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VERTEBRATE FAUNAL ANALYSIS OF THE ANDERSON CREEK SITE (45KP233)

KITSAP COUNTY, WASHINGTON

A Thesis

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Cultural and Environmental Resource Management

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by

Robert Jackson Holstine

July 2017

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

We hereby approve the thesis of

Robert Jackson Holstine

Candidate for the degree of Master of Science

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Dr. Megan Partlow

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Roger Kiers

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Dean of Graduate Studies

ABSTRACT

VERTEBRATE FAUNAL ANALYSIS OF THE ANDERSON CREEK SITE (45KP233)

KITSAP COUNTY, WASHINGTON

by

Robert Jackson Holstine

July 2017

The Anderson Creek archaeological site (45KP233) was excavated by the Washington State Department of Transportation (WSDOT) in 2015, as part of a fish passage replacement project in Puget Sound. Faunal analysis of remains from this excavation was completed by the author in collaboration with Dr. Megan Partlow. Analysis documented a variety of mammal and fish remains, consisting primarily of salmon, flatfishes, deer and elk. In addition to general faunal results reported to WSDOT, I discuss bone fragmentation, herring in regional sites, and the value of 1/16” fine screen sampling and analysis. To address the last, I compared fish identifications from excavation unit DR3 between the 1/8” and larger mesh fraction and the 1/16” fine mesh fraction. The fine mesh sample yielded larger numbers of bones identified, and a small but statistically significant difference in proportions of different fish groups. Given the high cost of recovery, sorting, and analysis of 1/16” samples, I recommend that it be used for only a small sample at shell midden sites like 45KP233 in the Salish Sea.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Roger Kiers, Erin Littauer, and the rest of the Washington State Department of Transportation, for the excavation of the Anderson Creek site, and granting me permission to use the faunal assemblage for this thesis. Without their effort and trust, I would not have reached this point. I would also like to thank Dr. Megan Partlow, whose help and guidance was nothing short of saint-like. Without her, I would still be sorting bone from broken shell.

Next, I would like to thank Dr. Patrick Lubinski: Despite my best efforts, he was able to push me through to the finish. I couldn't have done this without his support and patience. This section would not be complete without thanking Dr. Steven Hackenberger, whose unmatched enthusiasm is always a source of encouragement.

Last, I would like to thank my parents, Craig and Marsha, for being so incredibly supportive and for not letting me starve during my studies. I am very thankful for their constant encouragement and faith in my ability to succeed. I would also like to thank all my other assorted family and friends. Thank you all for putting up with my preoccupation and indecision for these past four years.

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CHAPTER I

INTRODUCTION

The Washington State Department of Transportation (WSDOT) is in the process of replacing more than 800 fish-passage barriers throughout western Washington (Roger Kiers, personal communication, 2016). Many of these construction projects are in places likely to have been used in the past and with archaeological remnants since they are located along fish-bearing streams. The projects in coastal settings could potentially be located in shell middens, a site type known to have abundant archaeological materials including faunal remains. Such sites are complicated and expensive to investigate, and so information on the relative benefits from different screen size recovery methods are important to understand for planning such investigations.

The Anderson Creek site (45KP233) was excavated in 2015, as mitigation for one of these culvert replacement projects (Kiers 2016). The work done on this site might be used to help guide future culvert replacement archaeological excavations. This excavation used a variety of screen sizes in recovery of faunal remains, including 1/16" mesh for possible recovery of small fishes, particularly herring (Kiers 2015). Herring (*Clupea pallasi*) is the single most ubiquitously found fish taxon on the Northwest Coast, occurring in 169 of 171 assemblages according to McKechnie et al. (2014).

The project used nested water screens with 1/2", 1/4", 1/8" and 1/16" mesh. The 1/8" and larger screen fractions produced such a quantity of materials that in the laboratory only 25% of the resulting matrix was sorted into shell and faunal remains for analysis. Still, this produced over 15,000 bone specimens for analysis. Analysis of this faunal material would require expertise in fish remains, an extensive comparative collection, and a substantial amount of time. Upon agreement with WSDOT, this faunal collection was provided to Robert Holstine and Dr. Megan Partlow for analysis.

The faunal study attempted to answer three basic research questions: 1) What are the principal fauna exploited at this site, 2) How does bone taphonomy inform understanding of site formation history, and 3) Are the methods used for data collection necessary for an accurate and comprehensive analysis? In this thesis, these research questions were addressed systematically with an examination of the faunal remains present at the site, the taphonomy of those remains, and the methods with which the remains were collected. For this latter methodological concern, a comparison of results from the larger screen sizes (1/4" and 1/8") to that of the fine screen mesh (1/16") was made. The purpose for this comparison was to establish whether a significant difference in the presence of small fish bones can be observed.

Excavation revealed seven distinct stratigraphic layers, all of which were excavated by natural level, and were designated Layers 1 through Layer 7. These were further broken down into sub-levels (i.e. 5A and 5B) and variously contained historic artifacts, pre-historic artifacts, and faunal remains. The bulk of the identifiable remains was recovered from Layer 6, which is a shell midden layer that yielded conventional radiocarbon dates of 220±30 BP (Beta-450929), 540±30 BP (Beta-450930), and 670±30 BP (Beta-450931) (Partlow and Holstine 2017). This analysis focuses primarily on the comparison of Level 6 with all other layers present at the site, but also includes comparisons to other sites in the region, in order to address issues of screen size, seasonality, and the complications associated with a highly fragmented assemblage.

This project contributes to the understanding of the site and its taphonomy, to the existing body of literature in the region, as well as providing a simple cost analysis for future data recovery excavations. Site 45KP233 is a site that is representative of temporally comparable sites, as well as an example of the type of site that the WSDOT will potentially encounter on future fish-passage projects. The relatively limited number of fish analyses in South Puget Sound also make this study one of some significance.

Organization of Thesis

In Chapter II, I discuss the environmental and cultural setting of the Kitsap Peninsula, and the South Salish Sea. Chapter III describes the study area and cultural history of 45KP233 and establishes a history and background of coastal archaeological sites in Washington, as well as reviews previous works done on the effects of screen size on faunal recovery. In Chapter IV, I explain the methodologies used in this thesis and the results of my analysis. In Chapter V, I discuss the results of my collaborative faunal analysis of the Anderson Creek site with Dr. Partlow, and initial interpretations from our technical report (Partlow and Holstine 2016). In Chapter VI, I expand on findings from the technical report and discuss other results and methodological issues involved with the analysis, and draw thesis conclusions.

CHAPTER II

STUDY AREA

The study site lies within the Puget Sound Basin. The Puget Sound Basin, or the Salish Lowland (Haugerud 2004), is the large forearc depression between the Olympic and the Cascade mountain ranges. It reaches from British Columbia to Chehalis, Washington, and has been subjected to many glaciations. Today, the landmass filling much of the interior of the Puget Sound Basin is the Kitsap Peninsula, bordered by Puget Sound to the north, east, and south, and by Hood Canal to the west. The Kitsap Peninsula was most recently glaciated in the late Pleistocene by the Puget lobe of the Cordilleran ice sheet (Haugerud 2009). This left behind vast amounts of glacial outwash and till in broad open troughs, which are now occupied by waterways, such as Sinclair Inlet, where the site is located (Figure 1). The site lies along the shallower, west end of the inlet, along the edge of the tidal mud flats, making it an ideal place for harvesting fish and shellfish.

The average rainfall in Bremerton, Washington, over the record from 1948 to 2005, is 51.73 inches of precipitation per year, with an average minimum temperature of 34.2 ˚F in January and average maximum temperature of 75.4 ˚F in August (Western Regional Climate Center 2017). The flora and fauna of the region are typical of temperate, coastal rainforests. The Kitsap peninsula is covered in mixed evergreen and deciduous forest comprised of western red cedar (*Thuja plicata*), Douglas-fir (*Pseudotsunga menziesii*), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), Oregon ash (*Fraxinus latifolia*), red alder (*Alnus rubra*), big-leaf maple (*Acer macrophyllum*), Pacific madrone (*Arbutus menziesii*) (Knoke 2004), as well as various other water tolerant, temperate species. According to the Washington State Department of Fish and Wildlife (2017a), local wildlife includes mountain beaver (*Aplodontia rufa*), American beaver (*Castor canadensis*), striped skunk (*Mephitis mephitis*), American elk (*Cervus elaphus*), black-tail, mule, and white-tail deer (*Odocoileus sp.*), mallard duck (*Anas platyrhynchos*), and many other species of mammals and birds as well as several species of snakes and turtles.

The Washington State Department of Fish and Wildlife (2017b) lists common fishes caught in Puget sound; many of these species are commonly found in coastal Puget Sound shell midden sites. These species include (but are not limited to) *Squalus suckleyi* (Spiny Dogfish), *Raja binoculata* (Big skate), *Clupea pallasii* (Pacific Herring), *Oncorhynchus kisutch* (Coho salmon), *Oncorhynchus tshawytscha* (Chinook salmon), *Embiotoca lateralis* (Striped seaperch), *Leptocottus armatus* (Pacific staghorn sculpin), as well as many rockfish and flounders.

Culture History

The site lies in a region known to be a traditional territory of the Southern Coast Salish (Suttles and Lane 1990). At European contact, the Southern Coast Salish subsisted on a combination of vegetable collection, land game, shellfish and fishing, with salmon making up the bulk of consumption (Suttles and Lane 1990). The Southern Coast Salish in the Sinclair Inlet area during the historic period are listed by Suttles and Lane (1990)

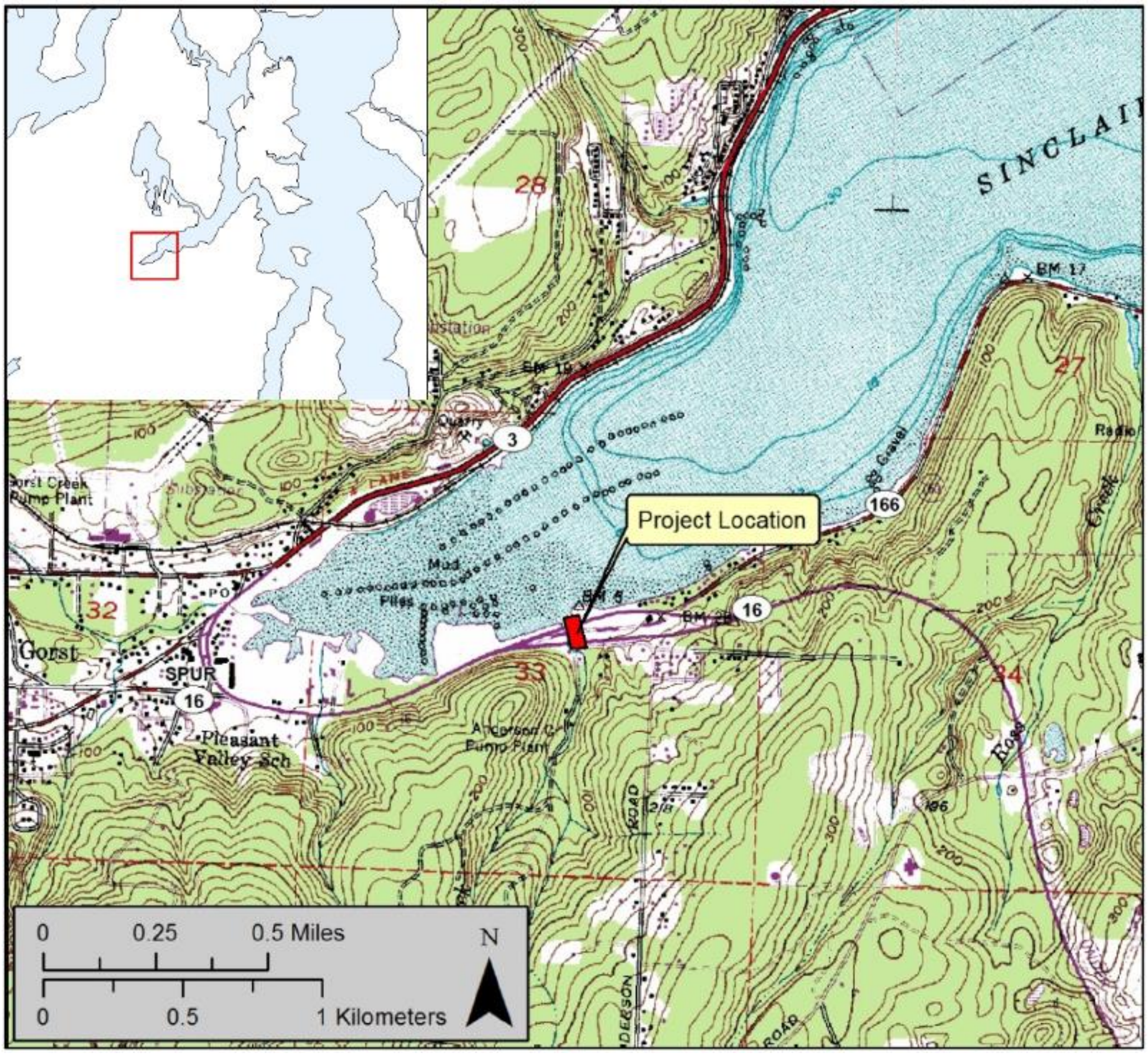

Figure 1. Site location within Sinclair Inlet of Puget Sound (Kiers and Littauer 2014:Figure 1).

