

Flake Patterns on Rapa Nui's (Easter Island) Stemmed Obsidian Tools
(Mata'a): A Preliminary Analysis of Tool Use

By Mila Lassuy

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Abstract

Stemmed obsidian tools (*mata'a*) are a ubiquitous component of the archaeological record of Rapa Nui (Easter Island), and have long figured prominently within archaeological debates on the island's prehistory.

Although they are one of the most common artifacts found on the island, much uncertainty exists regarding the uses and function of these tools.

Most ethnohistoric and contemporary accounts have presented *mata'a* as spear-heads, and modern researchers have included this as evidence for a violent history of widespread warfare on the island.

Recent studies, however, have shown that *mata'a* are unlikely to have been designed as weapons but possibly were more general purpose cutting tools or agricultural implements.

In this thesis, I attempt to build on these recent studies about potential *mata'a* use by documenting and statistically analyzing use-wear and flake patterns on these tools. By cataloguing the shapes, sizes, and location of the flakes on these tools and performing a series of statistical analyses, I present new quantitative evidence on patterns of use-wear and potential uses of *mata'a*. The results have important implications for the potential function of *mata'a*, adding another layer of evidence for understanding the role of the tool on the island.

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Introduction:

Rapa Nui (Easter Island) is a small volcanic island in the Pacific, with a land-area of 164 km². It was formed by three volcanic events, which led to the creation of the geographic features on the island.¹ Rapa Nui is most commonly known for the giant stone statues (*moai*) that are distributed across the island and are often seen in popular media. It is less known that in addition to these megaliths, small worked stones cover the island. One of the most common types of worked stones are the *mata'a*, stemmed obsidian tools, found all across the island. Often depicted only as the worked stones alone, *mata'a* were historically hafted.



Figure 1: Example of a historically collected Hafted mata'a hafted to a wooden handle. From the British Museum collections (Photo by T.L. Hunt, 2016)

¹ Vezzoli, L. and V. Acocella. 2009. Easter Island, SE Pacific: An end-member type of hotspot volcanism. Geological Society of America Bulletin 121(5–6):869–886.

Though perhaps not as visually stunning as the statues (*moai*), the *mata'a* play an important role in understanding Rapa Nui's past. Historically, Rapa Nui has been portrayed (both in popular and archaeological literature) as having a very large population and then suffering a collapse, fueled by human greed, violence, and lack of environmental consciousness. This collapse narrative rests on a few pillars: confusion about the date of Rapa Nui's colonization, interpretation of deforestation as a result of human activity rather than invasive species and natural causes, and ethnohistoric writings claiming rampant warfare and weaponry^{2,3}. This thesis will focus specifically on the warfare and weaponry element of that narrative. Since first documented by European explorers, the *mata'a* have been interpreted as weapons. Their ubiquity in the archaeological record, along with the ethnohistoric writings of warfare, has been used as evidence for a violent, warring community. Although they have been consistently referred to as weapons and spears, recent archaeological studies indicate that there is little evidence outside of early ethnohistoric reports. Recent studies have shown that due to blade shape it is not likely that these tools were manufactured to be weapons⁴, which supports a few earlier micro-usewear studies which concluded that the tools were used primarily for agricultural studies^{5,6}. Research has yet to be done regarding the specifics of how the *mata'a* were moved while in use. This thesis attempts to serve as a preliminary analysis of how the *mata'a* were moved in their daily use, using location, size, and shape of visible flake scarring as clues to how the tools were moved as they were being used. In this study, I use the term "movement" to

mean the motions in which the *mata'a* was put through, as it was used in the daily lives of the Rapanui. An analysis of *mata'a* movement is an important addition to the ongoing debate surrounding Rapa Nui's past, specifically its history of violence, and assumed periods of warfare. Studying the movement of the *mata'a* will give indicate the motions made by the person holding the *mata'a*, providing insight in to *mata'a* use. In order to do this study, I investigate 10 questions:

- 1) Are there more flakes on the upper or lower portions of the *mata'a*?
 - This will provide insight into the position in which the *mata'a* was held as it was moved. If the flakes are mostly in one location versus the other, it will indicate that the *mata'a* was held primarily upright, sideways, or in a downward position.
- 2) Are there more flakes on the dorsal or ventral faces of *mata'a*?
 - This will provide insight into the way in which the *mata'a* was used. If the flakes are mostly on one face or another, it will indicate that the *mata'a* were used in such a way that only one face of the tool was actively in use.
- 3) Are there more flakes on the left or right sides of *mata'a*?
 - This will provide insight in to the position in which the *mata'a* was held as it was used. If flakes are mostly on one side or another, it will indicate that the *mata'a* were held in such a way that only one side was in active use. Left and right are from the perspective of the dorsal side.
- 4) Is there a flake size that is more prominent than other flake sizes?
 - This will provide insight into how forceful the movements are. If there is a higher incidence of flakes of one size over another, it

² Diamond, J. (2005). *Collapse: How societies choose to fail or succeed*. Penguin.

³ Hunt, T. L., & Lipo, C. P. (2012). Ecological Catastrophe and Collapse: The Myth of 'Ecocide' on Rapa Nui (Easter Island).

⁴ Lipo, C. P., Hunt, T. L., Horneman, R., & Bonhomme, V. (2016). Weapons of war? Rapa Nui *mata'a* morphometric analyses. *Antiquity*, 90(349), 172-187

⁵ Church, F., & Rigney, J. (1994). A micro-wear analysis of tools from Site 10-241, Easter Island—an inland processing site. *Rapa Nui Journal*, 8(4), 101

⁶ Church, F., & Ellis, J. G. (1996). A use-wear analysis of obsidian tools from an ana kionga. *Rapa Nui Journal*, 10, 81-88.

will indicate that the *mata'a* were moved consistently in ways that produce that size of flake. This information could potentially also inform us about the types of materials the tools were used on, however this I do not investigate that in this study.

- 5) Is there a flake shape that is more prominent than other flake shapes?
 - This will provide insight into the direction the *mata'a* were moved, and what type of motion was employed. If one flake shape is more prominent than the others, it will indicate that the *mata'a* were consistently moved in a manner which creates the certain flake shape. For example, if there are predominantly narrow flakes, it will indicate that the *mata'a* were moved in longer motions.
- 6) Are flake size and flake shape independent?
 - This will provide insight in to whether the *mata'a* were moved in one or more ways that create patterns between flake size and shape. If flake size and shape are not independent, it will indicate that the *mata'a* was used in a consistent pattern, which created certain flake sizes in certain shapes. We cannot limit the motions to one, because it is possible that more than one motion creates similar flakes.
- 7) Are *mata'a* face and flake size independent?
 - This will provide insight into the way that the *mata'a* was held and used. If one face has more flakes of a certain size than another, it will indicate a difference in method of use between the two faces.
- 8) Are *mata'a* face and flake shape independent?
 - This will provide insight into the way that the *mata'a* was held and used. If one face has more flakes of a certain shape than another, it will indicate a difference in use style between the two faces.
- 9) Are *mata'a* side and flake shape independent?
 - This will provide insight into the way that the *mata'a* was held and used. If one side has more flakes of a certain shape than another, it will indicate a difference in use style between the two sides.

10) Are *mata'a* side (left/right) and flake size independent?

- This will provide insight into the way that the *mata'a* was held and used. If one side has more flakes of a certain size than another, it will indicate a difference in use style between the two sides.

These questions will provide insight to general questions regarding the type and location of wear on *mata'a*. These answers will be an important addition to the framework of *mata'a* study.

Background

Environmental Context

Rapa Nui was formed by three volcanoes. It is located about 3,500 km from the coast of Chile to the east and over 2,000 km from the Pitcairn Islands to the west. The island has a few types of lithic resources, primarily red scoria, basalt, and obsidian. Obsidian is the material from which the *mata'a* are created.

There are four obsidian sources on the island, all located towards the Southwestern corner (Fig. 2).

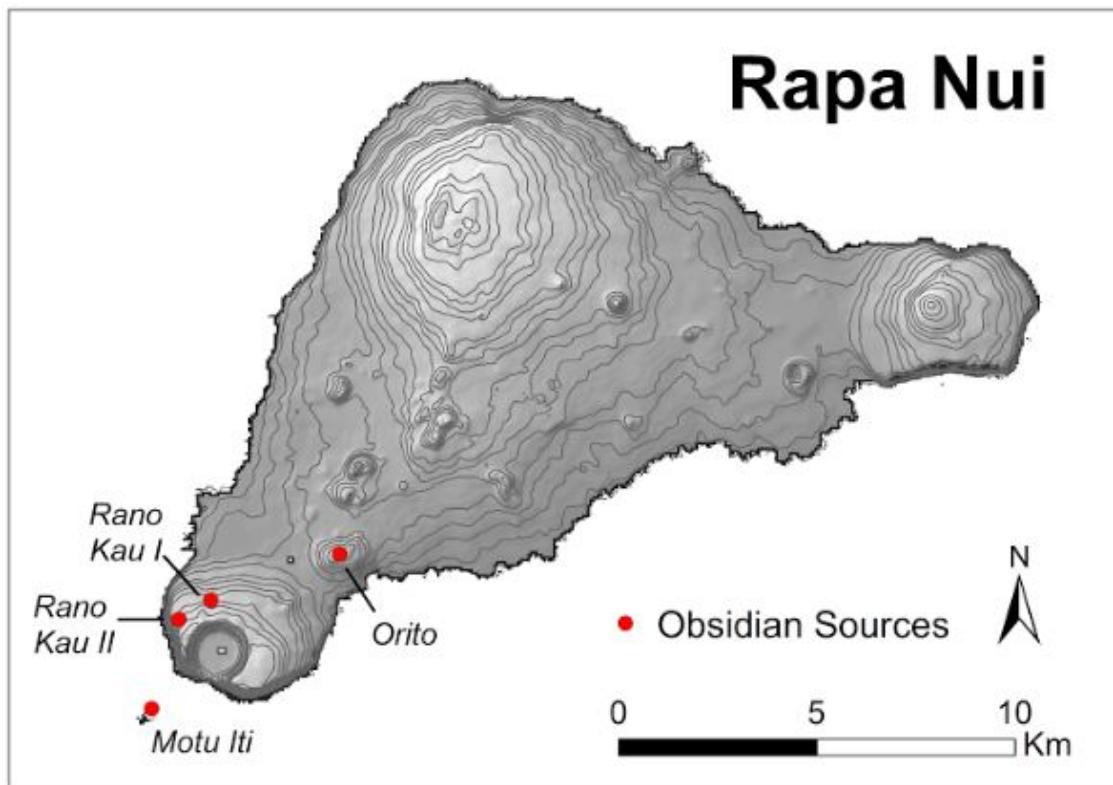


Figure 2: Topographic Map of Rapa Nui with Obsidian Sources (Created by Robert DiNapoli)

Archaeological Context

Lithic resources were a large part of Rapanui life. In addition to the *mata'a*, there were a variety of other lithic tools (such as obsidian flake scrapers, or tools made from basalt) on the island. The Rapanui people even developed an agricultural system involving lithics. They created a system using "lithic mulch."⁷ The deliberately rocky fields allowed for more productive land use on the

⁷ Wozniak, J. A. (1999). Prehistoric horticultural practices on Easter Island: lithic mulched gardens and field systems. *Rapa Nui Journal*, 13(3), 95-99.

windblown island, lessening erosion and holding in moisture in the soil⁸. This type of agriculture was widespread on the island^{9,10}. Often, the gardens are found to have high densities of obsidian debitage mixed in with the porous volcanic rocks which make up the mulch.¹¹ This might suggest that obsidian tools, potentially *mata'a*, are being used in the practice of gardening (i.e. digging) or used to process products of the agricultural practice (i.e. cutting crops).

Mata'a are historically linked with warfare rather than agricultural or domestic use, through the accounts of European's visiting the island. This has played an important role in defining the "collapse" framework through which the island is often viewed.

Historical Descriptions of Mata'a

The first mention of (what is likely) a *mata'a* in written history is seen in a captain's journal from the 1722 Dutch expedition which first made contact with Rapa Nui. The mention of what is likely a *mata'a* appears as the captain, Cornelius Bouman, describes the islanders' mealtime activities, stating that they

⁸ Ladefoged, T. N., Stevenson, C. M., Haoa, S., Mulrooney, M., Puleston, C., Vitousek, P. M., & Chadwick, O. A. (2010). Soil nutrient analysis of Rapa Nui gardening. *Archaeology in Oceania*, 80-85.

⁹ Wozniak, J. A. (1999). Prehistoric horticultural practices on Easter Island: lithic mulched gardens and field systems. *Rapa Nui Journal*, 13(3), 95-99.

¹⁰ Ladefoged, T. N., Stevenson, C. M., Haoa, S., Mulrooney, M., Puleston, C., Vitousek, P. M., & Chadwick, O. A. (2010). Soil nutrient analysis of Rapa Nui gardening. *Archaeology in Oceania*, 80-85.

¹¹ Wozniak, J. A. (1999). Prehistoric horticultural practices on Easter Island: lithic mulched gardens and field systems. *Rapa Nui Journal*, 13(3), 95-99.

