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# Turbo Shell Scrapers from the Society Islands: An Ethnohistorical and Microfossil Analysis Approach

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# *Turbo* Shell Scrapers from the Society Islands: An Ethnohistorical and Microfossil Analysis Approach

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by

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## Introduction

Shell played an essential role as a raw material in Polynesia and the broader Oceania region throughout prehistory. Ethnographic and archaeological investigations have documented the vast array of shell species used for various functional and ornamental purposes, including weapons, razors, fishhooks, and net weights (see Szabo 2010). Despite having such an abundant and consistent presence within the archaeological and ethnographic record, shell artifacts remain a relatively understudied area of archaeological research in Polynesia, especially compared to other raw materials such as stone. There is a further discrepancy in the amount of research completed on formal shell artifacts and tools versus that done on informal shell tools. Formal shell artifacts are shells that have been purposely modified through reduction techniques to produce a particular object, such as fishhooks, beads, and broad-rings (Langley et al. 2018; O'Day and Keegan 2001; Szabo 2010). In contrast, informal or expedient shell tools are shells that have been minimally modified or have no modifications other than from use-wear (O'Day and Keegan 2001). These include items such as shell scrapers, peelers, and fishhook tabs. Few studies have been conducted investigating informal shell tools, thus it remains difficult to differentiate naturally broken shells from minimally modified shell artifacts. This thesis concentrates on a specific form of expedient tools from the Society Islands, *Turbo* shell scrapers.

Shell scrapers and peelers are a common informal tool utilized by Pacific Islanders, and many archaeologists have noted such artifacts during excavations (Allen and Ussher 2013; Barton and White 1993; Green et al. 1967; Kirch 1988; Sinoto and McCoy 1975; Spenneman 1993; Spoehr 1957; Suggs 1961; Rolett 1998:238). Shell scrapers are often unmodified other than by any damage caused by use; however, some scrapers fashioned from gastropod species have an intentional perforation on their body whorl, presumed to facilitate their use as vegetable peelers (Suggs 1961:128; also see Rolett 1998: 238). Four of the *Turbo* shells in this study have such modifications to their body whorls.

In general, shell scrapers in Polynesia were fashioned from a variety of shell species, including *Pinctada* (pearl shell), *Turbo, Tridacna* (giant clam*)*, and *Cowrie* (see Table 1). *Turbo* shells (gastropods) appear to be one of the more uncommon species utilized as scrapers. There are only two instances where archaeologists specifically discuss use of this species for scrapers. Spoehr (1957:157) recovered *Turbo* scrapers with possibly intentional body whorl holes in his excavation of the Objan Site on Saipan in the Mariana Islands (Micronesia) dating to about AD 800. Skjølsvold (1972:32-33) recovered three modified *Turbo* shells from the Marquesan Islands, which resembled *Tonna* shell scrapers excavated in the Marquesas Islands and Samoa; however, these *Turbo* shells were fragmentary with decomposed edges making it impossible to make any certain classifications. The circular perforations in these shell's body whorls may also have been the result of meat extraction (Allen and Ussher 2013: 2800). Thus, there are presently few instances of recorded shell scrapers made from *Turbo* in Pacific Island archaeological sites. Rather, *Turbo* shell is most often discussed in terms of manufacturing fishhooks and net weights (Green et al 1967: 184-190; Szabo 2010:117). When discussed, scrapers fashioned from gastropods tend to be identified as used in food production, typically for scraping vegetables, a classification based on ethnographic analogy (Skjølsvold 1972; Spennemann 1993; Suggs 1961). With these considerations in mind, my thesis aims to explore whether *Turbo* shell were used as scrapers in the Society Islands and if so, for what activities and on what types of materials. Secondly, rather than solely relying on ethnographic analogy, I use archaeological science techniques along with data derived from ethnohistorical sources to refine our understanding of expedient shell tool use.

**Table 1**: Archaeological Recorded Shell Scrapers in Oceania

| **Type** | **Form** | **Location** | **Source** |
|---|---|---|---|
| *Turbo* Scrapers | Gastropod with body whorl hole | Mariana Islands (Micronesia); Marquesan Islands | Skjølsvold (1972:32-33); Spoehr (1957:157) |
| *Pupura persica* Scraper | Gastropod with body whorl hole | Marquesan Islands | Rolett (1998:238) |
| *Tonna* Scraper | Gastropod with body whorl hole | Marquesan Islands | Buck 1930: 684; Suggs 1961: 127; Sinoto 1966 |
| *Tridacna* Scraper | Bivalve; unmodified with wear along edge | Mo'orea (Society Islands) | Green et al. (1967: 196) |
| Cowrie Scraper | Gastropod. Two predominate forms 1) large portion taken out of body 2) edge removed to create cutting edge | Mo'orea; Tonga | Green et al. (1967: 197): Spennemann (1993) : Kirch (1988:208); Suggs (1961: 128) |
| Pearl Shell Scraper/Grater | Bivalve | Marquesas; Mo'orea | Emory and Sinoto (1964)/Sinto (1979:127); Rolett (1998:236); Green at al. (1967:196) ; Suggs (1961: 128) |
| *Strombus luhuanus* Peeler "Paring Knife” | Gastropod with body whorl hole | New Caledonia | Gifford and Shutler (1956: 65) |
| *Fasciolaria filamentosa* "Paring Knife” | Gastropod with body whorl hole | Fiji; New Caledonian | Gifford (1951: Fig 1A) |

Microfossil analysis is a rapidly developing field within archaeology that provides novel insights into tool function, diet, paleoenvironmental conditions, and plant and landscapes histories (Allen and Ussher 2013; Flenley et al. 1991; Kirch et al. 1991; Stevenson et al. 2017; Szabo and Koppel 2015). This technique has been employed to study stone tools in the Pacific, often in combination with use-wear analysis (see Kahn 1996). Although shell scrapers are also a common tool identified in Pacific Islands archaeology, there have been far fewer published studies utilizing microfossil analysis and/or use-wear analysis to investigate shells as tools (see Spennemann 1993; Szabo and Koppel 2015 for use-wear studies). Only four published studies worldwide have utilized microfossil analysis to investigate residues on shell artifacts, three of these derive from Oceania (Allen and Ussher 2013 in the Marquesas; Barton and White 1993 in Papua New Guinea; Huard and Burley 2017 in Tonga; Ciofalo et al. 2020 in the Northern Caribbean). Each study successfully recovered microfossils and identified them to a particular botanical taxon, except for Huard and Burley (2017), who merely used a Lugol test to affirm the presence of starch. Allen and Ussher (2013) provided direct evidence of the translocation of five plant crops to the Marquesas Islands and demonstrated that bivalve shell scrapers have more generalized functions than ethnohistorical sources suggested. Similarly, Ciofalo et al. (2020) found that microfossil evidence on bivalve scrapers from the Dominican Republic and Turks & Caicos Islands contradicted ethnohistorical narratives, which describe bivalve shell scrapers exclusively as manioc peelers. Furthermore, they were able to investigate how food was processed using bivalve shells and the mobilization of plant taxa across the islands by identifying specific plant taxon microfossils on the scrapers. Thus, previous microfossil research on shells has demonstrated the potential to recover plant residues from shell tools and the wealth of information that can be recovered. Yet, these previous microfossil and use-wear studies, with the exception of Spennemann's (1993) experimental work on cowrie shell scrapers in Tonga, have all been conducted on bivalve shells. Bivalve shells are made from two paired shells connected with a hinge; gastropods (univalve) shells consist of a single piece of shell that forms a cone or disk (Claassen 1998:16-18). Due to this focus on bivalve scrapers much more is known regarding how use-wear patterns appear on bivalves compared to gastropod shells. No previous study has considered the unique biological and mechanical attributes of *Turbo* shells' structure and how this shell species reacts to various sorts of use and post-depositional alterations. Thus, my thesis investigation into a gastropod species, *Turbo setosus*, broadens the existing literature on shell tools beyond bivalves.

My study has four main research objectives. The first goal is to utilize the direct historical approach to identify the variety of ways that pre-contact Māʻohi, people from the Society Islands, employed shell in their daily lives. This is an important first step as archaeologists often exclusively associate shell scrapers, both bivalves and gastropods, with food preparation. Yet problematically, ethnohistoric sources from the region tend to demonstrate a broader variety of ways in which shell scrapers were employed. The second objective is to determine whether *Turbo* shells recovered from pre-contact archaeological sites in the Society Islands were used as tools. This is an important question because post-depositional alterations can sometimes create edge wear on shell edges that mimic use-wear leading us to identify shells as scrapers even though they were not used as such. By analyzing these archaeological shells for microfossils and evidence of edge damage, I should be able to determine if these shells were used as scrapers since we can expect that a shell scraper would show characteristic use-wear damage and/or plant residues. The third objective is to determine potential uses for *Turbo* shell scrapers based on the results of microfossil and preliminary use-wear analysis. Evidence of residues on the shells may indicate specific contact materials the shell was used on. Furthermore, preliminary data from shell use-wear analysis will strengthen the microfossil analysis study by determining if the shells display signs of modification or not, which is important for understanding how any residues were deposited on the shell scraper. The fourth and final objective is to test if probable shell scrapers preserve in varied archaeological contexts. The sample of potential scrapers derive from two types of sediment matrix: sandy sediment contexts and waterlogged contexts. Thus, I test whether the different deposition environments of the artifacts affects the results of microfossil and use-wear analysis. This is an important consideration for tool studies as post-depositional alterations could potentially mimic use-wear. Furthermore, not all microfossils survive equally in all environments; therefore, we must consider the effect of the depositional context on artifacts which could skew our understanding of how shell scrapers were used in the past.

In the following thesis, I first use the direct historical approach to survey late seventeenth, eighteenth, and nineteenth-century European explorer and missionary accounts of the Society Islands and broader Polynesia region. The goal is to illustrate the various ways in which Māʻohi and other Pacific Islanders used shell in their daily lives. Next, I review the microfossil analysis literature to provide background of the multiple ways microfossil analysis has contributed to archaeology in the Pacific and more broadly. The second half of the thesis focuses on direct analysis of probable shell scrapers recovered from archaeological sites on the islands of Raʻiātea and Mo'orea in the Society Islands. My analysis is two-fold. The first set of data includes low power use-wear analysis of archaeological shells to identify probable areas of use and potential types of activities. The second set of data consists of microfossil analysis of samples taken from the shell artifacts' edge to determine if any micro-residues can indicate types of raw materials worked with the potential shell tools. Finally, I synthesize the microfossil and use-wear analysis data and compare these with the ethnohistoric descriptions to discuss the implications of my results for understanding the use of shell scrapers in the Society Islands. I end with a discussion of several methodological problems encountered with the shell microfossil analysis that contributes more broadly to developing more accurate research designs in future Polynesian shell tool research.

## Ethnohistorical Documented Use of Shells in the Pacific Islands

Several European nations sponsored Pacific Island expeditions in the late seventeenth, eighteenth, and nineteenth centuries. Many European explorers wrote accounts of their voyages which included observations of the Pacific Islands and the people and cultures they encountered. The goal of the various European voyages was often to explore the region in a scientific manner; thereby, the European accounts of Polynesian cultures are generally considered accurate and align with scientific principles of their day (Lepofsky 1999; Kahn 2005: 88-91). Moreover, multiple people on the same voyage often wrote separate accounts, allowing for source comparisons for accuracy (Kahn 2005: 90). These accounts provide a rich source of ethnohistoric information on the people, their material culture, and their ways of life; however, it is a biased perspective. Rousseau's notion of the "noble savage" continuously permeates their accounts and as a result, early sources often depict an idealistic utopia that lacks depictions of daily life (Kahn 2005: 89; Lepofsky 1999: 3-5; Smith 1950), including the manufacture and use of stone and shell tools (Kahn 1996: 50-51). Later accounts, particularly those of missionaries, shifted their attitude and viewed Pacific Islanders as lazy and idle; these accounts similarly rarely mention daily work (Lepofsky 1999: 6).

For the large part, European explorer and missionary accounts are highly biased towards elite culture. European voyagers mostly resided on elite land near the coast and focused on elite ceremonies, religious rites, and political situations (Hamilton and Kahn 2007: 131, 133-34; Lepofsky 1999:3-6). Consequently, they largely overlooked everyday customs and non-elite activities or if mentioned, the accounts are brief and vague about such topics. It should also be noted that European explorers often conflated different islands or characterized groups of islands as a single island. For example, descriptions of the island of Tahiti are often construed as observations deriving from the entire Society Islands archipelago (Lepofsky 1999: 4). Despite these shortcomings and biases, these sources can still be useful as European accounts sometimes mention shell tools in association with specific activities or as items integrated into other forms of material culture (See Table 2 for a cumulative list; see Appendix A, Table A for source materials). As such, European explorer and missionary accounts provide a good starting point to understand how Polynesian societies employed shell as a tool and raw material. Below I survey

European accounts mainly of the Society Islands, but in some cases, turn to accounts from the broader region of Polynesia, to illustrate how pre-Contact Māʻohi used shell in their daily lives.

