/Olosega. From the U.S. Geological Survey.

On the southern coast of Ofu Island lies the Va’oto Plain, home to the Va’oto Lodge which has served as headquarters for many research teams throughout its years of business on Ofu. The Va’oto site is located within the yard of the lodge, the datum point established on a corner of the concrete patio of the main lodge house. Running east-west across the southern Va’oto Plain is a concrete airport runway. Seaside of the runway is the area named by the research team “Coconut Grove.” Ofu Village is located about two kilometers northwest of Va’oto along the west coast of the island. Cultural occupation of the Va’oto Plain, has been dated to 2700-2800 BP (Clark 2011, Quintus and Clark 2012).

Figure 4: Map of Ofu with sites. Map from U.S. Geological Survey.

The environment of the Samoan Archipelago is characterized by dense vegetation as a result of heavy rainfall and high humidity (Kikuchi 1963), making travel through the interior of the islands difficult at best without the use of machetes to clear a makeshift trail. Volcanic high islands, they exhibit dramatic topography with rocky coastlines, fringing reefs, coastal plains, and steep rises to the mountainous interior.

Islands as Laboratories

Islands have long been thought of as natural laboratories for studying various social and cultural phenomena. This concept was first recognized by Darwin and Wallace and has been a continuing theme in anthropology. Archaeologists (e.g., Clark and Terrell 1978) highlight their relative size, the various environmental factors at play, and their relative isolation. Islands can serve as a place to examine social and cultural phenomena under controlled conditions, as well as a wide array of different sizes, locations, climates, and complexity to choose from when appropriate (Clark and Terrell 1978:293).

Kirch also points out the benefits of islands as model systems for the theory of human ecodynamics because of "the complex interactions between human populations and the ecosystems they inhabit" (Kirch 2008:9). From this theoretical perspective, humans and their behavior are directly related to their environment or ecosystem (Kirch 2008). In an island environment such as the Samoan Archipelago, so easily affected by changing environmental conditions, ecological factors must be stressed as well as the dynamism of those factors in an ever-changing environment. The islands are changing at a more spatially observable scale than if we were to study a continental landmass; thus those changes may be more apparent and are quite useful for studying the sociocultural phenomena that would occur as a result of these dynamic environments. Natural or cultural aspects that might normally be overlooked or are too difficult to identify in another setting are easier to witness in an island setting. Additionally, because of the relative isolation of islands, it is not such a daunting task to recognize trade and interaction with other islands. The presence of a non-native species or material may indicate interaction with others or new inhabitants, and may provide a basis for sourcing initial and continuing migrations to the islands.

CHAPTER 2. RESEARCH OBJECTIVES AND METHODS

Given the amount of shell debris recovered on Ofu in previous archaeological investigations by the NDSU research team and others (see Kirch and Hunt 1993), a project focused on this significant resource seemed appropriate and much needed in order to complete a full site assessment of Va'oto and for future research applications at other sites, such as Coconut Grove and Ofu Village. The following will outline the objectives of this research and explain, in detail, the methods employed to accomplish these objectives.

Research Objectives

Because there has been so little research strictly focused on marine resources in this archipelago, this study will not only add to the currently small volume of research, but hopefully will spark further interest in carrying out marine resource analyses. For an area where marine resources have played an important role in the diet, there is a surprising lack of academic investigation focusing on this aspect. Additionally, this research is but a small portion of the overall research project conducted by several members of past NDSU research teams. It is my overall goal that this portion of research is able to aid in others' archaeological interpretations regarding Va'oto, Coconut Grove, and Ofu Village.

Shell fishhooks made from the *Turbo* shell (*Turbo* spp.), a marine gastropod common to the Pacific islands, have been recovered in relative abundance in on Ofu Island. In fact, excavations carried out by NDSU have produced one of the largest fishhook and fishhook manufacturing assemblages of any site in Samoa. Some pieces of *Turbo* shell have been interpreted as tabs, a stage in shell fishhook manufacture after a piece of shell is removed and prior to drilling a hole to form the hook. A major goal of this project is to determine if these tabs were made purposefully or if they might have occurred unintentionally, as simply a common breakage pattern of *Turbo* shells.

Figure 5: *Turbo* recovered from excavation with hole.

Figure 6: *Turbo* tab.

Figure 7: *Turbo* tab with hole.

Figure 8: Finished fishhook.

Overall research goals for archaeological, ethnographic, and experimental methods were directed toward the following topics:

- *Observe current shellfish collection methods.*

By examining current practices related to marine resource procurement, though far removed from the practices of prehistoric Samoans, it may be possible to get an idea of the behaviors needed and constraints encounter when humans collected shellfish on Ofu in the past. Any additional understanding would be beneficial when postulating ideas of past practices and potential limitations.

- *Observe current processing methods.*

A better understanding of possible processing methods may help to illuminate why certain species may have been favored over others or why certain shells are recovered nearly intact and others completely shattered.

- *Identify any observable differences between shells broken for food procurement versus those used for tool manufacture.*

Any information gained from investigating this question will be useful in interpreting past, present, and future recovered shellfish assemblages on Ofu. Rather than labeling all shell remains as midden, it may be possible to separate refuse of tool manufacturing from actual midden.

- *Identify any observable changes in human foraging patterns on shellfish over time.*

This objective is important in terms of either aligning with, or differentiating Va'oto, Coconut Grove, and Ofu Village from To'aga and other coastal sites in the Samoan archipelago.

- *Determine whether there is any evidence of resource depression caused by overexploitation.*

This will be useful in terms of assessing the potential vulnerability of the marine environment near these coastal sites. If evidence of overexploitation is found, it could aid in future reef management plans.

Methods

The goal of this study was to gain a broader understanding of the implications of the nature and volume of shell within an archaeological deposit. Because this was intended to be as holistic as possible, archaeological, ethnographic, and experimental methods were employed in the research.

Archaeological Methods

Archaeological investigations were undertaken in the past, prior to my involvement with the project in 2010. Those materials and excavation data are also used in this study. Excavations were conducted at Va'oto, Coconut Grove, and Ofu Village, which served to supplement past excavation data from 1997, 1999, 2010, and 2011 at the Va'oto site as well as 2011 data from the Coconut Grove site. The Ofu Village site was first opened up as an excavation site in 2012 as part of Seth Quintus' doctoral research. The unit included in this study is located in the front yard of a home within the village on the coastal plain of Ofu. This site has proven productive; however dating has revealed that this unit only represents about the past 500 years or so of occupation on the island. Quintus has continued work in Ofu Village, but the midden data from that work was not available for this study.

Units were excavated by stratigraphic layer and further divided into 10 cm arbitrary levels in order to maintain vertical control. Upon encountering a new layer, a new level would commence, in keeping with previous excavations and standards of methods.

Figure 9: Author's photo showing 2010 Va'oto excavation.

Interviews

Prior to my arrival in American Samoa in 2011, I submitted my plan for this portion of research to the NDSU Institutional Review Board (IRB) and received approval for this project. Ethnographic research was conducted in the form of interviews with local residents who may have had knowledge of the oral history of the area and of resource collection practices both past and present (e.g., Aswani and Lauer 2006; Aswani and Allen 2008). Accompanied by an employee of the National Park of American Samoa who is also a native of Ofu, we walked through the village seeking out older residents who might be able to recall marine resource collection in the past. The individuals were established via a snowball sampling strategy, i.e., once a participant was identified, they identified other potential participants. Unfortunately, many people have relocated to the larger island of Tutuila, and as a result there were fewer people available with whom to interview. Nonetheless, five people were available and provided information for the study. Interviews also addressed oral historical knowledge of how to collect marine resources, how the learning of marine resource collection methods is accomplished, and traditional practices of exclusion/inclusion (e.g., gender differences, age differences, outsider vs. insider). Questions were selected from those outlined and approved in my research proposal and plan submitted to the IRB. That plan included the following:

1. *How long have you engaged in marine resource collection (fishing or shellfish gathering) practices?*
2. *How have these practices changed throughout time?*
3. *How has the marine environment changed over time?*
4. *Have any changes in practice been due to environmental changes, or vice versa?*
5. *Are you aware of any other methods used?*
6. *What sort of oral history of fishing/shellfish gathering are you aware of?*
7. *Who typically participates in various fishing/gathering practices?*
8. *When fish or shellfish are collected, are they used for anything other than as a food resource?*
9. *What is done with the remains of these animals (shells, bone, etc.)?*

Interview questions followed the conversation, and control over what topics were covered was largely in the hands of those interviewed. The course of questions was based on the aspects of fishing, shellfish gathering, or environmental changes of which they were aware of.

Participant Observation

After establishing an initial contact on Ofu, I asked those affiliated with our overall research project about their knowledge of shellfish gathering. I inquired as to whether or not people still engaged in this activity, had any knowledge of it, or knew anyone who might know more information. It was through this initial contact that I was able to make arrangements with an individual on Ofu who still engaged in this activity. Through my initial contact, I was able to discuss my tentative plan and the aforementioned questions that I wished to address for this research activity.

Experimental Methods

Breakage of 38 *Turbo* shells was accomplished utilizing a fist-sized *umu* (earth oven) stone as a hammer and the coastal beach rock as an anvil. The *umu* stones were used because of the ready supply next to the lodge where we stayed, and the stones were a usable size. After breaking several shells, the *umu* stones also broke apart having been previously weakened by fire. Stones comparable in size and shape were then picked from the beach where the experiment was taking place. Shells were struck one at a time until broken enough to adequately allow for resource extraction with minimal damage to the meat and visceral mass. Each shell was bagged separately after being broken and a series of photographs and videos were taken by Dr. Donald Schwert to document the process and findings.

Laboratory Methods

All materials from 1997, 1999, 2010, 2011, 2012, and 2013 (2013 data forthcoming) were shipped to the Archaeology Materials Laboratory at the Department of Sociology and Anthropology, North Dakota State University. This was done in order to insure proper storage of the materials, full analysis, and material security.

Analysis of marine resource exploitation for this project was focused on the shellfish assemblage of each archaeological layer in order to determine their relative distribution throughout the first approximately 1000 years of human occupation on Ofu and to assess the contribution of shellfish to the protein requirements of the human population (e.g., Erlandson 1988).

Many individuals worked on shell midden sorting in the lab throughout the past 17 years, with several different lab supervisors, meaning that the work done and the focus of each supervisor has been variable. Students worked in the Archaeology Materials Lab for class credits with variable hours and on a semester by semester basis. This resulted in questions regarding data consistency and recording methods. Data from the 1997 field season has proven too difficult to locate and unfortunately will not be included in this analysis, contrary to my original research proposal. Additionally, preference for using minimum number of individuals (MNI), number of identified specimens (NISP), and weight has shifted over the years and as a result, the only constant has been weight. As a result, most analysis will focus on overall shell debris weight as a gauge for assessing exploitation focus over time.

In keeping with past laboratory methods, midden bags were sorted individually by students working in the archaeology lab. Data from each bag were recorded on a form and included all information regarding location, depth, and place within the archaeological sequence. Midden was sorted first by genus, then species if immediately recognizable or if multiple species were found. Once sorted, genus/species bags were weighed, and NISP and MNI estimated. Individual forms were entered into Excel spreadsheets and from there, compiled into site consolidation spreadsheets.

Changes in average body size were also examined using the *Turbo* opercula recovered in excavation. These can be easily recognized by their paucispiral, rigiclaudent morphology (Checa and Jimenez-Jimenez 1998), and may be useful as a *Turbo* measurement device, as they are most likely to be found intact and may reflect on the size of *Turbo* species over time. A reduction in mean shell size may reflect intensive human predation of a particular genus that may in turn suggest a reduction in the mean shell age of a genus. As a result of exploitation, younger individuals will grow faster because of more access to food. Because of the fast growth of these individuals, the population will exhibit overall a younger mean shell age (Swadling 1976).

CHAPTER 3. LITERATURE REVIEW

Theoretical Background and Orientations

Human behavioral ecology provides a theoretical framework on which to structure research pertaining to human and environmental interaction because it provides an explanation of the changes in human behavior as a result of environmental constraints (Hames 2001; Winterhalder & Smith 2000). In a more general behavioral ecology mindset, marine animals, mainly shellfish, are thought to be marginal food resources because of their relatively low net energy return (Bicho & Haws 2008); i.e., with the time it takes to gather the resources and effort to process them, the small amount of edible resource is not worth the energy spent. Archaeologists in other environments may only consider shellfish as a supplement to diet or serving as a risk-avoidance strategy (Bicho & Haws 2008). However, when taken in the context of island subsistence systems, marine resources may make up a major component of diet. As a result of such dietary prevalence, many cultural customs, practices, and aspects of material culture centered on some aspect of marine materials have been developed over time.

Though human behavioral ecology encompasses a number of theories, the most useful in light of this project is foraging theory. Foraging theory, like many human behavioral ecology concepts, is based on a cost-benefit analysis. In this case, net energy gained through foraging is established by examining time spent searching for prey and time spent handling the item (Morrison and Hunt 2007). In an archaeological context, search time and handling time cannot be observed, but it is commonly assumed that assessing shellfish gathering does not pose a substantial problem because of their relative immobility and similarity in the ways they are processed (Morrison and Hunt 2007:327).

In the analysis, potential prey is ranked according to the amount of energy returned upon consumption; size is usually used to approximate the energy gained (Morrison and Hunt 2007). In applying prey choice models to foraging theory, foragers are expected to include certain prey types in their diet according to their energy return and availability. Prey with a greater energy return is ranked highest. If encounter rates decrease, foragers will add lower-ranked prey to their diet, increasing diet breadth but decreasing foraging efficiency (Morrison and Hunt 2007). Using this model, we should see lower-ranked resources being added to the diet as higher-ranked resources decline (Grayson and Cannon 1999). Though a system of ranking has not been established here, I will focus on several genera of shellfish that are most commonly exploited and therefore assumed to be favored. Additionally, marine shellfish may reflect changes in sea temperatures by an increase or reduction in size. By combining knowledge of present-day shellfish species preferences of Samoans with changing percentages of species represented in the archaeological record, changes in the environment can be postulated (Renfrew and Bahn 2010).

Significant problems, however, have been raised with assumptions used by foraging theory relating to handling, and ethnoarchaeological research has shown that handling and processing techniques range from culture to culture. In their examination of the Meriam of the Eastern Torres Strait, Australia, Bird and Bird (2000) and Bird et al. (2002) argue that midden analysis consistently underestimates the representation of large-shelled species, most notably *Tridacna*, as these are the most likely to be processed where encountered or close by before returning to the site. Additionally, the groups performing these acts may also influence handling and processing (Bird and Bird 2000). For example, children, because of their relative size and strength constraints, encounter higher ranked taxa less frequently and as a result will exploit a wider array of resources (Bird and Bird 2000:473).