“cut bananas with a sharp small black stone around the stem.”¹²

Bouman remarks throughout his journal that there is little violence at all on the island. He does not mention any spears, or weapons. Bouman even explains that, upon the Dutch arrival, “the inhabitants [of Rapa Nui] had absolutely no weapons at all, they approached us in multitudes with their bare hands in order to welcome us, hopping and jumping for joy.”¹³ The primary act of violence in Bouman’s writing on Rapa Nui, in fact, is when “9 or 10” Rapanui people, shot dead by members of Bouman’s crew without command.¹⁴

¹² Von Saher, H. (1994). The Complete Journal of Captain Cornelis Bouman, Master of the ship Theinhoven, Forming Part of the Fleet of Jacob Roggeveen, from 31 March to 13 April 1722 During Their Stay Around Easter Island. *Rapa Nui Journal*, 8(4), 100. Retrieved July 31, 2016.

¹³ Von Saher, H. (1994). The Complete Journal of Captain Cornelis Bouman, Master of the ship Theinhoven, Forming Part of the Fleet of Jacob Roggeveen, from 31 March to 13 April 1722 During Their Stay Around Easter Island. *Rapa Nui Journal*, 8(4), 99. Retrieved July 31, 2016

¹⁴ Ibid.

The Spaniards came across the island in 1770, and *mata'a* are mentioned in writing again. This time, the *mata'a* are presented as possible weapons, though the lack of lethal use is clear. Spanish captain Don Felipe González wrote in his journal that he suspected the Rapanui to be “faint-hearted,” as “they possess no arms, and although in some we observed sundry wounds on the body, which we thought to have been inflicted by cutting instruments of iron or steel, we found that they proceeded from [sharp-edged] stones, which are their only weapons of defence and offence.”¹⁵ González, like Bouman, writes that when the expedition first made contact with the island, the islanders had “no implements of war about them; I only saw many demonstrations of rejoicing and much yelling.”¹⁶

¹⁵ Ship logs of 1770 voyage of Captain Don Felipe González (B. G. Corney, Trans.). (n.d.). Retrieved July 31, 2016, from <https://www.easterisland.travel/easter-island-facts-and-info/history/ship-logs-and-journals/don-felipe-gonzalez-1770/>

¹⁶ Ibid.

Just four years after the Spanish made contact with Rapa Nui, Captain James Cook led an expedition to the island. Journals from the Cook expedition do not mention a joyous greeting, however they mention that when the islanders crowded to the shore to see the ships “not one of them had so much as a stick or weapon of any sort in their hands.”¹⁷ Though the greeting wasn’t a violent one, Captain Cook’s expedition is the first to label the *mata’ā* as actual weapons, describing “lances or spears made of thin ill-shaped sticks, and pointed with a sharp triangular piece of black glassy lava,”¹⁸ seen across the island. Cook’s journals claim that “as harmless and friendly as these people seemed to be, they are not without offensive weapons, such as … spears; which are crooked sticks about six feet long, armed at one end with pieces of flint.”¹⁹ This “spear” terminology stuck.

Over the next 100 years, short visits from European missionaries and explorers brought more reports of the *mata’ā* as weapons, and of the supposed prevalence of warfare. The “spear point” classification became official in a book titled “Te Pito Te Henua, or Easter Island.” Written in 1891 by explorer and “paymaster” William Thomson, the book features an appendix of artifacts, including a photo of what we now know as a *mata’ā*.

¹⁷ Cook, J. (n.d.). Easter Island ship logs: James Cook, 1774. Retrieved July 31, 2016, from <https://www.easterisland.travel/easter-island-facts-and-info/history/ship-logs-and-journals/james-cook-1774/>

¹⁸ Hunt, T., & Lipo, C. (2011). *The Statues that Walked*, 96-97. New York, NY: Free Press.

¹⁹ Cook, J. (n.d.). Easter Island ship logs: James Cook, 1774. Retrieved July 31, 2016, from <https://www.easterisland.travel/easter-island-facts-and-info/history/ship-logs-and-journals/james-cook-1774/>

Accompanying the photo is the label “obsidian spear points,”²⁰ and a description detailing how the *mata‘a* were used, supposedly fixed to longer sticks and thrust or thrown during the islanders as “the chief weapon used...in their frequent strife.”²¹ English archaeologist Katherine Routledge published a book titled “The Mystery of Easter Island” in 1919, and in it she uses the word “spearpoint” to refer to *mata‘a* synonymously. She discusses the role of the *mata‘a* as “both a spear and a javelin,”²² based on discussions with the local people. In 1940, Swiss anthropologist Alfred Métraux also published a book about the island, his entitled “Ethnology of Easter Island.” The book again referred to the *mata‘a* as spearpoints throughout the book, taking the nature of the tools to be given. He cites earlier European writings that claim that wounds from *mata‘a* “were always fatal, if they were deep enough.”²³ It is interesting to consider how much of an impact the earlier European interactions may have had on Rapanui behavior by the early and mid-1900s. By that point, the islanders had been exposed to European ideals, weapons, and violence for around 200 years. It is possible that the role of the *mata‘a* changed in Rapanui society over time, in response to European interaction.

²⁰ Thompson, W. J. (1891). Te Pito te Henua; or, Easter Island, 182. US National Museum Annual Report 1889. Retrieved August 1, 2016, from <https://archive.org/details/tepitotehenuaor00thomgoog>.

²¹ Ibid.

²² Routledge, K. (2005). *The Mystery of Easter Island*, 219. Cosimo, Inc..

²³ Métraux, A. (1971). *Ethnology of Easter Island*, 165. Bishop Museum Pr.

It is important to consider ethnohistoric information, but it is equally as important to consider what implicit bias those ethnohistoric records may hold. All of the writings about *mata'a* (and all of early Rapa Nui) are produced by European visitors. Not all of these visitors were not there to truly learn the culture, language, or traditions, and none stayed long enough to do much more than record observations. Of course, their observations were made through their own worldview, and as such what they recorded likely has a strong Eurocentric bias. Even Thompson, who did aim to gain an understanding of the local culture and traditions was not immune to his own worldview. These writings are necessarily are in a context that their writers understand. It is not the fault of the Europeans that they recorded what they saw in a way that they understood, however it is faulty to assume today that these records are entirely factual and accurate. Archaeological evidence must be examined alongside ethnohistoric information.

Osteological Evidence of Warfare

One of the most telling elements of warfare in the archaeological record is injuries on skeletal remains. A study by Owsley et al. in 1994²⁴ examines injuries on Rapanui remains, as does an expanded study by Owsley in 2016.²⁵ The expanded study looks at skeletal remains of Rapanui people collected from

²⁴ Owsley, D. W., Gill, G. W., & Ousley, S. D. (1994). Biological effects of European contact on Easter Island. In *Edited by CM Stevenson, G. Lee, and FJ Morin, Easter Island in Pacific Context: South Seas Symposium: Proceedings of the Fourth International Conference on Easter Island and East Polynesia. Easter Island Foundation* (pp. 129-34).

²⁵ Owsley, D. W., Barca, K. G., Simon, V. E., & Gill, G. W. (2016). Evidence for injuries and violent death. *Skeletal Biology of the Ancient Rapanui (Easter Islanders)*, 72, 222. Chicago

12 institutions. Though many of the bones are comingled, based on the number of frontal bones found, the minimum number of individuals included in the study is 469. Owsley found that the majority of the injuries were found on cranial bones, and appeared to be the result of blunt-force trauma. Though many crania did show some injury damage, very few showed lethal trauma²⁶. People may have been hitting each other in the head, but they were not killing each other. There was one individual whose cranial injuries indicated that they had been stabbed in the head with an obsidian implement, which may have been a *mata'a*,²⁷ and this is very important to note. It is clear that the *mata'a* had the ability to be used as weapons, however as there is only evidence for one individual being injured by obsidian implement, it appears unlikely that this was the sole or primary *mata'a* purpose.

In addition to the low percentage of bones with injuries, Owsley also states that the data "do not easily conform to the expectations envisioned for periods of intense violence as described in ethnohistoric and other accounts" based on two other lines of evidence.

Firstly, the distribution of injuries is inconsistent with injuries found in societies engaged in violent conflict. "Numerous trunk and upper limb injuries would be expected for individuals engaged in major episodes of warfare,"²⁸ according to

²⁶ Owsley, D. W., Barca, K. G., Simon, V. E., & Gill, G. W. (2016). Evidence for injuries and violent death. *Skeletal Biology of the Ancient Rapanui (Easter Islanders)*, 242

²⁷ Owsley, D. W., Barca, K. G., Simon, V. E., & Gill, G. W. (2016). Evidence for injuries and violent death. *Skeletal Biology of the Ancient Rapanui (Easter Islanders)*, 246

²⁸ Owsley, D. W., Barca, K. G., Simon, V. E., & Gill, G. W. (2016). Evidence for injuries and violent death. *Skeletal Biology of the Ancient Rapanui (Easter Islanders)*, 244

Owsley. The majority of injuries noted on the remains are on the skull. In fact, of the few injuries noted on the clavicle and upper limb, all but one are healed, indicating their non-fatal nature²⁹.

Secondly, the age/sex trauma pattern does not match the profile for a society engaged in violent conflict. Though young males (typically the principal fatalities in instances of warfare) do show a higher rate of cranial injury, they do not appear to have a higher rate of fatal wounding. In addition, female skeletal remains show a slightly higher percentage of postcranial fractures. Owsley suggests this is likely due to ulna fractures as a result of defensive movements stemming from domestic violence³⁰

Owsley notes that while soft-tissue injuries can be fatal, and are not represented in the skeletal record, it is unlikely that those injuries were common, given the types of materials the Rapanui would have had for weapons. As such, Owsley states that “the types and frequencies of injuries observed in Rapanui skeletal remains cannot convincingly be attributed to massacre events or an intense, prolonged civil war”³¹

Artifactual Evidence for Weapons and Warfare

In addition to osteological evidence, evidence of weaponry can be very telling of war in the archeological record. There have been a few formal analyses of

²⁹ Owsley, D. W., Barca, K. G., Simon, V. E., & Gill, G. W. (2016). Evidence for injuries and violent death. *Skeletal Biology of the Ancient Rapanui (Easter Islanders)*, 244

³⁰ Ibid.

³¹ Ibid.

mata'a, which examine microscopic usewear, *mata'a* blade shape, and stylistic variation in attempts to better understand the function of the tool.

In the mid-1990s, a series of studies were done on the microwear on obsidian tools on the island, aiming to find out on which materials they were used.

Church and Rigney (1994) examined an obsidian assemblage from an inland site, Site 10-241, in South-Central Rapa Nui. The assemblage contained 1136 items. Of these, two were complete *mata'a*, 11 were *mata'a* fragments, four were possible drills, and the rest were useddebitage. Eighteen items were chosen for analysis, in order to provide a variety of artifact classes and proveniences. These items were examined by the high-power approach (see page 22) with an incident light microscope with 80x-1000x magnification, and striations, abrasions, and polishes were documented. These instances of wear were compared against wear present on experimentally developed tools. This allowed the researchers to determine the activities performed, since they knew which actions were performed with the experimentally produced tools, and could compare flakes on these to the flakes on the archaeological tools. This comparison led to the conclusion that the most common activity the *mata'a* was used for was scraping, followed by cutting. Other actions identified were sawing and whittling. Church and Rigney also attempt to determine the materials worked, again relying on comparison with experimentally developed tools. They conclude that the primary materials worked were fresh plants, followed by soft

wood and fish.³² They conclude that the activities shown by the wear “are inconsistent with the original proposed function of these tools as spearpoints.”³³ Potential limitations of this research include the very small number of complete *mata'a*, the lack of macroscopic analysis, and the reliance on experimentally produced tools. Such experiments, while potentially entirely valid, are inherently incomplete. Since modern archaeologists can only take very educated guesses at the potential movements made and materials worked by the tools, there is always the possibility that a motion or material doesn't occur to the experimenters. It is probably impossible to consider every single possible movement a tool could make. Another issue inherent with relying on experimentally produced data, especially when dealing with lithics, is the potential for more than one action to produce similar results³⁴. Photos of their example results are shown, and appear to be different enough at the microscopic scale to be identifiable, however this is always something that must be kept in mind when doing or reading a study that includes replicated experimental tools as a reference. Chuch and Ellis (1996) performed a similar study a few years later. This study again used the high-power approach to examine 36 obsidian artifacts from Ana Kionga, a cave site on the island. Two of these artifacts were full *mata'a*, and the others were large obsidian flakes³⁵.

³² Church, F., & Rigney, J. (1994). A micro-wear analysis of tools from Site 10-241, Easter Island—an inland processing site. *Rapa Nui Journal*, 8(4), 101

³³ Church, F., & Rigney, J. (1994). A micro-wear analysis of tools from Site 10-241, Easter Island—an inland processing site. *Rapa Nui Journal*, 8(4), 104

³⁴ Dibble, H. L. (1997). Platform variability and flake morphology: a comparison of experimental and archaeological data and implications for interpreting prehistoric lithic technological strategies. *Lithic technology*, 22(2), 150-170.

³⁵ Church, F., & Ellis, J. G. (1996). A use-wear analysis of obsidian tools from an ana kionga. *Rapa Nui Journal*, 10, 81-88.