**Table 2**: Activities associated with shells as described by Ethnohistorical Sources

| **Use** | **Total Mentions** | **Specific Shell Species** |
|---|---|---|
| Personal Adornment | 53 | *Pinctada margaritifera* (pearl shell), Tridacna shell, *Gafrarium pectinatum* (bivalve clam) |
| Decorated Canoes | 7 | Shell of Sea Ear (Abalone), Pearl Shell, Limpet Shell |
| Cloth Production | 7 | Mussel Shell, *Tellina gargadia,* Cockle Shell |
| Shaving | 7 | Bivalves |
| Tattooing | 4 | --- |
| Mourning Rituals | 15 | Pearl Shell |
| Armor and Weapons | 9 | Pearl Shell, Sharpened Mussel Shells |
| Food Preparation | 6 | --- |
| Knives | 7 | --- |
| Fishing (Hooks, Net Weights) | 24 | Pearl Shell; Mussel Shell, Conney Shell (Conidae shell) |
| General Tool | 5 | --- |
| Wood working | 1 | --- |
| Clapper (*Tettè*) in Performances | 2 | --- |

*Personal Adornment*

Ethnohistoric sources most often described shells as being worn as items of personal ornamentation. Of the 146 mentions of shell in the sources, 36% described shell use for personal adornment. Many Polynesians, including the Māʻohi of the Society Islands, wore shells as necklaces, bracelets, earrings, rings, amulets, headdresses, and nose ornaments (Banks 1896; Cook 1772-1775; Cook 1776-1780; Oliver 1988). Morrison, Tobin, and Anderson described a common necklace in which a pearl shell (*Pinctada margaritifera*) was strung on plaited hair and hung around the neck (Anderson in Cook 1776-1780: 931; Morrison 2012: 926; Tobin in Oliver 1988:268). This necklace type has been found in archaeological contexts in the Society Islands by Emory and Sinoto (1964:150) at the Maupiti Burial site where they recovered two pearl shell breastplates/necklaces. In one burial, a polished pearl shell was placed on the pelvis and a trimmed shell shaped like a shoe-horn placed on top of the first shell. A second burial had a polished pearl shell with a small perforation near the shell hinge placed on the upper breast of the skeleton.

Pearl shell is the most common species of shell that Europeans identified in association with adornment; however, they also mention *Tridacna* shell and Venus shell (see Table 3).[1] More broadly within Oceania, archaeological evidence demonstrates that Pacific Islanders employed various other species of shell for personal adornment (Langley et al. 2018). For example, Langley et al. (2018) investigated the manufacture of conus-multi-sectioned broad rings from a Lapita site on the island of Efate. These rings consist of three to four sections of *Conus* spp. shell drilled and joined together with thread. Lapita peoples would have worn these as a band around the arm or leg. While the Lapita culture predates Polynesian societies, they are believed to be ancestral to Polynesians (Jennings 1979: 19; Kirch 2017:185-188).

Ethnohistoric sources also documented Polynesian peoples using shells to decorate other forms of material culture. Many sources described anthropomorphic wood carvings whose eyes were often inlaid with shells; such sculptures adorned canoes in New Zealand, Tonga, and elsewhere (Banks 1896: 241; Cook 1821; Wales in Cook 2017a:264). Additionally, canoes were sometimes decorated with red, yellow, and black feathers, dog's teeth, and small unidentified white shells (Cook 2017b:512, Anderson in Cook 2017c:936). Morrison described pearl shells decorating carved images of household gods along with human hair, teeth, nails, and red feathers

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[1] This reference to Venus shell likely refers to *Gafrarium pectinatum*, a bivalve clam shell in the Veneridae family (Salvat and Rives 1975:295). The Tridacna genus is another common clam found in the Pacific.

(Morrison 2012:733, 881). Polynesian people also decorated personal belongings such as bone and wood combs by embedding shell into these objects (Anderson in Cook 2017c:810). As these examples demonstrate, European explorers and missionary accounts suggest the use of shell in works of art and personal adornment and in ritual contexts.

### *Objects of Exchange*

Kirch (1988) argues that shell objects, particularly bodily adornment artifacts, were valuable objects of exchange throughout Oceania, with specific sites specializing in the production of certain types of artifacts. Ethnohistoric sources seem to support the claim that shell objects were exchanged throughout Oceania and the broader region. In Australia, Cook (1821:160) described an encounter with two indigenous men, in which Cooks' men attempted to trade for the Australians' shell necklaces; however, the Aboriginal Australians could "not be persuade[d] to part with [their necklaces] for anything [the Europeans] could give them." The men's refusal to trade may indicate the high value of their necklaces or a perhaps just the desire to be left alone. Other shell artifacts that were not bodily ornaments also may have had exchange value. Robertson (1948:171,183) described exchanging iron nails for shell fishhooks on the island of Tahiti (Society Islands) during his voyage on the H.M.S Dolphin from 1766 to 1768. Morrison (2012:3202) also discussed the dispersal of iron works and other European goods left by the explorers to other islands in return for pearl shell and pearls. Maximo Rodríguez, an interpreter for Spanish missionaries, recounts the Māʻohi asking for a hog in exchange for each pearl shell they collected for making *parae*, a ceremonial mourning mask (Corney 1918:205). Both hogs and iron objects were valuable to the Māʻohi (Kahn In Press: 49; Green et al. 1967:185). The exchange of such objects for shell artifacts demonstrates the value that shell and shell objects had in the late pre-contact to early contact era Society Islands.

Certain species of shell, especially pearl shell, appear to have been more valued than other shell species. Pearl shell is the most mentioned shell species in the ethnohistoric accounts. This large amount observations of pearl shell may be a result of the European infinity for pearl shell but also may indicate a Māʻohi preference for pearl shell in specific activities due to specific physical characteristics of the shell (see below for discussion in rituals and fishhook manufacture). This preference is noteworthy as pearl mollusks are sparse in the waters of the Windward Islands (eastern islands) in the Society Islands, including Moʻorea and Tahiti. Unworked pearl shells are rarely found on the surface or in excavations except in small quantities of waste manufacture (Green et al. 1967: 185). This paucity of unworked pearl shell in the Society Islands contrasts with excavations in other Polynesian archipelagos, such Green's (Green et al. 1967) excavation in Mangareva (Gambier Islands), where unworked pearl shell composed of 10 to 20 percent of the shell content. The small size of unmodified pearl shell found in excavations attests to its value as a raw material as it was too valuable to be wasted (Green et al. 1967). This value is further illustrated in the importation of pearl shell to Tahiti through the exchange of European iron works as discussed above (see Morrison 2012). Thus, pearl shells appeared to have greater value than other shells in Society Islands and were preferred for specific activities, necessitating trade between islands.

### *Cloth Production*

Several historic sources document the use of shells in the production of barkcloth (*tapa*) from tree bark on Tahiti and in Tonga (Anderson in Cook 1776-1780: 906; Banks 1896: 146, Cook 182; Corney 1914: 459; Forster 1996: 274; Morrison 2012: 2488, 2529). This cloth was manufactured from several different trees, including the paper mulberry (*Morus papyrifera*), wild-fig tree (*eaoùwa),* and breadfruit (*Artocarpus atilis*); yet, the process of cloth manufacture was consistent across species (Cook et al. 1821:206, Forster 1825: 275).[2] To make the cloth, Māʻohi first stripped a tree of its branches and slit the bark longitudinally to remove it from the tree. The removed bark was then soaked in water. After being thoroughly soaked, women separated the inner bark from the outer green bark by scraping the outer bark with a shell until it was completely removed and only the inner bark remained. The species of shell used for this scraping is unclear; however, ethnohistoric sources describe Māʻohi using mussel shells, *Telina gargadia,* and cockle shell (Banks 1896:146; Cook et al. 1821:206; Morrison 2012: 2488, 2529). Given that various species are mentioned, it is possible that no specific species was preferred for this activity.

### *Personal Hygiene*

Ethnographic sources recount how Polynesian peoples used shells to shave. The men shaved their facial hair by taking two bivalve shells and placing one shell under the hair. The other shell was then used to scrape the hair off. The process was long, and Captain James Cook reported that chiefs would often come to European ship to have their beards and hair cut by the European barbers due to the monotonous nature of shaving with shells (Banks 1896:146; Cook 2017b:113; Cook 2017c:930, 1040; Forster 1825:249; Oliver 1988:270). According to Bligh, none of the sailors could bear the process of shaving with the shells as it was painful and tedious (Cook 2017b:113).

### *Tattooing*

Tattooing was a widespread practice throughout Polynesia. Ethnohistoric sources often referred to this practice as “tattowing” or scarring (Cook 1821: 190). Pacific Islanders used

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[2] The species of the wild fig tree (eaoùwa) that was used in the manufacture of cloth is unclear from the ethnohistoric sources, although Forster (1825:275) says it is related to *Ficus indica* and *Ficus aspera.* Most likely the species of fig tree used in tapa cloth manufacture was *Ficus tinctoria* (Neich and Pendergrast 2004:85)

various types of materials to create the needles needed to apply the tattoo, including bone, pearl shell, and shark's teeth (Furey 2017; Sinoto in Jennings 1979:113). Banks (1896:129–130) described how the lower end of the tattooing needle had sharp tines or teeth cut into it, while the upper end was attached to a handle. The needle's teeth were then dipped into a black substance and stabbed quickly and deeply into the skin by hitting the handle with a stick. Examples of tattooing needles constructed from different materials can be found in the Bishop Museum collection in Hawaiʻi (Emory and Sinoto 1964). Only 17 pearl shell tattooing combs have been recovered in Oceania and all from archipelagos in French Polynesia (Society Islands, the Marquesas Islands, Austral Islands) (Molle and Conte 2013:2). However, all shell tattoo combs date to between the 11th and 15th centuries, several centuries before the European explorers, thus, Molle and Conte (2013: 217) argue these are an earlier form of tattooing needle. In later periods, Pacific Islanders more often used bone needles (see Kirch et al. 1995). However, Anderson, Cook, and Banks all described instances in which Pacific Islanders used shell as needles, thus, the lack of later archaeological evidence may be due to less common use or lack of preservation. Interestingly, no bone tattoo combs have been excavated from archaeological contexts in the Society Islands (Furey 2017:170).

### *Mourning Activities*

Activities associated with mourning the deaths of individuals often included shell tools or artifacts. Polynesians, usually women, would cut their faces, hands, arms, and legs with pieces of sharp shell, stone, or shark teeth when family members died or were killed (Cook et al. 1821; Anderson in Cook 2017c:815; Banks 1896:251, 310; Corney 1914, 1918:190). Although the sharp implements did not cut deep, the cuts would bleed heavily: Captain Cook believes this act was a sort of sacrifice (Cook et al. 1821). Additionally, Māʻohi constructed ceremonial mourning masks, called *parae*, for their chief mourners from pearl shell and oyster shells. *Parae* were made of intricate designs of shells and worn on the head and face; they were often decorated with feathers, dog hair, and shark's teeth (Corney 1918:93, 231; Morrison 2012:3527). These mourning masks were prestige items due to the detailed craftsmanship that went into their manufacture and the use of highly valued pearl shells (Kahn In press). Pearl shells were likely the preferred raw material for constructing *Parae* because this species has a glinty and shiny surface. This is believed to bring attention to the wearer and attracted spirits in mourning rituals (Kahn In press).

### *Armor and Weapons*

European explorers often described shells as a part of the weapons and armor used by Pacific Islanders. Shells decorated breastplates (*taumi*) worn by warriors in the Society Islands and Australia (Cook et al. 1821). In the Cook Islands, Hamilton, the surgeon on the ship Pandora, described men wearing gorgets of pearl shell as armor for their throats (Oliver 1988:268). Additionally, Pacific Islanders would sharpen shell by rubbing it on a stone and then use this to tip arrows and spears (Cook 2017b:320; Robertson 1948:124). Shell was also broken and stuck in resin at the end of lance to create jagged spikes such as those described by Banks (1896: 318) in Australia.

### *Fishing*

European explorers commonly mentioned Polynesian fishhooks in their journals; indeed, fishhook manufacture is the second most common activity associated with shell in the ethnographic and historic sources after personal adornment. Approximately, 16% of the mentions of shell were in association with fishing. Polynesians often used shell, along with bone and wood, as raw materials to make fishhooks. Banks (1896:155) described two types of fishhooks made from shell in Polynesia. The first was composed of a trolling lure shank made of pearl shell attached to a bamboo rod. On the shank, Polynesians often tied dog’s or hog's hair to imitate a fish's tail. This fishhook type did not require bait, and Banks believed it was superior to any European method for catching bonito (tuna). The second kind of fishhook was made from pearl shell (or any other hard shell) and was shaped into an inwards pointing hook. Fishhook blanks were made by cutting the edges of a shell with another shell. The shell blank was then filed with a coral file into a specific shape (shell fishhook blank), and a hole was bored into the middle using a sharp stone. Files were used to complete the hook (Banks 1896:155).

Pearl shell is commonly cited in association with fishhook manufacture. The physical structure of pearl shells is laminated, so it is easy to work at the same time as being remarkably tough/durable. Moreover, the shiny surface, which makes it desirable for mourning rituals, also attracts fish. Although Banks and other ethnohistorical sources most often identified pearl shell in association with fishhook manufacture, archaeological evidence indicates that *Turbo* shell, particularly *Turbo setosus*, was a common raw material for making fishhooks in addition to pearl shell (Kahn in press: 53, Green et al. 1967:184-85, Sinoto and McCoy 1975: 161-162). *Turbo* was usually used to make one-piece hooks, including small rotating and jabbing styles. Similar to pearl shell, the surface of *Turbo* species also shines making it useful for fishing (Green et al. 1967:185). *Tridacna* and Conidae shell sometimes also served as raw materials used in fishhook manufacture (Green et al. 1967:185). Additionally, shells were used as octopus lures (Cowrie and *Turbo*) and fishing line and net weights (*Tridacna* and *Turbo*) (see Forster 1825:283, Emory in Jennings 1979: 216; Kirch 1988: 205). In sum, shell was an important raw material, playing a key role in the manufacture of fishing gear. Given that fishing was a main form of daily subsistence for the Māʻohi, it is likely that many Māʻohi used shell tools on a daily basis.

*Subsistence and Food Preparation*

Polynesian diets were generally diverse, consisting of fruits, vegetables, pig and dog meat, fish, and shellfish. European explorers often described Polynesian communities collecting shellfish to eat while they themselves were served shellfish by people of different islands. Sinoto and McCoy (1975:152) provided archaeological evidence that Māʻohi consumed *Turbo* meat. At the Vaito'otia-Fa'ahia site on Huahine, they excavated two stacks of unbroken and unburnt *Turbo* shells between two in situ upright timbers interpreted as house posts, suggesting that the shells had been boiled and the meat picked out with a pick. However, as the ethnographic sources demonstrate, Pacific Islanders used shellfish for many activities beyond subsistence, including food preparation. They often employed shells as scrapers or knives according to historical sources. Banks (1896:140) described the use of a shell to peel or cut off an 'apple's' skin, likely referring to *Spondias dulcis*. The Māʻohi man picked up a shell off the ground to use in the peeling process, which Banks believed looked awkward and wasted half the apple. Banks (1896:101) and Cook (1821a) wrote about the same instance on their 1768 voyage in which Māʻohi on Tahiti used a shell to scrape the hair from a dog after singeing it over a fire. Banks claimed this was the same method used to remove the hair from a pig before cleaning and cooking. Morrison (2012: 3402) observed a similar process of cleaning a hog on Tahiti, however, he saw the Māʻohi using sticks and coconut shell to scrape away the hair. Therefore, it seems likely that shell was not the only material used for this activity; however, these observations provide direct evidence that shell was used as a tool for food perpetration.

