MAKING SENSE OF MONUMENTALITY: A MULTISENSORY ARCHAEOLOGICAL APPROACH TO HAWAIIAN RITUAL ARCHITECTURE

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DEDICATION

To the next seven generations,
Who will build upon the pasts that we rediscover today.
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Nothing takes place in a vacuum, least of all the completion of a doctoral degree. While the formal path and requirements of this endeavor belong to the university setting, the broader experience of its completion touch on every aspect of one's life, including the people and communities upon which any scholar depends for personal and professional wellbeing. I would like to take this chance to acknowledge the exceptional formal and informal support that I have received throughout my education and specifically while pursuing a Ph.D.; without it my journey to this position simply would not have been possible.

Since this dissertation holds “place” to be an important concept, the power of places in shaping my education, and indeed this research, is a good place to start. Places are alive in the ways that they incorporate people, things, memories, and meanings, and these incorporations are important foundations of culture. From our family home in Arizona to the locales I've had the opportunity to live and work in, my good fortune is to know a series of strong, powerful, places—and the cultures that create and perpetuate them. Coming to know Hawai‘i, an experience that spans well more than a decade now, has simultaneously been the most challenging and rewarding connection with place in my personal and professional development. To acknowledge its fundamental influence is to celebrate and foreground indigenous Hawaiian culture, which offers relevant and illuminating perspectives when it comes to the practice, value, and potential of archaeology, among much else. The privilege of being exposed to the knowledge that lies in Manoā, Kāne‘ohe, Kohala, Kaho‘olawe, and Kalaupapa, among many other corners of these islands, as the result of pursuing this degree cannot be understated. I deeply value what I have learned here along with the people who have brought such knowledge to life, and aspire to carry the very best of these sensibilities forward not only as an academic but also as a person.

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While acknowledging the power of people in one’s life with mere words is a challenge, it is hardest of all to encapsulate the gratitude and admiration I have for Susie. Not only has she provided support in many forms, more importantly during this time she has also led the way toward new and exciting chapters in our lives. It is the spirit required by the latter that makes it a delight to explore and share this world with her as my wife, and I look forward to doing exactly that with the demands of the doctorate more of a memory and less of a reality. A hui hou!
Both archaeological and ethnohistoric records reflect the vital importance of monuments known as heiau within Hawaiian society prior to the abolishment of the traditional religious system in AD 1819. With notable variety in both form and function, Hawaiian elites built and used heiau to realize both singular (e.g., initiation of war) and cyclical (e.g., seasonal sacrificial offerings) ends. Earlier scholars have investigated heiau extensively, with archaeologists recording and studying the material dimensions of their extant physical remains (e.g., construction materials, location, size, chronology), ethnohistorians writing about the myriad rites and rituals associated with their construction and use in ancient times, and cultural practitioners considering their significance in contemporary society for the past, present, and future. This dissertation examines a specific class of ancient Hawaiian monumental architecture—known as a luakini heiau—in the context of chiefly authority, with a specific interest on how such places impacted ancient Hawaiian populations via the senses. Monumentality and its experience through sight, smell, taste, touch, and feel are used to underwrite a multisensory survey of a particular Hawaiian luakini heiau known as Pu'ukoholā, significant for its important role as an instrument of power in King Kamehameha I's unprecedented rise to power during the late 18th century. While previous research has highlighted the unparalleled material, historical, and cultural significance of Pu’ukoholā, only lightly have these aspects been considered as interrelated and in the terms of the senses. The collection and analysis of the archaeological, ethnohistorical, and ethnographic data under the lens of sensory archaeology reconsiders the multifaceted impact of the heiau on the senses, and reveals an indivisible and historically contingent entity that encompassed—but also surpassed—its constituents and in doing so catalyzed society itself.
# TABLE OF CONTENTS

Acknowledgements........................................................................................................iii
Abstract..........................................................................................................................v
List of Tables ....................................................................................................................ix
List of Figures ..................................................................................................................viii
List of abbreviations and/or symbols............................................................................xi
Preface ...........................................................................................................................vii
Chapter 1: Monumentality ................................................................................................18
  Introduction ....................................................................................................................18
  Monumental architecture in the Hawaiian Islands.........................................................21
    Archaeologists and heiau ............................................................................................23
    Luakini heiau ............................................................................................................27
  Ritual practices .............................................................................................................32
  Rethinking monumentality ..........................................................................................34
  Archaeological approaches to place ............................................................................39
  Dimensions of monumentality .....................................................................................43
  Monumental architecture and authority ......................................................................48
  Structure of the dissertation .........................................................................................50
Chapter 2: Sensory Exploitation ....................................................................................51
  Introduction ....................................................................................................................51
  Biological signaling theory ...........................................................................................52
    Sensory exploitation ...................................................................................................54
    Cultural traditions .......................................................................................................56
  A vast sensitivity ............................................................................................................57
  The significance of awe ...............................................................................................58
  Monumental architecture and the senses .....................................................................61
  Sensory Archaeology .................................................................................................62
Chapter 3: Pu‘ukoholā Heiau ..........................................................................................65
  Introduction ....................................................................................................................65
  Context of the study area .............................................................................................66
  Environmental setting ..................................................................................................67
    Location .......................................................................................................................67
    Geology .......................................................................................................................70
    Sediments ...................................................................................................................71
    Climate .........................................................................................................................73
    Water sources .............................................................................................................75
    Vegetation ...................................................................................................................76
    Fauna ...........................................................................................................................79
  Social, historic, and archaeological setting ...................................................................80
    Land divisions .............................................................................................................80
    Settlement patterns ...................................................................................................83
    Ethnohistoric accounts of Pu‘ukoholā Heiau .............................................................86
    Historical accounts ..................................................................................................87
    Modern jurisdiction ..................................................................................................92
List of Tables

Table 1. Diverging connotations of monument and monumentality, developed from Hung (1995).................................................................35

Table 2. Traditional and modern land divisions of the study area.......................81

Table 3. Early European accounts and sensory references, derived from Greene 1993.................................................................................91

Table 4. A Hawaiian view of expanding empiricism, Sight (from Meyer 2001, 131). ..........................................................................................101

Table 5. Eight criteria for determining the visual structure of landscapes (after Higuchi 1983, 4)................................................................108

Table 6. Apprehensive potential of sensory modalities across physical space. .... 110

Table 7. “There are other names to designate the features of the land” (Malo 1971, 17-18), emphasis added. .................................................................113

Table 8. “Classification of the features of an island,” elevational zones (Malo 1971, 16-17).................................................................................115

Table 9. Ethnohistoric references to various components of luakini heiau (with visual references italicized), adapted from Valeri 1985..............................119

Table 10. Number of precision GPS data points collected, accepted, and rejected during the microtopographic survey. Microtopographic data is located in Appendix A. ..................................................................................125

Table 11. Maximum distances within a specified angle of depression at Pu’ukoholā heiau based on variable terrain height. ............................................129

Table 12. Access classification of interior space at Pu’ukoholā heiau......................140

Table 13. Definitions of four visual dimensions of perception, after Higuchi (1983). .................................................................................................144

Table 14. Points of observation in relation to Pu’ukoholā heiau by distance, change in elevation, and angle of incidence.................................................148
Table 15. Scoring the four visual dimensions of perception at Pu‘ukoholā heiau from various points of observation on a scale of 1 (low ranking) to 5 (high ranking).

Table 16. Distance thresholds and range of view.

Table 17. Location analyzed by viewshed analysis for Pu‘ukoholā heiau.

Table 18. Total area visible from location of Pu‘ukoholā heiau at three distance thresholds.

Table 19. Mountain summits visible from the Pu‘ukoholā point of origin with bearing, distance, and elevation at summit.

Table 20. Visual angles of incidence calculated for an observer (height=2 m) located at the Pu‘ukoholā point of origin to the six visible mountain summits.

Table 21. Tabulation of mean visible area at three distance thresholds for Pu‘ukoholā heiau and fifty randomly selected locations (SD=sample standard deviation).


Table 23. Hierarchy of a Hawaiian musical system (after Tatar 1993, 2).

Table 24. Sensory references in Hawaiian terms for drums and drum accessories (originally compiled by Tatar 1993:5, emphasis added to denote sensory references).

Table 25. Experiments comprising the archaeoacoustic survey.

Table 26. Collection points and their distances and directions to the projection station in Experiment No. 1.

Table 27. Collection points and their distances and directions to the projection station in Experiment No. 2.

Table 28. Projection Points with their description and distances to the collection point in Experiment No. 3.

Table 29. Projection Points and their distances and directions to the collection point in Experiment No. 4.

Table 30. Ranking of Experiment No. 2 collection points by sound intensity.
Table 31. Soundscape values and derived benefits of quality soundscapes (from Dumyah and Pajanowski 2011, 1331)........................................................................................................218

Table 32. Types of sounds recorded within Pu'ukoholā heiau, organized by phonic classes..................................................................................................................................................224

Table 33. Index values for acoustic diversity generated using R (SEEWAVE). .........225

Table 34. Soundscape types and conservation planning principles relevant to the soundscape of Pu'ukoholā heiau (adapted from Dumyah and Pajanowski 2011, 1335).........................................................................................................................................................................228
LIST OF FIGURES

Figure 1. Contemporary wooden images (kiʻi) at Puʻuhonua O Hōnaunau National Historic Park on Hawaiʻi Island.................................................................21

Figure 2. Architectural Fantasies with Temples and Pyramids. Filippo Juvarra (1704). Courtesy National Gallery of Art, Washington.................................39

Figure 3. Peacock Feather Fan. Edna C. Rex. Courtesy National Gallery of Art, Washington.................................................................51

Figure 4. The eight major islands of the Hawaiian archipelago, with the island of Hawaiʻi indicated (red arrow).................................................................68

Figure 5. The Big Island of Hawaiʻi with points of reference mentioned in the text marked with red arrows (Kaʻiu-Kona, bottom; Puʻukoholā Heiau National Historic Site, middle; Hawi, top).................................................................69

Figure 6. Mean annual rainfall on the island of Hawaiʻi (courtesy Giambelluca et al. 2013), with the general location of the study area indicated by a red arrow.....74

Figure 7. The Big Island, depicting moku and ahupua’a boundaries (courtesy Wilson and Jay 2016), with the general location of the study area (Kawaihae) indicated by a red arrow.................................................................82

Figure 8. Puʻukoholā Heiau National Historic Site (courtesy National Park Service). ........................................................................................................94

Figure 9. Elevation, section, and plan of Jeremy Bentham’s Panopticon penitentiary, drawn by Willey Reveley, 1791 (Public domain)......................................104

Figure 10. Magellen Ashtech GPS antennae with Puʻukoholā heiau in the distance. ........................................................................................................122

Figure 11. A pair of photographs illustrating the survey line roving around extant architecture (L) and across the landscape (R), collecting points every five meters.........................................................................................123

Figure 12. Plot of microtopographic GPS data points collected at Puʻukoholā Heiau National Historic Site. Only points with valid elevation readings are shown (n = 9,759). These represent a 95% success rate during the microtopographic survey.........................................................................................125

Figure 13. Topographic projection (contour interval of 0.50 meters) of full project area coverage, Mailekini heiau (tan - left), Puʻukohola heiau (tan – right). Park
Headquarters (gray – right), Visitor Center (gray – bottom), access road, and paths........................................................................................................................................ 126

Figure 14. Enlarged projection of Mailekini heiau (L) and Pu‘ukohola heiau in related topographic context (contour interval of 0.50 m). Paved Park visitor paths outlined, seasonal drainage indicated................................................................. 128

Figure 15. The area adjacent to Pu‘ukohola heiau that lies within a 10 degree angle of depression relative to views originating on the western interior edge of the structure. The top value is the viewing distance in meters; the bottom value is the elevation in meters above sea level. ............................................................................................................ 130

Figure 16: Access analysis of interior space of Pu‘ukoholā heiau. Higher numbers represent less restricted space; lower numbers represent more restricted space........................................................................................................................................ 137

Figure 17. Access analysis of interior space of Pu‘ukoholā heiau. Blue lines connect units with identical access scores, in order to consider ease of movement. .... 138

Figure 18. Access analysis of interior space of Pu‘ukoholā heiau. High and low access analysis score values are color-coded, in order to consider zones of access based on degrees of restriction. ........................................................................................................ 139

Figure 19. Detailed map showing survey points of observation (denoted by file numbers) established to analyze the visual dimensions of perception around Puʻukoholā heiau........................................................................................................................................ 147

Figure 20. View of Puʻukoholā heiau from Point of Observation No. 2. (8213), 95.8 m distant with an angle of incidence of 13.3°)........................................................................................................ 149

Figure 21. Select views of Pu‘ukoholā heiau used for analyzing the visual dimensions of perception at Puʻukoholā heiau. From left to right, the corresponding point of observation numbers are: 2, 4, 11 (top row); 12, 13, 14 (middle row); 16, 18, 21 (bottom row)................................................................................................................. 152

Figure 22. Viewshed generated from the Puʻukoholā heiau point of origin spanning the islands of Hawai‘i, Maui, and Kaho‘olawe. ................................................................. 159

Figure 23. Extent of viewshed generated from the Puʻukoholā heiau point of origin on the Big Island of Hawai‘i................................................................. 160

Figure 24. Pie graph depicting percentages of surface area within the Puʻukoholā point of origin viewshed keyed to major Hawaiian mountains (clockwise starting with Mauna Loa)........................................................................................................ 163
Figure 25. Graphical comparison of views to six mountains within the Pu'ukoholā point of origin viewshed, plotted by angle, distance (line), and total surface area (circle). Numbers correspond to percentage of surface area within the total viewshed.  

Figure 26. Extent of viewshed generated from the Pu'ukoholā heiau point of origin along leeward coast of the Big Island of Hawai'i.  

Figure 27. 50 randomly selected points within a 5 km radius of Pu'ukoholā heiau.  

Figure 28. Land area visible (km²) within 500 m of randomly selected points (n=50) as compared to Pu'ukoholā heiau (yellow bar).  

Figure 29. Land area visible (km²) within 5 km of randomly selected points (n=50) as compared to Pu'ukoholā heiau (yellow bar).  

Figure 30. Total land area visible (km²) from randomly selected points (n=50) as compared to Pu'ukoholā heiau (yellow bar).  

Figure 31. Sound data captured in a spectrogram, including frequency in kilohertz (kHz), time in seconds, and amplitude in decibels (dB).  

Figure 32. Sound data captured in a waveform, including time in seconds and amplitude in kilo-units (kU).  

Figure 33. The intensity and shape of sound as revealed in a combined waveform/spectrogram view (with left and right channels). Here, intensity (wind interference) visible in the waveform lessens leading up to a sine wave sweep (deliberate broadcast) visible in the spectrogram.  

Figure 34. Collection station (back, left) and projection station (right) set up during the archaeoacoustic survey within Area Two (Experiments No. 1 and 4, below).  

Figure 35. Projection Station set up within Pu'ukoholā heiau during Experiment No. 2, below.  

Figure 36. Collection Station set up within Pu'ukoholā heiau during Experiment No. 3, below.  

Figure 37. Example waveform (top) and spectrogram (bottom) of a signal broadcast (sine sweep) recorded during the archaeoacoustic analysis.  

Figure 38. Exploded view of isolated frequency sweep from example sound collection file.
Figure 39. Sample of data points, placed relative to two data collection groups ("control" transect and "test" transect marked by the lower and upper blue lines, respectively)................................................................................................................................................. 200

Figure 40. Distribution of projection station (SO) and collection points (CP) for Experiment No. 1........................................................................................................................................................................................................................................................................................................ 202

Figure 41. Distribution of projection station (SO) and collection points (CP) for Experiment No. 2........................................................................................................................................................................................................................................................................................................ 203

Figure 42. Distribution of collection point and projection points (PP) for Experiment No. 3........................................................................................................................................................................................................................................................................................................ 205

Figure 43. Distribution of collection point and projection points (PP) for Experiment No. 4........................................................................................................................................................................................................................................................................................................ 207

Figure 44. Experiment #1. Collection Point 5 (left), placed approximately 34 meters in front of the Projection Station and Collection Point 9 (right) approximately 22 meters to the rear. The blue arrow indicates the direction of sound projection........................................................................................................................................................................................................................................................................................................ 209

Figure 45. Comparison of waveforms and spectrograms from Experiment No. 1, CP5 (left) and CP9 (right). Note the greater intensity of the frequency sweep signal (represented by the darker line) in CP5 spectrogram, despite being twelve meters more distant from the Projection Station than CP9........................................................................................................................................................................................................................................................................................................ 210

Figure 46. During Experiment No. 2, six collection stations were placed within Pu‘ukoholā heiau and the projection station was placed centrally on a raised terrace in the northern half of the structure. The blue arrow indicates the direction of sound projection........................................................................................................................................................................................................................................................................................................ 211

Figure 47. Waveform and spectrograms from collection points located in the interior space of Pu‘ukoholā heiau during Experiment No. 2. Clockwise, from top right: CP1, CP2, CP3, CP4, CP5, CP6........................................................................................................................................................................................................................................................................................................ 213

Figure 48. Experiment No. 2, CP7 (165 m west of source, on coast) with no detectable signal........................................................................................................................................................................................................................................................................................................ 214

Figure 49. Experiment No. 2, CP9 (123 m west of source) with clearly detectable signal ........................................................................................................................................................................................................................................................................................................ 215

Figure 50. Experiment No. 2, CP11 (77 m west of source, eastern exterior edge of Mailekini heiau) with faintly detectable signal........................................................................................................................................................................................................................................................................................................ 215

Figure 51. Experiment No. 3, PP7 (projected from 163 m west of collector on coastline to heiau)........................................................................................................................................................................................................................................................................................................ 216
Figure 52. Experiment No. 3, PP11 (projected from 67 m west of collector, east of Mailekini heiau in a depression)...........................................................................................................................................................................217

Figure 53. Location within Puʻukoholā heiau (marked by red star) where environmental soundscape recordings were collected. ................................................................. 220

Figure 54. Frequency-amplitude plot, 10:00—10:15 AM, Puʻukoholā heiau...........222

Figure 55. Frequency-amplitude plot, 10:00—10:15 PM, Puʻukoholā heiau...........223

Figure 56. Acoustic diversity plotted by time of day (blue=left channel, red=right channel). ...........................................................................................................................................................................................................................................225

Figure 57. Movements of the Haʻa Akeolokia by Francis Sinenci (illustrations by Robin Deutschendorf). ............................................................................................................. 242

Figure 58. Words of the Haʻa Akeolokia (motions in parentheses) ......................... 243
LIST OF ABBREVIATIONS AND SYMBOLS

Numerous Hawaiian words are included in this text. The usage of ‘okina (glottals) and kahako (macrons) follows Hawaiian spelling as referenced in Hawaiian Dictionary: Revised and Enlarged Edition, by Mary Kawena Pukui and Samuel H. Elbert (University of Hawai‘i Press) and Place Names of Hawai‘i, Revised and Expanded Edition, by Mary Kawena Pukui, Samuel H. Elbert and Esther T. Mookini (University of Hawai‘i Press). In direct, cited quotations, the original spelling and usage of ‘okina and kahako is transcribed without modification. Following the Style Guide of the University of Hawai‘i at Mānoa, Hawaiian words are not italicized.
PREFACE

The research for this dissertation was completed between 2008 and 2016 at Puʻukoholā heiau, beginning with the design and facilitation of an archaeological field school (Monumental Architecture Field School, 2008). From 2008-2011 involvement continued through participant observation in reconstruction efforts for the heiau, contributing to repair damages Puʻukoholā sustained as the result of two earthquakes in 2006. The remainder of the research was conducted as a series of multisensory surveys, accomplished through multiple visits to the research area starting in 2012 and carried out under permits issued by the National Park Service and in collaboration with indigenous practitioners during and around the Hoʻokuʻikahi event hosted at Puʻukoholā annually. The majority of the multisensory fieldwork was concluded by 2014. Preliminary results of the research were disseminated at the August 2015 Hoʻokuʻikahi event to local stakeholders and within the archaeological community at the Society for American Archaeology annual meetings in April 2016. While reliant on an impressive corpus of existing scientific and cultural work and the gracious collaboration of multiple parties, I take responsibility for all shortcomings. However flawed, I hope this contribution will advance the imperative of connecting enduring places like Puʻukoholā heiau with the past, present, and future in meaningful ways.
Chapter 1: Monumentality

Ozymandias

I met a traveller from an antique land
Who said: "Two vast and trunkless legs of stone
Stand in the desert. Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them and the heart that fed:
And on the pedestal these words appear:
'Vey name is Ozymandias, king of kings:
Look on my works, ye Mighty, and despair!'
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away."

Percy Bysshe Shelley, 1818

Introduction

Thousands of years of human history and the collective toil of untold generations is left to us in the shape and form of monumental architecture. In a spectacle of apparent abundance and outward permanence these massive construction projects are found in what is left of early civilizations ranging from
Mesopotamia to Mexico, societies that prospered across centuries. Considered in total the nature and quantity of monumental projects is prolific; the most famous examples of these ancient projects, such as the Great Pyramid of Giza and Machu Picchu, maintain a high status even in the context of modern, global society. Underwriting entire sectors of the tourism industry, these architectural spectacles of the past are famous destinations that draw many thousands of visitors every year, each person attracted toward the old locales for different reasons but all inevitably left to contemplate variations on the same question: Why did the people of antiquity put such great effort toward designing, constructing, and conserving massive, spectacular buildings, and how were they incorporated into various societies?

The scope and nature of monumental architecture in the archaeological record is, indeed, impressive. Furthermore, the independent origin of these spectacular building efforts among their respective societies is assured by archaeological evidence (Trigger 1990, 120; DeMarrais et al. 1996). The widespread distribution of monumental architecture around the world has attracted constant inquiry throughout the history of archaeology, across most if not all major schools of thought (Burger and Rosenswig 2012, 3). The cumulative efforts of culture historians like V. Gordon Childe (1958) and James A. Ford (1969), processualists such as Colin Renfrew (1973) and David Wilson (1988), and post-processualists including Christopher Tilley (1994), Richard Bradley (1998), and Barbara Bender (1999), to name but a few, represent a diverse body of scholarship and underscore an enduring question of archaeologists, echoing that of the layperson but adding a social implication: Why is monumental architecture frequently found in association with evidence of marked social stratification and hierarchical organization and by what means were they connected to social processes?

Focusing on the historic landscape of the Hawaiian Islands to look back centuries, this dissertation introduces a multisensory approach and the theoretical concept of sensory exploitation to the archaeological, ethnohistoric, and ethnographic study of a luakini heiau, a class of temple central to traditional
Hawaiian society. By explicitly linking monumentality to the human experience of sight, hearing, taste, touch, and smell, new insights on how such massive buildings were essential to fundamental social processes—such as the establishment and maintenance of political authority—are proposed and explored. Encompassing traditional archaeological approaches to landscape and architecture while extending further into the sensory and perceptual realm, the ramifications of this research impact contemporary understandings of monumental architecture across academia and industry and foreground their valuable—but threatened—presence in the past and future of Hawaiʻi.
Monumental architecture in the Hawaiian Islands

Although geographically the most isolated archipelago on the planet, the Hawaiian Islands belong to a widespread group of connected Polynesian chiefdoms that share a common cultural origin (Sahlins 1957; Hommon 2013; Kirch and Green 1987). Based on archaeological, ethnohistoric, and historic sources, for nearly a millennium Hawai‘i was inhabited by a highly stratified society, characterized by a high level of sociopolitical complexity (Earle 1978, 1997; Kirch 1985, 2010; Kolb 1999). With initial colonization dated most securely to between AD 940-1130 (Athens et al. 2014), and a decline in long-distance voyaging between AD 1400 and 1778, several centuries had passed with lessened cultural influence from beyond the archipelago. At the time of initial contact between Kanaka Maoli (Hawaiian) and
British culture in the late 18th century (1778), the society of the islands was characterized by monumental architecture, feudal-like land tenure practices, ritual taboos and etiquette, and internecine warfare (Kolb 2006, 657). Considered the most complex of Polynesia’s pre-European political systems, Hawaiian chiefly organization was instituted through land and resource use that enabled extensive agricultural and aquacultural production across multiple levels of territorial divisions (Kirch 1985, 2). As part of these activities, ancient Hawaiians engaged in prolific vegetation clearance, farming, and building and transformed the island landscapes upon which they lived. The primary building method was drylaid stone masonry, a skillset that was refined to the highest level. The sum result of their endeavors is the ubiquitous presence of surface architecture across all manner of landforms and environments, including “walls, terraces, platforms, enclosures, pavements, alignments, mounds, paths, pits, ditches, and/or clearings” (Dye 2011, 93). Conglomerations of these forms appear to have been frequently configured and combined such as to create complex architectural forms and foster centers of activity.

An infrastructure of networked temples, known as heiau, took on greater complexity within the burgeoning sociopolitical system (Kirch 1985; Earle 1987; Cordy 2000). Beyond Hawai‘i, other Polynesian polities engaged in the building of similar forms of monumental architecture (Graves and Green 1993; Graves and Ladefoged 1995; Kirch 1990), such as the marae and ahu of Aotearoa and Rapa Nui, respectively. Governance in ancient Hawai‘i came to be carried out in accordance with a religious and political order, known as the kapu system. Integrating many aspects of life including religion and politics and directing the establishment and upkeep of laws and regulations, kapu “defined boundaries of propriety and by extension, qualified forms of freedom and framed the spaces of license within society as well” (Young 1998, 76). Authority was shared among several classes of people, the ali‘i (political elite, local and district chiefs or kings), kāhuna (formal priests and other experts), and part-time (informal) practitioners (Valeri 1985). Status was derived by various means across these classes. In the case of the
individuals who held the highest status—the aliʻi—their social standing was inherited by birth through the mother’s line, a condition reflected by the great importance attached to the recollection and recitation of genealogical heritage and achievements for chiefly lineages. Individuals of the highest status, such as powerful aliʻi, were capable of initiating the largest and most socially significant construction projects such as the building of large heiau. In bringing together the various elements of Hawaiian society, heiau were seats of a seasonal, regulated, and strict cycle of activities that facilitated a form of social reproduction (Ibid. 1985) and manifested the prevailing social order (Kolb 2006; McCoy 2014).

Archaeologists and heiau

Archaeologists began studying Hawaiian heiau in the late 19th and early 20th centuries, documenting the various aspects of the structures as well as recording oral histories from people who had knowledge of their location and histories. Across the Hawaiian archipelago, on each of the major islands, pioneering efforts were made by a cadre of early researchers including Thomas G. Thrum (1907a, 1907b, 1908a, 1908b, 1909, 1910), John F. G. Stokes (1991), Wendell C. Bennett (1930, 1931), Kenneth Emory 1924; J. G. McAllister (1933), Winslow Walker (1933), and Henry Kekahuna. While these efforts were successful on a practical level, multiple issues arose as attempts were made to analyze the collected data, one of which was the difficulty of classifying heiau based on their physical attributes. From the time of Thrum’s early survey onward heiau resisted such classification, even as they stimulated curiosity. Thrum sounded a blend of frustration and intrigue when he wrote, “In all the heiaus [sic] visited on the two island of Oahu and Kauai, there are no two alike in plan. Some indicate such individuality even in their ruins as to make one hunger for their history” (Thrum 1907c). Stokes, who examined well over 200 heiau over the span of several years, echoed Thrum’s sentiments by declaring that,
“...it is almost impossible to find, today, two temple foundations alike” (Stokes 1991, 21).

Stokes’ unpublished maps and notes were compiled and published by Thomas Dye as a book entitled *Heiau of the Island of Hawai‘i: A Historic Survey of Native Temple Sites* (Stokes 1991). The edited volume presents the findings of Stokes’s many months of fieldwork on the Big Island in 1906. Integrated with his archaeological observations, however, came information from another source: the ethnohistoric accounts of Native Hawaiian historians, principally the writings of David Malo and Samuel M. Kamakau. Stokes found these writing particularly helpful for developing what he called a basic understanding of heiau. On the subject of heiau variability, Stokes (1991, 21) highlighted the accounts of Malo (see 1951, 161), positing that the perplexing particularities he had observed between structures may in fact have been an intentional effort on the part of their builders:

The endless variety in size, shape, and form puzzled me exceedingly until I reread Malo's description. The basis on which these kahuna kuhikuhipu'uone worked, according to the accounts, was that if a certain form of ancient temple had caused its builder to succeed in his enterprise, it would be equally lucky for his patron. I believe that it was not merely the form but also particular features and their arrangement; otherwise, but one type of temple would have survived. Under this condition, as the work of the augurs continued, so also continued the confusion in temple plans.

Despite the particularities, Stokes and the other researchers of his era compared heiau that had survived into the early 20th century with the abundance of information written down in the ethnohistoric texts of Malo, Kamakau, and others. In certain, specific cases, their persistence was rewarded with success, but ultimately it became clear that the types of foundations observed were not all meaningfully linked to the classes of worship and functions they once served.
Archaeological research into the middle of the 20th century, meanwhile, devoted comparatively few resources and less concentrated attention to surface architecture such as heiau, turning in favor to consider newly discovered archaeological sites found to contain stratified cultural deposits (Kirch 1985). With the advent of radiocarbon dating, these contexts offered researchers the valuable chance to obtain absolute dates associated with sizable artifact assemblages.

Archaeological excavations increased throughout the islands, eventually returning to the subject matter of heiau. Starting in the 1960s, a series of heiau foundations were excavated. Initial excavations identified internal walls in the foundation of one heiau, leading to the interpretation that multiple phases of construction had taken place (Ladd 1973)—and instigating the idea that larger and progressively more elaborate temples may have been built over substantial periods of time. Distinct building stages were also identified during excavations conducted by Green (1980) and Davis (1986). This period of archaeological research has been discussed as the “excavation period,” in contrast to the earlier “survey” period of heiau investigations (Dye 1989, 4). Michael Kolb (1991) later identified building phases through the selective excavation of seven heiau on Maui and then extrapolated these phases to more than 100 heiau he identified from the island.

While the wholesale excavation of heiau slowed during the 1980s, renewed efforts were underway to better understand other aspects of the structures, spurred on by the diachronic implications in the work of Ladd and others. Working on Maui, Kolb (1992) investigated diachronic change by using historic and ethnographic sources to generate expectations, and then tested them using archaeological data. Applied as a relative dating method, architectural seriation was used to chronologically order numerous heiau on both Maui and Hawai‘i (Graves and Cachola-Abad 1996; Mulrooney and Ladefoged 2005; McCoy et al. 2011). Chronologies were also developed based on the absolute dating of heiau, including through the sampling of short-lived taxa recovered in architectural contexts (Kolb 2006; McCoy et al. 2011) and applied to accelerator mass spectrometry.
Archaeologists have also applied U-Thorium dating of corals to heiau as well (Kirch and Sharp 2005; Weisler et al. 2005; Kikiloi 2012). Overall, the ordering of heiau in terms of both space and time continues to be accomplished through a mix of methods, drawing variously on strategies that combine direct dating, architectural seriation, and oral traditions.

Other archaeological studies have pioneered the investigation of more contextual or environmental aspects of heiau, aspects hinted at and discussed by ethnohistoric accounts as well as archaeological studies, but rarely formally investigated. These include the consideration of morphology and the use of space across various forms of traditional Hawaiian architecture through time including luakini heiau (Ladefoged 1998), as well as broader spatial analyses of heiau in relation to ahupua’a boundaries, traditional Hawaiian territories (Mulrooney and Ladefoged 2005). The orientation of heiau has also been investigated, showing that in certain instances their foundations exhibit associations between alignment and the compass directions of specific astronomical constellations and associated deities in the traditional Hawaiian pantheon (Ruggles 2015). Recording the orientation of heiau on Maui, Kirch (2004, 106) suggested that heiau were preferentially oriented according to astronomical, ethnohistoric, and landscape factors. Further, he claimed that “heiau were in many cases clearly situated to take advantage of these viewsheds.” Building on a large dataset covering a significant portion of the leeward Kohala field system, Phillips et al. (2015) investigated aspects of intervisibility and documented a shift in the construction of locally-based agricultural heiau whereby fewer structures were built through time, but the new structures exhibited an increase in size and expanse of viewshed.

Yet concurrent with the expanded body of knowledge concerning the archaeological aspects of heiau, obtained largely through innovative methods and persistent research, basic tasks such as the identification of heiau among other types of surface structures continues to hold challenges. Increasing levels of development and a growing cultural resource management industry in the Hawaiian Islands has
resulted in the increasing need to determine the function of structures as they are encountered during archaeological surveys and to facilitate evaluations of significance. Dye (2009, 102) alludes to the difficulties of the field technician when he writes, "...the use of geometric forms is an analytic device that aims to provide some clear points of formal reference in an archaeological landscape in which ideal forms are rarely, if ever, realized." The most difficult aspect as it concerns heiau, however, comes back to reconciling their diverse material dimensions and behavioral "functions" as a subject of study (Cachola-Abad 1996), a conundrum that impacts large and small heiau alike. In this respect, successes in the future will likely build on those of the past, maximizing opportunities where archaeological approaches can be supported by a diverse body of cultural guidance, either written (such as in the case of the ethnohistoric sources) or in practice (such as by cultural practitioners). In terms of heiau, much of what is known about their construction and use still goes back to the writings of the Native Hawaiian historians of the 19th century including Malo, Kamakau, as well as John Papa ʻIi (1959). While they did not record a great deal of information regarding the building of lesser structures, their writings as they concern luakini heiau—the class of large sacrificial temples—are more extensive. Just as many others—for example Stokes at the turn of the century and the Hawaiian cartographer Henry Kekahuna in the 1950s—once looked to them, so we do again, this time to revisit the luakini.

**Luakini heiau**

As introduced, heiau vary greatly in their size, function, and scope. In traditional Hawaiian society, the material and societal demands of constructing a large heiau meant that they were necessarily tied to sponsors of high social standing and their concomitant access to resources. Conversely, individuals of lesser status were limited to building heiau for which modest amounts of material and social capital was sufficient. Within this negotiated context of needs, desires, and power,
Heiau were built to a wide range of scales and constructed for variety of intended purposes such as, "to bring rain from heaven and make the crops abundant, bringing wealth to the people, blessing to the government, prosperity to the land" (Malo 1951, 176). No matter its size or the intentions behind it, the integrity of a heiau hinged on its benefactor's adherence to the strict body of knowledge and protocol required by the kapu.

The largest and most significant structures, known as luakini heiau or luakini poʻokanaka, were monuments built by aspiring or ruling chiefs or kings in association with the conduct of notable activities including those related to religion, warfare, the collection of tribute, and the practice of associated rituals. The presence and intent of a luakini heiau is further summarized by Kamakau (1976, 134)

Heiau poʻokanaka, “heiaus of human heads,” were very large and were called luakini... They were built on hills, ridges, headlands, or on level ground (puʻuhonua) on the way from the seashore to the mountains where heiaus had formerly been built. There were many kinds of sites, kahua, on which to build heiaus [sic], and they were pointed out by those who knew their locations, the poʻe kuhikihi puʻuone.

When a ruler sought to commission a luakini heiau, the first step was to determine whether a current luakini heiau should be refurbished or whether a new one should be constructed. Malo (1951, 161) reports that, “The king, in the first place, inquired of his high priest in regard to the building of a luakini; whether he thought the old luakini would answer, provided the houses and the fence were renewed; whether the old stone wall should be allowed to remain; and whether the old idols should still continue to be used.” In the event that an “old” luakini would suffice, steps were taken to make the heiau noa (free/null) through the lifting of the kapu in order for the tasks necessary for its refurbishment to be carried out. Once these activities were completed, the kapu was reinstated and the heiau was once again restricted. In the event that a new luakini heiau was to be constructed, a
plethora of other tasks became obligatory, ranging from the determination of its placement to the sourcing of massive quantities of the necessary materials. The construction of a luakini heiau from scratch also required adherence to a rigorous ritual protocol, as well as engineering and construction techniques capable of mitigating the particular stresses encountered through the building of massive structures by drylaid masonry.

Individuals belonging to a subset of the kāhuna class, known as the kuhikuhipuʻuone, held specialized knowledge of locating and building structures. Regarding luakini heiau, Kamakau (as cited in Stokes 1991, 32) writes that: “These temples could not be built on sites casually chosen, only on sites anciently built upon by the old people and since (probably) forgotten. The kuhikuhipuʻuone were the only people who knew where the ancient temples formerly stood.” Malo (1951, 161) adds that they were:

...acquainted with the heiau which had been built from the most ancient times, from Hawaii to Kauai, some of which had gone into ruins. These kuhi-kuhi-puu-one knew all about these old temples, because they had studied them on the ground, had seen their sites and knew the plans of them all.

The role of the kāhuna kuhikuhipuʻuone has been more closely considered by Kolb (1992, 14, emphasis added), who compares the Hawaiian specialists to architects. However, he also notes a fascinating degree of variability in how structures may have been intentionally varied with respect to design or conformance to standards of any kind:

The responsibilities of the kahuna kuhikuhipuʻuone suggest that the one goal when constructing a new temple was to imitate, or at least incorporate, architectural elements of heiau built by successful rulers. The knowledge of the kahuna kuhikuhipuʻuone, however, was not used to assure accurate duplication of an old plan.
of construction, but to create new architectural elements or incorporate combinations of older elements. Thus an architect’s goal was to design something unique and unlike any previously built structure (Buck 1964, 514) but which would immortalize and bring success to a chief by incorporating design features used in the temples of prosperous rulers.