History of Archaeological Research in Samoa

Missionary accounts, material culture studies, and descriptions of a few structural/architectural remains comprised the entirety of research into Samoan prehistory from the late 19th century, up until the first half of the 20th century when archaeological fieldwork really picked up beginning in the 1960s (e.g., Green and Davidson 1969a, 1974a,b; Jennings and Holmer 1980; Jennings et al. 1976). Archaeological investigations in Samoa did not take place until 1957 when Golson did limited survey and excavation on ‘Upolu, with that work published in Green and Davidson’s (1969a) subsequent volume. Green and Davidson (1969a, 1974b) and their colleagues conducted survey and excavation on ‘Upolu, Savai’i, and Apolima. That work was followed by Jennings, Holmer, and others on ‘Upolu, Manono, and Savai’i (Jennings et al. 1976; Jennings and Holmer 1980; Jennings et al. 1982). Following that early research in western Samoa, more work was carried out in American Samoa, although it was initially sparse (e.g., Kikuchi 1963, 1964; Frost 1976, 1978; Clark 1980, 1981) until the mid-1980s when several individuals (Clark and Kirch most notably) began much more frequent work and publications (Clark 1996). Though contract work has occurred in American Samoa with greater frequency than that of published academic study, the reports are not as readily accessible, and contract work in Western Samoa is essentially nonexistent.

Archaeological Research on Ofu

Past archaeological research on Ofu Island has been sparse until very recently. In 1962, Kikuchi and Sinoto visited Manu'a during a survey of Tutuila and Aunu'u (Emory and Sinoto 1965; Kikuchi 1963). Clark visited Manu'a while compiling an inventory of cultural resource sites, recording eight sites on Ofu (Clark 1980), followed by Hunt and Kirch's reconnaissance of Manu'a (1988). A reconnaissance survey of the road linking Ofu and Olosega was completed in 1992 by Best (1992). Kirch and Hunt (1993) completed an extensive archaeological project on Ofu in their work at the To'aga site. As part of his own research interests and also serving as an archaeological field course designed to train students in the basics of archaeological work through North Dakota State University, Clark and students have completed field seasons at the Va'oto site (AS-13-13) in 1997, 1999, 2010, 2011, 2012, and 2013 (Clark 2011, 2012), as well as work at the Coconut Grove site (AS-13-37) in 2011, 2012, and 2013 (Quintus and Clark 2013), and at Ofu Village (Quintus, in preparation). Survey on inland Ofu along with very limited test excavations have been carried out by Clark and Quintus (Clark et al. 2012; Quintus and Clark 2013), with Quintus conducting dissertation research on inland and coastal sites on Ofu. The Va'oto site has been incredibly productive in terms of shell recovery, pottery, fishhook and fishing gear artifacts, and a small amount of lithic artifacts. Full reports on the Va'oto and other Ofu research are forthcoming by Clark, Quintus, and colleagues.

Marine Resource Studies in Samoa

The report on the Lotofaga site on 'Upolu was perhaps the first examination of marine resource exploitation in Samoa (Davidson 1969). Three studies, two undertaken on Ofu and one on Tutuila, are the exceptions to the limited research on marine exploitation in American Samoa (Kirch and Hunt 1993; Craig et al. 2008; Morrison and Addison 2008, 2009). On the south coast of Tutuila, Morrison and Addison (2008) documented long-term stability in marine resource exploitation at Fatu-ma-Futi through the use of behavioral ecology foraging models. However, that interpretation has been challenged by Quintus (2011:132) who has argued that abundance reduction as indicated by total weight reduction in the sequence through time is suggestive of changes. This is not dealt with by Morrison and Addison, but it is unclear whether these changes were caused by social or natural forces.

Nagaoka (1993) examined the faunal assemblages from the To’aga site on Ofu, noting the various fluctuations between levels as well as changes in certain species represented. Her research indicated that little change in marine exploitation could be detected within the assemblage, even just after colonization, leading her to suggest that limited, if any, resource depression occurred. While there was some fluctuation in the assemblage, the abundance and size of three key genera *Turbo*, *Trochus*, and *Tridacna*, often used as indicators of past subsistence change, remained stable throughout the sequence. The relative stability of these key species could be attributed to To’aga not being the initial site of occupation. That idea comes from Steadman’s observation that aside from a loss of some wild bird species, there was a relative lack of major faunal changes, making this case very different from other island groups at the time of initial human impact (Steadman 1993; Davidson 2012).

More recently, building on previous modern and historic research, Craig et al. (2008) examined the long-term dynamics of small-scale subsistence as well as standing stocks on Ofu. They found that subsistence fisheries on Ofu and Olosega have been sustainable throughout the study years, perhaps due to declining human populations that have less reliance on subsistence fishing. This study included both data collection to assess catch composition and an ethnographic portion consisting of interviews with village elders. Craig informed Jeffrey Clark, however, that their conclusion may not hold in the prehistoric period due to differences in subsistence base in the two times (pers. comm., Jeffrey Clark). From the time of initial European contact to the present day, Samoan culture has undergone some substantial changes. Subsistence has changed drastically since the import of canned foods and now fast food chains. Dilcher (2012) provides a startling account of her experience as a second year medical student in American Samoa. Speaking with a local doctor practicing in American Samoa, they discuss the Americanization of Samoan diet and changes in lifestyle from active to sedentary:

> This decrease in physical activity has been compounded by Americanization of the Samoan diet, particularly with food high in fat, processed carbohydrates, sugar, salt, and foods low in fiber, vitamins, and minerals. Portion sizes have increased greatly. Patients at the VA clinic commented that it was rather common to eat three or more eggs, several thick slices of Spam, a few scoops of rice and toast for breakfast, four to five sandwiches for lunch, and meat and rice for dinner, in addition to snacks such as Bongo chips and Saimin throughout the day (Dilcher 2012:68).

Clearly, current subsistence practices are drastically different than they were even a century ago. This information can be taken as a warning to any archaeologist who lends too much credence to current cultural practices. This may serve as a reminder to refrain from attempting to apply contemporary models of behavior to prehistoric cultures.

Expanding the scope of research to subsistence and settlement changes that influence marine resource exploitation, research on land use in inland Olosega Island was carried out by Quintus (2011) who, along with Clark et al. (2012) for Ofu, suggested that a large-scale population movement from coastal areas to inland sites took place within the last 2,000 years, which would have had significant effects on behavioral patterns of marine resource exploitation, particularly in regards to resource disposal and processing.

The increased distance from procurement sites to habitation sites may have resulted in differential processing techniques including on-site processing which would result in decreased visibility of certain taxa within the archaeological sequence. This could also result in certain areas becoming designated processing sites, further complicating the assessment of an archaeological site as shells may be present in vast quantities giving the appearance of a large-scale settlement.

In inland Ofu, a small test pit was cut into a shallow pit feature near a residential terrace. Within this pit, beneath a layer of soil fill, was a dense layer of marine shells. Still much investigation remains to be done at this site. Questions remain concerning the motivation for a population movement inland and whether coastal occupation was completely abandoned at the time of inland settlement or if settlements existed throughout the island. Jennings et al. (1982:100) argued that for Western Samoa the coastal areas were the preferred location for settlement since initial occupation. However, as a result of a growing population, eventually all suitable coastal areas had been inhabited and villages were only left with the option of expanding inland. When populations began to decline, inland settlements began to empty and settlements were again concentrated on the coastal areas of the islands (Jennings et al. 1982:100). A question worth investigating is how subsistence might have changed with those populations that were relocated to the inland settlements.

CHAPTER 4. SAMOAN CULTURAL HISTORY

In order to postulate ideas of prehistory, it is necessary to be familiar with the culture history of the peoples we study. While it must be recognized that current practices or even historical practices may not directly relate to those interpreted from the archaeological record, our understanding of contemporary cultural practices may provide insight and ideas from which to draw when interpreting prehistory. Taken with a grain of salt, ethnographic and ethnohistoric data can be incredibly useful tools for archaeologists and provide evidence of our roots within anthropology.

Within Oceania, the region of Fiji-Tonga-Samoa has been regarded as the "Polynesian homeland" thought to be the area where proto-Polynesian traditions first emerged (Green 1967). This is in part due to the area's relative geographical separation from Island Melanesia and the East Polynesia region, resulting in similar cultural traditions (Sand and Addison 2008:1). Traditionally, Samoans were (and still are) members of a stratified system of title-holders, or *matai*, and non-title-holders (Sahlins 1958:29). *Matai* are the heads of families and further separated into chiefs, or *ali'i,* and talking chiefs, *tulāfale* (Sahlins 1958:29). As Grattan (1948:10) describes it, a family, or '*āiga*, is not defined in the same way as a European family, a biological group, but is additionally defined by marriages or "adopted connections" of those who acknowledge the same person as their *matai*. Already somewhat difficult to follow, this can be further complicated by Samoans' ability to claim relationship through both male and female ancestors, allowing individuals to belong to many families (Grattan 1948:10). Furthermore, titles do not pass in a linear fashion from father to son; rather, the whole family would meet and select an individual who will best represent the family in good light (Grattan 1948:13). Family ties can be quite confusing to an outsider, even more confusing still are the lines separating a family’s land, which may fluctuate from year to year or depend on from whom the information is coming.

The political structure of Samoa is played out in spatial terms during *fono*, or village council, meetings where the higher-ranked *matai* are seated closer to the central house posts with rank declining farther out (Shore 1982:80). It is well-documented that complex chiefdoms were in place at the time of European contact, and while Ofu, Olosega, and Ta’u were ruled as separate polities, the Tui Manu’a, who was the highest-ranking title in Manu’a, was paramount over the entire Manu’a group (Sahlins 1958).

One idea of settlement is that the Samoan Archipelago was settled by descendants of seafaring populations originating perhaps in Taiwan, who moved into island Southeast Asia and spread eastward through Near and into western Remote Oceania (Kirch 2000). These people developed a unique cultural complex first appearing in the Bismarcks around 3,600 BP, known as Lapita, after the location in New Caledonia where the first piece of distinctive, dentate-stamped pottery diagnostic of the cultural complex was recovered (Green 1979). To some, this distinctive pottery constitutes the only evidence that is sufficient for deeming a location a Lapita site. However, the entire cultural complex (Golson 1971) is distinctive and some contend that a Lapita site can exist without dentate-stamped pottery. Archaeological evidence suggests that the Lapita peoples were the original settlers of Samoa and from that cultural base developed the distinctive Samoan culture (Green and Richards 1975). The Mulifanua site on the west end of ‘Upolu is the only site in Samoa that has produced the distinctively decorated Lapita pottery. However, a number of sites that do not contain dentate-stamped Lapita sherds but do contain other artifacts of the cultural complex have dates that have been suggested to be roughly contemporaneous with known Lapita sites (Kirch and Hunt 1993; Clark 1993, 2012; Clark and Michlovic 1996). Others have argued that these suggested early sites are in fact not as old as true Lapita sites elsewhere in the Pacific (Rieth and Hunt 2008).

Subsistence

In order to understand the significance of research into marine resource exploitation, it is necessary to discuss the overall subsistence base of Samoans prehistorically.

Terrestrial Food Production

Food production in the Samoan archipelago in more recent time periods is likely to have been based on swidden horticulture and arboricultural gardens with primary crops such as taro, giant taro, yams, banana, coconut, and breadfruit (Quintus 2012). Crops were likely grown in areas cleared of vegetation through the implementation of slash-and-burn horticultural practices, as evidenced by secondary growth forests (Nunn 1990). Davidson (2012) maintains that it is difficult to assess prehistoric food production systems because of a lack of surface structures that are hallmarks of those activities. At least later in the sequence, however, Quintus (2012) argues that for Olosega the production system was characterized by arboriculture and dry-land cultivation with multi-cropping occurring in swidden gardens. On Olosega, Feature 38, a long ditch that cuts across the interior of the island, is interpreted by Quintus (2012:137) as having been used to drain water and sediment away from arboriculture systems and residential areas downslope of the ditch, with the potential to replenish nutrients within the streambeds with channels draining off from the ditch.

Terrestrial Animals

It has been postulated that early colonizers brought with them pigs, dogs, and chickens as well as crops (Kirch 2000; Quintus 2012). Along with those animals brought to the islands, early colonizers likely also exploited native birds and bats already present. Addison and Matisoo-Smith (2010) propose that a new population that was not Lapita arrived at around 1500 BP. These new people would have introduced new rats, dogs, and chickens that would have been available to exploit as food resources. It was this new human population that constituted the ancestral base for the development of Samoan culture.

Marine Resources

Throughout Oceania, a moderate to heavy reliance on marine resources is exhibited, with those resources including shellfish as well as near shore and pelagic fish. Of shellfish, three genera are exploited most frequently on Ofu, the *Turbo*, *Tridacna*, and *Trochus,* and are used not only as food resources but as material for tool and ornament manufacture, as is documented from the archaeological remains on Ofu. Shellfish can be plucked from the reef or rocky coastlines during low-tide with relative ease. Shells are abundant throughout all cultural layers on Ofu and appear to have been heavily exploited for food and artifacts. Netting, angling, gleaning, and poisoning are likely to have been used to acquire fish in the reef zone (Buck 1930:418). Small fish bones are present throughout cultural layers; however species identifications have not yet been carried out in order to allow for a full assessment of fishing practices.

Material Culture

Material culture in Samoa consists primarily of stone adzes, other lithic tools, fishing gear, ornaments, and pottery. The stone adze typology presented by Green and Davidson (Green and Davidson 1969b) consists of a series of defined adze types. A flake-tool technology was also present in prehistoric Samoa consisting of classes of scrapers, drills/burins, adzelets, and bifaces (Clark et al. 1997). The presence of volcanic glass flakes is also noted; however very few show any evidence of use or characteristics of tools (Clark et al. 1997:296).

A number of shell artifacts were made and used in prehistoric Samoa, most notably *Turbo* shell fishhooks, of which 23 hooks or fragments have been recovered from the Va’oto site alone and 28 at the To’aga site by Kirch and Hunt (1993). A slew of other fishing gear is found in Samoa including octopus lures, net weights, and line sinkers, as well as manufacturing gear such as sea urchin spine files. At Va’oto, shell beads have also been recovered of varying size as well as two fragments of *Tridacna* shell arm bands. Pottery is abundant, although it has most often been low-quality, fragmentary pieces, prone to crumbling during transport.

