Ts'a7inwa (gooseneck barnacles) as a proxy for archaeological efforts to understand shellfish as food in Nuu-chah-nulth territories

by

Meaghan Efford
Bachelor of Arts (Honours), University of Victoria, 2016

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We acknowledge with respect the Lekwungen peoples on whose traditional territory the university stands and the Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land continue to this day.

Supervisory Committee

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Abstract

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This thesis examines the comparative abundance of shellfish from archaeological assemblages on the west coast of Vancouver Island in Nuu-chah-nulth territories. Eighteen sites spanning the Nuu-chah-nulth region emphasize the diversity in invertebrate foods that have been consumed 5000-150 years ago: Yaksis Cave, Loon Cave, and Hesquiat Village at Hesquiat Harbour; Chesterman Beach; Spring Cove; Ts'ishaa, Ch'ituukwachisht (North and South), Tl'ihuuw'a, Shiwitis, Huumuuwaa, Maktl7ii, Huts'atswilh, Kakmakimilh, Kiix7iin, and Huu7ii. Invertebrate zooarchaeology is an understudied field that has the potential to impact ecological restoration and conservation efforts. Ubiquity, or frequency of occurrence, provides a measure of abundance for a target taxa or species through a percent presence/absence approach. Regionally conventional methods of invertebrate analysis, including weight-based quantification, primarily favour heavy and robust bivalves, such as clams and mussels, and diminish the presence of other frequently occurring invertebrates. Ubiquity-based quantification shows how frequently 'other' shellfish have been utilized over time and across archaeological deposits. Gooseneck barnacles (*Pollicipes polymerus*) are often considered rare, an unimportant intertidal resource, but ubiquity-based analyses show that they are far more abundant than previously appreciated. A methodological combination of these two approaches shows vastly different perspectives on shellfish abundance, and this has implications for how the dietary role of shellfish is understood and discussed in archaeological discourse.

Table of Contents

List of Tables

List of Figures

Acknowledgments

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Chapter 1: Introduction

Introduction

Relative to vertebrates, invertebrates on the Northwest Coast are an under-researched and under-appreciated resource zooarchaeologically and this has influenced their perceived status as a marine resource (Moss 1993). Barnacles specifically have been unrecognized archaeologically with few research efforts dedicated to their use (Fournier and Dewhirst 1980:62; Moss and Erlandson 2010:3360). This thesis demonstrates that weight-based analysis of zooarchaeological shellfish remains provides a very specific understanding of shellfish abundance. Commonly utilized weight-based quantification methods are often compared to those that count and compare the minimum number of individuals (MNI) necessary to account for all preserved invertebrate remains. Instead, this thesis compares and combines weight-based methods with ubiquity-based methods. Ubiquity measures the frequency of occurrence, rather than the amount present. This simple but underutilized approach for determining frequency does not overshadow smaller or more fragile shellfish taxa with robust and weighty bivalves. Ubiquity is appropriate for multiple small volume assemblages, as it provides a different perspective on how frequently a taxon occurs in an archaeological context (McKechnie and Moss 2016:472). Ubiquity is particularly useful when applied across datasets that contain differences in methods of recovery and quantification or in the size of fragmented animal remains (McKechnie and Moss 2016:471–472). To examine this topic, I compile and analyse data from 18 archaeological sites along the west coast of Vancouver Island in Nuu-chah-nulth traditional territories, including a cluster of sites in Barkley Sound where shellfish assemblages have been sampled and identified. The analysis of ubiquity can

overcome methodological inconsistencies because it quantifies only the presence or absence of an identified species or taxon across samples and sites that may have had significant discrepancies in sample size. Sample size discrepancies can influence abundance calculations more significantly if the method of quantification is looking at how much material is present, including weight, MNI, and NISP calculations. Ubiquity simply records if the target is present, and the percentage of presence across all samples and/or sites.

This project is a contribution to the 2017-2022 collaborative plan between the University of Victoria's Department of Anthropology, the Tseshaht First Nation, Pacific Rim National Park Reserve, and the Bamfield Marine Sciences Centre. The main objective of this thesis is to establish an archaeological menu of shellfish that were commonly harvested and consumed in archaeologically sampled Nuu-chah-nulth territories over thousands of years. This is the first thesis to examine patterns of shellfish use across multiple sites on the west coast of Vancouver Island. Additionally, a methodological comparison and combination allows for a fresh perspective on shellfish abundance and brings shellfish that are rarely discussed into the spotlight. I focus on gooseneck barnacles (*Pollicipes polymerus*), called *Ts'a7inwa*[1] in Nuu-chah-nulth (Ellis and Swan 1981; Sumpter 2005), as a proxy for underappreciated invertebrate foods, towards understanding shellfish use in Nuu-chah-nulth territories. Rather than arguing that gooseneck barnacles are one of the most important contributors to archaeological measures of diet, I use gooseneck barnacles as an example of a species that has been underappreciated as a result of weight-based measures.

[1] This spelling is based on a practical orthography (McMillan and St. Claire 2005) in which the underlined 7 is equivalent to a glottal stop symbol 'ʔ' in international orthography.

Research Questions

The four research questions I address are as follows:

1. *What does archaeological analysis of shell middens on the West Coast of Vancouver Island reveal about the harvesting and management of shellfish resources in Nuu-chah-nulth traditional territories?*
2. *Will applying ubiquity calculations to the existing weight measures of shellfish provide a different perspective of comparison? What differences, if any, are there between the profile of shellfish harvested and consumed between weight-based measures and ubiquity-based measures?*
3. *How do zooarchaeological sampling and sample recovery methods, such as displaced volume, screen size, and sample type (auger, column, unit), influence the comparative abundance and presence of target species?*
4. *How can the relative importance of shellfish impact the legal protection of Indigenous gooseneck barnacle harvesting, and Indigenous claims to accessing and managing goosenecks as a marine resource?*

These questions build on Pacific Northwest Coast zooarchaeological analyses, but address shellfish in a more comprehensive approach than has been done previously. Shellfish are an important coastal resource with long-standing significance for site architecture, community work, and diet, and this is demonstrated in archaeological evidence that spans the Holocene.

Significance

In 2009, the Supreme Court of Canada recognized Nuu-chah-nulth Aboriginal rights to fish and sell fish: this decision did not pertain to gooseneck barnacles or other shellfish taxa, other than noting that clam licenses are inexpensive and plentiful, and that geoduck is not included (Ahousaht Indian Band and Nation v. Canada [Attorney General], 2009 BCSC 1494). While shellfish remains are plentiful in coastal archaeological sites throughout the Pacific Northwest Coast and represent a key constituent in large ‘shell midden’ site deposits, quantitative analyses of shellfish are less frequently conducted than would be expected given their prominence in the archaeological record. Zooarchaeological analyses of fish and mammals are more common in the majority of

research oriented archaeological projects in the region but fine screen invertebrate analyses remain rare relative to large vertebrates such as mammals (McKechnie 2013). Ethnographic records and present-day Nuu-chah-nulth harvesting indicate use of gooseneck barnacles (Ellis and Swan 1981; Moss and Erlandson 2010; Nuu-chah-nulth Tribal Council 2010), but they appear to be absent or poorly preserved in archaeological material (Fournier and Dewhirst 1980:96). A common archaeological perception of shellfish is that they are not a particularly important resource, often with the provision that only a few shellfish taxa could be important (Moss 1993). This limits the ability of the courts to recognize Nuu-chah-nulth rights to harvest and sell shellfish, and to protect shellfish and intertidal ecosystems from damage.

Gooseneck Barnacles

Gooseneck barnacles (also called goose barnacles) are rising in popularity in high end restaurants in British Columbia and appear in relatively low abundance by weight archaeologically. A recently reopened cooperatively managed commercial harvest in Clayoquot Sound is revitalising gooseneck barnacle harvesting in Nuu-chah-nulth waters[2]. Gooseneck barnacles (*Pollicipes polymerus*) are prized in Nuu-chah-nulth cuisine (Ellis and Swan 1981; Gagne et al. 2016; Nuu-chah-nulth Tribal Council 2010:14). They require particularly daring harvesting practices due to their highly exposed, slippery intertidal zone habitat (Ellis and Swan 1981:34). The peak season for gooseneck barnacles is in the winter (ibid.) Low tides, when gooseneck barnacles are most accessible, occur in the dark (1981:34). The commercial harvest of gooseneck barnacles in British Columbia takes place in Clayoquot Sound . The 2016 update to the

[2] http://www.haoom.ca/

ecological assessment framework for gooseneck barnacles, under the Department of Fisheries and Oceans Canada, claimed to integrate local ecological knowledge (LEK) and technological developments to the assessment process. This was a collaborative project between five Nuu-chah-nulth First Nations, known collectively as the T'aaq-wiihak First Nations, and the Department of Fisheries and Oceans Canada (Gagne et al. 2016:1). The report provides valuable information regarding harvestability and the current legal environment in which gooseneck barnacles are consumed. The assessment recommends that sites, which may include one or more individual beds, are selected with the advice of local harvesters, and that accessibility and safety are important considerations for choosing sites at which to survey and harvest (2016:29).

Figure 1: Gooseneck barnacle, M. Efford

The capitulum (see Figure 2) is covered by five calcareous plates, two terga, two scuta, and one carina, that protect the organism (Álvarez-Fernández et al. 2013:1373). The grey capitular plates are the elements that most readily preserve in the archaeological record, and they do not resemble other invertebrate remains. Harvestable conditions include 1) market peduncle length range, 20-80mm, 2) accessibility, including safety considerations, and 3) live removal, requiring the barnacles to have grown on a

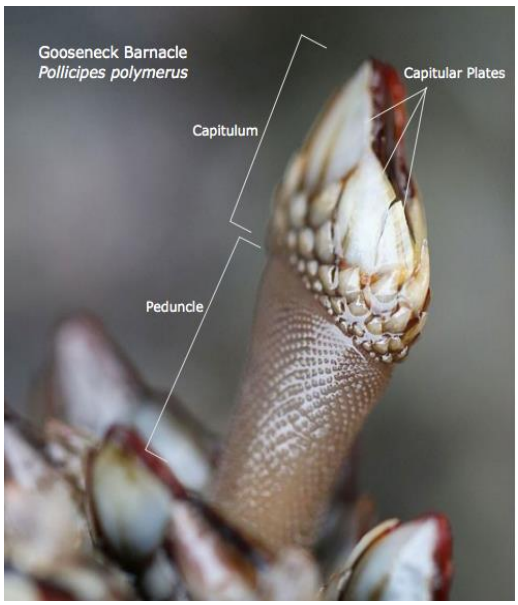


Figure 2: Basic gooseneck barnacle anatomy. Photo credit: Peter Pearsall/U.S. Fish and Wildlife Service.

biological substrate, not bare rock (Gagne et al. 2016:3). Due to their shared preferred highly exposed environment, they can be found in the lower intertidal zone with the larger mussels. The estimated maximum age of goosenecks is 12 years (2016:7) and they grow up to 10cm in length (Bernard 1988:288). The peduncle is a long and flexible muscular column that supports the body or capitulum, which is covered by many calcareous plates of varying size (see Figure 2) (1988:289). These plates are the only portion of the gooseneck organism that is preserved archaeologically.

Figure 3: Intertidal mapping of mussel and gooseneck barnacle habitat at low tide: Historical Ecology and Coastal Archaeology 2017, project camera

Contribution of This Project

Shellfish assemblages are not an archaeological focus for most coastal researchers. While several ongoing projects focus on bivalves and shellfish management, such as the Clam Garden Network[3], zooarchaeological research efforts have a tendency to emphasize fish and mammals, with shellfish an occasional small-scale addition. A considerable

[3] https://clamgarden.com/

literature focuses primarily on quantitative methods (Glassow 2000; Mason et al. 1998), the cultural significance of shellfish (Claassen 1991; Moss 1993), and occasionally on an underappreciated taxon (Croes 2015; Moss and Erlandson 2010). Barnacles are under-identified and under-analysed throughout zooarchaeological research efforts on the Northwest Coast (Moss and Erlandson 2010). Gooseneck barnacles specifically have been studied in an archaeological context outside of the Pacific Northwest, namely in Spain from the Neolithic to the present day (Álvarez-Fernández et al. 2010, 2013). The under-appreciation of barnacles in archaeology, including goosenecks, was first acknowledged academically in the Pacific Northwest region in 1980 (Fournier and Dewhirst 1980). Barnacles are occasionally discussed as back up foods, or starvation foods, that are only relied upon when more desirable invertebrates such as clams and mussels are depleted (Cannon et al. 2008:11) with other research efforts arguing the opposite (Erlandson 1988:107, 2001:291; Moss 1993). The analyses presented here address a gap in the literature that has been identified by these zooarchaeological researchers: few research efforts look at the variety of taxa present in shell midden material across multiple sites, and this limits our understanding of invertebrates as food. This thesis is the first to evaluate the relative abundance of shellfish across multiple western Vancouver Island sites comparing quantitative methodologies and taxonomic compositions in order to highlight underappreciated taxa. I examine invertebrate assemblages building off previous zooarchaeological research efforts but focusing on the analysis of ubiquity (McKechnie and Moss 2016; McKechnie 2013).

Taxonomic Specificity and Uncertainty

> *"In material sciences, we expect observer-error and inter-observer variabilities".*

(Horsburgh et al. 2016:357*).*

In the initial stages of assemblage analysis, the identifiability of specimens is assessed by the analyst(s), influencing the structure of the data and possible future inter-analyst and inter-site comparability (Gifford-Gonzalez 2018:169). This process, described by Driver as "group[ing] specimens into meaningful categories", is based on the knowledge of the analyst (Driver 2011:20). Different analysists have differing levels of certainty, experience, and confidence. The extent of fragmentation can influence the confidence and increase the time required to analyse a given sample. Most recovery methods favour larger screen sizes for analysis (1/4 inch/6.35mm), a decision that allows for more samples to be analysed but also fails to catch the smaller fragments that are caught in 2mm and 1mm fraction sizes. Sources of uncertainty in zooarchaeological analysis are often 1) the experience and confidence of individual analysts, 2) the disparity of experience and confidence between analysists, 3) the state in which archaeologists find the sites and remains on which they perform their analysis, and 4) the quality of the comparative collections that are used to identify specimens, among other factors. The analysis methods archaeologists use tend to focus on certain robust, easily identifiable shellfish, rather than capturing the species diversity present. Zooarchaeological analyses of shellfish along the Pacific Northwest Coast often focus on weight-based or MNI-based quantification methods, when shellfish assemblages are quantified at all. Like most zooarchaeological measures of abundance, estimates produced by proportional measures tend to emphasize specific, especially prevalent taxa which therefore tends to dominate interpretive discussions. The methods deployed by zooarchaeologists are of course at play here: without the ability to identify less abundant and more fragile shellfish, the

results of analysis continue to support these arguments. Clams, mussels, and other robust shellfish are discussed as more archaeologically valuable, limiting the ability of archaeological evidence to support claims of traditional use across greater species diversity.

Inter-observer error has a recognized impact on zooarchaeological research. Identification using morphological analysis is the standard in zooarchaeology, and it is the method used to identify shellfish to species when possible in this research. However, it is worth noting that the quality of morphological analysis can be difficult to determine without more than one analyst asking the same questions of the same material. Some species are easier to identify than others, with some clam species being very difficult to differentiate when the fragments are smaller than 6.35mm ($^1/_4$ inch), the most commonly utilized screen size. This is not an issue unique to shell remains but one relevant across zooarchaeological analyses. Column samples, columns of sediment removed from the wall of an excavation unit, are now the standard for midden sampling on the west coast of Vancouver Island, and in British Columbia more broadly.

It is common for archaeological analysis to inform the ecology of the past, but Horsburgh *et al.* recommend the use of ecological data to inform archaeological analysis (2016:356). When a species that is not ecologically likely to occur is identified, or even if a species is ecological likely and has not been identified, it may be an opportunity to question the identification methods being employed. Jonathan Driver identified a significant concern in identification and classification methods within zooarchaeology: "most zooarchaeologists have assumed that the system with which they describe specimens may be imported intact from zoology" (Driver 2011:19). Driver noted that

most invertebrate identification focuses on “relatively complete shells and exoskeletons” and so in his view, this concern is more acute within vertebrates. While his critique focused on analysis of vertebrates, Driver identified a concern that applies to invertebrate analysis. He argues that some species are very easily identified to the species level due to their remains being so distinct from any other species while others are not easily distinguished from related species and so are often identified to family or sub-family, which automatically causes issues of comparison and relative abundance (2011:24). This is highly dependent upon the confidence and experience of the analyst. Those easily identified species will be assessed as more abundant. Driver did not propose a solution to this problem in 1992 (re-published in 2011), but Donald Mitchell did in 1990.

Mitchell discussed MNI (minimum number of individuals) and NISP (number of identified specimens) rather than weight, but he argued that the undermining factor in faunal analysis in the percentage of the fauna that remains unidentified (Mitchell 1990). The unidentified portion can be a significant percentage of the assemblage, and can unequally affect major taxonomic groups, which can make it difficult to determine the relative importance of mammals, birds, fish, and shellfish (Mitchell 1990:240). His focus was the question of “how much food different sources contributed to the diet” (1990:239), which is not necessarily the focus of this research. His 1990 paper shows that there are shortcomings to any quantitative method, and he suggests that broader taxonomic categories (i.e. mammal, bird, fish, shellfish) will provide a more accurate and fuller picture of the overall diet that is comparable across sites. Rather than comparing the relative significance of individual species, Mitchell argued that using broad taxonomic groups speaks to human activity and community behaviour through evidence

of harvesting and hunting. Quantitative methods can seem to lose sight of human behaviour in favour of assigning percentages to individual species or groups of species to determine how much they contributed to the diet. Mitchell's suggestion focused on addressing concerns with using bone weight and meat weight of mammals, but his recommendation to simplify the identification process is helpful for understanding broadly how different taxonomic groups contribute to diet. This recommendation relies on the presupposition that broad taxonomic groups are similar to how communities conceptualized their diets. Categories such as shellfish, land mammals, marine mammals, fish, birds, plants, and others require different harvesting and hunting methods: it is possible that communities would categorize food resources by the methods with which they are acquired.

The majority of the data included in the analyses presented in this thesis are reported quantifications of specimens performed by other analysts. There is no clear answer to the concern that zooarchaeological data varies in inter-analyst and inter-site comparability, but that should not stop archaeological inquiry that attempts to compare data across sites that has been performed by different analysts. While MNI was utilized at Ch'ituukwachisht (Cree Island, 131T and 132T), Tl'ihuuw'a (Nettle Island, 305T), Shiwitis (Gilbert Island, 82T), Huumuuwaa (Village Island, 304T), Maktl7ii (Wouwer Island, 206T), and Huts'atswilh (Dicebox Island, 83T and 129T) for bivalve umbos (see Table 3), MNI was not used at any of the other sites references in this project for invertebrate analysis, and NISP was not used for invertebrate analysis at any of the sites I reference here.

Conclusions

This chapter introduces this research and its contribution to the discipline of archaeology in the Pacific Northwest. I show how this project fills a hole that has been identified by experts in coastal archaeology and archaeology of shell remains. Chapter two addresses the literature and research efforts that deal with shellfish archaeology on the west coast of Vancouver Island and nearby areas. I provide archaeological and historical ecological context within which this project is situated. I discuss how shellfish are perceived through the literature and how this project builds upon existing research efforts in the Pacific Northwest.

Chapter three grapples with the quantitative analysis of shellfish remains through a number of methodological comparisons. Through a combination of reported weight-based measures of all shellfish identified at one of the sites and ubiquity calculated using those measures, I show how a combined approach provides a more comprehensive understanding of what invertebrate foods are present and where they are found archaeologically. I use weight-based quantification as the foundation with which I calculate ubiquity because it is the method used across all 18 sites. MNI and NISP were not conducted across the range of sites with the exception of some MNI bivalve analysis that is not included here (Table 3). In addition, I show differences in comparing the results of weight and ubiquity analyses, and what the relationship between sample size and taxonomic richness looks like in this region. Chapter four brings together answers to the four research questions and argues the significance of this research, and future research possibilities.

A Note About Terminology

Gooseneck barnacles are crustaceans but are generally discussed as a shellfish species in archaeological analysis of invertebrate remains as their plates are produced by calcification. While not all of the invertebrates included in this research are shellfish, invertebrates in general are quantified, analysed, and discussed archaeologically as falling under the term shellfish (Erlandson 2001:293) and I continue that tradition in this thesis. In general, crab, shrimp, prawns, and lobster are not preserved archaeologically and so are not included in the term "shellfish" in this context. I use the terms "invertebrate" and "shellfish" interchangeably and specify when necessary.

Chapter 2: Shellfish archaeology and Nuu-chah-nulth shellfish management

Introduction

This chapter provides an overview of the existing literature that discusses shellfish as a marine resource in Nuu-chah-nulth traditional territories. I review how shellfish are recovered and analysed during excavations on the western coast of Vancouver Island, and the commonalities in how archaeologists generally identify and discuss shellfish. I examine the level of taxonomic specificity and identification methods and note the quantity of shellfish quantified varies greatly across research efforts, with influencing factors including excavation, sampling, quantification, and analysis. While there are many commonalities between the approaches to quantitative analyses performed at each of the sites included in this thesis, there are some notable differences including differential recovery methods and analytical effort in addition to environmental factors and to the community specific use of associated middens. Some other differences are methodological in nature and are presented in Table 3. This chapter focuses on the contribution of shellfish to archaeological analysis in Nuu-chah-nulth territories. See Figure 4 for a map of the 18 datasets examined in this project. The subdiscipline of zooarchaeology, including the archaeological study of shellfish, and the research framework of historical ecology, provide the methodology and theoretical foundation. This chapter seeks to answer the following question:

1. *How does the archaeological analysis of shellfish from shell middens on the West Coast of Vancouver Island provide information on the harvesting and management practices in Nuu-chah-nulth traditional territories?*

Based on weight-based measures, many invertebrates appear to be rare or far less abundant than more robust and well-preserved bivalves such as mussels and some clam

species. Destructive recovery techniques and highly fragile shell structure hide the true diversity of shellfish resources, and colonial narratives have shaped the ways in which archaeologists conceive of shellfish (Menzies 2015; Moss 1993). An example of these processes is exemplified by northern abalone (*Haliotis kamtschatkana*): ecological and archaeological narratives are based on a perceived lack of abundant evidence and argue that abalone consumption became common only after sea otter populations declined after European contact and influence, overriding Indigenous knowledge and stories of abalone as food (Menzies 2015). Conventional archaeological inquiry of shellfish indicates a lack of extensive use. North American archaeology as a discipline is predisposed to be unfamiliar with the consumption of most shellfish, including barnacles (Moss and Erlandson 2010:3360). Regularity of use can be quantified through ubiquity (i.e., percent presence) by accounting for the frequency of each taxon in small archaeological samples taken widely across archaeological sites, providing a big-picture of community use across time and space (McKechnie and Moss 2016). Even small or fragile shellfish can be evidence of use in a presence/absence model.

Literature Review

In this section I discuss the literature upon which this research builds. The theoretical framework, historical ecology, situates the approach I take. A brief discussion of Nuu-chah-nulth histories and ethnographies is followed by analysis of two early contact narratives that provide insight into the ways in which archaeological inquiry conceive of shellfish. In the sub-section *Pacific Northwest and Nuu-chah-nulth Archaeology*, I outline some key points regarding archaeological work on the Pacific coast. I discuss the

literature that focuses on archaeological work in Nuu-chah-nulth territories with a particular focus on zooarchaeological efforts.