37 total instances of wear were documented. Documented wear included polish, striations, and residues, and was compared against wear from previously experimentally produced tools. It was concluded that the wear was produced by a set of actions: cutting, scraping, sawing, whittling, and hafting. 81% is attributed to cutting and scraping. Church and Ellis also use residue analysis and experimentation to conclude that materials worked by the *mata'a* were primarily plants (51%), followed by bone (16%), wood (14%) and hide (14%). Unfortunately, Church and Ellis do not specify which animal this hide may have come from. This study was primarily aimed at understanding the role of the cave-site, however Church and Ellis state that the microwear on the tools is indicative of "a wide range of domestic activities," and do not mention the tools showing wear indicative of weaponry.³⁶ This study shares similar limitations to the previous study, in that it relies on experimentally produced tools as a reference, does not include macroscopic wear, and has a very low number of complete *mata'a* actually examined. This thesis will complement these papers by adding a macroscopic analysis, as well as observing where on the tool the wear is located, and whether there are any clear patterns in flake distribution.

More recently, Lipo et al. 2016 conducted a morphometric analysis of the tools, examining *mata'a* shape variability. The guiding hypotheses were that if the

³⁶ Church, F., & Ellis, J. G. (1996). A use-wear analysis of obsidian tools from an ana kionga. *Rapa Nui Journal*, 10, 87

mata'a were systematically produced weapons of warfare, their distal ends would:

- 1) Be “constrained in shape due to the demands of performance in combat”
- 2) “Show a tendency towards a spear-like shape that is consistent with the penetration of enemies.”³⁷

The study looked at a total of 423 *mata'a*. Using elliptical Fourier analysis, outlines of the *mata'a* were compared over each other, looking not only for overall trends but also for “aspects of shape that might distinguish subgroups from each other.”³⁸

Results of the analysis indicated that *mata'a* shapes “vary continuously in their outlines,” and that “there were no subsets of distinctive, lanceolate-shaped objects or any other subgroups.”³⁹ The study concludes that the analysis produced evidence that “fails to support hypotheses about the use of [the *mata'a*] as lethal weapons involved in systematic warfare.”⁴⁰

There have been a number of studies in the past which attempt to classify *mata'a* in to categories^{41,42,43}, such as specific cutting and scraping *mata'a*, however no set of classifications has emerged as a strong and definitive list of types, and as such, classifications are not often taken in to account in current

³⁷ Lipo, C. P., Hunt, T. L., Horneman, R., & Bonhomme, V. (2016). Weapons of war? Rapa Nui *mata'a* morphometric analyses. *Antiquity*, 90(349), 180.

³⁸ Ibid.

³⁹ Ibid.

⁴⁰ Lipo, C. P., Hunt, T. L., Horneman, R., & Bonhomme, V. (2016). Weapons of war? Rapa Nui *mata'a* morphometric analyses. *Antiquity*, 90(349), 184.

⁴¹ Thomson, W. J. (1891). Te pito te henua; or, Easter Island. Smithsonian Institution. P.536

⁴² Routledge, K. (1919). *The Mystery of Easter Island: The Story of an Expedition*. P. 223

⁴³ Bormida, M. (1951). Formas y funciones del ‘mata’, el mas conocido artefacto de la arqueología de Pascua. Archivo para las ciencias del hombre, 4(part 1), 2.

mata'a literature. In 2000, Dr. Ayres conducted a study in which he examined tool typology and usewear across Rapa Nui.⁴⁴ He concluded that the *mata'a* were a type of tool, within a larger spectrum of Rapanui tools. Rather than being a class of tool, with individual *mata'a* types within that class, the *mata'a* were instead a single type of tool.

In a similar vein, a study was recently done which examined stylistic variability of *mata'a* using frequency seriation, in an attempt to study cultural interaction and cultural transmission across the island. The results demonstrated a “strong spatial and temporal pattern among assemblages,” primarily in the manufacture method of the stem. The blade shape (distal end) varied widely across the island. There did not appear to be any strong spatial or temporal patterns among the distal ends of the *mata'a*. The findings allow for a conclusion that the *mata'a* may not fit in to a set of functional classifications, as their blade shape varies so widely, however the *mata'a* can be potentially classified by location and temporality when looking at the stems^{45,46}. This lack of pattern among the distal, blade end of the tool supports the multi-use tool hypothesis rather than the weapon hypothesis, or any hypothesis which furthers a single use. The

⁴⁴ Easter Island Obsidian Artifacts: Typology and Use-wear. In Easter Island Archaeology: Research on Early Rapanui Culture, C. Stevenson, W. Ayres (2000). eds. Los Osos: Easter Island Foundation.

⁴⁵ Lipo, C. P., Hunt, T. L., & Hundtoft, B. (2010). Stylistic variability of stemmed obsidian tools (*mata'a*), frequency seriation, and the scale of social interaction on Rapa Nui (Easter Island). *Journal of Archaeological Science*, 37(10), 2551-2561.

⁴⁶ Lipo, C. P., Hunt, T. L., & Hundtoft, B. (2015). AN ANALYSIS OF STYLISTIC VARIABILITY OF STEMMED OBSIDIAN TOOLS (MATA'A) ON RAPA NUI (EASTER ISLAND). *Lithic Technological Systems and Evolutionary Theory*, 225.

variable blade shape suggests that the *mata'a* were not manufactured differently for different tasks, suggesting they held many roles.

Lithic Usewear

There has been extensive research done regarding lithic usewear analysis, both in terms of usewear studies themselves, and in terms of studies done on the effectiveness of usewear analysis as a field. Early lithic studies focused heavily on classifying tools into categories (e.g. scraper, adze, drill, arrow), using primarily morphological attributes⁴⁷. The categorized tools were then used to infer function, as well as broad society-wide changes in the communities being studied.⁴⁸ For example, this meant looking at a rounded tool and inferring it as a scraper, or looking at pointed tools and assuming them to be spears. Classification investigations can be very telling and are still an employed method of study today, however another method of functional analysis, complementary to classification studies, emerged soon after early studies.

Russian archaeologist Sergei Semenov pioneered the technique of examining the wear on the tools and performing experiments to re-create wear patterns. He did not disavow classifications, however he furthered the perspective that “functional attribution based in simple analytical description with no direct

⁴⁷ Marreiros, J. M., Bao, G., & Bicho, N. F. (2015). Use-wear and residue analysis in archaeology. Springer International Publishing

⁴⁸ Marreiros, J. M., Bao, G., & Bicho, N. F. (2015). Use-wear and residue analysis in archaeology. Springer International Publishing.

evidences of use was erroneous.”⁴⁹ He argued that, while “typology assumes an important role in archaeology,” understanding the tools “shouldn’t be limited by typological classification...Paleolithic studies need a paleoethnographic and paleotechnical reconstruction of the past human societies,”⁵⁰ where “paleoethnographic” refers to broad typologies and “paleotechnical” refers to evidence-based wear studies. Though many of Semenov’s experiments were later critiqued on their validity in associating specific flake patterns with specific worked materials⁵¹, he laid the groundwork for examining lithics with from-the-tool evidence as opposed to solely through the morphologic lens. He pioneered the method of lithic study which observes aspects of wear on individual tools. He observed things like flake patterns, striations, and abrasions on individual tools, while the rest of the lithic analysis community focused on observing broad descriptive elements of the tools, primarily shape. While shape can be a telling factor when determining tool function, wear on the tools complements these broader studies with specific information about each tool, so that function may be more comprehensively inferred.

⁴⁹ Ibid.

⁵⁰ Semenov, S. A. (1970). The forms and functions of the oldest tools. *Quartär*, 21, 1-20.

⁵¹ Marreiros, J. M., Bao, G., & Bicho, N. F. (2015). Use-wear and residue analysis in archaeology. Springer International Publishing

Following the introduction of usewear analysis, many researchers have debated how this analysis is best done.

There has been a large focus on experimentation^{52, 53}, which in turn created a focus on experiments with blind tests, as a method of verifying experimental results^{54, 55}. Early usewear studies focused mainly on low-power magnification examination, examining only what could be seen with the eye.⁵⁶ This method soon proved to make extremely detailed work difficult, as it only allowed for somewhat preliminary conclusions to be made, such as method of tool movement.⁵⁷

High-power analysis, introduced by Lawrence Keeley in the early 1980s, allows for a more detailed and comprehensive lithic analysis. Using high-powered microscopy, researchers can observe wear such as microabrasions, striations, or polishes created from repetitive movements.⁵⁸ There has been much debate about the limitations of each type of study, however it is generally concluded that the two methods are complementary in terms of functional analyses.⁵⁹

⁵² Odell, G. H., & Cowan, F. (1986). Experiments with spears and arrows on animal targets. *Journal of Field Archaeology*, 13(2), 195-212.

⁵³ Fischer, A., Hansen, P. V., & Rasmussen, P. (1984). Macro and micro wear traces on lithic projectile points: experimental results and prehistoric examples. *Journal of Danish Archaeology*, 3(1), 19-46.

⁵⁴ Evans, A. A. (2014). On the importance of blind testing in archaeological science: the example from lithic functional studies. *Journal of Archaeological Science*, 48, 5-14.

⁵⁵ Odell, G. H., & Odell-Vereecken, F. (1980). Verifying the reliability of lithic use-wear assessments by 'blind tests': the low-power approach. *Journal of field Archaeology*, 7(1), 87-120.

⁵⁶ Marreiros, J. M., Bao, G., & Bicho, N. F. (2015). Use-wear and residue analysis in archaeology. Springer International Publishing

⁵⁷ Ibid.

⁵⁸ Ibid.

⁵⁹ Odell, G. H. (2001). Stone tool research at the end of the millennium: classification, function, and behavior. *Journal of Archaeological Research*, 9(1), 45-100.

This study employs the former method of study: the low-power approach. Due to time constraints during data collection, the preliminary nature of this investigation, and a lack of this type of “preliminary” paper on the topic, examining solely the visible flakes and edge damage on the tools in order to make a statement about their movement seemed the best method of study for this research.

Flake patterns indicate a few aspects of tool use. Noting the location of the wear can indicate the manner in which the tool was held and used. If all flakes are on the left side of a tool, for example, it was held in such a way that the entire left side was put to use (i.e. sideways), and used solely on that one side. There is evidence that projectile points used as weapons typically feature large longitudinal flakes along one side of the tool in question⁶⁰. There are additional microscopic traces of weaponry use, the most prominent of which is the presence of striations oriented parallel to the long axis of the tool,⁶¹ however I do not observe microscopic aspects of wear in this study. When there is not a consistent flake pattern, it often indicates that the tools were multi-use tools.⁶²

⁶⁰ Dockall, J. E. (1997). Wear traces and projectile impact: a review of the experimental and archaeological evidence. *Journal of Field Archaeology*, 24(3), 321-331.

⁶¹ Ibid.

⁶² Odell, G. H., & Odell-Vereecken, F. (1980). Verifying the reliability of lithic use-wear assessments by ‘blind tests’: the low-power approach. *Journal of field Archaeology*, 7(1), 87-120.

One issue inherent in macroscopic analysis is that often flakes which are created by different motions appear to have identical shapes. This is particularly true in obsidian flaking, as the stone tends to flake into wide flakes more often than it flakes into any other shape.⁶³ These shapes may have slight consistent variances when observed microscopically^{64,65}, however at the level I observed, it is not possible to ascertain a difference. This limits my study in that it only allows me to offer a variety of potential motions as opposed to one, however as I will discuss later, that is not an issue given my conclusion.

Obsidian tools present other interesting dilemmas and opportunities for usewear studies. On one hand, the smooth and glassy nature of obsidian virtually eliminates mistaking grains or bumps in the stone itself as human-created wear.⁶⁶ In addition, obsidian lacks crystal structures (other than occasional, scattered small crystallite), which means that flakes creation is controlled by external force rather than the crystalline patterns in the stone.⁶⁷ This allows us to assume that the flakes observed are strong indicators of tool use.

⁶³ Domanski, M., Webb, J. A., & Boland, J. (1994). Mechanical properties of stone artefact materials and the effect of heat treatment. *Archaeometry*, 36, 177-177.

⁶⁴ Church, F., & Ellis, J. G. (1996). A use-wear analysis of obsidian tools from an ana kionga. *Rapa Nui Journal*, 10, 87

⁶⁵ Church, F., & Rigney, J. (1994). A micro-wear analysis of tools from Site 10-241, Easter Island—an inland processing site. *Rapa Nui Journal*, 8(4)

⁶⁶ Beyin, A. (2010). Use-wear analysis of obsidian artifacts from Later Stone Age shell midden sites on the Red Sea Coast of Eritrea, with experimental results. *Journal of Archaeological Science*, 37(7), 1543-1556.

⁶⁷ Ibid.

On the other hand, because it is formed by quickly cooled lava, obsidian is extremely brittle. Because of this brittle nature, it is susceptible to high amounts of post-depositional damage.⁶⁸ In this study, I was able to identify human-created flakes by their consistent placement along the edges of the tools, however I was unable to ascertain whether or not the edge damage I noted was pre- or post-depositional. I defined edge damage as wear present on the edge which was *only* present on the edge and did not flake either face. As such, though I recorded it, I do not consider edge-damage during the majority of my analysis. This limits this study in that I may be missing some information helpful to my questions, however not analyzing it removes the risk of over-counted data, and drawing false conclusions.