Settlement Timeline

In order to understand Samoan culture history, it is necessary to first understand how this archipelago came to be populated in the first place. Archaeologists are not quite at a consensus, although most can agree on the following ideas.

Initial movements of Austronesian-speaking peoples are believed by some archaeologists to have sprung out of Taiwan (Kirch 2000). However, to others, this movement is described as a "large-scale, but punctuated, migration beginning about 6,000 years ago in southern China" (Anderson and O'Connor 2008:3). The populations participating in this movement are generally regarded as having been speakers of languages in the Austronesian family, the most widely dispersed language family in the world, most concentrated in island Southeast Asia and the Pacific islands (Kirch 2000:91). There is no specific "Austronesian language" and very different languages likely could have existed within this language group (Clark and Kelly 1993). Regardless of language, these were a set of interrelated groups with similarities in their genome (see Clark and Kelly 1993). Upon reaching Melanesian Near Oceania, these peoples developed a distinct cultural complex, termed Lapita after the location of the initial archaeological site yielding a distinctive dentate-stamped pottery. This cultural complex spread quite rapidly eastward throughout the islands of Remote Oceania and is thought to have eventually given way to what developed into Polynesian culture.

A chronological framework for Samoan prehistory, first proposed by Green and Davidson (1974a) and maintained by them (e.g., Davidson 1979; Green 2002), delineates four periods based on settlement patterns comprising initial Lapita settlement, Polynesian Plainware, a Dark Ages where limited archaeological evidence has been found, and the last thousand years leading up to European contact.

The Lapita Period

The timing of the colonization of these islands is a point of debate, depending on the specific island and the acceptability of many of the radiocarbon dates presented.

Initial dates put Lapita arrival in Samoa at 3200 BP, however further analysis shifted that date to no earlier than 2900 BP (Anderson & Clark 1999; Burley and Clark 2003). The earliest date suggested by both Green and Kirch is about 3000 BP (e.g., Green 1974; Kirch (To'aga paper). On the conservative side, others argue for settlement at perhaps only 2900-2700 BP, based on acceptable dates at Mulifanua (e.g., Rieth & Hunt 2008). Mulifanua, the location of the first recovered Lapita sherds in Samoa, represents the initial phase of Lapita colonization associated with dentate-stamped pottery between 3000 and 2600 BP (Green, 1974, Petchey 2001, Rieth and Hunt 2008). Mulifanua, or Ferry Berth, constitutes the only site where the characteristic dentate-stamped Lapita pottery has been recovered. The site covers an estimated area 30-40 m wide by 110 m long and is suggested to have been on a former coral sand beach which was dredged up during construction for a ferry berth on the island of Upolu (Green 1974; Petchey 1995, 2001).

Green (2002) argued that there must be more Lapita sites either submerged or deeply buried in Samoa. Clark (1996) argued that this dentate-stamped decoration was abandoned in Samoa sooner than anywhere else in the central Pacific. This hypothesis is supported by Rieth and Hunt (2008), who argue that decoration was likely abandoned within 100-200 years of initial settlement. The sites of To'aga (Kirch and Hunt 1993) and 'Aoa (Clark and Michlovic 1996), although no Lapita pottery was recovered, do contain contemporaneous materials and are regarded as early coastal settlement sites. Rieth and Hunt (2008) employed a protocol of chronometric hygiene to the total of 236 radiocarbon dates for the archipelago at the time of the study and reduced the acceptable dates to a total of 147. Thus they argue for dates of 2500-2100 BP for Tutuila and 2700

BP for Ofu. Addison and Matisoo-Smith (2010) further argue for the dates of these initial deposits to be pushed up to 2400 BP if they were to line up with Petchey's (1995) analysis of Mulifanua vessel form. Her comparison of Mulifanua vessel form and decorative motifs with six other Eastern Lapita sites places the Mulifanua assemblage somewhere in between the Late Eastern Lapita and Early Eastern Lapita (Petchey 1995; Addison and Matisso-Smith 2010).

The Polynesian Plainware Period

The Polynesian Plainware Period which lasts roughly the next 1,500 years is characterized by a complete loss of the dentate-stamped Lapita pottery. Although Lapita pottery has only been found at Mulifanua, the Lapita cultural complex has been argued by many to have been present throughout the Samoan archipelago. It is when plainware, or undecorated, pottery is in use that early inhabitants of the archipelago shift to a new cultural phase. Addison and Matisoo-Smith (2010) propose an alternative model wherein Samoa was beyond sustainable limits of the Lapita expansion and as a result, Lapita people left Samoa after a short time. Samoa was permanently settled later when dentate stamping had been abandoned in Fiji/West-Polynesia (2010:369). Populations are postulated to have been relatively small and dispersed during this early settlement period (Addison and Matisoo-Smith 2010:6).

The "Dark Ages" Period

This period begins about 1500 BP and lasts until about 1000 BP. The term "Dark Ages" refers to the overall lack of knowledge of this period. This is as a result of the small amount of work actively being done to recover sites from this time period. Both

Green (2002) and Davidson (1974) suggest that settlements expanded to other parts of the islands and populations may have shifted farther inland in order to gain suitable land for horticulture. Clark et al. and Quintus (Clark et al. 2012; Quintus 2011; Quintus and Clark 2012) have spent considerable time in recent years investigating inland settlement on Ofu and Olosega and have found an extensive network of terracing, ditches, mounds, and possible agricultural plots that prove inland settlement undeniable on those islands.

The Late Prehistoric Period

The Late Prehistoric Period begins at about 1000 BP and lasts until initial European contact, which was first recorded in 1722. This is the time period in which what we know as traditional Samoan culture developed (Green 2002; Quintus 2011). Within the Samoan archipelago, settlement increasingly moved inland as evidenced by surface remains, fortifications, and star mounds (e.g., Jennings et al. 1982; Holmer 1976; Wallin and Martinson-Wallin 2007).

The Historic Period

The Historic Period, beginning in the mid-late 1700's comprises the years following initial European contact. Since contact, the Samoan archipelago has been the location of many anthropological studies, and early missionary accounts provide some useful, if biased, accounts of island life in the early decades of the Historic Period.

CHAPTER 5. RESULTS

Excavation

Excavation information comes from four research projects directed by Dr. Jeffrey Clark. Parts of Ofu Island have been studied extensively by Dr. Clark's research teams, particularly the Va'oto Plain, since 1997. Shell midden data are from the 1999, 2010, 2011, and 2012 field seasons, and all include the Va'oto site. The Coconut Grove site is included in 2011 and 2012 data, and the Ofu Village site is included in the 2012 season. Results are reported for each excavation site by year. By combining excavation units for each field season, I have compressed the data into a more manageable format to compare and contrast exploitation on a site by site basis rather than within sites. Detailed data for each site are presented in the Appendix. Precise correlations of layers between sites have yet to be worked out.

AS-13-13, 1999

Table 1: Summary table of shell midden weights and taxa exploited from site AS-13-13 (1999).

Va'oto 1999			
AS-13-13			
	Layer I	**Layer II**	**Layer IV**
Total Shell Weight (g)	42.6	19781.9	50397.4
Number of Taxa Exploited	2	59	57

Laboratory analyses of this field season have taken place over the past decade and have been variable. Detailed data are presented in Table A1, found on page 75 of the Appendix. Midden data are only present for Layers II and IV (Layer I appears to be a sterile layer containing almost no shellfish remains) so I can only assume that midden was only recovered within these two cultural layers. However, with only two layers to compare, this provides a very clear contrast. Layer IV contained more shell debris than Layer II. Diet breadth is very close, only decreasing by two taxa in Layer IV, which is in keeping with other excavation data from the following years of field research on Ofu.

AS-13-13, 2010

Table 2: Summary table of shell midden weights and taxa exploited from site AS-13-13 (2010).

Va'oto 2010					
AS-13-13					
	Layer II	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**
Total Shell Weight (g)	2905.2	8119.8	38097.9	3440	2736.6
Number of Taxa Exploited	26	32	49	29	21

Comparing Va'oto site shell weight totals for the 2010 excavation shows a drastic increase in marine resource exploitation in Layer IV which is shown most apparently in exploitation of *Turbo* species. Detailed data are presented in Table A2, found on page 76 of the Appendix. Weight totals (*T. crassus* and *T. setosus* combined) range from 2294g in Layer VI, 1595g in Layer V, to a significant spike in Layer IV at a combined total of 17475g. Layer III reveals a decline with 3168g of *Turbo* recovered and steadily declining again in Layer II with only 1324g of *Turbo* shell recovered.

It appears as though overall diet breadth increased significantly in Layer IV, following a very slight dip in Layer V. Forty-nine taxa of shellfish were exploited during cultural occupation in Layer IV, which is a significant increase from Layer V. The number of species exploited wanes in Layers III and II. Diet breadth seems to follow closely in accordance with overall exploitation.

AS-13-13, 2011

Although excavation was conducted at the Va'oto site during the 2011 field season, the excavation units actually proved to lie just outside the actual occupation area and were therefore unproductive. Thus all data from 2011 comes from the Coconut Grove site (see Table 4).

AS-13-13, 2012

Table 3: Summary table of shell midden weights and taxa exploited from site AS-13-13 (2012).

Va'oto 2012						
AS-13-13 Site Totals						
	Layer I	**Layer II**	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**
Total Shell Weight (g)	0	1905.5	4038.8	6740.4	1125.6	9.8
Number of Taxa Exploited	0	24	30	29	24	4

Much like data from the 2010 field season, site weight totals by layer show an overall increase in shell midden during Layers IV and III at Va'oto. Detailed data are presented in Table A3, found on page 80 of the Appendix. Using the two major *Turbo* species as an example once more, totals are from Layer VI to Layer I as follows: 0.8g, 665g, 3690g, 2158g, 1297g, 0g. Other species exploited throughout the archaeological sequence exhibit similar patterns of waxing and waning, with the greatest shell volume occurring in Layer IV. Diet breadth also appears to increase and decrease along with weight. Layer VI shows a mere 4 species exploited, in Layer V the number jumps to 29 species exploited, in Layer IV and III the diet breadth is greatest at 29 and 30 taxa exploited, respectively, followed by 24 taxa in Layer II.

AS-13-37, 2011

Table 4: Summary table of shell midden weights and taxa exploited from site AS-13-37 (2011).

Coconut Grove 2011			
AS-13-37			
	Layer I	**Layer II**	**Layer III**
Total Shell Weight (g)	9047.3	6889.2	139.4
Number of Taxa Exploited	37	29	16

Three units were excavated in 2011 with 3 consistent layers. Detailed data are presented in Table A4, found on page 83 of the Appendix. Layer I is heavily disturbed by both gardening activities and bioturbation, Layer II is far less disturbed and Layer III is generally a layer of sterile dune sand. Shell weight from Layers III to I shows an overall increase in shellfish exploitation and diet breadth. Total shell weight and species exploitation for each layer is as follows: Layer III contains 140g of shell debris and 16 taxa were exploited, Layer II contains 6889g of shell debris and 29 taxa were exploited, and Layer I contains 9047g of shell debris and 37 taxa were exploited. Because Layer III is culturally sterile, any shell debris recovered is likely naturally occurring in the nearby beach sand or may have occurred as a result of bioturbation rather than as a result of human activity. Charcoal samples from the Coconut Grove site have yielded dates or 2370±30 BP and 2470±30 BP which puts this site potentially roughly contemporaneous with Va’oto or at least relatively close in time.

AS-13-37, 2012

Table 5: Summary table of shell midden weights and taxa exploited from site AS-13-37 (2012).

Coconut Grove 2012								
AS-13-37 Totals								
	Layer I	**Layer Ia**	**Layer Ib**	**Layer II**	**Layer IIa**	**Layer IIb**	**Layer IIc**	**Layer III**
Total Shell Weight (g)	2442.4	72.1	1009.1	704.8	49.1	408.1	336.5	726.7
Number of Taxa Exploited	23	6	17	13	8	14	13	9

Seven units were excavated during the 2012 field season in Coconut Grove. Layers were further divided into sublayers in the field as the sequence appeared more complex than the initial three layers defined during 2011 excavations. Detailed data are presented in Table A5, found on page 85 of the Appendix. Overall, the general trend shows marine resource exploitation increasing from Layer III to Layer I. No considerable changes in diet breadth were exhibited.

AS-13-41 2012

Table 6: Summary table of shell midden weights and taxa exploited from site AS-13-41 (2012).

Ofu Village 2012							
AS-13-41							
	Layer II	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**	**Layer VII**	**Layer VIIb**
Total Shell Weight (g)	292.7	229	636.9	252.1	1981.3	612.4	94
Number of Taxa Exploited	16	9	13	11	19	13	11

In 2012 one excavation unit was opened and though a much deeper deposit than that of Coconut Grove or Va’oto, it did not date to nearly as early as the other two sites.

The Ofu Village site has been dated to about A.D. 1400 (Quintus and Clark 2012). More recent excavations at this site have yielded deeper deposits and some very interesting data that is forthcoming, but not included in these analyses. Detailed data are presented in Table A6, found on page 88 of the Appendix. Although a much later deposit, this site exhibits a similar pattern to Va'oto and Coconut Grove with a significant rise in marine resource use shortly after occupation, followed by a fall.

Ethnographic Research

Ethnographic Interviews

I was only able to interview six individuals which is problematic in terms of sample size. However, the goal of this portion of the project was merely to gather any supplemental information that may provide insight when investigating archaeological questions. The individuals' responses have not been crosschecked against environmental, historical, or geomorphological data, and have not been interpreted as factual, but rather memories and opinions.

The individuals interviewed agreed that the coast used to be closer; one suspected that it was at one time 500 feet closer than it is now. They also believe that sea levels were at one time higher and corals were larger and more abundant. It was also agreed that women typically gathered shellfish, while fishing was primarily a man's task.

Shellfish gathering is not practiced for subsistence any longer. Although a few individuals still partake in the activity, it is not a necessary food source since the influx of canned and preserved goods that came to the archipelago under Western influences. Some years ago, the Samoans created shell necklaces and decorations to sell to tourists.

Many small shells (e.g. *Melampidae, Cypraea,* small *Trochus,* small *Turbo* opercula, etc.) can be used as beads. If shells are intended to be used as beads for necklaces or as some sort of decoration, the shell may be boiled to weaken the shell and allow for puncturing or cutting. There also exist some shells that will typically be collected to be used solely as a decoration. *Turbo petholatus,* a species not yet noted in the midden, is one such shell. If this shell is encountered on the reef, it will always be collected but not consumed. Rather than cracking open the shell to extract meat, the shell will instead be buried in the sand and left for three weeks. When it is dug up, the animal inside will have died and dried up enough to be popped out without having to damage the shell. These shells are used for decoration around the house and possess a beautiful, shiny, dark green-colored opercula.