The placement of a luakini heiau was an important first step, as—through the kuhikihipuʻuone—factors such as the locations of heiau and other sacred places, religious considerations (such as the domains of a particular god), proximity to communities, and topography were all taken into account. Kolb (1992, 15) also suggests that the concept of sanctity was an important consideration in placing a luakini heiau, with high ground “affirming the divine and inaccessible nature of high-ranking aliʻi, while affording an excellent view of the surrounding countryside and coast.” The orientation of a luakini heiau was also a carefully considered variable, although conformity to a mauka-makai (mountain-sea) alignment appears to have been more frequent than to any other cardinal or landscape-based alignment (Malo 1951; Shimizu 1980). The materials used for construction were generally less precious, with stone often obtained locally. The physical construction of heiau was founded upon a canon of common practices. Traditional Hawaiian builders did not use mortar of any kind; the erection of structures was driven by mastery of piling and stacking materials. Terrigenous and marine-derived clay, silt, sand, gravel, pebbles, cobbles, and boulders were also sometimes used. Building often incorporated topographic features rather than modifying or masking the natural features of the landform such as slopes, hilltops, caves, rock outcrops, and other attributes (Dye 2011). Subtractive methods of construction were also utilized, including the removal of soil and substrates to create or expand spaces for agricultural, habitation, or ritual purposes. Imported materials include certain types of stone, such as waterworn rocks, which in some cases are said to have been transported from significant distances away. There are also several examples of heiau that incorporate dressed basalt (e.g., Kukuipahu heiau in Kohala), materials that were likely quarried some distance from the building site.
The counsel of the kuhikuhi pu‘uone and other kāhuna, and a leader’s success (or failure) to realize both specific recommendations and well as to follow protocol throughout the construction process, was believed to be closely tied to the potential of a heiau to fulfill its intended purpose(s). It was neither a light nor easy undertaking for anyone involved, including the leader himself: “It was a great undertaking for a king to build a heiau of the sort called a luakini, to be accomplished only with fatigue and with redness of the eyes from long and wearisome prayers and ceremonies on his part” (Malo 1951, 159). Part of this undertaking occurred after the construction phase ended. In either case—whether a luakini heiau was rebuilt or newly constructed—following its completion it had to be consecrated. The consecration of a luakini heiau was a complex and involved process that included the purification of the entire district and a series of elaborate ceremonies. In addition to considerations such as its design and location, sacrificial demands were also central to the establishment and maintenance of luakini heiau. In the most stringent circumstances, both the scope and the nature of the sacrifices were substantial. When a chief or king established a luakini heiau, in accordance with the gravity of the undertaking, “…not even sacrifices of great numbers (lau) of bananas, coconuts, and innumerable offerings could free the kapu; only when a man was killed could it be free, noa” (Kamakau 1976, 134). Intentions and sacrifices were often linked to one or more of the various religious sects that existed within the kapu system. These sects were tied to the Hawaiian gods Kāne, Kanaloa, Kū, and Lono, arch deities that dwelled within a pantheon including other minor gods and goddesses as well. Each of the four principal gods were associated with specific subjects—such as war for Kū and the ocean for Kanaloa—along with a range of specific activities (Malo 1951, 159). Particular types of heiau were commonly associated with particular gods. Through these associations with specific gods, heiau were encompassed by Hawaiian mythology. Luakini heiau were specifically associated with Kū, akua ‘imi aupuni or “gods who seize governments” (Valeri 1985, 247). In the case of the kings of the island of Hawai‘i, Kū manifested in the form of Kū‘kailimoku, literally “Kū island snatcher.”
While the characteristics of luakini heiau have been seen to vary widely, Kolb writes that “One rule of heiau design, however, was to create a sacred space that was both architecturally unique and physically imposing” (Kolb 1992, 32). He echoes Stokes, who stated that, “Economy of labor was considered in heiau construction. I believe that the object in designing the largest temples (probably the sacrificial) was to present the most imposing structure possible” (Stokes 1991, 36). Along these lines, the “place of heiau,” their monumental aspects, and the way that the structures impose themselves on people and across the landscape remains a promising topic of research in Hawaiian archaeology. Related endeavors such as cultural practice and historic preservation, through contemporary activity and interests, are also vested in how these places once impacted people and thereby shaped society itself.

Ritual practices

Ultimately, the purpose of establishing a luakini heiau by any chief was to establish a place of worship (Valeri 1985, 173) and through ritual practice increase their power, authority, and governance (Kikiloi 2012, 77). The body of ritual practice linked to luakini heiau through ethnohistoric sources highlights the cyclical nature of activities, where acts such as the offering (or “sacrifice”) of commodities (such as fruit, animals, fish, and even humans) to deities were carried out. The sensory aspects of these undertakings are abundant; a good example can be found in the huikala rites required for the establishment of a luakini heiau. One particular rite, known as “the fetching of the haku ‘ōhi‘a tree” involves the departure of a party including the chief, ali‘i, priests, and people on a specified day of the month into the mountains to cut down a tree. The trunk of the selected tree will be used to carve the anthropomorphic image of Kū, and eventually reside within the confines of the luakini heiau itself. While the rite is extensive and not fully elaborated here (see
Valeri 1985, 264-279 for an extensive summary), the attention paid to aspects of sight, sound, and smell are particularly suggestive of the degree to which the senses were carefully considered and controlled in the context of luakini heiau and the activities surrounding them.

In terms of sight, the acquisition, transport, and eventual introduction of the haku ‘ōhi’a into the heiau is carefully controlled. Although ethnohistoric accounts vary in terms of exactly when and where the trunk is carved, each version stipulates that the anthropomorphic image is to remain invisible until it enters the temple itself—Kū’s return to human form, or reappearance, is planned (Ibid. 1985, 274). Furthermore, the visual qualities of the wood itself—vertical, strong, and red—are notable attributes of Kū. Sound also features heavily throughout the rite, in that the approach and cutting of the tree is carried out in silence—indeed the success of the ʻaha is dependent on silence and closely monitored. After the tree has been cut and a variety of other tasks completed, the procession that carries the haku ʻōhi’a off the mountain to the heiau is characterized as a loud, violent affair. In addition, the trunk was frequently covered in scented plants or “fragrant things” (Kamakau 1964, 12), highlighting the essential role of the smell of the wao akua (forest of the gods) throughout the luakini heiau ritual. Valeri (1985, 268) remarks that “…like music, speech, or color, perfume has the property, precious from a ritual standpoint, of evoking immateriality in materiality, abstraction and generality in the concrete and the individual... Thus is it the most apt to furnish experiences that are capable of multiple interpretations and may at the same time verify the most imaginary representations.”
Rethinking monumentality

What is meant by “monumental architecture”? The term is derived from the word monument and its Latin root *monumentum*, an instrument or medium that serves to remind and admonish. Monumental is linked to another Latin word, “monere,” which means to remind, advise, or warn (Morwood 2005). Yet as several scholars have recently pointed out (Osborne 2014; Scarre 2011), in archaeological and other contexts of usage, monument may be viewed as carrying a double (or altogether different) meaning, where in addition to (or instead of) referencing memorialization, the word strongly evokes the physical traits of [large] size and [enhanced] durability, bringing to mind aspects of labor investment and ambitious construction. This divergence reveals that the conceptual area generally occupied by the idea of monumental architecture carries both tangible and intangible connotations. From these two interrelated yet distinct areas of meaning, then, come the phrases most commonly deployed in discussions concerning the most overbuilt archaeological sites and structures of the past: “monument,” “monumentality,” and “monumental architecture.”

Given that this dissertation takes monumental architecture as a primary subject matter, further consideration of the term is warranted. Based on the proceedings of a conference entitled *Approaching Monumentality in the Archaeological Record*, James Osborne (2014, 3) considers how several academic disciplines – in particular art history and architecture – have engaged these varying terms and their meanings as adopted across a wide-ranging body of literature. In summarizing how the subject area of monumental studies has been treated over the past century by the humanities and social sciences, Osborne advocates for a “two-step process” to best approach monuments and monumentality. He and his colleagues interpret these topics as “closely related, but nevertheless distinct, phenomena” distinguished most succinctly as a *thing* (monument) on the one hand, and a *relationship* between thing and person(s) (monumentality) on the other.
Art historians are another group who are intimately familiar with the entangled world of the tangible (things) and the intangible (qualities). In his text *Monumentality in Early Chinese Art and Architecture*, Wu Hung (1995, 1) contrasts the term “monumentality” with that of “monument,” advocating that the “relative abstractness [of monumentality as a concept] offers flexibility for interpretation... [and] is not overburdened with preexisting connotations.” Hung (Ibid.) argues that “monument,” one the other hand, is firmly associated in contemporary usage with “giant, durable, solemn structures in public places” such as the Arc de Triomphe and the Statue of Liberty. The connotations that Hung assigns reinforce the divergence established above and encourage further consideration of terms related to monument and monumentality, along with their seemingly internal oppositions.

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*Table 1. Diverging connotations of monument and monumentality, developed from Hung (1995).*

Earlier definitions in art history may indeed indicate a shift in meaning. Alois Riegl (1996, 69) wrote in the early 20th century that a monument is a “work of man” created for the specific purpose of keeping a particular human deed or destiny alive and present in the consciousness of future generations. While not specifically addressing monumentality, under his terms a monument inherently subsumes both tangible and intangible aspects. Perhaps illuminating a shift in meaning and usage
over the following decades, both Osborne and Hung parse monument and monumentality with more explicit form and meaning distinctions. With regards to archaeology, this bifurcation is a helpful starting point because the materialist foundations of the discipline have long sought to account for—first and foremost—the physical dimensions and empirical aspects of monuments, even as others have been drawn to the mind, such as architectural theorist Christian Norberg-Schulz (1991, 5) when he wrote: “My primary aim is to therefore to investigate the psychic implications of architecture rather than its practical side, although I certainly admit that there exists an interrelationship between the two aspects.”

Archaeologists have sustained a rather more pragmatic approach to monumental architecture. Trigger (1990, 119) offers a representative “working” definition of monumental architecture in archaeology when he writes, “its principal defining feature is that its scale and elaboration exceed the requirements of any practical functions that a building is intended to perform.” However, while approaches by archaeologists are generally grounded in the overstated materiality of monuments, attention—although somewhat less explicit—has also always been paid to the intangible aspects of such places, sensu monumentality. Distinctions of form and meaning between monument and monumentality are especially relevant in an archaeological context because in practice, the interplay between the tangible aspects of a monument (size, labor and resource requirements, design elements, durability) with its intangibles of use and meaning (political, ritual, ideological i.e., memorialization and commemorative significance) are central to the study and understanding of any society. Osborne’s two step process, which can be referred to as the “form/meaning dialectic,” (2014, 4) or more simply a “relational viewpoint,” explicitly supports the interrelated but distinctive themes of monuments and monumentality in archaeology.

For the purposes of this dissertation the term “monumental architecture” is used to stress the relational viewpoint between the twin notions of monument and monumentality, in order to more accurately trace the significance of each within the
past and to tease apart the multidimensional effect of the two together. A study of monumental architecture under this definition should therefore incorporate both a form (monument) and specific aspects of its memorialization, commemoration, or other intangibles including ideology and beliefs (monumentality) associated with it. As an area of study, monumental architecture promises insight into how relatively large and durable structures might have materialized meanings, and the sociopolitical impact and potential of such processes. The ultimate challenge of studying monumental architecture in the archaeological record is not determining the specificity of these past meanings (which are specific to the social context of their production, and therefore difficult if not impossible to identify in the present) but rather how meaning was and is conveyed through the buildings themselves (Johansen 2004, 319).

In general terms, a relational approach to monumental architecture requires the identification and documentation of monumental qualities in building projects and the landscapes that they anchor, the identification and analysis of social and symbolic qualities in relation to the monumental characteristics of a place, and a wide-ranging consideration of how such entities develop across time and space. In addition to more traditional archaeological investigations of monumental metrics (i.e. size, materials, orientation), this approach also explicitly requires the consideration of how people and monuments have interacted in the past, and even how they continue to do so in contemporary settings. Christopher Woodward (2003, 69) boils down these values in describing a ruin:

...a ruin has two values. It has an objective value as an assemblage of brick and stone, and it has a subjective value as an inspiration...

Monumental architecture can be conceived as a short-circuit between the past and the present, because as monuments are physical eruptions of the past and views of the past are never static (Moore 1996, 94) so present interpretations must be dynamic. The exploration of monumental architecture through this dissertation
seeks to build on the work of other archaeologists as well as scholars in related disciplines by exploring how monuments and monumentality are closely related to what and how we sense places themselves. This pursues Osborne’s (2014, 4) suggestion that archaeology might “…resuscitate the Oxford English Dictionary’s transitive sense of the word: the active meaning of monument that has become obsolete should once again gain currency” (emphasis added).
Archaeological approaches to place

Viewing monumental architecture with a relational perspective—acknowledging the potential complexity of its form/meaning dialectic—highlights the need for an equally flexible construct to situate the entity of any built structure in relation to the rest of the world. Central to this need is the notion that people and environment are fundamentally interrelated or even mutually constituted, and that the context of any location and its character should be accommodated in understandings of the past. Places, understood not as simply locations but also as primary categories of human experience and social constructs (Bowser 2004; Feld and Basso 1996; Scheider and Janowicz 2009) are important for how they host the complex processes by which individuals and societies impart or assign meaning to their surroundings, and how surroundings thereby take on influence in return. As Lefebvre (1992, 216–217) writes:
The production of monumental space is a transformative process in which material, symbols, and signs are exchanged, symbolically grounding a given perceptual order (e.g., possible combinations of the cosmological, political, and social) to a set of material practices within a conceptually established social order.

In the Hawaiian context wahi pana, or places that are storied or celebrated, are recognized as places where ultimately “history has been shaped by those in power and commemorated in the landscape” (Carson 2012, 386). Accordingly, the idea of place, including monumental architecture, as a particular and meaningful location (Whitridge 2002; Agnew 1987) is a conceptual device that affords a high degree of compatibility with a wide variety of perspectives. Building on this elasticity, general anthropological accounts of place can seek to more fully account for the nuances of human interactions with the world and their meaningful relationships with their surroundings (e.g., Gregory and Urry 1985; Hirsch and O’Hanlon 1995; Low and Lawrence-Zúñiga 2003). Place and landscape are foregrounded in such accounts.

At times subtle and at other times outright, a shift toward the particulars of place has continued to affect the way that archaeologists approach the study of the material record over the last several decades and continues to have an impact at present. Central to these deviations is a marked swing in thinking about the concept of landscape in relation to culture, from “a passive backdrop or forcible determinant” to “an active and far more complex entity or relation to human lives” (Knapp and Ashmore 1999, 2). Social theorists have examined the ways that space in general and buildings in specific affect social reproduction (Bourdieu 1977; Foucault 1977; Lefebvre 1992), generally establishing that built space is a primary context for social interactions (Fisher 2009, 439). Viewed more broadly, the growth of landscape concepts, approaches, and terminologies may also be seen as linked to a disciplinary adoption of theories citing the human body and its actions as a primary referent for studies of past and present culture (Bourdieu 1977; Giddens
1986; Ingold 1993). In the context of social science, the 1960s and 1970s saw a marked split in approaches to the study of space—first in geography and closely followed by other disciplines—that spawned the emergence (or re-emergence) of two diametrically opposed perspectives, positivism and humanism, each generally pursuing a distinct agenda. Positivistic works tended to focus on the human occupation of physical space and used approaches prioritizing movement, node, network, and surface model analyses, for example. Humanist works focused more heavily on human values, beliefs, and perceptions, contrasting the abstractions of their positivist counterparts in doing so.

Part and parcel of conceptualizations of place, approaches to architecture can also be parsed along a spectrum stretching between positivism and humanism, clustering around notions of homogenous Euclidian space and heterogeneous natural and social space, respectively. Many contrasting sets of terms have been used to describe the edges of this spectrum, with Nili Portugali (2006) choosing “mechanistic-fragmentary” and “holistic-organic” to characterize two divergent (and dominant) schools of thought. Lefebvre (1992), however, sets the two in relation to one another by discussing abstract and transparent Euclidian space as a reduction of a more complex and dynamic heterogeneous whole. At various scales (e.g., landscape, building, body) the key point of variation—and sometimes contention—in these perspectives are the reductive tendencies or resistances inherent to each. In terms of architecture, a mechanistic-fragmentary approach separates elements and creates an environment of autonomous fragments, whereas its holistic-organic counterpart maps the ever-changing relationships between things and the host within a dynamic whole (Portugali 2006).

One can hardly contemplate place without bringing up the body. One starting point, asserted by Maurice Merleau-Ponty (2002), is that people are grounded in the physicality and material experience of the human body in the world. The reality of consciousness, a state which is necessarily attached to a body (the concept of body-subject, a mind physically embodied), equals that consciousness is corporeal, and
the physicality of bodies structures how things, places, and landscapes are experienced (Tilley and Bennett 2004; Bender et al. 2008). The connection between the physical and material and the body-subject is through the senses and perception. Body and perception order space through the specific identification of places within a locality, which is an important distinction from the ordering of space by directional coordinates (Fox 1997, 4). Such orders are particular to social context, and it has been argued (Bubandt 2006) that they form the basis for social praxis, influencing the placement of buildings and the performance of acts, for instance.

The orientation of the body in relation to place is manifested in culture, such as in the language of locations. Topogenies—the recitation of an order sequence of place names—are “a distinct means for the ordering and transmission of social knowledge” as James J. Fox (1997, 8) points out is common among Austronesian populations. Based on ordering, topogenies, and memory, conceptualizations of direction often exhibit a similar bodily origin. Again in terms of Austronesian culture, K. Alexander Adelaar (1998) identifies Daya “toward the interior” and laSud “toward the sea” as proto-Austronesian terms that define a fundamental axis of orientation in Austronesian societies. The seaward/landward directionality is further refined in Polynesian conceptualizations, which Matthew Campbell (2006) unpacks in a Rarotongan landscape where relatively higher status is associated with the seaward direction. Such landscape-based directionality, however, is also shown to exist in concert with an anthropocentric ‘point field’ model. A point field imagines space to extend indefinitely from a point of origin until it encounters another field, whereby a fluid border forms. In point fields, boundaries wax and wane according to the power of contending individuals, groups, or entities, a state that contrasts starkly with the ‘container’ model of space more familiar in contemporary Western perspectives, whereby borders are solid and defined thresholds, relatively rarely subject to change. While social underpinnings such as directionality and landscape or anthropocentric orientations are aspects of daily life in the past that are easily overlooked, archaeological investigations of place are challenged to account for the
roles they played within past societies. Given its apparent formality and elaboration, monumental architecture is an important line of evidence to examine how people exercised their frameworks of conceptualization, engaging in the humanization of space by transforming the local environment through a complex series of naturally and culturally-oriented processes (Erickson 2010).

**Dimensions of monumentality**

While presenting an outward appearance of stability, neither the form nor meaning of monumental architecture is inherently secure on the scale of decades or centuries, let alone millennia. The life histories of monumental architecture, contrary to their apparent permanence, show that they are dominated by the risk of outright destruction and have a high likelihood of being repurposed, rebuilt, or having their materials reclaimed. The leasing of the Roman Coliseum by the Popes in AD 1451 is given by Woodward (2003, 7) as one example of a notable structure that was summarily subjected to partial destruction. Despite often giving an impression of permanence, even the materials that form a monument are inevitably on their way to another use. Kaplan and Adams (1986) go so far as to suggest that the lifespan of any instance of monumental architecture is based more closely on the value of its construction materials (as well as their portability, or lack thereof), and less on the workmanship performed or the social significance of the building at the time of its construction. The biggest threat to a monumental building is more than likely to be people, even over natural threats such as the inevitable, daily toll of erosion or the spectacular destructive power of catastrophic events like earthquakes and floods. In Hawai‘i, many heiau foundations were repurposed by early missionaries and plantation owners and managers for building roadways, agricultural features, and churches.

The built environment and especially monumental works become a “rich and relatively durable medium for people to convey meanings that influence behavior
and interaction and, through the processes of social reproduction and transformation, create and promulgate ideologies that advance their interests” (Fisher 2009, 455). Yet just as the stones that compose the walls of a building are subject to myriad physical forces, monumental architecture—as part of the archaeological record—suffers the common fate of being naturally disrupted from the social context of its creation due to the passage of time and the dynamic and shifting nature of culture. This brings into focus the tenuous nature of the meaning of a monument, its “legibility,” and the decreasing likelihood of its being accurately “read” by the next human being who encounters it, let alone those who come along centuries later. While symbolic approaches, for instance, emphasize the role of built form in the communication of meaning by fleshing out the contexts in which past social interactions took place (see Lawrence and Low 1990, 482-491), getting at the meaning of the built form in the first place is another challenge altogether. To get beyond form, one must consider something more than form alone.

First, however, it is important to consider monuments and intention. For instance, there are types of monuments that, instead of aiming for legibility, court the imagination. Woodward (2003, 71) argues, “that if a tomb is too demonstrative... it is a natural reaction to make one’s excuses and hurry past. It is the passivity of Shelley’s monument which invites the imagination... It is a mirror in which Shelley’s image appears, in whatever form each of us imagines him.” In considering how meaning is a negotiation between the creator and the viewer, the design of any monument may seek to emphasize and bestow explicit—or, alternatively, mutable—characteristics. It is also possible for structures that were built with no symbolic or monumental intent to, with the passage of time, be administratively designated as monuments. In the UK, legislation can be passed to establish a “Scheduled Monument,” a state that reflects how valuations of historic worth shift hand in hand with social and political conservation hierarchies. In this context, monumentality is assigned to a structure through bureaucratic procedure, and removed—in theory—the same way, in the small print of paperwork. Other types of ruins can also challenge conceptions of what monumental architecture is and how it
fits into the lives of people. Contemporary industrial ruins in Britain—considered to be wasted space by many—have alternatively been noted for their value in terms of economic, social, material, and functional meanings (Edensor 2005, 7). Passive, mutable, unintended, and reclaimed architectural contexts that develop monumental qualities all highlight how the unintentional often plays an important role in the life history of any building (Riegl 1996). The fate of a monument is—if nothing else—to stand in the face of change.

Unintentional meaning can also be created through archaeological endeavor or any other activity that makes monumental architecture its subject matter. Stepping back into an earlier era, tracing the linkages between monumental architecture and archaeological inquiry, Bruce Trigger (1989) opines that the historic contemplation of ruins, generally monumental in nature, were frequently colored by worldviews of antiquarianism, colonialism, romanticism, and racism. Indeed, early connections between monumental architecture and Western society at large are important to note as they belie aspects of a modern fascination with monumental architecture and its malleable linkage to distant, shadowy pasts. Archaeology, a discipline with its roots in the 17th and 18th centuries is tied, in significant ways, to the modern discovery of, and fascination with, sites of monumental architecture and a host of ancient civilizations, along with the attention paid in more recent centuries to other aspects of past societies that exude monumentality. Although dalliances with exploration, antiquarianism, and travel have been largely abandoned for more scientific forms of inquiry, archaeology remains susceptible to the historical dangers of coloring monumental architecture inaccurately if anything less than a critical form of inquiry is taken. This state of affairs highlights that views of the past are never static and neither is the interpretation of monuments. The inherently multifaceted character of monumental architecture works not only on the scale of a discrete architectural object but simultaneously as a dynamic, changing place.
Intentional or ambiguous, stable or erratic, monumental architecture is a salient manifestation of monumentality. Monumentality can also be understood on its own terms, in the absence of a “constructed” monument. Having appraised the instability of monumental architecture and also the unintentional monumentality of ruins among other examples, we now pivot toward what can be called “non-monuments,” or places that exhibit hallmarks of monumentality but have no specific or notable physical form to distinguish themselves from their immediate surroundings or anywhere else. In the words of John Brinckerhoff Jackson (1980, 91), with reference to the battlefield of Gettysburg:

A monument can be nothing more than a rough stone, a fragment of ruined wall ...a tree, or a cross. Its sanctity is not a matter of beauty or of use or of age; it is venerated not as a work of art or as an antique, but as an echo from the remote past suddenly become present and actual.

In the absence of a formalized monument, anything (or everything) may come to express the monumentality of a battlefield, a rite, or a memory, and can thus be considered a de facto monument. Such an informal monument may not be large, durable, or even recognizable, contrary to the connotations of the term as defined and explored previously. Assuredly, the “echoes” of past events, even if they are not associated with a formal monument, are a common part of landscapes and are inseparable from places, even if only in the eye of the beholder. In the words of Pierre Nora (1989, 7) these are sites of memory, where “a sense of historical continuity persists” even if a real environment of memory does not. In this context, the relationship between a de facto monument and its monumentality is quite indirect, emphasizing that the cloak of monumentality is only loosely attached to physical forms even when it is still firmly rooted in place. Non-monuments, or indirect monumentality, are indicative of humanity’s ability to attach memories to places by one means or another. The knowledge and referencing of major mountaintops, as well as lesser puʻu (hilltops), most all of which were named yet
rarely modified, hints at the degree to which non-formal elements of the landscape were incorporated into Hawaiian place-making.

Indirect monumentality is of concern for archaeology because its de facto nature makes it difficult to identify in the physical record, but its presence may still exert considerable agency on the behaviors of people. For instance, Fontijn (2007) demonstrates how “invisible” places could have been just as important as highly formalized equivalents in ritual landscapes during the Bronze Age of the Netherlands. While monuments are readily identifiable when comparisons of their physical scale, construction, or elaboration differ significantly from other, quotidian versions of structures, indirect monumentality is a closely related but incomparable phenomenon due to its invisible attachment to one or more fragments of the landscape.
Monumental architecture and authority

Having established how monumental architecture incorporates dimensions of both monuments and monumentality, we come to the manner in which monumental architecture appears to have been integral to human societies. Monumental architecture is associated with “complex” societies around the world (Trigger 1990, 119), wherein complexity refers to a social structure characterized by hierarchical organization and unequal access to resources and power. In hierarchical societies, the production and circulation of goods typically transcends domestic units and, likewise, social power may be established and asserted far beyond the household group (Feinman and Nicholas 2004; Burger and Rosenswig 2012; Bayman 2002). Defined as mastery exercised over other people, social power has been theorized by Michael Mann (1986, 6) to have four sources: economic, political, military, and ideological. These sources are not mutually exclusive and may combine in a myriad of ways, such as elite power being tied to control over ideology and economic production in chiefdoms and other ranked societies (DeMarrais et al. 1996; Earle 1997), for instance. Turning to ideology, it is the ideological potential of monumental architecture as an instrument of power—and a force for domination—which we will consider more closely now.

Domination is defined by Weber (1978, 212) as “the probability that certain specific commands (or all commands) will be obeyed by a given group of persons” and further stresses that, “every genuine form of domination implies a minimum of voluntary compliance, that is, an interest (based on ulterior motives or genuine acceptance) in obedience.” As a form of domination, authority inherits the obedience of others not through outright coercion but rather with a degree of willingness. Likewise, Earle (1997, 3) defines authority as both the right and responsibility to lead, sanctioned by a group in recognition of the capabilities or social position of an individual. Both Weber and Earle view authority as a form of legitimate power whereby subordinates do not need to consider an authority correct in a rational or moral sense, but simply acceptable (if not desirable) enough
to not warrant resistance. The hallmark of authority, as a form of domination, is the willingness of subordinates to believe in the legitimacy of claims made by those who dominate. This willingness or interest contrasts with forms of domination that rely on coercive power to achieve compliance.

DeMarrais et al. (1996, 15) argue that, “ideology becomes an important source of social power when it can be given material form and controlled by a dominant group.” By this thinking, ideology is as much the material means to communicate and manipulate ideas as it is the ideas themselves, and the materialization of ideology is conceived as a way to spread or articulate power into increasingly larger social circles. As authority is part of ideology (Earle 1997, 3), it follows that the ideological potential of monumental architecture is—in part—its materialization of authority. Authority can be materialized in monumental architecture by incorporating religious, sacred, or spiritual forms, connections to well-established cultural beliefs, and/or the involvement of social elites, for example. Materialization may be enduring, but it may also be demonstrative. The building of monumental architecture is an undertaking that may impress subordinates, especially when it is carried out in a prescribed and deliberate manner, even by the subordinates themselves as when, for example, junior chiefs in Polynesia would be expected to contribute labor and resources to the build project of a paramount chief.

While monumental architecture cannot be assumed to be an a priori indicator of concentrated social power, authority, or the social hierarchies often observed in association, in many instances the material record offers further insights into how it developed or functioned. As DeMarrais et al. (1996, 17) point out, “By examining the means and forms of materialization we can begin to reconstruct the strategies through which ideologies were generated.” The archaeological record of the Hawaiian Islands is one case where monumental architecture presents itself through multiple lines of evidence, and in which both the means and forms of its materialization promise new insights on authority.
**Structure of the dissertation**

Having introduced a notable aspect of the archaeological record (luakini heiau), defined a general concept that describes its relationship to traditional Hawaiian society (monumentality), and asked the question of how such buildings functioned in the context of chiefly authority, the following chapters of this dissertation concern themselves with: a) introducing a theoretical framework—sensory exploitation—and its explanatory potential for the exertion of authority through emotional impacts predicated on both biological and cultural sensitivities; (Chapter 2); b) describing Puʻukoholā heiau, a luakini heiau and National Historic Site chosen as the study area for this research (Chapter 3); c) defining the senses in the context of the study area, and presenting results that analyze physiological and cultural interactions in the monumental setting; (Chapters 4 and 5); and finally, d) present a synthesis of the senses for the study area in both theoretical and social terms, and discuss the future direction and potential of sensory archaeology for understanding monumentality and advancing knowledge of the past, present, and future in Hawaiʻi (Chapter 6).
Chapter 2: Sensory Exploitation

Introduction

Building on the humanistic and political ideas introduced in the previous chapter, this dissertation also brings the form and function of traditional Hawaiian monumental architecture under the consideration of biological signaling theory. Drawing upon the concept of sensory exploitation (Joye and Verpooten 2013), the link between chiefly authority and the various aspects of multifaceted, monumental constructions like Hawaiian heiau is reconsidered. In this research, the widely discussed concept of costly signaling is endorsed with regards to its relevance to various archaeological accounts of monumental architecture. Following Joye and
Verpooten, however, it is contended that the less popularized concept of sensory exploitation is a significant and complementary concept to costly signaling and holds notable significance in its own right. Together, signaling theory and sensory exploitation assume that 1) a complex system of signals and receivers are at work in the natural world and are the result of a prolonged cultural evolutionary process; and 2) that as receivers, people possess preexisting sensitivities to particular sensory stimuli, to include “sensory, cognitive, or emotional sensitivities for visual, aural, or other perceptual stimuli/features” (Ibid. 2013:55).

Specifically, this chapter outlines the explanatory potential of sensory exploitation in terms of traditional Hawaiian society’s heavy investment in the construction and maintenance of monumental architecture (particularly luakini heiau) and the equally notable manifestation of a high degree of vertical social stratification. The theoretical perspective afforded by sensory exploitation—most importantly the foregounding of the senses in human experience and emotion—offers new ideas on how traditional Hawaiian monumental architecture was linked to social development and the maintenance of chiefly authority, and may also be relevant to better understanding and engaging the ethnohistoric and ethnographic records.

**Biological Signaling Theory**

Biological signaling theory, also referred to as signal evolution theory, consists of a broad collection of ideas developed in an effort to explain how systems of differential traits, or signals, evolved for the purposes of communication in the animal kingdom. Framed around the concept of a signal-receiver dyad, signals are recognized to exist in all major taxa of animals and to operate across all sensory modalities (Ryan and Rand 1993). A basic premise of signaling theory is that in order for signals to be effective transmitters of information, they must not only be
distinguishable from background noise but they also must differ from other signals. In evolutionary biology, understanding exactly why and how senders of a multitude of species have evolved elaborate signals relating to sexual selection—along with exactly why and how receivers have evolved preferences for such traits—has proven a perennial subject of research (Maynard Smith 1991), and also serves as a salient introduction to signaling theory in general.

Signaling theory can be introduced within the context of sexual selection, whereby signal evolution explains how receiver (e.g., females) choice can result in senders (e.g., males) evolving display traits (signals). In the context of display traits and sexual selection, these signals take various forms, including morphological characteristics, conspicuous movement(s), notable sounds, pheromones, or electrical discharges. Importantly, however, biological signaling theory is also applicable to cultural systems of selection. The process of selection (through preference) leads to the differential persistence and development of certain signals. In a resource-based mating system, males typically co-evolve signals that match the sensory biases of females. What researchers have found generally more difficult to explain, however, is why females have “evolved receiver properties that make one trait more attractive than another” (Ryan and Rand 1993, 188). A variety of hypotheses have been developed to address this issue.

At play within signaling is the fundamental issue of preference evolution. Built upon explanations of how preference evolution has evolved, in order to exercise preferences (and reflected by the evolution of marked traits whether natural or cultural) individual organisms possess sensitivities to particular stimuli. Building on this idea, one hypothesis advanced for the explanatory potential for preference evolution is that of sensory exploitation, which simply states that “preferences are manifestations between perceptual biases of the sensory system and properties of the stimuli” (Ryan and Rand 1993, 188). In other words, if a signal triggers a particular sensitivity, then preference may be granted based on the efficacy of the stimuli to shape a perception rather than (or in concert with) any
other specific quality (perceived or actual) of the signal. Equally important is the fact that sensory exploitation addresses instances when signal traits appear to have evolved *after* the preferences for such traits are already established. Significantly, such sensitivities can also function outside of the domain of sexual selection.

**Sensory exploitation**

As a complementary concept to costly signaling as well as other hypotheses that address preference evolution, sensory exploitation is based upon the idea that senders evolve display traits that derive success by exploiting preexisting “adaptive” sensitivities of receivers. Concomitantly, sensory exploitation hinges on the notion that senders can evolve display traits that exploit sensitivities developed for other purposes. In other words, instead of evolving in tandem with the preference(s) of a receiver, senders may develop signals that co-opt preexisting sensitivities. Preexisting sensitivities are likely to have developed as part of entirely unrelated evolutionary processes. As an example it has been suggested (Rodd et al. 2002) that the coloring patterns of male guppies mimic the preferred hues of food for females guppies. Within the framework of sensory exploitation, because female guppies have an adaptive sensitivity to such colors (evolved to discern preferred food during feeding activity) they also respond to males with similar coloring. Thus, males who exhibit food-like coloring are more reproductively successful than those who have not and the coloring becomes evolutionary advantageous.

Through this example several versions of sensory exploitation emerge. The sensitivity of female guppies for certain color hues due to an adaptive sensitivity developed through feeding and a resultant success of similarly-colored males, if causal, would exemplify an example of “strong” sensory exploitation. It is widely acknowledged, however, that sensory exploitation need not be mutually exclusive from other types of signaling, such as costly signaling. In fact, the preference of
female guppies for food-colored males may be co-evolved with a costly signal, meaning that females are attracted to the hues of food but since the color is hard to produce for males the signal also acts as an indirect indicator of male quality (Arnqvist 2006). This latter scenario would be an example of “weak” sensory exploitation, alternately referred to “sensory drive” elsewhere (Endler 1992). The third and final possibility is that the preference for orange food and orange mates evolved independently, in which case sensory exploitation would not be at play (Fuller et al., 2005). Acknowledging that costly signaling is also likely to be at work, this dissertation seeks to apply sensory drive or “weak” sensory exploitation to the study of Hawaiian heiau and accounts of their central role in the socio-political dynamics of the past, as well as considering how the structures potentially impacted populations through sensory sensitivities.

The evolutionary specifics introduced above have been explored from a Darwinian perspective in the functions of religious monumental architecture (Joye and Verpooten 2013). They argue that weak sensory exploitation, in addition to costly signaling, offers explanatory potential for religious monumental architecture and sheds light on why a high degree of costliness is embodied by high (tall) structures in particular. This application of sensory exploitation suggests that instead of the conspicuous wasting of resources, monumental architecture sought to overwhelm the sensory sensibilities of its target audience and thereby trigger a state of emotional and social susceptibility. Many sites, including those where leaders engaged in the “thrifty” use of resources while still projecting an impression of high cost, would seem to fit sensory exploitation over costly signaling. However, the two concepts are not mutually exclusive and a costly signal may often complement sensory exploitation, and vice versa.

To support how sensory exploitation works, several further ideas need to be explored, which include the potential adaptive sensitivities of humans to specific qualities of monumental architecture and the social significance of such a scenario. Following the theoretical lead of Joye and Verpooten (2013) and building on their
ideas, the concept of sensory exploitation is further unpacked in the remainder of this chapter in order to better frame archaeological inquiries into the form and function of traditional Hawaiian monumental architecture and their interaction with the human senses, which make up the research chapters presented shortly.

**Cultural traditions**

The concept of sensory exploitation is not limited to explaining patterns of sexual selection or to the domain of non-human animals, and may also be applied in the context of cultural transmission. Indeed, sensory exploitation is readily theorized in terms of humans and cultural signaling. Instead of determining genetic makeup, in this context sensory exploitation drives the development of particular traits that exploit pre-existing sensory sensitivities. The particular behavior(s) linked to the trait evolve if not hindered by costs, and in this way cultural traditions may develop by “piggy-backing on cumulative adaptive evolution” (Verpooten and Nelissen 2010, 1). Behavior(s) that result in traits that do not appeal to sensitivities do not persist because they become overlooked or ignored. Sensory exploitation takes on particular relevance when examining religion or other formalized practices, where the mechanism could drive the adoption of beliefs, conformance to ideology, and particular social structures or hierarchies through effective signaling. John Rick (2004, 86), writing about activity at the monumental center of Chavín de Huántar in the north-central Andes from BC 1300 to 600, recognizes the high value of being able to successfully appease the predilections (whether conscious or otherwise) of people when he writes that, “The potential payoff in increased authority would be great for those who learn to manipulate credibilities by understanding the effects of media, actions, and contexts on the susceptibilities of the human mind.”
A Vast Sensitivity

At the core of this research, and the theoretical framework outlined in this chapter, is the question of why monumental architecture is frequently linked to social settings where power and authority have been highly developed and exercised. Sensory exploitation posits that senders evolve display traits that exploit preexisting sensitivities of receivers, meaning that the key to a successful transmission is identifying a sensitivity (or sensitivities) to exploit. In terms of animals—including people—Joye and Verpooten (2013, 56) introduce “the tendency to consider large-sized objects or agents as powerful or dominant” as a widespread preexisting sensitivity, for which they coin the expression “an adaptive sensitivity to bigness.”

The literature underlying a possible human sensitivity to “bigness” is wide-ranging and extensive. Many animals are known to be keenly aware of the physical size of other individuals, because large size is a common characteristic of dominant individuals in many species and signals power and strength. As stated by Daniel Freedman (1979, 92), “Throughout nature the rule is the bigger, the more dangerous.” Size also translates into other social advantages—bigger male baboons, for example, have been observed to maintain a higher dominance rank than their smaller counterparts (Johnson 1987). In the case of social animals, a sensitivity for bigness is exploited during displays of dominance and is linked to the establishment or consolidation of social hierarchies. This sensitivity likely drives behaviors whereby an individual takes steps to appear larger when confronted or challenged. Body mass has also been shown to be highly correlated to dominance rank in an inter-species setting, such as the competitive interaction among a community of invertebrates in a Central American rainforest (French and Smith 2005), underscoring the widespread degree to which a sensitivity to bigness has been observed across the animal kingdom.
A variety of human behaviors also indicate a preexisting sensitivity to bigness. Schwartz et al. (1982) suggest that the sensitivity originates from parent-child interactions and how children are conditioned to associate the relative “largeness” of their parent(s) with total influence, which becomes a deeply engrained, size-based impression of social power. Further research indicate that the height of individuals is associated with power by others and taller people enjoy advantages in several important aspects of their careers, prompting Judge and Cable (2004, 428) to state that, “from a sociobiological perspective, height equals power and therefore demands respect.” Other behaviors reinforce this perspective, such as a podium where the winner is on the highest step, with lower steps on either side for those coming second (lower) and third (lower still). Impressions of power are also cast by other non-bodily references of size, height, and verticality, such as the visual representation of power as a vertical difference, a large font, a long line, and even in association with lofty environmental settings like mountains (for a review, see Joye and Verpooten 2013, 56). It is also noteworthy that “bigness” can be perceived and reacted to in certain non-physical entities, such as when an individual is referred to as a “big” personality or a memory is remembered as “overwhelming.”