as belonging to the Saktamish and Suquamish groups who spoke Lushootseed. In his recording of Suquamish place names, Snyder (1968) calls Sinclair Inlet by the Suquamish name of “stačábac” and “the whole inlet is known by this name.” “Stačábac” translates to “sea cucumber” in Lushootsheed (Waterman 2001:218). The head of Sinclair Inlet was recorded to have been home to a Suquamish seasonal fishing camp for chum

(*Oncorhyncus keta*) and Coho (*Oncorhynchus kisutch*) salmon, and huckleberry collection (Snyder 1968:131).

The site lies in a region that could have been occupied as early as 13,800 cal B.P. (Waters et al. 2011) if one accepts a human role for the Manis mastodon, but archaeological sites in Sinclair Inlet date no earlier than 4,000 years ago (Lewarch et al 2002:11). The early sites in Sinclair Inlet date to what Ames and Maschner (1999) name the Pacific Period for the Northwest Pacific Coast. They divide this into the Early Pacific Period (4400 to 1800 B.C.), The Middle Pacific Period (1800 B.C. to AD 200/500) and Late Pacific Period (AD 200/500 to 1775).

The Early Pacific Period is characterized by a shift in subsistence and settlement patterns, and an expanded use of intertidal resources (Ames and Maschner 1999). This period is expressed in the archaeological record in the form of large, thick, shell middens formed by the mounds of discarded mollusk shells, animal remains, and general rubbish (Ames and Maschner 1999). While most of the Pacific Coast sites of this period have dates ranging from 4400 to 1800 BC, large shell midden sites did not appear everywhere on the coast at the same time (Ames and Maschner 1999:89). Large midden sites of this type in Washington and Oregon tend to be younger; dating to around 1200 BC (Ames and Maschner 1999:89). This period is also characterized by increased production in food, by either developing a focal economy (focusing on several productive resources) or diversification (collection of all available types of resource). This could represent an increase in population, the intention to trade, or advances in storage technologies (Ames and Maschner 1999). These factors lead to/are a result of a less nomadic lifestyle, and increased sedentism among coastal tribes allowed for greater exploitation of resources. Shellfish are a good example of the relationship between sedentism and intensification in this region, because they can be collected by anyone, not just the able-bodied (Ames and Maschner 1999).

Ames and Maschner (1999:115) also point to the importance of both salmon and storage as focal points of coastal people's subsistence economies. Salmon were a predictable and reliable resource that could be exploited at specific times, and the ability to store this salmon relieved caloric stress from less productive seasons (Ames and Maschner 1999:116). While salmon were almost certainly a staple food source, researchers believe that salmon alone is not enough to sustain a people throughout the year. Ames and Maschner (1999:116) go on to describe the use of fish weirs designed, not to catch herring, but to provide attractive habitat for fish and mammals that would come to feed on the herring, and could be subsequently hunted in turn. This is an example of the wide use of "secondary resources," and is a way to exploit the entire food chain, rather than just a particular part.

Households were in close proximity to one another and represented residential corporate groups, where "the household functioned as an individual in economic production and consumption" (Ames and Maschner 1999:147). This organizational strategy allowed for the houses themselves to serve as shelter, a setting for rituals and ceremonies, and food processing, all for each family (Ames and Maschner 1999:147). House structures in the Early Pacific Period were mostly pit-houses, with a transition towards rectangular reed or plank houses towards the Middle Pacific Period. Different households would have different territories that they would exploit during different times of the year. This was accomplished with the use of rafts, and canoes to easily transport house-planks and possessions, to different house frames (Ames and Maschner 1999:148). This strategy is referred to as Historic Northwest Coast Sedentism and made coastal peoples highly mobile, while still maintaining a somewhat sedentary lifestyle (Ames and Maschner 1999:154).

The Middle Pacific Period (1800 B.C. to AD 200/500) is marked by a transition in housing from pit-houses to the plank house, as well as the widespread emergence of canoes (Ames and Maschner 1999). Subsistence patterns remained largely unchanged from the Early Pacific Period, but groups became even more sedentary than before, remaining in one place for much longer stretches of the year (Ames and Maschner 1999:93). Technological advances also improved the success rate for hunting larger marine mammals such as otters, seals, and whales (Ames and Maschner 1999:93).

The Late Pacific Period (AD 200/500 to 1775) is considered to be consistent with the historic record, with chipped stone tools being almost absent from sites, having been replaced by bone, or antler tools, as well as the presence of iron in later sites (Ames and Maschner 1999:144). There is also a shift from terrestrial hunting to a more marine economy, utilizing more marine mammals than were previously exploited (Ames and Maschner 1999:144). The appearance of large “reef nets” that were anchored in known salmon passages is also a development of the Late Pacific Period (Ames and Maschner 1999:144). The classic settlement form of this period is the plank house winter village occupied most of the year, and dispersed fishing villages and smaller settlements in the summer.

Archaeological excavations in Puget Sound reflect hunter-fisher-gatherer land use patterns of the traditional territory of the Suquamish Tribe. Stream-side geomorphic settings, where streams enter the Puget Sound, are common locations for archaeological sites in the region. Sinclair Inlet was likely the site of a series of multi-family, seasonal hunting and fishing encampments (Lewarch et al 2002). Faunal remains recovered from West Point Site (45KI428), in Seattle, show that deer and elk were being exploited at this site as early as 4,000 years ago, and as recently as 400 years ago (Lyman 1995).

The zooarchaeological record suggests that broad spectrum foraging patterns were in use throughout the Puget Sound throughout the Holocene (Butler and Campbell 2004:328). By comparing assemblages throughout Puget Sound, Butler and Campbell (2004:373) found that the use of the most abundant fish (salmon) did not increase relative to the use of other fish available in the area; in other words, there was no apparent intensification of salmon harvesting, relative to other potential prey, between 7000 and 150 years BP. Butler and Campbell’s (2004) study also compared coastal and riverine components, and found specialized harvest locations concentrated on salmon in the riverine environment, and herring in coastal settings, although not until 2500 BP (Butler and Campbell 2004:274). It is also stressed here that there was an increase in cervid use over time and that this may relate to the establishment of specialized upland hunting camps and improved logistical organization (Butler and Campbell 2004:275).

Europeans first arrived in Puget Sound with George Vancouver in 1792 (Boyd 1990), and this exploration was followed with the arrival of the Hudson’s Bay Company in the 1820s (Suttles and Lane 1990:481). Euroamerican settlement was based on the timber and fishing economy (Boyd 1990). Port Orchard, about a mile east of the site, was founded in 1886, by Fredrick Stevens, who named it for his Father, Sidney (Majors 1975). The city was incorporated in 1890, and renamed Port Orchard in 1903 (Majors 1975). Many of the early businesses in Port Orchard were to cater to the needs of logging companies and their laborers (Wetzel 1977), which established Sinclair Inlet as an adequate port for sea-going ships. With the construction of the Puget Sound Naval Shipyard, in 1891, across the inlet at Bremerton, the economic focus of Port Orchard became industrial in nature, with two saw mills, two shingle mills, and a terracotta sewer pipe plant (Wetzel 1977).

Study Site

This thesis focuses on the Anderson Creek site (45KP233). The excavation of the Anderson Creek site came as the result of the mandatory replacement of fish-blocking culverts throughout Puget Sound (Kiers 2016). The site lies where Anderson Creek crosses Washington State Route 16, approximately one mile west of Port Orchard, Washington, on the Southern shore of Sinclair Inlet. The site is on the western bank of Anderson Creek above the tidal mudflats (Figure 2).

Figure 2. Site 45KP233 boundary and location of recovery block (Kiers 2016:Figure 2).

45KP233 was identified during the archaeological survey that was conducted for the SR 16 Anderson Creek project in May, 2013 (Kiers and Littauer 2014). Midden deposits were encountered in three of five initial shovel probes within the Area of Potential Effect. North of the westbound lanes of SR 16, one positive probe contained whole and broken shell within a black matrix. Shovel probes between the lanes of traffic yielded sparse shell and historic debris that is believed to be associated with structures that were removed for the highway construction. Historic development and highway construction, along with bioturbation, have been noted as causes of disturbance at the site (Kiers and Littauer 2014).

Upon returning to the site for further investigation in September and October of 2013, five additional shovel probes were excavated (Kiers and Littauer 2014), and three of them yielded significant cultural materials. These positive probes extended the site boundary to the east, though it is unknown if the site continues on the west side of the creek channel. Excavation of two 1x1 m test units (TU1 and TU2) was done on either side of the SR 16 westbound lanes, adjacent to two of the positive shovel probes.

Because the testing indicated the site should be eligible to the NRHP and the fish passage project was to impact this site, data recovery excavations were called for and a data recovery plan prepared (Kiers 2015). Data recovery excavations were completed from September through October, 2015, consisting of an additional nine 1 x 1 m units (DR1-DR9) in a single block, placed adjacent to TU2 as indicted in Figure 2. These units, were excavated in natural levels, until culturally-sterile deposits were encountered. No stratigraphic layer, other than the modern fill, exceeded more than 10 cm in depth (Kiers 2016). After the units were completed, stratigraphic profiles were prepared.

Data recovery collection methods are described by (Kiers 2016). All of the site matrix was water-screened through nested screens with mesh sizes of 1/2", 1/4”, and 1/8”. Material was collected in the field from the 1/2" and 1/4” screens according to the protocol described by Kiers (2016), while the ⅛” material was bagged in bulk and brought to the lab for later sorting (Kiers 2016). Additionally, for the first bucket of each unit level, and each 4th bucket thereafter, a fine window-screen mesh (1/16”) was placed under the bottom of the nested screens to collect matrix that fell through the ⅛” mesh, in order to ensure the recovery of small-bodied fish bones, specifically herring (Kiers 2016).

This 1/16” matrix also was collected unsorted. Material collected from the site was bagged by unit and level, recorded on standard level forms, and photographed. Artifacts and formed tools warranted more detailed provenience and were plotted on a level form and bagged separately.

After materials were returned to the laboratory, they were sorted for analysis. According to Kiers (personal communication, 2016), the original intent was to sort bone and shell from all of the 1/8” and greater screen fractions, but this was so time consuming that an alternative strategy was used. For DR1 and DR2, this was completed, but afterwards only a 25% sample of the shell midden stratum (Layer 6) was sorted from the remaining units. Thus, the vertebrate faunal sample provided to the authors consisted of the ¼” and greater fraction for all units and layers, plus the ⅛” fraction for all units and layers except for Layer 6 of DR 3, 4, 5, 6, 7, 8, and 9, of which 25% is represented. The 1/16” fraction was not sorted at all from any unit, but a sample of this unsorted matrix from DR3 (all from DR3) was provided to the authors to evaluate the efficacy of 1/16” sorting and fish bone analysis.