⁶⁸ Ibid.

Analysis and Results

In this thesis, I describe and analyze flake and use-wear patterns on 47 *mata'a* from the collections housed at the Father Sebastian Englert Museum on Rapa Nui. These artifacts were surface-collected by Father Sebastian Englert during his surveys of the island in the 1930s. This dataset is limited by the fact that the artifacts have no provenience or provenance information, limiting the possibility for any chronological or geographical interpretations. I do not believe this is detrimental to my results, as it has been shown that blade shape varies widely and continuously across the island.⁶⁹ I perform this study accepting the *mata'a* as one class of tools on the island, rather than attempting to parse out various classifications of *mata'a*. This study focuses solely on the flakes on the individual *mata'a*, or what Semenov would refer to as the “paleotechnical” element of study.⁷⁰

Data Collection

The *mata'a* analyzed in this study are a part of the collection at the Father Sebastian Englert Anthropological Museum on Rapa Nui. The *mata'a* were part of a collection of tools with no provenience, provenance, or prior sorting, providing a wide range of sizes and shapes of *mata'a*. As these tools were brought in as surface collected tools, likely collected while surveying the island,

⁶⁹ Lipo, C. P., Hunt, T. L., Horneman, R., & Bonhomme, V. (2016). Weapons of war? Rapa Nui *mata'a* morphometric analyses. *Antiquity*, 90(349), 172-187.

⁷⁰ Semenov, S. A. (1970). The forms and functions of the oldest tools. *Quartär*, 21, 1-20.

it is also likely that these tools come from an assortment of locations on the island. While this allows variety, it limits further analysis into locational variance of tool use.

Mata'a were photographed from both dorsal and ventral sides and traced. The ventral side of the *mata'a* is defined as the face featuring a bulb of percussion (see Figure 4), which is formed when a large obsidian flake (which will become the *mata'a*) is broken off a larger obsidian core. The dorsal side (see Figure 3) is defined as the face lacking a bulb of percussion, and it often retains sections of cortex. Photos of all *mata'a* are included as an appendix (Appendix 1).



Figure 3: Example Dorsal Side with cortex. *Mata'a* 17-01-1331

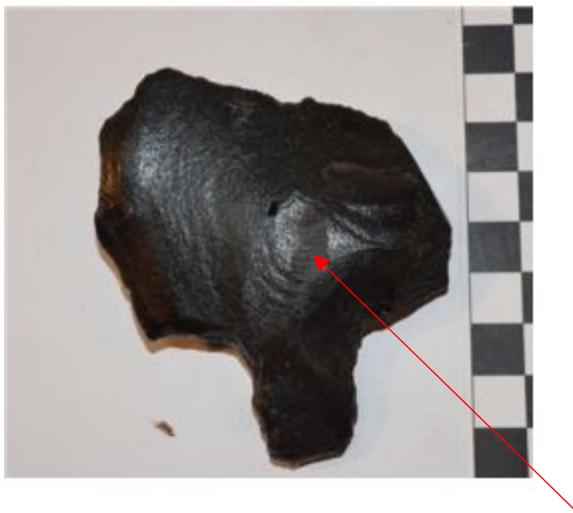
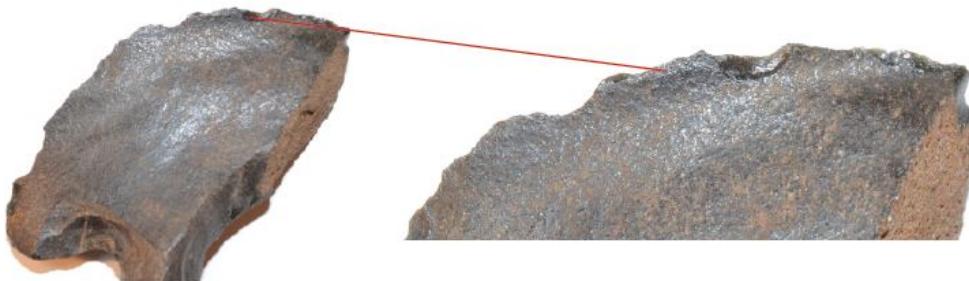


Figure 4: Example ventral side with bulb of percussion Mata'a 17-01-1329

On the traced images, the wear on each side was noted. The damage appeared to be primarily flakes, however edge damage was also present and noted. As noted earlier, though edge damage was originally noted, it was not analyzed as I was not able to determine pre- or post-deposition wear. The flakes were recorded in terms of size (small, roughly 0-1 centimeter, medium, roughly 1-3 centimeters, and large, 3 or more centimeters) and shape (wider than they were long, longer than they were wide, or approximately equal length and width.) The shapes were simplified after the initial recording to “Wide,” “Narrow,” and “Even,” (see below).

Flake Size			Flake Shape		
Small	Medium	Large	Wide	Narrow	Even
< 1cm	1-3 cm	> 3cm	Width>length	Length>width	Length=width



Mata'a 1715-01-0534

Small, wide



Mata'a 1715-01-0531

Medium, narrow



Mata'a 1715-01-0337

Large, even

Figure 5: Flake examples

After data collection, the traced *mata'a* images were divided into four quadrants, with the vertical divider being the center of the stem, and the horizontal divider being the measured middle of the tool (Figure 6). In addition to its size and shape, usewear was catalogued by its location (upper left, upper right, lower left, or lower right) and side (dorsal, ventral).. Initially categorizing wear in these specific categories allowed for broader categories to be put together (e.g. "left vs. right," "upper vs. lower," & "dorsal vs. ventral").

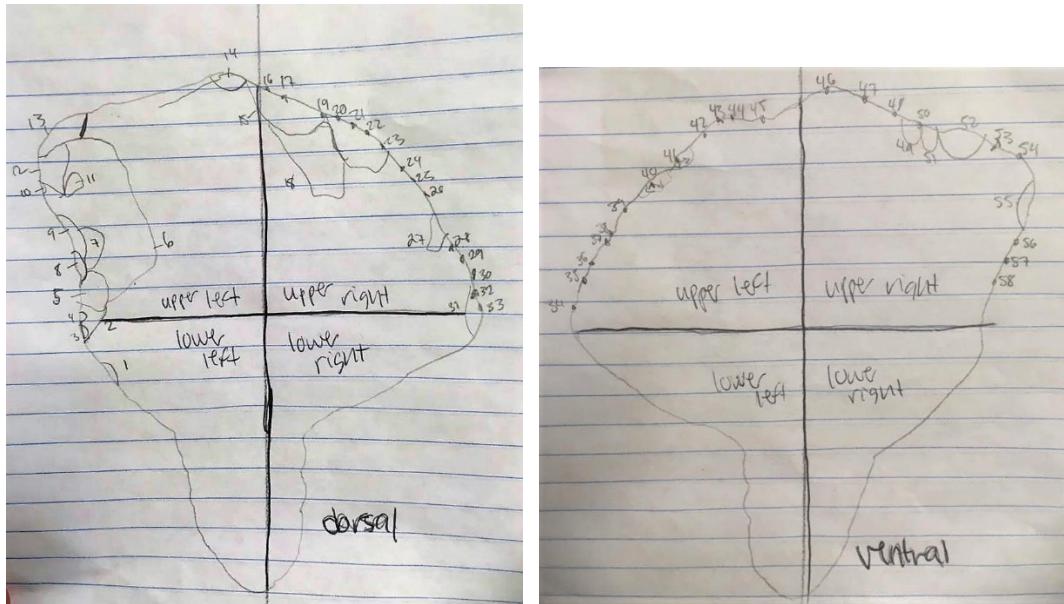


Figure 6: Traced & quartered *mata'a* examples

Research Questions

In my attempt to study *mata'a* movement through usewear on the tools, I investigated a series of questions. I've listed them again here. All questions were answered using R⁷¹.

⁷¹ R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>

1) Are there more flakes on the upper or lower portions of the *mata'a*?

- This will provide insight into the position in which the *mata'a* was held as it was moved. If the flakes are mostly in one location versus the other, it will indicate that the *mata'a* was held primarily upright, sideways, or in a downward position.

2) Are there more flakes on the dorsal or ventral faces of *mata'a*?

- This will provide insight into the way in which the *mata'a* was used. If the flakes are mostly on one face or another, it will indicate that the *mata'a* were used in such a way that only one face of the tool was actively in use.

3) Are there more flakes on the left or right sides of *mata'a*?

- This will provide insight into the position in which the *mata'a* was held as it was used. If flakes are mostly on one side or another, it will indicate that the *mata'a* were held in such a way that only one side was in active use. Left and right are from the perspective of the dorsal side.

4) Is there a flake size that is more prominent than other flake sizes?

- This will provide insight into how forceful the movements are. If there is a higher incidence of flakes of one size over another, it will indicate that the *mata'a* were moved consistently in ways that produce that size of flake. This information could potentially also inform us about the types of materials the tools were used on, however this I do not investigate that in this study.

5) Is there a flake shape that is more prominent than other flake shapes?

- This will provide insight into the direction the *mata'a* were moved, and what type of motion was employed. If one flake shape is more prominent than the others, it will indicate that the *mata'a* were consistently moved in a manner which creates the certain flake shape. For example, if there are predominantly narrow flakes, it will indicate that the *mata'a* were moved in longer motions.

6) Are flake size and flake shape independent?

- This will provide insight into whether the *mata'a* were moved in one or more ways that create patterns between flake size and shape. If flake size and shape are not independent, it will indicate that the *mata'a* was used in a consistent pattern, which created certain flake sizes in certain shapes. We cannot

limit the motions to one, because it is possible that more than one motion creates similar flakes.

7) Are *mata'a* face and flake size independent?

- This will provide insight into the way that the *mata'a* was held and used. If one face has more flakes of a certain size than another, it will indicate a difference in method of use between the two faces.

8) Are *mata'a* face and flake shape independent?

- This will provide insight into the way that the *mata'a* was held and used. If one face has more flakes of a certain shape than another, it will indicate a difference in use style between the two faces.

9) Are *mata'a* side and flake shape independent?

- This will provide insight into the way that the *mata'a* was held and used. If one side has more flakes of a certain shape than another, it will indicate a difference in use style between the two sides.

10) Are *mata'a* side (left/right) and flake size independent?

- This will provide insight into the way that the *mata'a* was held and used. If one side has more flakes of a certain size than another, it will indicate a difference in use style between the two sides.

Research Question 1:

I began by comparing the average number of flakes on the upper sections of the *mata'a* to the average number of flakes on the lower sections of the *mata'a*.

I began with this because while cataloguing, this difference seemed to be the most prominent. Upper sections of *mata'a* (no differentiation between dorsal/ventral or left/right) ranged in number of flakes from 20 to 54, averaging 32, while lower sections ranged from 0 to 24, averaging 4 (see table 1). This immediately seemed to indicate that wear was much more present on the upper

sections of *mata'a* than it was on the lower. This makes sense, given that the *mata'a* were known to be hafted, however further analysis was done in order to avoid assumptions and provide as thorough an analysis as possible.

Total:	47	all upper	all lower
		Min. :20.00	Min. : 0.000
		1st Qu.:25.50	1st Qu.: 0.500
		Median :31.00	Median : 2.000
		Mean :32.36	Mean : 4.021
		3rd Qu.:38.00	3rd Qu.: 6.000
		Max. :54.00	Max. :24.000

Table 1: Upper & Lower Mata'a Data

To visualize relationships among and between variables, I created histograms and boxplots of each dataset.