Breadfruit (*Artocarpus atilis*) was an important staple food throughout Polynesia. Pacific Islanders would remove the rind of this fruit as part of preparing many dishes such as *mahi* (fermented breadfruit paste). Morrison (2012: 3438) observed this on Tahiti where Māʻohi used a shell scraper to scrape off breadfruit's outer skin. Morrison's observation is crucial as it is direct evidence of a shell being used as a vegetable scraper in the Society Islands. Unfortunately, he does not detail a specific species. Shell was also used to clean dirt off kava (*Piper methysticum*) root after it was dug up in preparation to make a ceremonial drink on the island of Tongatapu in Tonga (Anderson in Cook 2017c:908, Samwell in Cook 2017c:1034). Unfortunately, the European explorers rarely elaborated on the preparation of food in their journals and thus, few sources explicitly associate shell with food preparation. However, archaeological evidence does provide direct evidence that Pacific Islanders utilized shell tools in food preparation more frequently than the ethnohistoric sources indicate (see Allen and Ussher 2013, Barton and White 1993, Green et al. 1967: 196-197, Spennemann 1993, Szabo and Koppel 2015). This incongruity between the archaeological evidence and the ethnohistoric sources supports how historic sources are biased towards extraordinary events such as ritual and major ceremonies rather than depicting the daily activities of commoners.

### *Other Tools*

Finally, ethnohistoric sources described shell used in ways which do not fit into any of the above-mentioned categories. Many Polynesian societies used both large and small shell and stone adzes and chisels for woodworking tasks (Green et al. 1967: 198, Suggs 1961: 115, 121). According to Cook on his first voyage to Tahiti, most small woodwork was done with shell (Cook et al. 1821). Sources described adzes made of shell, along with bone and stone. To make a fire, Mā‘ohi would cut a 5 to 6-inch groove with a shell in a stick in which they place a smaller stick. They then rubbed the two sticks together to create friction and fire (Morrison 2012:3395). Ethnohistoric sources also observed shells used as knives to cut nets, sharpen pieces of wood, and bore holes in other shells (Banks 1896:156, 315, 316; Anderson in Cook 2017c:813, 846, 939; Forster 1825:278). Finally, to procure gum from breadfruit trees to create resin or tar, Māʻohi scraped the gum from the trees with a shell, then fashioned it into a ball and boiled it to create the gum (Morrison 2012:1400). These various activities associated with shell demonstrate the multipurpose functions that shell could have and how shell was easily employed as an expedient tool.

### *Discussion*

As can be seen in Table 2, shells are most frequently mentioned in terms of their use in personal adornment. There are two possible explanations for this. This might express a bias towards brief and distant encounters with Māʻohi wherein only superficial comments on clothing and personal adornment were noted as opposed to tool use and manufactures. Yet, given that there is still widespread use of shell in personal adornment today in the Polynesia, it is highly likely that shell use as personal adornment was high in the pre-contact era as well (Kahn, pers. comm). When the sources are specific, pearl shell, Tridacna shell, and Venus clam shells are mentioned as raw materials used to fashion items of personal adornment. The second most frequent shell category are fishhooks fashioned from pearl shell, mussel shell, and conney shell.[3] *Turbo* shell was also a common shell used in fishhook despite not being mentioned by the historical accounts (see Green et al. 1967; Suggs 1963).

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[3] It is unclear what specific type of shell Robertson (1948) was referring to when he described fishhook made from conney shell; however, it is likely referencing Conidae shell (Green et al. 1967:185).

**Table 3**: Summery of Shell Species mentioned in Ethnohistorical Sources

| Shell Species | Class | Personal Adornment | Decorated Canoes | Cloth Production | Hygiene | Tattooing | Mourning |
|---|---|---|---|---|---|---|---|
| *Pinctada margaritifera* (Pearl Shell) | Bivalve | x | x | | | | x |
| Mussel Shell | Bivalve | x | | x | | | |
| Conidae shell | Gastropoda | | | | | | |
| *Tellina gargadia* | Bivalve | | | x | | | |
| Cockle Shell | Bivalve | | | x | | | |
| Abalone Shell | Gastropoda | | x | | | | |
| *Gafrarium pectinatum* | Bivalve | x | | | | | |
| *Tridacna* shell | Bivalve | x | | | | | |
| Limpet Shell | Gastropoda | | x | | | | |

**Table 3** continued.

| Shell Species | Class | Armor and Weapons | Food Preparation | As a Knife | Fishing | General Tool | Wood Working |
|---|---|---|---|---|---|---|---|
| Pinctada margaritifera (Pearl Shell) | Bivalve | x | | | x | | |
| Mussel Shell | Bivalve | x | | | x | | |
| Conidae shell | Gastropoda | | | | x | | |
| *Tellina gargadia* | Bivalve | | | | | | |
| Cockle Shell | Bivalve | | | | | | |
| Abalone Shell | Gastropoda | | | | | | |
| *Gafrarium pectinatum* | Bivalve | | | | | | |
| *Tridacna* shell | Bivalve | | | | | | |
| Limpet Shell | Gastropoda | | | | | | |

Shell is also commonly associated with mourning displays and mourning dress. Pearl shell is the only species identified in association with mourning costumes; however, pearl shell is considered to be a more superior and more valuable shell compared to other species and thus, the primary use of pearl shell in ceremonial mourning activities is unsurprising (Green et al. 1967:185). Additionally, researchers have suggested that the shiny surface of pearl shell attracted spirits in mourning rituals and thus, is why they are so valued (Kahn in press). Overall, pearl shell is used for the widest range of activities/artifacts, including both personal adornment, fishhooks and mourning material culture (see Table 3). This likely speaks to the fact that it was a good raw material to work, but also that it was highly valued for its color and shiny surface that came into play in both daily artifacts (fishhooks) and ritual costumes (*parae*). Ethnohistoric sources rarely mention shell in association with food preparation; however, this should not be taken as evidence that shell was not a common tool used for subsistence activities. Instead, the scarcity of shell mention in association with food preparation should be seen as ethnocentric biases of the sources, namely their focus on elite activities rather than the details of everyday life. Finally, as can be seen on Table 3, shell species were used for multiple activities and not exclusively for a single use. Each activity often had more than one shell species associated with it, if a species was recorded; therefore, shell species alone is not enough evidence to identify specific activities and the use of a specific species may be out of necessity or preference.

## Microfossil Analysis and Archaeology

Microfossils have been used to address a series of archaeological questions, including tool function (Barton and White 1993; Cook and Nugent 2009; Fullger et al. 2006), histories of plant cultivation and agriculture (Allan and Ussher 2013; Fullger et al. 2006; Horrocks et 2004; Horrocks and Bedford 2004), diet (Babot 2003; Ciofalo et al. 2020) and paleoenvironment reconstructions (Farley et al. 2018; Fullagar et al. 2006; Horrocks and Wozniak 2008; Lentfer et al. 2002). Microfossil is a heterogenous term that describes various botanical and mammalian remains not visible with the human eye and requiring a microscope to study. Here, I focus on micro-botanical fossils, nevertheless micro-mammalian remains, such as blood, collagen, and hair, have played a similarly important role in answering questions regarding tool use and foodways (e.g., Cooper and Nugent 2009; Loy and Hardy 1992).

Micro-botanical analysis studies are focused on various organic and inorganic plant remains. Pollen, phytoliths, and starch grain analyses are the most commonly utilized techniques (Horrocks 2020:191). Micro-botanical remains have been recovered from a wide variety of archaeological contexts worldwide, including ceramic vessels (Horrocks and Bedford 2004), stone and wood tools (Barton 2007; Barton and White 1993; Hardy and Svoboda 2009), coprolites (Horrocks et al. 2004; 2002), shell artifacts (Allen and Ussher 2013; Ciofalo et al. 2020) and soil samples (Carter 2003; Horrocks and Wozniak 2008; Lentfer et al. 2002). Once recovered, pollen, starch, and phytolith particles are identifiable to particular taxa or species by comparing the recovered grain's morphological structure and size to a modern plant reference collection. Researchers have varying levels of success at identifying specific microfossils due to a series of problems, including microfossil degradation, small quantities of recovered material, and the large range of morphological structures a specific plant's microfossils can have. However, identification is not always a requirement for specific archaeological questions; some researchers may take an assemblage-based approach that allows them to process large amounts of data to establish meaningful patterns without identification (Boyd et al. 1998; Lentfer et al. 2002).

Oceanic archaeology has particularly benefited from microfossil research due to the nature of its environment. The wet and tropical environments that characterize the Pacific Islands are not usually conducive to the preservation of macro-botanical remains, such as seeds, desiccate tubers, or wood; conversely, microfossils can survive in such conditions and for longer periods. Therefore, microfossil analysis allows researchers to access more nuanced information regarding human and environment interactions, agriculture, paleoenvironment conditions, and foodways which were inaccessible before the development of microfossil analysis (Allen and Ussher 2013:2799; Torrence and Barton 2006:30).

In this study, 20 potential *Turbo* shell scrapers were examined for microfossils, primarily focusing on pollen, starch, and phytoliths. Importantly, not all plants produce distinguishable microfossils, nor do all microfossils preserve equally. Therefore, it is necessary to examine and compare the major types of micro-botanical remains, namely pollen, starch, phytoliths, and macro-botanical traces of plant tissues, to ensure a greater understanding of shell tool use. To demonstrate the potentials and limitations of this methodology, I will review the major archaeological questions that Oceanic archaeologists have applied with each type of microfossil analysis to demonstrate how this field has contributed to archaeology in the Pacific and more broadly worldwide.

Archaeologists have long recognized the potential of pollen analysis for archaeology and have applied palynological techniques to study fossil pollen grains worldwide. Pollen grains are formed in the anther (male portion) of a flower, and as the plant matures, the wall of the anther will break and release the pollen for transfer to the female portion of the flower (Pearsall 2016: 185). Depending on the type of plant the pollen derives from, pollen can be dispersed across the landscape by wind, animal, water, or self-pollination. The archaeologists' consideration of these dispersal mechanisms becomes increasingly important when considering if pollen's presence in an archaeological context results from human activities or natural dispersal mechanisms. The mechanism of deposition can also inform on the type of plant. For example, the presence or absence of pollen residues in archaeological sediments can indicate if local plants were insect-pollinated or wind-pollinated plants because wind-pollinated plants result in a greater and more spread out presence of pollen in an environment (Horrocks and Wozniak 2008:137). Since pollen grains are organic, they are subject to decomposition. Pollen does not survive in all environments, nor do all pollen grains preserve equally well under the same conditions (Pearsall 2016:194). Waterlogged contexts, such as bogs and lake bottoms, are preferred areas to sample for pollen residues as the lack of oxygen in these contexts inhibits the decomposition of pollen grains (Pearsall 2016: 185). However, pollen deposited on soil surfaces can also be moved downwards by percolating groundwater and destroyed by oxygen and aerobic fungi; however, archaeological pollen and contexts can be protected from similar process by artifacts or shells (see Pearsall 2016: 203; Kelso et al. 1995). Thus, we might expect that any pollen found on the shell artifacts from the Society Islands to be authentic and to have been protected.

In Oceanic archaeology, pollen analysis has significantly contributed to knowledge regarding the spread of human populations throughout the Pacific and the impact of human colonization on island vegetation (Flenley et al. 1991; Kirch et al. 1991; Stevenson et al. 2017). For example, Flenley et al. (1991) recovered a continuous 30,000-year duration pollen record from cores samples taken from three volcanic craters on Rapa Nui (Easter Island). Using this long continuous pollen record, Flenley et al. (1991) distinguished between vegetation changes due to climate change and those due to anthropogenic influences to illustrate the impact of human activities on the landscape. Similarly, Kirch et al. (1991) used the pollen record recovered from stratigraphic cores from Mangaia in the Cook Islands to investigate human colonization's effect on island vegetation. Additionally, in the Pacific, pollen analysis is a useful proxy tool for identifying human presence since it can differentiate between Polynesian and European plant introductions and link these with movements of people in the pre-contact and post-contact eras (Horrocks 2020:187). Finally, archaeologists have used pollen to understand Polynesian agricultural and horticultural practices (Horrocks and Wozniak 2008). Pollen has not been as widely applied to tool studies as to other research questions; yet, Kelso et al. (1995) demonstrated that artifacts can protect pollen from contamination and decay caused by percolating groundwater when the pollen sample is taken from immediately under the artifact. Drawing from this observation, pollen grains stuck within holes or cracks (microenviroments) on the surface of shells may survive better than pollen located directly on the surface of an artifact. Therefore, we might expect that pollen may survive on shell scrapers if it is protected within cracks on the shells' surface.

Phytolith analysis identifies and interprets the biomineral deposits of silica accumulated at a cellular level in certain plants (Pearsall 2016: 253; Shillito 2018:1). The term phytolith most often refers to opaline silica ($SiO_2 \cdot nH_2O$), which accumulates within intercellular spaces and cell walls or infills the cell. In this way, accumulated silica adopts the cell's morphology. Thus, phytoliths are molds or casts of the original plant's cell morphology, which can be used to identify the plant taxa in which the phytoliths are formed (Cabanes 2020: 256). The ease with which phytoliths are identified varies based on the plant taxa and environmental and preservation factors. For example, phytoliths with similar forms may be found in unrelated plant taxa, or phytoliths with different forms may derive from the same plant taxa. However, the different morphology of phytoliths from different parts of the same plant can also aid researchers because they allow archaeologists to distinguish parts of the plants (leaves, stem, husk) which can help infer more specific agricultural practices (Shilito 2018:2). Also, the differential production of phytoliths in plants can present a problem as some plants do not produce silica at all, ensuring that these taxa are invisible in phytolith research. In contrast, other plants are overrepresented due to the high amounts of phytoliths they produce (Cabanes 2020: 268). Due to these issues of production, multiplicity, and the extensive range in morphology, archaeologists must be realistic about the achievable level of identification and conclusions drawn from phytolith analysis.