Theoretical Context: Historical Ecology

Historical ecology looks at human-environment relationships through deep time. This approach is a collaborative effort between diverse disciplines, including both anthropology and ecology, and seeks to understand how humans influence, interact with, persist in, and alter a particular local ecological setting. The relationship between human coastal populations and shellfish ecology can be better understood through the perspective of historical ecology (Ricka et al. 2016). It is interdisciplinary and future-oriented by nature, focusing on dynamic change in the environment over time and in relation to culture, and draws on "a broad range of qualitative and quantitative sources that vary in temporal and spatial coverage" (Beller et al. 2017:645). It does more than simply discuss ecology in the context of deep time: instead, it addresses the feedback loops and relationships inherent to the natural world, and often connects this to human culture, populations, and agriculture (Beller et al. 2017). Historical ecology is in a unique position to speak to how humans drive change in the world around them, in the ecosystems they live and interact in, by incorporating both spatial and temporal scales to the relationship between humans and the environment (2017:647). The discipline challenges the "pristine primitives" mindset that place indigeneity in a past time and place, separate from reality (Balée 2006:77). Historical ecology focuses on the reciprocal interaction of humans and environments over deep time and the results of those interactions (2006:82). Deep time is the concept of the past that spans "across decades, centeries, and millennia" (Braje and Rick 2013:303). This is valuable for understanding connections to place and the long-term, evolving and reciprocal relationships between

humans and their environments. Looking at what people eat and how they obtain it is a large part of this program as key examples of anthropogenic environmental change (Sepez 2008). Historical ecology addresses many themes, including climate and environmental change, policy and communication strategies, and resource management, among others (Armstrong et al. 2017:26). The two historical ecological themes on which this project focuses are 1) resource and environmental management and governance, and 2) methods and applications (2017:26–27).

These relationships can be seen in the archaeological record as far back as the Middle Stone Age (MSA) and Late Stone Age (LSA), through shell midden sites on the South and West Coasts of South Africa (Klein and Steele 2013). The two coasts have vastly different intertidal environments due to factors such as wave exposure and current temperature, and so the corresponding shell deposits reflect these differences in the species present (2013). These two components (MSA and LSA) also represented the two time periods, and there is a steep decline in mollusc size between the MSA and LSA deposits (2013:10913). This is mirrored in an increase in harvest population size over fourteen sites, suggesting that the intensity of harvesting increased with the populations (2013:10914). On the Northwest Coast of North America, the continuity of shellfish harvest is evident in the archaeological record through massive shell midden deposits. Yet, pervasive ambiguity and differences in opinion, interpretation, and misconceptions results in a divergence in the ways in which archaeologists conceive of shellfish in coastal diets throughout history (Erlandson 2001). There is a false dichotomy that shellfish are either costly to harvest, a poor nutrition source, and an unreliable resource, or they are highly nutritious, accessible, and abundant (2001). In reality the dietary role

of shellfish is much more likely a spectrum that is dependent upon other dietary resources and environmental change as well as risk such as in paralytic shellfish poisioning. Other factors include but are not limited to the life history factors of individual species and their response to human interaction and predation. The prevalence of shell deposit sites and both ethnographic and oral historical evidence suggest that shellfish have been an important resource for thousands of years. The perceived bias of the skill required for hunting relative to shellfishing is largely based on associations and connotations connecting shellfish with women and those with low social status (Erlandson 2001; Moss 1993).

Local ecological knowledge, or LEK, is based in generations of interacting with and living in local ecologies. This knowledge is essential to uncovering the historical ecology of those local environments and their relationships to the human communities that live within them. In 1999 a framework for gooseneck barnacle resource management was released by Fisheries and Oceans Canada (DFO) following concerns over a lack of information regarding the abundance and ecology of the species in Clayoquot Sound, BC (Gagne et al. 2016). These concerns resulted in the closure of the Nuu-chah-nulth gooseneck barnacle fishery, Ha'oom Wild Seafood (Gagne et al. 2016). The update for this 1999 framework was published in 2016 (Gagne et al.) and was a collaborative effort between the T'aaq-wiihak First Nations and the DFO, with an emphasis on Local Ecological Knowledge (LEK) from the fishers and harvesters. This updated report provides valuable ecological information about this species (*Ts'a<u>7</u>inwa*; *Pollicipes polymerus*), which is a delicacy both in British Columbia and in Spain. LEK is central to the assessment in this report and is necessary for successful fishery management (Gagne

et al. 2016). This report is not the first to suggest incorporating LEK into mariculture management, and LEK is becoming recognized as more and more valuable. Not only does LEK inform resource management planning, it also supports Indigenous governance and seascape management. Harvesting shellfish is a community event and provides educational opportunities for families and community members (Lepofsky et al. 2015). Clam gardens are an example of the continuous and community-based connection between coastal Indigenous peoples, the marine environment, and shellfish (Lepofsky et al. 2015). Harvesting strategies rely on ecological knowledge passed down through families and take advantage of local availability (Cannon et al. 2008). Archaeological evidence of Pacific Northwest shellfish harvesting appears to follow two trends: high species diversity and predictable proportional abudance, specifically a relience on mussels and clams and regular use of barnacles and gastropods (Cannon et al. 2008). Changes within those trends can be attributed to sociocultural, historical ecological, and environmental changes. Both trends are dependent on variation in coastal ecological factors, including wave exposure, intertidal zone morphology, accessibility, and storms, among others.

Nuu-chah-nulth Territories and Histories

In this section I briefly outline some important points that provide necessary historical and cultural context for the study region. The former colonial name 'Nootka' has been used to describe the people in all of the culturally-related communities along the west coast of Vancouver Island since Captain Cook recorded the name in ignorance at his arrival to Nootka Sound in 1778 (McMillan 2000:6). The name *Nuu-chah-nulth* (loosely translated: "all along the mountains") replaced *Nootka* in 1978 (McMillan 2000:6).

Regional dialectical differences in a shared language family were noted by early researchers and Nuu-chah-nulth speakers but the concept that the various communities were all one people persisted, possibly because of the notable close relationships between all of the Nations in the region (McMillan 2000:7–8). The Wakashan Migration Hypothesis suggests that an expansion of Wakashan from northern Vancouver Island happened around 2400 BP or soon after (McMillan 2003:250). This has been offered as an explanation for cultural shifts in Barkley Sound and elsewhere in Nuu-chah-nulth territories around that time.

Popular coastal foods were and are regionally variable based on local ecology, but include several fishes, marine mammals (including whales), invertebrates (Ellis and Swan 1981; Turner and Efrat 1982:10), as well as terrestrial mammals and a wide variety of plant foods (McMillan 2000:12; Nuu-chah-nulth Tribal Council 2010), including root vegetables (Deur 2005; Turner et al. 2009). Invertebrates are very accessible to sites that are in proximity to the shoreline, and a variety of shellfish and other invertebrates were harvested, including bivalves, barnacles, chitons, urchins, crabs, octopus, and gastropods (Ellis and Swan 1981; McMillan 2000:19; Nuu-chah-nulth Tribal Council 2010). Abalone (*Z̲aps'yin*, Barkley Sound dialect) is a low-tide delicacy: the meat eaten raw or cooked, and the shells used for fishing lures and adornments, including nose rings (Nuu-chah-nulth Tribal Council 2010:6). Gooseneck barnacles (*Ts'aZ̲inwa,* Barkley Sound dialect) are harvested with a prying stick and can be steamed, boiled, or roasted (Nuu-chah-nulth Tribal Council 2010:14). Crab, octopus, prawns and shrimp, sea anemone, and sea cucumber are also referenced as traditional foods (Nuu-chah-nulth Tribal Council 2010) but they are not well documented archaeologically. The harvesting of many

shellfish species was a practice that everyone could participate in but was commonly performed by women and children (McMillan 2000:19), with the exception of some specialized species such as gooseneck barnacles (Ellis and Swan 1981:34). Nuu-chah-nulth diets depend upon the marine environment for sustenance, a fact well supported by oral historical, ethnographic, and archaeological evidence (Ellis and Swan 1981; Sumpter 2005; Turner and Efrat 1982).

The Nuu-chah-nulth Tribal Council published a reference guide for traditional foods designed to be shared and used as a tool kit for communities (Nuu-chah-nulth Tribal Council 2010). I reference this source of knowledge as it is a detailed guide to harvesting some key foods and how to share that knowledge with a local community. Manhousat elder and wisdom keeper Luke Swan's account of marine invertebrates, recorded by David Ellis (1981), remains the most comprehensive ethnographic account of Nuu-chah-nulth marine invertebrate consumption, including harvest and preparation methods, preferences, seasonality, and descriptions, for the western coast of Vancouver Island. While Ellis and Swan recognize that local ecology influences both the availability of foods and the knowledge the corresponding community members have about those foods, their work documents a wide variety of cultural uses for invertebrates that are available in the intertidal (Ellis and Swan 1981:23). When Swan worked with Ellis, the Manhousat Nation was located in between Hesquiat Nation and Ahousaht Nation, north of Clayoquot Sound (Ellis and Swan 1981:13). The following descriptions and corresponding Manhousat names of some of these invertebrates come from this book.

The Nuu-chah-nulth names for the invertebrate foods discussed following are all from Ellis and Swan's invaluable text (1981). Barnacles (*tlaaʔulh*) were generally best in the

summer and are pried from rocks, but their edibility is influenced by toxic algae blooms (1981:26). Both barnacles (*huhu7a*) and limpets (*ch'a7uush*) are described as "occasionally eaten", consumed raw or steamed (1981:27). Goose(neck) barnacles (*ts'a7inwa, Pollicipes polymerus*) were "considered excellent eating by the Manhousat people", especially during the winter, and are collected at specific locations (1981:34).The pelagic gooseneck barnacle (*Lepas anatifera*) are not eaten. Gastropods with "an elongated, spiralling shell" (*7ish7iniitl*) are discussed together (e.g., *Nucella sp.* and others) as consumed and the shells later used for necklaces (1981:28). Black turban snails (*tl'achkwin, Tegula funebralis*) was only eaten in the spring time (after which time they would "grow legs", possibly due to hermit crabs taking over their shells) and were consumed raw (Ellis and Swan 1981:29). California mussel (*tl'uch'm, Mytylus californianus*) were important and collected year round, unless algae blooms were present (1981:29). Size was not a determinate of edibility but different locations, with different levels of wave exposure, would yield varying overall size and risk to the harvester (1981:30). Mussels can be roasted close to coals, steamed, or boiled, but Swan says they were never dried for the winter (1981:31). Bay (blue) mussel (*kw'uts'm, Mytilus trossulus*) are known to be toxic during the early spring, during herring spawn, and were never eaten raw (1981:33). Black katy chiton (*haaýishtuup, Katharina tunicata*) are a delicacy, especially in the spring: they are more tough over the summer through to the winter (1981:35). These chitons can be roasted and then placed in cold water before being removed from their shell, and can also be cooked in not quite boiling water (1981:38). Butter clams (*ya7isi, Saxidomus giganteus*) are described as "the single most important invertebrate species to be utilized by the Manhousat people" and have been

harvested by both men and women (1981:48). They can be cooked by steaming or roasting, but not eaten raw (1981:50). There are many more invertebrates included in Ellis and Swan's volume: this is only a short selection of some of the shellfish that are relevant to this project.

Invertebrate availability varies greatly depending upon environment, and the west coast of Vancouver Island hosts a wide variety of invertebrate foods. In Barkley Sound, there are a number of islands clustered that provide both exposed and protected shorelines (Figure 4). Bivalves are most abundant in the outer islands of this cluster and are highly available throughout the region, making them "a major source of protein in the Tseshaht" and other Nuu-chah-nulth nation diets (Sumpter 2005).

Early Contact Narratives

While it is not within the scope of this project to discuss the early European contact narratives in depth, they do provide written records of interactions with communities in the Nuu-chah-nulth region from the late 1700s and early 1800s. I discuss two here: a journal kept by John R. Jewitt published in 1807, and a journal kept by Jose Mariano Moziño in 1792.

By his own account, 19-year-old John R. Jewitt was captured by Chief Maquinna after the crew and commander of the ship Boston were killed (Jewitt 1807:3–4). Jewitt does not specify the First Nation other than saying that they are the Nootka, but they were specifically the Mowachaht Nation (McMillan 2000:15). Table 1 shows all the foods mentioned in Jewitt's journal over the time he spent with Maquinna's community. This is likely not a full list of all the foods consumed during that time: Jewitt often included the abbreviation "&c" for et cetera after a list of foods. This suggests that either he did not know the names of all of the foods traded and consumed, or that he simply did not think

them relevant or important. The only shellfish mentioned are clams, cockles, and mussels. Other invertebrates, such as barnacles and gastropods, are likely to have been consumed but not recorded by Jewitt based on the archaeological evidence and oral historical record.

Table 1: Foods mentioned in Jewitt 1807

Shellfish	**Fish**	**Mammal**	**Oil/Blubber**	**Bird**	**Plants**
Clams, dried	Salmon spawn	Whale?	Train (whale) oil	Wild geese	Green pease** (sic)
Cockles, dried	Herring spawn	Sea otter	Whale blubber		
Mussels	Halibut, dried	Bear	Seal blubber		
	Herring, fresh and roasted		Porpoise blubber		
	Salmon		Sea cow blubber***		
	Small fish		Smoked blubber		
	Cod fish, dried				
	Dogfish				
	Lampreys*				
*Suggested not eaten **Likely pea shoots or similar ***Likely sea lion					

Jewitt complained many times in his entries about his and the sailmaker Thompson's living conditions: many specific issues seemed to be with hunger and the available food: "Thank God we have been very healthful during these last thirteen months. But now we begin to have a very heavy flux upon us, which is owning to the provisions we are forced to eat" (Jewitt 1807:20). In the first entries Jewitt called Maquinna 'their Chief', and after a two-month break in entries shortly after the capture, there was a shift in his language and he started to call Maquinna 'our Chief' for the remainder of the journal (Jewitt 1807:6).

Jose Mariano Moziño kept an account of his time as a botanist and naturalist on an expedition that stopped in Nootka Sound, originally published in 1792 (1970). He was the official botanist for the Juan Francisco de la Bodega y Quadra to Nootka Sound expedition in 1792 (1970:xxiii). His book is much longer than Jewitt's journal and

records his perspective on language, culture, flora, fauna, and traditions of the people he encountered. His experience of shellfish is vivid:

> Inside this same room of their house they make large fires, clean their fish, and remove shellfish and snails from their shells, leaving a large part of the remains thrown on the floor where it rots. This causes an unbearable repugnance to anyone who has not grown up in the midst of so much stench (Moziño 1970:19).

Table 2: Food mentioned in Moziño 1970

Shellfish	**Fish**	**Mammal**	**Oil/Blubber**	**Bird**	**Plants**
Not specified	Sardines *(likely herring and anchovy)*	Deer	Whale oil	Geese	Andromeda berries
Snails, not specified	Fish, *not specified*			Gulls	Blackberries
Abalone*	Smoked fish, *not specified*			Other aquatic birds	*Vaccinium* (incl. huckleberries and blueberries)
Dentalia				Eagle**	Crabapples
					Wild pears
					Madrone berries
					Currants
					Strawberries
					Wild rose haw, flowers and fruit
					Silver weed
					Angelica
					Lithosperm
					Trailing clover
					Kamchatka lily

*Referenced as a container, not for food (Moziño 1970:19)
**Use of their feathers, but not for food (Moziño 1970:20)

He is describing the accumulation of what we see in midden deposits and includes snails in his description. He makes several references to the use of dentalium shells for necklaces (1970:11–12, 35, 50). He notes that the ocean provides "their principle sustenance", but no longer references invertebrates as food, instead focusing on fish, deer meat, aquatic birds, and wild vegetables and fruits (1970:20). He also "presumes they scorn that of the bear and sea otter", with no suggestion that this presumption is based in any real fact (1970:20). Table 2 is not based on a detailed reading of his whole book, but rather on the few pages dedicated to food (1970:19–21). This table only shows the foods

that Moziño writes are eaten without the influence of him and his shipmates. Moziño lists many more plant foods than animal, which is likely due to his profession as a botanist rather than implying a heavier emphasis on these foods in the local diet.

While these two narratives record encounters in the same area, they were written by men with different backgrounds, both professionally and nationally. They use similar colonial language to describe the people they interacted with, describing all Indigenous people and communities in the area as "Nootka", a misunderstanding of the time. Moziño's account is very familiar as an early anthropological work, with descriptions of people, places, foods, customs, beliefs, language, and behaviours (1970). Jewitt in contrast, wrote of his experience becoming a relunctant part of Maquinna's community over a span of a few years (1807). The two narratives highlight the limitations of using ethnohistoric documents as evidence of resource use or lack therof.

Pacific Northwest and Nuu-chah-nulth Archaeology

> *"Recent research has now accumulated a wealth of archaeological information that demonstrates an enduring and continuous Indigenous presence along the outer coast of British Columbia stretching back many millennia."*
> (McMillan and McKechnie 2015:10)

The archaeological material recovery methods utilized today were pioneered in the 1970s by Richard W. Casteel at Simon Fraser University: questions surrounding appropriate mesh size, water screening, and column and auger sampling arose through his work on archaeological fish remains (Cannon and Moss 2011:6–8). With the rise in academic faunal research and the work of Pacific Identifications Inc. (Susan Crockford, Rebecca Wigen, and Gay Frederick), the predominant firm for analysing zooarchaeological remains and which utilizes the largest comparative collection in the

region[4], archaeological research efforts now have access to skilled, standardized faunal analysis (Cannon and Moss 2011:8). Fish and shellfish remains are the most abundant of any resource remains (Cannon and Moss 2011:1), and shell midden deposits are some of the most frequently occurring features on the coast (Stein 2008:62). The presence of shell remains has a significant impact on a site, both increasing the volume of the material present and changing the texture and appearance (Stein 2008:63). Changes in stratigraphy are used to determine changes in behavior: the rule of deposition states that material builds up over time, and without interference, newer material will build up on top of older material (Stein 2008). Shell near the bottom is often more fragmented than that near the surface due to taphonomic processes (Butzer 1982:39).

Three major excavation projects demonstrate extensive archaeological research efforts in Nuu-chah-nulth territories: Huu7ii on Diana Island (Huu-ay-aht First Nations) (McMillan and St. Claire 2012), and Ts'ishaa on Benson Island (Tseshaht First Nation) (Sumpter 2005), and Yuquot in Friendly Cove in Nootka Sound, on Nootka Island, one of the first major excavations on western Vancouver Island (Fournier and Dewhirst 1980; Clarke and Clarke 1980). All three are large and culturally important sites, and these projects were extensive and documented vast quantities of archaeological material. I only include Ts'ishaa and Huu7ii in my data analysis. They also resulted in comprehensive shell material analyses: Ts'ishaa (204T) has the most diverse profile of shellfish identified, due in large part to the time dedicated to this aspect of the project and the expertise of Ian Sumpter (2005). Similarly, Sumpter's work at Huu7ii resulted in an focused discussion of shellfish at this site, with the taxonomic composition of the

[4] Housed in the Department of Anthropology, University of Victoria

material unpacked in great detail (Sumpter 2012). Column and auger sampling remain the most common methods of material collection across the Northwest Coast (Cannon et al. 2008). Collection and analysis methods have an impact on results, including on comparability (Claassen 1998). Monks (2017) focused on climate change and adaptation of subsistence strategies in Nuu-chah-nulth history, with a particular attention to Toquaht Nation in western Barkley Sound, but did not focus on the relative abundance of shellfish.

Yuquot is a large site in Nootka Sound on Nootka Island, just off the western coast of Vancouver Island in Friendly Cove. The occupation at this site spans over 4000 years and is situated within the now amalgamated territory of Mowachaht and Muchalaht First Nations (Clarke and Clarke 1980:40). The zooarchaeological analysis at this site commenced in 1968 (Clarke and Clarke 1980:40) and included the first major analysis of barnacles in the Nuu-chah-nulth cultural region (Fournier and Dewhirst 1980). The invertebrate analysis at this site has been extensive and provides an example of detailed archaeological shellfish analysis. This site is not included in this analysis due to time constraints, but I do refer to this project as a source of knowledge and inspiration. I go into detail regarding the excavation and quantification methods performed for Ts'ishaa and Huu7ii in Table 3, but it is important to discuss the same factors from Yuquot as it is a site that has influenced archaeological research in the west coast of Vancouver Island since the late 1960s.

Clarke and Clarke report hundreds of sample units measured at 1.67 (5ft, 6") at Yuquot, along with large trenches (1980:41). Faunal material was then sorted into

mammal and bird (50% of the material[5]), fish (15%), and shellfish (35%), which included molluscs, barnacles, and sea urchin (1980:41). The shell material was sorted into gastropods, bivalves, and barnacles, identified, and weighed. The team also collected live molluscs from the closest permanent settlement at which they could obtain year-round assistance in the collection: Opitsat near Tofino, British Columbia (1980:41). A total of over 3000 living specimens were gathered over 1971, in order to understand the seasonality and dietary contribution of the archaeologically recovered molluscs (Clarke and Clarke 1980:41). The Yuquot project is also one of the few to directly discuss gooseneck (goose) barnacle: goose barnacles (identified as *Mitella polymerus*, synonymous with *Pollicipes polymerus*) are identified as ethnographically important, and although they have been consumed throughout the Nuu-chah-nulth region, they are not present archaeologically in Yuquot samples (Fournier and Dewhirst 1980:96). Additionally, the authors write that gooseneck and whale barnacles should or could be present if the remains survived, and imply that further sampling and quantification are necessary to see them (Fournier and Dewhirst 1980:96). MNI, meat weight, and shell weight were all employed at Yuquot (Fournier and Dewhirst 1980:93).

A 'semimicro' scale of analysis focuses on communities and the behaviours of individuals within those communities (Muir and Driver 2002:166), which can provide insight into community-level resource use across time. A collection of small samples collected at intervals going back in time (and down into the ground) can provide greater insight into this scale of deposition than larger samples have the ability to. The larger the assemblage (collection of samples collected from a site), the better the ability of the

[5] Likely by weight: not specified

material to "reflect the frequency and distribution of individual taxa" (Muir and Driver 2002:172). Smaller assemblages do not do this justice, and provide less insight into how a community uses resources (Muir and Driver 2002). While methods of excavation vary from site to site in the region (see Table 3), which influences sample and overall assemblage size as well as the results of quantitative analysis, the excavation and analysis methods used throughout the Nuu-chah-nulth region seem to follow these guidelines. Inter-site variation has an impact on how analyses can be performed across sites that have varying sample sizes and collection methods. The semimicro scale can be addressed through the analysis of many small, incremental samples over time, and through the application of ubiquity (presence vs. absence) (McKechnie 2013). Column, auger, and vibracore samples provide these incremental samples.

Description of Methods Across All 18 Sites

In this section I detail the individual research efforts addressed in this project. The 18 sites span the west coast of Vancouver Island and are all situated within the traditional territories of Nuu-chah-nulth nations. Excavation methods vary between the sites, as shown in Table 3. Some projects include multiple sites, and methods vary within projects.

Three distinct sites were excavated and analysed at Hesquiat Harbour: Yaksis Cave (DiSo-16), Loon Cave (DiSo-9), and Hesquiat Village (DiSo-1) (Calvert 1980). Yaksis Cave deposits were excavated by one metre square units and two 20 by 20cm columns, down to the cave floor (Calvert 1980:120). The evidence from this excavation suggested that this site was occupied approximately 740-530 years ago (1980:123). Loon Cave is larger and was a winter village, and even though the accumulation of deposits decreased the standing height of the cave there was no evidence found of deposits outside of the

cave entrance (1980:122). Calvert and team excavated deposits in 2m x 1m units and subsampled five 20cm by 20cm columns by screening these deposits through 2mm mesh. At both sites, the team collected vertebrate and invertebrate remains from the screens in the field in addition to during analysis of samples later. Loon Cave was occupied over approximately 1800-1000 years ago (1980:123). Hesquiat Village is a large shell midden, and the team excavated six units within a 2 x 2 m grid (1980:129). The deposits were screened using ¼ inch (6.35mm) mesh: the vertebrate remains, and some mollusc remains were collected (1980:129). Calvert (1980:133) argues that there are four cultural assemblages present with a mostly continuous deposition from approximately 1500-500 years ago (1980:123). Hesquiat Harbour groups merged during historic times to become one nation, taking the name of one of the important winter village sites, ḥiškʷi: Hesquiat is the anglicized spelling of ḥiškʷi·ʔath, "those who come from ḥiškʷi" (Turner and Efrat 1982:10).