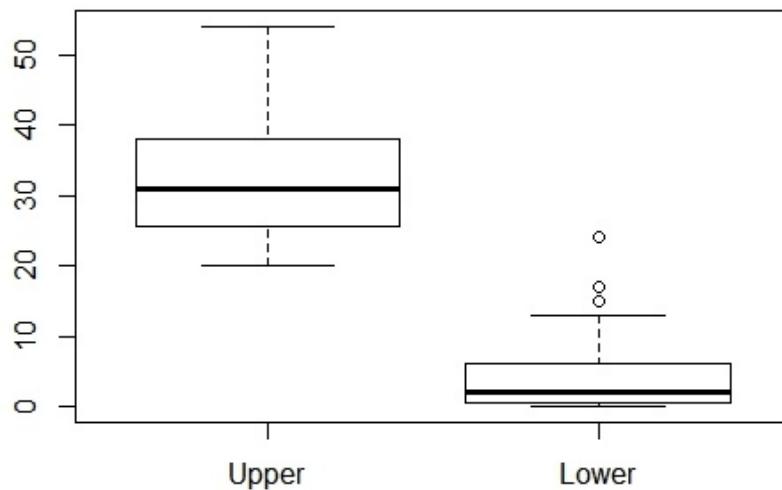


Figure 7: Upper and Lower *Mata'a* Flakes

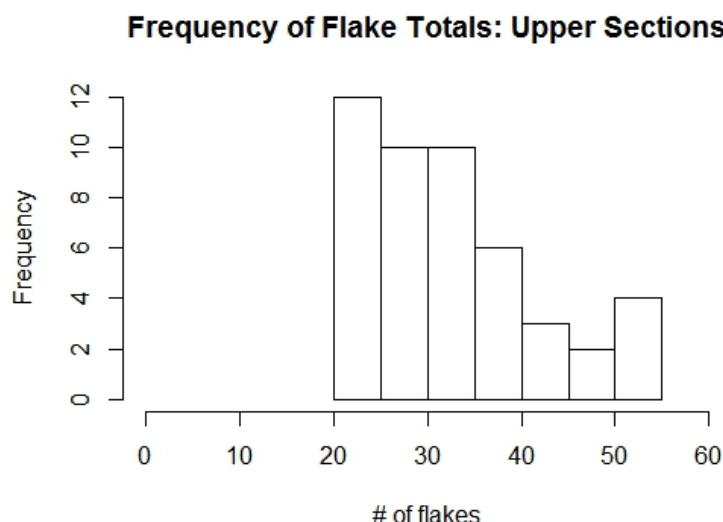


Figure 8: Upper Flake Totals Histogram

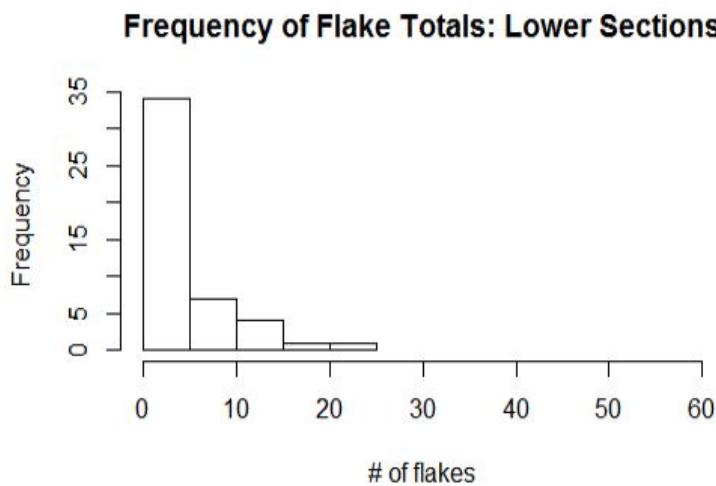


Figure 9: Lower Flake Totals Histogram

The histograms indicate that there are higher numbers of flakes on the upper *mata'a* sections than the lower sections. The histograms also indicate that the data are not normally distributed. Whether the data are normal or non-normal will determine which statistical tests are the most appropriate. For

example, departures from normality may violate the assumptions of parametric tests, such as the student's T test, and therefore a non-parametric test may be needed. Though this was pretty clear from the histograms, I performed a Shapiro-Wilks test of normality on both the upper and lower datasets in order to confirm. For this test, the lower the p-value, the less chance the data are normally distributed. The W value indicates the strength of the result. The upper dataset returned very low results ($W = 0.92846$, $p < 0.01$), as did the lower dataset ($W = 0.76353$, $p < 0.01$), indicating departures from normality.

Because the data is non-normal, I used a non-parametric test in order to test for a significant difference between the total number of upper and lower flakes. I used a two-sided Kolmogorov-Smirnov test (similar to a two-sided T-test for normally distributed data) to test this question. For this test, and all following significance tests, I test at the 99% confidence ($p=0.01$) level. The results of this test indicated a significant difference ($D=0.97872$, $p < 0.01$). The D statistic indicates the strength of the relationship, and the larger the number, the stronger the relationship. This D statistic indicates a very strong relationship, and the p-value allows us to conclude that there are significantly more flakes on the upper portion of the *mata'a* than the lower portion. Because my result was so strong, I chose to only examine the wear on the upper portions of the *mata'a* for the rest of the tests I performed.

Research Question 2:

I followed a similar procedure to answer this question as I did the first. The number of flakes on the dorsal side of the upper sections ranged from 5 to 30, averaging 16.6, and number of flakes on the ventral side ranged from 7 to 37, averaging 15.7 (see table 2). Histograms and the Shapiro-Wilks tests indicated that the dorsal face had normally distributed wear ($W = 0.96591$, $P=0.184$), however the ventral side did not ($W = 0.92217$, $P<0.01$). Because of the non-normality of the ventral face, I again performed the non-parametric KS test to test for a significant difference between the number of flakes on the ventral face versus the dorsal face. The results did not indicate a significant difference ($D=0.12766$, $p= 0.8384$). This is a weak relationship, and the difference is not significant. There does not appear to be a significant difference between the number of flakes on the dorsal face of the mata'a and the ventral face.

Upper Dorsal	Upper Ventral
Min. : 5.0	Min. : 7.00
1st Qu.:12.0	1st Qu.:12.00
Median :16.0	Median :13.00
Mean :16.6	Mean :15.77
3rd Qu.:21.5	3rd Qu.:19.50
Max. :30.0	Max. :37.00

Table 2: Dorsal & ventral Data

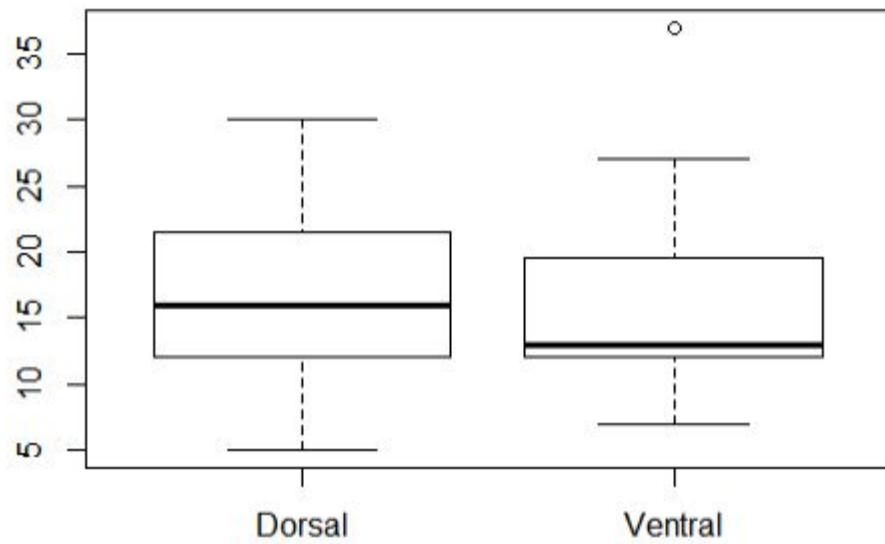


Figure 10: Upper Dorsal and Ventral Flake Totals

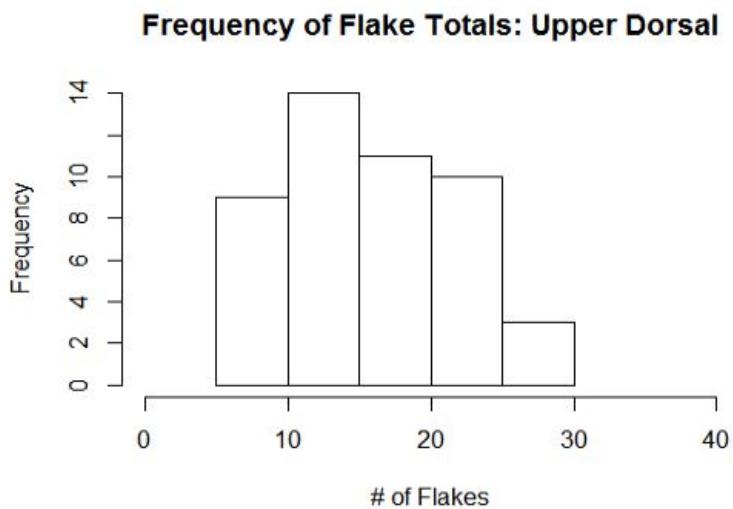


Figure 11: Upper Dorsal Flake Totals Histogram

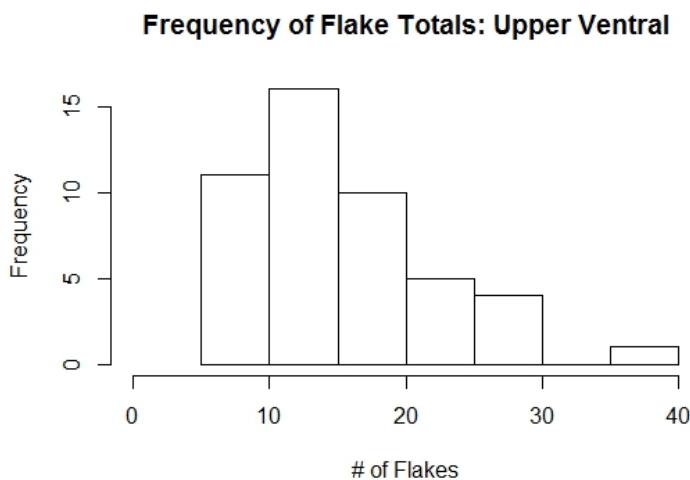


Figure 12: Upper Ventral Flake Totals Histogram

Research Question 3

I performed similar analyses to answer my third question. Left and right was decided from the dorsal point of view. Flakes on the upper left side of the dorsal face and flakes on the upper right side of the ventral face were combined as the “upper left,” and flakes from the upper right side of the dorsal face and the upper left side of the ventral face were combined as “upper right.”

The number of flakes on the left sections of the *mata'a* ranged from 6 to 30, averaging 15.85. The number of flakes on the right sections of the *mata'a* ranged from 4 to 29, averaging 15.15 (see Table 3). Histograms and Shapiro-Wilks tests indicated normality. Shapiro-Wilks results were ($W= 0.96806$, $p=0.2232$) for the left side and ($W= 0.96725$, $p= 0.2077$) for the right side. Even though these results would typically lead to a parametric test of significance (i.e. a Student's T Test), I performed a KS test in order to maintain consistency.

Very few other datasets tested to be normal. A KS test returned results which did not indicate significance ($D = 0.17021$, $p = 0.5038$). There does not appear to be a significant difference in the number of flakes on the left side of the *mata'a* and the right side.

Upper Left	Upper Right
Min. : 6.00	Min. : 4.00
1st Qu.:12.50	1st Qu.:10.50
Median :15.00	Median :14.00
Mean :15.85	Mean :15.15
3rd Qu.:19.00	3rd Qu.:20.00
Max. :30.00	Max. :29.00

Table 3: Upper Left & Right Data

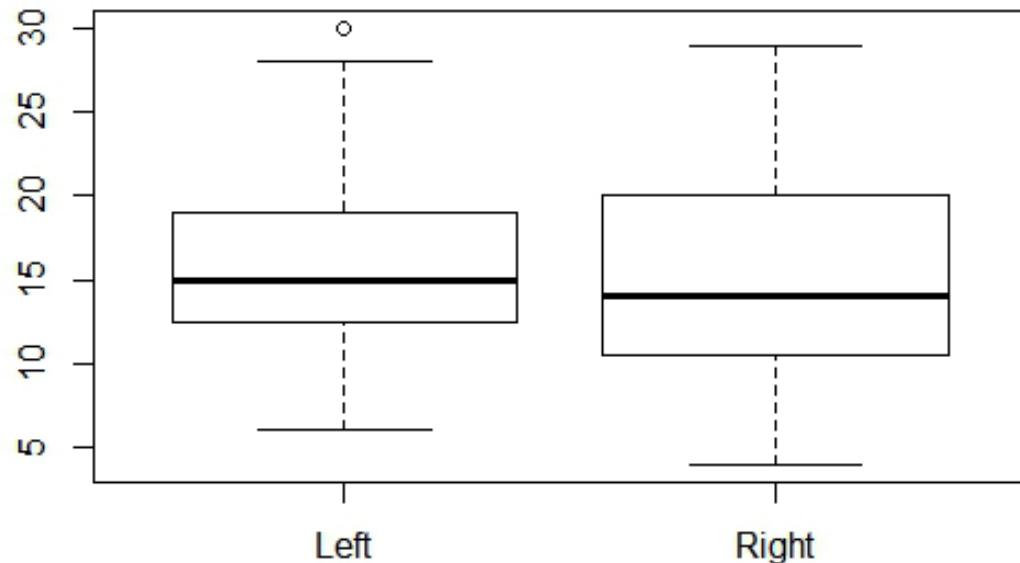


Figure 13: Upper Left and Right Flake Totals

Frequency of Flakes: Upper Left

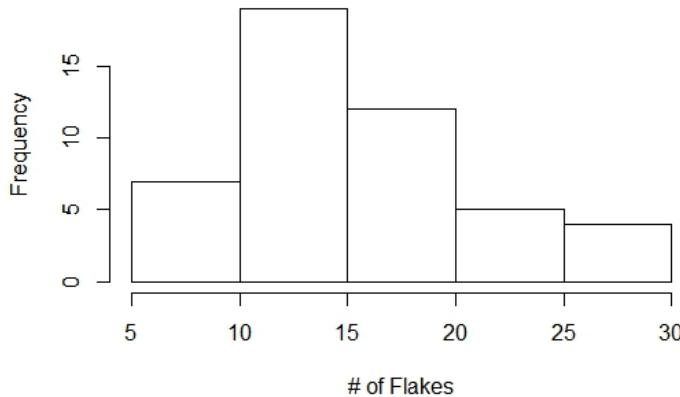


Figure 13: Upper Left Flake Totals Histogram

Frequency of Flakes: Upper Right

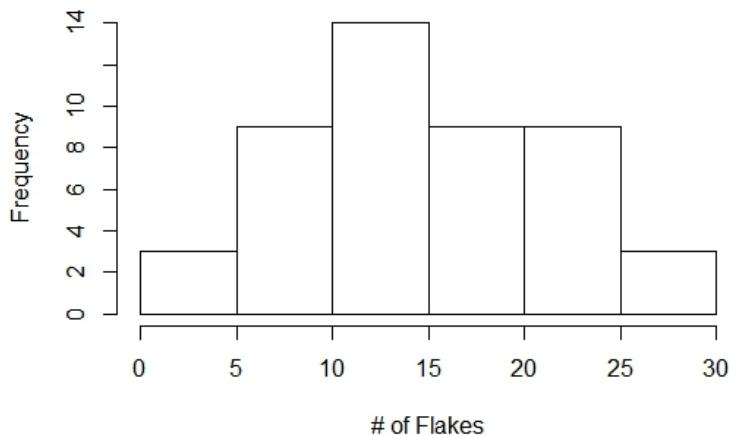


Figure 14: Upper Right Flake Totals Histogram

Research Questions 4:

The total number of flakes of each size, on each *mata'a* (on the upper portions) are summarized in table 4. The number of large flakes on the *mata'a* ranged from 0 to 9, averaging just over 2. The number of medium flakes ranged from 0 to 15, averaging just over 4. The number of small flakes on the *mata'a* ranged from 4 to 30, averaging just below 15. Edge damage was present on every

mata'a, ranging from just 1 occurrence to 28, averaging about 9 instances.