Similar to pollen grains, the manner of phytolith deposition is largely a genetic factor of the plant; however, environmental factors can also have a significant influence. For example, the high availability of silica and water flow helps phytolith production. Thus, phytoliths are produced in greater amounts in environments with high evapotranspiration rates instead of more temperate environments in which production is lower, leading to a smaller amount of recoverable phytoliths, which tend to be less formed (Shillito 2018:1). Thus, the conditions of the environment of research may dictate the success of phytolith analysis. However, since phytoliths are inorganic, they can survive for millions of years in harsh conditions, even being resistant to fire and digestion. Unlike pollen, phytoliths are limitedly affected by wind and water and tend to appear in situ; thus, their presence is often assumed to demonstrate highly localized information regarding plants (Horrocks 2004; Piperno 1988). Cabanes et al. (2012) criticized this assumption and suggested that bioturbation, seismic activity, and other post-depositional processes that affect sediment may also affect the phytoliths within them. Despite this criticism, phytoliths preserve in a broader range of contexts then pollen, which generally survive best in anaerobic contexts, including dry soil deposits. Thus, for this study, we might expect that phytoliths survive in both the sandy sediment deposits and the waterlogged deposits.

In the Pacific, phytolith analysis has often been applied to study plant domestication and agricultural practices (Kahn et al. 2014; Kirch et al. 2015). Much of the current understanding of the cultivation of plants comes from the journals of 18th and 19th-century European sources and indirect evidence such as landscape architecture and soil structure (Horrocks et al. 2004:251); thus, the direct evidence of agriculture that phytoliths and all microfossils can provide is crucial to a complete understanding of agriculture in Oceania. Researchers have demonstrated that it is possible to distinguish between the phytoliths formed in domesticated plants versus wild varieties of the same plant, which has aided in questions about crop domestication (Pearsall et al. 1995). However, Fuller et al. (2010) caution that such data should be treated tentatively until the full range of cellular morphology is determined (also see Shillito 2013). Identification of phytoliths to a plant taxon has been verified through blind testing such as Carter (2003), which demonstrated that phytoliths assemblages could act alone or as proxy evidence to identify species in archaeological contexts.

Starch grain analysis is a relatively new paleoethnobotanical method that seeks to recover and identify starch grains from archaeological contexts, including artifacts, sediments, dental calculus, and coprolites. Starch is a complex, soluble carbohydrate that is the main substance of food storage in a plant (Horrocks et al. 2004; Farley et al. 2018:248). Starch granules have a high degree of molecular and crystalline order giving the granules semi-crystalline properties and making them birefringent, meaning that an extinction cross is visible on each grain when viewed under cross-polarizing light. This cross allows for starch to be differentiated from other microfossils with relative ease and is essential for identifying modifications to the starch caused by decay, environmental conditions, or human activities such as cooking (Farley et al. 2018: 248).

Starch analysis has many advantages over phytoliths and pollen analysis. Unlike phytoliths and pollen, starch is often stored in the areas of the plant that are consumed, such as seeds, tubers, and roots; thus, it is beneficial for providing direct evidence of human diets and foodways (Barton and Matthews 2006:36). Furthermore, certain taxa or parts of plants such as tubers and roots do not contain phytoliths and have been hard to trace archaeologically (Barton and Matthews 2006:36). Starch analysis has thus proven vital in identifying subsistence plants in areas of the world where starchy tuber foods are a main staple in the diet, particularly in Oceania (Allen and Ussher 2013:2799). Starch analysis has contributed to tracking crop introductions across the Pacific and changing agriculture practices (Allen and Ussher 2013; Farley et al. 2018; Fullagar et al. 2006; Lentfer et al. 2002). For example, Fullagar et al. (2006) used starch analysis to provide the first direct evidence of the processing of *Colocasia esculenta* (taro) and *Dioscorea sp*.(yam) in Kuk Swamp, New Guinea, by identifying these starch grains on 12 artifacts from the early and mid-Holocene. Similarly, Allen and Ussher (2013) reconstructed a timeline of the translocation of *Ipomoea batatas, Piper methysticum, Dioscorea sp, Artocarpus altilis, Colocasia esculenta* to the Marquesas Islands through starch analysis of shell tools in correspondence with radiocarbon dates. Significantly, starch granules can be modified by food processing, such as grinding or fermenting. These processes cause characteristic and identifiable changes to the granules' morphology, which can help identify cultural practices, particularly food processing, in the past (Babot 2003; Ciofalo et al. 2020). Finally, starch analysis has also aided in tool function studies as residues associated with specific artifacts may indicate particular activities (see Allen and Ussher 2013; Barton and White 1993; Cook and Nugen 2009; Ciofalo et al. 2020; Fullger et al. 2006).

Tool studies have especially benefited from the combination of starch analysis with use-wear analysis to determine how the tool was used (cutting, scraping, etc.) and the material on which the tool was used (wood, plant, animal, etc.), similar to the research design of my study. The combined approach is useful because not all raw materials and actions will produce use-wear edge damage and not all microfossils survive equally; therefore, evidence from both starch and use-wear analysis can be combined to fill in gaps in the data (see Allen and Ussher 2013;

Hourd and Burley 2017). Szabo and Koppel (2015) preformed a series of use-wear experiments to demonstrated that limpet shells were used as scrapers by Pleistocene people in Indonesia. In their experiments, they found that that softer contact materials do not produce as extensive of edge damage as hard contact materials. Therefore, archaeological tools used on soft materials may show minimal or even no use modification which could be mistaken for naturally caused damage and thus, the artefact could be mischaracterized as not used. However, if starch analysis and use-wear analyses are used in a combined approach, researchers can often differentiate between tools with minimal modification used on soft materials (with starch granules) versus items not used as tools. Thus, the combination of use-wear and starch analysis (or any microfossil analysis) can create more nuanced interpretations regarding tool function.

Despite the advantages of starch and the significant contributions the method has made to archaeology, starch analysis has been subject to significant criticisms. Similar to phytolith analysis, starch analysis is subject to multiplicity and redundancy issues (Henry 2020: 97-98). Additionally, starch morphology can change as plants age. Therefore, great care must be taken to create a reference collection consisting of the full range of possible starch morphologies for each taxon. Furthermore, researchers must be careful to avoid overconfident identification of starch grains. One of the more contentious issues in starch research is the lack of understanding regarding the mechanisms contributing to the survival and digenesis of starch grains (Mercader et al. 2018). Starch can survive for long periods of time in various contexts include dry and desiccated conditions, waterlogged sites, extremely acidic or basic sediments, and burials close to heavy metals (Langejan 2010). However, starch is vulnerable to degradation by physical, biological, chemical, and thermal processes that can affect the grains before and after deposition (Crowther 2018). Pearsall (2016: 351) identifies two broad categories that influence degradation:

soil properties (acidic pH, moisture levels, etc.) and soil constituents (enzymes, fungi); conversely, any environmental conditions (anaerobic, waterlogged, basic pH) that prevent these factors may aid in preservation.

Many researchers argue that starch best survives in micro-environments such as in the cracks of an artifact or in charred residues which protect the granules from microorganisms and enzymes and fluctuations in soil pH and temperature (Barton and Mathews 2006; Haslam 2004; Pearsall 2016). In contrast, Mercader (2018: 780) argues that crevices alone are unlikely to protect starch from hydration or decay and may actually promote degradation. These preservation issues are still unresolved as researchers disagree on how and why starch survives for so long and how this affects interpretations. My study adds to this ongoing discussion by testing if starch grains on potential shell scrapers might preserve better in waterlogged versus non-waterlogged deposits since the shell artifacts derive from both types of deposit. Drawing from the conclusions of past research, we may expect that the potential shell scrapers found in waterlogged contexts would have better preserved starch than those in dryer sandy sediment; furthermore, we might expect starch to preserve if it is protected in microenvironments on the edge of the shell.

**Table 4**: Preservation of Microfossils in Various Depositional Contexts derived from Langejans (2010) and Pearsall (2016)

| | Pollen | Phytoliths | Starch |
|---|---|---|---|
| **Oxygen Levels** | | | |
| Anaerobic | ■ | ■ | ■ Unclear when waterlogged |
| Aerobic | ▨ | ■ | ▨ |
| **Moisture Level** | | | |
| Desiccate | □ | ■ But produced in smaller amounts and less formed in dry environments | ■ |
| Fluctuating | ▨ Percolating Water | □ Uncertain how Percolating water could affect | ▨ |
| Waterlogged | ■ | ■ | □ |
| **Matrix Type** | | | |
| Associated with Artifact | ■ | □ | ■ |
| Unprotected | ▨ | □ | ▨ |

| | |
|---|---|
| Good Preservation | ■ |
| Poor Preservation | ▨ |
| Unclear | □ |

Lastly, the level of contamination of samples is an on-going issue in archaeological starch research. There is little agreement over what procedures constitute thorough and reproducible anti-contamination protocols in laboratories (Crowther 2014). For example, a common procedure is to utilize "powder-free" gloves; however, it is widely acknowledged that these gloves are not starch-free, only that they have less starch (Crowther 2014: 91). Additionally, airborne starch within labs has been shown to contaminate samples and warp results (Laurence et al. 2011). Researchers have also demonstrated how samples can be contaminated in the field during excavation. Mercader et al. (2017) argue that modern introduced starches and archaeological starches may be impossible to differentiate when the granules are morphologically similar. Thus, problems concerning contamination continue to present problems for starch analysis.

These three-microfossil analyses have largely developed independently and, consequently, were applied separately from each other. However, as described above, each approach has its limitations. Horrocks (2020:191) suggests that these limitations may be corrected by combining all three analyses so that the conclusions of each can strengthened each other and/or reveal incongruencies that may illuminate problems with the analysis. More recent microfossil analysis has applied this approach; however, a combined approach takes more time and money to complete due to additional recovery procedures and analysis. This research project chose to look for all microfossil particles in order to reduce the problems which may occur with a single microfossil approach. Furthermore, the conditions of the archaeological deposit affect the preservation of each microfossil (see Table 4). Waterlogged context seems to aid the preservation of pollen and starch by restricting microorganisms' access to the plant remains. Sandy sediments do not provide the same anaerobic environment and thus, may aid in degradation, especially in the case of pollen in which water percolation can move modern pollen and enzymes downwards. Additionally, microenvironments on shells edge may protect starch and pollen grains from degradation in all deposits; although this issue is still debated. By looking at all microfossils, there is an increased likelihood of recovering any plant material despite the preservation issues.

## Archaeological Context

The Society Islands are comprised of 11 islands located in Central Eastern Polynesia. Two cultural/geological groups split the archipelagos: the Windward Society Island group, consisting of Tahiti, Moʻorea, Maiaio, Meʻetia, and Tetiaroa, and the Leeward group, comprising of Raʻiātea, Taha'a, Porapora, Huahine, Tupai, and Maupiti. Kahn et al. (2017; also see Kahn 2014, 2018) has put forth a chronology of the archipelago consisting of four phases: Colonization Phase, Development/Expansion Phases, Classic Phase, and Post-Contact Phase. The Colonization phase, AD 950-1200, includes first island colonization and settlement. The Developmental Phase (AD 1200-1350) saw the expansion of the Ma'ohi populations along the coasts as they focused on agriculture and animal husbandry. Evidence of shared Archaic artifact styles suggests intensive inter-archipelago interactions during this period. In the Expansion Phase, beginning about 1350, the Ma’ohi expanded their settlements into inland valley contexts and intensified their agricultural practices. The Classic Phase, AD 1600 to 1767, saw regional variation in material culture and architectural styles between the Leeward and Windward Island groups. During this period, an increasingly powerful socio-ritual elite emerged, and the Ma'ohi population intensified their construction of monumental temples and ritual centers. Finally, the Post-Contact Period began in 1767 as the Europeans first arrived in the Society Islands.

The 20 shell artifacts (Table 5) analyzed in this study were recovered from two archaeological sites in the Society Islands, one on Ra‘iātea and the other on Mo'orea. Shell artifacts from sites on separate islands were chosen to provide a broader geographic range of analysis for the study. All of the shell artifacts were fashioned from *Turbo setosus*. Additionally, none of the probable shell scrapers were washed before the microfossil analysis or the use-wear analysis, following standard procedures in microfossil analyses.