Participant Observation

Upon arriving at Va'oto Lodge in 2012, we were greeted by the other guests; two employees of the National Park of American Samoa. While speaking with Tish Peau, a park archaeologist who grew up in Ofu Village, I was delighted to find out that she was aware of several individuals who took part in shellfish gathering. She offered to introduce me to one of them and set up an evening when I could accompany them on a shellfish gathering trip. Prior to setting out gathering *Turbos,* we discussed what I was hoping to learn from taking part in this activity, as well as going over what we would be doing during this trip, i.e., what to look for, how to collect the shellfish, where we might be going, and what sort of supplies I would need to bring.

When I spoke of gathering shellfish, many locals were unclear to what I was referring. I found it most beneficial to bring examples of shells along with me when conducting interviews or informal conversations that might broach this topic. When shown a *Turbo* shell, locals recognized it as *alili*. Before the advent of flashlights, Samoans fished and gathered shellfish by torchlight or during a full moon when the sky is illuminated. The Samoan word *lama* means “a method of fishing by torchlight,” and *alili* can refer to both a shellfish in general but more specifically *Turbo* (Milner 1976). Our *Turbo* collecting, or *lama alili*, took place after dark at low-tide near the pier at Tumau’i Point, in about knee-deep water at the height of each incoming wave. We collected *Turbo* along the rocks bordering the coast. The original location for this trip was to have been the north and east side of Ofu, near the former Sili village on the northwest coast of Olosega. Unfortunately, the other individuals that were to accompany my informant were not able to join us, therefore we went to Tumau’i Point because it was nearer the informant’s home. We did not go past the rocks near the shore because my reef shoes were deemed inadequate and too slippery for walking farther out on the reef itself. Equipped with reef shoes, a 5 gallon bucket (the informant had his own mesh bag), and bright flashlights, *Turbo* were plucked upon encounter at each receding wave and collected in the bucket. This continued until the bucket was about half-full and the informant had a full bag. All sizes encountered were collected.

Altogether our trip lasted about 20 minutes and we stopped collecting not when there were no more to collect, but rather when we had more than enough food. When asked how to store the *Turbo* my informant stated that they would keep overnight and that we could wait to process them; they did not need to be kept in water. Gastropods encountered in the water were almost exclusively *Turbo* (*Turbo crassus, Turbo setosus*), though one single *Cypraea* sp. was encountered. None of my informants were aware of anyone eating *Cypraea*. Out of the 41 total *Turbo* that were collected, 3 were consumed and discarded that night and 38 kept for experimental research the following day.

Figure 10: *Turbos* collected.

The *Turbo* itself consists of a muscular foot that is connected to the operculum. The head, gills, and other organs make up the middle portion, and the visceral mass, which contains the digestive cecum (liver, digestive gland) and gonad. Currently, the muscular foot is consumed and often prepared as a side dish with coconut cream and lime. All informants told me that the midsection was to be discarded (head, gills, etc.) and one stated that the visceral mass could be eaten in addition to the foot.

Given the ease of collection and abundance of *Turbos* in such a small area, it is likely that a large portion of shellfish gathered on any given day would have been processed where collected. Beachrock provides a solid, stable surface, and the proximity to a water source is useful for washing away shell debris. This means that much of the marine resource exploitation on Ofu is not represented in the midden.

Experimental Project

Following collection, I inquired about processing of the *Turbo*-including how to break open the shell and which parts to consume. I was informed that it was best done on the beach rock where water was readily available to rinse the shell debris from the meat. My initial contact and I, along with some student spectators, made our way to the beach to do some preliminary "test breaks" to find out how difficult this task might be and to experience eating the shellfish raw as it may have been consumed by early inhabitants of these islands and as it is still consumed on occasion today.

Figure 11: Photo showing processing site.

Figure 12: Author breaking *Turbo*.

Figure 13: Author breaking *Turbo*.

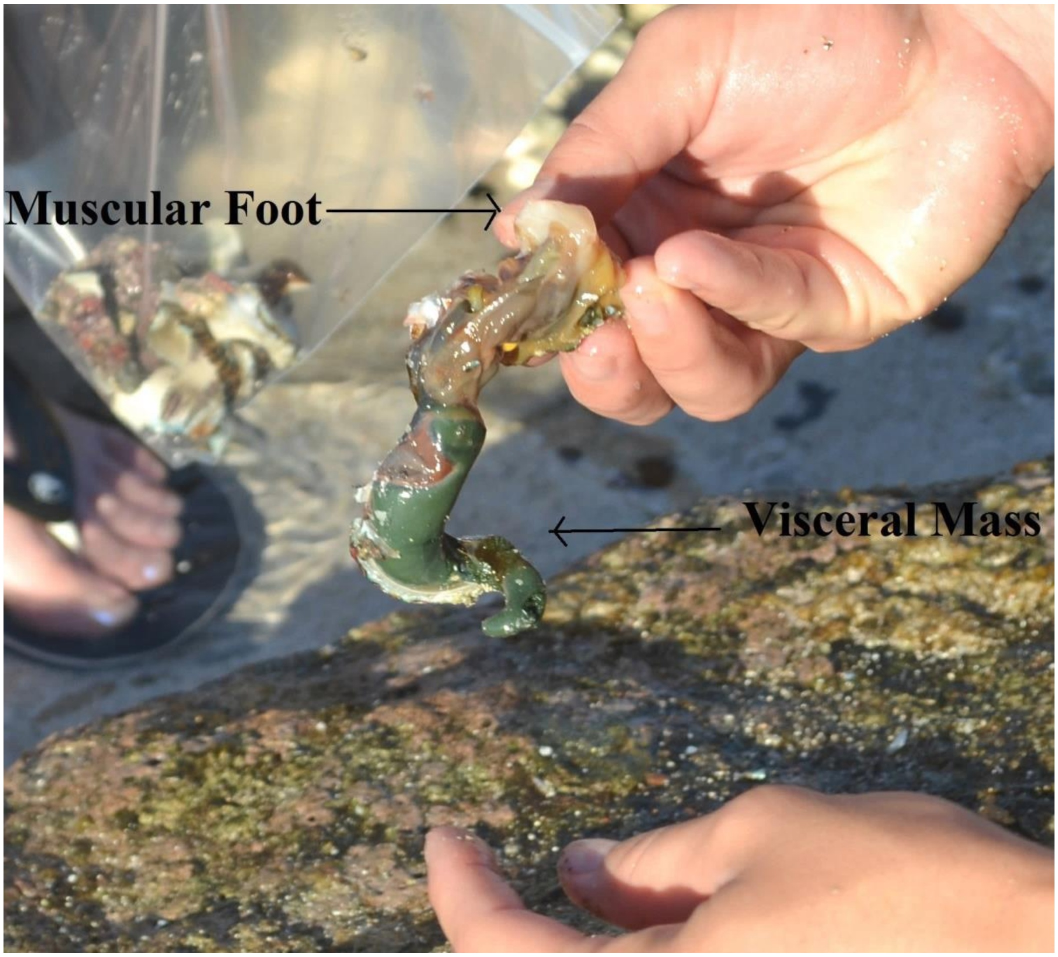
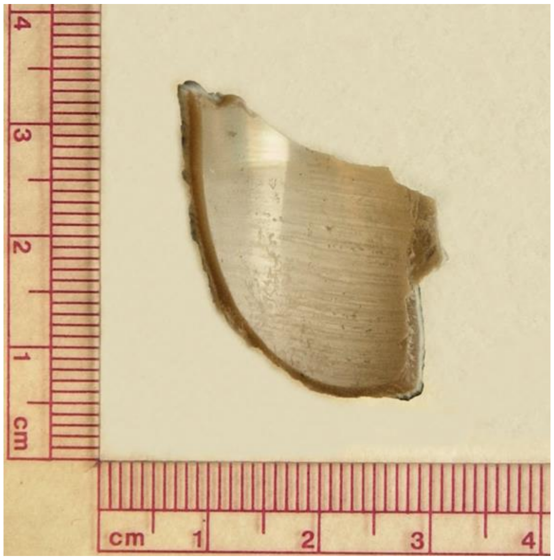


Figure 14: *Turbo* removed from shell, showing edible portions: muscular foot and visceral mass.

Since this first attempt at breaking these shells was performed with a modern hammer, their breakage patterns were not recorded for this study. However, the experience did serve as a preliminary lesson in breakage technique and anatomy of the shellfish. My contact noted that the very delicate, coiled visceral mass was “the best part” and that the midsection should be discarded and washed away. The muscular meat attached to the operculum of the animal is the primary source of food from the *Turbo*. The operculum must be detached from the meat, either ripped, bit, or cut, and the section of the body (the midsection) between the meat and the visceral mass discarded. A benefit to performing this act on the beach is a ready source of water to wash the meat of any shell debris before consumption.

The following morning I returned to the beach with Rachel Geiser, an undergraduate student working on the project, along with Dr. Donald Schwert who photographed and took video of the process. I first chose *umu* stones to use as a hammerstone both because of their convenient size and shape and because they were readily available near the lodge after a recent *umu*. After the first few attempts at breaking open the *Turbo*, my *umu* hammerstone fractured into several pieces. The same happened with my backup *umu* hammerstone, thus I was left to comb the beach for an appropriately-sized stone. Stones that had not previously been fired held up to the repeated pounding against shell and beach rock, as should have been expected from the start.

All attempts to extract meat from the shell, without significant damage to the meat, resulted in the complete breakage of the shell. While single holes were initially attempted (to mimic other *Turbo* shells found within midden deposits), extraction was simply not possible without causing significant damage to the animal's coiled visceral mass, which is considered the delicacy according to ethnographic information, and necessitated some sort of implement to detach the muscular portion from the shell. Out of the 38 shells that were broken completely, the breakage pattern of 10 exhibited an oval, curvilinear shape with smooth edges. These characteristics are consistent with confirmed fishhook manufacturing debris (debris with evidence of polish on the external side).



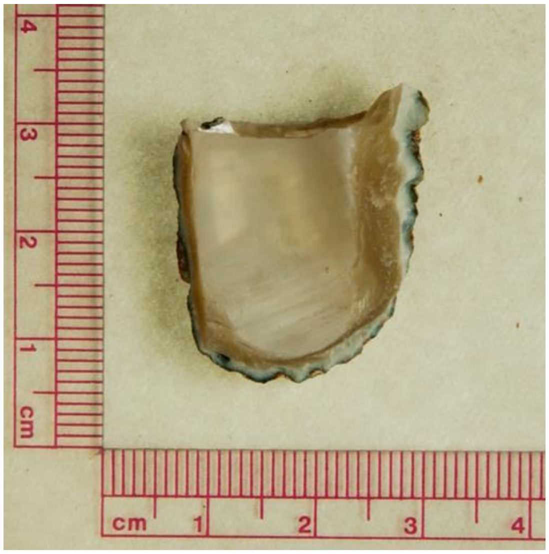


Figure 15: Shell fragments from two *Turbos* broken in the experimental project.

Table 7: Experimental *Turbo* breakage data.

Spec #	Wt (g)	Shell Wt (g)	Operculum Wt (g)	Animal Wt (g)	Columella Length	Operculum min	Operculum max
1	182	135	7	40	8.7	2.8	3.2
2	280	197	6.8	76.2	9	2.9	3.3
3	218	159	5.7	53.3	6.4	2.7	3
4	188	113	3.7	71.3	7	2.4	2.8
5	111	80	3.4	27.6			
6	186	140	1.4	44.6	7.6	2.7	2.9
7	112	81	2.7	28.3			
8	148	112	3.2	32.8	7	2.2	2.6
9	122		3.5				
10	143	106	3.4	33.6	7.1	2.4	2.6
11	150	112	2.5	35.5	7	2.4	2.7
12	129	89	3.6	36.4	7.1	2.2	2.6
13	181	128	5.8	47.2	6.5	2.5	2.9
14	190	146	4.2	39.8	7.5	2.5	2.9
15	178	133	4.1	40.9	8	2.5	2.9

Table 7. Experimental *Turbo* breakage data (continued)

Spec #	**Wt (g)**	**Shell Wt (g)**	**Operculum Wt (g)**	**Animal Wt (g)**	**Columella Length**	**Operculum min**	**Operculum max**
16	120	86	3.1	30.9	6.9	2.3	2.7
17	151	118	3.9	29.1	8	2.5	2.8
18	89		2.6				
19	53	40	1.6	11.4	5.3	1.8	2.2
20	134	98	3.2	32.8	7.2	2.4	2.8
21	142	112	1.1	28.9	7.7	2.3	2.7
22	152	110	4	38	7.6	2.5	2.8
23	119		1.6				
24	109	77	1.9	30.1	7	2.2	2.6
25	138	100	3.4	34.6	6.6	2.4	2.8
26	141	105	3.7	32.3	6	2.3	2.8
27	59		1.6				
28	117	86	2.5	28.5		2.5	2.9
29	124	83	3.1	37.9	8	2.4	2.7
30	163	105	2.4	55.6	6	2.5	3
31	118	89	2.8	26.2	5.4	2.1	2.6
32	123	87	2.4	33.6	5.5	2.2	2.6
33	121	86	2.1	32.9	6.2	2.3	2.7
34	174		4.3		7.8	2.5	2.9
35	107	72	3.2	31.8	6.3	2.2	2.6
36	125	95	3	27	7	2.2	2.5
37	110	86	2.4	21.6	6.4	2.5	2.9
38	92	66	1.7	24.3	5.7	2.1	2.5