Chesterman Beach (DgSi-67) is a shell midden site near present day Tofino that was excavated following road construction and clearing of a residential lot (Wilson 1994:7). After shovel testing, the team excavated 1x1m units and screened using 6.35mm (¼-inch) mesh nested in a 3.2mm ($^1/_8$ inch) mesh base to catch smaller remains, and 10x10cm column samples were collected from the side walls of the two units (Wilson 1994:8). The analysis of the shellfish consisted of weight based analysis of both the ¼-inch and 3mm column samples and starts out with a presence/absence record to "provide an economical overview of site content" (1994:24). A judgemental sample of shell was collected and it is unclear whether that sample was included in the analysis with the column samples

(Wilson 1994:8). The author concludes that this analysis suggests a non-winter occupation (1994:24) from 1270-1000 years ago (1994:27).

At Spring Cove in Ucluelet (DfSj-57), two 1 x 1m excavation units were placed near "disturbed" portions of the site and their placement was adjusted after human remains were found (Spady and Wigen 2008:12). One 10x10cm column sample was collected in 10cm levels from the south wall of Unit 1A (Spady and Wigen 2008:12).

The 1995/1996 sampling at Ts'ishaa (204T) on Benson Island focused on a single auger test (204T2) to a depth of 2.78m of midden terminating with beach sands starting at 278cm below surface (Sumpter and Fedje 1997:2). While four auger tests were performed (204T1-4), only the material collected from 204T2 was included in the reported faunal analysis (Sumpter and Fedje 1997:3). The shellfish analysis was restricted to all of the remains collected in the 6.35mm mesh and 25% of the remains from the 2mm mesh: the later was included to include smaller species such as urchin (1997:3). Later, Ian Sumpter analysed invertebrate material from three columns collected in 1999 (Unit S14-16/W25-27) and 2001 (Units S56-57/W50-52 and S62-64/W62-64) (Sumpter 2005). Column sample levels were collected in 10cm levels and wet screened through nested hands screens with four fraction sizes: 25mm, 12.5mm, 6.35mm, and 3mm (1", ½" ¼", and $^{1}/_{8}$" respectively) (Sumpter 2005). Approximately 30-50 percent of the #levels from the three columns were fully analysed for quantitative faunal data (Sumpter 2005).

Seven of the Barkley Sound sites fall under a single project: Maktl7ii (206T on Wouwer Island), Huumuuwaa (304T on Village Island), Shiwitis (82T on Gilbert Island), Lower Huts'atswilh (83T on Dicebox Island), Upper Huts'atswilh (129T on Dicebox Island), North Ch'ituukwachisht (131T on Cree Island), and South Ch'ituukwachisht

(132T on Cree Island) (McKechnie 2013). Weight was the primary method of analysis, identifying mussels, clams, and barnacles as the most abundant by weight and amounting to 98% of the shell material from the ¼-inch mesh: all other species fell into the remaining 2% (2013:270). That 2% included gastropods, urchin, and chitons: these are identified as lightweight and/or poorly preserving species (2013:272). Figure 7.8 (McKechnie 2013:276) compares the relative abundance by weight between the different sites in the project, demonstrating that mussel is far more abundant in a highly exposed site such as Makt7ii on Wouwer Island compared to a more sheltered site such as Shiwitis on Gilbert Island. Specific date ranges for individual sites are included in Table 3.

Kakmakimilh on Keith Island (DfSh-17, 306T) is situated in Tseshaht territory in the Broken Group Islands. It is relatively protected, nestled within the Broken Group archipelago. This thesis utilizes data from the 2017 and 2018 field school excavations: which I have presented in a report for the Bamfield Marine Sciences Centre as a student member of the Historical Ecology and Coastal Archaeology Field School (Efford 2017). The site has been dated to 4000-150 years before present with shell bearing sediments dating to within the past 2000 years (Smith et al. 2012:3; McKechnie et al. 2019). The site was recorded archaeologically in 1975 by Denis St. Claire, and there was been extensive mapping, recording, and limited sampling of the site since (Smith et al. 2012:3). I participated in intertidal mapping and clam garden assessment of this site in the summer of 2017. Although I only include data from the 2017 and 2018 excavations, in July 2019 the student excavation team uncovered geoduck at Kakmakimilh in a 500 year old clam bake, indicating that geoduck was consumed prior to European contact

(Titian 2019). The significance of this archaeologically novel species identification is not considered further in this thesis but indicates the importance of archaeological efforts to scrutinize shellfish assemblages.

Kiix7in is a historically important village in Huu-ay-aht territory which has two main components in which invertebrate analysis is a focus: House 10 (1612T1) and House 11 (1612T2). Kiix7in was at points the capital of the Huu-ay-aht First Nation and the site is of great significance (Huu-ay-aht First Nations 2000:33–35). Shellfish from two of six auger tests were analysed: Test 1612T1 from House 10 and Test 1612T2 from House 11, with 10cm diameters with levels taken approximately every 20cm (Sumpter et al. 2006:26). The material was screened through $^{1}/_{8}$ inch mesh screens (2006:26). House 10 has been dated to 500 years up until contact 200-150 years ago, and House 11 has been dated to 5,300 years up until the same contact period (Sumpter et al. 2006:17–18). The 5,300 years before present date comes from a percussion core sample that went 194-204cm below surface in House 11, and the lowest column sample level from the same house was taken from 180-200cm below surface. Although the dating material was not taken from the auger, it was taken in the same House area at a very similar depth, and is an associated date.

Huu7ii (DfSh-7) is located on Diana Island in the Deer Group Islands (see Figure 4). It is the village from which the Huu-ay-aht First Nation takes their name (Mackie and Williamson 2003:107). The village "is the centre of the traditional territory of the *Huu7iitath*, one of the formerly independent political units that amalgamated to form the modern Huu-ay-aht First Nations" (McMillan and St. Claire 2012:1). The site has two main components: the main village area and the back terrace. Two column samples were

excavated, one from Unit N10-12/E2-4 in House 1, and one from Unit N4-5/E0-2 from the back terrace (Sumpter 2012:191). House 1 (col. N10-12/E2-4) dates to 400-1200 years before present (2012:193), and the back terrace (col, N4-6/E0-2) dates to 5000-3000 years before present (2012:195). The team used 6.35mm and 3.2mm mesh screens to separate the bulk column samples, which yielded the shellfish remains addressed in this project (McMillan and St. Claire 2012). As at Ts'ishaa, Sumpter recognized that weight-based methods obscure non-bivalve molluscs (Sumpter 2012).

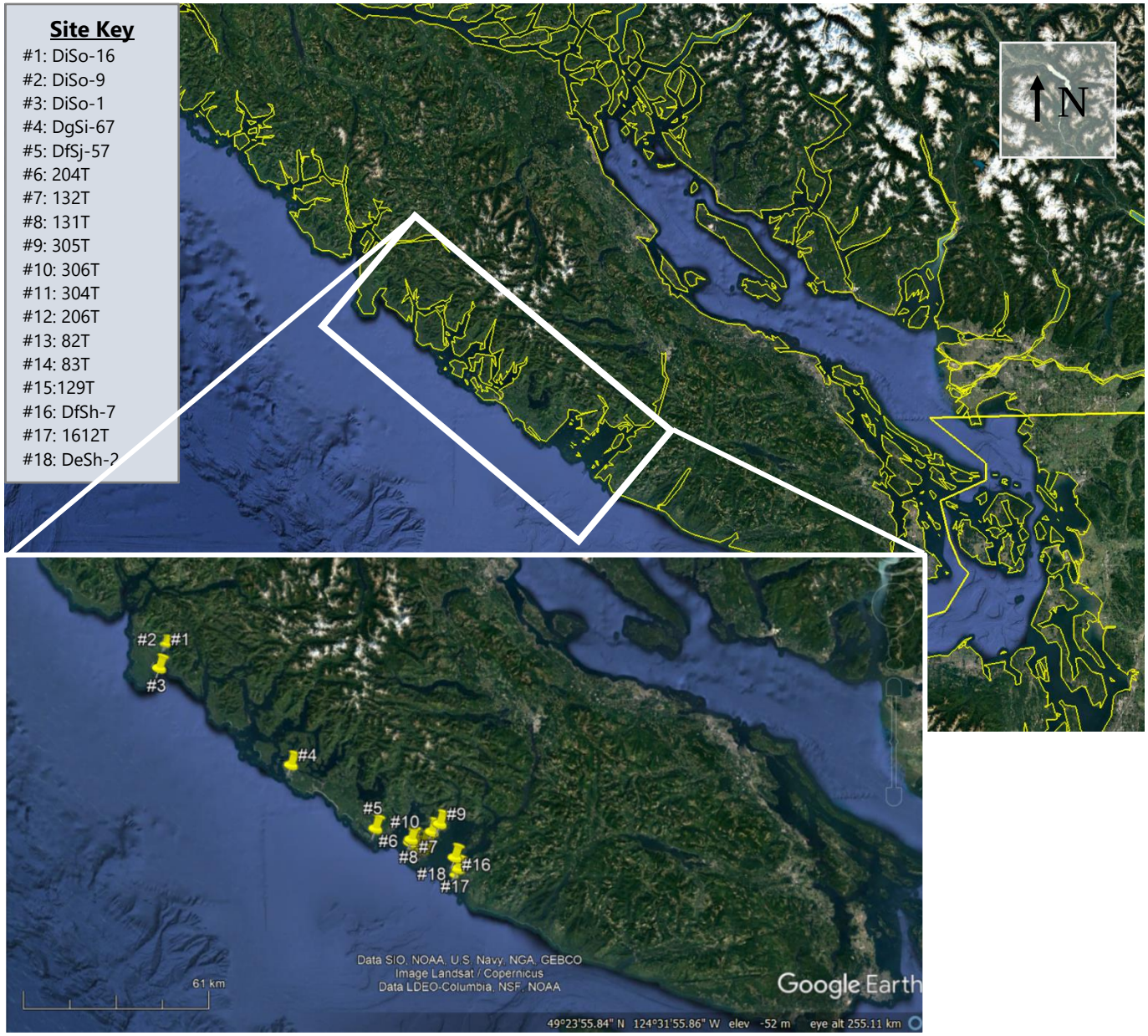


Figure 4: Map of study sites on Western Vancouver Island from Google Earth Pro with scale and source information

Table 3: List of Sites with Excavation and Regional Information

Region	**Site name**	**Site Number**	**References**	**Excavation Method/ Screen Size**	**Quantification Method**	**Estimated Date Range of faunal assemblage** (years Before Present)
Hesquiaht	Yaksis Cave, Hesquiat Harbour	DiSo-16	(Calvert 1980) - Excavation :Pages 118-133 - Quantification: Pages 142-204 - Dating: Pages 123	1 metre square units, 10cm arbitrary levels, ¼ in mesh	Weight	740-530
	Loon Cave, Hesquiat Harbour	DiSo-9		2x1m units, 5cm combined arbitrary/cultural levels, 2mm mesh		1800-1000
	Hesquiat Village	DiSo-1		2 metre square units, 10cm combined arbitrary/cultural levels, ¼ in mesh		1500-500
Tlaoquiaht	Chesterman Beach	DgSi-67	(Wilson 1994) - Excavation: Pages 7-8 - Quantification: Pages 24-26 - Dating: Page 27	1 metre square units, 5cm levels, 6.35mm and 3mm mesh, judgemental shell collection and column samples	Weight	1270-1000*
Ucluelet	Spring Cove	DfSj-57	(Spady and Wigen 2008) - Excavation: Pages 12-14 - Quantification: Pages 33-34, and Tables 11-14 on Pages 53-56 - Dating: Pages 59-60	1 metre square units, 10cm arbitrary levels, ¼ in mesh, column sample (10x10x10cm) of south wall of Unit 1A	Weight of remains	2000-500*
Tseshaht	*Ts'ishaa,* Benson Island	DfSi-16 (204T)	(Sumpter and Fedje 1997) - Excavation: Page 2 - Quantification: Pages 3-4 - Dating: Page 4	Four auger tests, sediments collected in bulk samples at 5-10cm increments	Weight from 6.4mm mesh and 25% of total 2mm mesh fraction	2000-1000 (auger)* 5000-3000 EPC 1800-250 LPC
			(Sumpter 2005) - Excavation: Page 136 - Quantification: Pages 136-138 - Dating: Pages 44-45 (Table 2) and 74-77 (Table 7)	Column samples collected during 1999 (Unit S14-16/W25-27) and 2001 (Units S56-57/W50-52, S62-64/W62-64)	Weight and umbo counts	
	Ch'ituukwachisht, Cree Island, North	131T	(McKechnie 2013) - Excavation: Pages 257, 266 - Faunal ID and Quantification: Pages 262, 266-267, Tables 7.1 and 7.2 - Dating: Table 6.3 on Pages 255-256	Auger samples, 6.35mm mesh	Weight Umbo MNI for bivalves	2200-800
	Ch'ituukwachisht, Cree Island, South	132T				2600-1300
	Tl'ihuuw'a, Nettle Island	305T				1150-750
	Shiwitis, Gilbert Island	DfSh-29 (82T)				1200-150
	Huumuuwaa, Village Island	DfSh-4 (304T)				3300-300
	Maktl7ii, Wouwer Island	DfSi-19 (206T)				1800-500

Region	Site name	Site Number	References	Excavation Method/ Screen Size	Quantification Method	Estimated Date Range of faunal assemblage (years Before Present)
	Huts'atswilh, Lower Dicebox Island	DfSh-31 (83T)				1000-500
	Huts'atswilh, upper Dicebox Island	DfSh-79 (129T)				500-200
	Kakmakimilh, Keith Island	DfSh-17 (306T)	(Efford 2017) - Excavation: Page 6 - Quantification: Pages 6-7 (Smith et al. 2012) - Dating: Page 3	(2017 and 2018 excavations) Column samples from excavation Units 7 and 8; ¼ inch and 2mm mesh	(2017-2019 analysis based on 2017 and 2018 excavations) Weight	2000-150
Huu-ay-aht	*Kiix7iin,* House 10	1612T1	(Sumpter et al. 2006) - Excavation: Pages 12 and 17 - Quantification: Page 25-28 and Appendix 5 - Dating: Pages 17-18, Tables 2 and 3	Auger coring: one each from House 10 and House 11; 10cm diameter, approx. 20cm intervals; ¼ and $^{1}/_{8}$ inch mesh	Weight	500-150
	Kiix7iin, House 11	1612T2				5300-150**
	HuuZii, Diana Island	DfSh-7	(McMillan and St. Claire 2012) - Excavation: Page 191 - Quantification: Pages 191-197 - Dating: Pages 33 and 93	Column samples from north wall of Unit N4-6/E0-2 and west wall of Unit N10-12/E2-4, shell recovered from 6.4mm and 3.2mm mesh	Weight	1200-400 (col. N10-12/E2-4) 5000-3000 (col, N4-6/E0-2)

*Date ranges informed by re-calibration using the Intcal 2013 curve in Calib 7.10 in June 2019 (Reimer et al. 2013)
**This date may not reflect oldest occupation date, which is likely not as old

Table 4: Individual sites with excavation and sample size factors (yellow to dark green gradient indicates a scale from small to large numbers)

Site name and location	Identification	Total weight of ID'd shellfish (g)	Total excavated volume (L)	N sample levels	N shellfish taxa
Yaksis Cave, Hesquiat Harbour	DiSo-16	5,230.60	4	1	20
Loon Cave, Hesquiat Harbour	DiSo-9	112,167.50	8	2	27
Hesquiat Village	DiSo-1	12,325	20	5	31
Chesterman Beach	DgSi-67	429.2	3.5	7	11
Spring Cove	DfSj-57	1,511.50	12	12	18
Ts'ishaa, Benson Island	DfSi-16 (204T)	45,659.5	76.7	39	60
Ch'ituukwachisht, Cree Island, North	131T	12.8	4	5	2
Ch'ituukwachisht, Cree Island, South	132T	507	15.1	19	6
Tl'ihuuw'a, Nettle Island	305T	99.8	5.9	7	10
Shiwitis, Gilbert Island	DfSh-29 (82T)	1,337	21.5	29	15
Huumuuwaa, Village Island	304T	1,495.5	17.4	33	14
Maktl7ii, Wouwer Island	206T	1856.1	40.9	61	14
Huts'atswilh, Lower Dicebox Island	DfSh-31 (83T)	9052.1	74.5	86	17
Huts'atswilh, Upper Dicebox Island	DfSh-79 (129T)	3838.7	120.6	129	17
Kakmakimilh, Keith Island	DfSh-17 (306T)	6,242.4	56.4	55	24
Kiix7iin, House 10	1612T1	539	3.9	5	13
Kiix7iin, House 11	1612T2	1,639.8	7.9	10	18
Huu7ii, Diana Island	DfSh-7	3420.4	8.4	7	19

Shellfish Recorded at Project Sites

All shellfish that were quantified and reported in the resources for the sites included in this study are listed in Table 5. The shellfish in Table 5 are organized by general taxa, with the exception of mussels in their own category. The distinction between mussels and other bivalves (mostly clams) is common in archaeological reporting of shellfish. Table 5 is not organized hierarchically. I identified 76 shellfish categories, including combined *misc.* and *all* categories, and some different common names that refer to the same scientific name, including but not limited to purple-hinged/giant rock scallop, rose-painted clam/rose-petal semele, and chocolate/fenestrate limpet (see Table 5). The category *Balanus sp.* refers to the 'large barnacle' and 'small barnacle' categories used at Ts'ishaa (Sumpter and Fedje 1997) and Spring Cove (Spady and Wigen 2008). Acorn barnacles (*Balanus glandula*) and thatched barnacles (*Balanus cariosus*) are listed separately because they are more specific categories. All *Tresus sp.* are listed under horse clams.

Table 5: List of all identified invertebrates across all 18 sites[6]

Category	Scientific Name	Common Name
Barnacles	*Balanus sp.*	
	Balanus cariosus	Thatched Barnacle
	Cryptolepas rhachianecti	Whale Barnacle
	Balanus glandula	Acorn Barnacles
	Pollicipes polymerus	Gooseneck Barnacles
Chitons	*Mopaliidae sp.*	
	Katherina tunicata	Black Katy Chiton
	Cryptohiton stelleri	Giant Western Fiery Chiton
	Cryptohiton stelleri	Giant Pacific Chiton
	Mopalia muscosa	Mossy chiton
	Tonicella lineata	Lined Chitons
	Cryptochiton stelleri	Butterfly Chiton

[6] This Table is not organized in any hierarchical manner.

Category	Scientific Name	Common Name
	Polyplacophora sp.	
Mussels	*Mytilus sp.*	
	Mytilus edulis	Bay Mussel
	Mytilus californianus	California Mussel
Marine Gastropods	*Haliotis kamtschatkana*	Northern Abalone
	Lirulara sp.	
	Tegula pulligo	Dusky Tegula
	Astraea gibberosa	Red turban snail
	Tegula funebralis	Black turban snail
	Lacuna sp	Winkles/Periwinkles
	Bittium eschrichtii	Giant Pacific Coast Bittium
	Bittium eschrichti	Eschricht's Bittium
	Bittium sp.	
	Lacuna variegata	Variegate lacuna
	Buccinidae sp.	Whelks
	Searlesia dira	Dire Whelk
	Amphissia sp.	
	Colubraria nitidula	Carpenter's dwarf triton
	Lirabuccinum dirum	Spindle whelk
	Ocinebrina lurida	Lurid Rocksnail
	Columbellidae sp.	Dovesnails
	Littorina sp.	Periwinkle
	Thais emarginata	Emarginate dogwinkle
	Thais lamellosa	Frilled Dogwinkle
	Nucella lima	File Dogwinkle
	Nucella canaliculata	Channeled Dogwinkle
	Nucella sp.	Dogwinkles
	Polinices lewisii	Lewis's Moon Snail
	Ceratostoma foliatum	Leafy Hornmouth Snail
	Olivella biplcata	Purple Olive
	Crepidula adunca	Hooked Slipper Snail
	Littidae sp.	
Urchins	*Strongylocentrotus purpuratus*	Purple Sea Urchin
	Strongylocentrotus droebachiensis	Green Sea Urchin
	Strongylocentrotus sp.	
Limpets	*Emarginula fissura*	Slit Limpet
	Megathura crenulata	Keyhole Limpet
	Acmaea testudinalis scutum	Plate limpet
	Acmaea pelta	Shield limpet
	Acmaea persona	Mask limpet

Category	Scientific Name	Common Name
	Acmaea digitalis	Finger Limpet
	Acmaea mitra	Whitecap Limpet
	Lottia digitalis	Ribbed Limpet
	Crepidula fornicata	Slipper Limpet
	Tectura fenestrata	Chocolate/Fenestrate Limpet
	Patellidae sp.	
Clams and other Bivalves	*Bivalvia sp.*	
	Hinnites multirugosus	Purple-hinged/Giant Rock scallop
	Chlamys hastata	Spiny Pink Scallop
	Glans carpenteri	Carpenter Carditid
	Hiatella sp.	Saltwater clams
	Siliqua patula	Razor Clams
	Clinocardium nuttalli	Basket Cockle
	Cardiidae sp.	
	Gamelia septentrionalis	Bittersweet Clam
	Protothaca staminea	Littleneck Clam
	Saxidomus giganteus	Butter Clam
	Hiatella sp.	Nesting Saxicave Clam
	Tresus sp.	Horse Clams
	Semele rubropicta	Rose-painted Clam or Rose-petal Semele
	Pododesmus cepio	Pearly Monia
	Macoma secta	Sand Clam
	Tellina bodegensis	Bodega Clam
	Solamen columbianum	BC Crenella

Methodological Context

Conventional Methods

This section details the most commonly utilized methods of analysis employed to understand shellfish in archaeological deposits. Different techniques result in different interpretations, and archaeologists globally seek to compensate for analytical bias and error (Glassow 2000; Mason et al. 1998; Mitchell 1990; Wessen 1988). One method commonly employed in zooarchaeology, and shellfish archaeology by extension, is minimum number of individuals (MNI). Traditional MNI (tMNI) calculates the minimum

number of individuals that accounts for all elements that identify a taxon. Another method is to use the non-repetitive element, or NRE-based, MNI. This method requires a pre-determined element, the NRE, that can be used to identify specimens to a taxon. To be as accurate as tMNI, NRE-based MNI relies on the NRE being intact in all specimens that are identifiable without a pre-determined element (Giovas 2009; Harris et al. 2015). Using these two methods on the same samples or assemblages will produce different results: the absolute difference between the results of tMNI and NRE-based MNI will increase with sample size (Giovas 2009). Another option is to tailor MNI to be assemblage-specific and reporting the modifications clearly (Harris et al. 2015). Fragile shellfish will require more identification elements than more robust specimens, for example, and increasing the ways in which we can identify a specimen increases the quantifiable abundance (2015). NISP, or number of identified specimens, is integral to calculating MNI.

Another method is weight-based quantification. This calculates for proportional mass, which raises concerns regarding differing robustness across species and assumed shell midden homogeneity (Mason et al. 1998). There is also the issue of what some archaeologists consider missing mass, the portion lost to decomposition, chemical dissolution, and the amount that passes through screens used in the field (1998). Compared to MNI calculations, weight-based calculations provide very different assessments of proportional abundance, which causes differing interpretations of shellfish historical ecology (ibid.). Weight-based quantification makes comparison difficult due to differing robustness between species (Glassow 2000): for instance, clams are usually hardy and robust shellfish, while abalone is highly fragile and breaks up into thin, light

fragments. Another option is to use these two methods together, as separately they may not be meaningful ways with which to understand taxonomic significance or prehistoric populations and environments. Both methods require updates and revisions, but they could possibly make up for the other's shortcomings if used together (Glassow 2000; Mason et al. 1998). Methodological shortcomings cause widely differing representations and interpretations of faunal material, which is problematic but expected in quantitative analysis.