CHAPTER III

FISH ZOOARCHAEOLOGY

In this section, I will explore past research done regarding the impact of screen size on taxonomic diversity of faunal remains. This literature review considers many aspects that must be addressed when deciding the appropriate screen size for a given excavation. The size of local or expected fauna, the condition of the remains present at the site, and the research questions themselves will all dictate the screen size necessary for a given excavation. This section also reviews the results of faunal analyses done at sites of similar age, and similar site types in order to give a fuller understanding of the context of the Anderson Creek site (45KP233).

Fish Bone Recovery and Screen Size

The role of screen size in faunal analysis is to provide a means of standardization of sampling and collection. Different sampling techniques may yield different results. The role of screen size has been discussed in recovery of faunal remains increasingly since the 1990s (e.g., Gordon 1993; Shaffer 1992, Stewart et al. 2003; Partlow 2006). Screen size is a particularly important issue in the recovery of fish remains, especially since some fishes like herring are quite small and would not be recovered in larger mesh screens. The use of 1/8” mesh is widely recommended for adequate recovery of fish remains over the use of 1/4” mesh (Vale and Gargett 2002, Moss and Cannon 2011, Stewart et al. 2003), but whether or not 1/16" mesh is necessary, especially in light of its time commitment, is unclear.

I should note that the metric conversions for screen size can be confusing. A straight conversion would be as follows: ¼" = 6.35 mm, 1/8"= 3.175 mm, 1/16"= 1.5875 mm, 1/32= 0.7938 mm. Some report different numbers, however. Stewart et al. (2003) use ¼"= 5.6 mm, 1/8"= 2.8 mm, 1/16"= 1.4 mm, and 1/32"= 0.7 mm. The difference might lie in the straight conversion as opposed to the actual size of the openings once the wire mesh is excluded.

In the study done by Stewart et al. (2003) on auger samples from coastal British Columbia archaeological sites, researchers compared the relative identifiability of zooarchaeological vertebrate remains recovered from various screen sizes. This study showed that while the use of small screen sizes (such as 1/32") will yield a far greater number of specimens, the number of specimens that can be identified, to class or better, will become smaller and smaller. Stewart et al. (2003) showed that of faunal remains recovered in the 1/32" screen, only 3.5% of these were identifiable. The 1/16" mesh screen showed the highest simple diversity (in terms of NISP). The 1/8" screened samples had the greatest percentage of identifiable specimens (Stewart et al. 2003).

Stewart et al. (2003:61) state that the 1/16" screen was necessary for the recovery of small, non-salmonoid species, and that the 1/8" sample significantly underrepresented herring in the assemblage. This suggests that the use of 1/16" screen should be used wherever small bodied fish, such as herring, are expected to be found. While Stewart et al. (2003:61) back up this point, they also concede that it is done at the cost of considerable time and effort, and go on to suggest that while 1/16” screen should be used, only a portion of the site should be analyzed for small bodied fish. It should be noted that their main argument is that specimens are lost in the larger screen sizes, but they did not specifically investigate its role on taxonomic proportions. I compared their data (Stewart et al. 2003:Table 2) for herring which showed this taxon made up 8/86 NISP (9%) of the 1/8” fraction and 149/573 NISP (26%) in the combined 1/16” and 1/8” fraction.

Elizabeth Gordon (1993) examined screen size with a Hawaiian fish assemblage. Through examination of the Nu’alolo Kai remains, it was found that remains recovered from the 1/8” and ¼” screens were a function of both sample size and the physical size of the taxa being recovered (Gordon 1993:7). Remains recovered from the initial excavation of the site, from 1958-1960, were recovered using ¼” screens, and amounted to an NISP of 1,417 (Gordon 1993). When combined with the results of the 1/8” screens from the 1990 excavation, the fauna recovered from the ¼” screens, in 1960, represented only 15% of the total NISP for the site (Gordon 1993); just 1,417 of 8,318 fish bones recovered from the site. Gordon (1993) concludes that screen size does play an important role in the recovery of faunal remains in archaeological sites: ¼” screen creates a biased sample, favoring larger bodied fish, and leaving small bodied fish underrepresented. Therefore, the use of 1/8” screen is required to accurately sample a site.

Partlow (2006) examined screen size effects on fish bone recovery from a coastal shell midden site in the Kodiak Archipelago, Alaska. In Partlow’s (2006) study, it was concluded that systematic screen sampling is necessary to maintain representative taxonomic proportions. Determination of screen size, ideally, should consider the types of fauna present at the site, the degree of fragmentation, and the research questions posed: at sites where the processing of only large bodied fish (like salmon or halibut) has occurred, ¼" screen could be adequate, but if processing involved bone fragmentation, or small bodied fish, then 1/8" screen or smaller is necessary (Partlow 2006).

In a study of fish remains from Tonga, Nadia Densmore (2009) concluded that the use of 1/8" and 1/16" screens provides a more accurate relative abundance of species when fish remains are present at the site, when compared to ¼" screen collected samples. Densmore found that while the additional remains were not statistically significant in terms of the goal of their study, they did present a better representation of resource utilization at the site. The samples at the site that were collected with the ¼" screen did not maintain an accurate relative abundance of fauna at the site, when compared to those of the 1/8" and 1/16" samples (Densmore 2009). The relative abundance of large and small bodied fish is an important detail for understanding the purpose of the site.

Vale and Gargett (2002) investigated screen size effects in a coastal Australian archaeological site, in which most of the expected taxa were large bodied fishes. They note that the 1/16" sample provided some very small fish vertebrae which could possibly be the stomach contents of larger fish that were the presumed target for human consumption. Given this, they did not feel that the 1/16" sample provided information that was not captured in the 1/8" sample. But they do note that adequate screen size depends on the research question, fish body and element size.

Zohar and Belmaker (2005) reanalyzed the results of the study done by Vale and Gargett (2002). They attest that the study done by Vale and Gargett (2002) used flawed methodology, and reached incorrect conclusions. Zohar and Belmaker (2005:1) employed Vale and Gargett's data in a new analysis using a statistical method called "the equivalent alpha diversity method for abundification." While Vale and Gargett looked separately at species richness and taxonomic abundances, Zohar and Belmaker (2005) suggest that these two factors should be examined together. The authors show that the use of smaller screen size changes the relative abundance patterns in both NISP and MNI. They argue that the use of fine mesh screens cannot be over-stressed, because it provides a more complete view of species richness, skeletal part representation, body size distribution, and taphonomic patterns. Using the before mentioned statistical technique, Zohar and Belmaker (2005) demonstrated that taxonomic diversity would have been more rich than reported by Vale and Gargett. Based on the results of the equivalent alpha diversity method for abundification, Zohar and Belmaker's data support the opposite conclusion as that of Vale and Gargett; that the use of 3 and 1 mm mesh screens is an important tool in measuring the diversity of archaeological assemblages.

In conclusion, there is a diversity of opinion on the necessity for using 1/16" screen for the recovery of small-bodied fishes. Those that argue it is necessary include Gobalet (1989), Stewart et al. (2003), Densmore (2009), and Zohar and Belmaker (2005). For example, Gobalet (1989) notes its necessity for the recovery of three-spine stickleback, freshwater sculpin, and other small fish from interior California sites. Stewart et al. (2003) showed that 1/16" sample was necessary to avoid underestimating herring abundance in British Columbia auger samples. On the other hand, Moss and Cannon (2011), Gordon (2002), and Vale and Gargett (2002) do not support this position.

Moss and Cannon (2011:285) suggest that 1/8” mesh is adequate for recovering herring bones. At present, the importance of 1/16” mesh for herring recovery is uncertain, particularly given its expense in excavation, sorting, and analysis.

Fish Assemblages in the Salish Sea

A number of previous faunal analyses have been reported for sites in the region. While there are only a few coastal, fish-bearing sites reported from Southern Puget Sound, such as the Bay Street Shell Midden (Lewarch et al. 2002), and Qwu?gwes (Wigen 2013), there are a few other pertinent sites a bit further afield. One site worth discussing and considered for comparison in this thesis is Tse-whit-zen, currently being analyzed by Dr. Virginia Butler and her students, and reported in several theses (e.g., Mohlenhoff 2013). A more complete list of comparable fish assemblages in the Salish Sea is provided in discussions at the end of Chapter IV and in Chapter V, and a map of key sites is provided near the end of Chapter IV.

The closest reported faunal assemblage to the site is from the Bay Street Shell Midden. The Bay Street Shell Midden (45KP115) was found in nearby Port Orchard during construction excavation for the foundations of a new Municipal Building (Lewarch et al. 2002). Intact shell midden deposits of over 2 meters in depth were identified and subsequent data recovery took place in June of 1998. Data recovery found three occupation components that were dated to approximately 800 to 130 years BP, with Component 1 from 800-550 B.P., Component 2 from 550-130 B.P., and Component 3 at about 130 B.P. No structures were identified at the site. Excavated sediments were screened through nested 1”, ½”, ¼”, and 1/8” mesh.

Analysis of fish remains was completed by Dr. Virginia Butler (Portland State University) and analysis of the remaining fauna was done by Amy Dugas and Dr. Lee Lyman. The mammal, bird, and reptile sample of 1,722 NISP included *Cervus elaphus* (Wapiti), *Odocoileus hemionus* (mule deer), *Ursus americanus* (black bear), *Canis* sp. (dog), and *Aplodontia rufa* (mountain beaver) (Lewarch et al 2002:113). The fish sample of 4,034 NISP included *Squalus suckleyi* (Spiny dogfish), *Hydrolagus collei* (Spotted ratfish), *Clupea harengus* (herring), Salmonidae (salmon), Gadiformes (codfishes), Batrachoididae (toadfishes), Scorpaeniformes (sculpins), Embiatocidae (surfperches), and Pleurectiformes (flatfishes) (Butler and Baker 2012). Radiocarbon dates from the Bay Street Shell Midden (45KP115) place settlement and use as contemporaneous to that of the Anderson Creek Site (45KP233). Relatively low numbers of bird and mammal remains, compared to those of fish, suggest that the site was primarily a fishing and shellfish gathering camp (Lewarch et al 2002).

The Qwu?gwes site, is located at the southern end of Eld Inlet, in Puget Sound (Croes et al. 2007; Croes2013). The site was excavated under the direction of Dr. Dale Croes from 1999 to 2009. It is temporally comparable to Anderson Creek, with the earliest component dating to approximately 700 BP (Croes 2013). Qwu?gwes is a shell midden and intertidal wet site with an associated fish trap. A total of 55, 1x1 meter excavation units were completed at Qwu?gwes. Excavation was done using gentle garden spray nozzles to remove substrate and expose artifacts. Debris removed from the units was wet screened, through nested screens with ½”, ¼” and 1/8” mesh. The site is interpreted as a seasonally-occupied food processing camp dating between 700 and 150 BP (Croes 2013:iv). Over 100,000 shellfish hinges were recovered from excavation. A total of 20,658 specimens of vertebrate faunal remains were recovered from the site, the vast majority of which are fish and mammal (77% and 21.5% of the assemblage, respectively (Croes 2013:4) the fish remains at Qwu?gwes are almost entirely salmon. Besides fish and shellfish, this site yielded mallard duck, muskrat, mountain beaver, beaver, deer, and elk (Croes et al 2007).