**Table 5**: Probable Shell Scrapers from the Society Islands

| Sample No. | Island | Site | Block | Unit | Layer | Level | Object | Location of Uae | Time Period | Waterlogged? |
|---|---|---|---|---|---|---|---|---|---|---|
| MT-01 | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP6 | B | 7 | 2-1 | Aperture | AD 1650-1800 | moist |
| MT-02 | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP6 | B | 7 | 2-2 | Aperture | AD 1650-1800 | moist |
| MT-03 | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP6 | B | 7 | 2-3 | Aperture | AD 1650-1800 | moist |
| MT-04 | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP4 | B | 7 | 3-1 | Aperture | AD 1650-1800 | moist |
| MT-05 | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP4 | B | 7 | 3-2 | Aperture | AD 1650-1800 | moist |
| MT-06a | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP6 | B | 7 | 16-a | Aperture edge | AD 1650-1800 | moist |
| MT-06b | Raiatea | RAI-1 Sunset Beach SB#3 |  | TP6 | B | 7 | 16-b | Body whorl edge | AD 1650-1800 | moist |
| MT-07a | Mo'orea | ScMo-350 | 4 | N83 E128 | C | 3 | 4-a | Aperture edge | AD 950-1200 | Yes |
| MT-07b | Mo'orea | ScMo-350 | 4 | N83 E128 | C | 3 | 4-b | Body whorl edge | AD 950-1200 | Yes |
| MT-08 | Mo'orea | ScMo-350 | 4 | N82 E125 | C | 3 | 4 | Aperture | AD 950-1200 | Yes |
| MT-09 | Mo'orea | ScMo-350 | 4 | N82 E127 | C | 3 | 1 | Aperture | AD 950-1200 | Yes |
| MT-10 | Mo'orea | ScMo-350 | 1 | N101 E102 | B | 2 | 10 | Aperture | AD 1400-1600 | No |
| MT-11 | Mo'orea | ScMo-350 | 4 | N98 E128 | A | 5 | 6 | Aperture and body whorl | AD 1800-modern? | No |
| MT-12 | Mo'orea | ScMo-350 | 4 | N82 E127 | C | 2 | 7 | Aperture and body whorl | AD 950-1200 | Yes |
| MT-13 | Mo'orea | ScMo-350 | 3 | N98 E127 | C | 1 | 6 | Aperture | AD 1050-1200 | No |
| MT-14 | Mo'orea | ScMo-350 | 4 | N82 E127 | C | 3 | 1 | Aperture | AD 950-1200 | Yes |
| MT-15 | Mo'orea | ScMo-350 | 3 | N98 E125 | C | 2 | 6 | Aperture | AD 1050-1200 | Yes |
| MT-16 | Mo'orea | ScMo-350 | 4 | N83 E126 | A | 4 | 13 | Aperture | AD 1800-modern? | No |
| MT-17 | Mo'orea | ScMo-350 | 4 | N83 E126 | C | 1 | 1 | Aperture | AD 1050-1200 | No |
| MT-18 | Mo'orea | ScMo-350 | 1 | N100 E102 | B | 1 | 12 | Aperture | AD 1400-1600 | No |
| MH-2015-7 | Mo'orea | ScMo-350 |  | N95 E121 | C | 3 | 5 | Aperture | AD 1200 | yes |
| MH-2015-8 | Mo'orea | ScMo-350 | 4 | N83 E126 | C | 4 | 5 | Aperture and body whorl | AD 1200 | yes |

Six of the potential shell scrapers derive from excavations on Sunset Beach on the northwestern coast of Raʻiātea in the Uturoa District. Kahn (2018) provides a report of this excavation. The potential scrapers derive from Sunset Beach #3 (SB#3). They were found in two test pits (TP#4 and TP#6) with similar stratigraphy. The main cultural deposit was LII, which was split into the upper LIIa and LIIb. LIIa was a grey medium-grained sand with a small amount of discontinuous bone, infrequent stone tools and flakes, and a low frequency of historic objects. LIIb was mostly under the water table and consisted of light-medium silty sand with a higher silt context than LIIa. LIIb contained more animal bone (rat, pig, and dog) and shell materials than LIIa, including evidence of fishing materials such as cut shell, fishhooks tabs and blanks, and unfinished fishhooks. The shell artifacts were found in LIIb in both TP#4 and TP#6. Samples from short-lived species (*Cocos nucifera* and *Aleurites moluccana* endocarps) recovered from LIIb were radiocarbon dated. These samples calibrated to the range AD 1674–1942; the samples' calibrated dates have multiple intersects, and LIIb most likely dates to the early 18th and early 19th centuries, which suggests that the six probable shell scrapers date to the Classic and Post-Contact periods (see Kahn 2018: 32-33 for more details). All of the Raʻiātea shells derive from a moist but not completely waterlogged layer (LIIb).

The other fourteen probable shell scrapers were recovered from excavations at ScMo-350, a multi-component coastal site in Haumi Bay on Mo’orea. Kahn et al. (2017) provides the excavation report for this site. Four blocks were excavated in 2014 and 2015, which revealed seven stratigraphic deposits, with most cultural deposits extending across the entire site. In Blocks 3 and 4, the deepest cultural deposit layers (VI and VII) were under the water table.

Eight of the analyzed probable shell scrapers were recovered from Block 4. Seven samples derived from Layer VII which consisted of the earliest deposits. Other material and features in this layer included two aligned postholes, ash dump, charcoal, land snails, faunal remains, numerous fragments of cut and worked shell, and infrequent lithic and shell tools (a pearl shell coconut grater and trolling lure). The two postholes with the associated ash dump replete with charcoal, bone, and charred bone tentatively suggest that a cook house existed in the eastern part of Block 4 (N98 E122). Radiocarbon dating on short-lived species sampled from Layer VII date the deposit between the 11th and 12th centuries (AD 950-1200), placing the deposit and its contents in the Colonization Phase. Layer VII was a medium grey wet sand approximately 37-50 cm thick, most of which was under the water table. Two of the shell artifacts were derived from Block 4 Layer I, a later deposit. Layer I consisted of a mix of traditional Ma‘ohi and historic artifacts, and subsistence remains; this evidence suggests widespread use of the site in the 18th century and beyond. Layer I had a dry sandy matrix.

Block 3 samples include two samples from Layer VI, along with other faunal and shell remains, cut shell, and lithic artifacts. A subsurface feature (ftr 27) was also found in Layer VI. This feature consisted of two aligned basalt cobbles associated with scattered *‘ili ‘ili* (waterworn pebbles often used as pavements associated with domestic sites) and vesicular basalt cooking stones; thus, suggesting the presences of a cooking or domestic structure. This cultural deposit was dated between AD 1039-1298, the later part of the Colonization Phase. LVI’s matrix was very similar to LVII in Block 4 (medium grey, wet, fine sand) with the majority of the deposit (other than first 10 cm) under the water table. Finally, the last two probable scrapers were recovered from Block 1, Layer IV. LIV consisted of a pre-contact cookhouse (AD 1400-1600). In addition to the two probable shell scrapers, this layer included flakes, adze flakes, animal bones, fishing materials, basalt cooking stones, fire-cracked rock. LIV was a light tan sand that was not waterlogged. In summary, most of the Mo’orea shells were closely associated with a domestic site or cookhouses and/or associated with manufacture and subsistence materials. All of the shells were recovered from sandy matrixes but as the depth of the matrix increased the amount of moisture also increased. Eight of Mo'orea shells, recovered from the deeper cultural deposits, derived from waterlogged layers. The level of moisture is important for considerations of how the environment of deposition affects the survival of microfossils residues.

## Methods of Microfossil Analysis and Shell Edge Wear Analysis

### *Micro-fossil Analyses*

A team of archaeologists, under the direction of Dr. Jennifer Kahn, had performed preliminary analysis of the probable shell scrapers before this project had been designed. All twenty samples were specifically set aside for microfossil analysis and were, therefore, not washed and stored in individual bags. This was done to: 1) avoid modern contamination and 2) provide the most "pristine" surface for sample collection. However, a downfall of this procedure is that the dirt and soil can obscure detailed analysis of edge damage and other signs of use. Before the microfossil analysis, the samples were handled with bare hands. Two separate microfossil analyses were conducted by different ethnobotanists: two of the samples were examined in 2015 by Mark Horrocks (MH) at Microfossil Research Ltd, and eighteen of the samples were examined in 2020 by Monica Tromp (MT) in the Archaeobotany Laboratory, Otago Archaeological Laboratories at the University of Otago. Each analyst used different methods to extract, quantify and identify microfossils (see Table 6).

MH analyzed two of the probable shell scrapers (MT-19 and MT-20) for phytoliths and starches; six soil samples from the same site were examined along with the scrapers for phytolith and pollen microparticles. Horrocks washed the edge of each shell artifact to extract any starch or phytolith remains. He then prepared the remains for analysis using the density separation method and absence/presence noted (Horrocks 2005). The residues were mounted on slides and examined microscopically. The risk of contamination was minimized by using specific plastic tools such as stirrers and pipettes and powder-free gloves (see discussion above regarding issues of starch contamination and gloves).

**Table 6:** Comparison of Microfossil Analysis Procedures

| | **MT** | **MH** |
|---|---|---|
| **Extraction Procedure Followed** | Spot Sample Method | Density Separation Method and absence/presence noted |
| **Microfossils Targeted** | Pollen, Phytoliths, Starch | Phytoliths, Starch; Pollen needs separate procedure |
| **Microscopic Examination Before Extraction** | Yes - to examine for obvious residue | Yes – examined macroscopic plant remains when noticed during preparation of samples |
| **Location of Sample** | Target obvious residues and potential microenvironments (cracks, holes); smaller specific areas on shell sampled by swabbing targeted spot | Washed entire edge of shell; larger area sampled |
| **Sample Size** | Smaller sample needed; however, if too small residue available then could not preform SEM-EDS | 2.5- 3.0 cm$^3$ needed |
| **Contamination Prevention Measures** | No gloves; Empty test tube to act as control for modern lab contamination | Powder Free Gloves; Plastic Tools |

MT analyzed 18 potential shell scrapers for any microparticle residue, including phytoliths, starches, and pollen. Prior to the analysis, all the samples were examined under a low power microscope for any obvious adhering residues. If obvious residue was present, then that location was chosen to be sampled; if no visible residue was present, MT sampled an area on the shell that may have acted as a micro-environment where residues could have been trapped, such as a crack or hole. Depending on the sample location, the potential residue was pipetted off the surface, and the area of potential use was soaked in Millipore water, and/or the residue was scraped off using a starch-clean dental pick. The residue was placed in a 15 ml tube then mounted on a slide for immediate microscopic analysis. The slide was scanned for any microfossils; any microparticles present were counted. Any residues that were thought to have a non-organic origin, such as pigment, were examined using a Hitachi TM3030 Tabletop scanning electron microscope coupled with Bruker Quantax 70 energy dispersive X-ray spectroscopy system (SEM-EDS). A blank sample (empty tube) was analyzed in the sample manner as the samples to measure potential contamination during the analysis. In order to minimize modern contamination further, MT did not use gloves under the rational that even power-free gloves contain starch and can introduce modern contamination into archaeological samples (MT, pers. comm; also see Crowther 2014: 91).

### *Shell Edge-Wear Analysis*

In addition to the microfossil analysis, I measured and weighed each probable shell scraper. I used low power microscopy to perform a preliminary use-wear analysis, looking for the presence or absence of modification resulting from the shell's use as a tool. Other Pacific Island shell tools studies have used both low power and high-power microscopy to examine potential use-wear. Szabo and Koppel (2015) used a low power stereo microscope to examine archaeological and experimental *S. flexuosa* specimens in their use-wear experiments for potential edge-damage; those specimen with possible signs of cultural modification were then analyzed with low voltage scanning electron microscopy (high power). Szabo and Koppel (2015) set a precedent for my study' use of low power analysis to identify the presence of potential use-wear on shells.

Three factors were considered in this preliminary edge damage analysis, including the shape and form of the modification, the extent and location of the modification, and the shell tool's size (Hourd and Burley 2017). For each sample, I used a 10X loupe lens to examine the lip of the shells' aperture (see Figure 1) for evidence of use. Signs of use included flake scars, rounded or ground down edges, polishing, and beveled edges. In addition to modification on the lip, some of the samples (n=4) had body whorl holes which were also considered as potential locations for use-wear. In some contexts, in French Polynesia and Melanesia, gastropods were intestinally modified to create a hole in the body whorl that could be used as a scraping edge (see Rolett 1998; Skjølsvold 1972; Suggs 1961). Care was taken to assess if each sample had edge damage consistent with use or with post-depositional alterations. Shells can become damaged from taphonomic processes at work on the shell, including weathering, perforation, fragmentation, abrasion, encrustation, dissolution, and heating (Classen 1998: 53-66). Significantly, I propose that waterlogged contexts might produce a higher number of samples with post-depositional alterations than non-waterlogged but still buried contexts, due to the greater jostling of the shell in waterlogged context then in more stable contexts.

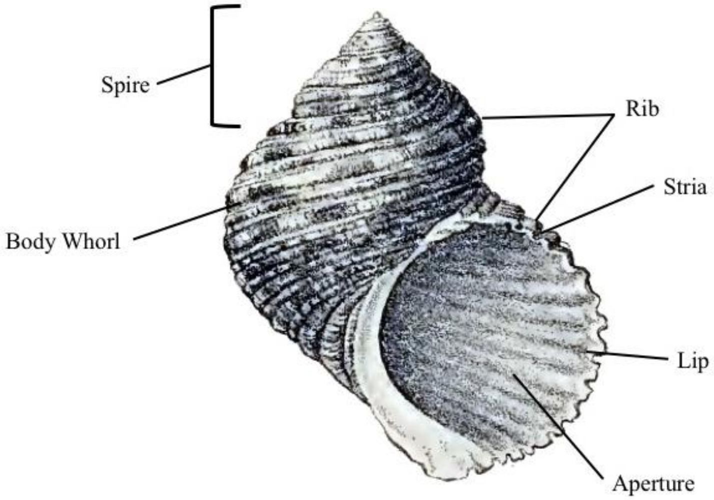

Figure 1: *Turbo setosus* Anatomy; Illustration by GW Tyron (1888)

While more detailed use-wear analysis will continue after I have completed an experimental archaeology program using *Turbo* shells as scrapers, I assessed each of the 20 shell samples for evidence of potential natural edge damage versus edge use-wear damage derived from tool use. Importantly, there have been no previous use-wear studies on *Turbo* shells which considers the unique biological and mechanical attributes of *Turbo* shells' structure and how this shell species reacts to various sorts of use and post-depositional alterations. Due to this lack of previous experimental and taphonomic research on *Turbo* shell, I had to draw on use-wear studies of other raw materials for guidance regarding how use damage may appear on *Turbo* shell.