Shortcomings in zooarchaeological analyses have been a recognized concern in archaeology for some time. The main concerns with are 1) the challenge of comparability both across assemblages and between taxa within an assemblage, 2) the lack of taxonomic assessment reliability and result accuracy, and 3) the unidentified portions of the samples or assemblages, and 4) the ways in which identified specimens relate to the meals that generated them (Mitchell 1990). Regional analyses of subsistence are difficult due to "the inconsistency of field methods and reporting" (Hanson 1991:378). Inconsistency may come from discrepancies across numerous factors, from identification and analysis to the fragility of many shellfish species. The unidentified portions can be anywhere from 25-80% of the assemblages across taxonomic groups, so it cannot be assumed that these portions will only include species and taxa already accounted for in the identified portion (Mitchell 1990). A solution utilized in the analysis of fish remains is the "five cranials and specials" identification method, which increases the types of elements that can be used to identify a species (Lambrides and Weisler 2015:844). The 'special' elements are those that are "selectively diagnostic to certain taxa" (Giovas and LeFebvre 2018:60). This approach could potentially decrease the amount of unidentified

shell material and would draw on the knowledge of the analysist regarding what elements are unique to a given species. One potential solution that Mitchell (1990) advocates is to limit identification to broad categories of fish, bird, sea mammal, and land mammal: this would drastically reduce the number of unidentified specimens but would also limit the options for comparing species and taxa (ibid.). These broad categories would also be insufficient for the purposes of historical ecology and ecosystem modelling. Live meat weight calculations are yet another quantification option. The goal of these methods is often to establish proportional abundance and to understand the relative significance of different types of food resources within and across sites (see Moss 1993). Dietary reconstruction is a limited use of zooarchaeological data, and techniques such as those outlined above can lack precision (Wessen 1988). In British Columbian archaeology there is often a seemingly binary approach to shellfish, broadly speaking, either as a staple food or a starvation alternative (Erlandson 2001; Wessen 1988). Some research has been done on cultural significance of shellfish based on distribution of deposition within archaeological sites: for example, looking at what species are present in and near higher versus lower social ranked houses within a community (Wessen 1988), and on the ritual deposition of shell material (Klokler 2017:653). The evidence on the Northwest Coast suggests that shellfish have been a staple in coastal diets for thousands of years. Shellfish are underrepresented and underappreciated in archaeological research efforts due to both archaeological techniques and cultural connotations (Moss 1993; Wessen 1988). Other resources, including birds and plants, are also highly underrepresented in archaeological inquiry. Although midden material is a focus of excavation, the methods that are used to quantify and understand midden material are behind those that address other protein

sources, like mammals and fish. Mitchell's concerns are as relevant now as they were in 1990, but they are not the focus of my research. However, the efforts made to highlight and address the concerns of zooarchaeological analysts provide the inspiration for comparative analysis of methods. I build on that approach by comparing and then combining two different methods of analysis to provide a different perspective on shellfish abundance.

Discussion

This chapter has sought to establish what the existing literature tells us about the value of shell middens as sources of historical ecological data, and to establish the common methods that archaeologists often employ in zooarchaeological analyses. This provides a foundation on which this thesis can examine a unique dataset that brings together a wide range of previously examined sites within the study region to see regional and local abundance trends.

Discussion of archaeological efforts to date

Sites with dedicated, comprehensive analysis of shellfish remains are scarce in the Pacific Northwest Coast, with most of those available dedicated to clams, clam gardens, and mussels, with a few notable exceptions (including but not limited to: Butler et al. 2019; Moss and Erlandson 2010). Shellfish are understudied relative to the number of projects excavating archaeological sites and midden material. Excavations at relatively large sites, like Ts'ishaa and Huu7ii, resulted in vast amounts of material. At Ts'ishaa, 163 m^3 was excavated from the main village (McMillan and St. Claire 2005:40) and 44.7 m^3 was excavated from the back terrace (2005:72), and yet only 43.7 kg of shellfish was identified and quantified (Sumpter 2012:138). At Huu7ii, 124.9 106.1 m^3 was excavated

from House 1 (McMillan and St. Claire 2012:28) and 18.8 m3 from the back terrace (2012:91), but only 3.4 liters of shellfish was identified and quantified (Sumpter 2012:191). Considering the size of these sites (both over 15,000 m^2) the fact that much less than 1% of excavated material is analyzed means that an infinitesimally small amount of shellfish has been identified from the deposits preserved at these sites. Such extremely small sample sizes are quite relevant to the observations and interpretations of taxonomic richness. Moreover, at most sites, like Ts'ishaa Huts'atswilh, Kiixin, and Huu7ii, the time investment required for shellfish analysis meant that a only a portion all of the relevant samples recovered could be subjected to analysis of shell material: instead, every other level was analysed in order to save time while still analysing as much of the site deposits as possible (McKechnie 2013). Some important Nuu-chah-nulth sites, like the Toquaht sites T'ukw'aa and Ch'uumat'a (McMillan 2000) are not included in this project due to the lack of shellfish identified and quantified. Yuquot (Clarke and Clarke 1980; Fournier and Dewhirst 1980) is another important Nuu-chah-nulth site that has not been included due to time constraints of this thesis project.

So, *what do shell middens on the West Coast of Vancouver Island tell us about the harvesting and management of shellfish resources in Nuu-chah-nulth traditional territory?* Shell middens are archives of information on the historical ecology of the communities in which they are created and maintained. They preserve the remains of many dietary resources, including fish, mammals, birds, and shellfish. The material collected from shell middens provides information on what shellfish have been consumed over time, and how the role of those shellfish changes over time. While previous research has unpacked what has influenced our perceptions of shellfish as a marine resource, this

thesis demonstrates that there are far more shellfish present and commonly utilized than weight-based measures alone have led us to believe. Conventional methods of analysis, including minimum number of individuals (MNI), number of identified specimens (NISP), and comparable weights, attempt to establish which faunal species are most abundant relative to others. The relative abundance can then be used to answer questions surrounding resource use. The application of ubiquity does not take away from that goal. Establishing relative abundance should not be at the expense of less abundant or highly fragile shellfish becoming recognized as marine resources that have been harvested over hundreds or thousands of years. Using ubiquity can provide an opportunity to compare the relative abundance of different resources without Shell middens accumulate over long periods of time and can provide valuable information about community utilization of an interaction with intertidal resources.

Chapter three focuses on a methodological comparison between weight-based and ubiquity-based analysis of the relative abundance of identified shellfish. I unpack the "other" shellfish component of middens, which often only make up 1-5% of the midden material when quantified by weight, and test to see if adding identified material from smaller fraction sizes has an effect on the total abundance of the gooseneck barnacles specifically.

Chapter Three: Towards a new archaeological framework for measuring the relative abundance of shellfish through a methodological comparison

Introduction

In this chapter, I show that shellfish are a vital resource in coastal diets on the western coast of Vancouver Island and have been for thousands of years. I argue that shellfish are an underappreciated resource archaeologically, and this has influenced their status as a marine resource. Shell middens are massive accumulations of primarily human harvested shell material as well as fish, bird, and mammal bones, and are found in abundance in coastal Indigenous settlements in British Columbia. These deposits can take thousands of years to accumulate into large landforms altering the shape of shorelines. The presence of a shell midden alone suggests that shellfish were consumed consistently over a long period of time. The goal of this research is to provide scientific evidence of traditional shellfish use to support Nuu-chah-nulth asserted rights to access and manage shellfish resources in their territory and to highlight a greater range of resource use than is currently considered in academic and legal arenas. Additionally, by using a historical ecological framework (Beller et al. 2017), this project focuses on shellfish taxa that are underrepresented in archaeological discourse by applying a simple archaeological quantification method to a combination of existing and new data from western Vancouver Island. Indigenous shellfish harvesting is a largely untapped source of knowledge that can inform discussions of Indigenous access to, and management of, marine resources in both the past and present (Cannon et al. 2008; Lepofsky and Caldwell 2013; Lepofsky et al. 2015; Moss 2011). I emphasize the wide variety of shellfish species that were harvested and consumed over thousands of years. I address gooseneck barnacles as a case study,

due to their perceived insignificance archaeologically using conventional weight-based methods and recent popularity in high-end restaurants in Canada and the United States. Canadian restaurants source their gooseneck barnacles from Ha'oom through bulk supplier Hub City Fisheries (personal communication, Nuu-chah-nulth Fisheries Department July 4, 2019) when they can afford them: Marben, a restaurant in Toronto, Canada, used to serve Nuu-chah-nulth goosenecks on their menu, but they are currently too expensive (personal communication, Marben Restaurant, July 5, 2019).

Shellfish are a globally vital source of nutrition (Erlandson 2001). Yet there are contradictory perspectives on shellfish archaeologically, compared to other protein sources (Moss 1993). Many shellfish taxa, especially gooseneck barnacles, appear to be rare in the archaeological record based on weight-based quantification biases, in which gooseneck barnacles are dwarfed by comparatively more robust and abundant bivalves such as clams and mussels. Regularity of use can be quantified through ubiquity (i.e., percent presence) by accounting for the frequency of each taxon in small archaeological samples taken widely across archaeological sites, providing a big-picture of community use across time and space (McKechnie and Moss 2016). Combining ubiquity with existing weight-based measures provides a more robust understanding of the variety of shellfish that have played a dietary role in Nuu-chah-nulth territories.

Gooseneck barnacles are a traditional food in Nuu-chah-nulth territories, and are harvested with mussels (Ellis and Swan 1981; Nuu-chah-nulth Tribal Council 2010:14). Ethnographic records and present-day Nuu-chah-nulth harvesting show regular use of gooseneck barnacles, but they are absent, or recorded in very small amounts, in most archaeological assemblages due to the small size and fragile composition of their shell

plates (Fournier and Dewhirst 1980). Weight-based quantification methods, and a common focus on large fragments, result in gooseneck barnacle plates being lost or under recorded. Because of this, weight-based quantification has the analytical consequence of dramatically under-representing the abundance of individual species and a host of similar fragile taxa. Weights are recorded to the second decimal place in grams, and gooseneck plates can weigh less than 0.01g. It may take over a dozen plates to register a whole number on the scale.

Building on my (Efford 2017) and my supervisor Iain McKechnie's (McKechnie 2013) ongoing research in the Broken Group Islands, this chapter develops measures of ubiquity (frequency of occurrence) for a variety of rare shellfish taxa across many depositional contexts and site assemblages on western Vancouver Island (McKechnie and Moss 2016). This project integrates data from over 350 previously processed fine-screen auger and vibracore samples from eight sites tested spanning the past 2,500 years, and ongoing research conducted by the University of Victoria (UVic) archaeological field school. In addition, I gather data from previously conducted faunal analysis tables from academic publications and archaeological reports. This research is logistically supported by a collaboration plan between the Tseshaht First Nation, Pacific Rim National Park Reserve, the Bamfield Marine Sciences Centre, and the UVic Department of Anthropology (Tseshaht First Nation et al. 2017). In this chapter I ask:

2. *Will applying ubiquity calculations to the existing weight measures of archaeological shellfish provide a different perspective of comparison? What differences, if any, are there between the profile of shellfish harvested and consumed between weight-based measures and ubiquity-based measures?*

Specifically, I demonstrate differences between the weight-based and ubiquity-based perspectives of relative abundance. The degree of difference between these perspectives

is established through the comparison of overall weight, percent presence, and the visual representation of taxonomic richness data using figures and tables. In this work, a 'profile' is the menu of all taxonomically distinct shellfish that can be identified as present in a given sample, regardless of the proportional amount. The purpose of the profile approach is to illustrate the range of species represented in a given site, and therefore reflecting the community harvest and consumption. A second related question I examine in this chapter asks:

3. *How do zooarchaeological sampling and sample recovery methods, such as displaced volume, screen size, and sample type (auger, column, unit), influence the comparative abundance and presence of target species?*

To address this question, I conduct two quantitative analyses that will be connected to the context of each site: I compare the relative abundance of all identification categories recorded across the 18 sites included in the project first by weight and then by ubiquity value, which is calculated using the recorded weights reported in the data tables and publication(s) relevant to each site. The sampling and recovery methods will be connected to the results of the analysis to determine whether that context has any influence on the relative abundance of shellfish. A more thorough examination of shellfish, highlighting a previously underrepresented richness in the archaeological record, is necessary to understanding the continuity of coastal subsistence practices. This project therefore contributes to improving archaeological shellfish analyses and supports Indigenous rights to harvest and exchange marine resources. Table 6 below shows a complete list of the sites included in this research, organized from North to South.

Historical Ecology

The theoretical framework on which this project is built was described in more detail in chapter two. Historical ecology incorporates relationships inherent in ecosystems but

connects this to human cultural practices that in turn have environmental consequences. Its value is that it "can address long-term changes to population size, density, distribution, and structure" at the population level, and trophic connections at the community level (Beller et al. 2017:646). The deep time perspective on human interactions with their local ecology, particularly regarding resource use, is the strength of this framework at the ecosystem level (2017:646) and is foundational to the approach I take here.

Zooarchaeology

This research draws on foundational quantitative archaeological work (Grayson 1984; Lyman 1986, 2015, 2017). Lyman argues that since the zooarchaeological record is finite, it "should be used to the fullest extent possible" (Lyman 2017:349). Archaeological shell remains are not utilized to the fullest extent possible. While time consuming, analysis of smaller fraction sizes is important to understanding the taxonomic composition of archaeological deposits, and the dietary contribution of resources in the past. Laundry lists, or species lists, are described by Lyman as lists of identified species with their quantification values (reported weights, number of skeletal elements, etc.), with little to no analysis (Lyman 2015:43). They are a starting point in that they are usually an initial step, but not a form of analysis themselves. If the report does not address the anthropological components, including dietary contribution, seasonality, procurement, and exploitation factors, then it is a laundry list (Lyman 2015:43–44). While I only address these factors in brief in this thesis, what I present here is more than merely a list in that I am focusing on the methodological analysis, rather than a standard site report format. However, the portion of this thesis that is a laundry or species list is valuable: "laundry lists have always been and likely always will be a part of zooarchaeological research in part because the data they contain have analytical value" (Lyman 2015:48).

It can be argued that rank orders (see Table 9 and Table 11) are ordinal scales of analysis because they involved "an ordering of discrete categories into *a meaningful sequence of classes ranked along a continuum*" (emphasis original) (Gifford-Gonzalez 2018:389). An example of a ratio scale by contrast would be the discrete measurement of faunal remains using detailed quantification methods, in which "*zero is a fixed point in relation to the scale established*" (emphasis original) (2018:389). The application of ubiquity falls in a grey zone: while there is a fixed point of zero in relation to the scale of presence, and there is an exact value between one measurement and another, ubiquity values are not nearly as detailed as weights or MNI. Ubiquity is most detailed when applied within a single site and calculated across many small samples. It is less appropriate and vague when applied using just a fewer large samples. Establishing relative abundance of resources is an important part of zooarchaeological analysis. While ubiquity and weight based analyses provide very different assessments of overall relative abundance across all identified taxa in the region, the three most abundant shellfish resources are the same between the two methods (see Table 9 and Table 11) and I believe that the use of MNI would likely yield the same result.

In addition to issues of quantification variability, zooarchaeologists struggle with variation in recovery methods. American and Canadian archaeologists still primarily use ¼ inch (6.35mm) screens, which compromises the amount of material that is analysed and resulting analysis (Grayson 1984:168–172), despite adoption of smaller screen sizes in England, Spain, South Africa, and elsewhere. Perhaps this is due to the fact that the discipline of zooarchaeology is relative young in English-speaking North America compared to Europe (Grayson 1984:1). Despite variation in methods, zooarchaeology

seeks to address fundamental resource management and engagement questions through time (Grayson 1984:16).

Study Region and Site

Table 6: Individual sites with identification and assemblage characteristics

Region	Site name	Site Number	Excavation type	Avg displaced vol. excavated per sample (L)	Total weight of shellfish identified (g)
Hesquiaht	Yaksis Cave, Hesquiat Harbour	DiSo-16	Unit Sample	4.0	5,230.6
	Loon Cave, Hesquiat Harbour	DiSo-9	Unit sample	4.0	112,167.5
	Hesquiat Village	DiSo-1	Unit sample	4.0	12,325.0
Tlaoquiaht	Chesterman Beach	DgSi-67	Column sample	0.5	429.2
Ucluelet	Spring Cove	DfSj-57	Column sample	1.0	1,511.50
Tseshaht	*Ts'ishaa*, Benson Island	DfSi-16 (204T)	Column sample (2005) Auger (1995)	2.0	45,659.50
	Ch'ituukwachisht, Cree Island, North	131T	Auger	0.8	12.8
	Ch'ituukwachisht, Cree Island, South	132T	Auger	0.8	507
	Tl'ihuuw'a, Nettle Island	305T	Auger	0.8	99.8
	Shiwitis, Gilbert Island	DfSh-29 (82T)	Auger	0.7	1,337
	Huumuuwaa, Village Island	DfSh-4 (304T)	Auger, matrix	0.5	1,495.50
	Maktl7ii, Wouwer Island	DfSi-19 (206T)	Auger	0.7	1856.1
	Huts'atswilh, Lower Dicebox Island	DfSh-31 (83T)	Auger	0.9	9052.1
	Huts'atswilh, Dicebox Island	DfSh-79 (129T)	Auger, Excavation unit	0.9	3838.7
	Kakmakimilh, Keith Island	DfSh-17 (306T)	Column sample (2017/2018) Auger (2013)	1.0	6,242.40
Huu-ay-aht	*Kiix7iin*, House 10	1612T1	Auger	0.785	539
	Kiix7iin, House 11	1612T2	Auger	0.785	1,639.80
	Huu7ii, Diana Island	DfSh-7	Column sample	1.2	3420.4
NOTE: See Table 3 in chapter two, page 34 for excavation, quantification, and dating reference details for all sites					

Methods

This project draws data from published articles, books, and archaeological permit reports as well as student field work at the archaeological site of Kakmakimilh (306T) on Keith Island over the 2017 and 2018 field seasons. I am involved in the quantitative analysis and identification of the samples from Kakmakimilh. In addition to the regional data collection and analysis, I also include an identification verification of five of the sites, processing a sub-sample of the 2mm fractions to determine whether the addition of the 2mm fraction size would significantly increase the abundance of gooseneck barnacles. The recovery and quantification methods reported for each site are summarized below.

Recovery methods

Table 6 above shows all of the sites included in this research, listed from north to south and organized by sub-region. Because all of the sites in this study are drawn from different projects, the recovery methods vary. There is some overlap in researchers and technicians involved, excavation type, and the average displaced volume of the excavated sample. Some factors are displayed in Table 6. This aids in the assessment of possible factors that influence the presence or absence of target shellfish at a given site. The table shows that auger samples do not exceed 1 litre in the average displaced volume of the excavated sample. Rather, column and unit samples tend to result in larger average displaced volumes. The three Hesquiat Harbour sites (DiSo-16, DiSo-9, and DiSo-1) are outliers in the recovery method, with larger average displaced volume of the excavated samples, and larger total weight of shellfish identified. Rather than use column samples or auger tests to collect data, the excavation team used unit sampling (Calvert 1980:118–

133). This resulted in larger samples and far more material, with fewer samples overall. The variation in recovery methods makes it difficult to apply a fine-grained quantification method (such as weight) and compare across sites with much accuracy of results. For example, weight-based analyses will favour sites with more material excavated and quantified because there is more material weighed, compared to sites with many small samples. Ubiquity simply addresses what is present and in how many contexts those identified species or taxa are present, without a bias towards how much there is. The issue of inconsistent methods is not entirely overcome through the use of ubiquity, but it does allow those species that are not automatically favoured by weight-based methods to be compared to those that are on a purely presence/absence model.

Quantification methods

Taxonomic Identification

The identification of shell remains across all samples and sites within this study was based on morphological characteristics of shellfish to taxa and/or to species, using reference collections and zoological reference materials, performed by zooarchaeologically trained analysts. There is some variation in how the weights or percentage of overall weight of each identified grouping is reported, but they are all translatable into a single method of weight in grams, to species or group (indeterminate mussel, indeterminate clam). With the exception of the 2017 work done at Kakmakimilh (306T), and the additional 2mm fraction size analysis of samples from Maktl7ii (Wouwer Island), I was not involved in the actual shellfish identification for these sites but compiled and integrated previously collected and reported data. As a faunal analyst, I learned to identify those morphological characteristics of shellfish through hands-on practice, with the aid of shellfish identification guides (Harbo 1997, 2011), beach

collected specimens, and advice from Iain McKechnie and retired lab instructor Rebecca Wigen. These guides contained photographs of live shellfish, not archaeological specimens.

Weight Based Abundance

Once separated into identification categories, faunal remains are usually weighed on a scale to an accuracy of two decimal points in grams. Weights are one of the most commonly utilized method of quantification in shell analysis in the Pacific Northwest. Reported weights for identified shellfish were drawn from archaeological publications, including permit reports and scholarly articles. These weights were consolidated into a single spreadsheet with corresponding context information, including column sample level depth and radiocarbon dates when available. Weight-based quantitative analysis of shellfish remains is common practice in the Pacific Northwest, and all the data sources for this project use weights or weight percentages that could be translated into weights by dividing by total reported weights. Indeterminate/all categories do not include others that would normally fall under that if they are identified separately: for example, gooseneck barnacles are not included under the indeterminate/all barnacle category if they are reported separately. The individual samples within each site could then be compared within and across sites. Each site was analysed separately with the same questions, listed below in Table 3, to provide a basis for comparison. The results from asking these questions are explored in the Results section below.

Ubiquity: Frequency of Occurrence

It is important to critique conventional tools and continually question why methods and frameworks are used to ensure that we are aware of the biases and limitations of our work. This project combines two methods, weight and ubiquity, to address the limitations

of both methods. Ubiquity measures regularity of use, or percent presence, by accounting for the frequency of each taxon in small archaeological samples (McKechnie and Moss 2016). These can be taken widely across archaeological sites, providing a big-picture of community use across time and space. Frequency is measured by accounting for presence or absence of a taxon, for example, in each sample, and then calculating the "percentage of contexts in which a certain item is present or absent" (McKechnie 2013:262). The following formula describes the process of calculating ubiquity (U) by dividing the number of times a taxon is present (N_{taxon}) by the total number of contexts in which it could be present (N_{total}). Ubiquity is more commonly applied as a quantitative measure in paleoethnobotany and paleobotany (Lepofsky and Lyons 2003; Pearsall 2000:192) which allows small, light plant and seed remains to be quantified.

$$U_{taxon} = N_{taxon}/N_{total}$$ (Diehl 2017:197)

The concept of abundance usually invokes an impression of a copious quantity, rather than simply a frequency of occurrence, which could also be described as saturation. Relative abundance is the concept with which archaeologists conceive of and discuss resources, and so it is the term I use here. However, I recognize that gooseneck barnacles, while frequently occurring and seemingly commonly consumed (see Table 7 and Table 11), are not apparent in copious quantities the way mussels and clams are.

Ubiquity is not a new method, but it is one not often employed by zooarchaeologists, and is a straightforward way in which to compare the frequency of occurrence across taxa (McKechnie 2013:263-264). It also allows for this information to be compared across and within sites using small samples, which is beneficial for larger sites or multi-site studies (McKechnie 2013; McKechnie and Moss 2016). If a taxon can be identified, it can be

counted as present in a frequency across a number of examined contexts. In this way, more rare or fragile shellfish are less likely to be outweighed by the hardier, more bulky shellfish. A strength of this method is that it is a straightforward approach to considering the regularity of use across multiple periods at a site or multiple sites within regions. Any identifiable species or taxon can be marked as present, either during weight or count based quantification often from existing data tables commonly reported in zooarchaeological analyses. When performed on column, auger, or repetitive bulk samples, each individual sample is analysed as a depositional moment. Rather than separating out fraction sizes with nested geological sieves, all mesh sizes can be combined when examined or reported whether in weights, counts, MNI, or another method. Even small fragments or whole gooseneck barnacle plates that may otherwise be too light to register on a conventional scale can be recorded as present.