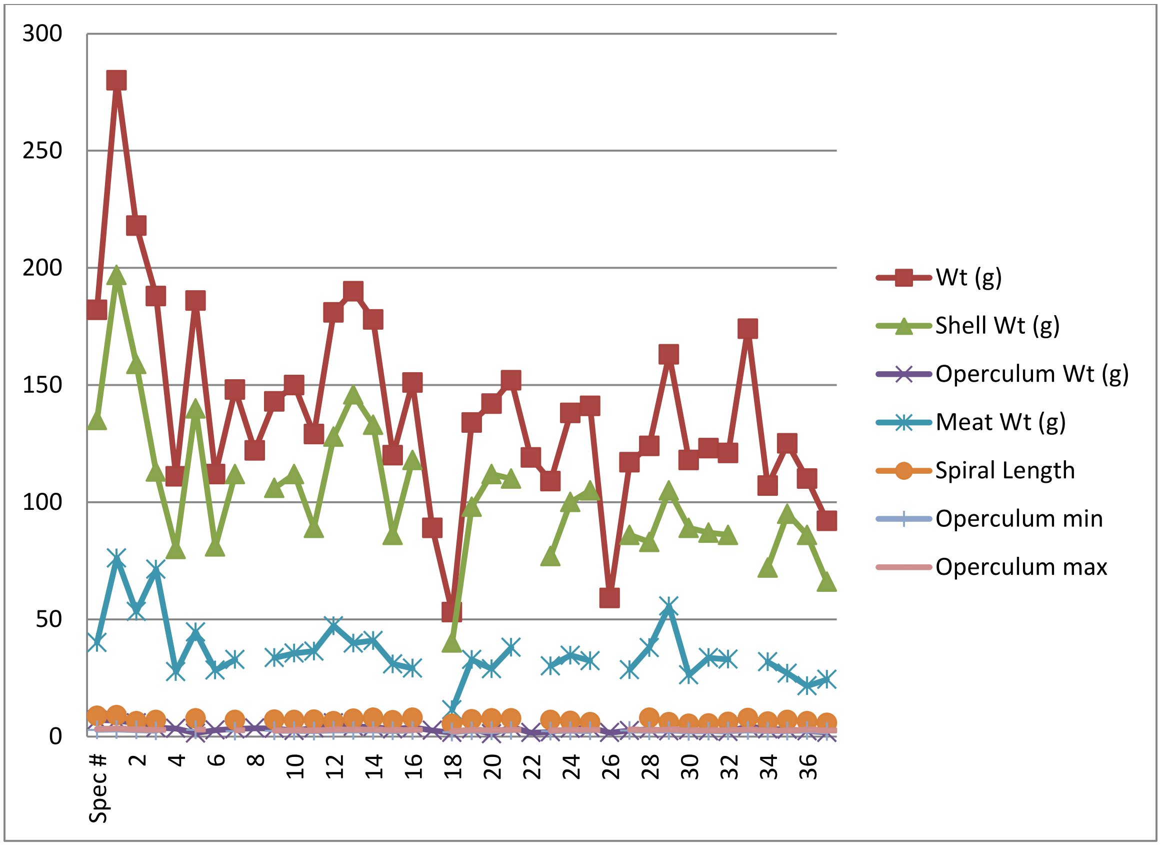


Figure 16: Graph illustrating Table 7 *Turbo* data

Opercula sizes showed very little variability overall with maximum sizes ranging from 2.2 cm to 3.3 cm. The three largest opercula (3cm, 3.2cm, and 3.3cm) and longest columella lengths came from the only three *Turbo crassus* that were collected. These shells were also the most difficult to break due to the thicker and less fragile shell. Columella lengths overall range from 5.3 cm to 9.0 cm and individual shell weight (not including meat or operculum) ranges from 40 g to 197 g. Differences in minimum and maximum diameter of opercula only range from 3mm to 4mm, highlighting the regular formation patterns of opercula.

While the overall weight, shell weight, and meat weight correlate somewhat, a number of anomalies exist. I also expected to see a close correlation between operculum size, operculum weight, and meat weight; however, this correlation appears to be loose at best. One problem is the small amount of variability overall in operculum size. Conversely, operculum weight displays no obvious parallels with other data fields.

Using the data illustrated in Figure 16, the average shell weight for that assemblage is 104g and average animal weight is 36g. Taken as a representative sample, this number can be applied to the *Turbo* data in the archaeological tables in order to estimate the number of *Turbos* represented as well as the animal/meat weight. Since the animal is not fully consumed, edible meat weight must be calculated separately from animal weight. The animal has three distinct sections and one is very likely to have not been consumed. The muscular foot is the most likely to have been consumed but visceral mass may have been consumed as well. The simplest way is to reduce the average meat weight by thirds, and use either 1/3 of the animal weight for the muscular foot, or 2/3 for both the foot and visceral mass.

For example, *Turbo* shell weight for AS-13-13 2010, Layer IV is 17475g. If the average shell weight is 104g then there likely are 168 *Turbos* represented. Total animal weight of 168 *Turbos* is 6048g. Edible meat including only the muscular foot would be 2016g, and if visceral mass is included, 4032g. While the meat weight might not be easily divided into three equal parts, this at least provides an estimation of what might have been available for consumption.

Common Turbo Break Points and Potential Causes

In past excavations, *Turbo* shells are often found near-whole with only a single hole. These holes are most-often found in one of three places, each as a result of different potential causes. Through a combination experimental research, laboratory analysis, and in-field observation, a preliminary typology can be established.

Type 1: Tab Manufacture

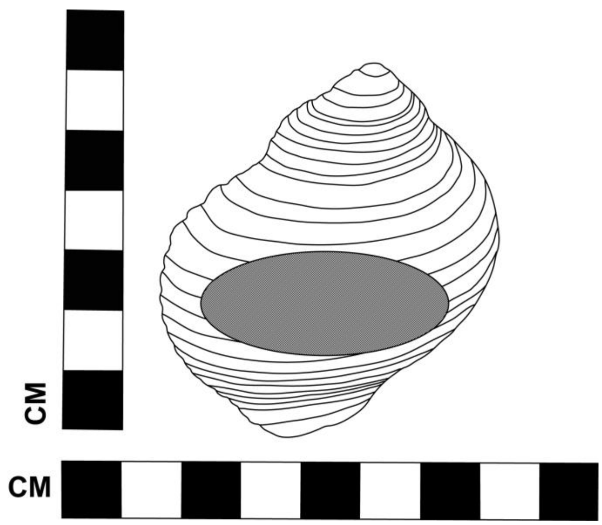


Figure 17: Dorsal side of *Turbo* with portion removed for fishhook manufacture, drawing courtesy of Nathan Smith.

This hole is potentially the result of tab manufacture. In my experimental project, I found that it is quite difficult to remove the animal from a *Turbo* shell without breaking the shell entirely. It would also be impractical to produce a single hole on the opposing side of the aperture, rather than simply expanding upon it. Without any additional tool to extract the animal and without any archaeological evidence of past extraction tools, the animal was likely extracted after the shell had been broken entirely. Thus, a single, oval hole on the dorsal side was likely attributed to an intentional break in order to produce a shell tab that would later be worked into a fishhook.

Type 2: Limpet Feeding

Figure 18: *Turbo* with Limpet and resulting scar, from Va'oto archaeological assemblage.

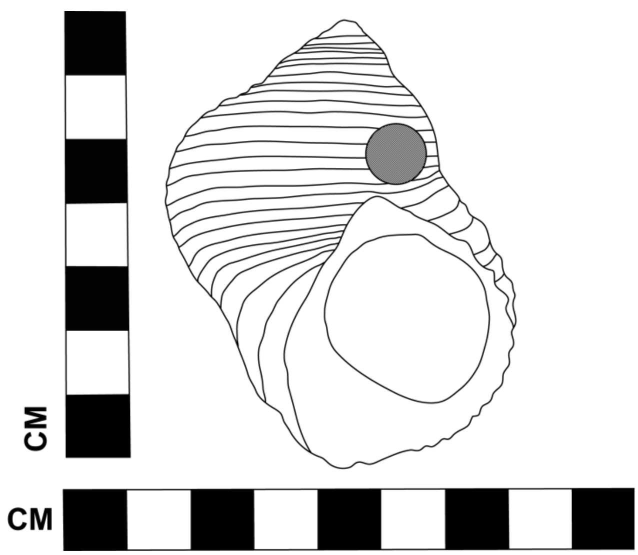


Figure 19: Ventral side of *Turbo* with portion gone due to Limpet feeding, drawing courtesy of Nathan Smith.

Type 2 is a small, circular hole most often present on the upper whirls of the *Turbo*, where the shell is quite thick. While sorting and measuring midden from Va'oto, a *Turbo* with a limpet still attached was found and photographed. After examining the others in the deposit, a characteristic limpet scar was found on several others, and some had worn all the way through. Limpets like *Cellana* and *Hipponix* will attach to a *Turbo* and feed off of the bacteria present on the shell (Poulicek *et al.* 1997). A significant scar can be left on the *Turbo* and eventually develop into a hole. Since there is no current or archaeological evidence on Ofu of animal extraction through a small hole, Limpet feeding is likely the cause.

Type 3: Crab Break

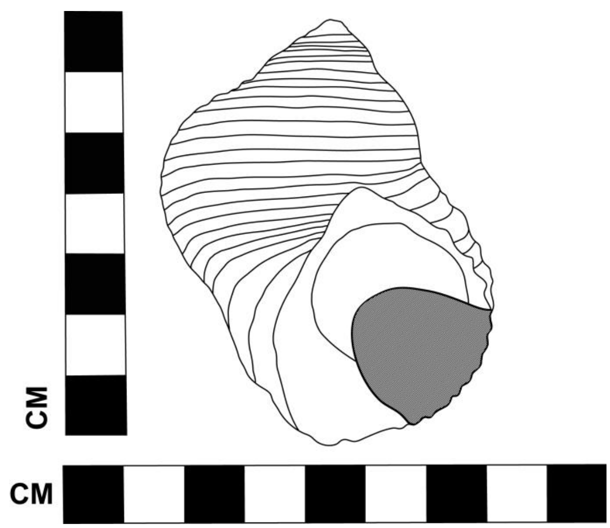


Figure 20: Ventral side of *Turbo* with portion of aperture missing due to crab break, drawing courtesy of Nathan Smith.

Type 3 is a break located on the outer lip, where a C-shaped portion has been removed. These types of shell breaks are commonly observed on the beaches of Ofu associated with hermit crabs. It is possible that this break could result from being dragged along the ground when the crab walks. This could also be the result of a crab intentionally breaking the aperture, thereby expanding the available space when a larger shell is not available.

CHAPTER 6. DISCUSSION

Observable changes in foraging behavior did occur on Ofu, although not in the manner originally expected. Shellfish exploitation experienced an overall change in terms of both amount exploited and number of species exploited. When shell volume per species increased, more species were exploited. Following foraging models, one would expect to see an increase in diet breadth accompanying a decrease in shell volume per species. This change in diet breadth is thought to serve as a way to make up for lost calories when more favored species have been overexploited. Because that is not the case on Ofu, I would argue that either marine resources became more important as a food source during the time of Layer IV at Va'oto, Layer I at Coconut Grove, and Layer VI at Ofu Village, or there was a significant increase, followed by a decrease, in population size at each site. The results did not line up with foraging theory like I had expected. This could be the result of a variety of reasons including a misjudgment of which taxa were the most favorable, using shell weight alone rather than MNI, or it could be that foraging theory is not applicable here.

Shellfish gathering is not commonly practiced on Ofu Island currently; thus it is difficult to assess handling and processing based on current evidence. The few individuals who do take part in this activity do so very rarely and only focus on *Turbo,* or gather intermittently for decorative or curiosity purposes. Ethnographic accounts do identify a gender split between fishing and shellfish gathering with women primarily gathering shellfish and men doing the fishing, though it is unclear how this may be expressed in the archaeological record.

Although *Tridacna* shell did have a presence in the archaeological record, weight was very low given the average whole shell size. When whole shells were recovered, they were of very young and small individuals. This may imply that *Tridacna* were processed where encountered, or close by, likely on the beach near the reef, rather than transported back to habitation sites. This is likely due to the large size and amount of energy required to transport, and then process these large shellfish. The presence of smaller individuals in deposits could have been transported back to the habitation site along with a larger shellfish harvest.

In comparison with the To'aga site, also on Ofu, the assemblage exhibits the same focus on a few taxa including *Turbo*, *Trochus*, and *Tridacna*. Where the two sites differ is in terms of shellfish variety. The To'aga site exhibited an overall pattern of high diversity in shellfish foraging (Nagaoka 1993). Though changes in exploitation exist from layer to layer, diet breadth does not undergo any drastic changes, species exploited merely shift throughout with seemingly no apparent pattern. This has been interpreted to indicate exploitation of naturally abundant or culturally preferred taxa (Nagaoka 1993) and indicates a relatively stable marine environment exhibiting little change in composition over time.

Though the same taxa appear to have been favored overall at Va'oto, Coconut Grove, and Ofu Village, diet breadth changed throughout each deposit. Unexpectedly, increases in diet breadth occurred simultaneously with increases in shell volume within favored species. This implies both changing cultural practices, including an increased focus on shellfish gathering, or settlement shifts to and then away from these three sites. Given the pattern of a sudden increase early in the deposits, and then a gradual waning, I argue that this pattern of marine resource exploitation represents a population arrival marked by 1) the initial representation of shell midden, 2) a human population growth exhibited by the overall increase in shell midden, followed by 3) a human population shift coinciding with shell midden decreases both in volume and variety. This human population shift may very well coincide with movement further inland and an increased focus on terrestrial resources, or simply a shift away from these sites in particular. Given this coincidental pattern throughout sites on Ofu, it is more likely to represent a human population shift rather than a decrease in marine resource exploitation because this pattern is exhibited in different time periods throughout Ofu. In my assessment, marine resource exploitation on Ofu Island as evidenced by the Va'oto site, Coconut Grove, and Ofu Village, represents an overall abundant and stable marine environment through time while human populations shifted throughout the island, exploiting the resources of each area.

It is worth noting that since both the research teams and the roster of students and supervisors performing laboratory analysis were different throughout the years, there may have been some discrepancies in interpretation. These discrepancies could include species identification, midden versus artifact interpretation, and methods of recording and analyzing information and how that was expressed in an Excel document.

Observations from Research Objectives

Through a combination of ethnographic and archaeological research, the objectives stated at the beginning of this paper have been addressed.

- *Observe current shellfish collection methods.*

Turbo are collected at low-tide when they are easily accessible and can be plucked from the rocks with little difficulty. Methods of procurement could very well have been the same in prehistory for gastropods similar to *Turbo* in size and anatomy.

- *Observe current shellfish processing methods.*

Turbo can be easily transported from a collection site and do not need to be processed immediately. Shells can be broken apart with rocks and the meat rinsed of any shell debris before consuming. If shells are intended to be kept intact a shell may be buried long enough for the shellfish to dehydrate and be easily removed with no damage to the shell. These methods could have been performed in the same way prehistorically as none of them require modern tools or materials.

- *Identify any observable differences between shells broken for food procurement versus those used for tool manufacture.*

This evidence suggests that it is possible that breakage due to food extraction could be mistaken for tabs used in the fishhook manufacturing process from the general shape of the breakage alone. These convenient breakage patterns also suggest that an opportunistic individual could have used the shell that was initially broken for meat extraction in order to manufacture fishing gear by utilizing the shell debris left over. The only reliable way to distinguish between a tab and natural breakage is to determine if there has been any sort of reduction attempts including edge-grinding or some sort of initial markings of drilling. It is unclear however, how much natural edge-wear may take place within a deposition over the course of several hundred to 2,500 years, making the task of differentiating between naturally worn or purposefully ground edges more difficult.