Because I was unable to ascertain what edge damage was due to use and what was caused post-deposition, I do not include edge damage in any of my following investigations, and do not perform any tests of significance with edge damage included.

LARGE	MEDIUM	SMALL	Edge Damage
Min. :0.000	Min. : 0.00	Min. : 4.00	Min. : 1.000
1st Qu.:1.000	1st Qu.: 2.00	1st Qu.:10.00	1st Qu.: 5.000
Median :2.000	Median : 4.00	Median :14.00	Median : 9.000
Mean :2.298	Mean : 4.34	Mean :14.77	Mean : 9.468
3rd Qu.:3.000	3rd Qu.: 6.00	3rd Qu.:19.00	3rd Qu.:12.000
Max. :9.000	Max. :15.00	Max. :30.00	Max. :28.000

Table 4: Flake Size Data

In order to visualize the data, I created a boxplot and histograms. The boxplot indicates a large difference between the amount of small flakes and the amounts of large and medium flakes. The difference between medium and large flakes is harder to discern from the boxplot.

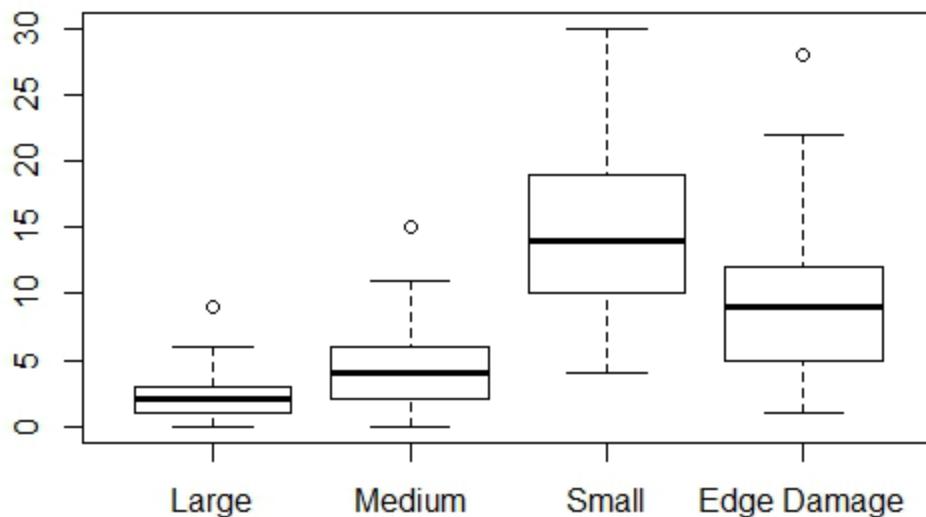


Figure 15: Flake Size Boxplot

Frequency of Large Flakes

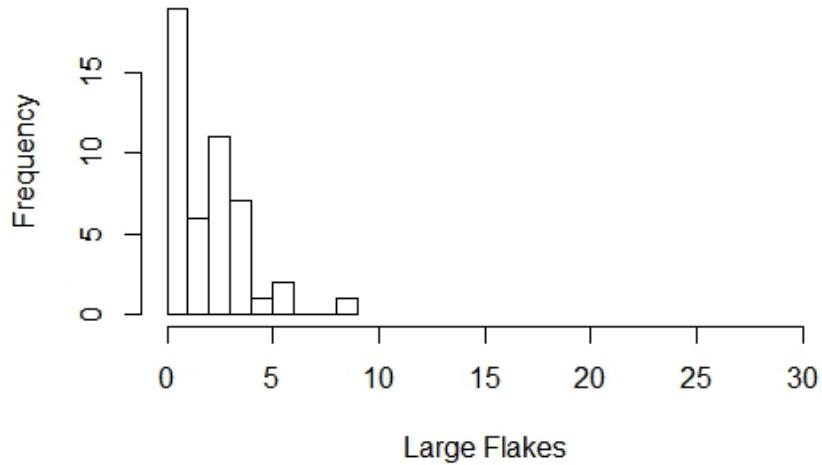


Figure 16: Large Flakes Histogram

Frequency of Medium Flakes

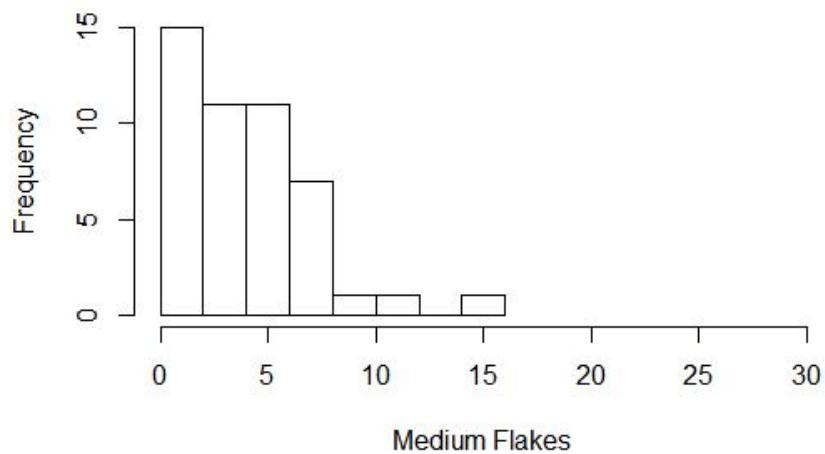


Figure 17: Medium Flakes Histogram

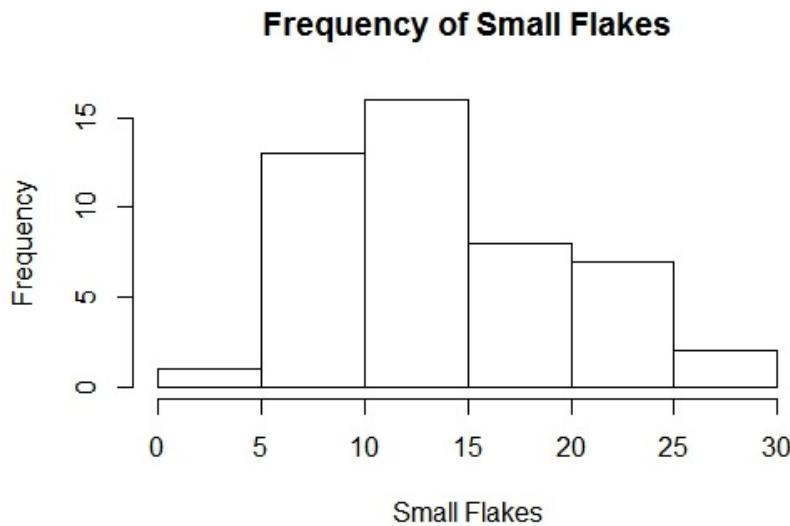


Figure 18: Small Flakes Histogram

Histograms and Shapiro-Wilks tests of the large and medium flake size data indicate non-normality (both p-values for the S-W tests were less than 0.01). Small flakes appear to have a normal distribution ($W=0.96121$, $p = 0.1202$). Though the small flakes data is normal, I continue to use non-parametric tests, as everything I compare the small flakes data against is non-normal. I performed one-sided KS tests of the flake sizes against each other, in order to determine whether or not one flake size was significantly more prevalent than other flake sizes. Because of the results of the boxplot, I chose to do one-sided tests to see if the differences shown were significant. I tested whether or not there were more small flakes than large ones, more small flakes than medium ones, and more medium flake than large ones. The amount of small flakes appeared to be significantly higher than the amount of large flakes ($D=0.93617$, $p < 0.01$) and the amount of medium flakes ($D=0.80851$, $p < 0.01$), and the

amount of medium flakes appeared be significantly higher than the amount of large flakes ($D=0.3617$, $p < 0.01$).

All of the KS tests performed returned significant results. This allows us to conclude that there are significantly more small flakes than large or medium flakes, and that there are significantly more medium flakes than large ones. The D-statistic indicates the strength of the significant difference (the higher it is the stronger it is), and as such we can see that though there are significantly more medium flakes than large flakes, this difference is not as strong as the differences between the number of small flakes and large ones, or small flakes and medium ones.

Research Question 5:

In order to answer the question “Is there a flake shape that is more prominent than other flake shapes,” I performed similar analyses to those used to answer question 4.

The number of wide flakes on each *mata'a* ranged from 6 to 49, averaging about 21. The number of narrow flakes ranged from 0 to 33, averaging around 6, and the number of even flakes ranged from 0 to 24, averaging about 5. I created boxplots and histograms to visualize the data.

wider than L	Longer than w	Equal LW
Min. : 6.00	Min. : 0.000	Min. : 0.00
1st Qu.:16.00	1st Qu.: 1.500	1st Qu.: 2.00
Median :21.00	Median : 4.000	Median : 3.00
Mean :21.45	Mean : 5.702	Mean : 4.83
3rd Qu.:25.00	3rd Qu.: 7.500	3rd Qu.: 7.50
Max. :49.00	Max. :33.000	Max. :24.00

Table 5: Flake Shape Data

The boxplot indicates a higher occurrence of wide flakes than either of the other two. Narrow and even flakes appear to have relatively equal distributions.