A drawback of ubiquity is that it is best suited to many small samples rather than few large samples (McKechnie and Moss 2016:472). For example, column and auger sample are often 10 times smaller than excavation unit levels (e.g., a typical column sample level is 1 liters compared to 100 liters in a 10-cm level in a 1x1 m excavation unit unit), and provide many more instances of deposition (spatially discrete samples) than the unit samples which tend to aggregate larger volumes. Column, bulk, and auger samples are intentionally incremental, contained samples. Auger samples, however, can be smaller in volume than column samples, which will have an impact on the taxonomic richness of the sample (see Sample Size and Presence of Shellfish sub-section in

Results). Weight, MNI, and NISP measures the abundance of identified taxa in a higher resolution than ubiquity in that they provide a very detailed assessment of how much

material is present in a quantified sample. Ubiquity simply records the presence and should be used in combination with another more detailed method of quantification (i.e. weight, etc.) to ensure that future analysis of reported data is possible.

The ubiquity value, or percent presence, is the number of times a taxon is present, divided by the number of times it could possibly be present. In shell midden deposits where shellfish consistently occur even in small volume samples, this measure can be used as a proxy for the regularity of a specific taxonomic use as it accounts for the occurrence of this taxa across a range of archaeological contexts within a site or among many sites across a region (Lepofsky and Lyons 2003; McKechnie and Moss 2016). Target shellfish are marked as present or absent in a table or list in every sample. Ubiquity can provide a broader perspective on the range of consumed species, rather than placing a heavy emphasis quite literally on a small number of abundant shellfish that were only part of a larger menu. While this thesis focuses on one of the many shellfish species that have been consumed by Nuu-chah-nulth communities, my goal is not to argue that gooseneck barnacles are one of the most important contributors to the diet: rather, I use gooseneck barnacles as an example of a species that has been underappreciated as a result of weight-based measures, when they clearly have been an important regularly harvested resource for millennia. The majority of the ubiquity analyses included in this project are focused on establishing a spatial understanding of gooseneck barnacle use throughout Nuu-chah-nulth territory.

Fraction Size and Abundance

The standard screen size for zooarchaeological quantification in the Pacific Northwest is ¼ inch, or 6.35mm (James 1997:385; Stewart and Wigen 2003:27), nested into 2mm and then 1mm screens, the contents of which are rarely quantified. This is the case

despite recognition that “substantial amounts of faunal and other materials” are not represented in this larger fraction size (James 1997:385). The standard in England is to used nested 4mm, 2mm, and 1mm screens, and to process the smaller fraction sizes for identifiable shell elements (Campbell 2017:275–282). Since the 1970s, the standard for processing shell remains in South Africa has been to use $^{1}/_{8}$ inch (3.2mm) and ½ inch (12.7mm) screens (Jerardino 2014:58). An important study in Spain found that gooseneck plates were found in 8mm, 4mm, and 2mm screens, with a vast difference in the size of those remains (Álvarez-Fernández et al. 2013:1374). More plates were found in the 1mm fraction size, but were too fragmented to be used in that particular study (Álvarez-Fernández et al. 2013:1375). Outside of the Pacific Northwest, analysis of smaller screen sizes (smaller than ¼ inch) appears to be much more common.

Table 7 shows the results of a verification test I performed on five of the sites to determine if the addition of smaller fraction sizes would increase the ubiquity of gooseneck barnacles. The purpose of this test was to evaluate the degree to which screen size influences the ubiquity of target species or taxa. The effectiveness of this process would be established if the test results in a notable increase in the abundance of the target species. Shellfish were identified and weighed from ¼-inch mesh and bagged by the original analysis, and I analysed a portion of the 2mm fractions from a range of auger sample bags in order to evaluate the degree to which there is an increased ubiquity of gooseneck barnacles. The goal was to look at a minimum of 25% of the total samples from each of the five sites (Table 7). The only site for which fewer than 25% are included is Huts’atswilh (83T, Lower Dicebox Island) due to time constraints. Only 12% of Huts’atswilh was tested. The results of this test discussed in the Results section below

(Table 7). The 2mm samples were selected randomly and not based on the presence or absence of identified gooseneck barnacle in the 6.35mm data reported. The whole 2mm sample was emptied into a paper lined tray and assessed for the presence of gooseneck barnacle plates. All plates were removed and weighed: if remains were too light to register on the digital scale used, they were estimated to weigh 0.01g to ensure their presence was noted. These sites are all within the Barkley Sound region, in Tseshaht First Nation territory (McKechnie 2013).

An experiment published by Gordon observed a six-fold increase in total sample size by using $^{1}/_{8}$ inch screens compared to the ¼ inch screens (1993:455). While these larger samples take more time to analyse, "the use of smaller screen fraction provides a more representative sample" compared to samples containing only larger screen fractions (1993:458). James reported a faunal assemblage loss of 75% through ¼ inch screens at Maricopa Road, a site in Arizona (James 1997:395). When 6.35mm and 2.8mm screen fraction sizes are compared rather than combined, they provide a very different perspective of relative abundance at Kosapsom, a Coast Salish site at the south of Vancouver Island: the larger screen size emphasizes mammals, and the smaller emphasizes fish (Stewart and Wigen 2003:29–31).

Screen size is an important influencing factor for the quantification of invertebrate remains. Smaller fraction sizes not only catch more material, in particular fragmentary and smaller sized remains, but they also influence the end result of the quantitative analysis (Hanson 1991:379). While it is unreasonable to expect large-scale archaeological projects to use smaller (3mm, 2mm, and 1mm) screen fraction sizes due to the time constraints of most projects, I argue that the addition of small-scale secondary analyses of

smaller screen sizes may have a significant impact on the results of the project's quantitative analysis of zooarchaeological remains. This is not an issue limited to invertebrate remains: fish vertebrae and other small, thin bones and otoliths are often too small to be caught by 6.35mm screens, and herring is an example of a fish common to the west coast of Vancouver Island whose remains are un-emphasized by larger screen sizes (Hanson 1991:379).

Results

2mm Fraction Size Test

For this 2mm fraction size test (see Table 7), if the capitular places were too light to register on the scale used for this analysis, they were recorded as 0.01g to ensure their presence was noted. This is often the case even when many plates are found in a sample, as many plates do not always weigh 0.01g or more. Because of this, the precise weights for trace amounts of shellfish are estimates, but the percent presence is accurate. Gooseneck barnacles plates vary in size, both due to their placement relative to other plates on the live animal and due to age and size differences between harvested animals. If all the plates in a sample are of a similar size, a whole live barnacle has approximately 5 (Álvarez-Fernández et al. 2013:1373) large plates and many more smaller, triangular plates (the later of which do not appear archaeologically). The total number of plates could be divided by the approximate number of plates per individual barnacle to assess how many whole animals the remains represents. The increase in ubiquity in the righthand column of Table 7 shows that examining even a portion of the 2mm samples can provide in most cases almost or more than double the frequency of gooseneck barnacles, which demonstrates that this species has been far more frequently utilized than previously estimated. For all five sites, this test resulted in an increase in the abundance

of gooseneck barnacles. Assessing the ubiquity of a single species is a straightforward and relatively quick method of establishing a broad understanding of abundance.

Proportionately Most Abundant Shellfish by Weight

In this section I discuss the proportionally most abundant shellfish by weight at each site, and then across all sites to show possible regional patterns. Table 8 shows the reported weights for all identified shellfish from all sites, and Figure 5 compares the abundance of the top 20 shellfish by rank order (weight-based) with their ubiquity values. This demonstrates how different the results of abundance are between weight-based and ubiquity-based analyses. Table 8 lists the reported weights for all identified taxa, combined within sites to provide a single weight per taxon. I do not include the various miscellaneous categories that are often included to represent the unidentified portion of the assemblage (misc. clam, misc. shell). Although these are important to report, they are not necessary for my analyses. Table 10 is organized identically to Table 8, which provides the sample abundancy information but by weight. The presence of a taxon in Table 10 is based on the reported presence by weight. This is a site-based comparison, without adjusting for chronology. The total weights of each taxon in the righthand column shows the total weight reported for that taxa across all 18 sites. The very bottom right unit of Table 8 shows the total weight reported across all taxa and all sites: 202.8kg. While that number represents a very large study sample, it does not represent all of the shellfish remains that were present across all sites, only a percentage. Some shell material that was collected has never been analysed, and not all shell material is excavated. It also does not include the unidentified shell or shell that was identified in a general clam category. The total amount of identified shell without those categories in represented in the final row of Table 8 and ranges a great deal for each site. With this data we can also

more easily see the relative rank order, showing which taxa are more abundant by weight compared to the others. Table 9 shows the rank order of all identified shellfish taxa by weight. The section and tables following that address these same questions through ubiquity, which has a drastic impact on the rank order of all taxa. The most highly ranked shellfish by weight is butter clam, with *Mytilus sp.* coming in a close second. The total weight of the third shellfish, littleneck clam, is less than half of that of *Mytilus sp.* Mussels are listed as a separate category than other bivalves, and limpets are listed in their own category rather than being listed under marine gastropods in general. This is due both to trends in organization of invertebrate data in faunal tables, and in discussions of mussels and clams, and limpets and gastropods, as separate and distinct resources. The majority of the bivalves are clam species.

Table 7: 2mm Gooseneck Barnacle ID and abundance test

Site Name	Site ID	# of 2mm samples examined	% of 2mm samples examined	Gooseneck Ubiquity 6.35 mm	Combined 6.35 & 2mm Ubiquity	Ubiquity Increase w/ fine screen
Maktl7ii, Wouwer Island	206T	16/61	26%	18%	31%	+13%
Kakmakimilh, Keith Island	306T	15/55	27%	11%	24%	+13%
Shiwitis, Gilbert Island	82T	8/27	30%	7%	26%	+19%
Tl'ihuuw'a, Nettle Island	305T	7/7	100%	14%	29%	+15%
Huts'atswilh, Dicebox Island, Lower Village	83T	22/85	21%	38%	45%	+7%

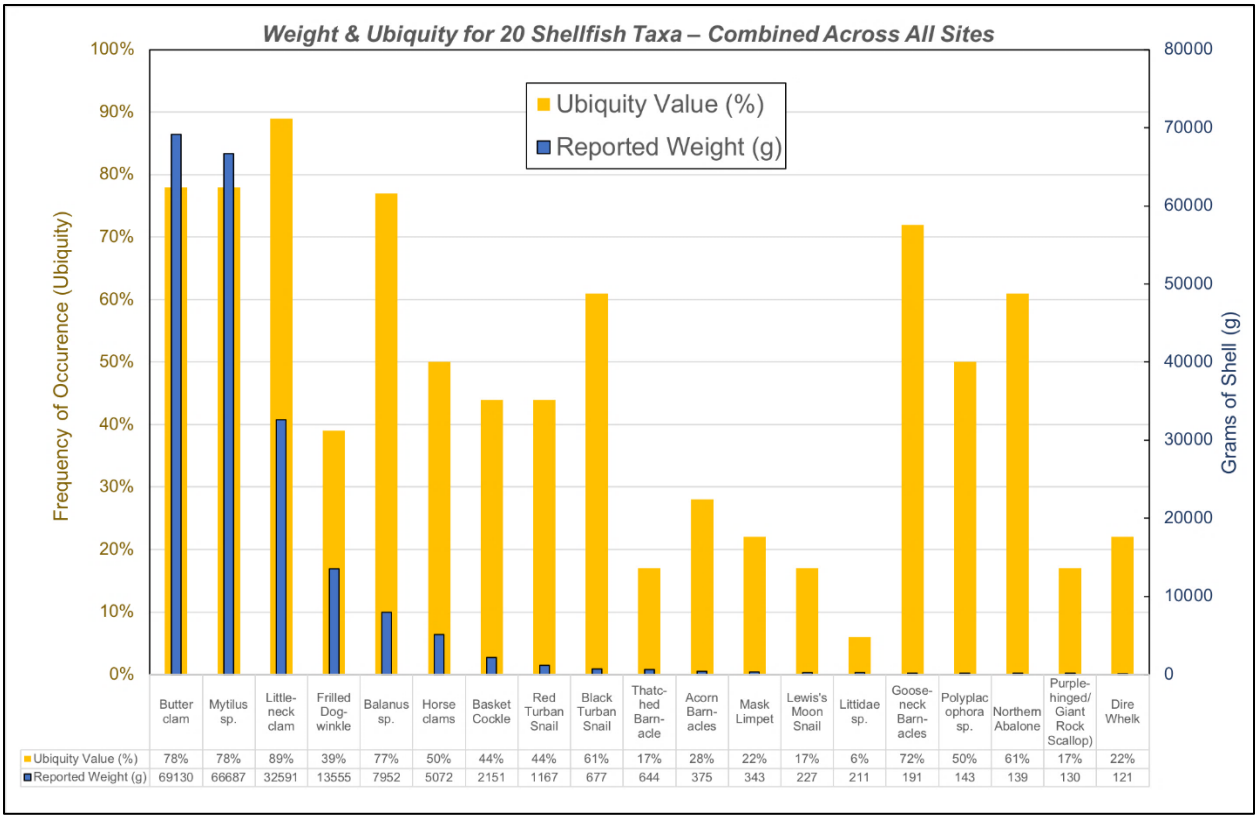


Figure 5: Compared abundance by weight and ubiquity by rank order top 20 by weight. Ubiquity values are shown in yellow-orange and weights are shown in blue.

Figure 5 shows the top 20 shellfish ranked by weight and compares that to the ubiquity value of the same taxa. The abundance by weight is shown in the blue bars, and the abundance by ubiquity is shown in the orange bars. The only two shellfish taxa that have a similar reflection of abundance are butter clam and *Mytilus sp.*, all other shellfish are far less abundant by weight than they are by ubiquity. Frilled dogwinkle stands out as an unexpectedly abundant shellfish by weight, but the grand majority (13,498.5g, over 99%) of this species comes from the three Hesquiat Harbour sites (DiSo-16, DiSo-9, DiSo-1). The analysts on the projects at these three sites, like *Ts'ishaa,* analysed a larger quantity of shell than the others. The total weight for each shellfish across all sites is presented in the far-right column, coloured light grey, of Table 8.

Table 8: Shellfish present by weight for all sites with total weights at far-right column (by taxon) and bottom row (by site)

		Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	Ts'ishaa, Benson Island	Ch'ituukwachisht, Cree Island, North	Ch'ituukwachisht, Cree Island, South	Tl'ihuuw'a, Nettle Island	Shiwitis, Gilbert Island	Huumuuwaa, Village Island	Kakmakimilh, Keith Island	Maktl7ii, Wouwer Island	Huts'atswilh, Dicebox Island, Lower Site	Huts'atswilh, Dicebox Island	Kiix7in House 10	Kiix7in House 11	Huu7ii, Diana Island	
		Site	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T1	1612T2	DfSh-7	**Total Weight in grams**
Barnacles	*Balanus sp.*		4.0	1.4	121.0	22.8		2843.3		64.7	7.7	189.1	375.4	468.3	436.1	2085.4	1049.2				7668.4
	Balanus sp.	Large Barnacle					153.2	54.4													207.6
	Balanus sp.	Small Barnacle					5.5	70.2													75.7
	Balanus cariosus	Thatched Barnacle		440.7	202.6									0.5							643.8
	Balanus hesperius	Whale Barnacle			0.9																0.9
	Balanus glandula	Acorn Barnacles			0.2									3.6				50.9	230.8	89.3	374.8
	Pollicipes polymerus	Gooseneck Barnacles					24.9	108.1		0.3	0.2	0.9	1.5	1.6	10.5	25.3	8.6	0.3	7.2	1.3	190.7
Chitons	*Mopaliidae sp.*					0.0		50.0						7.4							57.4
	Katherina tunicata	Black Katy Chiton		5.8			2.9	46.9										5.8	11.6	0.7	73.7
	Cryptohiton stelleri	Giant Western Fiery Chiton						47.7													47.7
	Cryptohiton stelleri	Giant Pacific Chiton																	9.4		9.4
	Mopalia muscosa	Mossy chiton		3.1				10.6													13.7
	Tonicella lineata	Lined Chitons						8.7													8.7
	Cryptochiton stelleri	Butterfly Chiton	8.2	10.6																	18.8
	Polyplacophora sp.	.									0.1	12.1	3.6	1.1	24.4	56.6	45.0		0.3	0.1	143.3
Mussels	*Mytilus sp.*			2.4	15.4			336.4	12.1	437.4	52.9	627.8	608.9	27.4	1116.0	4784.3	1747.8			2103.3	11872.1
	Mytilus trossulus	Bay mussel	58.1	1611.8	3.6		7.5	38.1													1719.1
	Mytilus californianus	California Mussel	100.8	5252.6	1440.7	373.9	1058.0	38890.3						2321.9				390.1	2107.2	1160.5	53096

		Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	Ts'ishaa, Benson Island	Ch'ituukwachisht, Cree Island, North	Ch'ituukwachisht, Cree Island, South	Tl'ihuuw'a, Nettle Island	Shiwitis, Gilbert Island	Huumuuwaa, Village Island	Kakmakimilh, Keith Island	MaktlZii, Wouwer Island	Huts'atswilh, Dicebox Island, Lower Site	Huts'atswilh, Dicebox Island	Kiix̲7in House 10	Kiix̲7in House 11	Huu7ii, Diana Island	
		Site	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T1	1612T2	DfSh-7	**Total Weight in grams**
Marine Gastropods	*Haliotis kamtschatkana*	Northern Abalone	6.3		7.3			48.9				5.7	22.8	25.5	2.1	12.4	0.4	0.1	0.2	6.8	138.5
	Lirulara sp.							11.8													11.8
	Tegula pulligo	Dusky Tegula						21.7						0.0							21.7
	Astraea gibberosa	Red turban snail		989.7				100.8			16.8	5.4	0.4	33.0		9.2	11.3				1166.6
	Tegula funebralis	Black turban snail	26.3	470.7	86.6		2.1	13.1				4.6	0.2	3.6		69.9	0.2			0.1	677.4
	Lacuna sp	Winkle/Periwinkle				0.3	0.1														0.4
	Bittium eschrichtii	Giant Pacific Coast Bittium						11.8						0.0							11.8
	Bittium eschrichti	Eschricht's Bittium		0.1										0.0							0.1
	Bittium sp.							15.3		2.6	0.3	24.0	4.6	4.2	20.8	13.7	4.8				90.3
	Lacuna variegata	Variegate lacuna						30.4													30.4
	Buccinidae sp.	Whelks												1.3							1.3
	Searlesia dira	Dire Whelk	10.7	93.7	5.4		10.7														120.5
	Amphissia sp.							15.3													15.3
	Colubraria nitidula	Carpenter's dwarf triton						8.7													8.7
	Lirabuccinum dirum	Spindle whelk						9.5													9.5
	Ocinebrina lurida	Lurid Rocksnail			0.1			11.6													11.7
	Columbellidae sp.	Dovesnails						31.1													31.1
	Littorina sitkana	Periwinkle		9.4	0.6			25.3								1.5	0.5				37.3
	Thais emarginata	Emarginate dogwinkle	3.1	7.9	11.2			18.5													40.7
	Thais lamellosa	Frilled Dogwinkle	728.3	11650.9	1119.3		0.4	28.4										6.2	12.4	9.5	13555.4

		Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	Ts'ishaa, Benson Island	Ch'ituukwachisht, Cree Island, North	Ch'ituukwachisht, Cree Island, South	Tl'ihuuw'a, Nettle Island	Shiwitis, Gilbert Island	Huumuuwaa, Village Island	Kakmakimilh, Keith Island	Maktl7ii, Wouwer Island	Huts'atswilh, Dicebox Island, Lower Site	Huts'atswilh, Dicebox Island	Kiix7in House 10	Kiix7in House 11	Huu7ii, Diana Island	
		Site	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T1	1612T2	DfSh-7	**Total Weight in grams**
	Nucella lima	File Dogwinkle			2.1			8.7													10.8
	Nucella canaliculata	Channeled Dogwinkle			0.7			43.9											0.6	0.9	46.1
	Nucella sp.						0.1	11.8					0.9	40.3		2.0	1.8	0.2	0.4		57.5
	Polinices lewisii	Lewis's Moon Snail	101.7	105.0	20.2																226.9
	Ceratostoma foliatum	Leafy Hornmouth Snail	4.4					1.2													5.6
	Olivella biplcata	Purple Olive		1.6	3.9																5.5
	Crepidula adunca	Hooked Slipper Snail			0.1			19.3													19.4
	Littidae sp.						0.2	52.0						157.9					0.3	0.6	211
Urchins	*Strongylocentrotus purpuratus*	Purple Sea Urchin						55.3										0.1	0.2	1.4	57
	Strongylocentrotus droebachiensis	Green Sea Urchin						15.1											0.4		15.5
	Strongylocentrotus sp.				7.8	0.1	0.2	57.6				0.1		0.3	3.7	2.0	0.4	0.1	0.9	2.5	75.7
Limpets	*Emarginula fissura*	Slit Limpet						12.0													12
	Megathura crenulata	Keyhole Limpet						19.1													19.1
	Acmaea testudinalis scutum	Plate limpet		1.9	9.2			18.4													29.5
	Acmaea pelta	Shield limpet	3.5	18.8	3.2			8.7													34.2
	Acmaea persona	Mask limpet	0.4	291.3	23.7			27.1													342.5
	Acmaea digitalis	Finger Limpet	0.2	20.1	0.5																20.8
	Acmaea mitra	Whitecap Limpet						8.7											0.1		8.8
	Lottia digitalis	Ribbed Limpet						38.2											0.1		38.3
	Crepidula fornicata	Slipper Limpet						12.7													12.7

		Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	Ts'ishaa, Benson Island	Ch'ituukwachisht, Cree Island, North	Ch'ituukwachisht, Cree Island, South	Tl'ihuuw'a, Nettle Island	Shiwitis, Gilbert Island	Huumuuwaa, Village Island	Kakmakimilh, Keith Island	MaktlZii, Wouwer Island	Huts'atswilh, Dicebox Island, Lower Site	Huts'atswilh, Dicebox Island	Kiix̲7in House 10	Kiix̲7in House 11	Huu7ii, Diana Island	
		Site	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T1	1612T2	DfSh-7	**Total Weight in grams**
	Tectura fenestrata	Chocolate/Fenestrate Limpet						4.0													4
Bivalves	*Patellidae sp.*													2.1					0.2		2.3
	Hinnites multirugosus	Purple-hinged Scallop (i.e. rock/giant rock scallop)		104.9	18.9			6.6													130.4
	Chlamys hastata	Spiny Pink Scallop																	0.1		0.1
	Glans carpenteri	Carpenter Carditid						11.8													11.8
	Hiatella sp.	Saltwater clams					0.1	28.3													28.4
	Siliqua patula	Razor Clams				7.2															7.2
	Clinocardium nuttalli	Basket Cockle	381.4	733.0	980.6		9.7	30.9						8.8				2.2	4.5		2151.1
	Cardiidae sp.					6.1							2.7	16.6	0.2	6.3	2.8			0.1	34.8
	Gamelia septentrionalis	Bittersweet Clam						14.7													14.7
	Protothaca staminea	Littleneck Clam	1506.0	28392.6	1349.2	1.6	168.7	126.2			8.2	81.1	45.7	636.9	17.3	86.2	38.2	37.7	92.4	3.0	32591
	Saxidomus giganteus	Butter Clam	1834.6	59151.9	5577.0		40.5	587.4			2.0	6.4	43.4	1494.2	1.6	293.1	84.1		11.2	2.7	69130.1
	Hiatella sp.	Nesting Saxicave Clam																		0.4	0.4
	Tresus sp.	Horse Clams	444.3	2750.8	1306.1			145.5						390.3		23.5	52.1	8.5	20.0		5141.1
	Semele rubropicta	Rose-painted Clam or Rose-petal Semele	4.4																		4.4
	Pododesmus cepio	Pearly Monia	3.9	44.8																	48.7
	Macoma secta	Sand Clam			6.6																6.6
	Tellina bodegensis	Bodega Clam			0.3																0.3

		Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	Ts'ishaa, Benson Island	Ch'ituukwachisht, Cree Island, North	Ch'ituukwachisht, Cree Island, South	Tl'ihuuw'a, Nettle Island	Shiwitis, Gilbert Island	Huumuuwaa, Village Island	Kakmakimilh, Keith Island	MaktlZii, Wouwer Island	Huts'atswilh, Dicebox Island, Lower Site	Huts'atswilh, Dicebox Island	Kiix̲7in House 10	Kiix̲7in House 11	Huu7ii, Diana Island	
		Site	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T1	1612T2	DfSh-7	**Total Weight in grams**
	Solamen columbianum	BC Crenella						11.8													11.8
		Total weight	5230.6	112167.5	12325	412	1484.8	44283.9	12.1	505	88.2	957.2	1110.1	5646.8	1632.7	7471.4	3047.2	502.2	2510.5	3383.2	202770.4

Table 9: Rank Order of All Identified Taxa by Weight

Scientific Name	Common Name	Total Weight	Rank order
Saxidomus giganteus	Butter Clam	69130.1	1
Mytilus sp.		66687.2	2
Protothaca staminea	Littleneck Clam	32591	3
Thais lamellosa	Frilled Dogwinkle	13555.4	4
Balanus sp.		7951.7	5
Tresus sp.	Horse Clams	5141.1	6
Clinocardium nuttalli	Basket Cockle	2151.1	7
Astraea gibberosa	Red turban snail	1166.6	8
Tegula funebralis	Black turban snail	677.4	9
Balanus cariosus	Thatched Barnacle	643.8	10
Balanus glandula	Acorn Barnacles	374.8	11
Acmaea persona	Mask limpet	342.5	12
Polinices lewisii	Lewis's Moon Snail	226.9	13
Littidae sp.		211	14
Pollicipes polymerus	Gooseneck Barnacles	190.7	15
Polyplacophora sp.	.	143.3	16
Haliotis kamtschatkana	Northern Abalone	138.5	17
Hinnites multirugosus	Purple-hinged/Giant Rock Scallop	130.4	18
Searlesia dira	Dire Whelk	120.5	19
Bittium sp.		90.3	20
Strongylocentrotus sp.		75.7	21
Katherina tunicata	Black Katy Chiton	73.7	22
Nucella sp.		57.5	23
Mopaliidae sp.		57.4	24
Strongylocentrotus purpuratus	Purple Sea Urchin	57	25
Pododesmus cepio	Pearly Monia	48.7	26
Cryptohiton stelleri	Giant Western Fiery Chiton	47.7	27
Nucella canaliculata	Channeled Dogwinkle	46.1	28
Thais emarginata	Emarginate dogwinkle	40.7	29
Lottia digitalis	Ribbed Limpet	38.3	30
Littorina sitkana	Periwinkle	37.3	32
Cardiidae sp.		34.8	32
Acmaea pelta	Shield limpet	34.2	33
Columbellidae sp.	Dovesnails	31.1	34
Lacuna variegata	Variegate lacuna	30.4	35
Acmaea testudinalis scutum	Plate limpet	29.5	36
Hiatella sp.	Saltwater clams	28.4	37
Tegula pulligo	Dusky Tegula	21.7	38
Acmaea digitalis	Finger Limpet	20.8	39
Crepidula adunca	Hooked Slipper Snail	19.4	40
Megathura crenulata	Keyhole Limpet	19.1	41
Cryptochiton stelleri	Butterfly Chiton	18.8	42
Strongylocentrotus droebachiensis	Green Sea Urchin	15.5	43
Amphissia sp.		15.3	44
Gamelia septentrionalis	Bittersweet Clam	14.7	45

Scientific Name	Common Name	Total Weight	Rank order
Mopalia muscosa	Mossy chiton	13.7	46
Crepidula fornicata	Slipper Limpet	12.7	47
Emarginula fissura	Slit Limpet	12	48
Lirulara sp.		11.8	49
Bittium eschrichtii	Giant Pacific Coast Bittium	11.8	49
Glans carpenteri	Carpenter Carditid	11.8	49
Solamen columbianum	BC Crenella	11.8	49
Ocinebrina lurida	Lurid Rocksnail	11.7	55
Nucella lima	File Dogwinkle	10.8	56
Lirabuccinum dirum	Spindle whelk	9.5	57
Cryptohiton stelleri	Giant Pacific Chiton	9.4	58
Acmaea mitra	Whitecap Limpet	8.8	59
Tonicella lineata	Lined Chitons	8.7	60
Colubraria nitidula	Carpenter's dwarf triton	8.7	60
Siliqua patula	Razor Clams	7.2	62
Macoma secta	Sand Clam	6.6	63
Ceratostoma foliatum	Leafy Hornmouth Snail	5.6	64
Olivella biplcata	Purple Olive	5.5	65
Semele rubropicta	Rose-painted Clam or Rose-petal Semele	4.4	66
Tectura fenestrata	Chocolate/Fenestrate Limpet	4	67
Patellidae sp.		2.3	68
Buccinidae sp.	Whelks	1.3	69
Balanus hesperius	Whale Barnacle	0.9	70
Lacuna sp	Winkle/Periwinkle	0.4	71
Hiatella sp.	Nesting Saxicave Clam	0.4	71
Tellina bodegensis	Bodega Clam	0.3	72
Bittium eschrichti	Eschricht's Bittium	0.1	73
Chlamys hastata	Spiny Pink Scallop	0.1	73

Most Ubiquitous Taxa by Number of Examined Contexts (ubiquity)

In this section I explore the proportionally most abundant shellfish by weight at each site, and then across all sites and identify preliminary regional patterns. Table 10 presents the presence of all identified shellfish across all 18 sites, combined across samples and depth (time). It is a spatial presentation of taxa presence. The far righthand column provides the ubiquity value of each taxon: the number of sites in which a taxon is identified is divided by 18. The bottom row of Table 10 presents the total number of taxa identified at each site. Some patterns are clear in Table 10: mussels are present in all sites, along with barnacles and clams in all but one under-analysed site (131T). *Ts'ishaa* on Benson Island (204T) has the most abundant collection of shellfish, with 55 taxa identified. This site had extensive faunal analyses performed, including shellfish, and this makes it stand out from the other sites.

Table 9 and Table 11 present the rank orders of identified taxa by weight and ubiquity, respectively. I combined some categories for ease of understanding and to eliminate taxonomically overlapping species (i.e. misc. barnacles, small barnacles, and large barnacles are now all under *Balanus sp.*). The top three shellfish have shifted, with *Mytilus sp.* now the most abundant at 100% present across all sites. This represents a more accurate picture of what we see in the field. It also means that it is not just clam gardens that are providing an important source of easily accessible protein, but also the lower reaches of the intertidal zone on the rocks. We now see that some of the less abundant shellfish (when assessed by weight) are actually more frequently present than previously appreciated: abalone, gooseneck barnacles, and *Strongylocentrotus sp.* now seem to be much more abundant. These are all shellfish that are frequently underappreciated by interpretations based on methods that also fail to appreciate the ever-

present mussel. We can group this rank order now into the top 20, which are all present at least 22% of the time: this calculation includes all individual samples across all sites. If we think about what humans consume and the remains they discard and consider an item that is present 20-25% of the time, these are not insignificant uses. In fact, they are consistently present in depositional events (small volume samples) meaning they may have been likely consumed and discarded every week, possibly daily, or even multiple times a day. Further, we can look at only the top five: *Mytilus sp.*, littleneck clam, butter clam, *Balanus sp.*, and gooseneck barnacles. Previously, gooseneck barnacle was ranked as 15th amongst many other taxa. This is a significant difference in perspective: gooseneck barnacles are far more abundant than analyses by weight can appreciate.

Table 10: Shellfish presence by ubiquity for all sites with total percentages at far right column (by taxon) and bottom row (by site)

		Site Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	*Ts'ishaa*, Benson Island	*Ch'ituukwachisht*, Cree Island, North	*Ch'ituukwachisht*, Cree Island, South	*Ti'ihuuw'a*, Nettle Island	*Shiwitis*, Gilbert Island	*Huumuuwaa*, Village Island	*Kakmakimilh*, Keith Island	*Maktl7i*, Wouwer Island	*Huts'atswilh*, Dicebox Island, Lower Site	*Huts'atswilh*, Dicebox Island	*Kiix7in*, House 10	*Kiix7in*, House 11	*Huu7ii*, Diana Island	
		Site ID	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T	1612T	DfSh-7	**Percent Presence**
Barnacles	*Balanus sp.*		x	x	x	x	x	x		x	x	x	x	x	x	x	x				77%
	Balanus cariosus	Thatched Barnacle		x	x									x							17%
	Cryptolepas rhachianecti	Whale Barnacle			x																6%
	Balanus glandula	Acorn Barnacles			x									x				x	x	x	28%
	Pollicipes polymerus	Gooseneck Barnacles					x	x		x	x	x	x	x	x	x	x	x	x	x	72%
Chitons	*Mopaliidae sp.*					x		x						x							17%
	Katherina tunicata	Black Katy Chiton		x			x	x										x		x	28%
	Cryptohiton stelleri	Giant Western Fiery Chiton						x													6%
	Cryptohiton stelleri	Giant Pacific Chiton																	x		6%
	Mopalia muscosa	Mossy chiton		x				x													11%
	Tonicella lineata	Lined Chitons						x													6%
	Cryptochiton stelleri	Butterfly Chiton	x	x																	11%
	Polyplacophora sp.										x	x	x	x	x	x	x		x	x	50%
Mussels	*Mytilus sp.*			x	x			x	x	x	x	x	x	x	x	x	x			x	72%
	Mytilus trossulus	Bay mussel	x	x	x		x	x													28%
	Mytilus californianus	California Mussel	x	x	x	x	x	x						x				x	x	x	56%
Marine Gastropods	*Haliotis kamtschatkana*	Northern Abalone	x		x			x				x	x	x	x	x	x	x		x	61%
	Lirulara sp.							x													6%
	Tegula pulligo	Dusky Tegula						x													6%
	Astraea gibberosa	Red turban snail		x				x			x	x	x	x		x	x				44%
	Tegula funebralis	Black turban snail	x	x	x		x	x				x	x	x		x	x			x	61%
	Lacuna sp	Winkles/Periwinkles				x	x														11%

		Site Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	*Ts'ishaa*, Benson Island	*Ch'ituukwachisht*, Cree Island, North	*Ch'ituukwachisht*, Cree Island, South	*Ti'ihuuw'a*, Nettle Island	*Shiwitis*, Gilbert Island	*Huumuuwaa*, Village Island	*Kakmakimilh*, Keith Island	*Makutl7ii*, Wouwer Island	*Huts'atswilh*, Dicebox Island, Lower Site	*Huts'atswilh*, Dicebox Island	*Kiix7in*, House 10	*Kiix7in*, House 11	*Huu7ii*, Diana Island	
		Site ID	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T	1612T	DfSh-7	**Percent Presence**
	Bittium eschrichtii	Giant Pacific Coast Bittium						x													6%
	Bittium eschrichti	Eschricht's Bittium		x																	6%
	Bittium sp.							x		x	x	x	x	x	x	x	x				50%
	Lacuna variegata	Variegate lacuna						x													6%
	Buccinidae sp.	Whelks												x							6%
	Searlesia dira	Dire Whelk	x	x	x		x														22%
	Amphissia sp.							x													6%
	Colubraria nitidula	Carpenter's dwarf triton						x													6%
	Lirabuccinum dirum	Spindle whelk						x													6%
	Ocinebrina lurida	Lurid Rocksnail			x			x													11%
	Columbellidae sp.	Dovesnails						x													6%
	Littorina sp.	Periwinkle		x	x			x								x	x				28%
	Thais emarginata	Emarginate dogwinkle	x	x	x			x													22%
	Thais lamellosa	Frilled Dogwinkle	x	x	x		x	x										x		x	39%
	Nucella lima	File Dogwinkle			x			x													11%
	Nucella canaliculata	Channeled Dogwinkle			x			x											x	x	22%
	Nucella sp.	Dogwinkles					x	x					x	x		x	x	x			39%
	Polinices lewisii	Lewis's Moon Snail	x	x	x																17%
	Ceratostoma foliatum	Leafy Hornmouth Snail	x					x													11%
	Olivella biplcata	Purple Olive		x	x																11%
	Crepidula adunca	Hooked Slipper Snail			x			x													11%
	Littidae sp.							x													6%
Urchins	*Strongylocentrotus purpuratus*	Purple Sea Urchin						x										x		x	17%

		Site Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	*Ts'ishaa*, Benson Island	*Ch'ituukwachisht*, Cree Island, North	*Ch'ituukwachisht*, Cree Island, South	*Tl'ihuuw'a*, Nettle Island	*Shiwitis*, Gilbert Island	*Huumuuwaa*, Village Island	*Kakmakimilh*, Keith Island	*Makutl7ii*, Wouwer Island	*Huts'atswilh*, Dicebox Island, Lower Site	*Huts'atswilh*, Dicebox Island	*Kiix7in*, House 10	*Kiix7in*, House 11	*Huu7ii*, Diana Island	
		Site ID	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T	1612T	DfSh-7	**Percent Presence**
	Strongylocentrotus droebachiensis	Green Sea Urchin						x											x		11%
	Strongylocentrotus sp.				x	x	x	x				x		x	x	x	x	x	x	x	67%
Limpets	*Emarginula fissura*	Slit Limpet						x													6%
	Megathura crenulata	Keyhole Limpet						x													6%
	Acmaea testudinalis scutum	Plate limpet		x	x			x													17%
	Acmaea pelta	Shield limpet	x	x	x			x													22%
	Acmaea persona	Mask limpet	x	x	x			x													22%
	Acmaea digitalis	Finger Limpet	x	x	x																17%
	Acmaea mitra	Whitecap Limpet						x											x		11%
	Lottia digitalis	Ribbed Limpet						x											x		11%
	Crepidula fornicata	Slipper Limpet						x													6%
	Tectura fenestrata	Chocolate/Fenestrate Limpet						x													6%
	Patellidae sp.					x								x					x		17%
Bivalves	*Hinnites multirugosus*	Purple-hinged/Giant Rock scallop		x	x			x													17%
	Chlamys hastata	Spiny Pink Scallop																	x		6%
	Glans carpenteri	Carpenter Carditid						x													6%
	Hiatella sp.	Saltwater clams					x	x													11%
	Siliqua patula	Razor Clams				x															6%
	Clinocardium nuttalli	Basket Cockle	x	x	x		x	x						x				x	x		44%
	Cardiidae sp.					x							x	x	x	x	x			x	39%
	Gamelia septentrionalis	Bittersweet Clam						x													6%
	Protothaca staminea	Littleneck Clam	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	89%
	Saxidomus giganteus	Butter Clam	x	x	x		x	x			x	x	x	x	x	x	x		x	x	78%

		Site Name	Yaksis Cave Hesquiat Harbour	Loon Cave Hesquiat Harbour	Hesquiat Village	Chesterman Beach	Spring Cove	*Ts'ishaa*, Benson Island	*Ch'ituukwachisht*, Cree Island, North	*Ch'ituukwachisht*, Cree Island, South	*Tl'ihuuw'a*, Nettle Island	*Shiwitis*, Gilbert Island	*Huumuuwaa*, Village Island	*Kakmakimilh*, Keith Island	*MakuTii*, Wouwer Island	*Huts'atswilh*, Dicebox Island, Lower Site	*Huts'atswilh*, Dicebox Island	*Kiix7in*, House 10	*Kiix7in*, House 11	*HuuTii*, Diana Island	
		Site ID	DiSo-16	DiSo-9	DiSo-1	DgSi-67	DfSj-57	DfSi-16 (204T)	131T	132T	305T	82T	304T	DfSh-17 (306T)	DfSi-19 (206T)	DfSh-31 (83T)	DfSh-79 (129T)	1612T	1612T	DfSh-7	**Percent Presence**
	Hiatella sp.	Nesting Saxicave Clam																		x	6%
	Tresus sp.	Horse Clams	x	x	x			x						x		x	x	x	x		50%
	Semele rubropicta	Rose-painted Clam or Rose-petal Semele	x																		6%
	Pododesmus cepio	Pearly Monia	x	x																	11%
	Macoma secta	Sand Clam			x																6%
	Tellina bodegensis	Bodega Clam			x																6%
	Solamen columbianum	BC Crenella						x													6%
		Total # Identified	20	27	31	9	15	55	1	4	8	11	12	21	10	15	15	12	15	16	79

Table 11: Rank Order of All Identified Taxa by Ubiquity

Scientific Name	Common Name	Percent Presence	Rank Order
Mytilus sp.		100%	1
Protothaca staminea	Littleneck Clam	89%	2
Saxidomus giganteus	Butter Clam	78%	3
Balanus sp.		77%	4
Pollicipes polymerus	Gooseneck Barnacles	72%	5
Strongylocentrotus sp.		67%	6
Haliotis kamtschatkana	Northern Abalone	61%	7
Tegula funebralis	Black turban snail	61%	7
Polyplacophora sp.		50%	9
Bittium sp.		50%	9
Tresus sp.	Horse Clams	50%	9
Astraea gibberosa	Red turban snail	44%	12
Clinocardium nuttalli	Basket Cockle	44%	12
Thais lamellosa	Frilled Dogwinkle	39%	14
Nucella sp.	Dogwinkles	39%	14
Cardiidae sp.		39%	14
Balanus glandula	Acorn Barnacles	28%	17
Katherina tunicata	Black Katy Chiton	28%	17
Littorina sp.	Periwinkle	28%	17
Searlesia dira	Dire Whelk	22%	20
Thais emarginata	Emarginate dogwinkle	22%	20
Nucella canaliculata	Channeled Dogwinkle	22%	20
Acmaea pelta	Shield limpet	22%	20
Acmaea persona	Mask limpet	22%	20
Balanus cariosus	Thatched Barnacle	17%	25
Mopaliidae sp.		17%	25
Polinices lewisii	Lewis's Moon Snail	17%	25
Strongylocentrotus purpuratus	Purple Sea Urchin	17%	25
Acmaea testudinalis scutum	Plate limpet	17%	25
Acmaea digitalis	Finger Limpet	17%	25
Patellidae sp.		17%	25
Hinnites multirugosus	Purple-hinged/Giant Rock scallop	17%	25
Mopalia muscosa	Mossy chiton	11%	33
Cryptochiton stelleri	Butterfly Chiton	11%	33
Lacuna sp	Winkles/Periwinkles	11%	33
Ocinebrina lurida	Lurid Rocksnail	11%	33
Nucella lima	File Dogwinkle	11%	33
Ceratostoma foliatum	Leafy Hornmouth Snail	11%	33
Olivella biplcata	Purple Olive	11%	33
Crepidula adunca	Hooked Slipper Snail	11%	33
Strongylocentrotus droebachiensis	Green Sea Urchin	11%	33
Acmaea mitra	Whitecap Limpet	11%	33
Lottia digitalis	Ribbed Limpet	11%	33
Hiatella sp.	Saltwater clams	11%	33
Pododesmus cepio	Pearly Monia	11%	33

Scientific Name	Common Name	Percent Presence	Rank Order
Cryptolepas rhachianecti	Whale Barnacle	6%	46
Cryptohiton stelleri	Giant Western Fiery Chiton	6%	46
Cryptohiton stelleri	Giant Pacific Chiton	6%	46
Tonicella lineata	Lined Chitons	6%	46
Lirulara sp.		6%	46
Tegula pulligo	Dusky Tegula	6%	46
Bittium eschrichtii	Giant Pacific Coast Bittium	6%	46
Bittium eschrichti	Eschricht's Bittium	6%	46
Lacuna variegata	Variegate lacuna	6%	46
Buccinidae sp.	Whelks	6%	46
Amphissia sp.		6%	46
Colubraria nitidula	Carpenter's dwarf triton	6%	46
Lirabuccinum dirum	Spindle whelk	6%	46
Columbellidae sp.	Dovesnails	6%	46
Littidae sp.		6%	46
Emarginula fissura	Slit Limpet	6%	46
Megathura crenulata	Keyhole Limpet	6%	46
Crepidula fornicata	Slipper Limpet	6%	46
Tectura fenestrata	Chocolate/Fenestrate Limpet	6%	46
Chlamys hastata	Spiny Pink Scallop	6%	46
Glans carpenteri	Carpenter Carditid	6%	46
Siliqua patula	Razor Clams	6%	46
Gamelia septentrionalis	Bittersweet Clam	6%	46
Hiatella sp.	Nesting Saxicave Clam	6%	46
Semele rubropicta	Rose-painted Clam or Rose-petal Semele	6%	46
Macoma secta	Sand Clam	6%	46
Tellina bodegensis	Bodega Clam	6%	46
Solamen columbianum	BC Crenella	6%	46

Patterns of Community Use

It is well understood in archaeology that the analysis of species diversity and taxonomic richness can speak to past ecosystems and environments as well as harvesting behaviour (Cruz-Uribe 1988:179). We can also see changes through time, especially when combined with absolute dating methods, such as radiocarbon dates. Individual level samples are especially useful in this, showing changes going down into the ground and therefore back in time. Shell middens are created by people, whether deliberately or not, and they become part of the site architecture (Butzer 1982:38) in that other structures are built on and around the deposits. Humans have dramatic impact on their environment over time, and while not all evidence of this activity survives to be analysed by archaeologists and historical ecologists in the future, a great deal of it does and decomposing shell can provide a high-preservation, alkaline environment that counteracts the acidic groundwater that can wear at vertebrate and invertebrate remains over time (Álvarez et al. 2011:1). They are archives of human-environment interaction and can provide a window into how communities manage and consume intertidal resources (Erlandson 1988). Clam gardens, the rocky intertidal zone, and the tidal pools are all important sources of protein for communities on the coast (Lepofsky et al. 2015). Data span 18 sites throughout Nuu-chah-nulth territory, and makes it very clear that shellfish have been important to Nuu-chah-nulth communities for thousands of years. The protection of the intertidal zone from ecological damage and contaminants is essential if these important ecosystems are going to continue to feed communities in this region far into the future.

Sample Size and Presence of Shellfish

As the size of an analysed sample increases, the number of species or taxa identified within that sample will increase up to a point. The effect of sample size on sample richness is well understood as an important factor in archaeological analysis of midden material: there is a high correlation between the two factors until a certain amount of material has been analysed (Cruz-Uribe 1988; Grayson 1984).

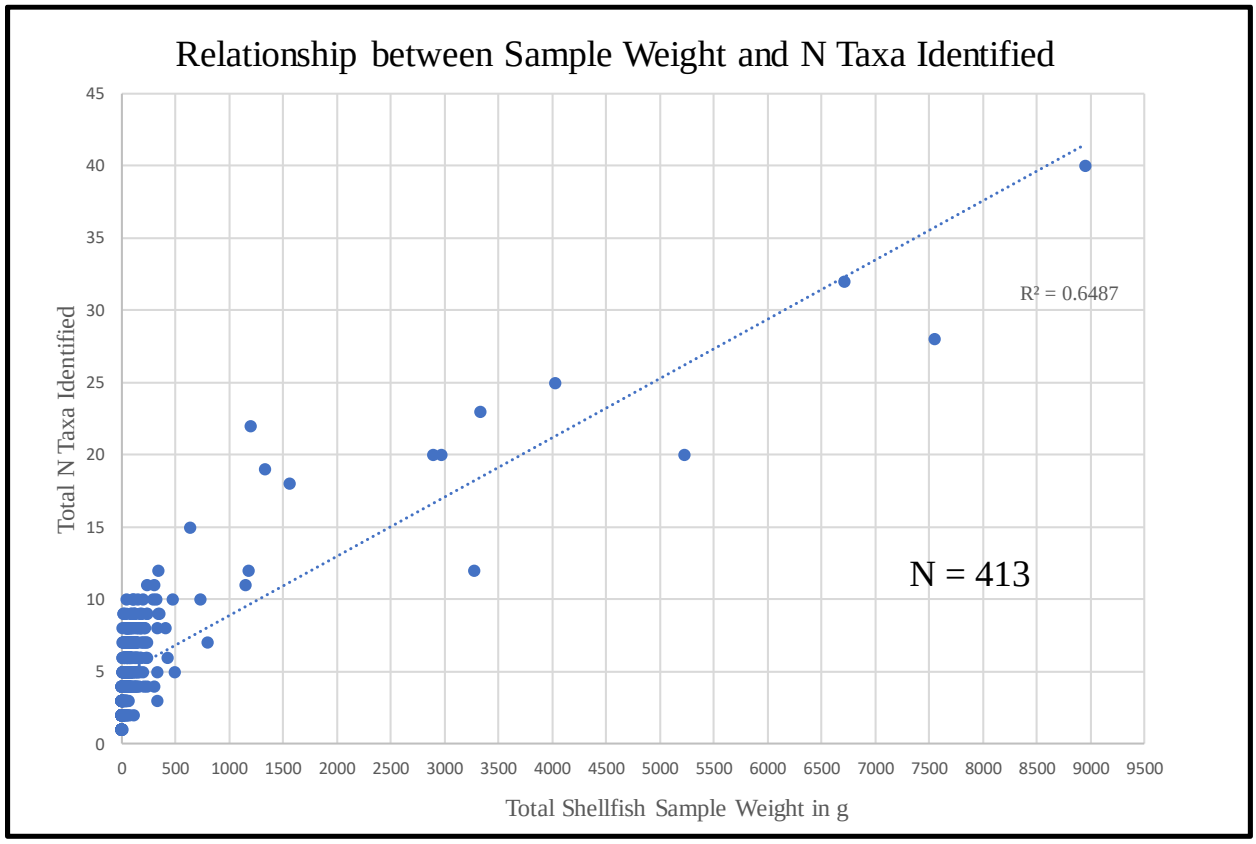


Figure 6: Relationship of sample size and the number of taxa.