- *Identify any observable changes in shellfish foraging patterns over time.*

The volume of shell debris at AS-13-13 exhibits a marked increase during Layer IV. In this layer, an increase in diet breadth is also expressed in the number of species present. The same trend is exhibited in Layer I at Coconut Grove and Layer VI at Ofu Village. Though the time periods are much closer in comparison between Coconut Grove and Va'oto, the Ofu Village site was dated only to the past 500 years so these data are not contemporaneous with the other sites. However, the similar trend observed within the Ofu Village midden data may at least indicate that human exploitation of shellfish continued to exhibit periods of favorability from site to site.

- *Determine if there is any evidence of resource depression caused by overexploitation.*

No convincing evidence of resource depression was found in excavation data, however, more consistent analysis practices may allow for further investigation into this question. Overall, the changes in species exploited including a broader range of species exploited and an increase in volume overall seem to reflect either a more general preference for shellfish or an overall increase in focus on marine resource exploitation during this time period. Alternatively, this rise and fall of the number of species exploited and overall volume of shellfish exploited could reflect a population that grew (either overall population growth or an increase in population at a specific area) and as a result, there was a need to expand the range of species exploited. When populations declined, the range of species exploited declined as well. Since this rise and fall happens at a different time at each site, this could be indicative of population growth in each specific area, or a mobile population. The pattern of marine resource exploitation reflects that of a relatively stable marine environment with either shifting cultural practices or population shifts. There is currently no evidence that would suggest that the marine environment was drastically affected by human foraging practices on Ofu Island.

Originally it was thought that measurements of *Turbo* opercula may reflect the size of *Turbo* shells and possibly the amount of meat contained within each shell. Measurements of *Turbo* collected during the shellfish gathering trip proved to be loosely correlated and as a result, opercula measurements at this site likely do not provide any useful insight into *Turbo* size. Although *Turbo* opercula measurements from excavations were taken and compiled during laboratory analysis, they were not included in this research because of a lack of evidence supporting the merit of estimations of *Turbo* sizes based on sizes of opercula.

CHAPTER 7. CONCLUSIONS

Although ethnographic research of present populations cannot provide concrete answers to questions of prehistoric behavior, it can serve as a useful tool for making inferences of past behavior when studied in conjunction with archaeological data. By utilizing a more holistic approach to research it has been possible to gain more insight on marine resource exploitation and its implications for the fishhook manufacturing process on Ofu Island since human occupation. The seemingly stable marine environment further emphasizes the resiliency of the fringing coral reef surrounding Ofu Island and solidifies the merits of continued study of the reef.

The reef that surrounds at least the southwestern portion of Ofu seems to have remained relatively stable with regard to marine resources and was exploited in different areas at different times. This indicates a very mobile population, although not because of lack of resources. There do not appear to have been any shortages in marine resources during any of these periods, thus mobility was likely a function of culture, rather than a necessity of nature.

The use of foraging theory did not produce as clear-cut results as I had hoped. It is possible that this theory is not valid in this particular case. Another possibility is that the theory was not applied correctly. Results may have been different had I used MNI instead of, or in conjunction with weight.

Certainly much more work can be done on this island to gain a greater understanding of marine resource use. A first step would be to establish a more effective way of measuring the size of shellfish within midden. While it is surely possible to measure shells that are a part of a natural deposit, measuring shells of animals used as a food resource is much more difficult. Operculum measurement, at least in this study, did not provide a clear enough correlation to shell size, and since those *Turbo* that were broken apart to consume the meat are far from intact, it is not possible to get an accurate estimate of their former intact size.

With regard to the ethnographic portion of this study, it may be useful to expand the interviews to other islands in the archipelago. Olosega would be comparable, but like Ofu, there are very few people left that could answer these questions, producing another very small sample size. It is also possible that Ta'u could be more productive. Additionally, since many people have moved from Manu'a to Tutuila, more people may be identified there. With the larger islands of western Samoa, surely one could find a great number of people to interview, but the reefs on those islands are quite different.

This project utilized a variety of methods and addressed several research topics. The key findings of this project are as follows:

- *The Va'oto, Coconut Grove, and Ofu Village sites do not follow the expected pattern laid out by foraging theory.*
- *Human exploitation of shellfish underwent a rapid rise and gradual fall at each of the three sites, implying a mobile population.*
- *It is likely that a considerable portion of shellfish could have been processed where collected, given the ease and convenience of processing close to the water.*
- *Common Turbo break points can be classified into three types with three potential causes.*

- *Animal/meat weight can be estimated using the average shell weight calculated from the experimental portion of this project.*

Data from the three sites examined in this project reflect mobile populations that have exploited abundant marine resources in a resilient marine environment throughout prehistory and current studies can bring to light possible processing methods and results.

BIBLIOGRAPHY

Addison, David and Elizabeth Matisoo-Smith

2010 Rethinking Polynesian origins: a West-Polynesia Triple-I model. *Archaeology in Oceania* 45:1-12

Addison, David J. and Christophe Sand

2008 *Recent Advances in the Archaeology of the Fiji/West-Polynesia Region*. Department of Anthropology, Gender and Sociology, University of Otago

Anderson, Atholl and Geoffrey Clark

1999 The age of Lapita settlement in Fiji. *Archaeology in Oceania*. 31-39

Anderson, Atholl and Sue O'Connor

2008 Indo-Pacific migration and colonization- introduction. *Asian Perspectives* 47(1):2-11.

Aswani, Shankar and Melinda S. Allen

2008 A Marquesan coral reef (French Polynesia) in historical context: an integrated socio-ecological approach. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19:614-625

Aswani, Shankar and Matthew Lauer

2006 Incorporating fishermen's local knowledge and behavior into Geographical Information Systems (GIS) for designing marine protected areas in Oceania. *Human Organization* 65(1):81-102

Best, Simon

1992 *Archaeological reconnaissance survey and excavation of the Ofu-Olosega highway link.* Report on file, American Samoa Historic Preservation Office. Pago, Pago, American Samoa.

Bicho, Nuno and Jonathon Haws

2008 At the land's end: marine resources and the importance of fluctuations in the coastline in the prehistoric hunter-gatherer economy of Portugal. *Quaternary Science Reviews* 27(23):2166-2175

Bird, Douglas W. and Rebecca Bliege Bird

2000 The ethnoarchaeology of juvenile foragers: shellfishing strategies among Meriam children. *Journal of Anthropological Archaeology* 19:461-476

Bird, Douglas W., et al.

2002 Explaining shellfish variability in middens on the Meriam Islands, Torres Strait, Australia. *Journal of Archaeological Science* 29:457-469

Buck, Peter H.
1930 *Samoan Material Culture*. B.P. Bishop Museum Bulletin No. 75. B.P. Bishop Museum, Honolulu

Burley, David V. and Jeffrey T. Clark
2003 The archaeology of Fiji and Western Polynesia - a review. In, *Proceedings of the International Conference for the 50th Anniversary of the First Lapita Excavation (July 1952), Koné-Nouméa 2002*. C. Sand, ed. Pp. 221-240. Nouméa: Le Cahiers de l'Archéologie en Nouvelle-Calédonie 15.

Checa, Antonio G. and Antonio P. Jimenez-Jimenez
1998 Constructional morphology, origin, and evolution of the Gastropod operculum. *Paleobiology* 24(1):109-132

Clark, Jeffrey T.
1980 *Historic Preservation in American Samoa: Program Evaluation and Archaeological Site Inventory.* Report on file. Pago Pago: Historic Preservation Office, American Samoa Government.

1993 Radiocarbon dates from American Samoa. *Radiocarbon* 35: 323-330.

1996 Samoan prehistory in review. In, *Oceanic Culture History: Essays in Honour of Roger Green*. J. M. Davidson, B. F. Leach, A. Pawley and D. Brown eds., pp. 445-460. New Zealand Journal of Archaeology Special Publication.

2011 *The First Millennium in Samoa: Excavations at the Va'oto Site, Ofu Island.* Paper presented at the 2011 Lapita Pacific Archaeology Conference, Apia, Samoa, July 2011.

Clark, Jeffrey T. and Kevin M. Kelly
1993 Human genetics, paleoenvironments, and malaria: relationships and implications for the settlement of Oceania. *American Anthropologist* 95(3):612-630

Clark, Jeffrey T. and Michael Michlovic
1996 An early settlement in the Polynesian homeland: excavations at 'Aoa valley Tutuila Island, American Samoa. *Journal of Field Archaeology.* 23(2):151-168.

Clark, Jeffrey T., Seth J. Quintus., and Davis Bonk
2012 *A Reconnaissance Survey of Inland Ofu Island, Manu'a Group, American Samoa*. Report submitted to the American Samoa Historic Preservation Office, Pago Pago, American Samoa

Clark Jeffrey T. and John Terrell
1978 Archaeology in Oceania. *Annual Review of Anthropology* 7:293-319

Clark, Jeffrey T., E. Wright and David J. Herdrich
1997 Interactions within and beyond the Samoan archipelago: evidence of basaltic rock geochemistry. In *Prehistoric long-distance interaction in Oceania: An interdisciplinary approach.* Monograph 21. edited by Marshal Weisler. pp. 85-110. Auckland New Zealand Archaeological Association.

Craig, Peter, et al.
2008 Subsistence harvest of coral reef resources in the outer islands of American Samoa: modern, historic, and prehistoric catches. *Fisheries Research* 89:230-240.

Davidson, Janet M.
1969 Settlement patterns in Samoa before 1840. *Journal of the Polynesian Society* 78:44-88

1974 Samoan structural remains and settlement patterns. In, *Archaeology in Western Samoa,* Vol. II, edited by Roger C. Green and Janet M. Davidson. pp. 225-244. Bulletin of the Auckland Institute and Museum No. 7, Auckland Davidson, Janet M.

1979 Samoa and Tonga. In, *The Prehistory of Polynesia*. edited by Jesse D. Jennings. pp. 82-109. Cambridge and London: Harvard University Press

2012 Intrusion, integration and innovation on small and not-so-small islands with particular reference to Samoa. *Archaeology in Oceania* 47:1-13

Dilcher, Kendra E.
2012 Reflections on an eye-opening rural health experience of a second year medical student*. Hawai'i Journal of Medicine and Public Health* 71(4):68

Duncan, Robert A.
1985 Radiometric ages from volcanic rocks along the New Hebrides-Samoa lineament, in T.M. Brocher, ed., *Geological Investigations of the Northern Melanesian Borderland*. Houston: Circum-Pacific Council for Energy and Mineral Resources, pp. 67-76.

Emory, Kenneth P. and Yosihiko H. Sinoto
1965 *Preliminary Report on the Archaeological Investigations in Polynesia.* Unpublished Manuscript, on file Department of Anthropology, Bishop Museum, Honolulu.

Erlandson, Jon M.
1988 The role of shellfish in prehistoric economies: a protein perspective. *American Antiquity* 53(1):102-109

Frost, Janet
1976 Summary report of archaeological investigation on Tutuila Island American Samoa. *New Zealand Archaeological Association Newsletter*, 19:30-7.

1978 *Archaeological Investigations on Tutuila Island, American Samoa*. Unpublished, Ph.D thesis, Department of Anthropology, University of Oregon.

Golson, Jack
1971 Lapita ware and its transformations, in R.C. Green and M. Kelly (eds.), *Studies in Oceanic Culture History, Vol. 2*. Pacific Anthropological Records 12. Honolulu: Department of Anthropology, Bernice P. Bishop Museum, pp. 67-76.

Grattan, Francis J. H.
1948 *An Introduction to Samoan Custom*. Samoa Print & Publishing Company.

Grayson, Donald K. and Michael D. Cannon
1999 Human paleoecology and foraging theory in the Great Basin. In *Models for the Millenium: Great Basin Anthropology Today.* Salt Lake City: University of Utah Press, pp. 141-151.

Green, Roger C.
1967 Settlement patterns: four case studies from Polynesia. *Asian and Pacific Archaeology Series* 1:101-32.

1979 Lapita. In J.D. Jennings, ed., *The Prehistory of Polynesia*. Cambridge: Harvard University Press, pp. 27-60.

2002 A retrospective view of settlement pattern studies in Samoa. In, *Pacific Landscapes: Archaeological Approaches* T. N. Ladefoged and Michael Graves, eds., pp. 125-52. Los Osos: Easter Island Foundation

Green, Roger C. and Horace G. Richards
1975 Lapita pottery and a lower sea level in Western Samoa. *Pacific Science* 29(4):309-315

Green, Roger C. and Janet M. Davidson
1974a A radiocarbon and stratographic sequence for Samoa. *In Archaeology in Western Samoa,* Vol. II Bulletin 7. Pp. 212-224

Green, Roger C. and Janet M. Davidson (eds)

1969a *Archaeology in Western Samoa. Vol. I.* Bulletin 6. Auckland: Auckland Institute and Museum.

1969b Description and classification of Samoan adzes. In *Archaeology in Western Samoa*, Vol. I. Bulletin 6. Pp. 21-32

1974b *Archaeology in Western Samoa, Vol.II*. Bulletin 7. Auckland: Auckland Institute and Museum.

Hames, R.

2001 Human Behavioral Ecology. *International Encyclopedia of the Social & Behavioral Sciences.* Pergamon, Oxford. Pp. 6946-6951

Holmer, Richard N.

1976 Mt. Olo settlement pattern interpretation, in J.D. Jennings, R.N. Holmer, J. Janetski, and H.L. Smith, *Excavations on 'Upolu, Western Samoa*. Pacific Anthropological Records, No. 25. Honolulu: B.P. Bishop Museum, pp. 41-56.

Hunt, Terry and Patrick V. Kirch

1988 An archaeological survey of the Manu'a Islands, American Samoa. *Journal of the Polynesian Society* 97:153-183.

Jennings, Jesse D. and Richard N Holmer

1980 *Archaeological Excavations in Western Samoa*. Pacific Anthropological Records No. 32. Honolulu: Dept of Anthropology, Bishop Museum.

Jennings, Jesse D., Richard N. Holmer, and G. Jackmond

1982 Samoan village patterns: four examples. *Journal of the Polynesian Society* 91:81-102

Jennings, Jesse D., Richard N Holmer, Joel. Janetski, and H.I. Smith,

1976 *Excavations on 'Upolu, Western Samoa*. Pacific Anthropological Records, No. 25. Honolulu: B.P. Bishop Museum.