Tse-whit-zen was a large village site on the Olympic Peninsula, dating between 1824 and 54 cal B.P. (Mollenhoff 2013). It was excavated, and water-screened through nested 1”, ½”, ¼” and 1/8” screens. Like 45KP115, the faunal assemblage at Tse-whit-zen is almost entirely made of up fish remains. The fish remains are currently being analyzed by Dr. Virginia Butler and her students as part of an NSF-funded research project on the site. A comparative collection was assembled with the help of Dr. Virginia Butler, R. Kopperl, and R. Smith, who were able to loan specimens. This collection was based on the Marine Ecosystems Analysis report (MESA 1980), which is the compiled results of a three-year survey of fish in the Strait of Juan de Fuca. Mohlenhoff (2013) examined a sample of 10,358 fish bone specimens from a single 2 x 2 m unit for human fishing responses to a single earthquake event. She found that there was widely varied use of fish at Tse-Whit-Zen, including Pacific herring, small cottids and flatfish, Pacific cod, salmon, sablefish and spiny dogfish (Mollenhoff 2013). While there was a great deal of diversity present at the site, salmon made up only 10% of the assemblage in both the upper and lower components.

Table 1 compares NISP of the faunal fish remains at Tse-Whit-Zen, Qwu?gwes, and Bay Street. These sites have significant overlap of species, suggesting that there were similar subsistence strategies being practiced, and because they are temporally similar these sites are convenient for comparison. However, there are also significant differences between the sites. For example, unlike the assemblage at Tse-whit-zen, the fish remains at Qwu?gwes are almost entirely salmon. The species present at these similar sites provided a base of taxa to expect in the analysis of 45KP233, Anderson Creek.

Table 1. Fish Remains from Three Salish Sea Coastal

Order	Family or Species	Tse-Whit-Sen[1]	Qwu gwes[2]	Bay Street[3]
Chimeriformes	Spotted Ratfish - *Hydrolagus collei*	30	--	17
Squaliformes	Spiny Dogfish - *Squalus suckleyi*	153	490	59
Rajiformes	Skates – Family Rajidae	13	2	2
Acipenseriformes	Sturgeon – Family Acipenseridae	--	2	--
Clupeiformes	Herring - *Clupea harengus*	1,220	42	411
	Northern Anchovy - *Engraulis mordax*	1	--	--
Osmeriformess	Surf smelt- *Hypomesus pretiosus*	--	6	--
Cypriniformes	Minnows – Family Cyprinidae	--	5	--
	Suckers – Family Catostomidae	--	4	--
Salmoniformes	Salmon - Family Salmonidae	224	7,774	122
Gadiformes	Cods - Family Gadidae	296	7	54
Batrachoidiformes	Midshimpan – *Porichthys notatus*	--	49	10
Gasterosteidae	Bay pipefish – *Syngnathus leptorhynchus*	--	2	--
Scorpaeniformes	Rockfishes – Family Scorpaenidae	5	1	--
	Sablefish – *Anoplopoma fimbria*	127	--	--
	Greenlings – Family Hexagrammidae	30	--	--
	Sculpins – Family Cottidae	636	205	19
Perciformes	Surfperches – Family Embiatocidae	19	156	44
Pleurectiformes	Sand Flounders – Family Paralichthydae	19	--	6
	Righteye Flounders – Family Pleuronectidae	20	58	393
	Total fish specimens	2,786	14,034	4.034

[1] from Mollenhoff 2013:Table 4.1, [2] from Wigen 2013:Table 6, [3] from Lewarch 2002:Table 27. Remains included are identified to Family or better.

CHAPTER IV

METHODS AND RESULTS

Methods

The objective for this thesis was to gather quantitative data on species abundance and diversity at the Anderson Creek site, 45KP233. The collection had been stored, since its initial collection, at a WSDOT facility in Olympia, Washington. Material on the site was screened using 1/4” and 1/8” screens, as well as bulk samples collected from 1/16” mesh. All of the vertebrate faunal materials provided by WSDOT have been analyzed for this thesis. (See Chapter II for details on field recovery and the sample provided by WSDOT for analysis.)

Prior to analysis, the DR3 1/16” fraction matrix was sorted in the laboratory by the author to obtain faunal remains. Analysis was then attempted on all vertebrate faunal remains found in this matrix, as well as all other remains received. All analysis was completed by the author and verified by Dr. Megan Partlow. The basic analytical unit used in the analysis was an individual bone or bone fragment, referred to as a "specimen". Each specimen was examined and identified to taxon, element, portion, landmark and side as possible.

Faunal samples were separated by taxonomic class and identified as close to the species level as possible, with the exception of fish ribs, fin rays, spines and hypurals, which were enumerated as unidentified fish. This level of identification was done predominantly through direct comparison to the specimens available in the CWU comparative collection, as well as several on loan from the Burke museum. All fish, birds, and mammals with current or historic distributions in Washington have been considered (Burke Museum 2013; Eschmeyer and Herald 1983; Somerton and Murray 1976, Peterson 1990, Whitaker 1980; Wydoski and Whitney 2003). When taxonomic identification of terrestrial mammal elements was impossible, the elements were organized by Thomas's (1969) size classification system, with the addition of an additional sixth size class. This sixth size class was used to classify mammals between 200-1,500 kilograms. Element naming conventions and siding for mammals followed Gilbert (1990), Gilbert et al. (1985) for birds, Wheeler and Jones (1989) and Cannon (1987) for fish. Taxonomy follows the Integrated Taxonomic Information System online (www.itis.gov) as of June 2016, except for fishes listed in Page et al. (2013).

A number of taphonomic and other variables were recorded for each specimen: burning, weathering stage, root etching, breakage type, age indicators, and maximum length. Weathering stage was recorded as Stage 0 (unweathered) to Stage 5 (falling apart) after Behrensmeyer (1978), Lyman and Fox (1989), and Todd et al. (1987). The surface of each mammal, bird, and reptile specimen was examined with the use of a 15X hand lens for signs of modification (e.g., cutmarks, rodent gnawing).

Once the collection had been analyzed, it was entered into a relational database, designed by Dr. Patrick Lubinski (CWU), in Microsoft Access. All faunal data were entered into the database, and queries were run to determine taxon and element counts. Taxonomic abundance was measured using number of identified specimens (NISP; Payne 1975). Faunal specimens identified as artifacts (e.g., bone points or awls) were excluded from the analyses. For the purposes of this thesis, results were aggregated into six analytical units: Layer 2A, 3A, 4A, 5 (A and B), 6 (A, B, and C), and 7A. No faunal remains were received for Layer 1.

A report was prepared for WSDOT (Partlow and Holstine 2017) for their use in fulfilling the terms of their obligation for archaeology data recovery work at the site. This thesis incorporates and builds on that report.

Report Results

The majority of the results of the collaborative analysis with Dr. Partlow were provided in a report written to comply with obligations from WDSOT archaeological data recovery excavations at the site (Partlow and Holstine 2017). The results and discussion already completed for that report are summarized and somewhat repeated in this chapter. The following chapter (V) will move beyond results in the report to additional results and discussion by the author.

A total of 15,086 bone specimens were analyzed. These were distributed unevenly among the six analytical units and nine excavation units, with the majority from Layer 6 and DR3 (Table 2). The majority of specimens were from the ⅛" and larger size fraction, but 24% were derived from the 1/16" DR3 sample. Layers 1A-5A are historic in age but the underlying Layers 6 and 7A are prehistoric. Layer 6 is a shell midden with a 19th century coin near its top and lower radiocarbon dates from 220-670 BP. Layer 7A is pre-shell midden and has a radiocarbon date of 850 BP.

The assemblage was highly fragmented (only 4 specimens were complete) and included many small bone fragments: 94% (14,146/15,086) of the faunal specimens from the site measured 1 cm or less in length. (When only ⅛” and larger fractions are considered, 92% of specimens are <1 cm, 10,558/11,502). Most specimens had indeterminate breakage (>99%); six specimens had recent breakage only, while two specimens had obvious green breakage. Because of the high degree of fragmentation, only 22% (3,245/15,086) of the faunal specimens were identified to the order level (e.g. Artiodactyla or Pleuronectiformes) or better.

Table 2. 45KP233 Faunal Remains by Analytical Unit

Analytical Unit	All NISP	NISP 1/16”[1]
Layer 2A	478	0
Layer 3A	60	7
Layer 4A	207	33
Layer 5	2,578	1,005
Layer 6	7,641	1,599
Layer 7A	4,122	945
Total by layer	15,086	3,589
DR1	1,818	0
DR2	3,292	0
DR3	6,172	3,589
DR4	457	0
DR5	524	0
DR6	840	0
DR7	683	0
DR8	85	0
DR9	1,215	0
Total by DR unit	15,086	3,589

[1] The 1/16” sample is derived from DR3 only, and Layer 2A did not extend into this unit.

Eighteen different taxonomic groups were identified, including seven different mammals and nine different fishes (Table 3). All of these taxa were present in the ⅛" fraction and no new taxa were identified in the 1/16" sample. Mammal taxa from the site as a whole include mountain beaver (*Aplodontia rufa*), beaver (*Castor canadensis*), cottontail rabbit (*Sylvilagus* sp.), striped skunk (*Mephitus mephitis*), deer (*Odocoileus* sp.), American elk (*Cervus elaphus*), and cattle or bison (*Bos* sp./*Bison* sp.). Fishes include Pacific spiny dogfish (*Squalus suckleyi*), skate (Family Rajidae), Pacific herring (*Clupea pallasii*), smelt (Family Osmeridae), salmon or trout (Family Salmonidae), cod (Family Gadidae), Pacific staghorn sculpin (*Leptocottus armatus*), surfperch (Family Embiotocidae), and starry flounder (*Platichthys stellatus*). (Note that the remains identified as salmonids are almost certainly Pacific salmon (*Oncorhynchus* sp.), but since these were vertebra and teeth fragments that were not examined in sufficient detail to rule out trouts of the genus *Salvelinus*, they are listed as Family Salmonidae.) Fish remains dominate, with 64% of the total site assemblage, followed by mammals (29%), birds (<1%), and snake (<1%).

Fish remains from all size fractions were mostly (87%; 8,318/9,593) unburned and unstained. A minority (11%) exhibited clear signs of burning, with 10% (984) blackened and 1% (93) calcined. A small number (2%; 199) exhibited some more ambiguous dark staining, presumably from mineral accumulation. The majority of fish bones (97%; 9,314) were unweathered to lightly weathered (Stage 0-1), although almost 3% (247) exhibited Stage 2 weathering and <1% (33) exhibited Stage 3. Almost none of the fish bones showed root etching (n=16). The general lack of weathering and root etching imply that most of the fish assemblage was buried relatively quickly and deeply.

The mammal assemblage as a whole was also primarily (77%; 3,320/4,328) unburned and unstained, although 16% were blackened (690) and 1% were calcined. Another 94 specimens exhibited some kind of dark mineral staining that was clearly not burning, and 175 specimens exhibited an ambiguous discoloration either from burning or staining. The majority of mammal remains (69%; 2,974) were unweathered to lightly weathered (Stage 0-1), while another 22% (943) had Stage 2 weathering, 9% (408) had Stage 3 and three specimens had Stage 4. Most of the mammal remains showed no sign of root etching, although 8% (397) showed light etching and 7 showed heavy etching. The variable nature of weathering and root etching imply that the mammal assemblage may have had a mixed taphonomic history, with some buried relatively quickly and deeply and others exposed prior to burial, shallowly buried, or re-exposed after burial.

The majority of the mammal assemblage (99%; 4,289) showed no signs of modification. Some 20 specimens exhibited digestive polish or etching and one specimen had rodent gnawmarks. Cutmarks were found on seven specimens: an elk scapula, a deer second phalanx, two metapodial distal shaft fragments from deer/sheep, pronghorn/or goat, a deer-size femur shaft fragment, a deer-size longbone shaft fragment, and a deer to elk-size scapula blade fragment.