The Significance of Awe

While the presence of emotions is muted in the archaeological record, they were nevertheless intrinsic to past societies. Specific emotions, importantly, may be tied to specific processes. In the context of sensory exploitation, an emotion of likely importance is that of “awe”. While similar emotions, such as reverence or submission, are important, awe is uniquely situated when it comes to the study of power because of how it links sensory experiences with common human sensitivities (e.g., hearing, seeing) and social processes (e.g., loud or patterned sounds). In developing a prototype of awe (Keltner and Haidt (2003, 297) write:
In the upper reaches of pleasure and on the boundary of fear is a little studied emotion—awe. Awe is felt about diverse events and objects, from waterfalls to childbirth to scenes of devastation. Awe is central to the experience of religion, politics, nature, and art. Fleeting and rare, experiences of awe can change the course of a life in profound and permanent ways.

Rising into the realm of the emotions, anthropological theorists such as Max Weber and Emile Durkheim offer a helpful starting point. Looking at the dynamics of power and social order, Weber touched on awe with regards to charismatic leaders, recognizing “the unprecedented and absolutely unique and therefore divine” as a most powerful of means by which rational rule can be disrupted (Weber 1978, 1117). Similarly, Durkheim (1972) also called out the potency of awe-like emotions in the matter of fueling political, social, and religious movements, speculating that extreme emotions can wield such overwhelming influence so as to shatter a person’s worldview and replace it entirely with the desire to follow the collective. Awe, therefore, is of great potential value to anyone challenged with the task of affecting the worldview of other people.

Keltner and Haidt (2003, 303) survey the scholarship awe and assert that, “Across disciplines, theorists agree that awe involves being in the presence of something powerful, along with associated feelings of submission. Awe also involves a difficulty in comprehension, along with associated feelings of confusion, surprise, and wonder.” Further, they identify what they call two foundational features to the awe prototype: 1) perceived vastness; and 2) need for accommodation. Perceived vastness refers to “anything that is experienced as being much larger than the self, or the self’s ordinary level of experience or frame of reference” and need for accommodation refers to the “...process of adjusting mental structures that cannot assimilate a new experience” (Ibid. 303–304). Perceived vastness and a need for accommodation fit together in the idea that the experience of perceived vastness creates a need for accommodation because it exposes the inadequacy of a person’s
mental structure or frame of reference to make sense of what they comprehend. In instances where the need for accommodation is not satisfied people can feel bewildered or terrified. In instances where the need for accommodation is satisfied feelings of “enlightenment or even rebirth” can accompany the expansion of their mental structures to accommodate new realities. In other terms, the successful accommodation of perceived vastness is similar to what Maslow (2014, 90) calls “conversion experiences.”

Awe-based experiences are notable because they have the potential to influence the outlook of more than just a single individual. The perception of vastness, whether or not it is accommodated, results in the sense of a diminished self. Thus, the stimulation of awe has significant implications for the development of status hierarchies in groups of people. Reverence, devotion, and “the inclination to subordinate one’s own interests and goals in deference to those of the powerful leader” may be strengthened and justified by the promulgation of awe (Keltner and Haidt 2003, 307). In order to benefit from the hierarchical potential of awe, however, a leader (or potential leader) must disrupt the cognitive conceptions of others in order to benefit from the behaviorally submissive and open state of mind that is likely to result. Applied to theories of war, the doctrine of shock and awe (or rapid dominance) is modeled after the impact that the use of atomic weapons had on Japan during WWII. Ullman and Wade (1996, xxvi) write that, “The Japanese simply could not comprehend the destructive power carried by a single airplane. This incomprehension produced a state of awe.” They argue that such incomprehension and the state of awe that it triggered is what led to the submission and willingness of the Japanese to surrender and thereby ended the war.
Monumental Architecture and the Senses

As effective stimuli, entities that can elicit a response of awe from people are potentially powerful. Enlightenment, rebirth, and conversion are all words that emphasize the strong emotional potency of awe, and which also underscore the altered state of an individual who has encountered a vastness of suitable intensity and revised their cognitive conceptions in order to accommodate it. Sensory exploitation proposes that in addition to signaling the capabilities of someone or something to control the large quantity of resources required for their construction, specific sensory aspects of monumental architecture are likely to have sparked subjective impressions of power when perceived by the people around them as drastically vast. Joye and Verpooten (2013, 56), put it this way:

Thus, in addition to the fact that in religious monumental architecture power is evident from the fact that massive amounts of energy and labor were necessary to erect these structures, the sensory exploitation perspective extends these views by suggesting that also particular formal attributes of these buildings (especially height) lead to subjective impressions of power.

Additionally, social vastness is understood to not be limited to physical size such as height. Articulated more broadly, the potential domain of vastness diffuses and encompasses various social forms of notability such as fame, prestige, and money. In addition, social vastness can harness entities of the natural world when their presence is incorporated into systems of meaning. If natural phenomena are ascribed to a cultural entity (such as a god or a king), then the apparent environmental vastness of volcanoes, thunder, lightning, and earthquakes, for example, might function in a double fashion by eliciting awe and simultaneously reinforcing the system of meaning by ascribing such vastness to an authority.
In order to better understand costly signaling and the other hypothesis of biological signaling theory, it is arguable that sensory exploitation adds important insights. The study of monumental architecture under the lens of sensory exploitation is an inherently multisensory undertaking. Not only should the archaeological record be examined for traces or proxies of human sensory processes, but the role of the senses should also be considered collectively. Sensory exploitation demands that we examine the archaeological record for evidence of how monumental architecture may have played a role in such a process, by indoctrinating people into religious, political, and/or other institutional forms of social cooperation and subordination, including the propagation of social hierarchies. To investigate the senses in the past, we turn to sensory archaeology.

**Sensory Archaeology**

In considering how things (including places) actively impact people, one unavoidably encounters the fundamental centrality of the senses to human experience. We sense the multifaceted dimensions of place, and it is along the avenue of the senses by which people are or become affected by what is occurring around them or what they are doing. In the case of monumental architecture, it is clear that the built environment is often painstakingly constructed—in part—to be experienced. Stark (2016, 89) writes of ritual practice in pre-Ankorian Cambodian shrines as, “spectacles of riotous color, pulsing sound, and pungent smells.” Despite being a fundamental observation archaeologists have been, with the partial exception of sight, relatively slow to investigate the senses. However, as recent inquiries into the sensual realm are made by archaeologists (such as by Skeates 2010; Hamilakis 2011; Day 2013), a broader field of sensory studies in the social sciences and humanities (Classen 1993; Howes 1991; Smith 2007; Howes and Classen 2013) grows increasing relevant. Questions of how people in the past might have not only responded to various sensations encountered at specific places and
times, but also how the senses have always been in play when it comes to influencing, controlling, and structuring experience—and also how the senses relate to greater social processes—are all relevant and accessible for study in appropriate archaeological contexts. At the same time, a sensory archaeology acknowledges that the senses are not uniformitarian—not everyone can see, some people hear better than others, and some people have highly refined or specialized senses. What does exist, however, is what might be called a sensory baseline—the vast world of sensory stimuli upon which almost every person draws from in order to ascertain their surroundings.

People interact with the world through their senses. The senses also are the medium with which anybody creates and maintains identity, a process that draws on not not only the physiology of sensory organs but also the culturally constituted sensibilities of the mind. Taste, touch, smell, sight, and sound are the five senses recognized in the modern Western world, but this classification is not universal—it has been shown that other societies distinguish the human sensorium as composed of different numbers of senses and manifesting in different sensory hierarchies (Classen 1993; Houston and Taube 2000). An emphasis on the sensual is not necessarily novel. The “sensuous geographers” sought to apprehend the “fullness of a living world or everyday life as a multisensual and multidimensional situatedness in space and in relationship to place” (Rodaway 1994, 4). In archaeology, however, sensory emphasis has overwhelmingly been placed on sight. One primary reason for this is that it is not possible to excavate around smells, tastes, touches, or sounds and so the traditional archaeological toolkit is not equipped to accommodate let alone interrogate their ephemeral presence, nor does the typical research design seek to explicitly address them. Furthermore, the senses are are difficult to quantify. The sum of this equation is that the sensory dimensions of the past, generally, have been more convenient to disregard than to engage. The result, however, are accounts of the past that lack a major component and constituent of human existence and experience.
A great deal can be learned about the past even when the senses are overstepped, but as Watson (2001, 297) points out the task of building a bigger picture in terms of how places were used, how they functioned, and what meanings they held often requires the recognition of the sensory environment. This begins by recognizing the sensory quality of things, such how as stone artifacts have particular textures, or how certain woods are notably aromatic, for example. In no context does the point seem more relevant than in the case of monumental architecture, where the close association of sensory phenomena and highly structured space underwrote many types of social activity. To write off the sensory conditions of such contexts to happenstance and arbitrary conditions risks missing the finely developed intentions of monument builders and the cultural context in which the events of the past took place. The degree to which human ingenuity is hard at work in many of these places demands—even if beginning with a relatively unrefined approach—a closer look at their multisensory aspects. The expectation is that evidence will be found to support the notion that people in the past fashioned a unique and distinctive sensory environment by building monumental architecture, into which they integrated symbols, rituals, and tradition and out of which grew various forms of social authority and power.
Chapter 3: Puʻukoholā Heiau

The location of the royal and religious center at Kawaihae is unusual in that it lacks the dense population concentration and affiliated rich resource base that typifies most such centers (Tomanari-Tuggle and Tuggle, 2006).

Introduction

As the senses are both physically and socially constituted, establishing an overview of any study area with respect to each is important. The study area of this dissertation is anchored by Puʻukoholā heiau, an ancient temple built by the Hawaiian chief Kamehameha I in AD 1791. Known as a luakini heiau, Puʻukoholā was built in accordance with longstanding traditional Hawaiian practices that were sustained orally by a priestly class. However, the timing of its construction falls into the historical period when European visitations to the Hawaiian Islands were becoming more regular, and when circumstance and knowledge began to be recorded in various written forms. The origin of Puʻukoholā heiau in this context results in a variety of records that can be consulted for study, including ethnohistoric texts (e.g. Native Hawaiian historians writing in the 19th century), historic texts (e.g., early European voyagers), in addition to the archaeological record itself. Furthermore, Puʻukoholā heiau is situated within a unique environmental context, which may also be appraised in general and also for how it has changed over time. In order to study the sensory aspects of this place and begin to explore the potential of sensory exploitation and monumental architecture in ancient Hawaiian society, we turn to the fundamental environmental and cultural aspects that define the study area.
Context of the Study Area

Puʻukoholā, which translates into English as hill, or mound, of the whale, refers to a heiau constructed in the traditional Hawaiian manner—built wholly of drylaid stones stacked on top of one another without any form of mortar in between. Held together solely by friction and weight, the structure has an estimated volume of over 5,000 cubic meters (Mulrooney et al. 2005, 23). For the purposes of the dissertation, the study area includes the land holding of Puʻukoholā Heiau National Historic Site, an area totaling approximately 32.4 hectares. However, many of the sensory investigations undertaken during the course of this research extended into land holdings beyond those of the National Park Service. For this reason the introduction and discussion of the context of the study area is broadened to include a number of these adjacent lands, generally referred to as the study area and its environs.

The context of the study area and its environs can be discussed under two broad categories: 1) environmental; and 2) cultural. The environmental setting includes aspects of geographical location, geology, sediments, climate, water sources, vegetation, and fauna. Where human activity has impacted these aspects, it is examined. The cultural setting includes social, historical, and archaeological aspects to include settlement patterns, land divisions, historical accounts, ethnohistoric accounts, archaeological research, landscape modification and development, cultural activities, and modern jurisdiction. The environmental and cultural setting of the study area and its environs form the foundation for the research design outlined below, supporting and influencing the sensory archaeological, ethnographic, and ethnohistoric data collection, results, and discussion presented in Chapters 4-6.
**Environmental Setting**

The environmental setting of the study area exhibits many general natural characteristics that are common to locations throughout the Hawaiian Islands and further afield, incorporating large-scale processes including plate tectonics, global weather patterns, and evolutionary change. The study area and its environs also possess unique environmental qualities. Aspects of both general and unique characteristics are introduced and reviewed below, with any eye toward directing attention toward the particular sensory aspects of the place.

**Location**

Situated in the semitropics of the Pacific Ocean at approximately 20 degrees latitude in the northern hemisphere, the island of Hawai‘i is the largest landmass within the Hawaiian archipelago (Figure 4). It is also the furthest southeast, with the other major islands of Maui, Kaho‘olawe, Lana‘i, Moloka‘i, O‘ahu, Kaua‘i, and Ni‘ihau all positioned to its northwest, as are a series of numerous atolls known as the northwestern Hawaiian Islands. Although stretching thousands of miles across the Pacific, the entirety of the island chain is highly isolated from any other landmass. As a result of its location near the middle of the Pacific Ocean, the Hawaiian archipelago is the most isolated feature of its kind in the world. Multiple environmental aspects of the island chain reflect this isolation, namely the presence of particular plants and animals—many of which have evolved into endemic species due to their introduction into a unique ecosystem and subsequent separation from any outside influence.
Figure 4. The eight major islands of the Hawaiian archipelago, with the island of Hawai‘i indicated (red arrow).

The study area of the dissertation is situated at the base of the Kohala peninsula on the shores of an expansive, naturally sheltered bay known as Kawaihae. As a placename, Kawaihae is associated with both modern as well as pre-contact settlements located in the area. Kawaihae and Pu‘ukoholā Heiau National Historic Site occupy a section of the western coast of Hawai‘i relatively close to its northernmost tip, some 56 km (35 mi) north of the town of Kailua-Kona, 30 km (18 miles) south of Hawi, and 18 km (11 mi) west of Waimea (Figure 5). By boat to the north, the island of Maui lies approximately 75 km (47 mi), across the Alinuihaha Channel. Within the vicinity of Pu‘ukoholā Heiau National Historic Site are also Kawaihae Small Boat Harbor (north) and Spencer Beach Park (south). Although the area has been extensively modified to build the harbor facilities, the leeward (downwind) situation of Kawaihae Bay, along with its large size, have made it an
attractive anchorage for ships since long before the construction of the modern harbor.

Figure 5. The Big Island of Hawai‘i with points of reference mentioned in the text marked with red arrows (Kailua-Kona, bottom; Pu‘ukoholā Heiau National Historic Site, middle; Hawi, top).
Geology

The eminent origin of each of the Hawaiian Islands is a so-called volcanic “hotspot,” a feature beneath the floor of the Pacific Ocean where magma erupts through the lithosphere (“crust”) of the earth from its asthenosphere (mantle). The longevity of this hotspot is evident in the lengthy line of Hawaiian Islands themselves, each of which is the byproduct of large-scale eruptions derived from the same hotspot. Instead of consolidating as one island, however, the movement of the Pacific tectonic plate – which underlies the entire island sequence – to the northwest has resulted in the creation of a chain of islands. Thus, a northwestern/southeastern continuum of relative age exists across the Hawaiian archipelago. At the southeast edge of the chain, Hawai’i is the youngest island geologically and also features active volcanic eruptions (predominantly on its southeastern flanks, above the plume). The volcanic volatility of the Big Island is distinct from the other islands in the chain, all of which are considered to be volcanically extinct because of their separation from the hotspot due to the tectonic movement to the northwest.

The differential in geological ages between the various Hawaiian Islands and the volcanoes that comprise them underlies many other significant environmental traits, largely geological, that may be observed on the scale of the archipelago and even in the local context of the study area. These same dynamics explain why the northern Kohala formation of the Big Island, estimated to have formed some 700,000 years ago (Macdonald and Abbot 1970, 288), is the oldest landmass present on Hawai’i and also why it is a stable geological formation (with no threat of volcanic eruptions, although earthquake activity remains persistent). The study area is situated on the southern limit of the Kohala formation, upon the remnants of the Kohala Lava Plain near where it intersects the Waimea Slightly Dissected Upland (Armstrong 1973, 31). While the Kohala formation generally consists of two distinct and often overlain series—the Pololu Volcanic Series, followed by the Hawi Volcanic...
series in some areas (Macdonald and Abbot 1970, 295-300)—at the study site the later Hawi Volcanic series is not present, meaning that the various basalts (tholeiitic, tholeiitic olivine) and oceanites observed are derived solely from the Pololu Series (Macdonald and Abbot 1970, 296). As the oldest and therefore most weathered series on the island, the Pololu materials are distinct in comparison to many of the younger flows that still present as coherent surface deposits, such as anywhere south of the study area.

On a local scale, the study area encompasses a region that has been described as consisting of four major geological landforms (Carson 2006, 6). These are: 1) a low basalt ridge; 2) an area of rocky bench land, which Puʻukoholā heiau and Mailekini heiau have been constructed upon; 3) a swale, which is the bottom section of a gulch that originates far upland; and 4) a narrow coastal strip. The basalt ridge, as well as rocky bench land, are directed related to Kohala formation eruptions that occurred during the Pololu Volcanic Series and are the oldest features. The coastal strip is primarily related to the deposit of calcareous material through marine activity. These four geological landforms are readily noticeable to the casual observer, largely through variation in the type of vegetation that grows on each.

Sediments

Generally correlated to the four geological landforms introduced above, differentiation between sediment formation processes exist across the study area. The first distinction is the formation of sediments in place versus introduction by transport. In the case of the basalt ridge and the rock bench land, processes of local weathering are the primary agent in the development of relatively thin sediments. The swale—while also subject to sedimentation developed through local weathering—exhibits a greater quantity of transported materials derived from upslope. The sediments of the coastal strip, derived from both marine and
terrestrial parent materials, has developed through both localized weathering as well as the introduction of transported sediments from upslope and also along the coastline via wave activity.

Complex internal stratigraphy has been observed in areas of deeper sediment, attributed to the variable input of marine deposits, slope erosion, airborne terrigenous particles, localized weathering, and degradation of biomass (Carson 2006, 7). Areas of relatively deep sedimentary deposits, and complex internal stratigraphy, are largely limited to the swale and coastal strip landforms. The thin sediments have been described elsewhere (Sato et al. 1973, 26) as fine sandy loam over silt loam and loam, overlying pahoehoe bedrock and generally defined as the “Kawaihae Series” with further distinctions present. Whitish mineral precipitate is also present in the project vicinity, on basalt formations (Carson 2006, 7).

These thin, in situ, sediments, which derive from the basalt ridge and the rocky bench, have been classified as andisols and aridisols (Juvik and Juvik 1998, 92) associated with the Kawaihae and Puu Pa-Pakini-Waiaha soils (Sato et al. 1973). The transportation of fine sediments by wind is commonly observed within the study area. Periodic strong winds effectively sort silt via airborne transport, during which events “large clouds of reddish brown dust can be seen drifting…” (Carson 2006, 7). Waterborne transport can be similarly dramatic. During rainy episodes (rare, see climate below), surface sheet flooding often occurs, transporting silt downslope into low points such as the swale, other drainages, and the coastal strip. Wildfires also occasionally ravage the area, destroying vegetation and loosening soils, greatly increasing the change of sediment transport through the agents mentioned above.

The original configuration of the shoreline within the study area is also of note with respect to sedimentation processes. At Kawaihae Bay, historic records document the presence of a black sand beach over 1,200 m long with sections of
inland dune and an inner-bay reef as large as any other in the Hawaiian Islands (Tomonari-Tuggle and Tuggle 2006). These natural features were largely demolished during the 20th century (prior to modern construction projects, see Landscape Modification and the construction of the Kawaihae Harbor in 1959). The sedimentation of Kawaihae Bay proximate the study area has been exacerbated by the presence of the sizable breakwater to the north, resulting in the coverage of both natural and cultural features downslope of Puʻukoholā and Mailekini heiau.

Climate

Due to the prevailing tradewinds and the size of the island the leeward coast of Hawaiʻi and the shores of Kawaihae Bay in particular are among the most arid regions in the whole of the Hawaiian archipelago, receiving less than 25 cm of rainfall a year (Giambelluca et al. 2013). Furthermore, a high percentage of this rainfall often occurs during only a few inclement days within the year. Other types of precipitation occur in the region, namely fog drip in the middle-elevation zones of the mountain above the study area, but sporadic rainfall (and very occasionally, hail) is essentially the sole source of precipitation at Kawaihae. This leeward coast remains relatively dry due to being in the shadow of a large volcanic summits, with clouds passing by high overhead already having jettisoned the majority of their moisture. This dry, hot environment is the reciprocal to the opposite, windward, coast of Kohala, where tradewinds regularly deliver thousands of times more rainfall (> 4,000 mm/year) to the summit of Kohala mountain and into the deep, incised valleys beneath it such as Waipio. Rainfall comes from clouds that are blown in from the ocean and are pushed up against the mountain, triggering rainfall as the air is forced to rise (orographic lifting).

Despite being situated in a coastal environment in the semitropics, as a result of its particular situation Kawaihae is best characterized as a hot and dry place. The
French Captain de Freycinet, upon arriving early in the nineteenth century (1817-1820), wrote that, “Not an atom of greenery appeared before our eyes” (Greene 1993). One of the most significant physical and environmental relationships at Kawaihae is derived from dominant northeastern winds (the trade winds), which blow persistently from the northeast across the whole of the Pacific Ocean’s northern subtropics. In conjunction with the topography of the islands (and especially so in the case of the Big Island, which features several peaks over 4,000 masl), these regular trade winds result in differential patterns of rainfall between the windward and leeward sides of each island (Figure 6).

![Mean Annual Rainfall Island of Hawai’i](image)

**Figure 6.** Mean annual rainfall on the island of Hawai’i (courtesy Giambelluca et al. 2013), with the general location of the study area indicated by a red arrow.
The same widespread, hemispheric weather patterns that drive the tradewinds also play a role in the formation of ocean swell. In the wintertime swells develop in the north, usually from storms that develop near the Aleutian Islands, and then travel south to arrive in Hawai‘i. The study area is exposed to western swells predominantly but also the “wrap” of northern swells and therefore has surf in the winter, while it is generally protected from the southern and eastern swells that are typical during the summer and is therefore calm. Kawaihae Bay is known to have been a popular surfing location in the pre-contact era, and remains a noted surf break today.

**Water Sources**

Due to the hot climate and the general lack of precipitation, freshwater is scarce in the study area. While no perennial freshwater sources are readily apparent today multiple accounts suggest the presence of at least one freshwater spring in historic times. Captain George Vancouver noted a “fine stream,” from which he wrote of obtaining water in 1793 (Greene 1993). Other Europeans, however, later cited a Kawaihae water source as brackish (Lyons 1839). In recent years Carson (2006, 9) identified one freshwater spring within the study area, located underwater just meters from shore, and alludes to the possibility of another freshwater spring once being present in the vicinity. The place name of Kawaihae is likely to relate to the presence of freshwater. Pukui et al. (1974, 97) translate the name as “the water [of] wrath,” with a further reference to people said to “have fought for water from a pool in this arid area.” In any case freshwater in the study area is not to be found in any great abundance, neither in the past nor present. Kekahuna (1994, 21) refers to this spring as “The Water of Furious Contention,” perhaps underscoring the commodity of such a precious resource in the region.
Intermittent streams located in the nearby gulches of Pohaukole, Makahuna, and Poki‘iahua are also possible sources of water. Sections of exposed bedrock in these gulches (including the swale within the study area) hold limited quantities of freshwater in natural basins for a limited time but must be refreshed by precipitation or new flow activity. Due to an extremely drastic rainfall gradient as one moves upslope—it is only 18 km from Kawaihae to the summit of Kohaha Mountain (1372 masl)—it is also possible for upslope precipitation to introduce freshwater into the study area via flooding, which even if short-lived replenishes natural basins and catchments.

Vegetation

The arid setting and the general lack of freshwater combine to create a challenging environment for plant growth within and around the study area. While general climatic conditions (dry/wet, leeward/windward) have grossly characterized the island of Hawai‘i over many millennia, there have also been major changes in vegetative taxa since the arrival of humans. These changes are most marked at the lowest elevations, including at Kawaihae. Past vegetation can be considered for three eras: 1) pre-Polynesian; 2) Polynesian (pre-contact); and 3) Western (post-contact). Pre-Polynesian vegetation has been ascertained through wetland deposits, by coring sediments and identifying the pollen of specific species within a dated sequence. Such wetland coring has been conducted on the leeward coast of Hawai‘i in two locations environmentally similar to Kawaihae: Pauoa Bay in Kalāhuipua‘a ahupuaʻa (Welch 1989) and at Kaloko and ‘Aimakapā Fishponds (Douglas and Hotchkiss 1998). This research as well as that conducted in comparable environments on other Hawaiian islands supports Athens (1997) general proposition that pre-Polynesian lowland leeward vegetation was fairly uniform across the archipelago. Based on pollen analysis from wet cores, the pre-Polynesian vegetation of the study area (and the Kohala coast more generally) was a
dry forest dominated by Pritchardia palms and Dodonaea viscosa shrubs with an understory of Kanaloa kahoolawensis.

The arrival of Polynesians affected the vegetation of the Hawaiian Islands drastically. The most significant aspects of their arrival and settlement were their use of fire and the introduction of non-native animals (see Fauna, below). Tomanari-Tuggle and Tuggle (2006) contend that the presence of large quantities of charcoal in some pollen cores, such as at ‘Aimakapā, may indicate early periods of burning. In addition to the use of fire, Polynesians modified the natural setting through their usage of endemic species and the introduction of new species, transforming the natural setting into a cultural landscape (Tomanari-Tuggle and Tuggle 2006).

Excavations at the study area obtained the charred remnants of botanical remains in archaeological contexts, indicating the presence of kukui (candlenut or Aleurites moluccana), ‘akoko (Chamaesyze sp.), ʻōhiʻa (Metrosideros polymorpha), loulu (Pritchardia sp.), among others (Carson 2006).

Late 18th and early 19th century vegetation of the region has been reconstructed by McEldowney (1983), through the use of written records, relict vegetation, and Hawaiian vegetation patterns. McEldowney classifies the study area as a dry zone, containing two further designations (“Pili 1” and “Pili 2”) that correspond with elevation. The study area, contained in the lower portion of this dry zone (below an elevation of 366 m), is hypothesized to have been a sparsely vegetated landscape of scattered grasses and shrubs. The upper portion of the dry zone (367-732 m), above the study area, is hypothesized to have been a comparatively lush landscape, likely supporting perennial grassland (Ibid. 1983:416). Areas further upslope were also subject to drastic change with the arrival of the Polynesians. An extensive upland field system in the region likewise altered the native vegetation through wide-scale clearance (Ladefoged et. al 1996), which in turn likely indirectly affected the broader ecosystem of the study area in ways such as the lessened collection of precipitation through cloud drip, etc. Later, the clearance of forest was greatly accelerated with the development of the historic
sandalwood trade, as well as the introduction of ungulates including cattle and goats.

The arrival of Europeans brought the arrival of a number of drought-resistant plants to Hawai‘i. With defenses honed in Africa, Australia, and other arid environments, these plants spread rapidly and quickly out-competed many native species. Sparsely vegetated, lowland, leeward settings especially along the coast, such as that of the study area, were especially affected. Drought-resistant taxa now dominate the shoreline environment and the gulches within the study area. Kiawe (mesquite or *Prosopis pallida*) grows in dense configurations, flanked by weedy grasses. A grove of niu (coconut, *cocos nucifera*) persists in one area of the coast along with milo (Portia, *Thespesia populnea*). On the rocky bench and basalt ridge, outside of the gulches, the occasional mesquite persists, and in modern times the National Park Service has maintained a vegetated, grassy area that includes a number of noni (*Morinda citrifolia*) trees and raised beds for cultigens such as dryland taro (*Colocasia esculenta*) and sweet potato (*Ipomoea batatas*) in the vicinity of Pu‘ukoholā heiau. The taro and sweet potatoes are generally used for ceremonies and functions conducted in association with cultural groups and the National Park Service.

The micro-environmental vegetative changes at Kawaihae in specific are more difficult to ascertain. Taking the environmental studies in combination with historic journals provide insight into the area around the turn of the 19th century. Forests have been cleared and receded due to fire and grazing. Surface freshwater has become less abundant. Invasive species have proliferated. At the same time, Kawaihae was always a leeward, low-elevation location. It is highly likely that since the time of the construction of Pu‘ukoholā heiau the area has become more austere.
Fauna

Like the vegetation, the fauna inhabiting the study area has also varied drastically between pre-Polynesian, Polynesian, and Western phases. Located on the coast and with a limited amount of plant growth as reviewed above, in pre-Polynesian times the most common animals were likely to be seabirds. Other avian species would have been resident as well, though likely in lower numbers. No terrestrial mammals are endemic to the Hawaiian Islands, although turtles and seals are common marine mammals. Located on the edge of Kawaihae reef, which although it is not fully intact today was one of the largest reef systems in the Hawaiian archipelago, the marine resources in the study area would have been significant during both pre-Polynesian and Polynesian times. Lobsters, crabs, shellfish, urchin, octopus, and reef fish all would have been abundant. Opportunities to fish for pelagic species in deeper waters would also have been possible. Dune fishponds constructed sometime during Polynesian settlement in Kawaihae Bay indicate one form of intensified marine subsistence in the environs of the study area.

In addition to plants, Polynesians arrived with an assortment of animals, including pigs, dogs, and rats (Kirch 1989, 135). These species had an immediate and continued effect on Hawaiian ecosystems. The most significant animal introductions concerning the study area came with Europeans, however. Domesticates such as cattle, sheep, and goats arrived. Ungulates not only grazed extensively across the region, but the landscape was modified to accommodate them. Lightly forested areas were cleared by various means in order to increase grazing areas, large-scale earth movement was undertaken to construct groundwater-catching watering tanks, and fences and enclosures were built—sometimes using rock from older, pre-contact archaeological features. Furthermore, certain species of plants such as fountain grass and mesquite, prickly pear cactus, and mesquite, were introduced as livestock feed even as native species were
overgrazed. Located in proximity to the Parker Ranch, cattle were regularly driven to Kawaihae from the uplands, where they were penned and eventually loaded onto ships for transport.

**Social, Historic, and Archaeological Setting**

Social, historic, and archaeological aspects of the study area also underlie the research and findings of this dissertation in important respects. This remainder of this chapter reviews a number of topics related to these influences around Puʻukoholā heiau, including settlement patterns, land divisions, ethnographic accounts, historical accounts, archaeological research, landscape modification, cultural activities, and its modern jurisdiction. Combined with the environmental settings reviewed previously and set against the great backdrop of Oceanic prehistory (D. V. M. Stephen 2001), these topics establish the overall context under which this multisensory approach to monumental architecture was carried out.

**Land Divisions**

Traditional Hawaiian culture imposed divisions on the land. At the highest level, moku (districts) were recognized. Districts, for much of Hawaiian history, were the main political units and the domain of separate, often competing chiefs. The study area is situated in the northernmost district of the Big Island, Kohala. As mentioned above, this district roughly corresponds to the geologic features of Kohala mountain. In modern times, the district of Kohala is divided into two districts of Hawaiʻi County: North Kohala and South Kohala. The study area is located at the southern edge of South Kohala near the adjoining district of Kona.
Within districts, smaller delineations of land known as ahupuaʻa were designated under traditional Hawaiian land divisions. These were the main economic unit. Configured radially, ahupuaʻa generally consisted of a strip of land that ran from the coast into the mountains and generally encompassing productive agricultural areas and/or population centers. Land divisions were mutable; the ahupuaʻa of Kawaiehae was split at some point prior to or during the rule of Kamehameha I resulting in two ahupuaʻa (reflected by the Hikina, or 2, modifier). Archaeologists have studied the fracturing of ahapuaʻa into smaller areas in relation to agricultural intensification (Ladefoged and Graves 2008).

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Modern</th>
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<tbody>
<tr>
<td>Hawaiʻi (Kingdom, post-1795)</td>
<td>Hawaiʻi (State, U.S.A., post-1959)</td>
</tr>
<tr>
<td>Kohala (Moku)</td>
<td>Hawaiʻi (County, ”Big Island”)</td>
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<tr>
<td>Kawaihae Hikina* (Ahupuaʻa)</td>
<td>South Kohala (Judicial District)</td>
</tr>
</tbody>
</table>

*Subdivision of earlier Kawaihae ahupuaa

Table 2. Traditional and Modern Land Divisions of the Study Area.

The study area is located in the moku of Kohala, and the ahupuaʻa of Kawaihae Hikina (often referred to as Kawaihae 2, Figure 7). Kawaihae Hikina extends up the slope of the Kohala Mountains approximately 11 km to roughly 1370 masl. In modern terms it is recognized as belonging to the South Kohala Judicial District.
Figure 7. The Big Island, depicting moku and ahupua’a boundaries (courtesy Wilson and Jay 2016), with the general location of the study area (Kawaihae) indicated by a red arrow.
Settlement Patterns

Knowledge of settlement patterns on the Kohala coast based on the study of the material record begins with archaeological studies conducted in the 1960s and 1970s, which focused on Lapakahī ahupua‘a in North Kohala. These studies included investigations of surface architecture in the area, with a specific focus on their chronological and spatial patterning (Newman 1969; Pearson 1969; Tuggle and Griffin 1973). The projects initially addressed a discrete location, Koaie, known to have been a pre-contact Hawaiian coastal village, and subsequently spread along the coastline as well as into the uplands. Facets of the research examined surface architecture to determine residential, agricultural, and ritual features (Rosendahl 1972, 1994). Complexes of C-shaped and L-shaped residential structures were subsequently excavated; the temporal relationship between structures was analyzed using volcanic glass and unidentified charcoal that were recovered. While the use of volcanic glass as an absolute dating method has since proven unreliable in Hawai‘i, the radiocarbon analysis of charcoal samples indicate that the region was settled as early as the 14th century AD, and suggest that settlement was initially seasonal in nature but transitioned into a network of permanent, dispersed settlements in later centuries (Rosendahl 1994, 64). Initially, colonization was thought to have been established in the form of maka‘āinana (commoner) settlements, with the possible involvement of resident low-ranking chiefs. Small settlements likely dotted the coast in this manner, each depending on local resources including fresh water and marine access.

Cultural resource management projects, driven by the commercial and governmental development of land, have also carried out archaeological investigations along the leeward Kohala coast. These projects have been completed in two distinct areas, one near the northern tip of the Kohala peninsula in Kapa‘anui, Puakea, and Mahukona ahupua‘a (Schilt and Sinoto 1980; Burgett and Rosendahl 1993; Dunn and Rosendahl 1989; Kaschoko 1982; Wulzen and Goodfellow 1995)
and the other just north of Kawaihae in Kahua and Waika ahupua’a (O’Hare and Goodfellow 1995; Graves and Franklin 1998). In the north, unidentified charcoal associated with deposits from residential features (interpreted as either temporary or permanent residences) were dated to AD 1400-1600, while in the south similar features revealed dates between AD 1400-1750. This reinforced the idea of settlement and subsistence living by AD 1400, with an increase in the number of residences leading up the contact period in the late 1700s. In addition to an increased number of residences, potential for substantive interaction between distinct areas with distinctive resources such as coastal fishponds and upland agricultural fields eventually are surmised to have increased.

More recent work followed up on the chronology and spatial patterning of archaeological deposits and residential features in North Kohala. Field et al. (Field et al. 2011) focused on Pahinahina, Makiloa, Kālala, Makeanehu, and Kaiholena ahupua’a, recording 318 residential features in order to evaluate the chronology of settlement in the region. Using the excavation of residential features, artifact analysis, and absolute dating (short lived plant taxa, $^{14}$C), their results suggest subsistence activities occurring throughout prehistory (AD 1400-1520), but including a transition from localized household economies to ahupua’a wide socioeconomic systems (Ibid. 2011, 625) late in the sequence (AD 1650-1800). Their corpus of 49 $^{14}$C dates not only represent a sizable sample, but the work was also carried out in accordance with a method of stratigraphic and architectural recording for Hawaiian surface architecture (Dye 2009) to more accurately estimate the construction dates of architectural features.

Through the work reviewed above, three distinct settlement and subsistence systems (two constant, and one episodic) can be realized for the leeward Kohala coast and the study area based on archaeological and historic evidence (Tomonari-Tuggle and Tuggle 2006). These are: 1) light or seasonal settlement of commoners engaged in localized household economies (constant); 2) permanent settlement of commoners engaged in ahupua’a wide socioeconomic activities; 3) temporary
residence of high status individuals, ritual event participants, and labor or army forces (episodic).

It is arguable as to whether Kawaihae supported a highly concentrated population people for any long period of time, relative to other population centers in the Hawaiian Islands. Regardless, it is a location known to take on significance at a number of intervals throughout its history, and one that certainly sustained sizable numbers of people for limited periods of time. Overall, the model of a small settlement likely applies to Kawaihae, with periodic influxes of greater numbers of people taking place during many finite and unique occasions. In its initial settlement by maka‘ainana Kawaihae would have offered a range of subsistence potential, including foraging in Kawaihae Bay and the very large reef located within it. Over time, other forms of subsistence were intensified—evident in the development of infrastructure such as fish ponds and salt pans—and it is also likely that residents became involved in an ahupua’a wide, or inter-ahupua’a, subsistence system comprising a network of dispersed, permanent settlements as described by (Field et al. 2011) in the neighboring communities.