Kikuchi, William K.

1963 *Archaeological Surface Ruins in American Samoa*. Unpublished MA thesis, Department of Anthropology, University of Hawaii.

.

1964 Petroglyphs in American Samoa. *Journal of the Polynesian Society,* 73:163-166.

Kirch, Patrick V.
2000 *On the Road of the Winds: An Archaeological History of the Pacific Islands Before European Contact*. Berkeley: University of California

2008 The impact of the prehistoric Polynesians on the Hawaiian ecosystem. *Pacific Science* 36(1):1-14

Kirch, Patrick V. and Terry L. Hunt.
1993 *The To'aga Site: Three Millennia of Polynesian Occupation in the Manu'a Islands, American Samoa.* No. 51, Contributions of the University of California Archaeological Research Facility, Berkeley. Berkeley: University of California Research Facility.

Milner, George B.
1976 *Samoan Dictionary.* Polynesian Press.

Morrison, Alex E. and David J. Addison
2008 Assessing the role of climate change and human predation of marine resources at the Fatu-ma-Futi site, Tutuila Island, American Samoa: an agent based model. *Archaeology in Oceania* 43:22-34

2009 Examining causes and trends of marine Trophic level change: 1500 years of fish exploitation at Fatu-ma-Futi, Tutuila Island, American Samoa. *The Journal of Island and Coastal Archaeology* 4(2):177-194

Morrison, Alex E. and Terry L. Hunt
2007 Human impacts on the nearshore environment: an archaeological case study from Kaua’i, Hawaiian Islands. *Pacific Science* 61(3):325-245

Nagaoka, Lisa
1993 Faunal assemblages from the To’aga site. In *The To’aga Site: Three Millennia of Polynesian Occupation in the Manu’a Islands, American Samoa*. P.V. Kirch and T.L. Hunt eds. Pp. 189-216. Berkeley: Contributions of the University of California Archaeological Research Facility 51

Nunn, Patrick.D.,
1990 Recent environmental changes on Pacific islands. *Geographical Journal* 156:125-140.

Petchey, Fiona J.

1995 *The Archaeology of Kudon: Archaeological Analysis of Lapita Ceramics from Mulifanua Samoa and Sigatoka*, *Fiji.* Unpublished MA thesis, Department of Anthropology, University of Auckland

2001 Radiocarbon determinations from the Mulifanua Lapita site, Upolu, Western Samoa. *Radiocarbon* 43(1):63-68

Petchey, Fiona J. and David J. Addison

2008 Radiocarbon dating marine shell in Samoa – a review. In. *Recent Advances in the Archaeology of the Fiji/West-Polynesia Region*. D. J. Addison and C. Sand, eds. Pp. 79-86. Department of Anthropology, Gender and Sociology, University of Otago.

Poulicek, Mathieu, Jean-Claude Bussers, and Pierre Vandewalle

1997 Biology and description of *Antisabia juliae* sp. Nov., new Hipponicid gastropod commensal on *Turbo* spp. in Laing Island (Papua New Guinea). *Scientia Marina* 61(2):5-14

Quintus, Seth J.

2011 *Land Use and the Human-Environment Interaction on Olosega Island, Manu'a, American Samoa*. Unpublished M.S. Thesis, Department of Sociology and Anthropology, North Dakota State University

Quintus, Seth J. and Jeffrey T. Clark.

2012 Between chaos and control: spatial perception of domestic, political, and ritual organization in prehistoric Samoa. *Journal of the Polynesian Society* 121:275-302.

Renfrew, Colin and Paul Bahn

2010 *Archaeology Essentials, 2nd Edition, Theories, Methods, and Practice.* London: Thames & Hudson Ltd.

Richmond, Robert H. et al.

2002 Status of the coral reefs in Micronesia and American Samoa: US affiliated and freely associated islands in the Pacific. In *Status of Coral Reefs of the World*. Wilkinson, C. ed. Pp. 217-236. Australian Institute of Marine Science, Townsville, Queensland.

Rieth, Timothy M. Hunt, Terry L.

2008 A Radiocarbon Chronology for Samoan Prehistory. *Journal of Archaeological Science* 35:1901-1927.

Sahlins, Marshall

1958 *Social Stratification in Polynesia*. Seattle: American Ethnological Society.

Shore, Brad
1982. *Sala'ilua: A Samoan Mystery*. New York: Columbia University Press.

Steadman, David W.
1993 Bird bones from the To‘aga site: prehistoric loss of seabirds and megapodes. In *The To‘aga Site: Three Millennia of Polynesian Occupation in the Manu‘a Islands, American Samoa*. P.V. Kirch and T.L. Hunt eds. Pp. 217–228. Contributions of the University of California Archaeological Research Facility 51, Berkeley.

Stice, G. D. and F. W. McCoy
1968. The geology of the Manu'a Islands, Samoa. *Pacific Science*, XXII:427-57.

Swadling, Pamela
1975 Changes induced by human exploitation in prehistoric shellfish populations. *Mankind* 10(3):156-162.

Wallin, Paul and Helene Martinson-Wallin
2007 Settlement patterns – social and ritual space in prehistoric Samoa. *Archaeology in Oceania,* Supplement. 42:83-89

Winterhalder, Bruce and Eric Alden Smith
2000 Analyzing adaptive strategies: Human Behavioral Ecology at twenty-five. Evolutionary *Anthropology* 9(2):51-72.

APPENDIX. FULL MIDDEN DATA TABLES

Table A1: Va'oto site full midden data, weight (g), 1999 field season.

Va’oto 1999			
AS-13-13			
Taxa	**Layer I**	**Layer II**	**Layer IV**
Acmaea	-	2.4	0.6
Acrosterigma	-	-	-
Andara	-	-	5.3
Angaria	-	-	-
Architectonicidae	-	1.6	-
Arcidae	-	0.3	-
Asaphis	-	0.1	3.3
Atactodea	-	0.8	-
Bivalve	-	54.6	291.1
Cassididae	-	0.2	10.2
Cellana	-	12.7	31.6
Cerithiidae	-	78.6	149.8
Cerithium	-	10	5.4
Clypeomorus	-	7.1	103.8
Codakia	-	1.4	28.1
Columbellidae	-	-	18.4
Conus	-	160.6	354.9
Coralliophilidae	-	11.6	57.3
Crustacea	-	2	81.2
Cymatiidae	-	103.3	615.8
Cypraea	38.5	705.5	2540
Diatoms	-	-	1.2
Dosima	-	-	2.9
Drupa	4.1	89	176.6
Fasciolariidae	-	-	72.2
Fimbria	-	2.3	0.4
Fragum	-	4.7	-
Gastrochaenidae	-	0.5	-
Glossidea	-	-	8.5
Hipponicidae	-	9.1	0.3
Land snail	-	-	3.9
Littorinidae	-	49.6	55.2
Marginella	-	22.7	104.3

Table A1: Va'oto site full midden data, weight (g), 1999 field season (continued)

Taxa	Layer I	Layer II	Layer IV
Megelinae	-	0.5	-
Melampidae	-	23.3	275.4
Mitridae	-	1.9	9.9
Morula	-	2.4	18.4
Muricidae	-	5.5	-
Mytilidae	-	0.3	1
Nassarius	-	5.9	33.7
Neriidae	-	-	14.3
Nerita	-	243.9	442.4
Neritalineata	-	2.4	-
Neritopsis	-	4.6	13.9
Operculum of turbo	-	2071.5	4184.6
Pectinidae	-	2.5	-
Peristernia	-	1.9	34
Planaxis	-	7	8.2
Polinices	-	0.3	4.2
Pseudovertagus	-	4.1	108.8
Pyramidellidae	-	-	-
Sea urchin	-	131.1	3854.9
Siphonaria	-	2.1	5.1
Skeneidae	-	0.9	-
Spondyidae	-	2.9	-
Strombacea	-	1046.8	5161.4
Strombidae	-	3.2	6.9
Strombus	-	97.4	131.5
Tectus	-	22.2	13.8
Tellina	-	39.8	95.8
Tellinidae	-	-	19
Thaididae	-	70	549.2
Thais	-	432.8	740.9
Tridacna	-	737.2	2276
Trochaceastraea	-	3.5	-
Trochidae	-	4.4	0.4
Trochus	-	1213.5	3091.2
Turbinidae	-	15.9	40.5
Turbo	-	9054	17275
Turbo w/ operculum	-	-	42.3

Table A1: Va'oto site full midden data, weight (g), 1999 field season (continued)

Taxa	Layer I	Layer II	Layer IV
Unidentifed shell	-	3194.7	7221.2
Unidentified burnt shell	-	-	1.2
Vanikoridae	-	0.8	-
Vasum	-	-	-
Total Shell Weight	**42.6**	**19781.9**	**50397.4**
# Taxa Exploited	**2**	**59**	**57**

Table A2: Va'oto site midden data, weight (g), 2010 field season.

Va'oto 2010					
AS-13-13					
Taxa	**Layer II**	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**
Acmaea	-	-	1.2	-	-
Architectonicidae	-	-	3.1	-	-
Asaphis	-	-	-	-	-
Basalt	240.6	8.8	362.1	39.5	-
Bivalve (unidentified)	2.3	54.6	12.8	17	3.7
Botula	-	0.6	-	-	-
Bursidae	-	-	54.9	-	-
Cassididae	-	-	19.4	-	-
Cellana	-	4.9	12.9	-	-
Cerithiidae	-	15.4	378.79	24.3	0.5
Chamidae	-	-	51.6	-	-
Charcoal	-	-	0.2	-	-
Clypeomorus	-	-	6	0.4	-
Conus	11.6	89.5	290.7	31	21
Crab	8.1	26	102.3	15.8	3.8
Cymatium	7.7	207.2	487	84.8	3.9
Cypraea	128.7	519.1	1533	152.2	90.2
Diatom	-	-	0.3	-	-
Doreensis	-	50	-	-	-
Drupa	10.9	78.6	221.26	5	0.7
Fragum	-	-	-	-	-
Gastrochaenidae	-	-	7.8	-	-
Harpa	-	12.2	-	-	-
Hipponicidae	13.6	-	5.5	0.4	-
Littorina	11.1	5.9	8.1	-	0.8
Marginella	-	0.8	22.9	7.1	3.6
Melampidae	7.3	28.3	159.1	20.3	0.9
Mitra	5.1	1.8	10.3	2	-
Morula	-	-	319.6	-	-
Mytilidae	-	-	4.8	-	0.7
Nacella	-	-	-	-	-
Nassarius	-	1.7	222.8	0.4	-
Nerita	33	93.9	170.69	21.4	4.5
Neritopsis	-	-	13.1	-	-

Table A2: Va'oto site midden data, weight (g), 2010 field season (continued)

Taxa	**Layer II**	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**
Ostreidae	-	-	13.7	-	-
Phenocrysts	-	-	1.2	-	-
Pira sculptus	-	-	-	-	-
Planaxis	-	-	2.2	-	-
Polinices Melan.	-	-	0.5	-	-
Pseudovertagus	5.7	-	-	-	1.6
Sassurellidae	-	-	1.9	-	-
Sea Urchin	29.9	447	3644.09	207.3	13.6
Semesangulus	-	1.3	-	-	-
Strombus	18.3	35	146.9	20.5	16.4
Tectus	-	-	-	-	-
Tellinidae	51.2	12.1	225.4	48.2	-
Terebridae	0.7	-	-	-	-
Thais	84.3	229.1	966.1	44.1	21.6
Tonnidae	-	103.4	20.9	18.8	-
Trapezium	2.1	-	4.2	-	-
Tridacna	484	720.7	1879.1	298.7	118.8
Trochus	157.2	628.1	2296.6	186.8	3.2
Turbinidae	-	-	1.9	-	-
Turbo	1324.3	3168.4	17474.9	1595.2	2294.3
Turbo Operculum	34.6	488	1890.2	218.1	20.6
Vasum	97	92.6	532.3	35.5	-
Vermetidae	-	-	3.9	-	-
Veneridae Perlglypta Reticula	-	-	-	26.3	-
Unidentified	135.9	994.8	4509.69	318.9	112.2
Total Shell Weight	**2905.2**	**8119.8**	**38097.9**	**3440**	**2736.6**
# Taxa Exploited	**26**	**32**	**49**	**29**	**21**

Table A3: Va'oto site midden data, weight (g), 2012 field season.

Va'oto 2012						
AS-13-13 Site Totals						
Taxa	**Layer I**	**Layer II**	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**
Acmaea	-	-	-	-	-	-
Acrosterigma	-	-	-	-	-	-
Andara	-	-	-	-	-	-
Angaria	-	-	-	-	-	-
Architectonicidae	-	-	-	-	-	-
Arcidae	-	-	-	-	-	-
Asaphis	-	-	-	-	-	-
Atactodea	-	-	-	-	-	-
Bivalve	-	-	12	11.2	1.6	-
Bursidae	-	-	-	-	-	-
Bursidae	-	-	-	-	48.1	-
Cassididae	-	-	8.7	14.9	-	-
Cellana	-	-	-	-	-	-
Cerithiidae	-	3.9	97.5	27.4	-	-
Clypeomorus	-	-	-	-	-	-
Codakia	-	-	-	-	-	-
Conidae	-	5.9	8.7	19.6	9.9	-
Conus	-	13.2	50.3	65.1	-	5.3
Crab	-	1.4	10.7	11.8	1	-
Cymantium	-	8.1	21.9	74.4	28.6	-
Cymatium	-	6.9	13.3	57.1	-	-
Cypraea	-	51	332	290.7	14.3	-
Dosima	-	-	-	-	-	-
Drupa	-	7.5	36	43.6	0.9	-
Fimbria	-	-	6.8	-	-	-
Fragum	-	-	-	-	-	-
Gastrochaenidae	-	-	1.6	4.8	-	-
Gastropoda	-	6.8	19	-	-	-
Glossidea	-	-	-	-	-	-
Hipponix	-	0.6	4.7	3.2	-	-
Laemodonta ciliata	-	1.7	1.2	0.7	-	-
Littoeinidae	-	-	-	-	-	-
Littorina	-	-	-	-	0.3	-

Table A3: Va'oto site midden data, weight (g), 2012 field season (continued)