Figure 6 shows the relationship between the amount of shellfish identified (sample size) with the number of shellfish species and taxa the analysts identified using individual samples across all sites. The majority of data points are clustered below 500 grams of identified shell but the relationship between sample size and taxonomic richness remains strong as the sample size increase. I used a best-fit linear trendline in Excel. Each sample

has a total weight of identified shell material, and a distinct number of identification categories. The relationship between these two points is presented in Figure 6. This is a regional dataset but does not necessarily show a trend that will be reflected at individual sites: to explore this relationship at the local site level, Figure 7 shows the relationship between the amount of shellfish analysed and the number of identified shellfish taxa at the site level: the relationship between total amount of identified shell material and the total distinct number of identification categories per site is shown in Figure 7. Figure 8 narrows in to show the smaller sample sizes (outlined in a black box in Figure 7) in this relationship more clearly. These numbers are based on the data presented in Table 4: these data are the reported weights and identified shellfish categories reported by the original analysts. The number of distinct taxa categories reported by the original analysts in many cases include miscellaneous categories (misc. clam, misc. shell) that I do not include in my analyses.

Loon Cave (Hesquiat Harbour, DiSo-9) is an outlier, with a much greater quantity of shellfish analysed and fewer distinct taxa identified. Ts’ishaa (Benson Island, 204T) has the highest number of identified taxa (55, Figure 7). Both the North and South components of Ch'ituukwachisht on Cree Island have both the smallest samples and the lowest number of distinct taxa. Aside from Loon Cave, there is a strong relationship between sample size (represented by the amount of shellfish analysed) and number of distinct shellfish identified.

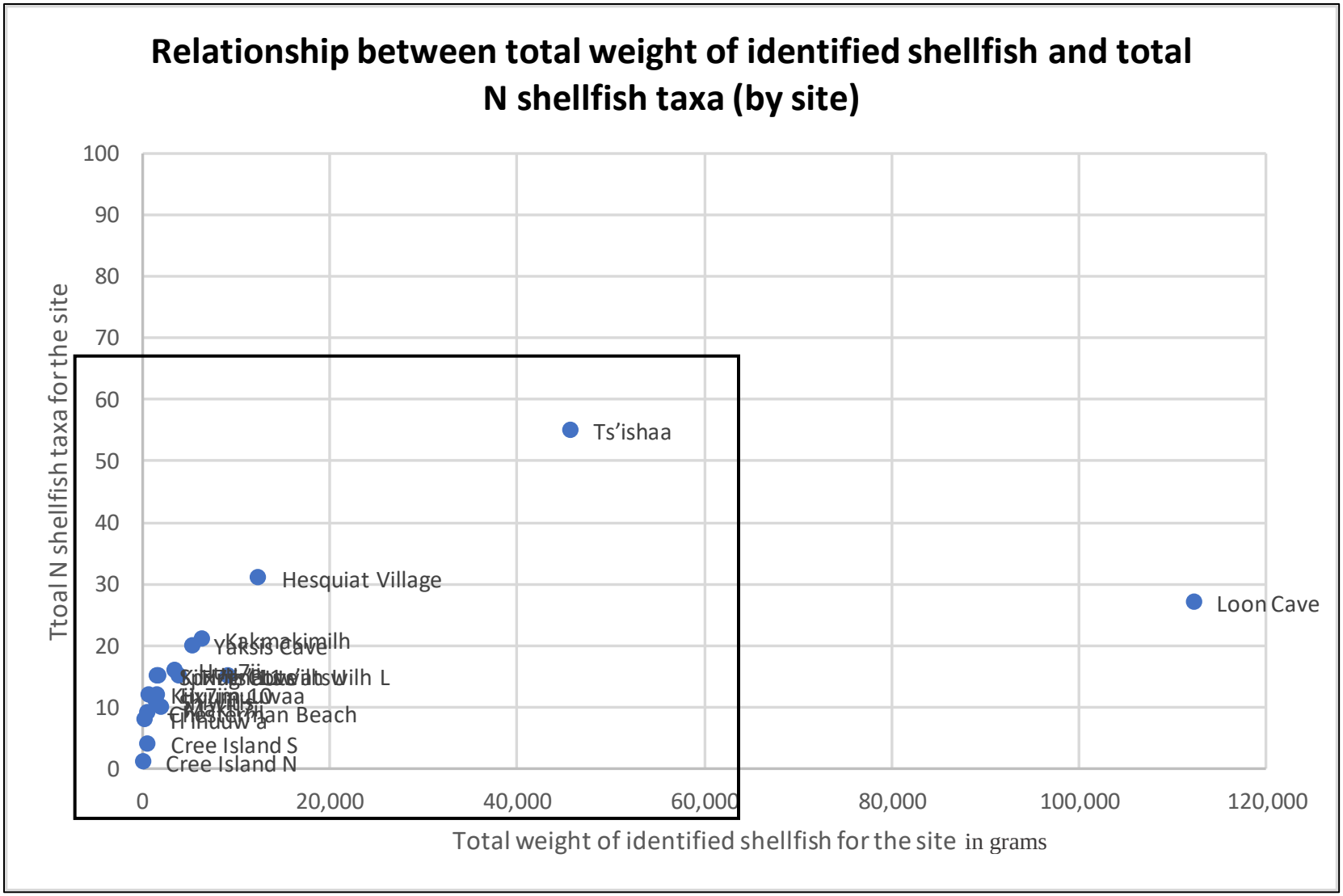


Figure 7: Relationship between Total weight of ID'd shellfish in grams and Total N shellfish taxa, all 18 sites

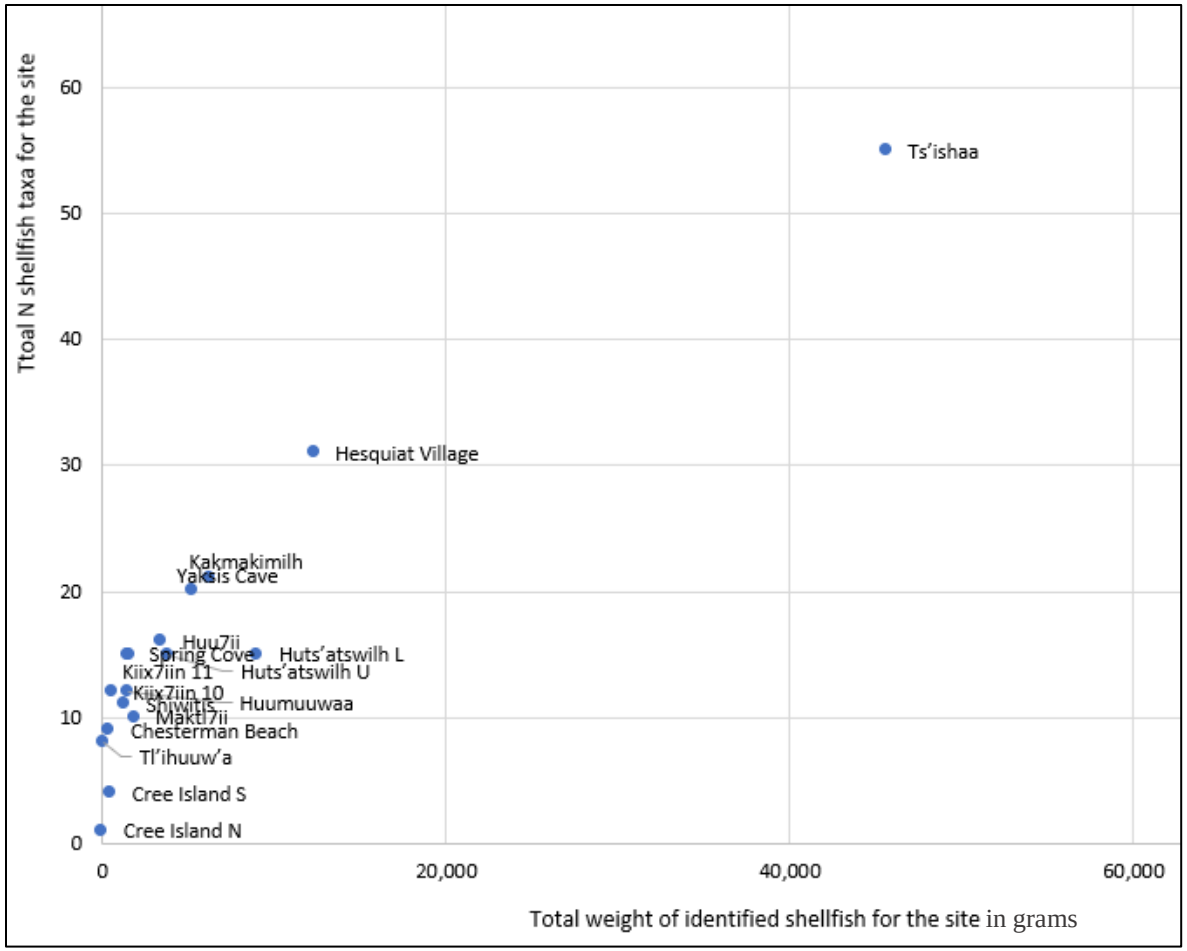


Figure 8: Relationship between Total weight of ID'd shellfish in grams and Total N shellfish taxa (by site): zoom in on Figure 7 box

Taphonomy and Factors of Preservation

Archaeological deposits are subject to "repeated mechanical and biochemical comminution and degradation, during and after occupancy of the site" (Butzer 1982:39). Taphonomic processes are those that impact remains after death or deposition, including disturbance. Shell remains are susceptible to disturbances that will influence the analysis. Two types of disturbance impact the preservation of faunal remains: biotic and abiotic. Biotic disturbance is caused by biological organisms, starting at deposition (Reitz and Wing 1999:115). Experiments in the 1980s and 1990s (e.g., Walters 1985; Wheeler and Jones 1989; Wing and Quitmyer 1992) demonstrated that sites with domestic animals will show a significant increase in the disturbance compared to sites with no domestic animals (Reitz and Wing 1999:115). Abiotic disturbance factors include weather, natural disasters, water flow, and seasonal changes, such as extreme dry or wet seasons (1999:116). Soil acidity, measured by pH, is another factor that influences preservation. As shell decomposes it neutralizes hydrogen ions and reduces the acidity, creating an ideal environment for the preservation of bone (1999:117). Some Nuu-chah-nulth cooking techniques for gooseneck barnacles include steaming in a fire pit or roasting over coals (Ellis and Swan 1981): this exposure to high heat may further break down the integrity of the shell material, and the thin nature of capitular plates would potentially be impacted by this exposure more than other species.

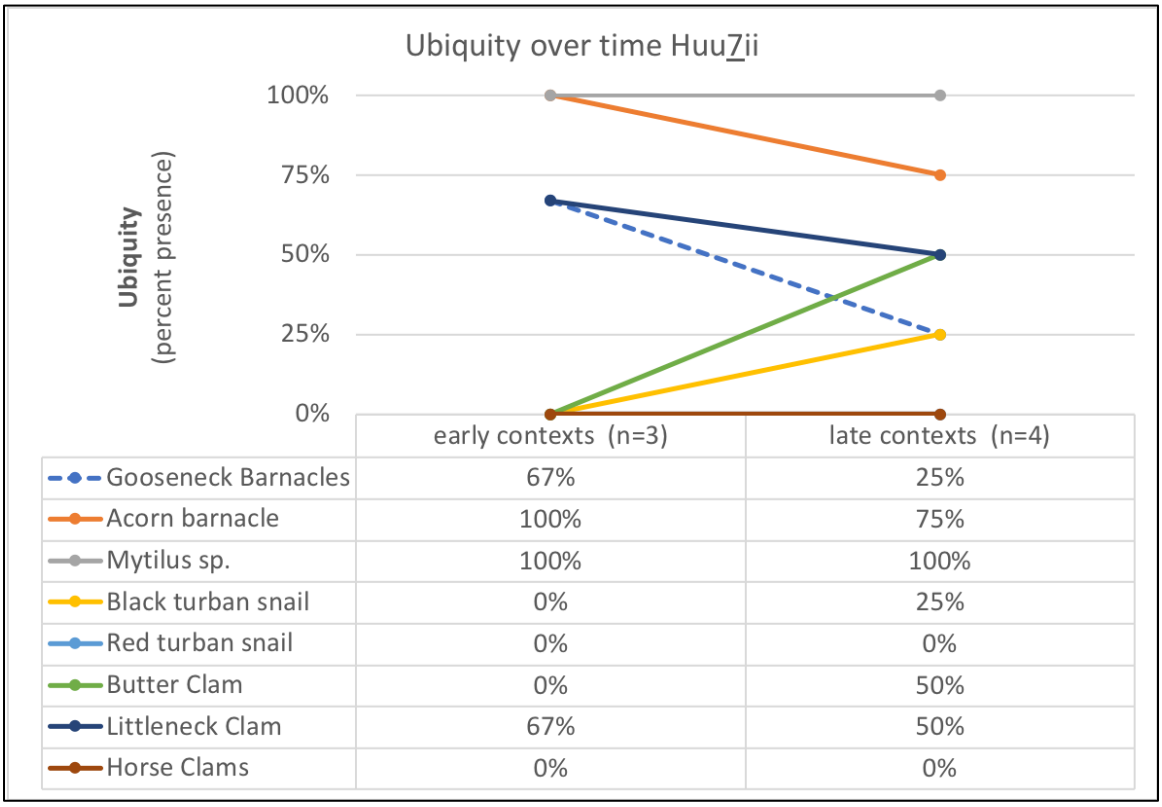
Comparisons between Weight and Ubiquity Results

In this section I compare results of weight-based and ubiquity-based analyses on the same samples. See Table 4 for compared site excavation and sample sizes. The site that falls in the middle of this comparison is *Ts'ishaa* (DfSi-16, 204T) on Benson Island. Hesquiat Harbour identified almost 130,000 grams of shellfish out of a reported 32 litres

of material (likely much more), a comparably high quantity, while *Huts'atswilh* on Dicebox Island (specifically DfSh-79, 129T) has comparably more total excavated material, but less total shellfish identified because it does not include smaller fraction sizes. The initial assessment of proportional abundance shows some commonly abundant shellfish that align with expectations. For example, *Mytilus* species, both as a general identification category and more specifically California mussel (*Mytilus californianus*), are some of the most abundant by weight in 72% of the sites (13 out of the 18)

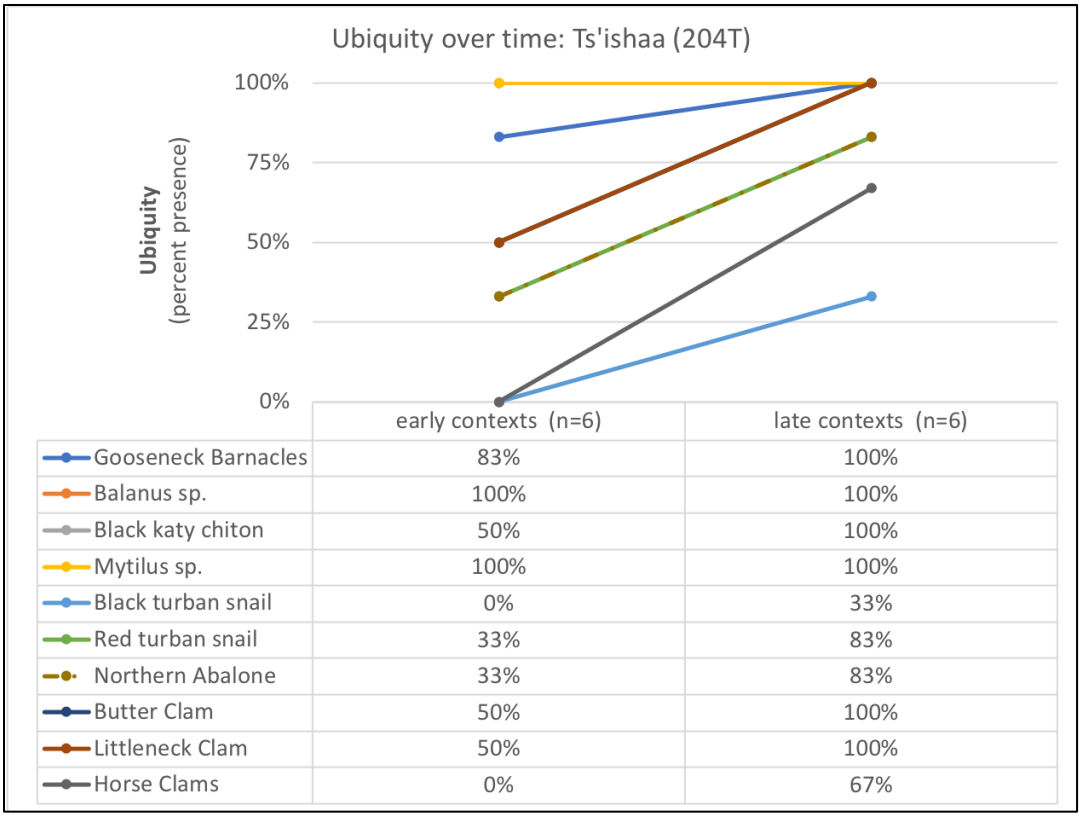
Change over Time

While this thesis project is primarily spatially focused, it is important to discuss change over time, and this section discusses some of the ways in which ubiquity can be utilized in an analysis of change over time both within and across sites. I use three case study sites to explore the use of ubiquity in change over time analyses of shellfish remains. Figures 9-13 compare the early and more recent (late) evidence of some of the key shellfish species and taxa for sites with temporally comparable data. These comparisons are based on the ubiquity of each species or taxa.



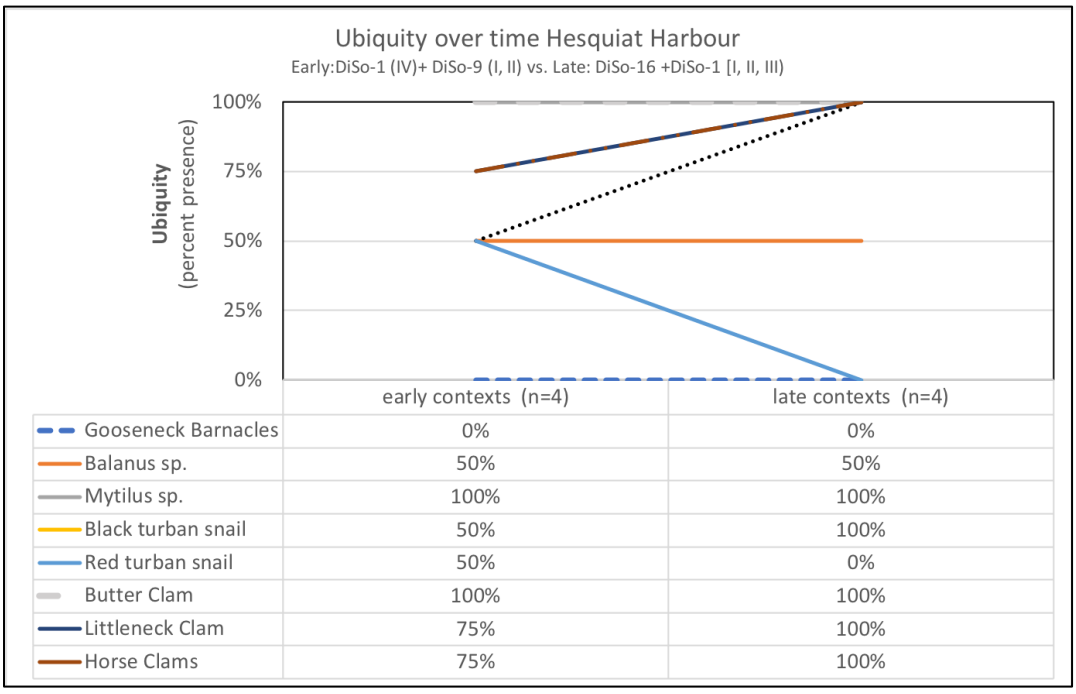
	early contexts (n=3)	late contexts (n=4)
Gooseneck Barnacles	67%	25%
Acorn barnacle	100%	75%
Mytilus sp.	100%	100%
Black turban snail	0%	25%
Red turban snail	0%	0%
Butter Clam	0%	50%
Littleneck Clam	67%	50%
Horse Clams	0%	0%

Figure 9: Temporal comparison of ubiquity at Huu7ii



	early contexts (n=6)	late contexts (n=6)
Gooseneck Barnacles	83%	100%
Balanus sp.	100%	100%
Black katy chiton	50%	100%
Mytilus sp.	100%	100%
Black turban snail	0%	33%
Red turban snail	33%	83%
Northern Abalone	33%	83%
Butter Clam	50%	100%
Littleneck Clam	50%	100%
Horse Clams	0%	67%

Figure 10: Temporal comparison of ubiquity at Ts'ishaa

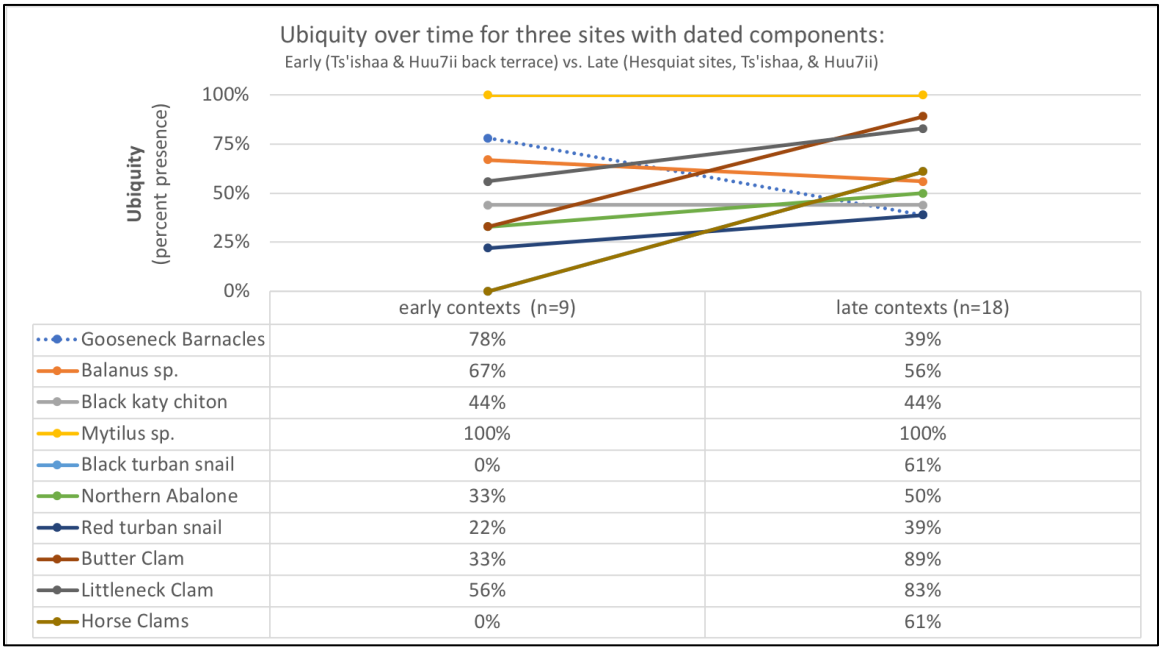


	early contexts (n=4)	late contexts (n=4)
Gooseneck Barnacles	0%	0%
Balanus sp.	50%	50%
Mytilus sp.	100%	100%
Black turban snail	50%	100%
Red turban snail	50%	0%
Butter Clam	100%	100%
Littleneck Clam	75%	100%
Horse Clams	75%	100%

Figure 11: Temporal comparison of ubiquity at Hesquiat Harbour

These three Figures (9-13) show the very different patterns. At *Huu7ii*, there is a significant decrease in the ubiquity of most of the shellfish (shown in Figure 9) with the

exception of butter clam and black turban snail, which were not identified in the early component, and *Mytilus sp.*, which remains 100% ubiquitous in both temporal categories. Horse clams were not identified. *Ts'ishaa* (Figure 10) is the opposite, with an increase in the presence of most of the species, with the others staying the same. Figure 11 shows change over time at Hesquiat Harbour sites Yaksis Cave (DiSo-16), Loon Cave (DiSo-9), and Hesquiat Village (DiSo-1). The material from these sites was collected in a few large samples, rather than several smaller samples. Mussels, black turban snails, and butter clams are the three most ubiquitous taxa. Littleneck clams and horse clams are also highly ubiquitous across all three sites, with some small increase in ubiquity. Gooseneck barnacle was not identified at either of these sites, and the category misc. clam was not used. Barnacles (*Balanus sp.*) maintain their ubiquity value as present 50% of the time across early to late components of Hesquiat Harbour.



	early contexts (n=9)	late contexts (n=18)
Gooseneck Barnacles	78%	39%
Balanus sp.	67%	56%
Black katy chiton	44%	44%
Mytilus sp.	100%	100%
Black turban snail	0%	61%
Northern Abalone	33%	50%
Red turban snail	22%	39%
Butter Clam	33%	89%
Littleneck Clam	56%	83%
Horse Clams	0%	61%

Figure 12: Compared presence over time for nine shellfish across two dated components

Figure 12 shows the change in the presence of nine shellfish taxa ranked by ubiquity across two dated components: Early (Ts'ishaa and the Back Terrace component of Huu7ii), and Late (Hesquiat Harbour sites, Ts'ishaa, and Huu7ii). With the exception of gooseneck barnacles, black katy chiton, and *Mytilus sp.*, there is an increase in the presence for all of the shellfish taxa. Gooseneck barnacles decrease in presence by 39%, black katy chiton maintains 44% present, and *Mytilus sp.* maintain 100% present across time.