Of interest to this dissertation are settlement patterns associated with ritual activity. The gathering of people and resources to build monumental architecture, such as the heiau of Mailekini and Pu’ukoholā, are examples of episodic presence, as well as the periodic residence of kings and other elites at the time of luakini ceremonies and other ritual activities. The labor necessary for the construction of Pu’ukoholā heiau in 1791 would have required scores of workers and support over the course of the year (Mulrooney et al. 2005). This would have also happened earlier in time, during the initial construction of Mailekini heiau, likely some centuries earlier. These populations would have dissipated following the construction of the monuments, however. In times such as these it is likely that additional resources would need to be brought to Kawaihae, as the subsistence appeared marginal even for full time residents.
Ethnohistoric accounts of Puʻukoholā Heiau

The chiefess asked, “Tell me how the rule over all the islands may become my lord’s.” Ka-pou-kahi answered, “Build a great house for the god and mark out its boundaries.” (Kamakau 1992a, 150)

Puʻukoholā heiau exists in close association with a group of other significant ancient Hawaiian archaeological sites at Kawaihae. Directly downslope to its west lies Mailekini heiau, and in the shallow coastal waters further west yet sits another heiau (now covered by silt) known as Haeokapuni. These three heiau are likely to have existed in one form or another prior to the time of Kamahameha, being mentioned as early as the 16th century in association with the chief Lonoikamakahiki (Fornander 1996, 103-22). Given the widespread practice of chiefs rededicating heiau while consolidating power (and often rebuilding them in the process), the presence, configuration, and design of each structure prior to the building or reconstruction of Puʻukoholā in 1791 by Kamehameha is difficult to ascertain. The three heiau are also co-located with an expanse of beach now known as Pelekane or the “Royal Courtyard,” long associated with Hawaiian chiefs and important events. The John Young homestead is also located nearby.

The late 18th century was a tumultuous time, with various chiefs vying for power across the Big Island. Central in these political struggles was the figure of Kamehameha, who came to wage a protracted contest with his cousin and foe Keōuakūʻahuʻula. Mentions of the building of Puʻukoholā heiau exist in various texts, with Samuel Kamakau offering a widely accepted version. According to Kamakau (1992a, 154), the building of Puʻukohola heiau by Kamehameha only came around after war had proven ineffective. In his words, “the power of the gods remained to defeat Keōuakūʻahuʻula.” Kamehameha sought to fulfill a prophecy given by a seer named Kapoukahi, who said that, “War shall cease on Hawaiʻi when one shall come
and shall be laid above on the altar (lele) of Pu‘ukoholā, the house of god” (Ibid. 157). Kamakau goes on to describe the endeavor undertaken to build Pu‘ukoholā heiau by Kamehameha, emphasizing the protocol that was followed, including direction by an expert versed in the placement and building of such structures, the work of all hands with the sole purposeful exception of one high ranking chief (Kamehameha’s own younger brother), and the rigid attention paid to the observance of all ordained regulations. With the heiau built but not consecrated, Kamehameha sent for Keoua. Despite being aware of the risk involved, Keoua traveled to Kawaihae. After a brief, one-sided “battle” upon his arrival on the coast below Pu‘ukoholā, Keoua and many of his retinue were slain: “By the death of Keoua Kauhu‘ula and his placing in the heiau of Pu‘ukoholā the whole of Hawai‘i became Kamehameha’s.” (Ibid. 158).

**Historical Accounts**

Many the earliest written accounts of Pu‘ukoholā heiau were made by Europeans who visited by ship. Areas observed include the village of Kawaihae as well as Pu'ukoholā heiau and the surrounding structures. Only one visit is recorded as being made to the area by Europeans prior to Pu‘ukoholā being built by Kamehameha in 1791; all other visits occurred afterward. These visitations were generally brief in nature, many involving only brief landfall if at all. The tone of early European observations with regard to Kawaihae may appear generally critical, with many mentioning it as hot and dry. Not all impressions were negative, however. It is equally important to mention that other aspects were noted favorably. An exhaustive summary of the descriptive accounts of Pu‘ukoholā heiau itself (vs Kawaihae in general) by foreigners (early Europeans) is given in Greene (1993) and reviewed for sensory references in Table 3. One significant aspect of these accounts is that they span the time between the enforcement and the overthrow of the traditional Hawaiian kapu system (1819).
The last known use of Puʻukoholā prior to the abolition of the kapu system was by Kamehameha’s son, Liholiho (Kamehameha II). Multiple sources (see Greene 1993, 81) write of Liholiho returning to Puʻukoholā following the death of Kamehameha in 1819 in order to reconsecrate the heiau as part of the traditional method of announcing one’s new role as leader. While most of these observations are derived from only brief visits to the area, the details are valuable to review in order to seek information regarding the sensory aspects of Puʻukoholā.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Date</th>
<th>Passages</th>
<th>Sensory references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archibald Menzies</td>
<td>1792-1794</td>
<td>“I went towards a little marae [temple]... This marae is situated on the summit of an eminence, a little back from the beach, and appears to be a regular area of fifty or sixty yards square, faced round with a stone wall of considerable height, topped with a wooden rail on which the skulls of these unfortunate warriors are conspicuously exposed. On the inside, a high flat formed pile is reared, constructed of wicker work, and covered either with a net or some white cloth.”</td>
<td>Menzies was not permitted to approach the heiau as it was in use and feared by his guides. This may explain his use of the word “little” to describe the structure.</td>
</tr>
<tr>
<td>Samuel Patterson</td>
<td>1804-05</td>
<td>[The Hawaiians] “...have an extraordinary [temple] on the island of Owhyhee, at Toahoi bay, which is very large, and the roof covered with human skulls, the white appearance of which, is discoverable at great distance, but otherwise it is like unto the others.</td>
<td>Patterson notes the visual display of skulls like Menzies, also citing that they were viewable from far away. His summation of “extraordinary” seems to derive from the “very large” size of Puʻukoholā heiau, and</td>
</tr>
</tbody>
</table>
“We saw here several morais, which belong to the chiefs of these parts, and may be recognized by the stone fence, and the idols placed within them.”

“The skulls on display are replaced by wooden images.

“there is a very large morai enclosed by a stone wall about four feet high. The statues seen here are colossal, and regularly placed; I have counted above forty of them. The earth is covered with pebbles, evidently thrown there by design... on the board which was placed in the middle of the enclosure, were exposed the dead bodies of those who had been strangled, or stoned to death; that the placed was tabooed for all the inhabitants, except the high priest, who repaired thither daily to consult the entrails of the victims.”

“...I visited Pu‘ukoholā, the large heathen temple... [which] appeared as much like a fort as a church... The frowning structure is so large and prominent, that it can be distinctly seen with the naked eye, from the top of Maunakea, a distance of about 32 miles.”

“The upper terrace was spacious, and much better finished than the lower ones. It was paved with various flat smooth stones, brought from a considerable distance... Holes were seen on the walls, all around this, as well as the lower terraces, where wooden idols of varied size and shape formerly stood, casting their hideous stare in every direction... On the day in which he [Kuka‘ili‘moku] was brought within its precincts,
vast offerings of fruit, hogs, and dogs, were presented, and no less than eleven human victims immolated on its altars. And, although the huge pile now resembles a dismantled fortress... it is impossible to walk over... without a strong feeling of horror."

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Text</th>
</tr>
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<tbody>
<tr>
<td>Artemas Bishop (with Kaʻahumanu)</td>
<td>1826</td>
<td>“Directing my attention to the crumbling walls of a large heiau, on an eminence, she said, “There is the spot where my husband used to worship his gods, and where many a human victim has been sacrificed. Let us ascend and see the place.” “But,” said I, “did you never go there?” “No,” she replied, “it would have been death for any woman to approach its sacred precincts.””</td>
</tr>
<tr>
<td>James Jarves</td>
<td>1837-42</td>
<td>“Its height is from eight to twenty feet, two to six feet wide at the top, which, being well paved with smooth stones, formed, when in repair, a pleasant walk. The entrance was narrow, between two high walls... The south end constituted an inner court, and was the most sacred place.”</td>
</tr>
<tr>
<td>Gorham D. Gilman</td>
<td>1844-45</td>
<td>“The holes where the Idols stood are distinctly visable [sic] the one in the center was very large and was seen at a great distance...”</td>
</tr>
</tbody>
</table>
| Samuel S. Hill        | 1848 | “After climbing a pathless steep to a further elevation of about two hundred feet, we came to the later constructed heiaus [sic] [Puʻukoholā]... That at the southern end is divided into narrow chambers, or gloomy cells, where the priests are said to have chiefly resided, and from which they issued only when the whole area of the grand department of the temple was filled with the worshippers of the idols before whom they practiced their abominable rites, and at whose altars they offered their sacrifices of human victims.”

No path up from “below”.

Suggests lots of people inside.
One question concerns the precise way the temple was used and the number and types of people who would have entered it at any given time, which appears to have become a common point of discussion among visitors. Bingham (in Greene 1993, 79) writes that, “terraces made convenient places for hundreds of worshipers [sic] to stand while the priest was within offering prayers and sacrifices of abomination,” however it is unclear where such information came from as he arrived after the kapu system was abolished. That the place was highly restricted, or kapu, is clear—but who might have attended or been involved in the rituals performed there at various times? There is also the question of how long Puʻukoholā was actively used after its construction. While it was built with a specific intent in mind (to obtain the favor of Kū and thereby achieve victory over Keoua), like many heiau, the regularity and nature of its use after the goal is achieved is not well documented. Multiple sources, several introduced above, suggest, however, that Kamehameha continued to use Puʻukoholā until his death.
Modern Jurisdiction

The modern jurisdiction of the study area comprises two primary entities. The first is the unincorporated community of Kawaihae, which has a population of approximately 20,000 people. The second is Kawaihae Harbor, built in 1959, which is a deep-water facility that handles a high percentage of the goods being imported or exported from Hawai‘i Island. Access in and out of the area is primarily by automobile transport, with the primary route of transport to and from Kawaihae being State Highway 270, which heads north into Kohala and south towards either Kona on the coast (via Queen Kaahumanu Highway, State Highway 19). The uplands of Waimea can also be accessed from the Kawaihae area via Kawaihae Road. Highway 270 (Akoni Pule Highway) comprises a business corridor through as it runs through town, runs directly alongside the harbor, and bisects the land holdings of PUHE although plans exist to reroute the highway away from Puʻukoholā.

Today, the structure known as Puʻukoholā heiau is situated within lands owned and managed by the National Park Service (NPS) of the United States. It is managed by the NPS as part of a designated historic area that totals 32.4 hectares (80 acres) of land, known as Puʻukoholā Heiau National Historic Site (PUHE, Figure 8). This jurisdiction superseded Puʻukoholā heiau’s designation as a national historic landmark on June 10, 1966. It became a National Historic Site on August 17, 1972 under Public Law 92-388 (86 Stat. 562), with the mission to restore and preserve the area including the John Young property. In addition to Puʻukohola heiau and the John Young homestead, the federal holding incorporates several sites of cultural and archaeological significance, to include Mailekini heiau, Hale o Kapuni Heiau, Pelekane, and a section of the Ala Kahakai (Historic Coastal Trail).

Facilities of the park include a recently built visitor center and parking lot (constructed in the early 2000s). The original visitor center, composed of portable trailers, has remained in use for administrative and office use. A separate,
permanent, structure also exists to provide a restroom facility at the headquarters complex. Also a big grassy lawn area, commonly used by park staff and special visitors to the park (not tourists, generally) such as educational and community groups. Adjacent to this area, recent years have seen the implementation of gardening or farming (kalo and other traditional crops). A series of paved pathways have been established across the land holdings of the park, mainly to provide vantage points and access (although not to the interiors of the structures, which is restricted) to Puʻukoholā and Mailekini heiau. A number of interpretive signs have been erected along these paths in order to present information to tourists. An audio tour is also available. People also regularly access the National Historic Site from Spencer Beach Park to the south during the opening hours of the park. While generally restricted, access from the Kawaiahe harbor to the north can also be obtained.
Landscape Modification and Development

Since the time of its initial construction and consecration until the present, Pu'ukoholā heiau and the surrounding area have hosted a wide variety of activities that have continued to affect the configuration and character of the place. Many of these processes are linked to its cultural status; following Pu'ukoholā heiau's
political and ritual abandonment with the abolition of the kapu system in 1819 the structure and its vicinity lost its ritual status (and the linked protections) and, like all heiau, became vulnerable to a host of destructive activities that were leveled at the focal points of the traditional system. Activities were free to be conducted in the area without taking the abandoned monument(s) into consideration. As a result, between 1819 and its designation as a National Historic Landmark in 1966 the landscape of the study area was heavily modified. The majority of these landscape modifications took place at the hands of historic and modern social forces, largely driven by regional economic development and trade as introduced above.

The importance and utility of Kawaihae as a shipping port grew during the historic era. Starting with local resources such as sea salt and sandalwood, coupled with the royal presence of Kamehameha, his advisors, and other social elites, Kawaihae established itself as a regular port of call for European ships (Greene 1993). In subsequent decades, trade and activity gradually transitioned from the provisioning of ships with local resources to commercial involvement in nascent industries, built on newly-introduced species such as cattle and sugar cane. As cattle became a burgeoning industry, stone wall construction in the area would have increased to both retain and restrict the livestock.

Kawaihae’s development and the form of its settlement has long been linked to the interior of the island. Like the cattle, which were grazed and grown in the uplands prior to being driven to the coast for slaughter or transport, agricultural produce from the uplands was also made available in Kawaihae during the historic era. Sweet potatoes—long a traditional Hawaiian crop (Ladefoged et al. 1996)—and later Irish potatoes were staple ship provisions. This lowland /lowland relationship echoed the pre-contact ahupua’a model well into the 1850s and 1860s, building on it with the export of goods including beef, pork, fowl, beans, wool, bullock hides, goatskins, and tallow (Greene 1993, 37). A smallpox epidemic occurred in 1853, resulting in a significant decrease in population.
Although the historic-era landscape modifications were notable, they paled in comparison to the physical modifications that took place in the modern era, a phase that accelerated drastically in the 1950s when construction began on a new harbor. The Kawaihae deep draft harbor, overseen by the U.S. Army Corps of Engineers, began with dredging operations. The harbor was completed in 1959 and expanded in 1962 with a widened channel and extended breakwater. Surrounded entirely by a breakwater against high surf of large basalt boulders, the creation of the harbor resulted in extensive and irreparable changes to the entire coastline of the Kawaihae area. Obliteration of the original beach, including formerly notable areas within which fishponds, salt pans, etc., once stood, occurred with the construction of the deep draft harbor and breakwater. The construction of the harbor also resulted in a large area being filled with dredged coral. Laying adjacent to Pelekane and at the foot of Puʻukoholā and Mailekini, this area containing an expanse of wasted coral has remained largely undeveloped.

Significant construction continued in late 1960s, with Operation Tugboat in 1969. Conducted by the U.S. Army Engineer Nuclear Cratering Group, this project used conventional explosives to blast out a basin at the southern end of the harbor for light draft vessels, including an entrance channel, a turning basin, and a west breakwater. The project was authorized under Section 301 of the River and Harbor Act of 27 October 1965, sponsored by the State of Hawaiʻi, Department of Land and Natural Resources, Division of Boating and Ocean Recreation. Multiple environmental issues, however, delayed its completion. Construction activity has continued at the harbor in recent years, with the improvement of the eastern portion of Kawaihae Small Boat Harbor. With permission from the Department of the Army, U.S. Army Corps of Engineers, Honolulu District, the state Department of Land and Natural Resource’s Division of Boating and Outdoor Recreation expanded and included 25 berthing stalls for light draft vessels. Accessible parking, trailer parking, gravel topped access road, parking, comfort station, outdoor shower, boat wash-down area and hose bibs are all part of the Phase I improvements.
Another important reconfiguration of the landscape came with highway and road construction. The coastal highways on the leeward coast of Hawai‘i were only completed in the 1970s. Route 19 (Kailua-Kona to Pu‘ukoholā) was completed in 1975, while Route 270 (Kawaihæ to Pololu, the ‘Akoni Pule Highway) was completed in 1973. Overall, the physical modifications that occurred during the latter 20th century clearly demonstrate, at the least, an inattention to the ancient monuments. A road was built between Pu‘ukoholā and Mailekini heiau to provide public access to Spencer Beach Park.

Archaeological Research at Puukohola

While the study area—anchored by Pu‘ukoholā heiau but also encompassing several nearby sites and connected to similar architectural structures in the region and beyond—has been subject to many prior archaeological research projects, none have included an explicit focus on the sensory aspects of the place. Previous projects range from the efforts of some of the earliest archaeologists to work in the Hawaiian Islands up to work completed recently.

In terms of cartographic activity, the mapping of the heiau in the 19th and early 20th century by several parties represents the first formal, recorded investigations of the structure by Western parties. Additional efforts were made by Lyons in 1853, Alexander in 1869, and Stokes in 1909 (Stokes 1991, 164–169). Structural analyses of the heiau were presented by Kikuchi and Cluff (1969), who conducted a manual survey of its architectural components. Stabilization work was conducted on Pu‘ukoholā between 1975 and 1979, under the direction of Edmund J. Ladd, who served as the Pacific Area archaeologist for the National Park Service at that time (Ladd 1986). Ladd performed emergency stabilization on the heiau after it sustained earthquake damage, also mapping the structure and making observations on the pre-contact construction techniques.
In more recent years, a number of extensive studies have been conducted around and including Puʻukoholā heiau. Tomonari-Tuggle and Tuggle (2006) authored a wide-ranging archaeological overview and assessment of National Park Service archaeological resources on the Big Island that included Puʻukoholā, while Carson (2005; 2006; 2012) competed data collection at two specific sites within the study area and directly adjacent to Puʻukoholā heiau. Archaeological activity addressing the heiau itself includes three-dimensional scanning to calculate volume and labor estimates by Mulrooney et al. (2005) and, following two earthquakes that occurred on October 15, 2016, stabilization and reconstruction activity (Johnson et al. 2013).

**Cultural activity**

After decades of relative solitude, Puʻukoholā heiau was formally visited on June 15, 1929, when the Order of Kamehameha unveiled a bronze plaque and commemorated the importance of the heiau in modern times. In 1991, another commemorative event was held, which subsequently became an annual gathering. Called “Hoʻokuʻikahi—To Unify as One,” the intent of the event was to heal the divisions that resulted from the sacrifice of Keōua by Kamehameha in 1791—two centuries prior—as part of the heiau’s consecration. Based on the discourse and intent behind Hoʻokuʻikahi and the creation of new meaning, Pu'ukoholā has been recognized as a place of living history, yet also—given the variety of stakeholders and influences—referred to as a “borderzone” (Tengan 2008, 101).
**The physical condition of Puʻukoholā heiau**

Based on historical and archaeological sources, Puʻukoholā heiau has remained largely unchanged in its basic design over the centuries since its construction. While minor rearrangements of its interior surfaces (such as pits and smaller internal features) is certain to have occurred, the fundamental configuration of its architectural stone foundation remains intact. The exception is the collapse and reconstruction of significant sections of its walls as reviewed above, carried out so as to minimally effect the configuration and form of the structure. Its relatively late construction, in AD 1791, makes it unique as many other heiau foundations had already fallen into periods of disuse and were redesigned at unknown intervals prior to their modern documentation. Puʻukoholā is likely to resemble its original character as closely as any other heiau in the Hawaiian Islands.

**Approaching the senses**

Given the challenges for traditional archaeology to address the senses, combined with the culturally sensitive place of Puʻukoholā, this dissertation presents a series of singular but interconnected analyses of sensory data. As a brand of experimental archaeology, these sensory experiments aim to ascertain some dimensions of the human experience at a luakini heiau by carefully examining the sensory dynamics of the contemporary setting and considering the results in relation to a historically and ethnographically-informed context. Although tempered by the acknowledgement that the sensory impressions of any two individuals, whether separated by large or small degrees of time, gender, age, or other demographic variables may vary markedly, the phenomenological concern of experience and its role in the past nevertheless persists. By applying both qualitative and quantitative methods to individual facets of sensory modalities, this
dissertation aims to increase our understanding of—and ability to accommodate and appreciate—such dimensions of the past.
# Chapter 4: Sight

<table>
<thead>
<tr>
<th>Sense</th>
<th>Description</th>
<th>Hawaiian term</th>
<th>English usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td>Ability to see</td>
<td>'ike (noun)</td>
<td>Seeing, sight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ka 'ike, ka 'ike 'ana, ka 'ikena</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>'ike (verb)</td>
<td>to see</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'ike</td>
<td>to know, to know by sight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nana</td>
<td>to look at, to observe</td>
</tr>
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*Source: Rubellite Kawena Johnson, 11 April 1997.*


## Introduction

This chapter presents research carried out to address the human sense of sight at Puʻukoholā heiau, framed by sensory exploitation and accessed through the multifaceted concept of place observed in the archaeological, ethnohistoric, and ethnographic records. First, the sensory modality of sight itself is broadly reviewed, sketching out its physiological basis as well certain various, general aspects of its significance to people and culture. Second, a brief review of archaeological research and sight, specifically in relation to monumental architecture and theories of power, is undertaken. Third, using Hawaiian ethnohistoric sources, a culturally grounded understanding of sight is established. Finally, various components of a multisensory survey are presented including microtopography, access, visual dimensions, and viewshed analyses in order to define and explore the various ways that the construction and use of Puʻukoholā heiau modified (and modifies) the way that
people see in relation to the implications of sensory exploitation and chiefly authority. Overall, this chapter explores how Puʻukoholā heiau structures and controls sight in a variety of discernable ways.

The human sense of sight

Our sense of sight is physiologically based upon the response of our eyes to light. As we move through the world, patterns of light are collected by the retina of each eye and are converted into neural impulses for processing by different parts of the brain. Sight, or vision (ophthamoception), is the visual perception resulting from this process. Certain anatomical and sensory facilities underlie human vision and its evolution. Diurnal by nature and are not well adapted to working or living in dark environments, even in brightly lit settings many people exhibit less than perfect vision. Instead, the visual capabilities of people are refined in other ways. Among mammals, trichromacy (color vision) is unique to primates including humans (Dulai et al. 1999). Trichromats possess three types of light sensitive cells in the retina, fine-tuned to wavelengths that appear red, green, and blue. Sensitivity to color in primates has been shown to be advantageous in selecting tender young (red) leaves and to distinguish certain types of ripe fruit (Dominy and Lucas 2001; Smith et al. 2003). In anatomical terms, the feature of two forward facing eyes affords stereoscopic vision, or the ability to “see” in three dimensions and readily distinguish depth. With practice, people show an ability to discern differences in depth as small as 10 μ m (0.01 mm) at a distance of 25 cm (Westheimer 1994, 205).

Overall, the importance and centrality of vision to humans is underscored by two details: 1) the visual cortex is the largest sensory center in the brain; and 2) greater than 80 percent of sensory input is visual (Classen 1993). Through capabilities such as color vision and depth perception, the human brain is highly sensitive to the visual aspects of its surroundings; people are highly adept at
recognizing qualities like shape (forms), size, color, brightness, contrast, pattern, texture, distance, depth, movement, and spatial positioning, as well as differences between them within any given setting. Through vision people effectively synthesize their environment and position themselves within it. Complex processes such as orientation and communication leverage the perceptual capabilities of vision as a form of apprehension. Let us begin with a discussion of sight and orientation, and how the ability to evaluate the structure of landscape is a basis for existence and the foundation for cultural practice.

In order to see something in a literal sense, by definition it must be visible. For this reason visibility and invisibility are two of the most fundamental considerations of vision. The binary mode of being visible or invisible has a host of implications, however, that are considerably less dualistic. Once someone or something becomes visible—even fleetingly—it generally becomes more knowable, and often more accessible. For instance, gaining sight is an important phase in hunting animals—many of which hid from view as a common form of defense. In another form of access, the expression of “land ho!” in sailing marks the sighting of land and holds great poignancy after a journey at sea, even if other signs of a nearby landmass have been noted previously (e.g. floating vegetation, cloud formations, certain birds, etc.). People are often motivated once something is “in sight,” because something becoming or being visible is associated with it being more concrete, more actualized. The control of visibility is an important way for people to structure an environment. When visibility is cut off, people often know less about what is going on somewhere. Where visibility abounds, those who possess it often have knowledge. Indeed, the control of sight is powerful enough so as to be implemented as a form of possession and authority, such as in Bentham’s (2016) architectural concept of a panopticon where prisoners are subject to the constant (but concealed) surveillance of their captors.
Figure 9. Elevation, section, and plan of Jeremy Bentham’s Panopticon penitentiary, drawn by Willey Reveley, 1791 (Public domain).

In another vein, however, sight is a form of being or becoming possessed. Things take ahold of us by sight. Sight is every bit as inward as it is outward; people are regularly impacted and affected by the sights that they see. As Elkins (1997, 43) writes, “Light burns into me; it remakes me in its own image.” Sensory exploitation, as introduced above, builds on this idea for sight as well as the other senses. While the senses have the potential to appropriate the world around us, at the same time they are also pathways into the body. In the case of sight this goes back to the physiological process through which we see. It is not technically-speaking an
outward process, but rather an inward one—light and its neural signature are physically penetrating our body when we see something. The dialectic between appropriation and apprehension is also expressed in architectural terms: the reciprocal building to the Panopticon—likewise featuring a line-of-sight design—is the coliseum, where instead of using vision to assert authority and to punish it becomes the means of entertainment and enjoyment for the spectator. Thus, as in the physical design of a building and its social application, the study of sight in the human domain requires engagement with an entangled set of ideas concerning structure, on the one hand, and culture on the other. We now turn to consider approaches to visual structure on the scale of landscape as well as on the scale of architecture.

Vision, visibility, and orientation

For humans, the domain of sight is closely associated with that of landscape itself. In many respects, conceptualizations of sight and landscape are interwoven—the term landscape is rooted in the idea of rendering a “natural” scene, such as in painting. Following this meaning of the term the Oxford English Dictionary (2013) defines landscape as “a view or prospect of natural inland scenery, such as can be taken in at a glance from one point of view.” As the primary physical constituent of landscape, the shape of terrain or the landform is the substrate upon which a host of visual phenomena emerge and interact. Given the diversity of geological processes and environmental settings around the world, landforms vary greatly in their aspects. In the case of an expansive, barren desert the landform can envelop a person in apparent physical consistency, rendering a level and immutable horizon in all directions; in rolling or mountainous country landforms can be highly complex with visual relations between a viewer and their surroundings changing with every step.
Various fields outside archaeology have developed formal approaches to the study of visual space. These include urbanism (Batty 2001; Turner et al. 2001), architecture (Benedikt 1979), and geography (Fisher 1995). After Llobera (2003, 26), these studies can be grouped into two categories: the built environment and ‘natural’ landscape. In either case, efforts to quantitatively measure landscapes have most often utilized the concept of the viewshed, or isovist, expressions that originate and are calculated from a single point and can be employed as a basic unit of analysis. Early efforts using this technique occurred in landscape architecture, where isovist analyses supported Gibson’s (1979) ecological theories of spatial perception. This theory posited that approaches based primarily on visibility analysis are of particular relevance to psychological, cognitive, and perceptual studies.

An interest in assessing the significance of visibility as it may be related to archaeological landscapes and/or sites is shared widely by archaeologists (e.g., Barnatt 1998; Fisher 1995; Fisher et al. 1997; Kirch 2004; Lake et al. 1998; Llobera 2001, 2003; O’Sullivan 2001; Tilley 1994; Wheatley 1995). Visibility mutually encompasses the location of sites such that it affects the view in a particular direction, or that it is visible from locations in the surrounding territory. Many regional analyses have addressed aspects of visibility as part of their studies. Three categories have been identified within which visibility can factor into site placement and orientation: astronomical, azimuthal, and ground-based (Fraser 1988, 326).

Spatial analysis in general within archaeology has developed considerably in recent years due to the advent of Geographic Information Systems (GIS), enabling the use of new analytical techniques to address aspects such as visibility. Based on an area’s digital elevation model (DEM), the viewshed procedures of GIS packages supersede analog practices by rapidly calculating which locations (i.e. grid cells) within a study area can be connected with an uninterrupted straight line (i.e. LoS). Though representative of line-of-sight on the ground, viewsheds are subject to a number of limitations including atmospheric conditions and the ability of the viewer
to resolve features, and error associated with the limitations of the DEM (e.g., altitude errors, curvature of the earth). The concept of cumulative viewshed analysis, introduced by Wheatley (1995), provided a method that, by layering all viewsheds calculated for a given geographic area upon each other, indicates locations of high visibility. High visibility is defined as grid cells that share positive line-of-sight relationships with a high number of other grid cells. A strength of the method was that it could be tested statistically, but its weaknesses included a variety of DEM-associated problems including accuracy, the edge effect, and atmospheric variance.

Subsequent GIS-based studies in archaeology have continued to wrestle with two main challenges evident in the early work of Wheatley and others (e.g., Lake et al. 1998). These are: 1) the difficulty of “stating statistically testable hypotheses from which it is possible to derive firm statements of significant association” (Fisher et al. 1997); and 2) the limitations inherent in DEMs including but not limited to the accuracy of algorithms, edge effects, and atmospheric variance (see Wheatley and Gillings 2000; Llobella 2003). To a degree, these problems compound one another as unchecked error introduced through DEMs or their analysis can compromise the validity of results. Llobella (2003, 25) has contributed widely to the exploration and retrieval of spatial properties from what he calls, “the visual structure inherent in space.” These testable studies have been framed, in part, as a reaction to earlier phenomenological interpretations of landscapes (see Tilley 1994) that were based on the interpretation of visual phenomena without the intention of replicating the results.

The analysis of sight and its interaction with and through landforms, or the visual structure of space, extends beyond (or deep into, rather) the realm of the viewshed. Postulated for the purpose of analyzing natural landforms, Higuchi (1983, 4) proposed eight criteria applicable to the study of any view or prospect (Table 5). These criteria are helpful for starting to evaluate how the visual structure dictated
by terrain—and also by the built environment—impacts the manner in which humans interact with their surroundings.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility or invisibility</td>
<td>The fundamental question of what can be seen and what cannot be seen from a given point.</td>
</tr>
<tr>
<td>Distance</td>
<td>The changes that take place in the appearance of an object as the distance between the observer and the object varies.</td>
</tr>
<tr>
<td>Angle of incidence</td>
<td>The comparative visibility of the various surfaces in a given landscape.</td>
</tr>
<tr>
<td>Depth of invisibility</td>
<td>The degree of visibility in terms of the unseen section with respect to the line of vision.</td>
</tr>
<tr>
<td>Angle of depression</td>
<td>Clarification of the viewer’s sense of position as he looks at a scene from above.</td>
</tr>
<tr>
<td>Angle of elevation</td>
<td>The nature of the upward view and the limits of visible space.</td>
</tr>
<tr>
<td>Depth</td>
<td>The degree of three-dimensionality of the landscape as it unfolds before the viewer.</td>
</tr>
<tr>
<td>Light</td>
<td>The transformations that take place as the position of light moves from front to side to back.</td>
</tr>
</tbody>
</table>

*Table 5. Eight criteria for determining the visual structure of landscapes (after Higuchi 1983, 4).*
In addition to interacting with terrain and architecture, sight allows us to ascertain characteristics of our environment—including artifacts and other organisms within it—based on visual traits. While other sensory modalities function across distance, vision is unique in being able to “reach out” the furthest and take in information regarding things that are far away. These traits include size, shape, color, texture, brightness, distance, contrast, movement, etc. Enmeshed in the apprehensive process of vision, sight is a primary means of communication and expression between individuals as well as among groups of people through such traits, oftentimes in the form of displays. The dynamic visual forms and processes through which people communicate and form expressions are referred to as visual culture (Skeates 2010, 8). While general spatial structure—derived from sight as well as from other factors—remains noteworthy, the manner in which different entities appear is a central facet of visual culture. Early work by Julian Thomas (1993) and Christopher Tilley (1994) focused on the art and architecture of megalithic burial monuments in Neolithic northwest Europe. Foregrounding the symbolic meanings and politics of visual displays, they asserted that visual (and physical) access to displays was controlled by their incorporation into restrictive architectural settings.

How do monumental architecture and sight fit together? As touched on above, sight is often the furthest reaching of the senses, in terms of its projection through physical space (Table 6). Through vision, a person is able to potentially identify buildings at a significant distance assuming a clear line of sight. Likewise, if visibility is high then people who occupy buildings are able to see others upon the landscape at a significant distance. Sight (and also sound) is an important consideration on the scale of how people design and navigate landscapes due to the relatively distant connections that can be facilitated through it. In certain contexts, such as the common act of approaching anything, sight can be thought of as a leading sense (excepting individuals who are blind or otherwise visually incapacitated).
<table>
<thead>
<tr>
<th>Modality</th>
<th>Maximum Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td>Very distant</td>
</tr>
<tr>
<td>Sound</td>
<td>Moderate → Distant</td>
</tr>
<tr>
<td>Smell</td>
<td>Close → Moderate</td>
</tr>
<tr>
<td>Touch</td>
<td>Immediate</td>
</tr>
<tr>
<td>Taste</td>
<td>Immediate</td>
</tr>
</tbody>
</table>

*Table 6. Apprehensive potential of sensory modalities across physical space.*

The potential role of other visual traits can be considered in the context of archaeology and architecture, such as depth. In terms of physiology, perception of depth is achieved through the dimensions of known objects and the processes of moving parallax and stereopsis. The sensation of depth, therefore, is first dependent on the presence of familiar things and then often on movement (even if only movement of the head). In the absence of bodily movement, vision, particularly eye movements within vision, are still used to sample the visual world. Gibson (1966, emphasis in original) writes, “What causes the eyes to move in one direction rather than another, and to stop at one part of the array instead of another? The answer can only be that interesting structures in the array, and interesting bits of structure, particularly motions, *draw* the foveas towards them.” In the context of sensory exploitation, what may be most critical is to examine the differences between visual traits like color and depth typically experienced by people and those which were novel or disruptive in terms of hue, configuration, or other attribute. In other words, what is it possible to make unique in the context of monumentality? How was depth highlighted? How was color used to create a novel experience? How were people impressed? This is true of all visual characteristics when it comes to monumental architecture—how would such a building, and its experience, differ from those belonging to more everyday and common settings.
Ethnohistory and sight

Ethnohistoric sources are especially valuable for offering a degree of cultural perspective on the significance of sight in the context of traditional Hawaiian society. Given that the authors in question were writing in the 19th century and committing the recollections of people from several generations prior to paper, they are neither comprehensive nor necessarily authoritative as a source for thinking about traditional practices in the late 18th century. In specific, the ways that sight impacted aspects of luakini heiau are sought. Several pertinent topics are: 1) accounts of how Hawaiians recognized and conceptualized the visual features of their island landscape and how they oriented themselves upon it; and 2) interior aspects of luakini heiau, including their internal design and the structures commonly placed within, and also the relation between the attendant rites and rituals of the luakini in relation to sight.

Digging into the idea of the landscape as a culturally constituted entity, the way that sight connects and integrates an individual to landforms and their various permutations is of interest. One of the most immediate uses of sight is its utility in apprehending—and characterizing—landscapes. Such characterizations can influence decisions, such as where to place and build structures. As introduced previously, archaeological studies of ancient Hawaiian architecture have focused on the placement of heiau and other structures, primarily in relation to other buildings, territorial boundaries, and environmental settings (settlement patterns, broadly speaking). Terrain or landform itself is easily imagined as a tabula rasa, a blank slate devoid of history and cultural meaning, and many archaeological approaches to space—due to necessity and otherwise—seemingly start with such a conceptualization. Ethnohistoric sources provide insights, however, into how ancient Hawaiians were keenly aware of landform as well as terrain features, zones, and divisions of space, and the degree to which such knowledge was readily available for decision making. This section presents some of these classifications in
order to begin integrating such sensibilities into the treatment of architecture and landscape.

One intriguing word that appears in the ethnohistoric record in regards to topography is “eminence.” Eminence, in English, has connotations of accumulated superiority, and may be deployed in reference to everything from a parcel of rising ground to the upward movement of a person in terms of social status. The term appears multiple times in Malo's *Hawaiian Antiquities* (1951, translated by Emerson), in a section designating what are called the “features of the land” (Table 7). The use is of interest in that the higher and more distinct a land feature, the more eminent its character is apparently considered to be.

<table>
<thead>
<tr>
<th>Hawaiian name</th>
<th>Land feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puu</td>
<td>The hills that stand here and there..., a lump or protuberance</td>
</tr>
<tr>
<td>Lalani puu/pae puu</td>
<td>If the hills stand in a line</td>
</tr>
<tr>
<td>Kini-kini puu/olowalu puu</td>
<td>If they form a cluster of hills</td>
</tr>
<tr>
<td>Ahua</td>
<td>A place of <em>less eminence</em></td>
</tr>
<tr>
<td>ohu</td>
<td>Lower still</td>
</tr>
<tr>
<td>Kahua</td>
<td>If of <em>still less eminence</em> (a plateau)</td>
</tr>
<tr>
<td>Lapa/kua-lapa</td>
<td>A narrow strip of high land, that is a ridge</td>
</tr>
<tr>
<td>Kaha-wai/awawa/owawa</td>
<td>A long depression in the land, a valley</td>
</tr>
<tr>
<td>Pali</td>
<td>Where the land rises up abrupt and steep like the side of a house</td>
</tr>
<tr>
<td>Opalipali</td>
<td>If less decided precipitous</td>
</tr>
</tbody>
</table>
Table 7. “There are other names to designate the features of the land” (Malo 1971, 17-18), emphasis added.

<table>
<thead>
<tr>
<th>term</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ala-nui/kua-moo</td>
<td>A long and narrow stretch of beaten earth, a road namely</td>
</tr>
<tr>
<td>Ala-loa</td>
<td>Where a road passed around the circumference of the island</td>
</tr>
<tr>
<td>Piina/hoopiina/koo-ku/auku</td>
<td>Where the road climbed an ascent</td>
</tr>
<tr>
<td>Ihona/alu/ka-olo/ka-lua/hooi-hona</td>
<td>Where a road passed down a descent</td>
</tr>
<tr>
<td>Oi-o-ina</td>
<td>The terraces or stopping places on a (step) road where people are wont to halt and rest</td>
</tr>
</tbody>
</table>

While the word choice of Emerson, the translator, is also at play the use of eminence to describe landforms is consistent with elevated positions conveying a sense of superiority and high status. Whether this assignment is made in a relative sense, as compared to other landforms, or more generally, is less clear. In Malo’s classification of landforms, however, seven out of 21 terms are used to describe high places. At the top of his classification appears the term pu‘u, defined as a hill. In between are a number of topographic features including configurations of multiple hills as well as ahua, ohu, and kahua. The last reference to “high” landforms is lapa, or ridge. Overall, the set of various designations reveals a keen sensitivity to topography in general, and to elevated landforms in specific. In this way, Malo’s characterization of landforms begins to indicate a sensory hierarchy with respect to ideas of high and low places.