Table 3: 45KP233 Faunal Remains (NISP) From All Size Fractions

Class	Order	Taxon	Common Name	L 2A	L 3A	L 4A	L 5	L 6	L 7A	Total
Mammalia (Mammals)	Rodentia	*Aplodontia rufa*	Mountain beaver	--	--	--	--	1	--	1
		Castor canadensis	Beaver	--	--	--	--	1	1	2
	Lagomorpha	*Sylvilagus* sp.	Cottontail rabbit	--	--	--	--	--	2	2
	Carnivora	*Mephitus mephitus*	Striped skunk	--	--	--	--	1	--	1
	Artiodactyla	*Odocoileus sp.*	Deer	3	--	1	4	18	--	26
		Cervus elaphus	American Elk	--	--	--	--	27	147	174
		D/S/P/G	Deer, sheep, pronghorn or goat	1	--	--	2	24	11	38
		Bos/Bison sp.	Cattle/bison			--	2	--	--	2
	Unknown	Size Class I-III	Mouse to rabbit-sized	84	--	6	32	55	47	224
		Size Class IV-VI	Dog to bison-sized	32	17	63	653	823	1,222	2,810
		Unidentified	Unidentified mammal	85	22	35	207	486	213	1,048
			Total Mammal	205	39	105	900	1,436	1,643	4,328
Aves (Birds)	Unknown	Unidentified	Unidentified bird	--	--	--	2	4	11	17
Reptilia	Squamata	Suborder Serpentes	Unidentified snake	--	--	--	1	5	7	13
Chondrichthyes (Cartilag. fishes)	Squaliformes	*Squalus suckleyi*	Pacific spiny dogfish	12	--	--	15	62	38	127
	Rajiformes	Family Rajidae	Skates	1	--	--	--	15	2	18
Actinopterygii (Ray-finned fishes)	Clupeiformes	*Clupea pallasii*	Pacific herring	2	--	--	--	11	26	39
	Osmeriformes	Family Osmeridae	Smelts	--	--	--	1	1	4	6
	Salmoniformes	Family Salmonidae	Salmon, trout, whitefish	40	4	9	416	948	597	2,014
	Gadiformes	Family Gadidae	Cods	1	--	--	1	5	--	7
	Scorpaeniformes	Unknown	Rockfishes, sculpins, greenlings	1	--	--	3	2	--	6
		Family Cottidae	Sculpins					7		7
		Leptocottus armatus	Pacific staghorn sculpin	--	--	--	28	52	15	95
	Perciformes	Family Embiotocidae	Surfperches	1	--	--	4	46	41	92
	Pleuronectiformes	Unknown	Flatfishes	16	--	9	56	353	140	574
		Platichthys stellatus	Starry flounder	2	--	--	--	--	--	2
	Unknown	Unidentified	Unknown fish	96	3	53	968	4,097	1,390	6,607
			Total Fish	172	7	71	1,492	5,599	2,253	9,594
			Total Id. to Class	377	46	176	2,395	7,044	3,914	13,952
			Unidentified	101	14	31	183	597	208	1,134
			Total	478	60	207	2,578	7,641	4,122	15,086

Detailed descriptions of faunal identifications by stratigraphic level (Layer 1A through 7A) are provided in the report (Partlow and Holstine 2016). These are not repeated in the thesis, except for Layers 6 and 7A, which are discussed here as they are the only prehistoric levels, and they compose the majority of the site assemblage (78%, 11,768/15,086). A comparison of all layers will be discussed in the following chapter.

Layer 6 Faunal Remains

Combined, the faunal remains from 6A, 6B and 6C total 7,641 NISP. Identified taxa include mountain beaver, American beaver, striped skunk, deer, American elk, bird, snake, Pacific spiny dogfish, skate, Pacific herring, smelt, salmonid, cod, Pacific staghorn sculpin, surfperch, and flatfish (Table 4). Layer 6 included 1,599 specimens from the $^{1}/_{16}$" sample from DR3.

Rodents are represented in these layers by mountain beaver and American beaver. A complete left calcaneus was identified as mountain beaver. A thoracic neural arch and dorsal spinous process was identified as American beaver. An additional four specimens identified as Mammal Size Class I (mouse-sized) and eight specimens identified as Mammal Size Class II (squirrel-sized) are likely from rodents as well. Mouse-sized specimens include a mandibular incisor fragment, an incisor fragment, a left ulna proximal shaft fragment, and a thoracic vertebra centrum fragment. Squirrel-sized specimens include a blackened incisor fragment, a fragment of tooth enamel, two longbone shaft flakes, a blackened longbone end fragment, and three fragments from unknown elements.

Table 4: Layer 6 Faunal Remains from All Size Fractions[1]

Order	Taxon	Common Name	NISP
Class Mammalia (mammals)			
Rodentia	*Aplodontia rufa*	Mountain beaver	1
	Castor canadensis	American beaver	1
Carnivora	*Mephitus mephitis*	Striped skunk	1
Artiodactyla	*Odocoileus sp.*	Deer	18
	Cervus elaphus	American Elk	27
	D/S/P/G	Deer, sheep, or pronghorn	24
Unknown	Size Class I	Mouse-sized	4
	Size Class II	Squirrel-sized	8
	Size Class III	Rabbit-sized	32
	Size Class I-III	Mouse to rabbit-sized	11
	Size Class IV	Dog-sized	19
	Size Class V	Deer-sized	217
	Size Class VI	Bison-sized	4
	Size Class IV-VI	Dog to bison-sized	413
	Size Class V-VI	Deer to bison-sized	170
	Unidentified	Unidentified mammal	486
		Total Mammal	1,436
Class Aves (birds)			
Unknown	Unidentified	Unidentified bird	4
Class Reptilia (reptiles)			
Squamata	Suborder Serpentes	Snakes	5
Class Chondrichthyes (cartilaginous fishes)			
Squaliformes	*Squalus suckleyi*	Pacific spiny dogfish	62
Rajiformes	Family Rajidae	Skates	15
Class Actinopterygii (ray-finned fishes)			
Clupeiformes	*Clupea pallasii*	Pacific herring	11
Osmeriformes	Family Osmeridae	Smelts	1
Salmoniformes	Family Salmonidae	Salmon, trout, whitefish	948
Gadiformes	Family Gadidae	Cods	7

Table 4: Layer 6 Faunal Remains from All Size Fractions[1] (continued)

Order	Taxon	Common Name	NISP
Scorpaeniformes	Family Cottidae	Sculpins	4
	Leptocottus armatus	Pacific staghorn sculpin	52
	Unknown	Rockfishes, sculpins, greenlings	2
Perciformes	Family Embiotocidae	Surfperches	46
Pleuronectiformes	Unknown	Flatfishes	353
Unknown	Unidentified	Unidentified fish	4,097
		Total Fish	5,598
		Total Identified to Class	7,044
		Unidentified	597
		Total	7,641

[1] The $^{1}/_{16}$" fraction in this layer yielded 3 Size I mammal, 5 Pacific spiny dogfish, 4 skate, 2 herring, 198 salmonid, 2 cod, 6 Pacific staghorn sculpin, 1 unidentified scorpaeniform, 13 surfperch, 12 flatfish, and 1,353 unidentified fish.

A total of 32 specimens were identified as Mammal Size Class III (rabbit-sized). They include seven longbone shaft flakes (one burnt or stained, one with possible digestive etching), and 25 fragments from unknown elements (seven blackened). Another 11 specimens were identified as Mammal Size Class I-III (mouse to rabbit-sized). They include six longbone shaft flakes (one blackened), and five fragments from unknown elements (two blackened). In addition, 19 specimens were identified as Mammal Size Class IV (dog-sized). They include nine longbone shaft flakes, a metapodial distal shaft fragment, two thoracic vertebra centrum fragments (one with digestive etching), a thoracic vertebra neural arch fragment, a vertebra centrum fragment, and five fragments from unknown elements (one with digestive etching).

Carnivores are represented by striped skunk. A left mandibular toothrow with first and second molars was identified as striped skunk. Rodent gnawing was found along the edge of the horizontal ramus.

Artiodactyls are represented by deer and American elk remains. A total of 18 specimens were identified as deer. They include a cervical vertebra zygopophysis, a left humerus shaft flake, two left humerus distal epiphysis fragments with recent breakage, a complete right cuneiform, a left metacarpal proximal shaft fragment, a first phalanx proximal shaft fragment, a first phalanx proximal epiphysis fragment, four first phalanx distal shaft fragments, two second phalanx proximal shaft fragments (one with cutmarks), a second phalanx distal shaft fragment with cutmarks, a second phalanx distal epiphysis fragment, and two complete third phalanges. Another 24 specimens identified as DSPG are likely from deer as well. They include two lumbar vertebra zygopophyses, a femur shaft flake, a left tibia distal shaft fragment, a left tibia distal epiphysis fragment, a right astragalus fragment, a left navicular cuboid fragment, two metapodial distal shaft fragments with cutmarks, two longbone shaft flakes, a first phalanx proximal shaft fragment, two first phalanx distal shaft fragments (one with digestive etching), a second phalanx distal shaft fragment, four second phalanx distal epiphysis fragments, a second phalanx fragment, two unknown phalanx distal shaft fragments, a complete accessory first phalanx, and a complete accessory second phalanx. An additional 217 specimens identified as Mammal Size Class V (deer-sized) are probably from deer. They include a scapula blade fragment with scratches perpendicular to the long axis, a right femur shaft flake with cutmarks perpendicular to the long axis, 72 longbone shaft flakes (12 blackened, two burnt or stained), two rib fragments, a lumbar vertebra zygopophysis, 10 vertebra centrum fragments, two vertebra centrum epiphyses, one vertebra neural arch fragment, three vertebra fragments, and 124 fragments from unknown elements (10 blackened, 17 burnt or stained, four with dark staining, one digestive etching, one with possible digestive etching).

A total of 27 specimens were identified as elk. They include 20 antler fragments (12 blackened, four with dark staining), a cervical vertebra zygopophysis, a scapula blade fragment with many scratches and grooves the length of the blade and cutmarks across one edge, a left lunate fragment, a blackened right metacarpal proximal shaft fragment, an innominate ischium fragment, and two blackened longbone shaft flakes. Another four specimens identified as Mammal Size Class VI (bison-sized) are likely elk as well. They include a left maxillary adult fourth premolar, a mandibular incisor fragment, a blackened metacarpal shaft flake, and a longbone shaft flake.

Another 170 specimens identified as Mammal Size Class V-VI (deer to bison-sized) and 413 specimens identified as Mammal Size Class IV-VI (dog to bison-sized) are likely from artiodactyls. Deer to bison-sized specimens include a tooth enamel fragment, a blackened tooth fragment, two scapula blade fragments, 30 antler fragments, five longbone shaft flakes (two blackened), two vertebra centrum epiphyses, and 129 fragments from unknown elements (18 blackened, one blackened with linear scratches and polish, two calcined, seven burnt or stained, one with dark staining). Dog to bison-sized specimens include nine longbone shaft flakes (four blackened), one blackened vertebra fragment, three vertebra centrum epiphysis fragments, and 400 fragments from unknown elements (69 blackened, one calcined, two burned or stained, four with dark staining, six with digestive etching).

A total of 486 specimens were so fragmented that they were not assigned to a mammal size class. All are fragments from unknown elements (120 blackened, three with digestive polish).

Birds are represented by four specimens, all duck-sized. These include a right coracoid fragment, a right radius proximal shaft fragment, a carpometacarpus distal epiphysis fragment, and a blackened phalanx proximal shaft fragment. Reptiles are represented by five vertebra centra identified as snake.

Cartilaginous fishes are represented by 77 specimens in Layer 6. A total of 62 specimens were identified as Pacific spiny dogfish. They include six complete vertebra centra, 50 vertebra centrum fragments (seven blackened), and six teeth (one blackened). A total of 15 specimens were identified as skate. They include 14 teeth (two blackened) and one dermal denticle.

There are 11 herring specimens, including a first vertebra centrum, a complete blackened abdominal vertebra, an abdominal vertebra centrum, seven caudal vertebra (one blackened), and one burnt or stained ultimate vertebra. A single caudal vertebra centrum was identified as a smelt.