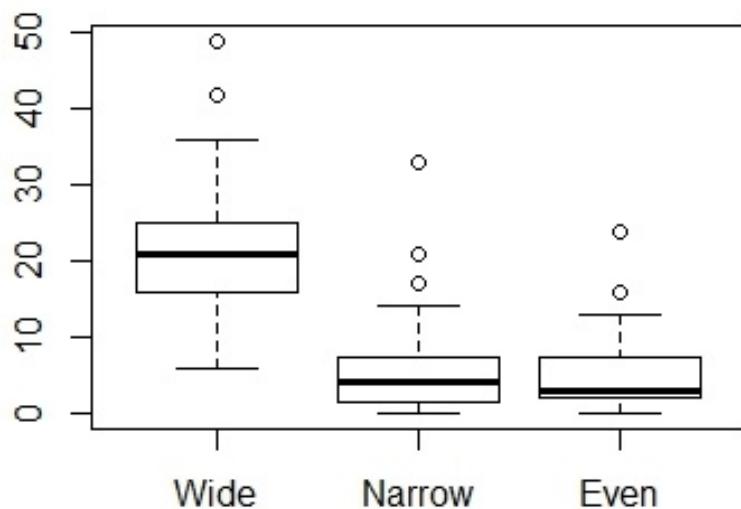


Figure 19: Flake Shape Histograms

Frequency of Wide Flakes

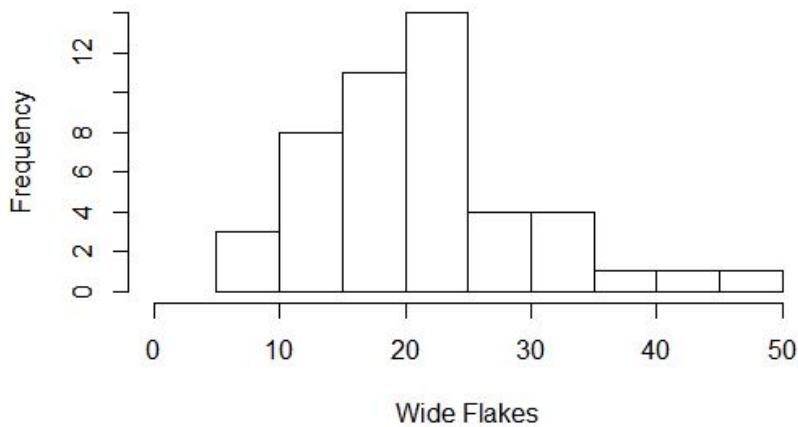


Figure 20: Wide Flakes Histogram

Frequency of Narrow Flakes

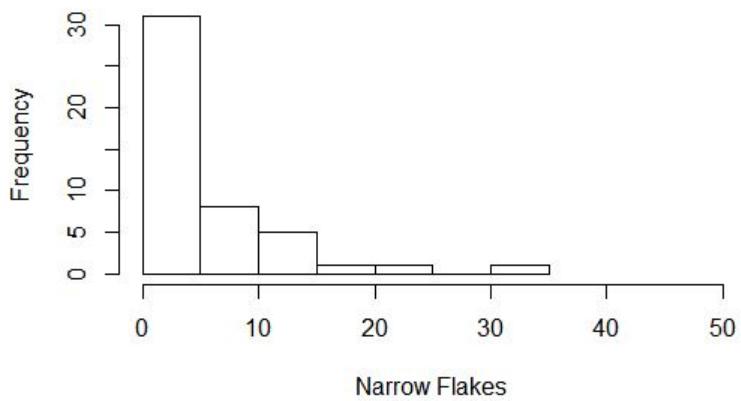


Figure 21: Narrow Flakes Histogram

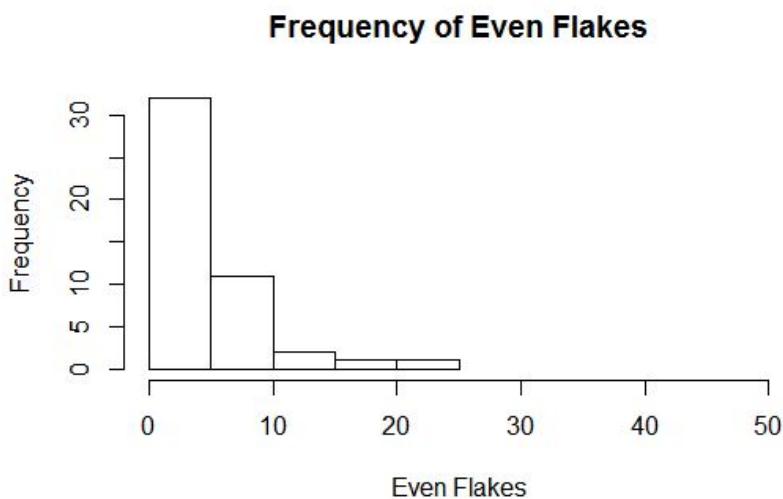


Figure 22: Even Flakes Histogram

Shapiro-Wilks tests proved the “narrow” dataset ($W = 0.76669$, $p < 0.01$) and the “even” dataset ($W = 0.81248$, $p < 0.01$) to be non-normal, and the “wide” dataset ($W = 0.95382$, $p = 0.06118$) to be normal.

Though the histogram and Shapiro-Wilks test result indicate normality of the “Wide” dataset, I again ran non-parametric tests to check for significant differences in flake shape, as the datasets I compared the wide data against was not normally distributed. I ran KS tests for wide flakes versus narrow flakes, wide flakes versus even flakes, and narrow flakes versus even flakes. There appeared to be significantly more wide flakes than narrow flakes ($D=0.78723$, $p < 0.01$), and significantly more wide flakes than even flakes ($D=0.85106$, $p < 0.01$), however there did not appear to be a significant difference between narrow and even flakes ($D=0.12766$, $p = 0.4649$)

Research Question 6:

To answer the question “are flake size and shape independent,” I visualized the data by creating a data table and a barplot, which plots the number of flakes of certain sizes by their shapes.

	Even	Narrow	Wide
Large	4	10	94
Medium	10	38	156
Small	145	120	430

Table 6: Shape Distribution Per Flake Size

Looking at the data initially, it appears that the flake sizes tend to be wide more often than not, however the difference is stark for both the large and medium flakes. While there are about

The barplot indicated that the majority of even, narrow, and wide flakes were small flakes, however wide flakes seemed to have a more even distribution of medium and large flakes.

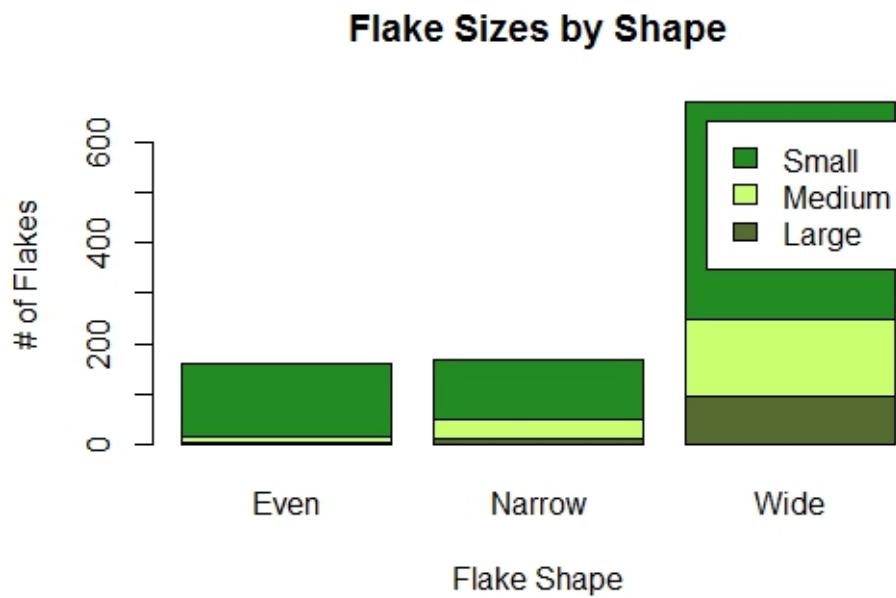


Figure 23: Flake Shapes by Size

In order to test whether or not there was a significant correlation between flake size and shape, I performed a chi-square test. Chi-square tests evaluate how likely it is that observed distributions occur due to chance. Low p-values indicate that it is unlikely the events occurred by random chance, and the chi-square statistic indicates the strength of the relationship. The higher the statistic, the stronger the relationship. Still working with a 99% (0.01) confidence level, this test returned a significant result ($X^2 = 52.607$, $p < 0.01$). The test results indicate that size and shape are not independent. Looking again at the barplot (fig. 23) there appears to be a high incidence of small flakes in every category, but a higher amount of medium and large flakes in the wide category.

Research Question 7:

To answer this question, I performed a similar set of analyses to the ones used to answer the previous question. I visualized the data by creating a barplot of how many of each sized flake were on each *mata'a* face. The barplot indicated that there were very similar flake size distributions on the dorsal and ventral faces.

	Dorsal	Ventral
Large	54	54
Medium	106	98
Small	379	316

Table 7: Flake Size Distributions By Face

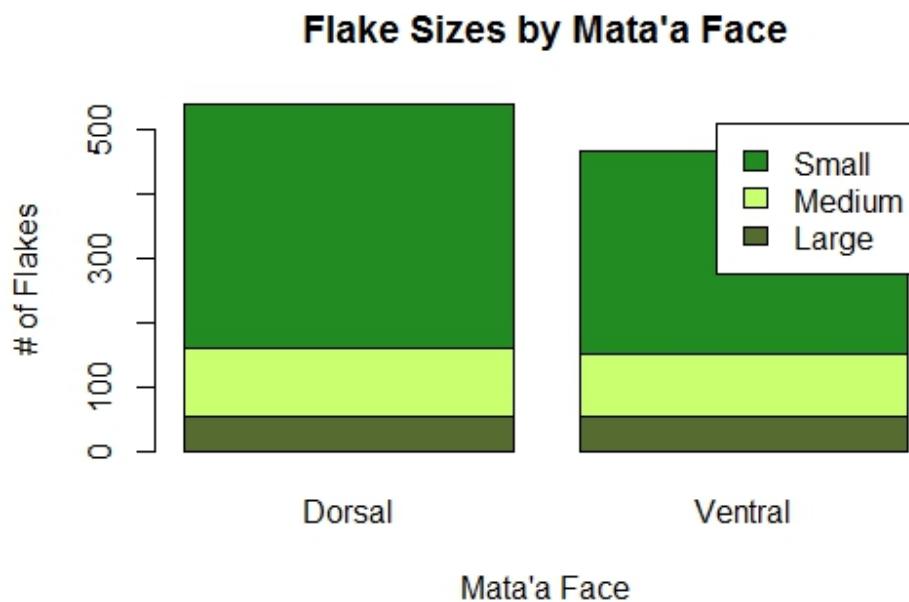


Figure 24: Flake Sizes by *Mata'a* Face

Though the barplot did not show much of a difference at all, I performed a chi-squared test in order to test whether there was a correlation between flake sizes and *mata'a* faces. The result was not significant ($\chi^2 = 1.0236$, $p = 0.5994$). Flake size and *mata'a* face appear to be independent.

Research Question 8:

I used the same analysis process for this question as I had for the previous two. To begin with, I visualized the data by creating a barplot of how many flakes of each shape were on each *mata'a* face.

	Dorsal	Ventral
Even	80	79
Narrow	80	88
Wide	379	301

Table 8: Flake Shape Distribution by Face

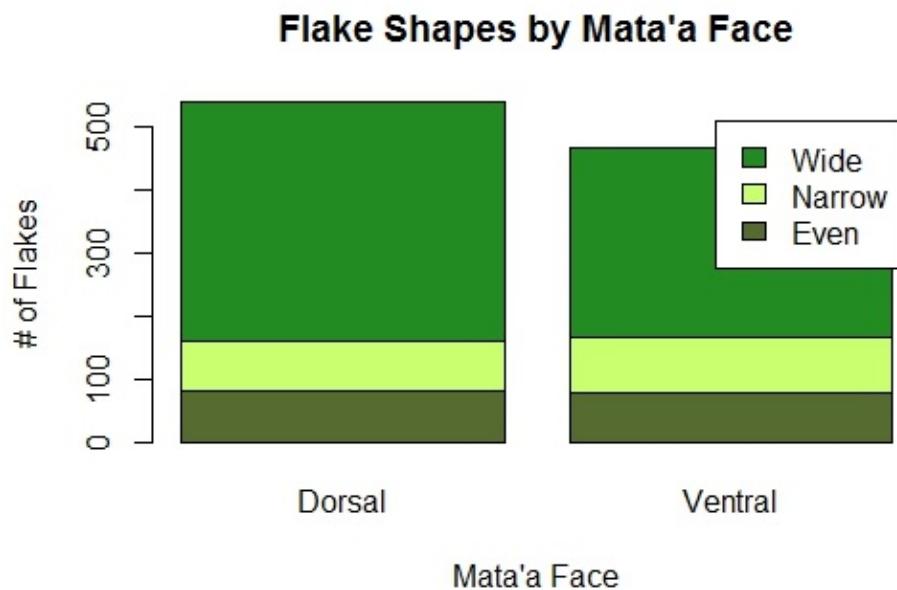


Figure 25: Flake Shapes by *Mata'a* Face

The bar plot does not show much of a difference between the different flake shapes present on either *mata'a* face. In order to test whether or not there was a correlation, I performed a chi-square test. The test result was not significant ($\chi^2 = 4.35$, $p = 0.1136$). Flake shape and *mata'a* face appear to be independent.

Research Question 9:

To answer the question “Are *mata'a* side (left/right) and flake shape correlated,” I again performed similar analyses. To begin with, I visualized the data by creating a barplot of the number of each flake size on the two *mata'a* sides.

	Left	Right
Even	86	73
Narrow	97	71
Wide	349	331

Table 10: Flake Shape Distribution by Side

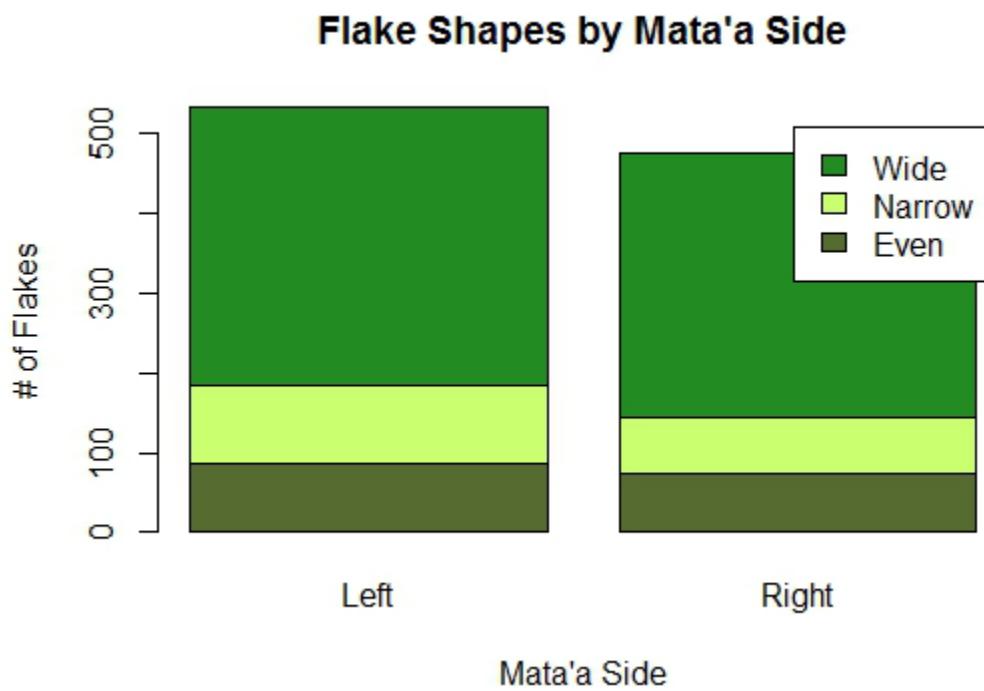


Figure 25: Flake Shapes by Mata'a Side

The barplot indicates that there is a slightly higher occurrence of even and wide flakes on the left side of the *mata'a* than on the right side. I performed a chi-square test to check whether or not flake size and *mata'a* side were independent. The test did not return a significant result ($\chi^2 = 2.3443$, p-value = 0.3097). It appears that flake shape and *mata'a* side are independent, and given the relatively small chi-square statistic, this relationship is weak.