Several use-wear studies on bivalves (Allen and Ussher 2013; Hourd 2015; Szabo and Kopple 2015) were used to develop an understanding of how shells react to being used on specific types of materials (hard or soft). Under the assumption that *Turbo* shell, as a hard material, will act similar to basalt tools in the region, Kahn (1996) was used as a source to determine what potential edge damage might look like. Drawing on these previous studies, edge use-wear is characterized as flake scars with terminations that extend into the surface, that are not single isolates but have adjacent scars, or that include rounding or polishing of the edge. A natural unmodified aperture lip is characterized with regular groves created by the ribs and stria as seen in Figure 1; however, an unused shell can also have damage caused by post-depositional alterations which must be distinguished from use-wear modifications. Natural damage is characterized by jagged aperture edge that lacked evidence of rounding or grinding or flaking. If edge damage is present, it often represents natural fractures broken at right angles. Non-used shells will also lack use-wear damage such as flake scars and worn-down ribs on the lip. Half-moon breaks may occur due to post-depositional damage and these breaks can look like flake scars. However, these half-moon breaks do not have terminations that protrude into the shell-like flake scars (Kahn 1996; pers. comm.). The damage caused by taphonomic processes can resemble use-wear evidence, especially when the use-wear is minimal (Szabo and Koppel 2015).

After the analysis, each shell sample was then assigned to one of three categories: probably used, potentially used, and probably not used. Shell artifacts characterized as "probably used" showed at least two use wear features clearly, usually flake scars and grounded down ribs on the shell’s lip. Artifacts in the "potentially used" category showed one feature of use wear, or if they showed more than one of the use-wear features, the modification was isolated without continuous areas of wear. In other words, the modification was not distinctive or extensive enough to identify with confidence as the result of human activities. Finally, shells designated as "probably not used" lacked any evidence of use-wear.

This use-wear study is a preliminary attempt to identify the presence or absence of use-wear to support the ethnohistoric observations and microfossil analysis; it should not be understood as a conclusive classification of use in these tools. The use of the tentative categories, "probably used," "potentially used," and "probably not used", reflect this notion. Furthermore, the use of previous bivalve and basalt tool use-wear studies as a guide for use-wear on *Turbo* shell was necessary due to the lack of *Turbo* shell research; however, it is also problematic. The biological and mechanical structure of shells is an essential consideration for use-wear studies because a shell's structure affects how it reacts to different types of impacts (Szabo and Kopple 2015). Thus, the different morphological structures of bivalves and gastropods could result in different use-wear patterns when the shell is used or broken. Furthermore, despite *Turbo* shell and basalt both being hard materials, the different structures of the two raw materials likely affects how they behave. Despite these issues, these sources (Kahn 1996; Szabo and Koppel 2015) act as important starting points for developing a model of use-wear identification for *Turbo* shell and how gastropods may potentially react to use and post-depositional alterations.

# Results

## *Microfossil Analysis Results*

The results of the microfossil analysis are summarized in Table 7. Overall, only the two probable shell scrapers (MH-2015-7 and MH-2015-8) had identifiable microparticles. 11 samples had microparticles that were not identifiable, other than a few instances of fungal hyphae (Figure 2). Hyphae are the filamentous structure of a fungus that physically bind soil particles together; they often act as primary contributors to decomposition in soils (Shumilovskikh and van Geel 2020: 77). Fungal hyphae cannot be identified morphologically, and their presence is likely the result of post-depositional processes. Sponge spicules were identified on four samples, reflecting the coastal site locations from which the shells were recovered. Five of the samples had visible adhering residues. A white residue was recovered from MT-04 and consisted of sand and sediment; it did not contain any microparticles. Potential residues were recovered from the inside of the apertures of MT-06 and MT-12; however, the only identifiable microparticles were fungal hyphae. Finally, MT-10 and MT-15 both had potential residues adhering to the edge of their apertures, but no microparticles were recovered. Seven of the samples had no recoverable microfossils, including three which had visible residue.

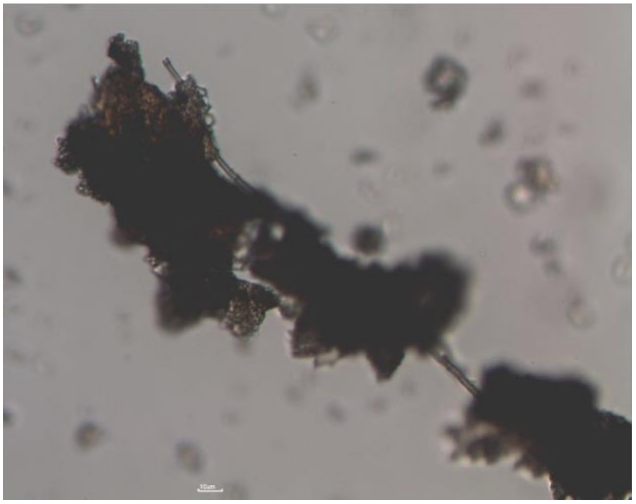

Figure 2. Example of fungal hyphae found in several samples. This is sample MT01. Scale bar is 10µm.

**Table 7:** Summery of Microfossil Analysis Results

| Sample No. | Phytoliths | Starch | Macroscopic Plant Material | Fungal Hyphae | Sponge Spicules | Unidentifiable residue |
|---|---|---|---|---|---|---|
| **MT-01** | | | | yes | | |
| **MT-02** | | | | yes | | |
| **MT-03** | | | | yes | yes | |
| **MT-04** | | | | | | yes |
| **MT-05** | | | | | | |
| **MT-06a** | | | | yes | | yes |
| **MT-06b** | | | | | | |
| **MT-07a** | | | | | | |
| **MT-07b** | | | | | | |
| **MT-08** | | | | yes | | |
| **MT-09** | | | | yes | | |
| **MT-10** | | | | | | yes |
| **MT-11** | | | | yes | | |
| **MT-12** | | | | yes | | yes |
| **MT-13** | | | | yes | | |
| **MT-14** | | | | | | |
| **MT-15** | | | | | | yes |
| **MT-16** | | | | yes | | |
| **MT-17** | | | | yes | yes | |
| **MT-18** | | | | | | |
| **MH-2015-7** | yes | yes | yes | | yes | |
| **MH-2015-8** | yes | | yes | | yes | |

Samples MH-2015-7 and MH-2016-8 provided the most secure microfossil evidence. Both samples contained microscopic fragments of charcoal but were not charred or burned themselves. This evidence reflects local human activities, specifically the burning of vegetation. Additionally, two types of starches were found on sample MH-2015-7. The first starch type was present as a small amount of well-preserved, individual starch grains. These starch grains are consistent with several different species of plants including the root of sweet potato (*Ipomea batatas)*, the corms of giant taro (*Alocasia macrorrhizos)* and giant swamp taro (*Cyrtosperma merkusii*), or the tuber of Polynesian arrowroot (*Tacca leotopetaloides)*. These taxa have starch grains that are hard to differentiate from each other, and thus, no absolute identification could be made. The second type of starch present was a single well-preserved starch grain consistent with the starch granules of the tuber of a spiny yam (*Dioscorea nummularia*). These two types of starches appeared in small amounts, suggesting that this shell scraper was not primarily used for food processing, at least not at the time of its deposition. MH-2015-7 was recovered from a waterlogged context. This anaerobic context may have acted as a protective environment for the starch granules; however, more starch may have also been present at deposition which was degraded or washed away. Due to MH's manner of extraction, it is impossible to know if the starch survived within a microenvironment on the shell surface since the general edge of the aperture was tested rather than a specific area.

Additionally, during the preparation of the MH-2015-7 and MH-2015-8, macroscopic plant material resembling small roots was found. The form of the small roots was tentatively identified as the adventitious roots of *Freycinetia* sp. (*ʻieʻie*). *Freycinetia* is a genus of woody climbers native to much of Polynesia; the inner portion of this plant was often used by Māʻohi for various purposes, including making baskets, fish traps, and construction of houses (Whistler 2009: 119-122). The subsequent microscopic analysis supported this initial identification of the roots by revealing that each of the probable shell scrapers contained large amounts of sheets of thick-walled polyhedral cells with some cortical tissue, consistent with the roots of *ʻieʻie*. Given that the recovery site has been characterized as a common domestic site focused on fishing and marine activities, evidence of the scraping of *Freycinetia* coincides with the activities that probably took place at the site. Notably, none of the six soil samples analyzed with these probable shell scrapers contained any noticeable evidence of *ʻieʻie* tissue indicating that the *Freycinetia* macro remains were not transmitted to the shells from the soil but instead, the plant remains were likely deposited through direct contact of the shell with the plant. It is worth reiterating that MH-2015-7 and MH-2015-8 underwent a separate microfossil analysis by Mark Horrocks than the other 18 shell samples, which Monica Tromp analyzed. The independent methods of recovery, analysis, and interpretation may account for the differing results; this matter will be discussed more in the next section.

### *Preliminary Use-wear Analysis Results*

The shell artifacts were divided into three categories, probably used, potentially used and probably not used, based on the presence/absence of use-wear, and the extent and clarity of the use wear. Three significant use-wear patterns were identified: flake scars, edge rounding, and the abrasion or grounding down of the ribs that end on the lip. Table 8 summarizes which use-wear patterns are found on each sample and the category each shell was placed into. Two of the shells (MH-2015-7 and MT-6) were identified as probably used based on distinctive and extensive use-wear evidence. MH-2015-7 (Figure 3) showed the best evidence of these use-wear patterns. The lip of the aperture had approximately 2.2 cm of use-wear along its edge characterized by two large flake scars on the inside of the aperture. The lip also showed evidence of edge row, defined as smaller scars within the proximal region of a larger microchipping (Kahn 1996: 165) In addition, the edge was slightly rounded inwards, suggestive of edge rounding from use. The entire lip of the aperture was grounded down so that the natural ribs were reduced and the edge was relatively flat; this suggests that the entire aperture was possibly used and not just the 2.2 cm part of the edge with flake scars. MT-6 had use-wear on both its aperture (MT-6a) and its body whorl hole (MT-6b). The probable shell scraper had about 2.0 cm of flakes terminating in step fractures near the top of the aperture. In addition, the natural surface of the edge was worn down, suggestive of edge rounding from use. The body whorl hole possibly shows evidence of polishing, discernable by a smooth, shiny area to the left of the hole; however, analysis with high power magnification will be needed to confirm this observation. Additionally, the MT-6's body whorl hole was regular in shape, and the edge was flattened on the right of the hole. Some residue was recovered from MT-6, but no microfossils beyond fungal hyphae were identified.

Figure 3. MH-2015-07's aperture edge with probable flake scars and edge abrasion

Ten of the shell artefacts were categorized as "potentially used" due to the presence of use-wear but at a lesser degree of confidence than for samples MH-2015-7 and MT-06. This classification reflects that these shells had at least one of the definable wear characteristics (flake scars, edge rounding or abrasion of edge); however, the modification was minimal, noncontiguous, or unclear. Szabo and Koppel (2015) note that their experimental working of soft materials, such as taro and yam, with unmodified limpet shells resulted in slight use-wear modifications. Therefore, the minimal modification or unclear features apparent on many of the shells in the "potentially used" category may represent softer contact materials. This finding is similar to stone tool experimental studies on soft materials (Kahn 1996: 157-170). Experimental shell tool use is required to understand the effects of different contact materials and taphonomic processes on *Turbo* shell edges. Finally, eight of the shells were classified as probably not used due to lack of apparent use-wear features. Most of these shells had modifications; however, the modifications appear to be the result of post-depositional factors due to the jaggedness and irregularity of the fractures and damage.

**Table 8**: Summery of Use-Wear Evidence

| | **Continuous Flake Scars** | **Individual Flake Scars** | **Edge Row** | **Edge Rounding** | **Grounded Edge/Flattened Ribs** | **Polishing** | **Use-Wear Category** |
|---|---|---|---|---|---|---|---|
| **MT-01** | | | | | | | Probably Not Used |
| **MT-02** | | x | | x | x | | Potentially Used |
| **MT-03** | | | | | | | Probably Not Used |
| **MT-04** | | x | | | | | Potentially Used |
| **MT-05** | | | | | | | Probably Not Used |
| **MT-06** | x | | x | x (body whorl) | x (aperture and body whorl) | x | Probably Used |
| **MT-07** | | | | | | | Probably Not Used |
| **MT-08** | | | | | | | Probably Not Used |
| **MT-09** | x | | | | | | Potentially Used |
| **MT-10** | | | | | | | Probably Not Used |
| **MT-11** | | | | | | | Probably Not Used |
| **MT-12** | | | | x | | | Probably Not Used |
| **MT-13** | x | | | | | | Potentially Used |
| **MT-14** | | x | | | x | | Potentially Used |
| **MT-15** | x | | | x | | | Potentially Used |
| **MT-16** | x | | x | x | x | | Potentially Used |
| **MT-17** | | | | | x | | Potentially Used |
| **MT-18** | | | | | | | Potentially Used |
| **MH-2015-7** | x | | x | x | x | | Probably Used |
| **MH-2015-8** | | | | x | x | | Potentially Used |

The location of modification on a shell and size of a shell are important factors as they may be related to the tool's functionality. In this study, the lip or edge of the aperture is the most common area of identified use. Most use-wear was located near the middle, or near the upper portion of the aperture's lips. Very little use-wear evidence was identified near the bottom of the aperture. Additionally, the use-wear stayed concentrated on the inside edge of the shell. No modifications or damage extended into the aperture hole more than a centimeter, and no evidence of use-wear was found on the lip's outer edge. This type of unifacial damage is consistent with scraping (Kahn 1996: 170).

Statistical analysis was preformed to see if the size of the shell correlated with the use-wear modifications (See Appendix A: Table C for calculations). The shells were split into two groups: those with use-wear evidence, characterized by shells in the probably used and potentially used categories (n=12) and those without use wear modifications (n=8). Then using weight as a proxy for size, the average weight was recorded for each group. The shells with use-wear were smaller (avg. weight=83.78 g) than the unmodified group (avg. weight=92.21). However, these did not prove to be statistically significant values (p=.73). Next, the height of the aperture of each shell was used as a proxy for shell size. The shells with use-wear had a greater height (avg. height=4.67 cm) compared to the group without use-wear (avg. height= 4.26). However, this was not a statistically significant value either (p=.17). Thus, shell size does not correlate with use-wear presence/absence.