Salmonids are represented by 948 specimens, including two maxilla fragments, 181 teeth (10 blackened), two thoracic vertebra centra, two thoracic vertebra centrum fragments, eight caudal vertebra centra (five calcined), one caudal vertebra centrum fragment, and 752 vertebra centrum fragments (94 blackened, two calcined, 22 burnt or stained).

Only five specimens from a small cod (e.g., Pacific tomcod *Microgadus proximus*) have been identified: three precaudal vertebra centra and two caudal vertebra centrum fragments (one blackened).

The assemblage includes 61 specimens identified as Scorpaeniformes. 52 specimens were identified as Pacific staghorn sculpin. They include a burnt or stained right preopercle fragment, three preopercle fragments (one calcined), a left posttemporal fragment, two right symplectic fragments, a symplectic fragment, three first vertebra centra (one blackened), a first vertebra centum fragment, 13 thoracic vertebra centra (one blackened), a precaudal vertebra centrum, a precaudal vertebra centrum fragment, 21 caudal vertebra centra (two blackened), and four caudal vertebra centrum fragments. An additional seven specimens were identified as sculpin (Family Cottidae). They include a blackened left epihyal fragment (c.f. Irish lord), a left proximal quadrate, four preopercle fragments, and a thoracic vertebra centrum. Another two specimens were identified as scorpaeniformes (rockfish, sculpin, or greenling). They include a first vertebra centrum and a precaudal vertebra centrum fragment.

There are 86 specimens identified as Surfperch. 46 specimens: a right exoccipital fragment, four first vertebra centra, 21 thoracic vertebra centra (one blackened), six precaudal vertebra centra (one blackened), a precaudal vertebra centrum fragment, and 12 caudal vertebra centra.

Flatfishes identified in this layer had a count of 353 specimens, all appearing to be from small flatfish (rather than large halibut, for example) and from a variety of elements. There are over a dozen different species of flatfish which inhabit Puget Sound. Due to similarities between species and gaps in the comparative collections at CWU and the Burke Museum, identifications were made conservatively. Specimens include a tooth, six unidentified toothed elements, a blackened basibranchial fragment, four basioccipital fragments (one blackened), two right dentary fragments, two complete left ectopterygoids (one burnt or stained), two left ectopterygoid fragments (one blackened), a right ectopterygoid fragment, an ectopterygoid fragment, a right epihyal fragment, a blackened epihyal fragment, a left exoccipital fragment, a right hyomandibular fragment, two first interhaemals, two left proximal maxilla fragments, a second pharyngobranchial, 28 pharyngobranchial fragments (nine blackened), six left proximal premaxilla fragments , seven premaxilla fragments (three blackened), three right proximal premaxilla fragments, one right premaxilla fragment, four premaxilla fragments (one blackened), a left proximal posttemporal fragment, two left posttemporal fragments (one blackened), a blackened right proximal posttemporal fragment, two posttemporal fragments (one blackened), six left proximal quadrate fragments (one burnt or stained), four right proximal quadrate fragments, seven scale fragments, 10 urohyal fragments (one blackened), 14 first vertebra centra, one first vertebra centum fragment, one second vertebra centrum, 12 thoracic vertebra centra (two blackened), two thoracic vertebra centrum fragments (one burnt or stained), 13 precaudal vertebra centra (three blackened), two precaudal vertebra centrum fragment, one complete caudal vertebra, 71 caudal vertebra centra (five blackened, two burnt or stained), 21 caudal vertebra centrum fragments (two burnt or stained), one caudal vertebra fragment, three vertebra centra, 83 vertebra centrum fragments (nine blackened, one burnt or stained), and nine vertebra fragments.

Some 4,097 fish specimens were not identified to an order level or better. They include a left articular fragment, a pharyngobranchial fragment, a left proximal premaxilla fragment, a vomer fragment, 1,932 ribs/spines/ray fragments (90 blackened, three burnt or stained), three thoracic vertebra centra, two precaudal vertebra centra, two caudal vertebra centra (one blackened), a caudal vertebra centrum fragment, two ultimate vertebra centra, two ultimate vertebra centrum fragments, an ultimate vertebra fragment, five teeth (one blackened), and 1,809 fragments from unknown elements (176 blackened, 16 burnt or stained).

Finally, 597 specimens were so fragmented that they were not identified to a class. Of these 30 were blackened, seven were burnt or stained, and one had dark staining.

Layer 7A Faunal Remains

Layer 7A, the earliest occupation of the site, produced a conventional radiocarbon date of 850±30 BP (Beta-450932). At a total NISP of 4,122, this layer produced the second largest faunal sample at the site, after Layer 6 with 7,641 NISP (see Table 5). Identified taxa include American beaver, cottontail, American elk, bird, snake, Pacific spiny dogfish, skate, Pacific herring, smelt, salmonid, Pacific staghorn sculpin, surfperch, and flatfish. Layer 7A included 945 specimens from the $^{1}/_{16}$" sample from DR3.

Rodents are represented by a single specimen identified as American beaver: a blackened first phalanx fused diaphysis and distal epiphysis. Additional probable rodent specimens include a single left femur fragment identified as a Mammal Size Class I (mouse-sized) and four Mammal Size Class II (squirrel-sized) specimens: three rib fragments and an isolated incisor fragment.

A total of two faunal specimens were identified as cottontail rabbit. They include a left humerus shaft flake and a radius shaft flake. Neither specimen was burnt. Another 35 specimens were identified as Mammal Size Class III (rabbit-sized). They include eight longbone shaft fragments (one blackened with green breakage), a vertebra centrum, and 26 fragments from unknown elements (two blackened). An additional seven specimens were identified as Mammal Size Class I-III (mouse to rabbit-sized): three longbone shaft flakes and four fragments from unknown elements (one blackened, one blackened with longitudinal scratches).

A total of 109 specimens were identified as Mammal Size Class IV (dog-sized) and could be beaver remains. They include a longbone shaft flake, a calcined lumbar vertebra neural arch fragment (cf. beaver), a vertebra fragment, and 106 fragments from unknown elements (three blackened, three burnt or stained).

Artiodactyls are represented in this layer by American elk remains and those identified as deer, sheep, pronghorn or goat (DSPG). A total of 147 specimens were identified as elk. The majority of these (145 NISP) were fragments of antler (28 blackened, 50 with dark staining). Additional elk specimens include a right distal scapula fragment with cutmarks around the circumference of the glenoid cavity, and a complete right blackened magnum.

Table 5: Layer 7A Faunal Remains from All Size Fractions[1]

Order	Taxon	Common Name	NISP
Class Mammalia (mammals)			
Rodentia	*Castor canadensis*	American beaver	1
Lagomorpha	*Sylvilagus sp.*	Cottontail	1
Artiodactyla	*Cervus elaphus*	American Elk	147
	D/S/P/G	Deer, sheep, or pronghorn	11
Unknown	Size Class I-III	Mouse to rabbit-sized	12
	Size Class III	Rabbit-sized	35
	Size Class IV	Dog-sized	109
	Size Class V	Deer-sized	156
	Size Class IV-VI	Dog to bison-sized	699
	Size Class V-VI	Deer to bison-sized	258
	Unidentified	Unidentified mammal	213
		Total Mammal	1,643
Class Aves (birds)			
Unknown	Unidentified	Unidentified bird	11
Class Reptilia (reptiles)			
Squamata	Suborder Serpentes	Snakes	7
Class Chondrichthyes (cartilaginous fishes)			
Squaliformes	*Squalus suckleyi*	Pacific spiny dogfish	38
Rajiformes	Family Rajidae	Skates	2
Class Actinopterygii (ray-finned fishes)			
Clupeiformes	*Clupea pallasii*	Pacific herring	26
Osmeriformes	Family Osmeridae	Smelts	4
Salmoniformes	Family Salmonidae	Salmon, trout, whitefish	597
Scorpaeniformes	*Leptocottus armatus*	Pacific staghorn sculpin	15
Perciformes	Family Embiotocidae	Surfperches	41
Pleuronectiformes	Unknown	Flatfishes	140
Unknown	Unidentified	Unknown fish	1,390
		Total Fish	2,353
		Total Identified to Class	3.914
		Unidentified	208
		Total	4,122

[1] The $^{1}/_{16}$" fraction in this layer yielded 1 snake, 8 Pacific spiny dogfish, 21 herring, 127 salmonid, 7 Pacific staghorn sculpin, 33 surfperch, 49 flatfish, and 699 unidentified fish.

A total of eleven specimens were identified as DSPG. They include a lumbar vertebra zygopophysis fragment, a left innominate acetabulum fragment, a right femur proximal diaphysis fragment, two femur proximal epiphyses (heads; one burnt or stained), an astragalus fragment, three left calcaneus fragments (one blackened), a longbone shaft flake, and a second phalanx shaft flake. Another 156 specimens identified as Mammal Size Class V (deer-sized) are likely DSPG as well. They include 33 longbone shaft flakes (one with green breakage, 17 blackened, one blackened with cutmarks), a lumbar vertebra zygopophysis fragment, a vertebra neural arch fragment, and 121 fragments from unknown elements (14 blackened, one burnt or stained).

An additional 258 specimens, identified as Mammal Size Class V-VI (deer to bison-sized), and 699 specimens, identified as Mammal Size Class IV-VI (dog to bison-sized) also are likely from artiodactyls. Deer to bison-sized specimens include one blackened antler fragment, two longbone shaft flakes (one blackened), two rib shaft flakes, and 253 fragments from unknown elements (71 blackened, one calcined, five burnt or stained, and six with dark staining). Dog to bison-sized specimens include eight longbone shaft flakes, a caudal vertebra centrum fragment, four vertebra neural arch fragments, a vertebra zygopophysis fragment, five vertebra fragments, and 680 fragments from unknown elements (50 blackened, one calcined, 71 burnt or stained, two with dark staining, two with possible digestive polish).

Some 213 specimens were so fragmented that they were not identified to a mammal size class. They are all fragments from unknown elements (27 blackened, one with dark staining).

There are 11 bird specimens in Layer 7; all duck-sized. These include a left radius distal shaft fragment, a burnt or stained vertebra neural arch fragment, and nine vertebra zygopophysis fragments (three burnt or stained). Reptiles are represented by just seven vertebra centra (one burnt or stained) were identified as unknown snake.

There are 30 specimens in Layer 7 that were identified as cartilaginous fish. A total of 28 specimens were identified as Pacific spiny dogfish: 37 vertebra fragments (one blackened) and one tooth. A total of two specimens were identified as skate: a vertebra centrum fragment and a tooth.

Layer 7 yielded 26 Herring specimens, all vertebra fragments. They include six first vertebra centra, 12 abdominal vertebra centra, five caudal vertebra centra, one caudal vertebra centrum fragment, and two unknown vertebra centra. A minimum of six individual herring are represented by first vertebra. Smelts in this layer were limited to four caudal vertebra centra (three burnt or stained).

There were 597 specimens identified as Salmonids, all either vertebra fragments or isolated teeth. They include two thoracic vertebra centra, one precaudal vertebra centrum, one precaudal vertebra centrum fragment, one caudal vertebra centrum, 471 vertebra centrum fragments, and 121 isolated teeth (one blackened, four calcined).

Fifteen specimens have been identified as Pacific staghorn sculpin: a right symplectic, two symplectics (side unknown), a first vertebra centrum, two thoracic vertebra centra, two precaudal vertebra centra, six caudal vertebra centra (two blackened), and one unknown vertebra centrum.

A total of 41 specimens were identified as surfperch: one basioccipital fragment, five thoracic vertebra centra (one blackened), nine precaudal vertebra centra (one burnt or stained), one precaudal vertebra centrum fragment, and 25 caudal vertebra centra (four blackened).