Careful attention to height in the form of elevation also appears elsewhere in Malo’s writings. The most commonly referenced traditional Hawaiian land division
is the ahupua'a, a radial land unit that typically runs from the coastline to the interior of an island, taking on significant political and economic importance. Another, less frequently discussed set of divisions are based wholly on elevation, setting the land in relation to the activities of people, the natural distribution of plants and animals, and the quiet domain of the gods. These belt or ring-like classifications of land are summarized by Malo and appear in Table 8.

<table>
<thead>
<tr>
<th>Hawaiian term from Malo</th>
<th>Definition from Malo</th>
</tr>
</thead>
<tbody>
<tr>
<td>kua-hiwi</td>
<td>“the mountains in [the island’s] centre, backbone”</td>
</tr>
<tr>
<td>Kua-lono</td>
<td>“peaks or ridges which form [the mountain’s] summits”</td>
</tr>
<tr>
<td>Lua pele</td>
<td>“the rounded abysses beneath [the peaks or ridges] are (extinct) craters”</td>
</tr>
<tr>
<td>kua-mauna</td>
<td>“a belt adjoining the rounded swell of the mountain, ...the mountainside”</td>
</tr>
<tr>
<td>kua-hea</td>
<td>“in which the small trees grow”</td>
</tr>
<tr>
<td>wao-nahele/ wao-eiwa</td>
<td>“where the larger size forest trees grow”</td>
</tr>
<tr>
<td>Wao-maukele</td>
<td>“Monarchs of the forest grow”</td>
</tr>
<tr>
<td>Wao-akua</td>
<td>“In which again trees of smaller size grew”</td>
</tr>
<tr>
<td>Wao-kanaka or mau</td>
<td>“Here grows the amau fern and here men cultivate the land”</td>
</tr>
<tr>
<td>apaa</td>
<td>“probably because the region is likely to be hard, baked, sterile”</td>
</tr>
<tr>
<td>Ilima</td>
<td>Reference to ilima flower, <em>Sida fallax</em></td>
</tr>
<tr>
<td>Pahee</td>
<td>Slippery</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>Kula</td>
<td>“plain, open country near to the habitations of men”</td>
</tr>
<tr>
<td>Kahakai</td>
<td>“the belt bordering the ocean...the mark of the ocean”</td>
</tr>
</tbody>
</table>

Table 8. “Classification of the features of an island,” elevational zones (Malo 1971, 16-17).

As in the classification above, wao is the name of wilderness or an uninhabited region, often the abode of gods, spirits, and ghosts. This highlights how Hawaiians may have viewed significant parts of the islands—and often the high places—as not conducive to the permanent presence of people, instead associating them with the gods and liminality.

The ways in which people orient themselves upon and within a landscape is also integrated closely with sight. One important aspect of orientation is not only location but also directionality. Malo (1951, 9) discusses directionality relative to one’s body, such as north (kukulu akau) and south (kukulu hema) when facing the sunset and the way that, “the names applied to the points of the compass are correspondingly all changed about” relative to the body. Other aspects of directionality also held important implications. “Kua a kānāwai,” or a back guarded by law, referred to the backs of certain chiefs which were kapu (restricted)—such chiefs were not to be approached from behind (Pukui and Elbert 1986). In such ways vision, orientation, and directionality were incorporated into the kapu system, which served to establish standards of accountability and enforced proper conduct through specific codes of behavior (Young 1998, 74).
The placement of structures took many aspects of orientation and directionality into account. Kamakau (1992b, 154) highlights the role of a traditional expert in bringing together the complexity of considerations in the specific case of constructing Pu‘ukoholā heiau:

The building of the heiau of Pu‘ukoholā was, as in ancient times, directed by an expert—not in oratory, politics, genealogy, or the prophetic art, but by a member of the class called hulihonua who knew the configuration of the earth (called kuhikuhi pu‘uone). Their knowledge was like that of the navigator who knows the latitude and longitude of each land, where the rocks are, the deep places and the shallow, where it is cold and where warm, and can tell without mistake the degrees, east or west, north of south. Such knowledge, taught on Kauai, one could apply anywhere in the world; so Ka-pou-kahi had instructed Ha‘alo‘u to the letter.

Just as the design and structure of luakini heiau foundations, built of drylaid stone, have proven to exhibit wide variety, their internal furnishings are also known to have displayed some latitude in their aspects. Again alluding to a sensory hierarchy related to height, the uppermost area or the innermost court of a luakini heiau was its most sacred division, and the superstructures built there fulfilled a variety of purposes. These structures were generally constructed out of perishable materials such as wood and other plant matter, and although there is little archaeological evidence of their presence they are known through ethnohistoric accounts as well as the observations of early Europeans. While accounts differ in their details, there is a general consensus in terms of the types, configurations, and functions of the structures internal to a luakini heiau (see Valeri 1985, 237–248).

<table>
<thead>
<tr>
<th>Structure</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paehumu (or pā)</td>
<td>A fence separating the temple or its</td>
<td>Cf. Malo 37.15; Kepelino</td>
</tr>
<tr>
<td><strong>inner precincts from the exterior</strong></td>
<td>1932:59, cf. 137</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>May be an <em>invisible barrier</em>, but most often is a fence of planks and poles on which images have been carved</td>
<td>McAllister 1933, 14</td>
<td></td>
</tr>
<tr>
<td>Banners or flags (lepa) may be placed around the temple to <em>signal</em> a taboo</td>
<td>Kamakau 1961: 202-3</td>
<td></td>
</tr>
<tr>
<td>'Anu'u (or lananu'u mamo)</td>
<td>A tower-like frame made of ohia <em>found at one end</em> of the sanctum sanctorum, the first structure to be erected in the temple</td>
<td>Kamakau 1976:135; Malo 1951:162; cf. Emory 1929:92</td>
</tr>
<tr>
<td>All the statues and houses are <em>oriented to it</em></td>
<td>Valeri 1985:238</td>
<td></td>
</tr>
<tr>
<td>Contains three levels or floors, <em>the top of which is the most sacred</em> and may only be accessed by the king and the high priest</td>
<td>Malo 1951:176</td>
<td></td>
</tr>
<tr>
<td><em>Height</em> up to approximately 20 m</td>
<td>Bell 1929-30, 1:78</td>
<td></td>
</tr>
<tr>
<td><strong>Hale mana (or hale mua or hale malu)</strong></td>
<td><em>Most important and largest house</em></td>
<td>Kamakau 1961:155; Pukui and Ebert 215</td>
</tr>
<tr>
<td><em>Small</em> images and paraphernalia are kept, as well as the feather gods when they are brought into the temple</td>
<td>Kamakau 1961:155</td>
<td></td>
</tr>
<tr>
<td>Kāhuna live in this house during some rites</td>
<td>Freycinet 1978:74</td>
<td></td>
</tr>
</tbody>
</table>
| **Hale pahu**       | Drum house, *positioned between* the mana house and the lele altar | Malo 1951:162; Íʻi 1963:35  
|                    | The house where the kāhuna did all their work                     | Kamakau 1976:138 |
| **Hale wai ea**    | *Smallest of the temple houses,* “Twice the length of the distance from fingertip to elbow in length, its height and breadth being half that measure” | Íʻi 1963:35  
|                    | Essential to the rites of the priest and the 'aha cord            | Fornander 1916-20, 6:18  
|                    | Literally means water of life, the house to revive life “ka hale I kamauliola” | Kamakau 1976:138 |
| **Hale umu**       | House of the oven where the temple fires are *lighted*; a shedlike structure where pigs were baked | Kamakau 1976:138 |
| **Lele**           | An alter where sacrificial offerings are put for the god          | Valeri 1985:240  
|                    | Usually an *elevated* wooden structure of various forms          | Hiroa 1957:522  
|                    | Usually *tall*, so that the offering can been *seen from a distance* | HEN,1:203 |
| **Images**         | *Depicting* the gods, the most important objects of worship (mea* | cf. HEN, 2:n. 69 |
The focal point of the visual symbolism of the ritual

Major Fixed images are erected in front of the tower and are laid out in either in a semicircle or in two parallel rows

The main image is just in front of the tower, minor fixed images are placed throughout the temple, and mobile images, made of wood or wicker covered with feathers (akua hulu manu), were housed in the hale mana when taking part in the rites

Table 9. Ethnohistoric references to various components of luakini heiau (with visual references italicized), adapted from Valeri 1985.

Inside a structure, the design of rooms, walls, and even decorations could impact the dynamics of visibility and be incorporated into cultural practice. Some ethnohistoric material holds hints for associations with visual traits such as colors. The color of wood holds special meaning in the luakini temple ritual, as it emphasizes the fundamental binary nature of the structure and holds symbolic significance. A luakini heiau can be built for works of war (heiau kaua) or works of peace (heiau loulu), which are “contrasts like other pairs of things like destruction and fertilization or life and death, always necessary to be present in any performance of the royal ritual” (Valeri 1985, 180). The wood of ʻōhiʻa is red in color and is associated with blood, violence, and destruction and is used for a heiau kaua.
Building a heiau with ʻōhiʻa will bring famine (Malo 1951, 189). In contrast, loulu palm is whitish green, associated with states of life and purity, and is used to build the loulu variety of luakini. Such contrasts, visual and otherwise, are asserted to have been inherent aspects of the luakini. Now we turn to more closely consider the dynamics of sight in this context.

Multisensory survey (sight)

In order to expand the study and understanding of vision at Puʻukoholā heiau, five separate components of a multisensory survey were undertaken and completed. These address 1) the microtopography of the study area; 2) access analysis of the interior space of the heiau; 3) the visual dimensions of perception as observed from points surrounding the structure; 4) viewshed analysis of short to distant views from the location of Puʻukoholā; and 5) an ethnographic vignette of sight in the contemporary setting of Puʻukoholā and the activities that take place there.

Microtopographic analysis

This section presents the results of a microtopographic survey carried out within the study area. Given the dependent relation between terrain and the visual affordances of people, the microtopographic setting of Puʻukoholā heiau is an important starting point for considering the dynamics of sight—as well as other sensory modalities—across the natural and cultural landscape. The objective of conducting a microtopographic survey is to establish a dataset useful for fine-grained analyses of the shape and character of the landform in relation to the
dynamics of vision, and also in relation to other sensory modalities such as sound, as presented in Chapter 4.

Background

Microtopographic survey is defined as recording terrain (elevation above sea level) at a high level of spatial resolution, generally to sub-decimeter accuracy. Microtopographic survey conducted with high-precision global positioning system (GPS) technology can result in the creation of highly accurate digital elevation models (DEMs), unobtainable by any other terrestrial survey method and marginally more accurate than the most applicable remote sensing method (e.g., compare to LIDAR with a vertical accuracy of 6-61 centimeters [cm], depending on the physical and material composition of the ground surface) (Hodgson & Bresnahan, 2004; Veneziano, 2002). Given the relatively open environmental setting of Pu‘ukoholā heiau and the study area, excellent conditions for GPS antennae reception of satellites exist. Microtopographic data can be applied to questions concerning what area of a natural landform have been modified by humans (Bewley & Raczkowski, 2000; Kvamme et al., 2006), the relation of geomorphic features to artifact distribution and architectural elaboration (Buck et al., 1999), indicators of topographic change over time, as well as the visual interpretation of the study area.
Methods

Efforts to establish the microtopography of the study area consisted of two primary tasks: the physical survey of the landform and the post-processing of the collected microtopographic data. Specifying a five meter survey transect interval and using an integrated GPS-based approach, survey data was collected using five simultaneously deployed Ashtech ProMark II receivers as roving units and one GPS base station on an established datum to collect data for post-processing differential correction.

The physical survey of the landform was carried out using a stop-and-go recording procedure along survey transect blocks, systematically covering the landform of the study area with the high-precision units. Roving units and their
operators were kept on course through the use of two small handheld Garmin GPS units. Once in formation, the outside members of the survey line of five rovers would maintain their pre-assigned northing, with the other three rovers filling the space between. Points were taken simultaneously with each unit, and once all points were taken the group would move forward five meters, stop, and repeat the process. In areas where satellite signal strength was an issue—usually as the result of dense overhead vegetation such as keawe trees—transects were abandoned in favor of directed coverage dictated by locations of adequate signal strength.

![Image](image1.jpg)

**Figure 11.** A pair of photographs illustrating the survey line roving around extant architecture (L) and across the landscape (R), collecting points every five meters.

In order to integrate cultural resources – namely extant monumental architecture such as Pu‘ukoholā and Mailekini heiau – a Real Time Kinematic system
(Topcon Hiperlite RTK GPS) was used. The Hiperlite system permitted the collection of an additional dataset at sub-centimeter accuracy. This data was valuable for defining and integrating architecture in our digital representation of the landform, by recording the “footprints” of the architectural structures within the landscape and thereby indicating where the natural landform transitioned into the built environment.

The second task, data processing, involved downloading and archiving the microtopographic data in an appropriate format, turning that data into a form readable by drafting and GIS software, and continuously checking for errors, compatibility, and overall data quality. Data was archived in Receiver Independent Exchange Format (RINEX) to ensure a non-proprietary medium with compatibility between GPS instrumentation and systems, and for delivery to project stakeholders such as the National Park Service. Subsequent processing of the microtopographic and architectural data collected via survey was conducted within AutoCAD and ArcMap (ESRI) to enable processing and analyses of the dataset.

Results and discussion

Microtopographic survey was conducted over 24 hectares (60 acres) with 10,268 data collection points, achieving a spatial resolution of +/- 2 cm horizontal, +/- 4 cm vertical. In sum, the +10,000 precision GPS points collected allows the creation of a three-dimensional model of the land surface at a resolution greater than one decimeter. Coverage includes the vast majority of the park’s land surface not presently obscured by heavy vegetation, excluding the John Young homestead and other federal land located across State Route 270. The area where GPS coverage proved to be the most difficult to obtain was in the north and was largely the result of several deep drainages and the presence of thick keawe or mesquite trees (*Prosopis sp.*) When satellite signal strength waned at any specified survey point but
a substitute reading was available nearby (within ~ 2 m) it was collected; this workaround, however, applied to less than 3% of total area surveyed.

<table>
<thead>
<tr>
<th>GPS points collected</th>
<th># Accepted</th>
<th># Rejected</th>
<th>% Accepted</th>
<th>% Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,268</td>
<td>9,759</td>
<td>509</td>
<td>95.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Table 10. Number of precision GPS data points collected, accepted, and rejected during the microtopographic survey. Microtopographic data is located in Appendix A.

Figure 12. Plot of microtopographic GPS data points collected at Pu‘ukoholā Heiau National Historic Site. Only points with valid elevation readings are shown (n = 9,759). These represent a 95% success rate during the microtopographic survey.
Microtopography provides a comprehensive model of the local setting. Turning to the CAD software representation of this data we see a detailed view of the study area’s natural topography. Several prominent drainages, park visitor paths, and modern architecture are also shown. It also reveals the extent of efforts made to return the area to a form more similar to the original late 18th century setting of the heiau; the path of the old Spencer Beach Park road, which once ran in between the Pu‘ukoholā and Mailekini, is no longer discernable in the half-meter contour map. Most importantly, the high degree of spatial resolution provided by microtopographic data can be used to more closely examine the visual structure of the study area.

Figure 13. Topographic projection (contour interval of 0.50 meters) of full project area coverage, Mailekini heiau (tan – left), Pu‘ukohola heiau (tan – right), Park Headquarters (gray – right), Visitor Center (gray – bottom), access road, and paths.

One observation made apparent by the high-resolution dataset is a stark difference between the two heiau in terms of their topographic setting, a condition that underlies and to a large degree determines their visual character. While
Mailekini is built across variable terrain, straddling one depression and extending into another, Puʻukoholā not only crowns a natural prominence but also exaggerates the natural landform with the manner in which it is “shaped” around it. In this way, Puʻukoholā exhibits a high degree of conformance to the natural landform, even as it builds upon it. The configuration of the “front” (seaward, makai) half of Puʻukoholā is constructed in a way so that the aspect of the natural landform is continued into the form of the structure itself, and vice versa. While Puʻukoholā is afforded much of its prominence by its higher elevation in comparison to Mailekini, it is also the case that it was built—as its name may suggest or reference—to integrate the hilltop and the fine-resolution landform data demonstrate just how its architectural footprint tracks the natural landform, as shown by the architectural footprint falling closely in line with the elevation contours. It “inherits” the upward projection of the landform on which it is constructed, and by design it takes full advantage of its elevated location overlooking the coastline and Kawaihae Bay.
Figure 14. Enlarged projection of Mailekini heiau (L) and Pu‘ukohola heiau in related topographic context (contour interval of 0.50 m). Paved Park visitor paths outlined, seasonal drainage indicated.

The documentation and analysis of microtopography leads to considering the natural divisions of the landscape with respect to vision. The built and natural setting of Pu‘ukohola’s paehumu, or pā, which would have separated the temple or its inner precincts from the exterior (remnants of which may still exist as rock walls that project from the northern and southwestern edges of the heiau), appears to coincide with aspects of a natural basin that exists downslope and to the generally west of the structure. A closer examination of this area based on its microtopography, using an index called the angle of depression, clarifies this visual relationship further.
The angle of depression is the angle between the horizontal and the ray entering the eye from an object or location being viewed (Higuchi 1983, 36). In the case of Puʻukoholā, calculating the angle of depression requires a starting elevation (the elevation of the heiau plus a hypothetical observer height or 32 meters above sea level in this case) and then projecting a ten-degree ray outward across the landform, identifying an area that falls beneath or within that ray using the microtopography of the landform. The lower the elevation of the surrounding landform, the more area will fall within an angle of depression. Dropping from an elevation of 32 meters above sea level (masl) to 0 masl, for instance, a 10 degree ray extends outward 181 m. Table 11 calculates three “edges” of a 10 degree angle of depression used to define an area within the variable microtopographic setting of Puʻukoholā.

<table>
<thead>
<tr>
<th>Observer height (masl)</th>
<th>Angle of depression (°)</th>
<th>Terrain height (m)</th>
<th>Maximum distance (m) within the angle of depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>10</td>
<td>0 (sea level)</td>
<td>181</td>
</tr>
<tr>
<td>32</td>
<td>10</td>
<td>10</td>
<td>125</td>
</tr>
<tr>
<td>32</td>
<td>10</td>
<td>20</td>
<td>68</td>
</tr>
</tbody>
</table>

*Table 11. Maximum distances within a specified angle of depression at Pu'ukoholā heiau based on variable terrain height.*

Projecting these values onto the study area reveals the extent of the landform that can be classified as falling within an approximately 10 degree angle of depression in relation to an observation point at the western edge of the interior terrace of Puʻukoholā heiau.
Figure 15. The area adjacent to Pu’ukoholā heiau that lies within a 10 degree angle of depression relative to views originating on the western interior edge of the structure. The top value is the viewing distance in meters; the bottom value is the elevation in meters above sea level.

A specification of 10 degrees is based on studies that suggest a relationship between angles of depression and the ease with which certain objects and things can be seen (Dreyfuss 1967). For people, 10 degrees marks the “normal line of vision” when standing (vs. 15 degrees when seated). Compounded with the idea that humans have a natural tendency, based on a near-constant need to watch where we step, to look down rather than up means that landscapes as viewed from above can appeal to people through a sense of nearness. Applied to the particular context of a harbor, bay, or body of water, having the surface of the water within an angle of depression of 10 degrees as related to the viewer has been suggested to be a primary factor. Regarding this sense of nearness or “visual unity,” Higuchi (1983, 41) writes that, “[it] means a sense of visual oneness with the body of water in the harbor, or the feeling that the port is spread out at one’s feet. When the water
surface is farther away than the line representing a 10 degree angle of depression, the port appears to be ‘there,’ rather than ‘here.’”

The “sense of visual nearness” afforded by a favorable angle of depression goes beyond the sensation of feeling as if a landscape is at one’s fingertips. It also exaggerates the physical elements of the setting, as the natural line of vision expands further from the viewer than would be otherwise possible. In doing so, environmental features such as expanses of water, topography, and even vegetative or geologic aspects of the setting are visually incorporated. In the case of Puʻukoholā heiau, an area based on a 10 degree angle of depression encompasses the shoreline of Kawaihae Bay, to include the locations of Pelekane, Mailekini heiau, and a significant expanse of land (~30,000 m²), all to the immediate west of the structure. Largely a product of the microtopographic setting of the heiau, the sense of nearness potentially afforded by this relationship nevertheless serves to visually incorporate a significant amount of additional space—including any structures and objects contained within it—with the cultural space of Puʻukoholā.

In order to consider the architectural form of Puʻukoholā heiau as well as other sight-based considerations such as aspects of its visual placement at a regional level, it is useful to now turn to other datasets generated as part of the multi-sensory survey. These include inquires into access and viewsheds, which are presented in order to build toward a fuller accounting of how various facets of vision were incorporated into the monumentality of Puʻukoholā.

Access analysis

This section presents an access analysis of Puʻukoholā heiau. The objective of access analysis is to examine how buildings structure patterns of movement and encounters that allow people to engage in or avoid particular forms of interaction
(Fisher, 2009). The section is broken down into background, methods, and results and discussion. Further consideration of the results—emphasizing how patterns of access at Pu'ukoholā integrate into the sensory environment as a whole—are addressed in Chapter 6.

**Background**

Access analysis is founded on an abstract conceptualization of built space, using conceptualizations of space syntax and its basic unit of analysis: the “bounded space.” It also encompasses other techniques such as isovist analysis (Benedikt, 1979). Under this framework, arbitrarily defined units of space within a structure are classified by how they relate to adjacent units in terms of ease (or restrictiveness) of accessibility. The underlying assumption of access analysis is that physical construction—while also holding neutral potential—can aid or impede not only the movement of a body through space, but also the perceptions of the body. For instance, vision is a form of access. By being able to see something or into something, a particular kind of admission is granted (or alternatively, denied) and oftentimes the decision to grant or restrict these forms of access is reflected in architectural planning. Addressing the evolution of authority and power at Chavín de Huántar, Peru, Rick (2004, 72) writes that, “Access across levels and to platform tops was tightly regulated by a series of formal and mostly narrow staircases, which are often foci of architectural planning themselves, forming axes and framing elements in the overall architectural layout.” In ways such as this, buildings and structures are designed and built taking vision-as-access, bodily restriction or support, and other sensory elements into careful consideration, often in a multisensory manner. This is recognized to be true in both utilitarian as well as ritual forms of construction; internal walls are built not only to serve as a physical impediment, but also (or primarily) because they afford visual privacy as well as auditory separation.
Access is conceptualized to manifest along a spectrum of restriction and permission. Open, less elaborated space is more accessible than impeded, separated space. As an example, having looked into and then chosen to walk an open path through a room, the least costs in terms of access can be theorized to occur while moving through the open, middle region of the room because—in architectural terms—relatively little is changing in the relation between the body and space during that phase of movement. That space will thereby be considered to be less restrictive and more permitted. While entering or exiting the room, approaching objects that may be placed in the room, or crossing architectural elements such as stepping up onto a platform or descending steps, however, greater costs are assigned because the elaboration of the space (whether built or movable) affords more potential attachments for meaning.

The necessary disclaimer—incorporating a theme of which runs through several of sensory experiments included in this dissertation—is that structures, especially those related to ritual practice, are hardly defined by (or limited by) explanations afforded on the basis of Euclidian, neutral space. In other words, the recognition is that not all space is equal; places and their parts are often emotionally charged and distinct even when their physical identicality is readily apparent. Access analysis is held to be a starting point, however, a quantitative tool for recognizing and conceptualizing how built space interacts with the body via the senses. Its shortcomings reveal a path forward, suggesting utility also as a stepping stone toward more refined accounts of how particular forms of architecture relate to how specific people behaved in the past, and for what reasons they did so. In this dissertation, access analysis highlights the need to address how a consideration of the senses was an active force in the layout and design of a structure and how people experienced its cultural constitution. It also seeks to contribute to archaeological efforts that seek to carefully consider interior space, going beyond the requisite treatment of simply noting its major architectural elements and calculating a total surface area. Its interpretations aim to highlight, rather than suppress, how the significance of architecture and its sensory qualities varies.
In terms of the sensitivities of ritual spaces, the tenants of access analysis (despite a grounding in abstracted, “dead” space) are paradoxically amplified when considered in relation to customary practices and their myriad ties to architecture. Walking up a flight of stairs in a normal, everyday setting is rarely notable; walking up the same flight of stairs while playing a defined role in a ceremony—in front of high status individuals—is a formal and constricted action. In this sense, one could argue that the “costs” of access are generally amplified in the context of the rigid practices and protocol often associated with ritual. In such settings the senses are heightened, and the delicacies of navigating built space are amplified in the presence of an authority. Actions such as crossing thresholds, moving between individuals, or taking unorthodox paths are more likely to be costly by infringing on restricted space. Finally, ritual activity can also take place at times when sight is impaired or suppressed, such as under the cover of darkness. In this setting sight is still often relied on for movement but people (especially those not intimately familiar with a structure) are more likely to follow accessible, standard paths. Authorities, also, often desire a manner of movement that achieves a “smooth” ceremonial effect and thereby avoids the disjunction caused by a stumbling body. The cost of movement becomes more delicate when any sense is suppressed; it is also noted that other senses are likely heightened as a result. While confirmation to social norms is usually imagined, access analysis in a ceremonial setting might also illuminate some potential manners in which subordinates could outrightly resist (or passively defy) regulations and custom, such as by exerting bodily agency in the form of unorthodox or inconsiderate movements.

The access analysis will use an architectural plan view map to conduct an access analysis of Pu'ukohola heiau. Focusing on the topological properties of built space, it invites behavioral, perceptual, and cultural considerations of how luakini heiau actively structured the experience of people, especially with respect to views, privacy, complexity, and spaciousness.
Methods

Access analysis is based on the idea that physical and social costs (e.g., fields of view, drawing attention to oneself) are associated with movement across and between architectural elements, such as when crossing the thresholds of doorways, moving up stairways or ramps, and entering distinct spaces. This analysis performs an access analysis of Puʻukoholā heiau based on the major architectural elements of the building (e.g. walls, steep slopes, terraces, etc.), by dividing the interior space of the structure into standardized units. Rankings may be calculated for the units based on how accessible or restricted the space around them is. The access ranking is based on two criteria: how many adjacent, available spaces there are to the space in question and whether or not an architectural element must be crossed to get to them, such as movement through a doorway or over a significant change in grade.

Using remotely sensed imagery, a scaled plan view map of Puʻukoholā incorporating its major architectural elements (entryway, terraces, platform, and backing walls) was drafted. With the exception of the narrowest uppermost sections and steep sides of the heiau’s backing walls (which were arbitrarily assigned a restriction ranking of “1”), the remainder of the structure was divided using an arbitrary grid system. The choice of 3-x-3 m units for each grid unit and therefore as the unit of analysis was made in order to target access at a scale beyond what someone can easily touch; to move to an adjacent unit would generally require looking prior to moving. Ranking for each unit within the interior space of the structure were determined using the following criteria: 1) number of adjacent, accessible units (high walls and steep drops were considered inaccessible spaces); and 2) ease or difficulty of access to adjacent units based on the presence or absence of architectural elements. Adjacent units that could be “moved” into without encountering an architectural element earned the unit under analysis two points. Adjacent units that could be “moved” into by crossing an architectural element earned the unit under analysis one point. The lowest possible access ranking was a
score of 1 while the highest was a score of 16, meaning that the most highly restricted units received low scores while the least restricted received high scores.

Results and discussion

The results of the access analysis conducted for Pu‘ukoholā heiau are presented across three separate but related Figures (16-18). The first figure displays the base map of the structure with the access score of each 3-x-3 m architectural grid square notated. The second figure depicts ease of access throughout the interior space of the structure by connecting grid squares with identical access scores with a blue line. The third figure assigns each unit a color by separating the access scores into four categories of accessibility: least restrictive (green), less restrictive (yellow), moderately restrictive (blue), and highly restrictive (red).
Figure 16: Access analysis of interior space of Pu‘ukoholā heiau. Higher numbers represent less restricted space; lower numbers represent more restricted space.
Figure 17. Access analysis of interior space of Pu'ukoholā heiau. Blue lines connect units with identical access scores, in order to consider ease of movement.
Figure 18. Access analysis of interior space of Pu'ukoholā heiau. High and low access analysis score values are color-coded, in order to consider zones of access based on degrees of restriction.
The access analysis of Puʻukoholā heiau offers a variety of insights into the structure, access, and sight. Topics include the various architectural components of the structure and their relation to degrees of access and restriction, the linearity of the interior space within Puʻukoholā, and the distribution of least-to-highly restricted space as realized through the analysis. In addition, it is also important to note the shortcomings of the analysis as applied to the ritualized space of a luakini heiau, and comment on the most appropriate and useful application of these findings.

Composed of a series of terraces, platforms, and high backing walls, the various architectural components that make up Puʻukoholā heiau are of a limited variety, but they are built to a massive scale and integrated in a complex fashion. While they have been identified previously, and studies of heiau generally include the identification of architectural components, the novelty of access analysis lies in how it relates architectural components to human behavior or experience—in this case what people might intuitively apprehend within an interior space (primarily based on sight) and where they might chose to move.

Operating under the tenet that the kapu status of the heiau meant that the entire area was treated as highly restricted, ritualized space, access analysis posits

<table>
<thead>
<tr>
<th>Access classification</th>
<th>Area (m²)</th>
<th>Percentage of interior space (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least restrictive</td>
<td>567</td>
<td>35</td>
</tr>
<tr>
<td>Less restrictive</td>
<td>486</td>
<td>31</td>
</tr>
<tr>
<td>Moderately restrictive</td>
<td>414</td>
<td>26</td>
</tr>
<tr>
<td>Highly restrictive</td>
<td>126</td>
<td>8</td>
</tr>
<tr>
<td>Totals</td>
<td>1593</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 12. Access classification of interior space at Puʻukoholā heiau.
that the movement of people through and within the structure would have generally followed the paths of least resistance (and that the structure might have been designed to facilitate such movements accordingly). In other words, when visible to authority figures or powerful entities (such as chiefly or learned individuals, or the gods themselves) people feel obliged to move with deference and care. While the introduction of objects and custom impacts such spatial agency greatly, on an architectural level thresholds, rooms, steps, and walls, etc. are challenges to careful and deferential movement.

Despite its large size and its open appearance, Puʻukoholā heiau exhibits a fairly structured access environment. The multiple terraces that compose its makai edge and the central platform in its northern half effectively introduce a number of minor but significant barriers to easy movement across otherwise open space. Coupled with the superstructures typical to a luakini heiau (known to be present while in use but whose exact locations are unknown today), objects, and ritual protocol, it becomes apparent that access within the structure was certain to be complex and generally restrictive. The linear configuration of many of the architectural features, however, is shown by the analysis to offer relative ease of access when moving north/south, based on the examined criteria. This could facilitate the movement of people in and out of the structure, and well as toward and away from the southern, far end of the interior space, the possible location of images and the anuʻu, etc. In addition, the presence of hale on the northern platform would disrupt access across that space, potentially pushing focus to the south as well.

The most constrained and highly restricted space of the heiau according to the access analysis is its entryway. Interestingly, the entryway to Puʻukoholā appears unique to known luakini heiau. Whether this is the result of intentional design or the practical solution to its hilltop placement is not knowable, but nevertheless the stairway from the exterior to the interior of the building is a relatively tight space that requires determined, sustained movement to either enter or exit the structure. The other area shown to be highly restricted in the analysis is
actually on top of the high backing wall, which is difficult to access and may or may not have ever been used for ritual or other purposes.

Access analysis is predicated on the conceptualization of space as a neutral, Cartesian medium, and its utility is broad and generalizing. While carrying reductionistic limitations, its application to architectural contexts, such as Puʻukoholā heiau, nevertheless begins to reveal the complex ways in which architectural space, sight, and movement interplay. Despite such utility, it is equally important to recognize that a universal, sterilized idea of “access” is easily overturned by historically contingent, culturally constituted protocol. To that end, the most appropriate use of this analysis is as an exploratory foundation, to which culturally based knowledge might be added to refute, sustain, or refine its attempts. The layering of cultural information, both from past as well as present uses, would further advance understandings of how the interior space of the heiau was linked to the senses.
Visual dimensions of perception

Background

The visual and bodily complexity suggested by the microtopography of Pu’ukoholā’s landform and the dynamics of access within its interior space invites closer consideration of how the heiau is visually apprehended. Whether inside or outside, the consideration of seeing and viewing for the particular manners of people is relevant to defining and understanding behavioral patterns. Structures and spaces, especially monumental ones, often act as key loci within a landscape. As Higuchi (1983, 184) has written, “In order for such elements [landmarks] to create spatial order, they must be seen, sensed, and constantly recognized... not merely as geographical entities but as identifying features of the landscape.” A closer examination of the visual dimensions in relation to a monumental structure such as Pu’ukoholā heiau foregrounds particular, visual qualities of architectural character and offers the potential to identify unique characteristics. Additionally, the variation in these qualities—depending on from where they are observed and the variability of terrain and/or design of a building in relation to that point—may also be considered.

Archaeologists have examined the “visual dimensions of perception” in relation to architecture in other parts of the world, such as in the Andes (Moore, 1996) and South Asia (Johansen, 2004), suggesting that the production of monumental space depends on clearly recognizable forms of the built environment. In each case they have built upon the work of Higuchi (1983) and Lynch (1960), who established four explicit visual dimensions of perception to better understand monumental architecture (Table 13). These four dimensions are: 1) clarity of form, 2) contrast with background, 3) prominence, and 4) sufficiency of mass to emphasize presence. These dimensions can be used as a qualitative means to assess how scale, functional utility, and visual prominence all play a role in how buildings
appear and—provided a degree of cultural and historic context—insight into how monumentality may impact social relationships through how it is visually perceived (Johansen 319, 2004).

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity of form</td>
<td>How obvious or identifiable are the various architectural traits of the structure?</td>
</tr>
<tr>
<td>Contrast with background</td>
<td>To what degree does the structure stand out from its surroundings?</td>
</tr>
<tr>
<td>Prominence</td>
<td>How eminent does the structure appear?</td>
</tr>
<tr>
<td>Sufficiency of mass to emphasize presence</td>
<td>How much of the structure is observable and/or accentuated?</td>
</tr>
</tbody>
</table>

Table 13. Definitions of four visual dimensions of perception, after Higuchi (1983).

The visual dimensions of perception, as applied to monumental architecture, focus particularly on qualities of visibility and physical presence in short- or middle-distance views. In addition to the four dimensions listed above, attention can also be paid to more particular aspects of three-dimensional space, such those related to changes in elevation, as previously introduced with the angle of depression in the microtopographic analysis. The angle of incidence between a viewpoint and a structure specifies, in degrees, how much a person needs to look upwards to directly view a building. For landmarks (ostensibly designed to be effective at garnering visual attention), a vertical angle of elevation in the range of five to ten degrees is expected. Higuchi (1983, 184) summarizes the physiological significance of an upward angle of incidence as follows:
A downward view is free and open whereas an upward view is limited and apt to be closed because the process of looking up at an object tends to limit the mobility of the human body and to cut off the line of vision at a point above the horizontal. With the most stable line of vision for the average person being about 10 to 15 degrees below the horizon, it follows that the very process of looking up involves a certain amount of stress.

An angle of incidence is calculated by measuring the slope between the top of a structure and the eyes of a person standing at a viewpoint. This angle can vary depending on the distance of the viewer from the structure, as well as the elevation of the viewer in relation to the uppermost extent of the building. Given variable topography, such as in the case of Puʻukoholā, angles of incidence can be expected to change due both distance and landform.

**Methods**

In order to evaluate the visual dimensions of perception at Puʻukoholā heiau, two qualitative lines of inquiry were pursued using photographs and geographic data obtained from the points of observation. The first analysis generally examines the visual dimensions of perception at Puʻukoholā heiau, based on the appearance and qualities of the heiau’s architectural form as seen from outside the structure. The second analysis examines variability in the visual dimensions identified, based on a subjective scoring how the perceptive aspects of the architecture shift based on where an observer is located around the structure.

Points of observation were established at regular intervals and varying distances around Puʻukoholā heiau (Figure 19); each location was recorded using
GPS. Photographs were taken from each point of observation at eye level. The use of setting the observation points at variable distances from the structure, and varying focal lengths for the photographs (17-40 mm), was implemented in order to incorporate the consideration of both scale and detail (two ways that structures are intentionally built and ordered) as part of the analyses. In addition, the views from multiple points of observation included aspects of Mailekini heiau, incorporated as it pre-dates Puʻukoholā and also because it significantly constrains movement in the area and therefore affects where Puʻukoholā is most readily observable from. The analyses of visual dimensions of perception did not take into account the presence or absence of other structures or architectural elements aside from Puʻukoholā heiau in the photographs, including Mailekini.
Figure 19. Detailed map showing survey points of observation (denoted by file numbers) established to analyze the visual dimensions of perception around Pu'ukoholā heiau.
Results and discussion

Distance, difference in elevation, and the angle of incidence were calculated for each observation point in relation to Pu‘ukoholā heiau, using geographical data (Table 14). Horizontal distances were determined from each observation point using the approximate center of Pu‘ukoholā heiau, while the angle of incidence was calculated using an observer height of 2 m and wall/structure height of 3 m. All metrics were matched to corresponding photographs.

<table>
<thead>
<tr>
<th>Point of observation</th>
<th>File no.</th>
<th>Distance (m)</th>
<th>Change in elevation (m)</th>
<th>Angle of incidence (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8209</td>
<td>160</td>
<td>23.6</td>
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<td>21</td>
<td>8283</td>
<td>120</td>
<td>20.0</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Table 14. Points of observation in relation to Pu‘ukoholā heiau by distance, change in elevation, and angle of incidence.
An overall review of the observation points based on the corresponding photographs and metrics introduces the visual dimensions of perception at Pu‘ukoholā heiau. First, Pu‘ukoholā heiau’s overall architectural form underwrites each visual dimension of perception at the structure. As reviewed previously, the architectural components of the heiau include its high backing wall(s), a central internal terrace and platform, several cascading terraces along its western (downslope, makai) edge, and an entrance in its northwest corner. Perceiving these elements (clarity of form) from anywhere outside the structure is, however, hampered by the elevated nature of the heiau on its open side(s) and the accordingly high angles of incidence encountered by a viewer as a result of either the landform dropping away or by high exterior walls. Additionally, ascertaining the nature and configuration of the discrete aspects of its form requires taking in multiple views due to the variable and non-symmetrical design of the structure.
Furthermore, significant internal features (such as the inner platform and the inner terrace) remain out of the line of sight from all locations outside the structure; these can only be perceived from within.