Research Question 10:

Analysis for this question was performed much like analysis for the prior 4 questions. I began by visualizing the data with a barplot of how many flakes of each size were on each *mata'a* side.

	Left	Right
Large	56	52
Medium	109	95
Small	367	328

Table 11: Flake Size Distribution by Side

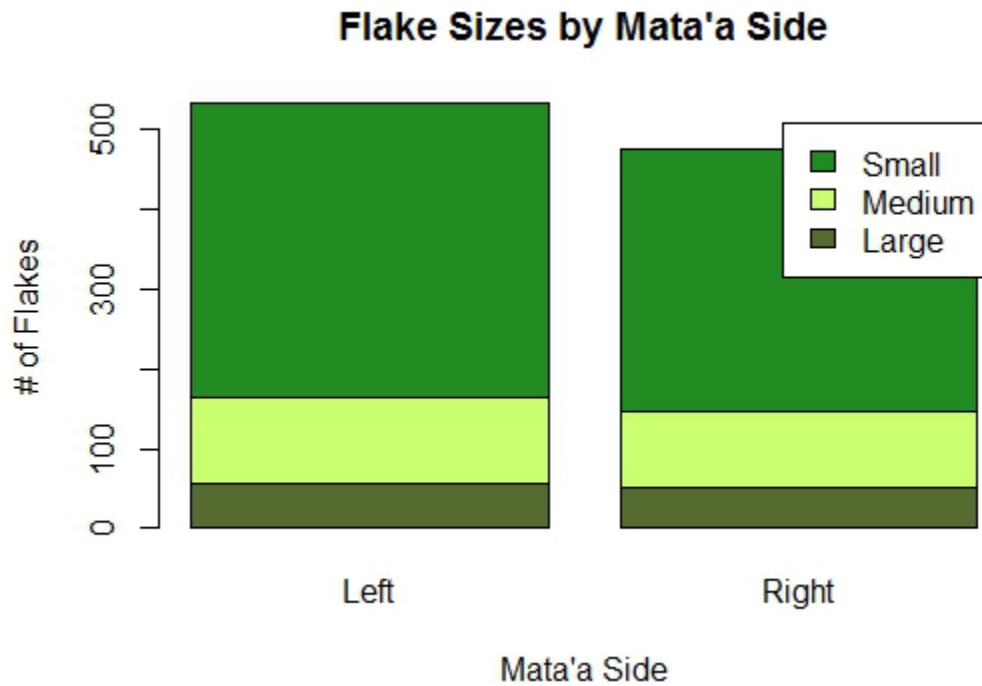


Figure 27: Flake Sizes by *Mata'a* Side

The bar plot did not indicate any obvious differences in the number of flakes of different sizes on either the left or right sides of the *mata'a*. There appear to be slightly more small and medium flakes on the left side, however large flake amounts appear almost identical. In order to see if there was any significant differences, I performed a chi-square test. The test did not return a significant result ($\chi^2 = 0.071235$, $p = 0.965$). Flake size and *mata'a* side appear to be independent.

Discussion:

Based on results obtained in the investigations detailed in my “Data” section, I compiled a table (Table 12), summarizing the answers to the questions posed for analysis.

Question	Answer	Test performed
Are there more flakes on the upper or lower portions of the <i>mata'a</i> ?	Yes - Upper	KS Test. D Statistic: 0.97872 $p < 0.01$
Are there more flakes on the dorsal or ventral faces of <i>mata'a</i> ?	No	KS Test. D Statistic: 0.12766 $p = 0.8384$
Are there more flakes on the left or right sides of <i>mata'a</i> ?	No	KS Test. D Statistic: 0.14894 $p = 0.6744$
Is there a flake size that is more prominent than other flake sizes?	Yes – Small.	Three KS tests. Small-Large: (0.93617, $p < 0.01$) Small-Medium: (0.80851, $p < 0.01$) Medium-Large: (0.3617, $p < 0.01$)
Is there a flake shape that is more prominent than other flake shapes?	Yes - Wide	Three KS tests. Wide-Narrow: (0.78723, $p < 0.01$) Wide-Even: (0.85106, $p < 0.01$) Narrow-Even: (0.12766, $p = 0.4649$)
Are flake size and flake shape independent?	No	Chi-Squared Test. $\chi^2: 52.607$ $p = 1.03e-10$
Are flake size and <i>mata'a</i> face independent?	Yes	Chi-Squared Test. $\chi^2: 1.0236$ $p = 0.5994$
Are flake shape and <i>mata'a</i> face independent?	Yes	Chi-Squared Test. $\chi^2: 4.35$ $p = 0.1136$
Are flake shape and <i>mata'a</i> side independent?	Yes	Chi-Squared Test. $\chi^2 = 2.3443$ $p = 0.3097$
Are flake size and <i>mata'a</i> side independent?	Yes	Chi-Squared Test. $\chi^2 = 0.071235$ $p = 0.965$

Table 12: Results Summary

The results of the analyses allow insight into *mata'a* use. With significantly more flakes on the upper portion of the *mata'a*, we can conclude that the *mata'a* were generally held at the stem (likely hafted) and used in a manner that almost exclusively utilized the distal end of the tool.

With no significant difference between the number of flakes on the dorsal and ventral faces of the tools, or the left and right side of the tools, we can conclude that the tools do not have a consistent use pattern. This supports studies which conclude that the *mata'a* were multi-purpose tools.

The results indicated that the wear was primarily small flakes and wide flakes, and that there was a correlation between flake size and shape. Almost all medium and large flakes were wide. This is characteristic of obsidian, and the medium and larger flakes likely occurred when the *mata'a* were used with a lot of force.⁷²

Flake size and shape appeared to be independent from *mata'a* face and side. The independence here supports the idea that the *mata'a* were multi-use tools, as there is no consistent pattern across the tools. If the tools were used as single-purpose tools, we would expect a flake pattern of some sort to emerge.

⁷² Conte, I. C., Fernández, T. L., Astruc, L., & Rodríguez, A. R. (2015). Use-wear analysis of nonflint lithic raw materials: the cases of quartz/quartzite and obsidian. In *Use-wear and residue analysis in Archaeology* (pp. 59-81). Springer International Publishing

Conclusion

Looking at the results as a whole, we can see that the *mata'a* were tools that were primarily used on their distal ends, with no consistent consideration as to which side or face of the tool was used. This supports a multi-use tool hypothesis. Were the tools used in one specific manner, we would expect a similar pattern to emerge.^{73,74}

The tools appear to have been moved in such a way that the vast majority of the flakes on the tools were small, wide flakes. This indicates that the *mata'a* were not used in large, forceful blows, as we would expect a higher proportion of the flakes to be larger were that the case.⁷⁵ Though there were medium and large flakes that were probable results of forceful motions, they occur significantly less often than the smaller flakes. However due to the breakage tendencies of obsidian, it is difficult to glean which motions *did* create the small wide flakes.

⁷³ Lerner, H., Du, X., Costopoulos, A., & Ostoja-Starzewski, M. (2007). Lithic raw material physical properties and use-wear accrual. *Journal of Archaeological Science*, 34(5), 711-722.

⁷⁴ Odell, G. H., & Odell-Vereecken, F. (1980). Verifying the reliability of lithic use-wear assessments by 'blind tests': the low-power approach. *Journal of field Archaeology*, 7(1), 87-120.

⁷⁵ Lerner, H., Du, X., Costopoulos, A., & Ostoja-Starzewski, M. (2007). Lithic raw material physical properties and use-wear accrual. *Journal of Archaeological Science*, 34(5), 711-722

Cutting and scraping motions create similar flake shapes⁷⁶, and as mentioned before, there are potentially other motions made which have not been replicated, but produce the same flakes. It is not unlikely, given the other findings of the study, that more than one of those motions was taken with the tool, and the inability to decipher the difference is not a problem, and is in fact more correct.

We know that obsidian flakes in the direction that the external force applied to it hits (due to the lack of crystalline structures), and as such we are able to determine which direction the tools were moved. The flakes on the tools almost exclusively flake in to the tools. This indicates that the tools were moved outward from the person holding them, in a forward motion. Were the tools used for a task such as sawing, given the properties of obsidian, we would expect the edges to be jagged and not to have such uniformly inward flakes.

From this study, we can conclude that the *mata'a* were multi-use tools, held at the stem (or on the wood hafted to the stem) and used primarily on their distal ends. We can conclude that they were moved in an outward direction from the person holding them.

These findings support studies which identify the *mata'a* in a multi-use tool. Though this study did not attempt to figure out materials identified, it is likely that, given previous studies, these tools were used in multiple ways in agricultural and domestic contexts.

⁷⁶ Conte, I. C., Fernández, T. L., Astruc, L., & Rodríguez, A. R. (2015). Use-wear analysis of nonflint lithic raw materials: the cases of quartz/quartzite and obsidian. In *Use-wear and residue analysis in Archaeology* (pp. 59-81). Springer International Publishing.

This is an important addition to the literature surrounding the “violent past” of Rapa Nui. The ethnohistoric record, as well as popular narrative on the island and around the world, would have us believe that the *mata'a* were dangerous and deadly weapons. Given the results of this thesis, alongside the existing literature about *mata'a* use traces and shape and the lack of fatal wounding in the osteological error, this does not seem to be the case. It seems likely that the *mata'a* were used in variety of contexts, potentially agricultural and domestic. This thesis does not support the hypothesis that the *mata'a* were primarily weapons, and as such offers a critical perspective of the widely popular “collapse” narrative of Rapa Nui.

This study is limited by the lack of provenance and provenience. Without this information, we are unable to perform studies investigating differences in flake patterns across locations, or time. In addition, this study could benefit from a larger sample size. These results are significant, and provide a preliminary insight into the tool use. Future study might include a larger sample of the tool, with provenance and provenience. Additional microscopic usewear analysis could be performed, and would complement this study in analyzing *mata'a* use.

Appendix 1: Mata'a



Dorsal

17-01-0514

Ventral



Dorsal

17-01-0515

Ventral



Dorsal



17-01-0516

Ventral



Dorsal



17-01-1517

Ventral



Dorsal



17-01-0528

Ventral



Dorsal



17-01-0529

Ventral



Dorsal

17-01-0530



Ventral



Dorsal

17-01-0531



Ventral



Dorsal

17-01-0532



Ventral



Dorsal

17-01-0533



Ventral



Dorsal

17-01-0534



Ventral



Dorsal



17-01-0535

Ventral



Dorsal

17-01-0536



Ventral



Dorsal

17-01-0329



Ventral



Dorsal

17-01-0330



Ventral



Dorsal

17-01-0331



Ventral



Dorsal

17-01-0333



Ventral



Dorsal

17-01-0334



Ventral



Dorsal

17-01-0335



Ventral



Dorsal

17-01-0336



Ventral



Dorsal



17-01-0337

Ventral



Dorsal



17-01-0317

Ventral



Dorsal

17-01-0318

Ventral



Dorsal

17-01-0319

Ventral



Dorsal

17-01-0322



Ventral



Dorsal

17-01-0323



Ventral



Dorsal



17-01-0324

Ventral



Dorsal

17-01-0325



Ventral



Dorsal



17-01-0518

Ventral



Dorsal



17-01-0519

Ventral



Dorsal



Ventral

17-01-0520



Dorsal



Ventral

17-01-0523



Dorsal



17-01-0521

Ventral



Dorsal



Private Coll. 1

Ventral



Dorsal



Private Coll. 2

Ventral



Dorsal

17-01-0522



Ventral



Dorsal

17-01-0524



Ventral



Dorsal

17-01-0525



Ventral



Dorsal

17-01-0526



Ventral



Dorsal

17-01-0527



Ventral



Dorsal



17-01-0509

Ventral



Dorsal



17-01-0510

Ventral



Dorsal



17-01-0511

Ventral



Dorsal



17-01-0512

Ventral



Dorsal

17-01-0513



Ventral

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