A total of 140 specimens were identified only to the Order Pleuronectiformes (flatfish). There are over a dozen different species of flatfish which inhabit Puget Sound. Due to similarities between species and gaps in the comparative collections at CWU and the Burke Museum, identifications were made conservatively. All of the flatfish specimens appear to be from small flatfish rather than large halibut, and they include a variety of elements. Specimens include a left proximal articular, a right dentary fragment, a blackened dentary fragment, a right proximal mandible, a right premaxilla fragment, a right proximal opercle, an ectopterygoid fragment, a blackened left proximal epihyal, a blackened left proximal exoccipital, a proximal quadrate, a complete right hypohyal, 20 pharyngobranchials (five blackened), two urohyal fragments, a complete first vertebra centrum, two first vertebra centrum fragments, three thoracic vertebra centra (one blackened), two thoracic vertebra centrum fragments, three precaudal vertebra centra, one precaudal vertebra centum fragment, one ultimate vertebra centrum, one ultimate vertebra centrum fragment, 13 vertebra centrum fragments (four blackened), 11 teeth, 42 scales (seven blackened), and one fragment from an unknown element. A minimum of two flatfish are represented by first vertebra.

A total of 1,390 fish specimens were not assigned to an order. They include a blackened right proximal articular, a right epihyal fragment, two pharygobranchial fragments (one burnt or stained), 399 ribs/spines/or rays, a complete first vertebra, a first vertebra centrum, a two thoracic vertebra centra, a blackened thoracic vertebra centum fragment, two caudal vertebra centra (one burnt or stained), three caudal vertebra centrum fragments, 31 vertebra centra (10 blackened), 111 vertebra centrum fragments, six teeth, two scale/scute fragments (possibly from a sturgeon), and 827 fragments from unknown elements.

A discussion of faunal remains from the shell midden level (Layer 6) compared to other layers, and additional topics, are covered in the following chapter. The remainder of this chapter repeats the faunal discussion from the report.

Report Discussion

In general, the 45KP233 site faunal assemblage reflects the types of subsistence resources available along the shores of Puget Sound and taken historically by the speakers of Southern Coast Salish. All of the taxa identified at the site are noted as food resources in Southern Coast Salish ethnographies (Haeberlin and Gunther 1930; Suttles and Lane 1990). These species were taken in a variety of ways. For example, blacktail deer and elk were hunted by the Salish using bow and arrow and drives (Suttles and Lane 1990:489). A variety of waterfowl, especially ducks, were captured by spears, nets, and snares (Suttles and Lane 1990:489). Fish resources were vital to the Southern Coast Salish, and they were harvested by a variety of methods (Haeberlin and Gunther 1930:28; Suttles and Lane 1990). Weirs, seines, and hook and line were used to catch salmon (Haeberlin and Gunther 1930:27). Special rakes and brush weirs were used to harvest herring (Elmendorf 1940; Suttles and Lane 1990:489). Brush weirs were used also to capture skate (Elmendorf 1940). Seines, hook and line, and leisters were used to catch flounders, while gorges were often used for sculpins (Haeberlin and Gunther 1930:28; Suttles and Lane 1990:489).

The analyzed assemblage is dominated by fish remains (64% of total assemblage NISP), with significant amounts of mammal remains (29%) but very little bird and snake, and no turtle. Deer and elk dominate the identified mammal remains from the site, while salmonids dominate the identified fishes. Important fishes in terms of taxonomic abundance are salmonids (67%; 2,014 of 2,987 fish identified to order or better) and flatfishes (19%), with small proportions of dogfish (4%), sculpins and surfperch (3% each), and traces of other fish groups. Taxonomic abundances do not change much from the oldest layer (Layer 7A) to the youngest (Layer 2A) of the site. The oldest layers (Layers 5-7) have the greatest taxonomic variety, including the presence of elk, birds and snakes; however this richness could be explained by their larger sample sizes. Layers 2A-4A have <500 NISP each, whereas Layers 5-7 have >2,500 each. The relationship between sample size and taxonomic richness is well known (Grayson 1984; Lyman 2008). The order of fish taxonomic abundance does not change through time: salmonids, flatfish, and Pacific spiny dogfish are consistently the three most abundant fish taxa throughout the layers.

All of the site fish remains are likely marine species, or at least no freshwater species were identified, implying little or no use of Anderson Creek except possibly for salmon. Most of the fish remains from the 45KP233 site appear to be from fish found in shallow, nearshore estuarine waters and potentially harvestable by weirs (see Byram 2002). Pacific staghorn sculpin are a very common shallow water species primarily found in estuarine environments, often in tidepools (Cook-Tabor 1999:Table 19, 37; Pietsch and Orr 2015:43). Flatfish tend to dominate shallow waters (<20 meters) in Puget Sound (Reum and Essington 2011:189) and starry flounders are extremely common in shallow estuarine environments (Cook-Tabor 1999:47). Surfperches primarily are found in shallow, intertidal, estuarine environments and are especially abundant in Puget Sound (Cook-Tabor 1999:42; Pietsch and Orr 2015:56). Pacific Spiny dogfish are common in southern Puget Sound and can be found from the intertidal zone to 1000 feet deep (Cook-Tabor 1999:3; Pietsch and Orr 2015:16).

The faunal remains reported here from the data recovery excavation are similar but not identical to remains reported from site testing by Kiers and Littauer (2014:67-69). Since the data recovery sample is much larger, there are of course taxa present in data recovery not found in testing. But there are also taxa found in testing not found in data recovery. Test Unit 2, located adjacent to the data recovery block, yielded 135 vertebrate remains. It differs in the presence of bear (*Ursus* sp., 2 phalanges) and cypriniform fish (1 vertebra) identified in testing but not in data recovery. Test Unit 1, located some 25-30 meters farther from the shore, yielded 48 vertebrate faunal remains. Test Unit 1 differs in the presence of squirrel (Family Sciuridae, 1), vole (*Microtus* sp., multiple burrow death elements), turtle (Family Emydidae, 1), and rockfish (*Sebastes* sp., 1).

The 45KP233 faunal assemblage adds to a growing body of data regarding late prehistoric Puget Sound subsistence. The blacktail deer and elk remains from the site support Wigen's (2013:141) conclusion that these two species are the most common mammal remains found in Puget Sound sites dating from the last 1500 years. The presence of deer, elk, and mountain beaver, along with the absence of sea mammal remains, at the 45KP233 site matches what was found at the nearby Bay Street Midden (45KP115) site (Lewarch et al. 2002:118). In their review of faunal assemblages from the Pacific Northwest, including Puget Sound, Butler and Campbell (2004:360) found flatfish, sculpin and surfperch to be important fisheries alongside salmon and herring.

Coastal Puget Sound fish faunal assemblages with radiocarbon dates similar to the 45KP233 site (e.g., dating to the last 800 years) and ⅛" screening include five other assemblages summarized in Table 6. Locations of key sites are provided in Figure 3. The 45KP233 fish assemblage appears most similar to the West Point, Component 5 fish assemblage, in that salmonids and flatfish are the two most abundant fish taxa at both sites. Another site which appears to have both flatfish and salmonids as the two most abundant fish taxa, followed by spiny dogfish, is the Old Man House site (45KP2; Schalk and Rhode 1985). This fish assemblage dates from approximately 1700 years ago to the historic period, and herring are abundant in only one excavation unit (Schalk and Rhode 1985:Tables 9-10).

It is interesting to speculate that some of the types of small fish found at the 45KP233 site represent the use of weirs to harvest nearshore fish resources. Weirs have been raised as a possible explanation for the variety of small fish from the Cama Beach site (Trost et al. 2011:277; Schalk and Nelson 2010:132). To date, archaeological fish weirs from Puget Sound appear to be relatively young, radiocarbon dated to the last 500 years (Elder et al. 2014:54). It has been suggested that older fish weirs are likely buried under "transgressive shorelines" (Elder et al. 2014:66). Earthquake-generated tsunamis, subsidence and uplift in southern Puget Sound, especially those known to have occurred around 1000 years ago (see Hutchinson 2015), could also have affected weir preservation and archaeological visibility.

Table 6. Dominant Fish Taxa from Puget Sound Archaeological Fish Assemblages

Site and Component	NISP[1]	Top 3 Orders (most abundant)	Reference
45KP233 (all)	2,293	Salmoniformes (66%), Pleuronectiformes (22%), Squaliformes (5%)	Partlow and Holstine 2016:Table 2
Burton Acres Shellmound (45KI437)	5,321	Clupeiformes (80%), Salmoniformes (11%), Pleuronectiformes (4%)	Kopperl and Butler 2002:Table 10.1
West Point (45KI428/429) Component 5	1,199	Salmoniformes (51%), Pleuronectiformes (24%), Scorpaeniformes (11%)	Wigen 1995:Table A5 19
Qwu?gwes (45TN240) 1999-2002	8,147	Salmoniformes (95%), Squaliformes (2%), Pleuronectiformes (<1%)	Wigen 2013:Table 12
Cama Beach (45IS2) Periods 4 & 5	19,685	Pleuronectiformes (24%), Scorpaeniformes (22%), Perciformes (18%)	Trost et al. 2010: Table B.9-B.10
Bay Street (45KP115)	1,135	Clupeiformes (36%), Pleuronectiformes (35%), Salmoniformes (11%)	Butler and Baker 2002:Table 3

1 NISP is those fish remains (Class Chondrichthyes and Actinopterygii) identified to the order level or better from the ⅛" and larger fraction. Sites included are <800 years old, and used 1/8" screen. Note that this table has been adjusted from the original report (Partlow and Holstine 2016:Table 9).

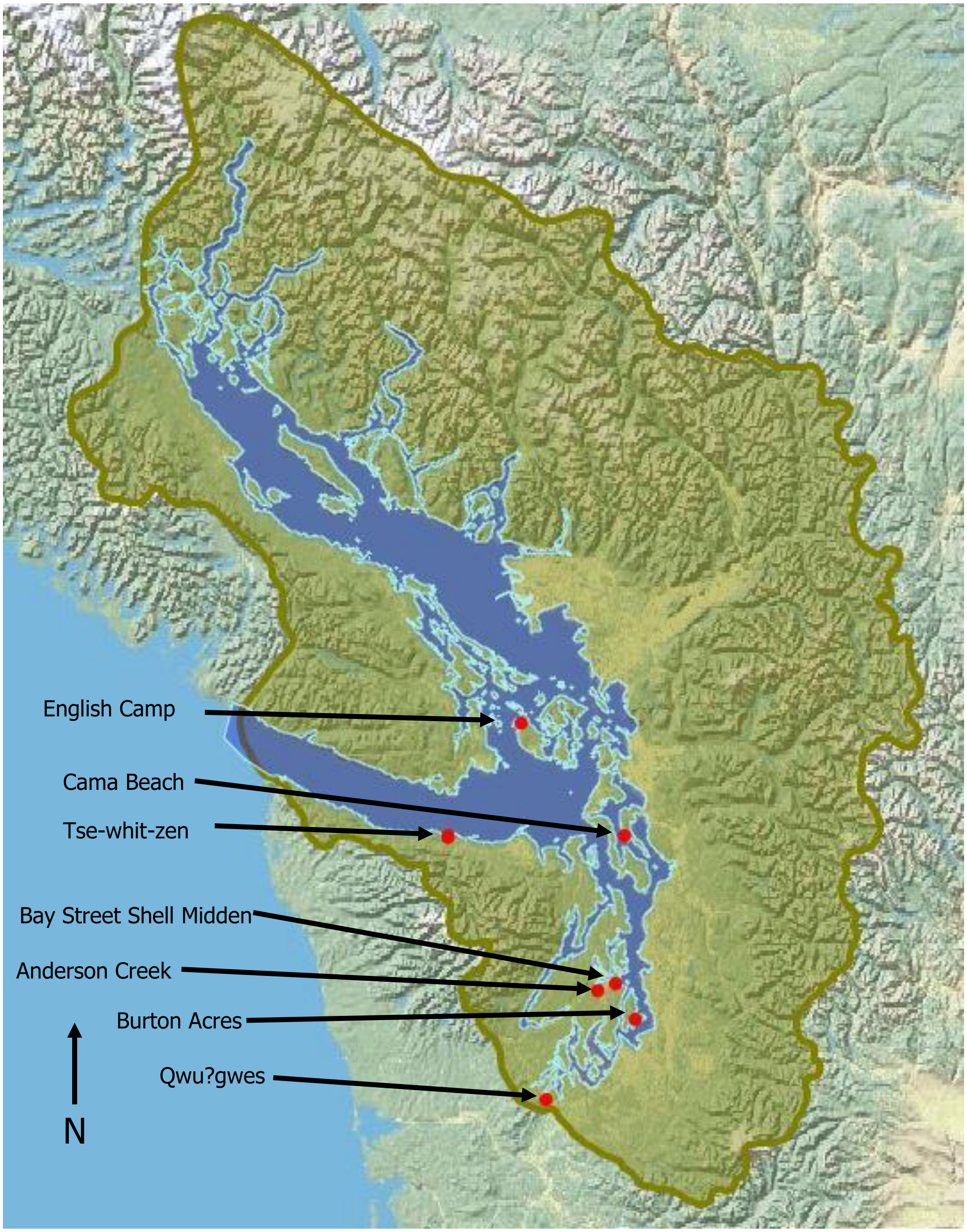

Figure 3. Location of key sites discussed in the text. Sites marked with red dots. Green outlines the Salish Sea Basin and dark blue is Salish Sea waterways. Base map from Encyclopedia of Puget Sound (2015).