Taxa	Layer I	Layer II	Layer III	Layer IV	Layer V	Layer VI
Littorizdae	-	-	-	-	-	-
Lucinidae	-	-	4.7	0.5	-	-
Marginella	-	2.2	3	2.3	-	-
Megelinae	-	-	-	3.1	-	-
Melampidae	-	0.8	11.5	42.5	6.8	-
Mitridae	-	-	4.7	-	1.1	-
Morula	-	-	-	-	-	-
Mytilidae	-	-	-	-	-	-
Nassarius	-	1.4	-	0.3	-	-
Nerita	-	15.1	43.1	34.6	9	-
Neritopsis	-	-	-	-	-	-
Olivia	-	-	-	18.8	-	-
Operculum of turbo	-	249.4	227.7	439.6	64.6	-
Patellidae	-	-	-	-	-	-
Patelloida	-	-	-	-	-	-
Pectinidae	-	-	-	-	-	-
Peristernia	-	-	-	-	-	-
Planaxis	-	-	-	-	-	-
Polinices	-	-	-	-	-	-
Pseudovertagus	-	-	-	-	-	-
Pyramidellidae	-	-	-	-	-	-
Sea urchin	-	9.7	282.7	427.1	57	-
Siphonaria	-	-	-	-	-	-
Skeneidae	-	-	-	-	-	-
Spondyidae	-	-	-	-	-	-
Strombidae	-	-	0.7	-	-	-
Strombus	-	7.9	33	28.1	2.8	-
Tectus	-	-	-	-	-	-
Tellinidae	-	7.4	16.6	28.6	1.4	-
Thaididae	-	-	-	-	-	-
Thais	-	48.1	91.2	242.8	98.4	-
Tridacna	-	58.9	168.6	468	-	-
Trochaceastraea	-	-	-	-	-	-
Trochus	-	43.2	240.7	309.4	36.3	1.6
Trochus	-	-	-	-	0.8	-
Tonnidae	-	-	-	-	1.3	-

Table A3: Va'oto site midden data, weight (g), 2012 field season (continued)

Taxa	**Layer I**	**Layer II**	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**
Turbo	-	1297	2159.3	3769.6	665.1	0.8
Unidentified	-	57.4	126.9	300.6	32.1	2.1
Vanikoridae	-	-	-	-	-	-
Vasum	-	-	-	-	41.4	-
Veneridae	-	-	-	-	2.3	-
Vermitidae	-	-	-	-	0.5	-
Total Shell Weight	**0**	**1905.5**	**4038.8**	**6740.4**	**1125.6**	**9.8**
# Taxa Exploited	**0**	**24**	**30**	**29**	**24**	**4**

Table A4: Coconut Grove site midden data, weight (g), 2011 field season.

Coconut Grove 2011			
AS-13-37			
Taxa	**Layer I**	**Layer II**	**Layer III**
Acrosterigma	-	-	-
Barbatia	1.1	-	-
Bivalve (unidentified)	8.1	14.3	-
Botula	-	-	-
Bursidae	23.4	2.8	-
Cassididae	-	-	-
Cellana	-	-	-
Cerithiidae	44.6	11	-
Clypeomorus	0.8	1.9	-
Codakia	0.8	-	-
Conus	98.3	49.4	0.9
Cymatium	62.2	33.9	0.6
Cypraea	760.1	254.3	1.9
Drupa	93.2	113.9	0.4
Dosina	-	1.7	-
Gastrochaenidae	-	-	-
Gouldia	-	0.6	-
Grammatomya	0.1	-	-
Harpa	-	-	-
Hipponicidae	10.2	8	-
Laemondonta	6.1	73.2	5.3
Littorina	-	0.1	-
Lucinidae	1.8	-	-
Marginella	6.2	2.7	-
Melampidae	59.3	192.4	2.8
Mitra	9.3	4.2	-
Modiolus	0.4	-	-
Molginella	0.9	-	-
Morula	0.4	-	-
Mytilidae	-	-	-
Nacella	-	-	-
Nassarius	2.7	0.2	2
Nerita	41.4	102.4	1.5

Table A4: Coconut Grove site midden data, weight (g), 2011 field season (continued)

Taxa	**Layer I**	**Layer II**	**Layer III**
Neritopsis	-	-	-
Ostreidae	-	-	-
Peristernia	0.5	-	-
Pira sculptus	-	-	-
Planaxis	0.8	-	-
Pseudovertagus	-	-	0.2
Sea Urchin	31.8	115.4	-
Semesangulus	-	-	-
Strombus	38.9	20.9	-
Tectus	-	1.9	0.4
Tellinidae	50.1	47.9	0.6
Thais	283.5	49.9	0.7
Tonnidae	0.9	4.6	-
Tridacna	251.3	371.1	-
Triphoridae	3.1	-	-
Trochus	420.1	199.4	-
Turbo	4558.2	3832.9	95.7
Turbo Operculum	1287.8	833.8	15.4
Vasum	133.5	-	1.9
Vermetidae	0.8	-	-
Unidentified	754.6	544.4	9.1
Total Shell Weight	**9047.3**	**6889.2**	**139.4**
# Taxa Exploited	**37**	**29**	**16**

Table A5: Coconut Grove site midden data, weight (g), 2012 field season.

Coconut Grove 2012								
AS-13-37 Totals								
Taxa	**Layer I**	**Layer Ia**	**Layer Ib**	**Layer II**	**Layer IIa**	**Layer IIb**	**Layer IIc**	**Layer III**
Acmaea	-	-	-	-	-	-	-	-
Acrosterigma	-	-	-	-	-	-	-	-
Andara	-	-	-	-	-	-	-	-
Architectonicidae	-	-	-	-	-	-	-	-
Arcidae	2.5	-	2.1	-	-	-	-	-
Asaphis	-	-	-	-	-	-	-	-
Atactodea	-	-	-	-	-	-	-	-
Bivalve	10.2	-	-	-	-	-	-	-
Bursidae	-	-	-	-	-	-	-	-
Cassididae	-	-	3.1	-	-	21.9	-	-
Cellana	0.8	-	-	-	-	-	-	-
Cerithiidae	-	-	109	-	-	0.6	-	-
Clypeomorus	-	-	-	-	-	-	-	-
Codakia	-	-	-	-	-	-	-	-
Conus	29.5	-	10.5	1.4	-	1.8	0.6	1.9
Crab	-	-	1.7	-	-	-	2.5	-
Cymantium	10.6	-	11.3	11.3	-	-	0.8	-
Cypraea	96.8	8.7	50.5	5.1	<1	13.8	13.4	3.6
Dosima	-	-	-	-	-	-	-	-
Drupa	18	5.4	3.2	-	-	5.1	-	-
Drupa	-	-	-	-	-	-	-	-
Fimbria	-	-	-	-	-	-	-	-
Fragum	-	-	-	-	-	-	-	-
Gastrochaenidae	-	-	-	-	-	-	-	-
Gastropoda	10.6	-	1.7	13.6	-	-	-	-
Glossidea	-	-	-	-	-	-	-	-
Hipponix	0.5	-	-	-	-	-	1.3	-
Laemodonta ciliata	4.3	-	1.9	2.8	2.7	-	-	-
Littoeinidae	-	-	-	-	-	-	-	-
Littorina	-	-	-	-	-	-	-	-
Littorizdae	-	-	-	-	-	-	-	-
Lucinidae	-	-	-	-	-	-	-	3.3
Marginella	0.8	-	-	-	-	-	-	-

Table A5: Coconut Grove site midden data, weight (g), 2012 field season (continued)

Taxa	Layer I	Layer Ia	Layer Ib	Layer II	Layer IIa	Layer IIb	Layer IIc	Layer III
Megelinae	-	-	-	-	-	-	-	-
Melampidae	2.4	-	-	0.8	0.5	-	0.1	-
Mitra	-	-	-	-	-	-	-	-
Morula	-	-	-	-	-	-	-	-
Mytilidae	-	-	-	-	-	-	-	-
Nassarius	-	-	-	-	-	-	-	-
Nerita	12.6	-	3.7	5.9	-	1.8	9.3	6.8
Neritopsis	-	-	-	-	-	-	-	-
Olivia	-	-	-	-	-	-	-	-
Operculum of turbo	333.5	16.3	92.1	39.2	4.6	42.9	32.2	16
Patellidae	-	-	-	-	-	-	-	-
Patelloida	-	-	-	-	-	-	-	-
Pectinidae	-	-	-	-	-	-	-	-
Peristernia	-	-	-	-	-	-	-	-
Planaxis	-	-	-	-	-	-	-	-
Polinices	-	-	-	-	-	-	-	-
Pseudovertagus	-	-	-	-	-	-	-	-
Pyramidellidae	-	-	-	-	-	-	-	-
Sea urchin	53.6	-	3.1	-	-	7.1	24.2	-
Siphonaria	-	-	-	-	-	-	-	-
Skeneidae	-	-	-	-	-	-	-	-
Spondyidae	-	-	-	-	-	-	-	-
Strombus	18.6	-	-	-	-	6.1	-	-
Tectus	-	-	-	-	-	-	-	-
Tellinidae	2.8	-	-	-	-	8.5	0.5	-
Thaididae	-	-	-	-	-	-	-	-
Thais	7.2	-	-	15.1	-	-	-	-
Tridacna	81.4	20.1	6.4	26.4	-	2.4	-	-
Trochaceastraea	-	-	-	-	-	-	-	-
Trochus	92.2	-	29.2	21.4	3.6	22.7	4.5	1.3
Tonnidae	-	-	-	-	-	-	-	-
Turbo	1483	16	631	507.1	9.5	254.9	203.4	665
Unidentified	161.2	5.6	48.6	54.7	1	18.5	23.8	8.9
Vanikoridae	-	-	-	-	-	-	-	-
Vasum	9.3	-	-	-	27.2	-	19.9	19.9
Veneridae	-	-	-	-	-	-	-	-
Vermitidae	-	-	-	-	-	-	-	-

Table A5: Coconut Grove site midden data, weight (g), 2012 field season (continued)

	Layer I	Layer Ia	Layer Ib	Layer II	Layer IIa	Layer IIb	Layer IIc	Layer III
Total Shell Weight	**2442.4**	**72.1**	**1009.1**	**704.8**	**49.1**	**408.1**	**336.5**	**726.7**
# Taxa Exploited	**23**	**6**	**17**	**13**	**8**	**14**	**13**	**9**

Table A6: Ofu Village site midden data, weight (g), 2012 field season.

Ofu Village 2012							
AS-13-41							
Taxa	**Layer II**	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**	**Layer VII**	**Layer VIIb**
Acmaea	-	-	-	1.9	2.3	-	-
Acrosterigma	-	-	-	-	-	-	-
Andara	-	-	-	-	-	-	-
Angaria	-	-	-	-	-	-	-
Architectonicidae	-	-	-	-	-	-	-
Arcidae	1	-	-	-	0.5	-	-
Asaphis	-	-	-	-	-	-	-
Atactodea	-	-	-	-	-	-	-
Bivalve	-	-	-	4	14.4	1.1	1.1
Bursidae	-	-	-	-	-	-	-
Cassididae	-	-	-	-	-	-	-
Cellana	-	-	-	-	7.8	1.2	<1
Cerithiidae	<1	-	-	-	-	-	-
Clypeomorus	-	-	-	-	-	-	-
Codakia	-	-	-	-	-	-	-
Conus	4.3	2.7	8.8	2.6	67	38.6	2.1
Crab	<1	-	-	9.6	-	-	<1
Cymantium	0.7	-	-	-	20.2	1.3	-
Cypraea	2.3	<1	13.5	15.1	138.1	57.3	<1
Dosima	-	-	-	-	-	-	-
Drupa	1	1.1	3.4	2.1	16.6	20.2	-
Fragum	-	-	-	-	-	-	-
Gastrochaenidae	-	-	-	-	-	-	-
Gastropoda	-	-	-	-	-	-	-
Glossidea	-	-	-	-	-	-	-
Hipponix	2	-	-	-	-	-	-
Laemodonta	-	-	-	-	-	-	-
Littoeinidae	-	-	-	-	-	-	-
Littorina	-	-	-	-	-	-	-
Littorizdae	-	-	-	-	-	-	3.7
Lucinidae	-	-	-	-	-	-	-
Marginella	-	-	-	-	-	-	-
Megelinae	-	-	-	-	2.8	3.2	-
Melampidae	0.7	-	1	-	-	-	-

Table A6: Ofu Village site midden data, weight (g), 2012 field season (continued)

Taxa	Layer II	Layer III	Layer IV	Layer V	Layer VI	Layer VII	Layer VIIb
Mitridae	-	-	-	-	-	-	-
Morula	-	-	-	-	-	-	-
Mytilidae	-	-	-	-	-	-	-
Nassarius	-	-	-	-	-	-	<1
Nerita	9.9	1.8	11.1	-	16.9	-	1.4
Neritopsis	-	-	-	-	-	-	-
Olivia	-	-	-	-	-	-	-
Operculum of turbo	-	-	-	-	-	-	-
Patellidae	19	5.1	30.1	36.1	258.2	68.4	21.1
Patelloida	0.9	-	-	-	-	-	-
Pectinidae	-	-	-	-	-	-	-
Peristernia	-	-	-	-	-	-	-
Planaxis	-	-	-	-	-	-	-
Polinices	-	-	-	-	1.3	-	-
Pseudovertagus	-	-	-	-	-	-	-
Pyramidellidae	-	-	-	-	-	-	-
Sea urchin	-	-	-	-	-	-	-
Siphonaria	-	-	-	-	-	-	-
Skeneidae	-	-	2.1	-	-	-	-
Spondyidae	-	-	-	-	-	-	-
Strombus	-	-	-	1.4	13	28.7	-
Tectus	-	-	62.1	-	-	-	-
Tellinidae	-	-	-	-	-	-	-
Thaididae	-	-	-	-	-	-	-
Thais	-	-	2.4	-	-	-	-
Tridacna	-	-	-	-	-	-	-
Trochaceastraea	129.1	8.9	62.5	-	1.9	34.6	-
Trochus	-	-	-	-	8.3	-	-
Tonnidae	10.7	1	10.9	19.5	206.7	66.6	18.1
Turbo	100.5	208.4	425.5	156.8	1158.7	289.5	46.5
Unidentified	10.6	<1	3.5	3	33.7	1.7	-
Vanikoridae	-	-	-	-	-	-	-
Vasum	-	-	-	-	-	-	-
Veneridae	-	-	-	-	-	-	-
Vermitidae	-	-	-	-	12.9	-	-

Table A6: Ofu Village site midden data, weight (g), 2012 field season (continued)

	Layer II	**Layer III**	**Layer IV**	**Layer V**	**Layer VI**	**Layer VII**	**Layer VIIb**
Total Shell Weight	**292.7**	**229**	**636.9**	**252.1**	**1981.3**	**612.4**	**94**
# Taxa Exploited	**16**	**9**	**13**	**11**	**19**	**13**	**11**