Figure 4: *Turbo Setosus* with perforation in body whorl (MT-06)

Five shell artifacts had potential body whorl holes (MT-06, MT-07, MT-11, MT-12, and MH-2015-8) (Figure 4). *Turbo* scrapers with body whorl holes have been identified in other archaeological contexts in the Pacific Islands (Rolett 1998:238; Spoehr 1957: 157). Additionally, Suggs (1961:127) described perforations on the body whorl of *Tonna* scrapers from the Marquesas Islands, which he describes as similar to *Turbo* scrapers from Micronesia and Melanesia. Suggs (1961) described the process of making one of these holes as the following. First, the body whorl of a *Tonna* shell would be perforated at a point by either drilling or punching the shell. The jagged hole would then be abraded against a stone to smooth the edges and make the hole bigger. This abrasion created a larger flat facet surrounding the hole. We may expect that the body whorl holes on *Turbo* shells may have been created similarly. However, Pacific Islanders did not always create body whorl holes for the purpose of scraping. Similar perforations are found on *Turbo* shells used as net weights (Kirch 1988: 204-205). These holes may also result from people purposefully puncturing the shell to obtain materials to create fishhooks (Kirch 1988: 204). Additionally, ethnographic analogy suggests that these holes may have been caused when people broke shells open in order to retrieve the meat from within (Allen and Ussher 2013; Skjølsvold 1972: 49). Thus, there are multiple explanations for why a hole may be present on a shell, and experiments need to confirm that these samples were used for scraping and not as net weights or fishhooks. In my sample set, MT-07 (sampled in the microfossil analysis as MT-07b) was identified as a body whorl hole created through taphonomic processes. Likewise, MT-11's body whorl hole was very jagged and had an irregular shape suggesting it was created by natural breakage. The other three body whorls (MT-06, MT-12 and, MH-2015-08) have fairly regular round shapes. They also display potential use-wear features, including beveled and flattened edges. These perforations are believed to have been purposefully created; however, it is difficult to say with certainty that these were created to act as scrapers or cut to manufacture fishhook tabs.

Researchers recognize that typological classifications of artifacts, including those applied to shell assemblages, are not a purely objective practice as they are always shaped by some extent to decisions made by the researcher (Kahn 1996:118). However, classifications of artifacts remain important to archaeological questions concerning foodways, diet reconstruction, and materiality. Therefore, use-wear studies and the typologies created through these studies should be dependent on experiments and theories concerning the fracture mechanics of specific species of shells which allow archaeologists to create models for expected use-wear patterns resulting from tool use or from other post-depositional factors such as weathering or trampling. Thus, additional experimental shell-tool studies are required to better understand the use-wear patterns evident on these archaeological shells. The purpose of this preliminary use-wear study was to support the microfossil results and to demonstrate why these shells were chosen to undergo microfossil analysis. In reexamining my research design, the use-wear analysis should have been done prior to the selection of shells for microfossil analysis in order to ensure the microfossil sample location was an area that had potential use-wear evidence.

## Discussion

The microfossil analysis and preliminary use-wear study presented here are not able to fully answer the original questions regarding how these potential shell scrapers were used. However, they do provide some novel insights regarding the shells' functions and reveal potential problems with microfossil analysis and tool function studies.

### *Function of Turbo Scrapers*

The recovery of microparticles on MH-2015-7 and MH-2015-8 provide new understanding regarding how *Turbo* scrapers were used. Previous archaeological research has identified *Turbo* shell as vegetable scrapers due to ethnohistoric and ethnographic observations. The two types of starch on MH-2015-7, which were consistent with several subsistence foods, suggest a similar interpretation for this artifact as a vegetable scraper. However, the evidence of a considerable amount of *Freycinetia* (*'ie'ie*) root suggests that both MH-2015-7 and MH-2015-8 had a significant amount of contact with *'ie'ie*. As previously mentioned, the roots of *'ie'ie* were used to manufacture fish traps and baskets in the Society Islands and more broadly throughout Polynesia (Whistler 2009: 119-122). Handy (1971:15), who conducted ethnographic research in the Society Islands in the 1920s, observed that the *'ie'ie* root is ordinarily scraped clean to prepare the inner woody portion as material to be used in craft activities; she also noted that specific fish traps require the rootlets to be split by a tool. She noted that shell scrapers were the original tool used to prepare wood for crafts but had largely been replaced by kitchen knives by the early 20th century (Handy 1971:12). Thus, the substantial amount of *'ie'ie* material on these two shell artifacts suggests that these scrapers were used for preparing *Freycinetia* root for crafting. This evidence of *Freycinetia* scraping for manufacturing fish traps is also consistent with the evidence for lagoon fishing at the Sunset Beach Site. The site contained evidence of the manufacture of fishing gear and faunal remains, predominantly of lagoon fish; such fish traps would have been used in the lagoon context.

**Table 9**: Summery of Use-Wear Analysis and Microfossil Analysis

| Sample No. | Probably Used | Potentially Used | Probably Not Used | Microfossil Evidence Present | Waterlogged? |
|---|---|---|---|---|---|
| **MT-01** | | | x | | moist |
| **MT-02** | | x | | | moist |
| **MT-03** | | | x | | moist |
| **MT-04** | | x | | | moist |
| **MT-05** | | | x | | moist |
| **MT-06** | x | | | | moist |
| **MT-07** | | | x | | Yes |
| **MT-08** | | | x | | Yes |
| **MT-09** | | x | | | Yes |
| **MT-10** | | | x | | No |
| **MT-11** | | | x | | No |
| **MT-12** | | | x | | Yes |
| **MT-13** | | x | | | No |
| **MT-14** | | x | | | Yes |
| **MT-15** | | x | | | Yes |
| **MT-16** | | x | | | No |
| **MT-17** | | x | | | No |
| **MT-18** | | x | | | No |
| **MH-2015-7** | x | | | x | yes |
| **MH-2015-8** | | x | | x | yes |

When coupled with a second line of evidence, notably edge damage, the interpretation of MH-2015-7 as a shell scraper becomes even stronger (see Table 9). MH-2015-7 had a significant amount of continuous modification on the lip of the aperture, including abrasion of the naturally elevated ribs, step scars, and some edge row. During their use-wear experiments on bivalve limpet shells, Szabo and Koppel (2015: 74) found that a relatively hard contact material is required to create regular flattened surfaces on the edge of a shell's aperture. Based on these observations, the ground down edge of MH-2015-7 may suggest impact with a hard material. *Freycinetia* root is considered a tough, fibrous, and thus moderately hard contact material, especially when compared to root vegetables which represent soft contact materials. Therefore, the two independent lines of evidence suggest that MH-2015-07 was used as a scraper to prepare and split *ʻieʻie* to get to its woody core. The two types of starch microfossil remains (sweet potato or taro or Polynesian arrowroot granules and spiny yam granules) and the macrofossil *ʻieʻie* remains recovered from MH-2015-07 associate this artifact with several contact materials and therefore, suggest this scraper may have been a multi-purpose tool used on more than one material. Other researchers have also found that shell scrapers may not have been used on exclusive materials but instead used on multiple contact materials (Allen and Ussher 2013). Shell scrapers might have always been used as a scraper, peeler or knife but on a variety of different materials, such as roots, fruits and vegetables. In contrast to MH-2015-07, MH-2015-8 lacks evidence for multiple contact materials, nor does it exhibit use-wear consistent with edge flattening indicative of contact with a hard material. Thus, the use-wear analysis does not support the microfossil evidence as confidently; however, MH-2015-8 could also have been used on softer contact materials that did not leave edge damage.

The lack of meaningful microfossil evidence on the other eighteen shell artifacts is reflective of several possibilities. The first possibility is that the shells were not used as tools as previously thought. Five of the shells did not have any use-wear evidence in addition to the absence of microfossils. The combined results of these two analyses suggests that these five shells artifacts were not used as tools or modified through any purposeful human activity. This data illustrates the difficulty of distinguishing between post-depositional damage cause by natural taphonomic processes and modification caused by use as a tool. This difficulty is amplified in the field where the lack of a clear understanding of shells as raw material and as informal tools has prevented better guidelines for identifying these objects during excavation. It is evident that better excavation guidelines for recovering shell artifacts are needed to prevent overinterpreting natural damage on shells and to ensure that all meaningful shell evidence is collected. In addition, microfossil analysts could provide instructions to archeologists regarding how to extract sediments with potential microfossils from artifacts in advance of the microfossil analysis. This would allow archaeologists to clean artifacts in order to conduct use-wear analysis before any microfossil analysis, allowing for better identification of post-depositional damage versus use damage and yet still maintain the possibility of conducting microfossil analysis.

Another possible reason for the lack of microfossil evidence has to do with microfossil preservation issues. My results demonstrate that approximately 10 of the shells (55% of the total) do not have meaningful microfossil evidence but do have potential use-wear modifications. The majority of these shells fall into the "potentially used" category except for MT-06, which is categorized as “probably used” due to the extent of the use-wear modification on its aperture and body whorl. This observation may be reflective of problems with the preservation of microfossils. Due to the presence of potential use-wear on these artifacts, the shells are expected to have been used as scrapers; however, the absence of microfossils suggests that these were not used. The contrasting results require us to consider why potential shell scrapers with use-wear damage may not have microfossil evidence. One possibility is that these scrapers were used on materials that does not tend to leave microfossil evidence. As discussed in the microfossil literature review, some plants do not produce certain microfossils or due to environmental conditions, produce less microfossils than elsewhere. A second possibility is that any microfossil residues that were once present on the probable shell scraper did not survive post-depositional processes, including decomposition. Here, the issue of the surrounding matrix associated with shell artifacts comes into play.

For these shell artifacts, one likely contributing factor to the lack of preservation could be the waterlogged contexts where most of the shells were recovered. Waterlogged contexts have been argued to be better environments for specific microfossil preservation because the lack of oxygen prevents several decomposition processes (Pearsall 2016: 185). However, I suggest that water may also wash away any visible residues that contain microfossils from the surface of the artifact. With low and high tides, artifacts suspended in a waterlogged context would likely be more jostled than those in a stable context. This unstable depositional environment may provide conditions that create a higher degree of post-deposition alterations, including modern edge wear damage and the removal of microfossil residues. 7 of the 10 shells with use-wear evidence but no microfossil evidence derive from moist or waterlogged context; therefore, if these shells were used as scrapers as the use-wear suggests, any microfossil residues which were once present may have been removed by the conditions of the depositional context. Furthermore, success in finding and identifying microfossils is more likely when residues are visible on the surface (M. Tromp, personal communication); therefore, the waterlogged context may remove any visible microfossil evidence before the shell artifacts were recovered and thereby, prevent the finding of microparticles. In this study only 5 of the shells had obvious residues: two which derived from waterlogged context and three from dry or moist context; however, none of these contained meaningful microfossil remains. Many microfossil researchers may also refute this claim as some studies have found that microfossils survive best in cracks and crevices of artifacts. Therefore, any microfossil particles that were present would have survived being washed away by water if they were protected in the microenvironments of crevices or cracks in a shell (Barton and Mathews 2006; Pearsall 2016).

In summary, we can draw limited conclusions concerning the potential uses of these probable shell scrapers; however, we can demonstrate how these results suggest a new understanding of *Turbo* shell scrapers. Previous archaeologists have identified various shell species as vegetable scrapers or peelers. Pearl shell scrapers have been identified throughout the Pacific, while shell scrapers fashioned from other species appear to have more limited use (Allen and Ussher 2013). *Tonna* shell scrapers have been recovered in Samoa and the Marquesas' Islands (Buck 1930; Suggs 1961:127), cowrie shells scrapers in Hawaiian, Society, Caroline and Marshall Islands (Green et al. 1967: 197; Kirch 1988:208; Spennemann 1993; Suggs 1961: 128), *Purpura persica* shell scrapers from the Marquesas (Rolett 1998), and *Strombus luhuanus* scrapers from New Caladonia (Gifford 1951: Fig 1A; Gifford and Shutler 1956: 65). *Turbo* shell scrapers have only been explicitly discussed twice. Spoehr (1957) recovered *Turbo* shell scrapers from a site in the Mariana Islands, and Skjølsvold (1972:32-33) recovered three modified *Turbo* shells from the Marquesan Islands, which resembled peelers, but the modifications could also have been the result of meat extractions.

As my ethnohistorical review demonstrated, there are relatively few mentions of shell tools associated with food preparation; however, ethnographic research throughout the Pacific has led to the common acceptance of shell scrapers as used primarily for food preparation. The microfossil results of MH-2015-7 and MH-2015-8 support this characterization. However, the evidence of *ʻieʻie* root also suggests a different use, the preparation of roots as raw materials used in constructing other forms of material culture. Ethnohistorical sources do not mention Māʻohi scraping *ʻieʻie* root for crafting, nor do archaeologists commonly attribute *ʻieʻie* root scraping as a function of archaeological scrapers. However, based on the microfossil analysis results and use-wear analysis on MH-2015-7 and MH-2015-8, we can draw two conclusions. First, shell scrapers may have been used for multiple purposes. Secondly, shell scrapers were used for purposes beyond those mentioned in ethnohistorical sources and beyond food preparation, contrary to how many archaeologists exclusively categorize them. Due to the lack of microfossil remains on the other shell artifacts, we cannot draw conclusions regarding how the other shells were used. The minimal microfossil evidence could be a result of the waterlogged deposits which washed any residues away or could be an indication that the shell was not used as a tool. The potential use-wear damage indicates some use as tools and the shells with minimal damage could be an indication soft material or no use. We are unable to make greater conclusions without use-wear experiments. However, despite the need for further research, my study adds to the small number of *Turbo* shell scrapers recorded in Polynesian archaeology and to the general knowledge regarding expedient gastropod scrapers.

### *Reflections with the Microfossil Analysis Methodology*

Finally, we must reflect on the methodology of the microfossil analysis and its limitations which may have influenced the present study's results. Importantly, the shells were analyzed by two different microfossil analysts, each with their own extraction processes. MH-2015-7 and MH-2015-8 were analyzed by Mark Horrocks (MH), who found both evidence of starch granules and *'ie'ie* cells. The other eighteen shells were analyzed by Monica Tromp (MT), who found little microfossil remains. While MH-2015-7 exhibits clear use wear, MH-2015-8 displayed similar use-wear to some of the shell samples analyzed by MT. There is no clear division in two groups of the shells according to their use wear which may indicate that one group was conclusively used as tools while the other was not. So here, we must question to what extent the specific extraction methods and broader laboratory procedures differ among the two analysts and if these independent methodologies may have resulted in the different results.