Turning to another visual dimension of perception, Puʻukoholā heiau stands out in the way that it is visually distinct from its surroundings (contrast with background). In terms of many sight-based characteristics, including color and texture, the visual appearance of the building is starkly different from the elements surrounding it. While this contrast depends on, and varies with, time of day and lighting, under almost all conditions the dry-laid stones of the structure are set off markedly by the sparse grasses and the patches of exposed natural landform that typify the ground surface which encompasses the heiau, as well as the sky above. Even when backlit, during the morning hours, the hulking form of the stacked structure is readily discernable from the intact hilltop on which it is situated. In addition, the near-constant motion of the grasses, active even in light winds, adds another element of observable contrast (movement vs. stasis) when it comes to the visual perception of the structure. While native grasses have largely been displaced by introduced species, the historic setting of the structure is certain to have exhibited similar interplay between the built and natural environment.

The third visual dimension of perception concerns how eminent Puʻukoholā heiau appears (prominence). Both the physical form (shape) of the structure as well as its height relative to the position of the viewer are primary factors for assessing visual prominence. As a result of the minor degree to which it projects or protrudes from the landform, Puʻukoholā is not exceedingly prominent in this regard. Instead, it appears to have been designed to correspond with the character of the terrain on which it is built (and named for, a hill or puʻu). Its architectural silhouette is only slightly disruptive to the curve of the natural horizon line. Puʻukoholā heiau is, however, prominent in the sense that it stands above nearly all the land that surrounds it, as reflected by the angles of incidence notated in Table 10 above. Across the observation points surveyed, the angles of incidence range between 0 to
14.7 degrees, which reflects the requirement for any observer to look up in varying degrees in order to regard the structure. This effect is most especially pronounced on the coastal side of the structure, as when approaching it from the shoreline anywhere along its western flank.

The fourth and final visual dimension of perception considers how much the design and situation of Puʻukoholā heiau accentuates its appearance as a large and imposing structure (sufficiency of mass of emphasize presence). In this case, through crowning an entire hilltop Puʻukoholā positively integrates much of the surrounding area, literally and figuratively building on the topographically dynamic setting to emphasize its presence. The placement of the heiau on a peaked landform also has the added benefit of requiring a lower volume of construction materials to achieve any specified size than if it was built on flat ground (Mulrooney et al. 2005). As touched on previously the clarity of its form is also in play, as the building cannot easily be apprehended from a single vantage point. This serves to further buoy its sufficiency of mass, through provoking movement on the part of anyone who attempts to regard it comprehensively.

As each of the four visual dimensions of perception manifest generally and can be considered on the scale of the structure as carried out above, it is also the case that they vary markedly depending on where an observer is situated within the vicinity of Puʻukoholā heiau. While the differences between various views cannot be quantitatively compared based on a photograph or otherwise, they can be subjectively assessed as a way of gauging their (relative) variation in terms of the visual dimensions of perception based on changes in viewing location.

This second analysis uses photographs taken from the 21 observation points (Figure 21, see Appendix B for the complete set of photographs) to generate relative scores for each of the categories pertaining to the visual dimensions of perception (Table 15). Through the scoring is based on subjective impressions of the photographs (based on the terms and definitions previously defined), the analysis
allows for: 1) a more concrete discussion in terms of the variability observable for each category of the visual dimensions of perception at Pu`ukoholā heiau; and 2) several explicit ways in which the strength or weakness of each dimension is tied to the specific location of any given point of observation in this survey.

![Select views of Pu`ukoholā heiau used for analyzing the visual dimensions of perception at Pu`ukoholā heiau. From left to right, the corresponding point of observation numbers are: 2, 4, 11 (top row); 12, 13, 14 (middle row); 16, 18, 21 (bottom row).](image)

<table>
<thead>
<tr>
<th>Point of observation</th>
<th>Clarity of form</th>
<th>Contrast with background</th>
<th>Prominence</th>
<th>Sufficiency of mass</th>
<th>Total</th>
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<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>92</strong></td>
<td><strong>77</strong></td>
<td><strong>67</strong></td>
<td>—</td>
</tr>
</tbody>
</table>

Table 15. Scoring the four visual dimensions of perception at Pu‘ukoholā heiau from various points of observation on a scale of 1 (low ranking) to 5 (high ranking).

Overall, the variability in each category is marked, meaning that the visual dimensions of perception at Pu‘ukoholā heiau change significantly depending on the viewpoint of the observer. Clarity of form, for example, is significantly more discernable (high ranking) from vantage points located to the north and or to the west. When observed from the east or south, the architectural form of the heiau is much less apparent. This specificity is also related to landform, as these are the directions where the terrain slopes downward from the heiau toward the coast (east) or along a descending ridgeline into a gulch (north). Similar variation, tied to directionality and/or the terrain, is suggested in the relative scores of prominence and sufficiency of mass as well. Contrast with background, on the other hand, is more constant regardless of where structure is viewed from—largely because when
viewing Pu‘ukoholā from close to mid-range the background to its architectural form is the sky.

A wide variety of other variables impact the visual dimensions of perception. Weather and lighting, for instance, affect what people see and the characteristics they perceive. The movement and activity (or intent) of a person in the vicinity of a structure such as Pu‘ukoholā will also impact how the dimensions of the structure are visually perceived. An individual transiting through the area on the upland, mauka side of the heiau and who does not directly approach the structure will apprehend a distinctly different set of dimensions than one who intends to visit Pu‘ukoholā and comes by sea, for instance. These dynamics can have relevance to understanding the past, and may also be useful for planning in the future.
**Viewshed study**

This section presents a series of viewshed analyses based on the location of Puʻukoholā heiau. The objective of the study is to generate quantitative and graphical datasets to compare and discuss the regional topographic setting of Puʻukoholā heiau with both proximate, non-site locations as well as the placement of other large, archaeological structures throughout the Hawaiian archipelago. Building on the previous methods of visual analyses, this undertaking aims to contribute to a broad examination of how Puʻukoholā heiau, as an example of monumental architecture, possesses a wide range of visual parameters and advance understandings of how visual factors were (and are) integrated into its social significance. The section is broken down into background, methods, and results and discussion.

**Background**

It is a common refrain for people, including archaeologists, to note that heiau are “prominently” positioned. But what does this mean? In specific, do heiau consistently occupy more topographically exposed points on the landscape? When applied to mountain peaks, prominence is a measure of the independence of a summit—how much it stands on its own. Fuller definitions of prominence, as introduced previously in this chapter, include qualitative aspects of terrain as well as cultural perspectives, but it the more explicit version that we turn to now. The use of a viewshed procedure can generate quantitative measurements of prominence to answer such queries, all based on the “function of height differential between an individual and his or her surroundings as apprehended from the individual's point of view” (Llobera 2001, 1007).

To consider the dynamics of landform in relation any given location, including the position of buildings, various manners of viewshed analysis offer a valuable tool. Viewsheds, from which estimates of the total land area visible from any specified location (and in reciprocal fashion the total land area from which that
specified location is visible) can be determined, are replicable calculations that can be conducted at any scale. Viewshed procedures are useful to begin considering the visual structure of a location at based on its mid to long-range views (as well as what is hidden from view). In order to analyze and compare the viewshed of Pu‘ukoholā heiau’s location, two locational datasets were used: 1) a series of locations proximate to Pu‘ukoholā and similar in terms of their environmental setting; and 2) a series of randomly selected points located within 5km of Pu‘ukoholā. While focused on Pu‘ukoholā heiau, this chapter also includes a third element that leverages locational data for a series of other comparable monumental archaeological structures in order to ascertain how consistent or disparate the viewshed of Pu‘ukoholā heiau is to other luakini heiau or monumental structures.

**Methods**

Viewshed analysis was conducted for a series of pre-specified locations using a continuous digital elevation model (DEM) for the Hawaiian Islands within an ArcGIS software package. The DEM (9 seconds, 10 m pixels) was derived from United States Geological Survey geographic data and uniformly post-processed to mitigate vertical artifacts in the virtual terrain surface and reduce excessive viewshed discontinuities. The locations for analysis (specified as UTM grid coordinates) were defined as single points, derived through either fieldwork or the analysis of remote imagery. All viewshed procedures were conducted using the same DEM.

In order to study the aspect of the landform chosen for the construction of architecture (site selection), determinations of intervisibility between points of interest and digital elevation model cells were made based on terrain height (vs. architectural height). However, the analysis did account for the height of a human observer by raising the observation point 1.75 m above ground surface. While many large heiau are architecturally complex and block views in certain directions from
within their interior space, this analysis seeks to consider the more fundamental visual relationship of how much of the surrounding landform can be seen from a specified location regardless of architectural elaboration. Regarding vegetation, the low elevation context of the study area is convenient because most of the points of interest and the surrounding environs are leeward and coastal where vegetation has long been dominated by grasses and shrubs with minimal trees as reviewed in Chapter 3; no accommodation for the blockage of views due to vegetation is made in this analysis.

Viewsheds were created in ArcGIS by querying points of interest for line of sight accessibility across the surface of the DEM. By generating a shapefile based on the results of the query, the “visible surface area” of the viewshed was calculated. In order to consider viewsheds at various distances, thresholds were applied to each set of calculations in order to measure a subset of the total visible surface area. Each threshold roughly corresponds with an equivalent “range of view” in human terms, such as close, medium, or distant views (Table 16).

<table>
<thead>
<tr>
<th>Threshold (m)</th>
<th>Range of view</th>
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<tbody>
<tr>
<td>500</td>
<td>Close</td>
</tr>
<tr>
<td>5,000</td>
<td>Close to medium</td>
</tr>
<tr>
<td>Unlimited</td>
<td>Close to distant</td>
</tr>
</tbody>
</table>

Table 16. Distance thresholds and range of view.

Two sets of related analyses were carried out: 1) an analysis of the viewshed of Puʻukoholā heiau, to include its visual relationship with close, medium, and distant views; and 2) the comparison of the viewshed from Puʻukoholā heiau’s location at all three distance thresholds to the equivalent viewsheds from a series of randomly selected points within five kilometers. These analyses collectively seek to
explore, characterize, and compare the viewshed of the location chosen for the construction of Pu‘ukoholā heiau, along with those of other sampled locations.

Results and discussion

From a point of origin at Pu‘ukoholā heiau (Table 17), a viewshed analysis was conducted to identify all visible terrain using an automated line of sight calculation within ArcGIS. The result was overlaid on base maps of the study area and region at varying scales, using colored shading to identify the visible areas (Figures 22, 23, and 26).

<table>
<thead>
<tr>
<th>Name</th>
<th>Island (district)</th>
<th>UTM (WGS-84)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pu‘ukoholā</td>
<td>Hawai‘i (Kohala)</td>
<td>5Q 204817 2217027</td>
</tr>
</tbody>
</table>

Table 17. Location analyzed by viewshed analysis for Pu‘ukoholā heiau.
Figure 22. Viewshed generated from the Pu'ukoholā heiau point of origin spanning the islands of Hawai’i, Maui, and Kaho'olawe.
Figure 23. Extent of viewshed generated from the Pu'ukoholā heiau point of origin on the Big Island of Hawai‘i.
Out of the total visible area calculated, thresholds were applied to the result to specify the amount of visible area at a series of distances from the point of origin (Table 18).

<table>
<thead>
<tr>
<th>Threshold (m)</th>
<th>Visible area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>0.33</td>
</tr>
<tr>
<td>5,000</td>
<td>13.95</td>
</tr>
<tr>
<td>Unlimited</td>
<td>719.22</td>
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</tbody>
</table>

Table 18. Total area visible from location of Pu‘ukoholā heiau at three distance thresholds.

The viewshed of Pu‘ukoholā heiau is useful for considering what can be seen from the location at the varying ranges of view. Starting at the unlimited range, or what can be considered “distant views,” the regional setting of Pu‘ukoholā heiau point of origin contains views to the peaks of six major Hawaiian summits. Table 19 reports data for the summit of each mountain in relation to the Pu‘ukohola point of origin. The viewshed coverage was more closely analyzed in relation to each mountain peak identified: Kohala, Mauna Kea, Hualalai, Mauna Loa, Haleakala (Maui), and Pu‘u Moaulanui (Kaho‘olawe).
<table>
<thead>
<tr>
<th>Mountain</th>
<th>Bearing (degrees)</th>
<th>Distance (km)</th>
<th>Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kohala</td>
<td>59</td>
<td>12.748</td>
<td>1670 (0.131)</td>
</tr>
<tr>
<td>Hualālai</td>
<td>187</td>
<td>37.864</td>
<td>2521 (0.067)</td>
</tr>
<tr>
<td>Mauna Kea</td>
<td>122</td>
<td>43.341</td>
<td>4205 (0.097)</td>
</tr>
<tr>
<td>Mauna Loa</td>
<td>159</td>
<td>64.978</td>
<td>4169 (0.064)</td>
</tr>
<tr>
<td>Haleakalā</td>
<td>329</td>
<td>88.008</td>
<td>3055 (0.035)</td>
</tr>
<tr>
<td>Pu'u Moaulanui</td>
<td>307</td>
<td>97.597</td>
<td>450 (0.005)</td>
</tr>
</tbody>
</table>

Table 19. Mountain summits visible from the Pu'ukoholā point of origin with bearing, distance, and elevation at summit.

The distant views of the mountain summits and their flanks were further considered as distinct components of the Pu'ukoholā point of origin viewshed. Visible surface area was estimated for each mountain. Combined with the “core” area of the Pu'ukoholā viewshed (the visible area in close proximity to the structure itself), the composition of Pu'ukoholā's viewshed can be considered by in terms of how much land area of each mountain is visible as compared to the others (Figure 24).
Figure 24. Pie graph depicting percentages of surface area within the Pu'ukoholā point of origin viewshed keyed to major Hawaiian mountains (clockwise starting with Mauna Loa).

In terms of the distant mountain views, most of the land visible from the location of Pu'ukoholā lies upon the flanks of Mauna Loa (37%) or Hualalai (26%). Mauna Kea (17%) and Haleakala (16%) feature secondarily in terms of land area visible. The remaining three percent of the viewshed consists of the vicinity of Pu'ukoholā itself, Kohala mountain, and Pu'u Moaulanui. The apparent presence of each mountain to a viewer hinges largely on how far away it is—a sizable amount of land at a great distance may not be as perceptible as a smaller area situated on a landform that lies closer to the viewer. Here, the view from the location of Pu'ukoholā to Mauna Loa, Mauna Kea, and Hualalai is notable, given that both Mauna Loa and Hualalai contribute more land area to the viewshed but are significantly further away (Mauna Loa) or significantly smaller in mass (Hualalai) than Mauna Kea. Pu'u Moaulanui is a dimunitive presence both in terms of distance and visible area (the potential cultural significance of seeing it being another
matter), likely to be visible in only in the very best of conditions if at all. These relationships are considered graphically in Figure 25.

![Graphical comparison of views to six mountains within the Pu’ukoholā point of origin viewshed, plotted by angle, distance (line), and total surface area (circle). Numbers correspond to percentage of surface area within the total viewshed.](image)

Figure 25. Graphical comparison of views to six mountains within the Pu’ukoholā point of origin viewshed, plotted by angle, distance (line), and total surface area (circle). Numbers correspond to percentage of surface area within the total viewshed.

In addition to visible land area, mountain peaks differ in their viewing angle. Using distance and elevation the visual angle of incidence, or the upward angle required to look directly at a specified point, were calculated for each of the mountain summits. The formula of \( \tan(Q) = A/B \), when \( A \) is opposite (elevation) and
B is adjacent (horizontal distance) values of a right triangle were used to calculate Q, the visual angle of incidence. Table 21 reports the calculated angles of incidence of the six summits from the Puʻukoholā point of origin for a human observer with an observation height of 2 m. The highest angle of incidence of the mountain peaks visible from the location of Puʻukoholā heiau is that of Kohala Mountain, at 7.46 degrees. This is followed by Mauna Kea at 5.56 degrees.

<table>
<thead>
<tr>
<th>Mountain</th>
<th>Angle of incidence (degrees above grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kohala</td>
<td>7.46</td>
</tr>
<tr>
<td>Mauna Kea</td>
<td>5.56</td>
</tr>
<tr>
<td>Hualālai</td>
<td>3.83</td>
</tr>
<tr>
<td>Mauna Loa</td>
<td>3.67</td>
</tr>
<tr>
<td>Haleakalā</td>
<td>2.00</td>
</tr>
<tr>
<td>Puʻu Moaulanui</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Table 20. Visual angles of incidence calculated for an observer (height=2 m) located at the Puʻukohola point of origin to the six visible mountain summits.

In terms of medium-range views (< 5,000 m), the viewshed from the location of Puʻukoholā heiau contains extensive coastal views to the north and south, as well as a “core” area of visible land that encompasses much of the terrain within several miles of the structure itself (Figure 26). This core area is slightly more concentrated to the north, where it also extends up the slopes of Kohala Mountain to the northeast. At the far edge of what would be considered a medium-range view, a sizeable area of land is visible on the Kona coast to the south, approximately 5 km distant. At close range (<500 m), good coverage of the area surrounding the structure in all directions is apparent. Within this range, however, the modern
artifact of Kawaikae harbor is present, inflating the land area estimation a modest amount if it was to be compared to one calculated for the historic setting.
Figure 26. Extent of viewshed generated from the Pu'ukoholā heiau point of origin along leeward coast of the Big Island of Hawai‘i.
While the geographical distribution of visibility from the location of Pu’ukohola provides a general sense of what can be seen in the vicinity of the heiau, with no comparative reference the visible land area values produced as part of the analysis are difficult to interpret. In order to consider the visible land area values more closely a series of randomly selected points can be used. By subjecting them to the same visible land area analysis, whether or not the location of Pu’ukoholā is noteworthy in terms of visible area can be addressed. Using the random point tool in ArcGIS, 50 random locations were selected; all random points are located within five km of Pu’ukoholā heiau (Figure 27).
Figure 27. 50 randomly selected points within a 5 km radius of Pu'ukoholā heiau.
A viewshed analysis was completed for each point to calculate the total visible area from each point, as well as within 5 km and 500 m thresholds. Figures 28 and 29 graph the results of the visible area analysis for the 50 points against each other as well as with the location of Pu'ukoholā heiau at the three varying distance thresholds. Total visible area viewshed data for the three distance thresholds is presented in Appendix C.

Figure 28. Land area visible (km$^2$) within 500 m of randomly selected points (n=50) as compared to Pu'ukoholā heiau (yellow bar).
Figure 29. Land area visible (km²) within 5 km of randomly selected points (n=50) as compared to Pu‘ukoholā heiau (yellow bar).

Figure 30. Total land area visible (km²) from randomly selected points (n=50) as compared to Pu‘ukoholā heiau (yellow bar).
Table 21. Tabulation of mean visible area at three distance thresholds for Pu’ukoholā heiau and fifty randomly selected locations (SD=sample standard deviation).

<table>
<thead>
<tr>
<th>Threshold (m)</th>
<th>Pu’ukoholā (km²)</th>
<th>Mean (SD); n = 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>0.33</td>
<td>0.20 ± 0.10 km²</td>
</tr>
<tr>
<td>5,000</td>
<td>13.95</td>
<td>6.59 ± 4.16 km²</td>
</tr>
<tr>
<td>Unlimited</td>
<td>719.56</td>
<td>635.63 ± 291.32 km²</td>
</tr>
</tbody>
</table>

Compared to the random sample of fifty locations within a five-kilometer radius, the location of Pu’ukoholā heiau clearly affords a high amount of visible land area at both close and medium ranges of view (greater than one standard deviation away from the mean value). While this analysis focused on land area, it is also worth noting the relationship between Pu’ukoholā, its viewshed, and the ocean. Located approximately 150 m from shore, the structure is built on a landform that is elevated in excess of 30 m above sea level. For an observer on the ground of average height (5 ft 10 in), the visible horizon is at a distance of approximately three miles out to sea. For the same individual standing on the spot where Pu’ukoholā is built (and not accounting for the extra height of the structure), they would be able to see approximately 13 miles out to sea. As a result of this, the location chosen for the construction of Pu’ukoholā offers an excellent vantage of the ocean. The land area values displayed above are therefore especially notable as in the viewshed calculations only terrestrial surface area (and not ocean surface area) was cumulated. As a result, the amount of area visible at close and medium ranges around Pu’ukoholā heiau must be especially high when compared to upland locations surrounded entirely by land.
Summary of findings (sight)

Building on ideas of place, monumentality, and power, this chapter presented original research to address the human sense of sight at Puʻukoholā heiau. Couched in the ethnohistoric and contemporary context of the monument and explored through four experimental analyses (microtopography, access, visual dimensions, and viewshed), the ramifications of vision are both diverse and complex. Overall, the neutrality of vision at Puʻukoholā heiau is to be questioned. In terms of the structure’s topographic placement with respect to the surrounding landform, its architectural design in relation to the human body, the variety of its visual character from various positions on the immediate landscape, and the dynamics of its intervisibility with its regional surroundings, the potential of vision to be incorporated into the pursuit and production of power is ample.

As integrated instruments of stately and religious power, luakini heiau such as Puʻukoholā blended the realms of the secular and sacred by harnessing multiple aspects of vision. Inseperable from the historical conditions of its creation, beginning with the asserted intention of Kamehameha to sacrifice his cousin and rival, ancient and contemporary actions are tempered by the terrain, personal sensitivities, bodily movement, and environmental factors of the landscape and place, many of which can still be accessed today. Just as fires lit at night would have allowed for distant visual contact and internal structures would have shielded people and things from general viewing, the complexities of vision at Puʻukoholā remain a potentially important subject of research.
### Chapter 5: Hearing

<table>
<thead>
<tr>
<th>Sense</th>
<th>Description</th>
<th>Hawaiian term</th>
<th>English usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing</td>
<td>to hear</td>
<td>lohe (verb)</td>
<td>to hear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lohena</td>
<td>what is heard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hoʻolohe</td>
<td>to pay attention, selectively</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hoʻolono</td>
<td>Lono is the god of sound</td>
</tr>
</tbody>
</table>

*Source: Rubellite Kawena Johnson, 11 April 1997.*


### Introduction

This chapter presents research carried out to explore the human sense of hearing at Puʻukoholā heiau, framed by sensory exploitation and accessed through the multifaceted concept of place observed in the archaeological, ethnohistoric, and ethnographic records. First, the sensory modality of hearing itself is briefly introduced, by sketching out its physiological basis as well certain general aspects of its significance to people and culture. Second, a review of archaeological research and hearing, specifically in relation to monumental architecture and power, is presented. Third, using Hawaiian ethnohistoric sources, a culturally grounded understanding of the interplay between hearing and aspects of traditional Hawaiian society is established by focusing on the history of the pahu (drum). Finally, various components of a multisensory survey are presented including archaeoacoustic and soundscape analyses in order to define and explore the various ways that the construction and use of Puʻukoholā heiau modified (and modifies) the way that people hear. Finally, the results of the research are weighed in relation to sensory exploitation, archaeological approaches and accounts of the past, and future undertakings. Overall, this chapter explores how Puʻukoholā heiau structures and
controls hearing in a variety of specific ways, and how these ways hold potential significance on many different levels.

**Human sense of hearing**

Hearing (or audition) is the detection of sound with the ears. Sounds—the transformation of vibrations into nerve impulses perceived by the brain—can vary in both their loudness (amplitude) and pitch (frequency). While individuals vary in their ability to detect sound, people are generally adapted to use sound in a multitude of ways: to learn about and navigate the world, to communicate and interact with other humans and animals through both formal languages and informal signals, and to express emotion. Most humans are able to detect, or hear, sonic frequencies within a range of 15,000 to 20,000 Hz (Skeates 2010, 13), a level of sensitivity that is remarkable in many respects. Consider, for instance, the dynamics involved to determine the directionality of sound. This requires the localization of sounds in the azimuthal plane by time differences, or calculating the time difference between when sound originating from one source is heard in different ears. If soundwaves originate directly in front of (or behind) the observer, then they arrive at the ears at the same time. If they originate anywhere else, then they will arrive at different times—thus indicating the direction of their source. Humans are able to use interaural time differences as small as 20-30 µs (0.00002 microseconds) to localize sounds and determine direction of origin (Cariani 2001, 78).

**Properties of sound and its analysis**

In order to introduce some of the methods and results of the multisensory survey analyses presented below, a brief review of the properties of sound and their application to its analysis is undertaken. Sound is generated by a source of vibration,
which produces waves of alternating compression and rarefaction. Sound waves travel by emanating from their source into an elastic medium, such as air or water. Depending on the viscosity of the medium the amplitude (power) of sound waves decreases, or attenuates, as they travel further from the source. Stokes law of sound attenuation states that the amplitude of a sound wave decreases exponentially with distance, dependent on the viscosity of the medium traveled (Stokes 1845). A sound, or acoustic signal, is therefore affected by how far it has traveled from its point of origin as well as the environment through which it has passed.

The analysis of a time-varying signal such as sound is well suited to digital analysis. This first requires, however, that an analog-to-digital converter, or digitizer, acquire the sound. Digitizers capture the continuously varying signal of a sound by sampling it at a specified rate, typically thousands of times per second. The precision of the capture depends on the rate at which amplitude measurements are made (sample rate, e.g., 44.1 kHz or 48 kHz), and the number of bits used to represent each amplitude measurement (sample size or bit depth, e.g., 8-bit or 16-bit).

The amplitude of sound waves can be measured in two domains: amplitude and time. Once acquired digitally, these domains can be examined several ways. One type of visual representation of an acoustic signal is a spectrogram. A spectrogram makes it possible to “view” a sound by separating the frequencies and amplitudes of its component simplex waves by applying a Fast Fourier transform to its digital form. In its visual form, the spectrogram itself, the horizontal direction represents time while the vertical direction represents frequency. Degrees of amplitude are represented by light-to-dark markings, with light equaling low energy and dark equaling high energy (Figure 31). For example, if a spectrogram has a dark area around a time of 2.3 seconds and a frequency of 3500 Hz, this means that the sound exhibited an abundance of energy for that frequency at that time. The spectrotemporal representation of sound afforded by spectrograms has been used.
extensively to compare sounds through visualization, such as for human speech (see P. Ladefoged 2000) and bird song research (see Baker 2001).

Figure 31. Sound data captured in a spectrogram, including frequency in kilohertz (kHz), time in seconds, and amplitude in decibels (dB).

Another way to visualize sound waves is with a waveform, which displays time on the horizontal axis and kilo-units (kU) as vertical striations whose length grows with the increasing amplitude of a sound (Figure 32). Compared to a spectrogram, which effectively shows the “shape” of sounds, a waveform offers a succinct view of the intensity of a sound. In addition to providing a visual reference of a sound wave's power, the amplitude values of the audio data in a waveform can be measured for maximum amplitude, minimum amplitude, and peak amplitude. By viewing spectrogram and waveform visualizations of a sound together, the shape and intensity of the sound are easily observed (Figure 33).

Figure 32. Sound data captured in a waveform, including time in seconds and amplitude in kilo-units (kU).
While visualizations of sound are useful in many ways, including measurements based on such digitizations, the social relevance of any given sound is rooted in the acoustic realm but flowers with the spectral and temporal aspects of sound perception, including the spatial dimension. The determination of directionality based on sounds, as introduced at the beginning of this chapter, is an example of a mechanism by which sound is integrated with a greater sense of awareness. As Tim Ingold (2007) writes, rather than hearing sound we hear “in sound.” Let us turn to how archaeologists have variously approached the study of sound and applied their findings to our knowledge of past societies.
Hierarchy of sound in ancient Hawai‘i

Archaeological studies of sound and hearing, focused on interpreting the physical remnants of past societies, are often hampered by the passage of time and the concomitant break and loss of cultural knowledge and traditions. Given the social nature of hearing, just like the other senses, this results in minimal insight into the cultural practices or associations of a society and can stymie attempts to better incorporate the significance of sound and hearing into accounts of the past. In the case of Hawai‘i, ethnohistoric literature offers a relatively rich contextual source that can illuminate contemporary understandings of how sound and hearing played a role in the past. This section delves into the ethnohistoric literature by introducing three types of sound-making instruments (voice, body, and drums) known in traditional Hawaiian practices, and recounts a traditional legend that contains several insights into the history of sound and hearing in the Hawaiian Islands.

Building largely on ethnohistoric accounts in an expansive account of Hawaiian drum dances, Elizabeth Tatar (1993, 2) suggests that the musical system of Hawai‘i reflects a “typical hierarchical organization of Hawaiian and Polynesian society.” In this scheme, various combinations of voice, body movement, and percussion combine to form a canon of cultural practice, which in turn forms a foundation for much production of sound. The presence of the body is omnipresent across these three categories, the differential having to do with how much emphasis is placed on movement itself—in other words how formalized and/or expressive body movement is. Mele hula kāʻekeʻeke is, for instance, a dance chant accompanied by two bamboo stomping tubes. The body can be used as a musical instrument—through actions such as hand clapping and foot stomping—and indeed the body is used to “play” musical instruments as well. The multisensory process of making music is yet another reminder of how integrated (and complimentary) each sensory modality is to another (e.g., sight and sound).
The hierarchical structure put forth by Tatar identifies voice, leo, as the “most important ‘instrument’ of musical performance.” Body movement, and then percussive instruments, follow voice in ranked importance. The logic is of the hierarchy is founded on the idea that both dance movement as well as percussive accompaniment support chanting, and not vice versa. Likewise, dance could be performed without percussion but not without chant (Table 23). Each “instrument” in this system can be considered more closely.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Terms/Name (Hawaiian)</th>
<th>Explanation</th>
<th>Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice</td>
<td>Leo</td>
<td>Expresses in various musical styles the various functions of chant texts</td>
<td>Most important</td>
</tr>
<tr>
<td>Body movement</td>
<td>Hula</td>
<td>Primarily expressive of the chant text</td>
<td>Second important</td>
</tr>
<tr>
<td>Percussive instruments</td>
<td>Pahu</td>
<td>“Keeping time”</td>
<td>Least important (supporting)</td>
</tr>
</tbody>
</table>

Table 23. Hierarchy of a Hawaiian musical system (after Tatar 1993, 2).

The voice is a fundamental sound. As in most other societies, in traditional Hawaiian culture it was used in the context of language (communication) as well as various kinds of expression and creativity. There are several formalized of uses of the voice in Hawaiian. Among them are mele, or chanted poetry. There were many different types of mele. Some examples are mele hanau (birth chants), mele inoa (name chants), and mele ko’ihonua (genealogy chants). As mentioned previously, dance supports chanting and it may also be accompanied by percussive instruments, thereby incorporating all three levels of musical instruments introduced above. One example of dance is the hula, which again takes a wide variety of forms that each have their own history. While mele and hula are of key significance to traditional
Hawaiian culture in certain particular forms, it is a percussive instrument and a physical object, the pahu, to which we turn now. The fact that drumming underlies other sources of sound only highlights how hearing was undoubtedly a complex and nuanced facet of many cultural endeavors in ancient Hawai‘i, especially in a ritual setting.

Pahu

This discussion of hearing in relation to heiau starts with the pahu heiau (temple drum), a shark-skin-covered wooden drum. Summarized as “a traditional Hawaiian musical instrument with an unusually rich historical and musical legacy... it was and continues to be of deep cultural significance to Hawaiians” (Tatar 1993, 1), the beating of the pahu was still talked about well into the 19th century, long after its ritualized use had faded with the abolition of the traditional kapu system. Constructed with great care, with prayers offered for each stage of their manufacture, pahu were important and revered objects for Hawaiians, surpassing characterization as an object to attain god-like status. In the Kumulipo, as translated by Lili‘uokalani (1972), pahu are born immediately following the births of the gods Kanē and Kanaloa.

The actual role of pahu in cultural practice was varied; the suggestion has been made that it started as a signaling device for religious contexts before being adopted as a musical instrument. The use of the pahu as a forms of signaling or indication (ho‘ailona) referenced in the ethnohistoric literature include the birth or death of a chief, the return of a son, or as a sign of sacrifice (Kamakau 1992a). Emerson writes that, “The drum, pahu or pahu-hula, of which there were various kinds, seems to have been used originally in religious ceremonies. Its use as an accompaniment to the hula was probably a later adaptation” (Emerson 1893, 24). There appear to have been two basic patterns of beating, one where the drum is
beaten fairly evenly in single beats the other beaten in rapid even beats resembling a “roll” (Tatar 1993). More specific communications may have also occurred, as is indicated by this passage: “It is claimed that the priests could send aerial messages by peculiar beats as the kapa beaters certainly did, but in neither case do we know the code. (Bringham n.d. Ms., 177 in Tatar 1993, 95).

The flexibility of the pahu to be used as both a signaling device and a musical instrument appears to be unique. Another signaling device, the conch shell (pū or maleonui), is not known to have been adapted in such a way. Pahu appear to have been distinctive in other manners as well, namely their close association with humans and gods as indicated by their presence in the Kumulipo. Although objects, they often carried names (e.g., La‘amaikaikahihi is associated with the pahu Hāwea and ‘Opuku) and traced in genealogies as well. Emanating from the “mouth” of the drum, multiple references associate drumming not with manufactured sound but with voice itself, as if a chant dwelled “within” the drumming (Kamakau 1992a). Pahu, as a device of the gods, were closely associated with the king as well, even used at times in place of his voice. John Papa ʻĪʻī (1959, 35) writes, “It was also said that the drums were sounded in the Pale Pahu when the king did not utter the ‘amama prayer.”

Ethnohistoric sources regarding the pahu, and more specifically the pahu heiau, retained the traditional terminology developed alongside Hawaiian drums and drumming. These terms are insightful not only for better developing a better understanding of how sound and its creation through drumming was conceived, understood, and verbalized, but also for how it related to other senses and how it was utilized. Table 24 highlights the sensory references contained within a variety of historic and ethnohistoric sources for drumming, adapted from a compilation by Tatar (1993, 5).
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Source</th>
<th>Sense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoaka</td>
<td>The crescent of the new moon. The arch or lintel over a door. <em>Brightness, shining</em> [Aka. The shadow of a person.]</td>
<td>Andrews 1865</td>
<td>Sight</td>
</tr>
<tr>
<td>Kāʻeke</td>
<td><em>To beat the drum.</em> Drum beating; the skill of drumming. He poe Akamai i ke kaeke.</td>
<td>Andrews 1865</td>
<td>Hearing, touch</td>
</tr>
<tr>
<td></td>
<td><em>To beat the drum.</em></td>
<td>J. S. Emerson n.d.</td>
<td>Hearing, touch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ms. :HEN:1:660-671</td>
<td></td>
</tr>
<tr>
<td>Kāʻekeʻeke</td>
<td><em>To beat or play the drum,</em> as in ancient times; e pai pahu, e hookanikani. A kind of drum made of the cocoanut tree. <em>The art of drumming.</em> Oia ka wa i laha mai ai ke kaekeeke.</td>
<td>Andrews 1865</td>
<td>Hearing, touch</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
<td>Reference</td>
<td>Type</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Kāʻekeʻeke</td>
<td>A single division of the long-jointed bamboo in indigenous to Hawaii, which was left open at one end. The joints... were of different sizes and lengths, thus producing <em>tones of various pitch</em>.</td>
<td>N. B. Emerson 1965[1909]:122</td>
<td>Hearing</td>
</tr>
<tr>
<td>Pahu</td>
<td>A barrel, cask, box, chest, etc. Note—A pahu was originally a hollow cocoanut [sic] or other tree with a shark skin drawn over one end and used for a drum; hence anything hollow and <em>giving a sound when struck</em> is a pahu.</td>
<td>Andrews 1865</td>
<td>Hearing, touch</td>
</tr>
<tr>
<td></td>
<td>The wooden kettle drum...of varying sizes from about a foot high is said to <em>have been beaten with the first or open hand, not with a stick</em>.</td>
<td>Roberts 1926:50</td>
<td>Touch</td>
</tr>
<tr>
<td>Pahu kanaloa</td>
<td>Prayer drum (perhaps from pahu kala loa, drum <em>proclaiming to a distance</em>).</td>
<td>Pukui and Elbert 1986</td>
<td>Hearing</td>
</tr>
<tr>
<td>Pahu kani</td>
<td>Drum. Lit., <em>sounding drum</em>.</td>
<td>Pukui and Elbert 1986</td>
<td>Hearing</td>
</tr>
<tr>
<td>Pahu kapu</td>
<td>The drum used in the heiau was <em>large and tall.</em></td>
<td>Pukui 1936 Ms.</td>
<td>Sight</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------------------------------------</td>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Pahu pa‘i</td>
<td>A drum for <em>beating at a hula</em>; o ka ili mano, he mea ia e hana ia ia pahupai.</td>
<td>Andrews 1865</td>
<td>Hearing, touch</td>
</tr>
<tr>
<td>Pūniu</td>
<td>The shell of a cocoanut [sic]; <em>to spin as a top.</em></td>
<td>Andrews 1865</td>
<td>Touch</td>
</tr>
<tr>
<td>Pūniu (hula)</td>
<td>Dance with <em>rattle-gourd</em> accompaniment (ulili).</td>
<td>Fornander 1916-1920:4:2-3</td>
<td>Hearing</td>
</tr>
<tr>
<td>Pūniu</td>
<td>The coconut drum, or puniu, the second type of <em>vibrating membrane</em>, was the snare drum of the Hawaiians.</td>
<td>Roberts 1926:50</td>
<td>Hearing, touch</td>
</tr>
</tbody>
</table>

*Table 24. Sensory references in Hawaiian terms for drums and drum accessories (originally compiled by Tatar 1993:5, emphasis added to denote sensory references).*

**The legend of Laʻamaikahiki**

The powerful history and presence behind sound and hearing in traditional Hawaiian society is reflected in another ethnohistoric account, the legend of Laʻamaikahiki. Recorded by multiple sources (in Hawaiian, translated variously to English), the legend is rife with references to the senses in general but holds special insight into the realm of sound and hearing specifically as it offers an account of how the drum was introduced to Hawaiʻi. The English version presented here a
When La’a from Tahiti came, here are the people who came with him—Kaikaikupolo the kahuna [priest], Kukeaoho’omihamiha the stargazer, Lukaukapawa the land expert [who advised where to build], Kupa the [temple] drum beater and Naula the prophet. Forty men handled the canoe. When they arrived, Hawai‘i was seen on the south side and the prow of the canoe passed by the windward [Koʻolau] side of Maui and the windward side of Moloka‘i as the drum was sounding over the ocean. A certain man named Haikamalama lived in Hanauma [O‘ahu], and he heard this thing sounding over the ocean, and it excited him. What is this strange thing, the voice of the sounding drum, the chanting voice made by beating of the drum. Then, Haikamalama imitated [the beats] by beating on his chest with the tips of his fingers. “E kai-e-kai-kupo-lo [the name of the kahuna on board]. E La’a, drumming on the ocean.” When the chanting and drumming stopped, Haikamalama knew all of it. The sounding [of the drum continued] on the sea on the Koʻolau side. And so Haikamalama ran as far as Makapu‘u [Point], and saw it [the canoe] sailing on the ocean. For that reason this one [he] ran upland as the canoe entered at Kawahaokamanō, this meaning that the canoe landed at Kāne‘ohe in Koʻolaupoko [district]. When the canoe anchored at Waihaukalua, this one [Haikamalama] stayed upland, beating with his fingers and chanting along with the chanting of Kupa...