Table 12: Compared early and late ubiquity of top 5 shellfish by site (Misc. clams also included). Green to Red colour gradient shows smaller (0%+) to larger numbers (up to 100%).

Site Name	Site #	Time Frame	Early or Late	N Total Samples	*Mytilus sp.*	Littleneck Clam	Butter Clam	*Balanus sp.*	Gooseneck Barnacles	Misc. clams
Yaksis Cave	DiSo-16	530-740	L	1	100%	100%	100%	100%	0%	0%
Loon Cave	DiSo-9	1000-1800	L	2	100%	100%	100%	100%	0%	0%
Hesquiat Village	DiSo-1	500-1500	L	5	80%	100%	100%	20%	0%	0%
Chesterman Beach	DgSi-67	1000-1270	L	7	100%	14%	0%	86%	0%	86%
Spring Cove	DfSj-57	500-2000	L	12	100%	75%	25%	83%	42%	92%
Ts'ishaa	204T (Auger)	1000-2000	L	26	100%	15%	23%	100%	0%	77%
Ts'ishaa	204T	250-1800	L	6	100%	100%	100%	100%	100%	100%
Ts'ishaa	204T	3000-5000	E	6	100%	50%	50%	100%	83%	100%
Ch'ituukwachisht (North)	131T	800-2200	L	5	80%	0%	0%	0%	0%	0%
Ch'ituukwachisht (South)	132T	1300-2600	L	19	79%	0%	0%	63%	11%	11%
Tl'ihuuw'a	305T	1100-100	L	7	71%	57%	29%	57%	14%	71%
Shiwitis	82T	150-1200	L	29	100%	76%	10%	90%	7%	90%
Huumuuwaa	304T	300-3300	L-E	33	97%	55%	33%	94%	12%	70%
Kakmakimilh	306T	150-2000	L	55	100%	80%	71%	82%	11%	82%
Maktl7ii	206T	500-1800	L	61	93%	28%	2%	87%	31%	67%
Huts'atswilh (Lower)	83T	500-1000	L	86	100%	55%	24%	98%	33%	85%
Huts'atswilh (Upper)	129T	400-12,000	L-E	129	84%	22%	9%	71%	9%	65%
Kiix7in, House 10	1612T1	150-500	L	5	100%	100%	0%	100%	20%	0%
Kiix7in, House 11	1612T2	150-5300	L-E	10	100%	100%	20%	100%	90%	0%
Huu7ii (N10-12/E2-4)	DfSh-7	400-1200	L	4	100%	50%	50%	75%	25%	50%
Huu7ii (N4-6/E0-2))	DfSh-7	3000-5000	E	3	100%	67%	0%	100%	67%	67%

Discussion

Rather than think about resources consumed by people in the past in isolation as a single proportional number over time, an archaeological perspective on the ubiquity of resources can help illuminate the foods we consume most frequently and to consider how they are important to health, relationship to harvest locations, our family recipes, and how we interact with and consider those resources. These analyses address patterning across multiple sites rather than primarily looking at change over time. My analysis of change over time using the ubiquity values of some target shellfish is brief and provides a limited understanding of how the presence of these shellfish changes over time (Figures 9-13 and Table 12). This is a starting point that demonstrates an avenue of inquiry that could aid in understanding the presence of shellfish in archaeological deposits across the Northwest Coast more broadly.

The combination of weight and ubiquity provides a detailed menu of invertebrate food sources across multiple sites. Mussels, clams, and barnacles are some of the most frequently consumed shellfish resources in Nuu-chah-nulth territory. While several barnacles indicated reduced use over time, gooseneck barnacles have remained a significant resource despite their low proportional weight across all sites (see Figure 12). This is a result that has not been observed through other research efforts on the west coast of Vancouver Island despite previous work discussing barnacles in the Pacific Northwest region (Fournier and Dewhirst 1980; Moss and Erlandson 2010).

Gooseneck barnacles have not been widely recognized as a regular food resource, and as their habitat is also home to mussels, a widely established significant food resource, it is important to address the question of whether gooseneck barnacles are present in the

archaeological record as an epibiont species. It is unlikely due to the oral historical record of gooseneck barnacles as a popular food resource (Ellis and Swan 1981; Nuu-chah-nulth Tribal Council 2010), and because many of the plates present archaeological have been exposed to heat (cooking), evidenced by their charred appearance. In addition, gooseneck barnacles can grow on some beds of California mussel and thus both taxa could be harvested simultaneously further enriching the intertidal harvest.

Species, genus, and family level identifications

If the purpose of the analysis is to determine how many species are present in the archaeological record at a given site, species level identifications are desirable. If the purpose is just to compare the dietary contribution of sea mammal, shellfish, fish, bird, and land mammal, species level identification is far from necessary and will only take up valuable time. Species level identifications are valuable for conservation and resource management questions, as the ecology of the identified species can support an understanding of necessary measures moving forward to protect or manage a present-day ecosystem and important harvesting sites. One of the benefits of ubiquity is that it compensates for indeterminate or 'all' classifications that can often influence the more specific species classifications. The shellfish reported in this thesis are based on reported identifications performed by trained faunal analysists. In some cases, I have combined similar categories in order to avoid repetitive categories, including *miscellaneous* and *all* sections (i.e. all mussel, misc. mussel) into their respective genus categories (*Mytilus* sp.).

Conclusions

This chapter has examined the relative abundance of shellfish through two different methods of analysis: proportional weight and ubiquity. I have shown that the application of ubiquity gives us a more thorough conception of how regularly certain

shellfish were consumed prior to the contact era (AD 1846) and allows lighter and more fragile shellfish to be seen alongside more robust and proportionally heavier species. The following chapter addresses my research questions, two of which were also addressed in this chapter and discuss the implications of shellfish archaeology on the legal environment surrounding Indigenous claims to access, manage, and protect marine resources. The following two questions were asked and addressed in this chapter, and are answered below:

2. *Will applying ubiquity calculations to the existing weight measures of shellfish provide a different perspective of comparison? What differences, if any, are there between the profile of harvested and consumed shellfish established through weight-based measures and that established through ubiquity-based measures?*
3. *How do sampling and sample analysis methods, such as displaced volume of excavated sample, screen size, and sample type (auger, column, unit), influence the comparative abundance and presence of target species?*

Question 2

Re-calculating shellfish abundance using ubiquity has resulted in a vastly different perspective on shellfish abundance and regularity of use than established weight-based methods. Many shellfish that were dwarfed by a few select bivalves can now be re-evaluated with a more equal weighting between taxa across the full range of shellfish that Nuu-chah-nulth communities consumed and deposited at these sites. This approach also shows that some of the most frequently consumed shellfish, including mussels, clams, and gooseneck barnacles, have remained important resources for coastal communities over thousands of years on the west coast of Vancouver Island. Figures 9-13 show the results of a temporal analysis of some of the more ubiquitous (across all sites) shellfish, comparing the presence of those taxa within three sites and across all 18. Analysis of the ubiquity of shellfish, rather than the reported weights, changes the

perspective: rather than looking at the amounts, ubiquity analysis examines at the frequency of use or presence across a range of depositional events. Weight-based analysis automatically ranks heavier and more robust shellfish that preserve well: in comparison, ubiquity analysis favours taxa that leave identifiable remains across a range of contexts.

Rank order by weight and ubiquity is a useful quantitative method for quickly assessing some of the most abundant as well as most commonly utilized resources. I have demonstrated the difference between rank orders based on reported weights and those based on the ubiquity of the same shellfish at the same sites (see Table 9 and Table 11). While *Mytilus* sp., littleneck clams, and butter clams still occupy the top three placements in the rank order, the application of ubiquity shifts their relative placements, which reflects the persistence of mussels throughout the west coast of Vancouver Island. Littleneck and butter clams are both highly abundant measured by proportional weight and ubiquity, but they are not present at 100% of sites nor in 100% of the samples. Mussels on the other hand are even more proportionally abundant through ubiquity. Fragmented mussel shell is more easily identifiable than fragmented clam shell: edges of fragmented mussel shell show filament layers, while clam and abalone break more cleanly. Mussel also tends to have an iridescent sheen that clam does not, and while the purple and blue tends to fade with time, the sheen does not. Barnacles (*Balanus* sp.) are much more common than weight-based analyses suggest, as are urchins (*Strongylocentrotus* sp.), northern abalone (*Haliotis kamtschatkana*), and gooseneck barnacles (*Pollicipes polymerus*). This shifted perspective shows that not only is there more variety in the common invertebrate foods consumed on the western coast of

Vancouver Island, but these Nuu-chah-nulth communities have been utilizing more of the intertidal zone than has been previously appreciated academically and legally.

Depositional Scale of Analysis

With the exception of the three Hesquiat Harbour sites, which had fewer but larger samples, I looked at a large number of small samples at the other 15 sites. This semimicro scale (Muir and Driver 2002) allows for an understanding of a community's local environment, including meals and depositional episodes, and for intra-site analysis, which is not possible with only total weights found at sites that combine all examined shellfish into one analytical unit. Rather, those flattened singular assessments of abundance can be of limited use for interpreting the patterning represented through frequency of presence across depositional histories and enhance inter-site analysis, providing improved characterization of regional and chronological patterning of resource use.

Question 3

The more material that is excavated and analysed, the more shellfish can be identified. Not all communities will use the same intertidal resources as their neighbours, likely due in large part to the local environment, although cultural preferences and trade networks are important factors. Smaller volume samples result in lower ubiquity values and lower taxonomic richness: the likelihood of encountering a taxon is greater in larger samples. Ts'ishaa, Huu7ii, and Kiix7in show high taxonomic richness, as do the Hesquiat Harbour sites: all six sites benefit from large samples. While the excavation team at Hesquiat Harbour used unit sampling, their sample sizes are significantly larger, which increases the taxonomic richness reported, as would any larger examined assemblage. The remaining Barkley Sound sites were excavated using auger sampling, which results in

smaller volume samples. Screen size also has a significant influence on how much gooseneck barnacle, our target species, is identified (Table 7). Smaller screen sizes catch fragmentary and smaller remains, but the results take much more time to quantify. Gooseneck (like many other barnacles) has been a vastly under-emphasized species (Moss and Erlandson 2010), and this research has looked at them in a very different perspective than has been previously attempted. If a goal of a given project is to look at the comparative abundance of as many shellfish species at the site as possible, weight-based measures using small samples will likely not yield enough information. Those methods do provide a cursory description of some of the more abundant shellfish.

Just because larger samples result in higher taxonomic richness does not mean that smaller samples are not important sources of information. Perhaps smaller samples, such as auger samples, would benefit more from an added portion of the smaller fraction size to increase the likelihood of identifying a greater number of invertebrates than with the larger fraction alone. In addition to combining the two quantitative methods, these analyses addressed the smaller fraction size. This approach had a significant impact on the relative abundance of the case study species: gooseneck barnacle.

Chapter 4: Conclusions

Introduction

Shellfish are an important marine resource, being an accessible source of protein, vitamins, minerals, and omega-3 fatty acids. Shell middens are a major part of the coastal landscape several world regions (Erlandson 1988; Erlandson et al. 2008; Claassen 1991; Stein 2008). While some research efforts (Claassen 1991; Moss 1993) addresses the stereotypes and common assumptions surrounding shellfish as a 'low ranked' resource and an archaeological material, shellfish remain understudied. The theoretical frameworks that shape and guide archaeological research in British Columbia do not seem to encourage basic quantitative analysis of shellfish. Instead, there is a tradition of sampling for shellfish when possible for the sake of tradition, and to investigate questions ranging from economic, dietary, and cultural contributions only when the project is primarily dedicated to shellfish. It is rarely the focus, and so our understanding of how communities have been utilizing this resource is lacking compared to other marine resources. The language we use may play a part in this: the word *midden* comes from the Danish *møddin*g, meaning "muck heap", from the Late Middle English *myddyng*[7]. The common conception is that middens are refuse has influenced how archaeologists interact with middens, including both in the field and the lab (Claassen, 1991:250). Middens are present in various sizes and play a role in the site architecture in various ways. The concept of shell-bearing sites (Claassen 1991:252) allows the inclusion of shell remains as a characteristic of the whole site, rather than the refuse heap of a site.

[7] Retrieved from Oxford English Dictionary, June 2019

In the following sections I address the three research questions addressed in the bulk of the previous chapters. I then address the last question that I proposed, which addresses the significance of this research.

Question 1: What does archaeological analysis of shell middens on the West Coast of Vancouver Island reveal about the harvesting and management of shellfish resources in Nuu-chah-nulth traditional territory?

The analysis of Nuu-chah-nulth shellfish use is limited by the scarcity of archaeological research efforts that have focused on shellfish analysis in the region. The methods utilized in the analysis of shellfish vary within the region (see Table 3). Total excavation volume, the total amount of shellfish identified and reported, the number of samples, and the number of shellfish taxa identified for each site vary greatly, and the relationship between these factors varies within each site (reported in Table 4). Some sites have large excavated volumes, but relatively small amounts of identified shellfish (i.e. Upper and Lower Huts'atswilh), while others have high numbers of identified shellfish, less excavated volume, and large amounts of shellfish analysed (i.e. the three Hesquiat Harbour sites). While I was able to compare these sites to a degree, an effort to standardize the data would be beneficial for a more accurate site comparison. I identified 76 shellfish identification categories, including combined *misc.* and *all* categories, and some different common names that refer to the same scientific name, including but not limited to purple-hinged/giant rock scallop, rose-painted clam/rose-petal semele, and chocolate/fenestrate limpet (see Table 5). Small and large barnacle categories were combined into *Balanus* sp. There is some overlap in categories due to the range of identification categories used across analysts: there are not 76 exact, distinct invertebrate species, rather there are 76 categories of identification. This process emphasizes that one of the significant issues of comparability is the standardization of identification

categories and the possibility that categories may differ between those researching foods and those eating them.

The analysis of midden material provides important information about the shellfish harvested by communities that create the deposits. While the methods suffer from a lack of standardization and comparability, that has not stopped archaeologists from attempting to understand what shellfish are important and to whom. The focus on bivalves is founded in this motivation to understand an underappreciated resource, and to protect it for present day and future generations of indigenous communities who rely on invertebrate foods, and have done so for millennia. However, this focus limits the discussion to one type of shellfish (bivalves, commonly clams and mussels) and excludes all barnacles and gastropods.

Rather than focusing specifically on the most abundant shellfish by weight, I tested the argument that mussels and some specific clam species are the most highly ranked species by combining weight-based analyses with ubiquity. This combination indicates that mussels, clams, and barnacles are indeed all important and there are many additional species within those categories that should be recognized as significant resources that have remained important over time. Through this analysis I review data from a selection of Nuu-chah-nulth coastal sites to show communities have been harvesting and consuming a wide range of shellfish, which indicates active and regularized harvesting and management for the patterns of consumption to last for hundreds, and in some case thousands, of years, without interruption. Determining management from shell remains is difficult due to the variety of other factors that influence invertebrate availability, including but not limited to environmental change, natural disasters, and invasive species.

I argue that the steady use of shellfish over thousands of years indicates the ability of a community to monitor the availability, seasonality, and impacts of human activity on resources. Within Nuu-chah-nulth territories, invertebrates have provided a readily available source of protein with a variety of options that are accessible.

The archaeological analysis of shell middens on the West Coast of Vancouver Island reveals a great deal about the harvesting and management of shellfish resources in Nuu-chah-nulth traditional territory. It is evidence that shellfish are an important resource and although most research efforts focus on a limited number of the shellfish identified, Nuu-chah-nulth communities have harvested a wide variety of invertebrate foods throughout the region. A more varied toolbox, rather than limiting the approach to only weight-based or MNI-based methods, will provide greater depth in understanding how valuable archaeological shell assemblages can be in providing data on the harvesting and management of shellfish by Nuu-chah-nulth communities.

Question 2: Will applying ubiquity calculations to the existing weight measures of shellfish provide a different perspective of comparison? What differences, if any, are there between the profile of shellfish harvested and consumed between weight-based measures and ubiquity-based measures?

The application of ubiquity on existing reported weights provides a vastly different perspective on the relative importance of shellfish. Not only do the rank orders of shellfish taxa differ, but the relative abundance also changes. The differences lie in how species are ranked as most abundant, as well as in what species garner greater attention. Weight-based measures alone primarily highlight butter clams, California mussel, and littleneck clams. This often fosters the incorrect impression that any other shellfish present were opportunistic or rarely used resources, rather than important and highly frequent contributions to a community's diet despite a comparatively small proportion by

weight. When combined with an analysis of the ubiquity for all of the identified shellfish, the description of what invertebrate foods are important contributors to the diet is greatly expanded to include barnacles, including gooseneck and acorn barnacles.

In addition to broad scale inter-site comparisons of shellfish presence, including an inter-site comparison of change over time across three sites, I performed intra-site comparisons that demonstrate the same variety that is reflected regionally. The key difference between using reported weights and the ubiquity measures calculated using those reported weights is the shift in focus, from three species to a much wider range.

Question 3: How does zooarchaeological sampling and sample recovery methods, such as displaced volume, screen size, and sample type (auger, column, unit), influence the comparative abundance and presence of target species?

Sample recovery methods have a direct influence on the taxonomic richness of a given sample or site. It is not a novel observation that more material means a wider range of evidence. There is a recognized relationship between sample size and sample richness, and smaller samples make it less likely that all taxa preserved at a given site are identified (Grayson 1984). This is only a problem if the goal is to identify as many shellfish species as possible rather than provide a relatively cursory description of some of the common shellfish. Unit sampling and column sampling result in the largest samples, but this requires more time to excavate and to process and are more destructive excavation methods. In the context of this project, a wide variety of shellfish was identified from samples collected through all of those methods. Some sites were sampled and processed to a lesser degree, and the number of identified shellfish was not necessarily a result of sample size. The quality of the comparative collection and the knowledge of the analyst(s) play an important role in determining the accuracy of identification as well as the amount of unidentified material.

Generally, a large number of small samples are collected using arbitrary or natural layers in the stratigraphy of the material, which provides an assemblage that ranges in size depending on how many samples are excavated and analysed. This is not always the case (see DiSo-16, DiSo-9, DiSo1 in Table 4) but it is more common with more recent work. This may be due to a shift in research strategies: rather than try to collect vast amounts of material, the goal is now to try to understand daily life for individuals and their communities at very deep and complex settlement sites. Smaller samples collected in layers going back in time can mimic the results of smaller scale (daily) consumption and deposits of food. Ubiquity has been utilized specifically to look at these daily lived experiences previously regarding fish (McKechnie 2013) but not shellfish to the same degree.

Question 4: How can the relative importance of shellfish impact the legal protection of Indigenous gooseneck barnacle harvesting, and Indigenous claims to accessing and managing goosenecks as a marine resource?

Archaeological work can be used to leverage legal arguments and can be accepted as scientific evidence in a court of law. The lack of research devoted to midden composition may have had an impact on the current state of shellfish as an unprotected resource for coastal Indigenous communities. Historical records, which are also often used in court decisions, have also underplayed the role of shellfish in coastal diets. The work to date has also primarily focused on clams and sometimes mussels. Future research could shift this and allow for the protection of shellfish and their sources from ecological damage due to overharvesting, infrastructure, oil and gas projects, among other sources. The assessment that shellfish are not important resources, and that only a few shellfish species could be important, limits the ability of the courts to recognize Nuu-chah-nulth rights to harvest and sell shellfish, and to protect shellfish ecosystems from damage.

Archaeological investigation primarily relies on the presence of material evidence, with a growing number of researchers looking to ethnographies. A lack of evidence of a particular resource would suggest a lack of use: if the archaeological evidence does not show use where an ethnography does, the material evidence (or lack thereof) is often considered more reliable (Menzies 2015). Rather than accepting a lack of archaeological evidence, I argue that quantitative methods may have been missing material evidence that reflects oral historical and ethnographic evidence.

Conclusions

This thesis has focused on a combination of two specific methods, weight and ubiquity, to quantify the presence and abundance of invertebrates as food on the west coast of Vancouver Island in Nuu-chah-nulth territories. A literature review outlines some of the foundational work on shellfish archaeology in the Pacific Northwest and in Nuu-chah-nulth territory more specifically. I have performed inter- and intra-site analyses of relative abundance and change over time. A significant result of these analyses is the expansion in the variety of invertebrates that can be discussed as commonly utilized by Nuu-chah-nulth communities.

Further Research

Invertebrate foods have lacked archaeological attention and effort and require much more research to fully understand their contribution to diets in the Pacific Northwest. It is vital for this research to gain traction and have the same attention devoted to it as other protein sources such as fish and mammals. Shell midden composition, proximity to clam gardens and fruitful intertidal zones, and exposure levels of the sites are all relevant and important directions of future research. Given the opportunity, I would expand this analysis to include more sites in Nuu-chah-nulth territories to have a richer discussion of

sampling methods and resulting analyses. Connecting the maps of midden locations to the location environments of harvesting effort (intertidal zones, clam gardens, etc.) can provide greater insight into how these communities have interacted with local environments.

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