MH and MT used different recovery processes, which may have resulted in different levels of success for each analysis. MH utilized a density separation method (Horrocks 2005; Horrocks 2020). This procedure requires a larger sample, and consequently, the entire edge is cleaned and the sediment around the area of use and inside of the shell is collected. In contrast, MT used a spot sample method, in which a smaller amount of sediment is collected from areas with visible residue and/or areas with cracks or holes, which may have acted as a micro-environment for any residues. A potential problem with this spot sample method is that since the use-wear analysis was not performed before the microfossil analysis, no specific areas were indicated to be sampled. In several cases, the sample was inadvertently taken in locations that may not have contacted any organic materials that would have left microfossil evidence. For example, MT-06a and MT-15 were both sampled several centimeters inside their apertures; however, their use-wear modification is concentrated on their aperture's edge and does not extend far into the shell. Thus, a better location to sample would have been to spot sample the area with modification as it is more likely the shell came into contact with the contact material there. This problem with the sampling location was in no way the fault of MT, but instead a lack of communication on the author's part regarding sample locations. Despite this miscommunication, MH’s procedure would have sampled more of the shell edge than MT’s spot sampling. This larger sample location would have covered more potential area in which the shell was in contact with the plant material and, therefore, may have resulted in recovering more microfossils.

Additionally, identification and interpretation of starch remains could also have a role in the differing results between MH and MT. As described in a previous section, starch analysis is a more recent method of ethnobotanical analysis. While starch analysis has shown great potential for addressing archaeological questions, the relatively new method still has major lapses in research that need to be addressed. These lapses include the lack of an adequate explanation concerning why starch polymers survive for millennia and issues concerning taxonomic identification due to the large range of starch granule morphology (Mercader 2018). Additionally, researchers are still faced with problems authenticating archaeological starch due to the lack of anti-contamination protocol and the extensive contamination of artifacts in the field and lab (Crowther 2013; Laurence 2011; Mercader 2017). While both MH and MT used steps to prevent contamination, MT expressed concern regarding the extent of unknown contamination that is still unaccounted for and took greater measures to prevent contamination including not wearing gloves and using a control to measure any contamination. At the time of the MH analysis in 2015, MH did not express the same concern regarding starch contamination possibly because only more recently have such concerns been brought to fore (see Crowther 2014; Mercader et al. 2017; Mercader et al. 2018). Therefore, it is a possibility that MH's lab could have more unaccounted-for contamination, which may have affected the results of his microfossil analysis.

In summary, perhaps the initial results and contributions of previous starch grain analyses have heightened our expectations for definitive conclusions. Until these concerns are addressed, archaeologists should avoid making definitive statements based solely on starch analysis results alone unless other data supports the conclusions, such as use-wear data or ethnographic observation. Additionally, archaeologists and ethnobotanical researchers should be realistic about what their methodology can achieve to prevent over-interpretation of the data. Thus, for the starch found on MH-2015-7, we should be tentative about identifying the granules to a specific taxon, especially because they were present in such small amounts. However, the plant cellular remains found within MH-2015-7 and MH-2015-8 are strengthened by the evidence of use-wear, so these conclusions are better supported.

## Conclusion

The ethnohistorical survey and microfossil analysis results were only partially able to address this project's original objectives and questions; however, the results also reflected larger issues in microfossil analysis methodology and highlight what these limitations mean for understanding the materiality of Pre-Contact Māʻohi culture. The ethnographic survey illustrated the large variety of ways Māʻohi at the Contact Period were using shells in their daily lives. Importantly, these observations reveal that expedient tools were employed for activities beyond food preparation such as shaving, tapa manufacture, and mourning rituals. These ethnohistoric sources and their observations of the Māʻohi and their material culture are important, despite their ethnocentric biases, as they provide insight into people's daily lives during the Contact Period.

The use-wear analysis conducted was a preliminary attempt to identify the presence or absence of use-wear. I recognize that this study's use-wear analysis was subjective as it was based on my understanding of use-wear patterns derived from bivalve scraper and lithic tool use-wear studies. Lithics and shells are two very different raw materials that produce different use-wear patterns when used; bivalve shells are also problematic comparisons to *Turbo* shells as different families of shells have vastly different microstructures, which affect how they react to impact forces whether human or natural (Szabo and Koppel 2015). Thus, the use-wear analysis results are approached cautiously to avoid over-interpretation. More thorough use-wear experimentation will be needed to understand the way *Turbo* shells react to different materials and impacts. However, these use-wear results are still significant as they support the microfossil evidence in many cases and suggest that at least some of these shell artifacts were used as scrapers. In contrast, the microfossil analysis only revealed plant remains on two shells. Therefore, no confident conclusion can be drawn concerning how the majority of these probable shell artefacts were used. However, the presence of use-wear patterns on twelve of the shells and microfossil remains on MH-2015-7 and MH-2015-8 suggest that some of these archaeological probable shell scrapers from the Society Islands came into contact with plant materials, possibly as the result of being used in human activities, such as vegetable scraping and preparation of materials for crafting. Therefore, based on the form of the *Turbo* scrapers compared to similar archaeological shell scrapers fashioned from other shell species and the microfossil and use-wear evidence, I suggest that *Turbo* shell scrapers are an identifiable shell tool in the Society Islands.

### *Future Research*

This study revealed several potential areas for future research. First, more intensive experimental use-wear analysis at moderate magnification power (up to 100x) needs to be conducted to better understand the use-wear patterns associated with *Turbo* shells. While these types of studies have been completed for bivalve scrapers (Allen and Ussher 2013; Huard and Berkley 2017; Ciofalo et al. 2020), no experimental use-wear research has yet to examine *Turbo* shell recovered from archaeological sites. Future research also needs to consider the biological and mechanical attributes of a *Turbo* shell's structure, as these factors can significantly impact the way a shell reacts to impacts. Investigating taphonomic structures of shells will help differentiate natural breakage, from modification, from human use. Experimental archaeology on

*Turbo* shell tools would also aid in future microfossil analysis on these artifacts, as it can indicate how residues tend to accumulate on shell scrapers as they are used. Observing how residues accumulate would allow researchers to predict better where to sample the shell for microfossils. An experimental program would also further our understanding regarding how a sites' depositional matrix might affect residue recovery and/or edge damage and post-depositional breakage.

Finally, microfossil analysts and archaeologists must work in closer collaboration to achieve better results. Microfossil analysts should be clearer about their sampling procedures and archaeologists must be direct about what specific edges they would like to be sampled, especially if the extraction methods do not sample the entire edge. Thus, future research needs to take in these considerations, in order to generate better results and interpretations.

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# Appendix A

**Table A: Ethnohistoric Documented Use of Shells with Sources**

| Use | Total Mentions | Specific Shell Species* | Source |
|---|---|---|---|
| Personal Adornment: necklaces, bracelets, earrings, nose ornaments | 53 | *Pinctada margaritifera* (pearl shell); Tridacna shell; *gafrarium pectinatum* (bivalve clam) | Cook 1821; Cook 1772-1775 (pp. 267, 375, 465, 505); Cook 1776-1780 (pp. 168, 280, 326); Anderson in Cook 1776-1780 (pp. 810, 815, 827, 931, 970), Samwell in Cook 1776-1780 (pp. 1003, 1010, 1038, 1231); King in Cook 1776-1780 (pp. 1391); Banks 1896 (p. 132, 59, 234, 310); Corney 1913 (p. 291); Corney 1914 (p. 37, 114, 312); Morrison 2012 (p. 350, 565, 859, 926, 928); Tobin in Oliver 1988 (p. 268); Bligh in Oliver 1988 (p. 262, 254, 266, 250); Forster 1996 (p 246) |
| Decorated Canoes | 7 | Shell of Sea Ear (Abalone); Pearl Shell; Limpet Shell | Cook 1821; Wales in Cook 1772-1775(264, 777); Cook 1776-1780 (pp. 512); Anderson in Cook 1776-1780 (pp. 936); Samwell in Cook 1776-1780 (p. 1038); Banks 1896 (); Morrison 2012 (p. 896); |
| Cloth Production | 7 | Mussel Shell; *Tellina gargadia;* Cockle Shell | Cook 1821; Anderson in Cook 1776-1780 (pp 906); Banks 1896 (p. 146); Corney 1914 ; Morrison 2012 (p. 2488, 2529); Forster 1996 (p. 274) |
| Shaving Faces and Heads of Men | 7 | Bivalves | Cook 1772-1775 (pp. 267); Cook 1776-1780 (p113); Anderson in Cook 1776-1780 (pp. 930); Samwell in Cook 1776-1780 (pp. 1040); King in Cook 1776-1780 (pp. 1665); Portlock in Oliver 1988 (p. 270); Forster 1996 (p 249) |
| Tattooing** | 4 | --- | Cook 1821; Cook 1772-1775 (pp. 504); Anderson in Cook 1776-1780 (pp 786); Banks 1896 (p. 129); |
| Mourning (Cutting face and head**or ceremonial dress) | 15 | Pearl Shell | Cook 1821; Anderson in Cook 1776-1780 (pp. 815); Banks 1896 (p. 251, 310); Corney 1914; Corney 1918 (p. 93, 205, 190, 231); Morrison 2012 (p. 701); Forster 1996 (p 278) |

| | | | |
|---|---|---|---|
| Armor and Weapons | 9 | Pearl Shell;<br>Sharpened Mussel Shells | Cook 1821; Cook 1772-1775 (pp 735); NB in Cook 1776-1780 (pp. 320); Banks 1896 (p. 318); Bligh in Oliver 1988 (p. 268, 269); |
| Food Preparation | 6 | --- | Cook 1821; Anderson in Cook 1776-1780 (pp. 908); Samwell in Cook 1776-1780 (pp 1034); Banks 1896 (p. 101, 140); Morrison 2012 (p. 3438) |
| Knives *** | 7 | --- | Anderson in Cook 1776-1780(pp. 813, 846, 939); Banks 1896 (p. 156, 316, 315, 321) |
| Fishing (Hooks, Net Weights) | 24 | Pearl Shell; Mussel Shell; Conney Shell (Conidae shell) | Cook 1821; Cook 1776- 1780 (pp. 321) Anderson in Cook 1776-80 (p. 939); Samwell in Cook 1776-80 (p. 1103); Banks 1896 (p. 155, 243, 316); Corney 1913 (p. 141, 328); Corney 1914 (p.57, 81, 281, 459); Morrison 2012 (p. 378, 898, 2365, 2546); Robertson 1948 (p 171); Forster 1996 (p 204, 283) |
| General Categorization of Tools by Source | 6 | --- | Cook 1821; Cook 1776- 1780 (pp. 174); Morrison 2012 (p 898, 2546); Robertson 1948 (p 124); Forster 1996 (p 278) |
| Wood working | 1 | --- | Cook 1821 |
| Clapper (*Tettè*) in Performances | 2 | --- | Bligh in Oliver 1988 (p107); Forster 1996 (p 279) |

*not an all-inclusive list as many of the descriptions do not detail the specific species of shell and archeological evidence has shown various other species used for these activities

** other materials such as bone, bamboo, flint, shark teeth also describe as being used in same activity

*** category used to describe when shell was used to cut non-food related materials or when source referred to shell as knives specifically

**Table B: Ethnohistoric Documented Uses of Shell in association with Food Preparation with Sources**

| Contact Material | Number of Mentions | Activity | Source |
|---|---|---|---|
| Dog | 1 | Singe dog over fire then scraped hair with a shell on the island of Otahite (Tahiti) | Banks 1896 (p. 101); Cook 1821a |
| Apple* | 1 | Peeling an apple by scraping or cutting off the skin in the South Sea Islands; Described as awkward process in which the man wasted much of the apple | Banks 1896 (p. 140) |
| Breadfruit | 1 | In the process of making pudding or pope, the people "scrape off the rind [of breadfruit] with shells [that had been] ground sharp for the purpose" | Morrison 2012 (p. 3438) |
| Kava | 2 | In Tonga, “the root is the only part us'd, which being dug up is given to the servants that attended, who breaking in pieces scrape the dirt off with a shell or a bit of stick” | Anderson in Cook 1776-1780(pp. 908); Samwell in Cook 1776-1780 (pp 1034) |

* Likely referring to *Spondias dulcis*

## Table C: Statistical Analysis of Use-Wear and Shell Size (Aperture Length and Weight)

| Use-wear Group | Number of Samples | Average Aperture Length | Average of Weight |
|---|---|---|---|
| Modified Group | 12 | 4.666666667 cm | 83.775 g |
| Non-Modified Group | 8 | 4.2625 cm | 92.2125 g |

**Weight (g)**

t-Test: Two-Sample Assuming Unequal Variances

| | *Potentially Used* | *Probably Not Used* |
|---|---|---|
| Mean | 83.775 | 92.2125 |
| Variance | 1185.371136 | 3579.192679 |
| Observations | 12 | 8 |
| Hypothesized Mean Difference | 0 | |
| df | 10 | |
| t Stat | -0.361032155 | |
| P(T<=t) one-tail | 0.362792968 | |
| t Critical one-tail | 1.812461123 | |
| P(T<=t) two-tail | 0.725585935 | |
| t Critical two-tail | 2.228138852 | |

**Length (cm)**

t-Test: Two-Sample Assuming Unequal Variances

| | *Potentially Used* | *Probably Not Used* |
|---|---|---|
| Mean | 4.666666667 | 4.2625 |
| Variance | 0.240606061 | 0.442678571 |
| Observations | 12 | 8 |
| Hypothesized Mean Difference | 0 | |
| df | 12 | |
| t Stat | 1.472031429 | |
| P(T<=t) one-tail | 0.08337399 | |
| t Critical one-tail | 1.782287556 | |
| P(T<=t) two-tail | 0.166747979 | |
| t Critical two-tail | 2.17881283 | |