When the canoes landed, kau-kau-kahe-le-ʻou-ʻou [sounded] the voice of the drum, ‘Opuku. La’a said, “Is this thing, the pahu kā’eke, known in your land?” “Yes. And the children and women know it.” Haikamalama was not telling the truth, but he really wanted to know how to play the pahu.

When he entered the homes of the local residents, he attached a shark-skin to a wooden container and placed this in
front of La‘a, and La‘a saw it was true. At Kualoa in Ko‘olaupoko is
the place where La‘a lived, and because of where he came from,
from Tahiti, he is called by the name La‘amaikahiki.

While other sources of the legend offer differing accounts, some even placing
the origin of the drum in Hawai‘i in association with other people and not abroad
with La‘a (see Emerson 1893), irregardless of its precise origin the tale establishes
the immediate impression that the instrument made across the islands with its
appearance. The transmittable power of La‘a or any other character would appear
to rest, at least in part, in an ability to produce and incorporate novel practices—
often relying on sensory characteristics to do so—into existing norms. The
manifestation of a unique sound alone—the beating of the pahu while approaching
O‘ahu—immediately had a significant effect, exciting an individual (Haikamalama),
transmitting knowledge (learning the beat of the drums), and taking action
(following the canoe from the Ka‘iwi coast over to Nāoneala‘a in Kāne‘ohe). In this
way, the beat of the pahu exhibits not only the potential to gather power and spark
action from sound alone, but also speaks to the social potential of the senses at
large.

Pahu heiau

With sound closely integrated into the ritual life of ancient Hawai‘i, one of the
most poignant settings for the creation of sounds—and for the experience of
hearing—was that of a heiau. Given their history, nature, and application to the
purposes of both signaling and ritual, the significance of pahu to heiau is
foreseeable. Rather than being a universal feature, however, certain heiau appear to
have been associated with drumming. More often than not, heiau associated with
drumming were places of the highest status, including luakini heiau, which featured
a specific and dedicated superstructure—the hale pahu. Kamakau (1976, 138)
writes that, “The hale pahu, drum house, was the house where the kahunas did their work; in it were the large and small pahu drums to give pleasure [to the gods], and there the god keepers, ka poʻe paʻa akua, recited formal prayers, kuili, all night long, and called to the gods to the constant beating of the drums, from evening until the bright light of morning.”

Certain rites associated with luakini heiau were closely connected to the presence, or absence, of sound. During the consecration of a luakini heiau—a notoriously onerous process—the ultimate service, the aha, hinges on silence or the absence of sound. Malo (1951, 170) describes the time in particular, “That evening all the people, commoners and chiefs, made themselves ready to pray to their own special gods for the success of the service, the aha, which was to be solemnized that night, being continued until morning. The special burden of their prayers was that it might not rain that night, that there might be no wind or thunder or lightning, that there might be no heavy surf, that no fire should burn, that there should be no sound or outcry from voice of man or beast that whole night until day; for thus would the conduct of the service be perfect. This was the character of the luakini service from ancient times down.”

While the connection between pahu and heiau has been only lightly explored in archaeology, it has been noted since the early days of research. Stokes (1991, 39) brings up the topic of sound in his book about heiau, in reference to informants on the island of Hawaiʻi who—unrelated to any particular heiau—recall beliefs about hearing the beating of the drums during a specific night of the month:

The most persistent survival from kapu times is the belief that the temple drums can be heard beating on the night of Kāne (the 27th of the month by the native calendar). Most of the natives questioned had either heard the drumming or believed that it could be heard. A variation of the account was that the beats could be heard every night but louder on the night of Kāne. The sounds were believed to arise only from the temples for human sacrifice.
The drumming cannot be heard when fully awake, the natives say, but only in the period of drowsiness as they are passing off to sleep. The beats are very distinct but, on becoming fully awake, cannot be heard. When one falls to sleep again, the beats are repeated, and so on. The sounds are described as several heavy, single beats of a drum at intervals of a second, alternating with a few lighter, quicker taps. I met one native who refused to believe they were drum beats, believing instead that they were caused by waves striking in the lava tunnels along the coast. This is one explanation, and I would also suggest heartbeats.

According to Tatar (1993, 33), Puʻukoholā is specifically associated with drumming (the source of this association is not specified) although no specific, named pahu are known for the heiau. While one cannot assume a static practice across time (nor even for various places at the same time), the concrete details—such as the history and insights into the tradition of drumming—that are available are of great value for contextualizing insights that are accessible in the archaeological record. It is clear that sound, and hearing, was an important component of Puʻukoholā heiau as well as many similar places across the archipelago. We now turn to a series of multisensory experiments that begin to explore how Puʻukoholā heiau interacts with sound, and aim to consider the result of such conditions upon the human sense of hearing in the past, present, and future.

**Multisensory survey (hearing)**

To address the sensory modality of sound, the multisensory survey conducted for this research carried out two hearing-focused experiments at Puʻukoholā heiau: archaeoacoustics and soundscape. Together, these sensory experiments aim to build a broader understanding of the way that hearing is, has
been, and should continue to be a significant aspect of the natural and social place of Pu‘ukoholā heiau.

**Archaeoacoustics**

The presence of sound in human life is ubiquitous, and plays a continual, central role in the core functions of every society. Although the past was filled with sound, the discipline of archaeology was largely founded on the analysis of physical and visual artifacts, a dynamic which has led to less attention being paid to the auditory aspects of ancient societies until relatively recently. The realization that special sounds are associated with sacred spaces (Eneix and Zubrow 2014), along with the fact that built environments impact sound, at times modifying its properties in novel ways, has stimulated a new wave of research. These observations and the broader study of sounds in prehistoric contexts have led archaeologists to suggest that—among other possible functions—certain places constructed in the past were explicitly meant “to be heard” (Devereux 1996; Watson and Keating 1999). This attention to sound is not confined to human activities taking place in built structures either, natural places and phenomena are also thought to have been incorporated through their aural effects (Holmberg 2012; Loose 2008). Thus, sound and hearing is an important aspect of how people arranged, organized, negotiated, and experienced the physical and social environments of the past.

As introduced above, the ritual setting is an area of particular interest for archaeologists as far as sounds and hearing are concerned. Ritual activity often incorporates instruments (voice, bells, drums, whistles, etc.) into its practices. Observable in contemporary practices worldwide and indicated in archaeological assemblages that contain sound-producing instruments, it is not uncommon for particular sounds to become focal and temporal elements of ritual practice, and particular sounds, like colors and other stimuli, have great potential to become
integrated into structures of hierarchy and power (Hosler 1994). While the sensory aspects of rituals and activities are widely acknowledged and ethnographically linked to certain objects in specific cultural contexts, research into the architectural record—the very settings of such “great sensory assault” as described of the Aztecs by Clendinnen (1991, 258)—has been minimal in terms of reckoning with its placement.

Set in the ritual centers of past societies, sounds are part of a greater sensory synaesthesia, which—entangled with the other senses—have the potential to make direct physiological impacts upon people. Hearing, for instance, holds the possibility that certain frequencies might specifically affect regional brain activity. The study of acoustics at archaeological sites has not only enjoyed increased disciplinary attention as of late—it has also been buoyed by the digital revolution of the past several decades. Melting together “music archaeology” (which was limited largely to analog activities) and acoustics brought around a distinct endeavor, now referred to as archaeoacoustics (Till 2014, 24). The advent of digital recorders and portable electronic technology, along with the corresponding increase in quality of sound production equipment (and access to it), has resulted in a level of accessibility and possibility for fieldwork that did not previously exist. Early efforts in archaeoacoustics were made at Stonehenge when the dynamics between sound, music, and architecture were first considered at the megalith site (Watson and Keating 1999). One of the primary realizations from the research was that all buildings (and in particular stone buildings) have a specific acoustic characteristic and that, like the manner in which Stonehenge was found to interact with sound, these dynamics are accessible for study. The need to address the phenomenon, it followed, was based on how the acoustics of a place permeate and characterize any activities, a dynamic that is especially relevant to formalized ritual practices.

The attention of other archaeologists has made additional progress in better documenting and understanding the interplay between acoustic space and ancient societies, many of whom participated in a conference at the MacDonald Institute at
Cambridge University (Lawson and Scarre 2006). With a wide variety of work undertaken, such as that of Devereux (2002) on lithophones, prehistoric stone circles, and chamber tombs, Reznikoff (2008) on cave acoustics (resonance in particular) in relation to cave paintings, and Waller (1999) on acoustics and rock art (echos in particular). The importance of sound at the household level has also been initiated (King and Sánchez Santiago 2011), while Cook et al. (2008) suggest that a certain range of frequencies, 90-130 Hz, may affect the prefrontal activity of humans. Their results suggested that a specific frequency, 110-112 Hz, results in lower activity in the left temporal region of the brain along with a pattern of asymmetric activity over the prefrontal cortex (shifting to right-sided dominance at 110 Hz). They interpret these data to be compatible with a “relative deactivation of language centers and a shift in prefrontal activity that may be related to emotional processing.” Debertolis and Bisconti (2013, 813) pursued this idea through fieldwork in Maltese temples, demonstrating the resonant qualities of particular architectural spaces and arguing that they had potential to “effect the emotional sphere of human consciousness” for those who may have interacted within.

**Background**

While ethnohistoric records as well as contemporary practitioners highlight the general significance of sound in traditional Hawaiian ritual practices, the ways that heiau – the ritual centers of the built environment and a focal point of the archaeological record in Hawai’i – might affect sound has yet to be systematically addressed. The archaeoacoustic analysis conducted at Puʻukoholā heiau sought to develop several initial, basic questions with respect to the properties of sound and the archaeological remnants of ancient Hawaiian ritual architecture.

The design of the archaeoacoustic activities sought to examine the acoustic properties of the architectural foundations of Puʻukoholā heiau in two ways. First, the structure was considered as a sound projection device. In other words, when
sound originates from within the heiau, where can it be heard (and where can it be heard the loudest)? Second, the structure was examined as a sound collection device. When sound originates from locations outside the heiau, what can be heard from within (and from what areas from outside the heiau can sounds be heard the loudest from within)?

The experiments inform the consideration of how human ritual activities that involved sound were linked to the immediate and surrounding environs. What is the acoustic “footprint” of the structure? What areas within the landscape are effective for their hearing or projecting sounds? What areas within the structure itself are effective for hearing or projecting sounds? In conjunction with establishing degrees of acoustic interplay between projection and collection points, data addressing the energy and attenuation of sound signals were also captured in order to monitor sound decay, whether moving outward from, or inward toward, the structure. The final question concerns this type of decay and asks—in anticipation of the process not being uniform (as it would be expected in a flat, featureless, environment)—how does the landscape and built environment of Puʻukoholā heiau impact acoustic dynamics in terms of the energy and directionality of signals?

Methods

Given the questions outlined above, the archaeoacoustic survey consisted of four interrelated experiments. Two experiments were designed to address the projection of sound from Puʻukoholā heiau, while the other two were designed to address the collection of sound at the heiau. Given the basic nature of the research questions, the research design used a comparative approach by duplicating sound projection and collection data collection in two environments: Puʻukoholā heiau itself, and an architecturally featureless and topographically constant area nearby.
By collecting data for both the projection and collection of sound in these two environments, the interpretation of each was enhanced.

The design and methods chosen for the experiment were also driven by the cultural sensitivity of Pu'ukoholā heiau. First, in addition to obtaining standard National Park Service permits (Application for Permit for Archaeological Investigations), special permission was obtained from the cultural authority of Pu'ukoholā heiau—Kahuna Nui Kaponoai Molitau—to enter its precincts for the express purpose of projecting and recording sound. While various approaches were discussed with the Kahuna Nui, ultimately two separate sounds were selected for broadcasting and recording between projection and collection points of the archeoacoustic survey. These were a steady tone and a frequency range sweep (sine sweep). The steady tone was set to 100.0 Hz with a gain of 0 and was broadcast for a duration of approximately six seconds. The frequency range sweep covered a range of 20.0 to 10,000 Hz over a duration of eight seconds. Ultimately, the frequency range sweep proved most suitable for analysis.

While tones and sweeps were decided to be the most appropriate type of sound to broadcast from within and across the precincts of the heiau for the purposes of an archaeoacoustic study, other types of sound might be appropriate depending on various circumstances. The projection of voice, of drums, or of other instrumentation could offer distinct opportunities depending on the intent of those designing and conducting the work in addition to its eventual audience. Recordings, or live performances, are both possibilities.
Projected sound was produced using a tripod-mounted Samsung DA-FM61C Bluetooth Wireless Portable Speaker mounted on a tripod at a height of approximately 1.5 meters above the ground surface (Figure 35). The Samsung speaker was paired with an Apple iPhone 5s. A signal generator application was used to generate the constant tone as well as the frequency range sweep. The output level for both the speaker and the phone were set at a constant and checked between every point.
Audio recordings were made using an Olympus Linear PCM Recorder (WS-802) set to PCM 44.1k in the Waveform Audio File Format (WAVE, .wav). The recorder was also mounted on a tripod at a height of approximately 1.5 m (Figure 36). A wind guard was used to shield its dual microphones for all recordings.
The digital audio files captured by the Collection Station were analyzed using Raven Pro 1.4 on an Apple MacBook Pro 2.5GHz Intel Core i7 with 16 GB 1600 MHz DDR3. Raven Pro is a software program for the acquisition, visualization, measurement, and analysis of sounds. The format of the files analyzed were: WAVE, 2 Channels, Sample Rate 44100 Hz, 16-bit signed. The software was used to generate two views of every soundfile: waveform and spectrogram (Figure 37).
Based on initial analysis, the frequency sweeps were identified to be the most useful field recording made for the purpose of answering the research questions. Using the spectrogram from each file, the approximately eight second frequency sweep was isolated for analysis (Figure 38). This selection was then saved as a 16-bit wave file and exported as a png view (to include both the spectrogram as well as the waveform views). These views were then evaluated and compared for degrees of amplitude and intactness of the signal (black/white) across the frequency range (kHz) and through time.
Figure 38. Exploded view of isolated frequency sweep from example sound collection file.

Two data collection groups were established within the study area (Figure 39). The “control” or landform group was established on a transect across undeveloped land, while the “test” or architecture group was placed on a transect that crossed both Pu‘ukoholā and Mailekini heiau. All data points were placed and analyzed relative to one of these two groups, with the test group also including a number of points located within the interior space of Pu‘ukoholā heiau.

These transects also differ in that the control group is placed across an area that is separate from the contemporary cultural activities that are conducted in relation to the heiau, whereas the test group crosses multiple areas of activity including 1) the interior of Pu‘ukoholā heiau; and 2) a large cleared area to the west (makai) of Pu‘ukoholā heiau commonly occupied by audiences and participants at certain times (e.g., the annual Ho‘oku‘ikahi event).

Environmental conditions remained relatively consistent throughout the experiments, with surface temperatures of approximately 80 degrees Fahrenheit,
approximately 73% humidity, and variable winds from the northeast between 5-10 miles per hour.

Figure 39. Sample of data points, placed relative to two data collection groups ("control" transect and "test" transect marked by the lower and upper blue lines, respectively).

Results and discussion

A total of 61 locations (points) were assessed during four interrelated survey experiments conducted, evaluating how they received (collection) or dispersed sound (projection) (Table 25). A summary of, and results for, each experiment are presented below. See Appendix D for the spectrograms from every collection point.
<table>
<thead>
<tr>
<th>Experiment No.</th>
<th>Number of Points</th>
<th>Type</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>Sound Projection</td>
<td>Landscape</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>Sound Projection</td>
<td>Architecture</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>Sound Collection</td>
<td>Architecture</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>Sound Collection</td>
<td>Landscape</td>
</tr>
</tbody>
</table>

Table 25. Experiments comprising the archaeoacoustic survey.

Experiment No. 1

Sound was projected across architecturally featureless, topographically constant terrain from a fixed point of origin (sound origin, SO). The projection station was moved to variable distances (collection points, CP) in line with a generally east/west (mountain/ocean) orientation (253 degrees magnetic) both in front of and behind the projection station (Figure 40). Collection point attributes are displayed in Table 26.
Figure 40. Distribution of projection station (SO) and collection points (CP) for Experiment No. 1.

<table>
<thead>
<tr>
<th>Collection point</th>
<th>Distance to projection station (m)</th>
<th>Direction to sound origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>111</td>
<td>West</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
<td>West</td>
</tr>
<tr>
<td>3</td>
<td>78</td>
<td>West</td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>West</td>
</tr>
<tr>
<td>5</td>
<td>34</td>
<td>West</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>West</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>West</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>East</td>
</tr>
<tr>
<td>9</td>
<td>22</td>
<td>East</td>
</tr>
<tr>
<td>10</td>
<td>44</td>
<td>East</td>
</tr>
<tr>
<td>11</td>
<td>60</td>
<td>East</td>
</tr>
</tbody>
</table>

Table 26. Collection points and their distances and directions to the projection station in Experiment No. 1.
Experiment No. 2

Sound was projected from Puʻukoholā heiau across the surrounding environs. The collection station was moved to variable distances in line with a generally east/west (mountain/ocean) orientation (253 degrees magnetic) both in front of and behind the projection station, and to both interior and exterior of the heiau (Figure 41). Collection point attributes are displayed in Table 27.

Figure 41. Distribution of projection station (SO) and collection points (CP) for Experiment No. 2.
<table>
<thead>
<tr>
<th>Collection point</th>
<th>Distance to projection station (m)</th>
<th>Interior/Exterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>15</td>
<td>Interior</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Interior</td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>Interior</td>
</tr>
<tr>
<td>4</td>
<td>37</td>
<td>Interior</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>Interior</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>Interior</td>
</tr>
<tr>
<td>7</td>
<td>165</td>
<td>Exterior</td>
</tr>
<tr>
<td>8</td>
<td>139</td>
<td>Exterior</td>
</tr>
<tr>
<td>9</td>
<td>123</td>
<td>Exterior</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>Exterior</td>
</tr>
<tr>
<td>11</td>
<td>77</td>
<td>Exterior</td>
</tr>
<tr>
<td>12</td>
<td>49</td>
<td>Exterior</td>
</tr>
<tr>
<td>13</td>
<td>32</td>
<td>Exterior</td>
</tr>
<tr>
<td>14</td>
<td>25</td>
<td>Exterior</td>
</tr>
<tr>
<td>15</td>
<td>28</td>
<td>Exterior</td>
</tr>
<tr>
<td>16</td>
<td>20</td>
<td>Exterior</td>
</tr>
<tr>
<td>17</td>
<td>32</td>
<td>Exterior</td>
</tr>
<tr>
<td>18</td>
<td>60</td>
<td>Exterior</td>
</tr>
<tr>
<td>19</td>
<td>88</td>
<td>Exterior</td>
</tr>
<tr>
<td>20</td>
<td>120</td>
<td>Exterior</td>
</tr>
</tbody>
</table>

Table 27. Collection points and their distances and directions to the projection station in Experiment No. 2.

Experiment No. 3

Sound was collected from within Pu‘ukoholā heiau. The projection station was moved to variable distances in line with a generally east/west (mountain/ocean) orientation (253 degrees magnetic) both in front of and behind
the collection station (Figure 42). Projection point attributes are displayed in Table 28.

![Figure 42. Distribution of collection point and projection points (PP) for Experiment No. 3.](image)

<table>
<thead>
<tr>
<th>Projection point (PP)</th>
<th>Description</th>
<th>Distance from collection point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NE, inside heiau</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Approximate center of interior platform</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>SE corner, inside heiau</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>SW corner, inside heiau</td>
<td>38</td>
</tr>
<tr>
<td>5</td>
<td>W edge inside</td>
<td>12</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Distance</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>6</td>
<td>NW corner, inside heiau</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>Shoreline</td>
<td>163</td>
</tr>
<tr>
<td>8</td>
<td>Between shore and Mailekini</td>
<td>133</td>
</tr>
<tr>
<td>9</td>
<td>Between shore and Mailekini</td>
<td>117</td>
</tr>
<tr>
<td>10</td>
<td>Between shore and Mailekini</td>
<td>94</td>
</tr>
<tr>
<td>11</td>
<td>Between Mailekini and Pu‘ukoholā</td>
<td>67</td>
</tr>
<tr>
<td>12</td>
<td>Between Mailekini and Pu‘ukoholā</td>
<td>44</td>
</tr>
<tr>
<td>13</td>
<td>Between Mailekini and Pu‘ukoholā</td>
<td>26</td>
</tr>
<tr>
<td>14</td>
<td>Between Mailekini and Pu‘ukoholā</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>Base of steps leading into Pu‘ukoholā</td>
<td>24</td>
</tr>
<tr>
<td>16</td>
<td>East of Pu‘ukoholā</td>
<td>22</td>
</tr>
<tr>
<td>17</td>
<td>East of Pu‘ukoholā</td>
<td>38</td>
</tr>
<tr>
<td>18</td>
<td>East of Pu‘ukoholā</td>
<td>65</td>
</tr>
<tr>
<td>19</td>
<td>East of Pu‘ukoholā</td>
<td>93</td>
</tr>
</tbody>
</table>

Table 28. Projection Points with their description and distances to the collection point in Experiment No. 3.
Experiment No. 4

Sound was collected on architecturally featureless, topographically constant terrain from a fixed point. The projection station was moved to variable distances in line with a generally east/west (mountain/ocean) orientation (253 degrees magnetic) both in front of and behind the collection station (Figure 43). Projection point attributes are displayed in Table 29.

Figure 43. Distribution of collection point and projection points (PP) for Experiment No. 4.
## Table 29. Projection Points and their distances and directions to the collection point in Experiment No. 4.

<table>
<thead>
<tr>
<th>Point</th>
<th>Distance</th>
<th>Direction to collection point</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP1</td>
<td>113</td>
<td>East</td>
</tr>
<tr>
<td>2</td>
<td>101</td>
<td>East</td>
</tr>
<tr>
<td>3</td>
<td>77</td>
<td>East</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>East</td>
</tr>
<tr>
<td>5</td>
<td>43</td>
<td>East</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>East</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>East</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>West</td>
</tr>
<tr>
<td>9</td>
<td>22</td>
<td>West</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>West</td>
</tr>
<tr>
<td>11</td>
<td>59</td>
<td>West</td>
</tr>
</tbody>
</table>

Conducted on relatively flat, featureless land southeast of Pu’ukoholā heiau, Experiment No. 1 set a useful baseline for the interpretation of subsequent datasets. Several key observations were made based on data collected during the first experiment, including: 1) the directionality of the sound created by the projection station; and 2) the rate of attenuation of the signal as distance increased between its projection and collection sources (Figures 44 and 45).

The sound created by the projection station was confirmed to be directional, meaning that the intensity of the signal captured by the collection station when placed in front of the projection station was greater than when placed—at a similar distance—behind it. This was anticipated, as the speaker of the projection station was intentionally oriented in a specific direction (approximately 253 degrees magnetic). The confirmation of the effect was helpful, however, as the
intensity/distance relationships between various collection points in front of and to the rear of the sound source informed the subsequent experiments as the orientation of the projection station speaker was consistently maintained.

Figure 44. Experiment #1. Collection Point 5 (left), placed approximately 34 meters in front of the Projection Station and Collection Point 9 (right) approximately 22 meters to the rear. The blue arrow indicates the direction of sound projection.
Figure 45. Comparison of waveforms and spectrograms from Experiment No. 1, CP5 (left) and CP9 (right). Note the greater intensity of the frequency sweep signal (represented by the darker line) in CP5 spectrogram, despite being twelve meters more distant from the Projection Station than CP9.

Given Stokes’ law of sound attenuation, the amplitude of the projected signals was expected to decrease exponentially with distance traveled. Experiment No. 1 generally confirmed this, with the exception of points affected by the directionality of the projection station. It is noted, however, that because the generation of waveforms and spectrograms renders intensity across frequencies visually and not numerically, a regression of amplitude is assumed to be present but the documentation of an explicitly exponential decrease was not an objective of the research design. The persistence of the signal at distance, however, was consistent with exponential decay and encouraged further testing using these methods.

Conducted within and around Puʻukoholā heiau, the second experiment generated a dataset comparable to that produced by the first experiment but in the context of a heavily modified, built archaeological setting (Figure 46). The signals collected by the interior and exterior stations suggest that the architectural landscape affects the attenuation of sound through factors other than distance, modifying the acoustic environment both inside and outside the temple. Inside the structure there is an indication of a possible “hot spot,” an area where audible sounds are more intense compared to elsewhere. Outside the structure several
“dead zones,” spaces where sounds may to be suppressed, appear to exist within the landscape as well as “remote collectors,” spatially distant locations that may collect sounds originating from the heiau better than their proximate surroundings.

In order to collect a subset of data addressing sound within the interior of the structure, six collection stations were set up within Puʻukoholā heiau (in addition to a long, generally east/west transect extending beyond the structure) with a projection station placed at the approximate center of the large, low interior platform in the northern half of the structure with its speaker oriented, again, at a bearing of approximately 253 degrees magnetic. The placement of the stations ranged from 6 m distant from the source (CP2) to 37 m distant (CP4).

Figure 46. During Experiment No. 2, six collection stations were placed within Puʻukoholā heiau and the projection station was placed centrally on a raised terrace in the northern half of the structure. The blue arrow indicates the direction of sound projection.
Distance between projection and collection points appears to be a mediocre indicator of sound integrity and intensity within the structure in Experiment No. 2. The collector that measured the most intense signal was CP5, situated somewhat centrally atop the far western edge of Pu‘ukoholā’s structural interior (and roughly in line with the orientation of the speaker). The second most intense signal was CP2, located somewhat centrally at the interior base of the western wall. CP1, in the northeastern interior corner, was third, followed by CP4 at the southwest interior platform edge. CP6, significantly closer to the projection station than CP3, measured a slightly more intense signal (Table 31). The waveforms clearly distinguish the difference between areas within the structure in terms of natural exposure; the presence of wind interference is evident in the data from collection points located along the western edge of the structure, and protection against the wind for collection points along the interior edge of the structure is equally reflected. Given that the projection station was oriented westward and leeward, however, the intensity and integrity of the interior collection points (CP 2 and 1) indicate that sounds may be better preserved against the base of the high backing wall of the heiau as compared to the outer (western) edge (Figure 47).

<table>
<thead>
<tr>
<th>Intensity Rank</th>
<th>Distance (m)</th>
<th>CP and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>5, west interior platform edge</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>2, east interior wall base</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>1, northeast interior wall base</td>
</tr>
<tr>
<td>4</td>
<td>37</td>
<td>4, southwest interior platform edge</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>6, northwest interior platform edge</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>3, southeast interior wall base</td>
</tr>
</tbody>
</table>

Table 30. Ranking of Experiment No. 2 collection points by sound intensity.
Figure 47. Waveform and spectrograms from collection points located in the interior space of Puʻukoholā heiau during Experiment No. 2. Clockwise, from top right: CP1, CP2, CP3, CP4, CP5, CP6.

Experiment No. 2 also exhibited results inconsistent with the expectations set by Stokes’ law of sound attenuation and the characteristics of exponential decay. No sound was detectable on the coast (Figure 48), but the signal became audible once slightly inshore (Figure 49)(165 m vs 139 m). Sound was constantly detectable over the effective middle range distance, up until Mailekini heiau, at which point a “dead zone” commenced (Figure 50). Within this dead zone, very little sound from Puʻukoholā was detectable. Based on these limited results, it appears that
Pu‘ukoholā projects sound outward a relatively long distance, but is acoustically muffled when it comes to projecting into its immediate environs. The same appears to be true on the windward side of the structure, where very little or no sound is detectable when standing against the wall on the exterior edge of the heiau, but sound is once again detectable a relatively long distance away. It is noted that although the effect is similar on both leeward and windward sides, it is less pronounced to windward, the likely the result of both the projection station orientation as well as possibly the architectural design of the structure and its structural exposure towards the coast. To the north, sound appeared to be effectively blocked but only one measurement was made, directly outside the heiau at the base of the steps.

![Figure 48. Experiment No. 2, CP7 (165 m west of source, on coast) with no detectable signal.](image)
Figure 49. Experiment No. 2, CP9 (123 m west of source) with clearly detectable signal.

Figure 50. Experiment No. 2, CP11 (77 m west of source, eastern exterior edge of Mailekini heiau) with faintly detectable signal.
In Experiment No. 3, an indication of being able to hear over great distances while stationed within the heiau was detected. Whereas when sound was projected from within Pu’ukoholā during Experiment No. 2 to a position on the coast and was inaudible, it was clearly audible during Experiment No. 3 when projected from approximately the same position on coast to the heiau (Figure 51). Also similar to the dynamics indicated by Experiment No. 2, as the projection point moved inland toward the heiau the audibility of the signal dropped off in the vicinity of Mailekini heiau (Figure 52).

Figure 51. Experiment No. 3, PP7 (projected from 163 m west of collector on coastline to heiau).
In sum, the findings of the archaeoacoustic experiments indicate that both the interior and exterior settings of Pu'ukoholā heiau may have unique auditory properties. Finer-grained acoustic investigations could better define these properties, while historical and cultural engagement with the topic of hearing in the context of a luakini heiau could further affirm the significance of what is heard and what is silenced.

**Soundscape**

Drawing on the physical characteristics of ambient sound, soundscape studies aim to identify and analyze the audible environment of a study area. Following the terminology of soundscape ecology, three main sources of sound can be identified – biophony (animals), geophony (environment), and anthropophony (human) (Villanueva-Rivera et al. 2011). By establishing baseline data for these
three sources, further questions regarding the characteristics and significance of sounds present in a study area can be advanced, offering unique insights into the natural and cultural dynamics of a place. On a fundamental level, soundscapes are recognized as both natural and cultural resources. This recognition is the result of how they offer benefits to people as well as to other species. Dumyahn and Pijanowski (2011, 1331) identify five soundscapes values and their associated benefits, including human health and wellbeing, wildlife impacts, sense of place, landscape interactions, and ecological integrity values (Table 31).

<table>
<thead>
<tr>
<th>Soundscape values</th>
<th>Associated benefits from soundscapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human wellbeing</td>
<td>Improved human health and welfare, reduced stress, improved quality of life, and equitable access to quality soundscapes</td>
</tr>
<tr>
<td>Wildlife wellbeing</td>
<td>Ability to hear predators, improved prey detection, improved vocalizing species communication, decreased stress, reduced need for vocalization modifications</td>
</tr>
<tr>
<td>Sense of place</td>
<td>Cultural, historical, and natural locations convey unique sounds that meaningfully connect humans to that place</td>
</tr>
<tr>
<td>Landscape interactions</td>
<td>Human expectations of the visual surroundings match the soundscape, increased aesthetic appreciation and evaluation of place and experience</td>
</tr>
<tr>
<td>Ecological integrity</td>
<td>Using soundscapes to monitor ecosystem function and sustainability, using biophony as an indicator of biodiversity, using soundscapes recordings to research effects of land use change</td>
</tr>
</tbody>
</table>

Table 31. Soundscape values and derived benefits of quality soundscapes (from Dumyah and Pijanowski 2011, 1331)

The field of acoustics, driven largely by advances in acoustic engineering, underpins much sound-related research. In this tradition sounds are both quantifiable and measureable. Efforts to identify, determine, and track sounds, such as the levels and effects of noise, have enjoyed broad success under the acoustic paradigm. While an acoustic perspective conceives of soundscapes as a cumulation of
sounds through the filter of location, more recently the reductionism inherent to that conceptualization has been questioned. By way of offering a complementary perspective to soundscape as a cacaphony of located, singular sounds, “an environment of sound (or sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society” has been proposed (Truax and Barrett 2011). This alternative focus on perception and interpretation intends to instill an inclusive understanding of how sound and sounds relate to places, and lead to additional questions such as how soundscapes are integrated into human societies and how that significance might be ascertained on a subjective, listener-centered basis (Schafer 1993). Perceptually-based categories include sound signals (“foreground sounds”) and keynote sounds (“background sounds”) as well as sounds that a community recognizes as culturally significant (“soundmarks”) (Truax and Barrett 2011, 1202).

Background

With a priority on documenting the architectural form of traditional structures and ensuring their physical preservation, knowledge of the auditory environments that encompasses ancient Hawaiian monumental architectural sites, such as heiau, is limited. The soundscape analysis conducted at Puʻukoholā heiau sought to 1) complete a basic survey of the types of sounds present within the study area and perform a foundational analysis of its composition; and 2) begin to consider the perceptual and cultural significance of the soundscape identified.
Methods

A series of environmental sound recordings were made at Pu‘ukoholā heiau, using a recorder centered on the platform within the interior space of the heiau (Figure 53). The recorder was mounted on a tripod at a height of approximately 1.5 m. A wind guard was used to shield its dual microphones for all recordings. Audio recordings were made using an Olympus Linear PCM Recorder (WS-802) set to PCM 44.1k in the Waveform Audio File Format (WAVE, .wav).

Figure 53. Location within Pu‘ukoholā heiau (marked by red star) where environmental soundscape recordings were collected.

Over a duration of 24 hours, near-continual recordings was made within the heiau, interrupted only to change the batteries of the recording device. The
recordings were subsequently sampled in order to obtain one uninterrupted fifteen-minute duration recording for each hour of the day, usually commencing at the top of the hour. Soundscape analysis was carried out using these 24 recordings or soundfiles. The digital audio files captured by the Collection Station were analyzed using Raven Pro 1.4 on an Apple MacBook Pro 2.5GHz Intel Core i7 with 16 GB 1600 MHz DDR3. Raven Pro is a software program for the acquisition, visualization, measurement, and analysis of sounds. The format of the files analyzed were: WAVE, 2 Channels, Sample Rate 44100 Hz, 16-bit signed. The software was used to analyze the recordings for sound events using playback and spectrograms. Aucacity is another software program for the visualization of sounds, it was used to generate frequency-amplitude plots. The soundfiles were analyzed using the SEEWAVE software tool for acoustic diversity.

Results and discussion

General characteristics of the soundscape are indicated by the distribution of frequency and amplitude within the soundfiles in relation to one another. Analysis of the soundfiles by frequency-amplitude plots identify several general trends that appear to be present within the Puʻukoholā soundscape, based on the collected samples (n=24) captured spanning two calendar days (6:00 AM, 22 March 2014 to 6:00 AM, 23 March 2014). Two different intensity peaks, manifesting at within two distinct frequency ranges, are identifiable relative to the dataset. One of these frequency-amplitude peaks is present during the daylight hours and one is present during the nighttime hours.

The frequency-amplitude peak noted during the daytime hours is defined by an increased intensity of low-frequency sounds beginning at approximately 9:00 AM, and sustained until approximately 5:00 PM. During this time, low frequency sounds (<500 Hz) maintain amplitude between -6 to -9 dB. Outside of these hours,
the amplitude drops to below -24 dB (with the exception of 12:00 AM to 1:00 AM, when it briefly climbed back up to a peak of -6 dB). Figures 54 and 55 show frequency-amplitude plots generally representative of daytime and nighttime samples; note the variation in the y-axis between the two figures and the increased amplitude of low-frequency noise at 10:00 AM versus 10:00 PM. See Appendix 5 for all frequency-amplitude plots.

Figure 54. Frequency-amplitude plot, 10:00—10:15 AM, Pu’ukoholā heiau.
The frequency-amplitude peak noted during the nighttime hours is defined by an increased intensity of 6000-8000 Hz frequency sounds beginning at approximately 7:00 PM, and sustained until no later than 6:00 AM. During this time, 6-8k Hz frequency sounds (<500 Hz) reach amplitudes of -48 db. Outside of these hours, the amplitude drops to below -75 dB.

Inspection of the soundfiles for sound events (discrete acoustic signatures) confirms a wide range of discrete events, including representative sounds from the clases of biophony, geophony, and anthrophony. While numerous discrete sound events were present across the recordings, they fall into nine specific categories (Table 32).
<table>
<thead>
<tr>
<th>Biophony</th>
<th>Geophony</th>
<th>Anthrophony</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Birdsong</td>
<td>4) Wind</td>
<td>6) Vehicular – “light”</td>
</tr>
<tr>
<td>2) Insect calls</td>
<td>5) Surf</td>
<td>7) Vehicular – “heavy”</td>
</tr>
</tbody>
</table>

Table 32. Types of sounds recorded within Pu‘ukoholā heiau, organized by phonic classes.

The soundfiles were further analyzed using the software R with the SEEWAVE tool for acoustic diversity. This analyses returns index values for both the left and right channels of each soundfile, which were tabulated (Table 34) and then plotted by time of day (Figure 56).

<table>
<thead>
<tr>
<th>Time of day</th>
<th>Left channel</th>
<th>Right channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:00</td>
<td>0.026279</td>
<td>0.257625</td>
</tr>
<tr>
<td>2:00</td>
<td>0.654998</td>
<td>0.090283</td>
</tr>
<tr>
<td>3:00</td>
<td>1.34031</td>
<td>1.372374</td>
</tr>
<tr>
<td>4:00</td>
<td>1.087</td>
<td>0.94879</td>
</tr>
<tr>
<td>5:00</td>
<td>1.123231</td>
<td>0.649638</td>
</tr>
<tr>
<td>6:00</td>
<td>0.675647</td>
<td>0.116586</td>
</tr>
<tr>
<td>7:00</td>
<td>0.303257</td>
<td>0.339053</td>
</tr>
<tr>
<td>8:00</td>
<td>0.162038</td>
<td>0.182549</td>
</tr>
<tr>
<td>9:00</td>
<td>0.244825</td>
<td>0.095545</td>
</tr>
<tr>
<td>10:00</td>
<td>0.045602</td>
<td>0.002518</td>
</tr>
<tr>
<td>11:00</td>
<td>0.025195</td>
<td>0.007792</td>
</tr>
<tr>
<td>12:00</td>
<td>0.090237</td>
<td>0.05006</td>
</tr>
<tr>
<td>13:00</td>
<td>0.001632</td>
<td>0.000309</td>
</tr>
<tr>
<td>14:00</td>
<td>0.03006</td>
<td>0.007983</td>
</tr>
<tr>
<td>15:00</td>
<td>0.035321</td>
<td>0.00454</td>
</tr>
<tr>
<td>16:00</td>
<td>0.000689</td>
<td>0.00054</td>
</tr>
<tr>
<td>Time</td>
<td>Value 1</td>
<td>Value 2</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>17:00</td>
<td>0.018483</td>
<td>0.007047</td>
</tr>
<tr>
<td>18:00</td>
<td>0.156416</td>
<td>0.076882</td>
</tr>
<tr>
<td>19:00</td>
<td>0.55271</td>
<td>0.426508</td>
</tr>
<tr>
<td>20:00</td>
<td>1.234995</td>
<td>1.163018</td>
</tr>
<tr>
<td>21:00</td>
<td>1.157852</td>
<td>1.053057</td>
</tr>
<tr>
<td>22:00</td>
<td>1.618286</td>
<td>1.538121</td>
</tr>
<tr>
<td>23:00</td>
<td>1.446817</td>
<td>1.373696</td>
</tr>
<tr>
<td>24:00:00</td>
<td>0.054474</td>
<td>0.134496</td>
</tr>
</tbody>
</table>

Table 33. Index values for acoustic diversity generated using R (SEEWAVE).

Figure 56. Acoustic diversity plotted by time of day (blue=left channel, red=right channel).
Based on the inspection of discrete sounds using spectrograms and the calculation of the acoustic diversity index using SEEWAVE, a marked contrast within the soundscape of Puʻukoholā based on diurnal and nocturnal settings—first evident in the frequency-amplitude plots—is suggested. Furthermore, the shift may be further characterized as dominated by anthrophonic sound during much of the day. Acoustic diversity appears suppressed from approximately 7:00 AM to 5:00 PM (SEEWAVE diversity index), coinciding with an increase in low-frequency sounds based on the frequency-amplitude plots. Spectrogram analysis suggests that the low frequency noise is anthrophonic in nature, derived from vehicular traffic transiting the study area on the state highway (“road noise”), as well as activity at Kawaihae harbor. It is likely that the increase in human activity (along with the lessened activity of non-human species, although birdsong is observed to be consistently present in the samples collected), effectively lowers the overall acoustic diversity index during the daytime. This is consistent with other research findings, such as “the observation that many biotic sounds, such as bird songs, are characterized by an intrinsic variability of intensities, while some types of human generated noise (such as car passing or airplane transit) present very constant intensity values” (Pieretti et al. 2011, 869). At night, acoustic diversity spikes from both 7:00 PM to 11:00 PM and again from 3:00 to 5:00 AM. Spectrogram analysis suggests that this activity is characterized by the acoustic activities of insects and reptiles.

In terms of perceptually-based categories of sound, the findings of this analysis suggest that the soundscape of Puʻukoholā heiau is most closely integrated with the industrial and trasporation activites of Kawaihae harbor, at least during the working hours of the day. The abundance of sound related to these activities, in addition to the absence of sounds related to other forms of human endeavor and the suppression of biophony, resembled what has been classed elsewhere as a “threatened soundscape” (Table 34). While the study area also exhibits characteristics of “natural quiet soundscapes” and “cultural soundscapes,” the high levels of anthrophonic activity along with visible and ongoing land use change in the
area support the assignment of the soundscape of Pu'ukoholā heiau to the threatened category.
<table>
<thead>
<tr>
<th>Soundscape type</th>
<th>Example(s)</th>
<th>Values</th>
<th>Threat(s)</th>
<th>Management goals</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural quiet soundscapes</td>
<td>Remote areas in parks, wilderness areas, volcano areas</td>
<td>Landscape interactions, experiencing solitude, sense of place, wildlife wellbeing</td>
<td>Anthrophony and biophonic invasive species that are loud</td>
<td>Protect area from human generated noise, especially low frequency sounds that can travel far or dispersed recreational noise</td>
<td>Monitor for changes in ambient sound levels</td>
</tr>
<tr>
<td>Threatened soundscapes</td>
<td>Predominantly high fidelity soundscapes that undergo increases in anthrophony, airport development, deforestation for agriculture</td>
<td>Ecological integrity, wildlife wellbeing, human wellbeing</td>
<td>Excessive noise, land use change</td>
<td>Mitigate excessive noise, improve technologies of sound producing object(s), limit additional noise pollution</td>
<td>Monitor for anthropophy and biophony levels</td>
</tr>
<tr>
<td>Cultural soundscapes</td>
<td>City markets, church bells in a small town, coastal areas with foghorns</td>
<td>Sense of place, cultural and historic values related to sounds</td>
<td>Loss of the sound generating objects (foghorns, church bells), increase in anthrophony</td>
<td>Recognize culturally significant sounds, identifying sounds, identify targets, maintain high fidelity soundscapes</td>
<td>Monitor culturally significant soundmarks and associated soundscapes</td>
</tr>
</tbody>
</table>

Table 34. Soundscape types and conservation planning principles relevant to the soundscape of Pu’ukoholā heiau (adapted from Dumyah and Pajanowski 2011, 1335).
Summary of findings (hearing)

Building on ideas of place, monumentality, and power, this chapter presented original research to address the human sense of hearing at Pu‘ukoholā heiau. Couched in the ethnohistoric and contemporary context of the monument and explored through two experimental analyses (archaeoacoustics and soundscape), the dynamics of hearing within the study area suggest that the detection of sound is not uniform and is linked to the design of Pu‘ukoholā heiau as well as to the historic and modern permutations to the landscape. Overall, the recognition of hearing at Pu‘ukoholā heiau as an active, if intangible, aspect of the place is highlighted.
Chapter 6: The Way Ahead

It can thus be said that kings fight by building temples and not only with arms (cf. Kamakau 1961, 85, 173, 135; in Valeri 1985, 235).

This dissertation commenced with the question, often posed by the traveler and the archaeologist alike (albeit taking slightly different forms) of, “why did various peoples of the past put a great deal of energy into monumental architecture?” Introducing the concepts of monumentality, place, and sensory exploitation paths toward new explanatory potential, this research has focused on one instance of traditional Hawaiian monumental architecture—the luakini heiau of Puʻukoholā. Through the results of a multisensory survey, Puʻukoholā heiau is asserted to exhibit a range of sensory attributes that have the synthetic potential to elicit a deep emotional response from people and thereby create subjective impressions of power. Based on this idea, the sensory attributes of heiau have been emphasized as a conduit for how the facilitation and institution of chiefly authority in ancient Hawaiʻi was accomplished, along with their cultural significance in contemporary and future settings. This concluding chapter aims to bring the background and research chapters together in a synthetic consideration of the senses at Puʻukoholā heiau, and close with a discussion of the kinds of differences that might be achievable using this line of research now as well as in the future.

In Chapter 1, a history of archaeological research in Hawaiʻi, including a review of scholarship concerning the luakini class of heiau, was reviewed and discussed. Transitioning to the concept of monumentality, a relational perspective—whereby the social significance of monumental architecture is dually rooted in physical and intangible attributes—was outlined. Introducing the supporting concepts of place (as a particular and meaningful location) and the body (as a
fundamental perceptual and physical grounding), the potential of monuments to establish and exert authority was brought up for reconsideration.

Drawing from biological signaling theory, Chapter 2 brought forward the concept of sensory exploitation and applied it to archaeology and the topic of monumental architecture in order to think about how the human senses might be related to the establishment and experience of power. Thinking in terms of monumental architecture, sensory exploitation proposes that certain pre-existing sensory sensitivities of people, namely a sensitivity to “vast” entities, creates a potential “backdoor” through which they can be greatly influenced. By building massive, complex, and impressive structures (integrated with extensive cultural belief systems), sensory exploitation advances the idea that the elites of past societies gained the opportunity to impress people enough to often ensure their submission and gain their allegiance, thereby perpetuating hierarchy itself.

Puʻukoholā heiau itself was introduced in Chapter 3, with an overview of its environmental setting, social, historic, and archaeological context, as well as the significance of the heiau complex as a study area. The presentation of research commenced in Chapter 4, including a background on the human sense of sight and its study in archaeology and Hawaiian ethnohistory, and continuing with a multisensory survey that included four experimental, sight-related analyses carried out within the study area: microtopography, access, visual dimensions of perception, and viewshed. A synthesis of sight in the context of monumentality, sensory exploitation, and Puʻukoholā heiau concluded the chapter.

Chapter 5 followed a similar form as Chapter 4, substituting hearing for sight in another wide-ranging consideration of Puʻukoholā heiau and its impact on the senses. Following a review of hearing in archaeology and applied to the context of Hawaiʻi—traced largely through the history of the pahu (drum)—hearing-related experimental analyses carried out in the study area were reported:
archaeoacoustics and soundscape, this time addressing hearing as well highlighting the intrinsic interrelatedness of the senses.

**Synthesis of Sight**

The results of the sensory experiments relate to a number of ideas linked to the concept of sensory exploitation, and tie into the cultural context of Puʻukoholā heiau indicated by the ethnohistoric record and experienced in the ethnographic present. Although it is relatively common in the modern world to stand within a high building and look out, an angle of depression—as established for Puʻukoholā heiau based on its elevated platform and the descending landform to the north and west—is likely to have been a unique viewing experience in the past. This manner of view can be gained by climbing something vertical, like a tree or perhaps a building, or by gaining the edge of a cliff, but the open, unobstructed, expansive view afforded by this luakini heiau—a lofted and backed platform nonetheless—would have been rare if not singular. Being situated above an expansive space, but not greatly distant, is a distinctive viewing experience and is afforded from within the interior of Puʻukoholā, looking down and across Mailekini, Pelekane, Kawaihae Bay, and along the coast.

The angle of depression presented by Puʻukoholā heiau’s microtopographic aspect is compounded by limitations in peripheral vision to both left and right (due to the high sidewalls of the structure) as well as a depth of invisibility directly ahead. Depth of invisibility means that the view over adjacent terrain is not continuous; it is interrupted and cut off (Higuchi 1983, 32), in this case by the leveled floor that dramatically falls away at the far extent of the heiau. These limitations serve to force any view to the exterior to middle and distant ground, or water. If standing or sitting far back enough (inside, toward the backing wall of the structure), the view of land is cut off. Focus moves to the horizon line between the
ocean and sky. Given that depth is reliant on dimensions of known objects, unless objects were on the water, such as boats, no reference for depth would be in view. Likewise, if stationary then moving parallax (which also relies on definitive forms) would be of little use. Stereopsis would likewise be of limited use. The cumulative effect of this is that a person sitting still in Puʻukoholā has a broad view of space (consisting of the ocean surface and sky) but their perception of depth and scale would be highly limited as compared to most any “normal” environment.

To return to the angle of depression, its effect would have perhaps been heightened further with luakini superstructures in place. The paehumu of Puʻukoholā, or knowledge of the precinct’s boundaries, would have been traceable to north and south, demarcating a sacred space and lending a further sense of boundedness. And as one stood within the structure, the anuʻu would have towered overhead. Hawaiians and Europeans regularly transited along the coastline, at times anchoring in the waters offshore. This landscape, replete with activity, would have all been pulled together by such a view, establishing visual unity and instilling a sense of awareness at the least, power and control at the most. The hierarchy of verticality, affording power to the highest level in multiple aspects of Hawaiian culture, may have had relevance.

The emotional response to such an experience, however, is likely to have been as varied as the people who took in the view. Although when looking into the distance over a great, featureless expanse (like the surface of the ocean) the muscles of the eye come to be literally at rest (Sewall 1999, 166), it is also possible that some, or many, who ended up on the platform were in a state of unease or even terrified, with the open view resulting only in a feeling of utter exposure. Others may have been so engrossed in the ceremonial aspect of participating in ritual acts that the view was hardly consequential. Furthermore, there is no authoritative reference that can provide insight into how many people—let alone their role or social standing—might have entered a place like Puʻukoholā heiau and had the opportunity to look outward.
Arguably, the results of the access analysis follow a similar pattern as the microtopography. The most salient tie-in to sensory exploitation is the seemingly unique nature of Puʻukoholā’s interior space. Contrasted with everyday life in the late 18th century, the very concept of “structures within a structure” was almost certainly limited to the largest of heiau. In terms of movement, the linearity indicated by the analysis may have further exaggerated the perceived size of the space by suppressing ease of movement across the width of the structure while promoting it along its length. The restrictiveness of the entryway could also enhance the perception of the space in any number of ways, including the promotion of a starkly dichotomous relationship between interior and exterior in terms of cultural inclusion/exclusion. The challenge of overcoming the exclusionary status as a direct result of the stairway’s delicate access dynamic was observed in the case of a small group of participants during the staging of formalities during Hoʻokuikahi in 2015.

The visual dimension of perception at Puʻukoholā heiau highlights one of the most obvious, and intuitively recognized, aspects of the structure. The prominence of the heiau when viewed from downslope in visual terms is subjectively affirmed with the analysis but in combination with the microtopographic findings the nature of Puʻukoholā’s prominence is worthy of further consideration. Although it certainly qualifies as a costly signal based on its monumental size and superlative (estimated) construction metrics (see Mulrooney et al. 2005), the reduced volume of the building materials required for Puʻukoholā—as compared to its apparent mass, due to its hilltop location—suggests another possibility. In an evolutionary framework, the building appears to fit the bill of a “‘thrifty’ signal—attaining impressiveness on the cheap. Instead of being labeled a dishonest or faulty signal and being penalized, however, sensory exploitation suggests that unless people were keenly aware of such “thriftiness” and care about the quantity of construction materials used, then the fact is insignificant. It is an emotional response based on an impression of “vastness” that is meaningful in this context, not a rational exercise predicated on the counting of stones. Each visual dimension examined, including form, contrast,
prominence, and mass, are a constituent of such an impression, but the overriding tenant would be that genuine monumentality superscedes the physical composition of the structure.

In order for monumentality to eclipse the physical composition of a built form the structure must incorporate other means of impression. One example, in this case related to the construction materials used to construct Puʻukoholā, is the immaterial substance of stories. Puʻukoholā offers several examples of oral legends that directly relate to the structure and are monumental in nature themselves. For example, popular belief holds that the construction of the heiau involved the carriage of stones from Pololu valley in North Kohala, over 20 km distant. This epic feat, which would have required large reserves of strength and endurance, lends power to a leader who could direct such labor and therefore to the structure itself, despite the ephemeral nature of the legend (and independent of its veracity).

Finally, the viewshed analysis offers several additional insights. First, the quantitative accounting of total visible area at three distance thresholds further confirms the notable situation of Puʻukoholā heiau in both close (< 500 m) and medium (< 5,000 m) topographic contexts. Second, at a distant range (unlimited distance) its location affords it visual access to a high number of mountain summits. The degree to which Puʻukoholā heiau appears to share intervisibility with its surrounding environs further establishes it as a focal point within and between many other places. While the dynamic of place and places is constantly changing, in a general sense the recognition of connections, such as intervisibility, affords opportunities for older modes of thinking to persevere, such as the idea of land as central to a Hawaiian process of remembering. Malo (1951, 1) opens Hawaiian Antiquities by writing that, “They do, however, mention by name the lands in which they sojourned, but not the towns and the rivers.” This naming of open land emphasizes the significance of the landscape itself as the domain for belonging, history, and life, and should draw attention to the opportunities afforded by interacting with it, through the senses or otherwise.
Synthesis of Hearing

The results of the sensory experiments in hearing relate to a number of ideas linked to the concept of sensory exploitation, and tie into the cultural context of Puʻukoholā heiau indicated by the ethnohistoric record and experienced in the ethnographic present. Most fundamentally, the notion that sound is not modified by the acoustic setting of a luakini heiau in significant ways would now need to be questioned, as the archaeoacoustics of Puʻukoholā appear to be entirely distinct. While the degree of intentionality behind the acoustic properties of the structure—and the extent that acoustics were deliberately integrated into traditional Hawaiian practices—is arguable, given the explicit association of Puʻukoholā with pahu as well as the significance of hearing in certain luakini rites this is a topic that deserves further attention.

From the angle of sensory exploitation, the idea of sound as monumental leads in interesting directions. The amount and fashion in which the built environment of Puʻukoholā heiau potentially endowed people to hear in unique ways (i.e., sound from far away, or no sound from nearby) may have opened up other avenues for making significant impressions upon people. Hearing anything once inside or on top of the structure is extremely difficult due to the acoustics of the structure. The way that the space variably broadcasts and suppresses audible connections may have once heightened the kapu, and even today increases the uncertainty of anyone who is not up on the platform a general awareness of activity may be established even while visual observation (and knowledge) of specific actions is denied.

Expanding beyond the heiau, the use of sound-making artifacts, such as drums, or voice, could have been a powerful means of incorporating areas for increased control. If people in power could reach anyone with an audible signal, then they could exert a degree of authority over them. In the way that it passes over and through walls and barriers, sound posseses the potential to be a very
authoritarian tool. More importantly it was likely one component in a collection of practices and a cultural system that underwrote a sensory whole, through which the total sum of such activities coalesced at the heiau.

The soundscape experiment lends a more contemporary angle to the presence and preservation of sound and hearing at Pu‘ukoholā heiau. The clear distinction between the diurnal and nocturnal characteristics of the Pu‘ukoholā soundscape reflect the degree to which the study area is impacted by human activity. Despite an abundance of birdcalls through the day, acoustic diversity remained very low. The low frequency and near-constant sounds emanating from the highway and the harbor are a significant presence. The ability of the heiau to impress people today, to be experienced in a neutral setting, are potentially compromised. During Hoʻokuikahi cultural practitioners and National Park Service staff expressed awareness of the distracting sounds but no action was taken. The long term preservation of significant places requires more than ensuring that they are not destroyed outright or left to physically deteriorate. Monumentality hinges on a paradigm whereby people and place are linked. In the case of Puʻukoholā, the stewardship of sound and hearing is an issue to address that promises much potential.

**Synesthesia**

In this multisensory survey of Puʻukoholā heiau, two of the senses—sight and hearing—have led the way. Overwhelmingly, this is because they are the most accessible in the archaeological and ethnohistoric records. Touch, taste, and smell, however, are hardly absent in this account. They are fully embedded within it, connected in a million small ways to vision and sound whose comprehension depends on the acceptance of the theory that none of the senses actually stand alone. Several of the experiments conducted within this dissertation well reflect this: access analysis for instance, although heavily reliant on vision is also
fundamentally based on the idea of touch—we navigate a structure with outstretched arms and by feeling the floor beneath our feet, even as we see our way forward. Taste and smell, never far away from the ritual aspects of eating and of sacrifice, are influenced from the moment one sees or touches food, hears the pour of a drink, or when rain falls to the desert floor and the land itself becomes fragrant. Nor are the senses limited to the five modalities arrived at by Western sensibilities—as Meyer (2001, Table 35) points out for Hawaiians, other cultural traditions parse and understand the senses differently. Proprioception, the art of knowing where you are (perception of movement and spatial orientation), for instance, can qualify as a sense all its own. While it is closely related to hearing, touch, sight, etc., this state of relatedness emphasizes the fundamental entanglement of the senses, no matter how they are conceived.
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</tr>
<tr>
<td></td>
<td></td>
<td>aʻo (verb)</td>
<td>to learn</td>
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<tr>
<td></td>
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<td>aʻo (verb)</td>
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<td></td>
<td></td>
<td>hoaʻo</td>
<td>to try to learn, to taste</td>
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<tr>
<td>Smell</td>
<td>&quot;breathe in&quot;</td>
<td>ihu</td>
<td>Nose</td>
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<tr>
<td></td>
<td></td>
<td>hanu</td>
<td>breathe in nose or mouth</td>
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<tr>
<td></td>
<td></td>
<td>ha</td>
<td>breathe in through mouth</td>
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<tr>
<td>Touch</td>
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<td>pa</td>
<td>to touch with the hand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pa</td>
<td>the “touch” of blowing wind</td>
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<tr>
<td></td>
<td></td>
<td>pa</td>
<td>the touch, as light</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ʻapo</td>
<td>to grasp with the hands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ʻaʻapo</td>
<td>“grasping” with the mind</td>
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<tr>
<td></td>
<td></td>
<td>ʻaʻapo kela keiki</td>
<td>fast in learning, quick in understanding</td>
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<tr>
<td>Awareness</td>
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Even with an explicit research focus on the senses, including the kinds of bounded and abstracted “experiments” that have been laid out in this dissertation, a sense of the greater whole must not be lost. In reality the senses do not sense alone, indeed that is the role of the body itself—a function necessarily accomplished on the level of the whole. When one sensory “channel” goes out another tunes in, or perhaps more appropriately—many other channels were already tuned in. The word synaesthesia describes how the senses can cross over and blend together; the
visual is tasted, sounds become colored. Ultimately, even if it not often made explicit it is clear that we sense with our entire selves. Expanding outward from the body it is the overlap of the senses with our environment that leads towards suggestions of why monumental architecture has proven to be a worthy investment of human endeavor over centuries and across continents.

It is the totality of our sensory awareness that is central to the theory of sensory exploitation and the way that a monument, like a luakini heiau, might impact people and impart awe. If we are impressed, it is because we have been affected—but that force is likely not to have been derived from a singular, sensory source. Emotional impressions are assembled from a complex variety of entities, rooted in the material as well as the intangible. The ultimate contribution of a monument is that it materializes and puts into place anything that is found, experienced, or held in close association with it (circumstances that can often be controlled). The vastness of monumental architecture and the activities built upon it has been known to grow powerful enough so as to effectively ascribe cultural meaning and social significance to strikes of lightning and rolls of thunder. In this way it is likely to have been an unsurpassable tool for the establishment of belief systems and the advancement of power.

The research design of this multisensory survey also included ethnographic activities, namely through participant observation in a variety of cultural activities centered on Puʻukoholā heiau. Largely thanks to the vision and encouragement of Daniel Kawaiʻaeʻa, the Superintendent of the National Historic Site and a Native Hawaiian with genealogical connections to the area, the resulting experiences are highly informative and widely applicable to the experimental work and the general thrust of this research. They include involvement in the reconstruction of Puʻukoholā heiau (the 2006 Earthquake Project, see Johnson et al. 2013 for a synopsis) as well as attendance at the annual event of Hoʻokuikahi (see Tengan 2008, 72–91 for insight into this event). One sequence of events that took place around the data collection required for this dissertation, however, offers insight into
how embedded sensory practices are between Pu'ukoholā heiau and the people who work in and around it today.

The idea of cultural protocol is to set favorable conditions for any form of interaction within a traditional setting. Such interaction might be between two people; it might also be between a person and a place. In the case of Hawai‘i and Puʻukoholā heiau, cultural protocol takes many forms, largely dependent on the timing and setting of the activity. Tourists, for instance, do not participate in any form of cultural protocol during their (typically brief) visits to the area. Native Hawaiians, however, often do. When it comes to performing any kind of work in or around the structure of Puʻukoholā heiau itself, the determination and practice of an appropriate protocol is increasingly standard today, even if that was not the case during the 20th century.

The collection of the microtopographic dataset (comprising over 10,000 individual data points, obtained over most of the Park’s land holdings) involved a significant amount of survey work. By coincidence, the required fieldwork was ultimately carried out at the same time as activities for the Earthquake Project were underway. At the invitation of the cultural advisors to the Earthquake project, and in order to bring our archaeological research and training program in-line with the ongoing reconstruction effort and the significance of working in the vicinity of Pu'ukoholā heiau, our group participated in the already-established set of cultural protocols, including traditional Hawaiian chants and activities on a daily basis.

One of our guides in this process, Francis Sinenci (a master stonemason and authority on traditional Hawaiian construction methods), ultimately choreographed a haʻa entitled Haʻa Akeolokia for the archaeological field crew. His apparent intention was to give the archaeologists an opportunity to practice and ultimately perform a haʻa in a traditional configuration, opposing the stonemason crew, at the conclusion of the field program at Pu'ukoholā. The specifics of the haʻa not only offer a degree of insight into a Hawaiian stonemason’s impression of what archaeologists...
do, it also highlights the physicality of archaeological fieldwork (Figure 57). (Apparently, as we were not conducting excavations, Sinenci was already familiar with other archaeological methods.)

Figure 57. Movements of the Ha’a Akeolokia by Francis Sinenci (illustrations by Robin Deutschendorf).

Haka Akeolokia

Leader: Ma koukou

Rest: Ai

Leader: Pa

All: Ea Ma Kou na Haumana Mai Akeolokia

Kane: Pali Ku ona Manua Helena

Wahine: Papa Hina o Amelika

All: Kaaa Saa Mana Mana

All: Hah Heh Hu x4 (cardinal directions)

(Stamp rotate) x3 Kui after turns
Leader: E Eko Ke Kahua

All: Hah Heh Hu (measure/trowel/screen)

Leader: Ho a’a ka wai wai (search diligently, looking down)

All: Hah Heh Huh

Kui

Leader: Ka Kau Ka Mana’o

All: Kiku (pecking back)

Haki Haki (cutting motion)

Hamo Hamo (rub-rub)

Leader: Kiloi

Leader: Pehea ka hana?

All: Mai kai!

Leader: Ua Pau.

Figure 58. Words of the Ha’a Akeolokia (motions in parentheses)

Ultimately, the performance of the Ha’a Akeolokia generated insight into the matter of sensory exploitation as well. Through the multisensory act of dance (involving vision, hearing, and touch), an activity partially chosen as a physical warmup for the equally-multisensory task of carrying and stacking heavy stones, participants were “opened up” to various forms of social interaction and “connected” to the place itself. Whether through the protocol of the ha’a or through the labor of stonemasonry, it was clear that the physical activity was a useful (if not key) strategy for achieving a favorable outcome, whether building a heiau or collecting microtopographic data. The value of constructing a monumental building, it seemed, might have also lay in the opportunity to involve and impress the participants in the work themselves. Authority may have ultimately been bolstered.
not by coercion, but by involvement, and even potentially through pride in one’s work.

It is in this vein that a multisensory approach to monumental architecture has been attempted. While steeped in archaeology, its pursuit in the milieu of the Hawaiian Islands has also driven engagement with the philosophies and approaches of other interest groups, namely Native Hawaiians. Through these interactions, an important aspect of taking a multisensory approach to monumental architecture is recognized to be the manner in which such places are fundamental to the good health of contemporary society, to which everybody belongs.

Challenges and Opportunities

While this dissertation has made headway against a number of philosophical and methodological challenges, it also recognizes that contemporary social forces are another challenge to advancing our knowledge of Hawai‘i’s past. The colonial experience in the Pacific is a “near and present reality” (Hanlon and White 2000, 2), and given the underpinnings of archaeology this presents a longterm challenge—but also opportunity—to the discipline at large and to archaeologists individually. The value of Puʻukoholā heiau in the face of this difficult reality is notable.

Not to be confused with a stance against archaeology itself, the need to deconstruct Pacific “prehistoric” as a concept is due to the way that it builds on watershed moments in European accounts at the expense of Indigenous history (Hau‘ofa 2003). By virtue of being completed in 1791, long after the initial arrival of Cook to the Hawaiian Islands, Puʻukoholā’s antiquity conveniently breaks traditional Hawaiian practice out of the stranglehold of a popularized “prehistoric” setting and forces the consideration of how Hawaiian society was integrating material and
social aspects of western society as it encountered them (see Bayman 2014). Kamehameha I, of course, is known as one of the most proactive individuals when it came to bending new knowledge and technologies to his own will and purpose. His epic saga, materialized in the heiau itself, further aligns with Hau'ofa’s (1993, 152) sentiment that Oceanic peoples “thought big and recounted their deeds in epic proportions”—in many respects this is a reference to monumentality itself. Work at Puʻukoholā, and in places like it, built on a fresh chassis of Hawaiian archaeology and history has the potential to underwrite the growth of fresh narratives, thereby removing the impediment recognized to be one of the main connections between culture and imperialism. Grounded in a physical monument, it would also be well suited to advancing a communitarian perspective (Gegeo 2001, 492) that fosters collaboration and is driven by a research agenda anchored in the interests and priorities of various stakeholders.

To its credit in Oceania and further afield, elements of archaeology have moved to increasingly question and destabilize orthodox historical narratives and are developing ways to accommodate and communicate a greater diversity of perspectives (Flexner 2013). For instance, the limitations of traditional, textual documents for addressing the gamut of human practices—including the senses—have been emphasized. Engaging the material record in archaeology through non-textual (and increasingly digital) forms such as photography, film, drawing, and theatre, for example (Morgan 2012; Witmore 2005; Pearson and Shanks 2001), is—if still under development—well on its way.

This investigation of the senses at Puʻukoholā heiau will have not, I hope, been an overstep. Rather, a sensory angle has been intended to be more in-line with Native epistemologies in several ways. The emphasis and priority on place, and its importance to knowing, is one epistemological constant (Meyer 2001, 128). The other is the struggle to recognize and accommodate the culturally relative nature of the senses, the “specificity of culture” (Ibid. 2001, 130), in order to expand the potential of empiricism itself. These are significant challenges that, while both
aspirational and germane to this work, surely demand the dedication of coming generations to realize. Given the variable and contextual nature of the senses between cultures as well as between individuals, sensory archaeology benefits from a diversity of practitioners, just as the long-term viability of archaeology at large is connected to issues of identity and representation (Stephen and Morgan 2014).

In the case of the Hawaiian Islands and the archaeological record of Kanaka Maoli culture, however, the involvement of Native Hawaiians in archaeological endeavors (sensory or otherwise) is an imperative that remains to be fully realized. In Kuleana and Commitment: Working toward a Collaborative Hawaiian Archaeology Kathleen Kawelu (2013) examines the sociopolitical history of archaeology in Hawai‘i. Based on the results of ethnographic investigation, Kawelu calls for increased collaboration and identifies two key narratives: 1) the continuation of Kanaka Maoli cultural practices and beliefs; and 2) a commitment to Hawaiian archaeology and Kanaka Maoli descendents from archaeologists.

Driven forward by the idea of the senses as intrinsic to the form, function, and feel of places such as luakini heiau, the ideas explored in this dissertation hint toward future opportunities where archaeology might support the continuation of cultural practices and beliefs and also engender collaboration. In exploring how monumentality is best defined not only by a physical structure but also in how people interact with and experience places through the senses, an archaeology of mana, or how power, authority, and legitimacy in Hawaiian chiefdoms came together, might be appropriately considered. Kikiloi’s (2012) treatment of Mokumanamana and Nihoa islands has already pushed in this direction, bringing together ideas of an isolated and seemingly inhospitable ritual center where “elite status, authority, and spiritual power originated and was continually legitimized” along a pathway to power. Furthermore, the assertion that thinking about mana has the potential to drive anthropological discourse while being both ethnographically vita and theoretically promising has also been made recently (Tomlinson and Tengan 2016).
The monumentality of luakini heiau, the centrality of sensory experience, and the promise of places like Puʻukoholā for the future may be best hinted at in the context of traditional Oceanic voyaging. In recent decades the reestablishment of navigation across the Pacific and beyond by traditional means has proven successful at rediscovering “highly specialized and especially powerful knowledge that has been lost, forgotten, and fragmented” (Genz 2011, 2). Like heiau, traditional voyaging canoes are monumental in that they are remarkable physical constructions (around which an extensive ritual process developed) but also meaningful entities upon which astonishing bodies of knowledge and ways of life were established. Just as the navigator depends on his senses to find his way, so does he or she who builds, maintains, and commemorates heiau. It is in precisely these sorts of settings that monuments and monumentality has always made the most sense.
Appendix A: Sight (microtopographic data)

Available at http://www.puukohola.shouldbedigging.com (428 pages)
Appendix B: Sight (Visual dimensions of perception photographs)
### Appendix C: Sight (viewshed data)

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Visible Area from random points (< 5000 m).
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Visible Area from random points (< 500 m).
Appendix D: Hearing (archaeoacoustic spectrograms)

Experiment #1
CP7 (1 meter away, to front), all audible
CP8 (12 meters away, to rear), can hear chant, windy
CP6 (15 meters away, to front)
CP9 (22 meters away, to rear), can still hear chant, windy
CP5 (34 meters away, to front)
CP10 (44 meters away, to rear), maybe heard chant after vehicle noise
CP4 (55 meters away, to front), no tone, chant audible
CP11 (60 meters away, to rear), possible faint word/s @ 30'
CP3 (78 meters away, to front)
CP12 (distance unknown, to rear)
CP2 (98 meters away, to front)
CP1 (111 meters away, to front), high wind?
Experiment #2
CP1 sweep, Northeast interior corner of heiau, 15 m from source.
CP2 sweep, East interior wall of heiau, 6 m from source.
CP3 sweep, Southeast interior corner of heiau, 33 m from source.
CP4 sweep, Southwest interior corner of heiau, 37 m from source.
CP5 sweep, West interior edge of heiau platform, 14 m from source.
CP6 sweep, Northwest interior edge of heiau platform, 20 m from source.
CP7 sweep, Baseline, at edge of coast, 165 m west of source.
Couldn’t hear anything, nothing detectable.
CP8 sweep, Baseline, 139 m west of source.
CP9 sweep, Baseline, 123 m west of source. Top of a small prominence, before path between Mailekini. Some wind. Sweep audible, no chant.
CP10 sweep, Baseline, West edge of Mailekini heiau, 100 m west of source. Wind somewhat blocked. Audio signal blocked too? Creates its own “space,” might have heard faint “words on the wind”
CP11 sweep, Baseline, East edge of Mailekini heiau, 77 m west of source. Very sheltered environment. Sweep audible, “nothing else that I could really make out”
CP12 sweep, Baseline, 49 m west of source.
Halfway upslope, sweep audible (but barely visible) in spectrograph, “maybe hearing the ocean more right here,” no chant
CP13 sweep, Baseline, 32 m west of source.
On modern pathway, sweep audible, could faintly hear oli, chant, by “taking earbud out of ear”
CP14 sweep, Baseline, East edge of Pu'ukoholā heiau, 25 m west of source. At base of structure. Sweep audible across more of its range? Tone too maybe. Cannot hear chant on recording. “Maybe the faintest of voices.”
CP15 sweep, Northeast of Pu‘ukoholā heiau, base of steps, 28 m northeast of source.
Traffic noise? Maybe just barely visible in spectrograph at 2:57.5 channel 2.
CP16 sweep, West of Puʻukoholā heiau at base of west wall, baseline, 20 m west of source. Maybe heard chant at 1:35? Could “hear faintest of voice on the wind”
CP17 sweep, Baseline, 32 m west of source. Small promince mauka of Pu'ukoholā. Getting dark. Sweep heard “pretty good,” def hear chant at 1:18
CP18 sweep, Baseline, 60 m west of source. “Pretty quiet and calm out here”. Reported hearing “partial sweep and nothing else”
CP19 sweep, Baseline, 88 m west of source. Motorcycle noise fading away. Insects fade out. Could still hear “tiny bit” of the sweep, just visible in spectrograph at 52”. 
CP20 sweep, Baseline, 120 m west of source. Insect buzz stops. Cricket chirp starts/continues. Loud passing car at 57". Could not “discernably hear” in the field but I think I do hear sweep in the recording at 40”. Yup, just barely visible at 40.5” in spectrograph.
Experiment #3
Sound received from Projection Point 1, sweep, Northeast interior corner of Puʻukoholā, projected 14 m NE of collector.
PP2, sweep, East interior wall of Puʻukoholā, projected 11 m E of collector.
PP3, Southeast interior corner of Pu'ukoholā, projected 34 m SE of collector.
PP4, Southwest corner of Pu'ukoholā, projected 34 m SW of collector
PP5, East edge of Pu‘ukoholā, projected 12 m W of collector
PP6, Northwest interior corner of Puʻukoholā, projected 16 m NW of collector
PP7, Shoreline, projected 163 m west of collector.
PP8, Between shoreline and Mailekini heiau, projected 133 m west of collector.
PP9, Between shoreline and Mailekini heiau, projected 117 m west of collector.
PP10, Projected from 94 m west of collector, at west edge of Mailekini heiau, Beep of construction trucks.
PP11, Projected from 67 m west of collector, east of Mailekini heiau in a depression
PP12, Projected from 44 m west of collector, between Mailekini and Puʻukoholā heiau on a hillslope.
PP13, Projected from 21 m west of collector, between Mailekini and Pu'ukoholā heiau on a hillslope.
PP14 Projected from 20 m west of collector, at exterior western edge of Pu‘ukoholā heiau.
PP15, Projected from 24 m northwest of collector, at exterior at base of steps of Puʻukoholā heiau.
PP16, Projected from 22 m west of collector, at exterior base of backing wall of Pu’ukoholā heiau.
PP17, Projected from 38 m west of collector, west of Puʻukoholā heiau.
PP18, Projected from 65 m west of collector, west of Pu‘ukoholā heiau on baseline.
PP19, Projected from 93 m west of collector, west of Puʻukoholā heiau on baseline.
Experiment #4
PP01, 113 m west of collection point on baseline. Chant just audible. Light to medium wind.
PP02, 101 m west of collection point on baseline. Take A (can be compared). Chant barely audible.
PP02, 101 m west of collection point on baseline. Take B (can be compared). Chant barely audible.
PP03, 77 m west of collection point on baseline. Take A.
PP03, 77 m west of collection point on baseline. Take B.
PP04, 54 m west of collection point on baseline.
PP05, 43 m west of collection point on baseline.
PP06, 24 m west of collection point on baseline.
PP07, 8 m west of collection point on baseline.
PP08, 4 m east (behind) collection point on baseline
PP09, 22 m east (behind) collection point on baseline
PP10, 42 m east (behind) collection point on baseline
PP11, 59 m east (behind)
Appendix D: Hearing (soundscape frequency-amplitude plots)

00:00
0900

1000
2300


Kohala District, Island of Hawai‘i (TMK: 3-5-7-02:11 and TMK: 3-5-7-03:1-3, 10-14, 16-18).” Report. Hilo: Paul H Rosendahl PhD, Inc.


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