CHAPTER V

POST-REPORT RESULTS AND DISCUSSION

This chapter reports analysis results, summary, and discussion of faunal remains from the Anderson Creek site that were not discussed in the contract report by Partlow and Holstine (2017). This work was produced subsequent to the report and was not produced in collaboration with Dr. Partlow. This chapter includes the following: the value of using 1/16” screens, herring in the Salish Sea, fragmentation at the site, layer comparison, seasonality, and conclusions.

Value of 1/16” Screen for Fish Analysis at 45KP233

One of the primary research goals in this analysis was to determine the necessity for the use of 1/16” screen in order to recover herring remains. As shown in the last chapter, the use of 1/16” screen at 45KP233 yielded an additional 3,589 bone fragments to the analysis. To address the value of the addition of these remains, here I address several questions: (1) What is the identification rate of the 1/16” fraction compared to the larger fractions? (2) Does the taxonomic diversity change significantly with the addition of the 1/16” fraction? (3) Do the taxonomic proportions change significantly with the addition of the 1/16” fraction? (4) What is the additional time investment for sorting and analyzing the 1/16” fraction?

The first concern is whether or not the identification rate of the 1/16” fraction is too low. In DR3 from Anderson Creek, there was a 27% identification rate (to taxonomic order or finer) for fish, from the ¼” + 1/8” fraction (513/1,894). The identification rate for fish from the 1/16” fraction of DR3 was slightly lower, at 20% (694/3,523). This rate is lower, but not so low that the effort does not seem worthwhile.

The second concern is whether addition of the 1/16” fraction increases taxonomic diversity. In terms of number of distinct taxa, or richness, the answer is no. No new taxa are added with the fine screen sample.

The third concern is whether addition of the finer screen sample provides significantly different taxonomic abundances. Table 7 shows taxonomic abundances of DR3 in 1/4, 1/8, and 1/16” samples. The largest change in abundance for any taxon in DR3 was for the Order Perciformes: NISP >1/8” = 5 (<1% of the total identified) to NISP <1/8” = 55 (5% of the total identified). This is a 5% increase in identified specimens. The next largest change in abundance was that of the Order Pleuronectiformes, with a 2% drop in identified specimens. Only two other orders showed a change in percent NISP: Scorpaeniformes and Clupeiformes. The increases in percent NISP identified were small, with 1% to 3% for Scorpaeniformes, and from 1% to 2% for Clupeiformes. The rest of the identified orders experienced no change in percent NISP with the addition of 1/16” screen samples.

Intuitively, the changes in taxonomic proportions with addition of the 1/16” sample are not striking, but might they be considered significant? To evaluate this, I began with a chi-squared test of the 1/8” and larger taxonomic proportions versus the 1/16” and larger proportion. To ensure the test was suitable (did not violate test assumptions), I removed Osmeriformes (which had a sample of 1 for both size fractions) and also Gadiformes (which had a larger fraction sample of 0). This test provided the following results: χ^2= 34.62, d.f.= 7, p<0.001. The difference in proportions is significant according to this test.

Table 7. Fish NISP for DR3 by Screen Size.

	¼”		1/8” + ¼”		1/16”+1/8” + ¼”	
Order	Count	%	Count	%	Count	%
Squaliformes (dogfish)	11	31	33	6	49	4
Rajiformes (skates)	-		4	<1	8	<1
Clupeiformes (herring)	-		1	<1	24	2
Osmeriformes (smelts)			1	<1	1	<1
Salmoniformes (salmon)	2	6	378	74	868	72
Gadiformes (cods)	-		-		2	<1
Scorpaeniformes (sculpins)	-		7	1	39	3
Perciformes (surfperches)	-		5	<1	55	5
Pleuronectiformes (flatfishes)	23	64	84	16	161	13
Total identified	36	100	513	100	1,207	100
Unidentified	14		1,381	--	4,210	--
Total	50		1,894		5,417	

A closer look at the Chi-squared adjusted residuals indicates that the differences between the size fraction samples is driven mostly by three orders (these are statistically significant cells): Clupeiformes (herring), Scorpaeniformes (rockfishes, sculpins), and Perciformes (perches). Table 8 shows the observed frequencies and adjusted residuals. Note that these significant orders are mostly small-bodied fishes (herrings, surfperches).

Another way to think about the taxonomic distributions is in terms of rank order, which is arguably the way people think about interpreting the important taxa. Both the size fraction distributions have the same rank order for the top two taxa, but vary for the lower ranked groups (Table 9). For example, the third highest rank switches from Squaliformes to Perciformes when adding in the 1/16” fraction, reflecting the addition of small surfperch vertebrae. These data reinforce the Chi-squared test and imply that there is a small but significant difference when adding in the 1/16” sample fraction.

Table 8. Chi-squared Adjusted Residuals for Size Fraction Order Distribution from DR3

	Counts		Adjusted Residuals	
	1/8” + ¼”	1/16”+1/8” + ¼”	1/8” + ¼”	1/16”+1/8” + ¼”
Squaliformes	33	49	1.7080	-1.7080
Rajiformes	4	8	0.1346	-0.1346
Clupeiformes	1	24	**-2.9672**	**2.9672**
Salmoniformes	378	868	-0.9866	0.9866
Scorpaeniformes	7	39	**-2.3880**	**2.3880**
Perciformes	5	55	**-3.8818**	**3.8818**
Pleuronectiformes	84	161	0.9434	-0.9434
Unidentified	1,981	4,210	-1.7050	1.7050

Note: Statistically significant cells are indicated in **bold.**

Table 9. Fish NISP Rank Order for DR3 by Screen Size.

	1/8” + ¼”		1/16”+1/8” + ¼”	
Order	Count	Rank	Count	Rank
Squaliformes (dogfish)	33	3	49	4
Rajiformes (skates)	4	6	8	7
Clupeiformes (herring)	1	7.5	24	6
Osmeriformes (smelts)	1	7.5	1	9
Salmoniformes (salmon)	378	1	868	1
Gadiformes (cods)	-	9	2	8
Scorpaeniformes (sculpins)	7	4	39	5
Perciformes (surfperches)	5	5	55	3
Pleuronectiformes (flatfishes)	84	2	161	2

The fourth concern is time investment. For DR3, I spent 59 hours sorting the matrix and completing faunal analysis. I did not record the time for sorting and analysis separately, and did not tally data entry or writeup either. The sorting process involved separating the bones from other materials in the 1/16" matrix, mostly shell. This process was made much faster about halfway through when I started passing the matrix through nested geological sieves of sizes 10, 40, 100, and 140 (2, 0.4, 0.15 and 0.10 mm, respectively).

In order to estimate the cost of sorting and analysis from this project, one can multiple the 59 hours of work by the likely hourly wage of the analyst. An archaeologist engaged in this work would be classified as "Transportation Specialist 4" according to WSDOT archaeologist Scott Willliams (personal communication 2017). According to the Washington State Office of Financial Management, the current maximum hourly wage for a "Transportation Specialist 4" position is $27.37 (WAOFM 2017). That means that regardless of previous analysis spending, or budget, the additional cost of sorting and analyzing the 25% DR3 fine screen samples would be $1,614.83. If one sorted and analyzed a 25% sample from the whole site, this would be an additional cost of roughly $14,000 ($1,614.83 x 9 DR units).

While 59 hours represented only a fraction of the total time spent on faunal analysis for the Anderson Creek site, it still constituted a substantial amount of time and effort for minimal returns. The addition of 1/16" samples at Anderson Creek did not result in new taxa, and did not substantially alter proportions of small-bodied fishes like herring or surfperches. Additionally, the nearby Bay Street Shell Midden site (45KP115) yielded a large number of small-bodied herring with no 1/16" samples (see next section). These observations might support an argument for not investing effort in 1/16" mesh samples for Puget Sound site fish recovery. However, there were statistically significant changes in fish taxonomic proportions and rank order distributions at Anderson Creek, so such a blanket recommendation seems unwarranted. Instead, I suggest the use of 1/16" screens on a small sample at each site in the Salish Sea.

Herring in the Salish Sea

Herring are known to be one of the most abundant species recovered from archaeological sites in the Pacific Northwest, and are what is known as a "foundation species," which supports both biological and cultural ecosystems (McKechnie et al. 2014:E807). Herring were first recorded in the Salish Sea in 1866, and were observed to be widespread and extremely abundant (Pietsch and Orr 2015). Herring are a species that are common in both coastal and offshore regions, and they are typically found from the surface to a depth of up to 250 m (Pietsch and Orr 2015). The archaeological record shows that herring is one of the most widespread and common species of fish to be exploited among coastal tribes in the Salish Sea (McKechnie et al. 2014:E809). McKechnie et al. (2014) found that herring were present in 169 out of 171 faunal assemblages that were examined, and was the most abundant taxon in the entire dataset. Table 10 shows the relative abundances of herring at Washington State archaeological sites in the Salish Sea.

Table 10. Herring Abundance at Washington Salish Sea Sites[1]

Site #	Site Name/Component	Total Fish NISP	% NISP Herring	Reference
Puget Sound Sites:				
45KI23	Duwamish No. 1	3,999	<1	McKechnie et al. 2014:Table S1
45KI428/429	West Point	8,057	2	McKechnie et al. 2014:Table S1
45KI437	Burton Acres	5,321	80	Kopperl and Butler 2002:Table 10.1
45KP115	Bay Street	806	43	McKechnie et al. 2014:Table S1
45KP233	Anderson Creek	9,594	<1	Partlow and Holstine 2017:Table 3
45MS50	Taba’das	1,248	2	McKechnie et al. 2014:Table S1
45PI974	Hylebos	1,226	43	McKechnie et al. 2014:Table S1
45TN240	Qwu?gwes	14,269	<1	Wigen 2013:Table 6
Other Salish Sea Sites:				
45CA523	Tse-Whit-Zen	10,358	12	Mohlenhoff 2013: Table 4.2
45IS2	Cama Beach	16,154	4	McKechnie et al. 2014:Table S1
45IS119	Penn Cove	160	1	McKechnie et al. 2014:Table S1
45IS263	Fromme	401	6	McKechnie et al. 2014:Table S1
45SJ24	English Camp Operation A	18,654	68	McKechnie et al. 2014:Table S1
45SJ24	English Camp Operation D	15,168	20	Kopperl 2011: Table 12.2
45SJ169	--	3,223	52	McKechnie et al. 2014:Table S1
45SJ200	Kona Trust	126	25	McKechnie et al. 2014:Table S1
45SJ252	Qelqe>Nip	373	19	McKechnie et al. 2014:Table S1
45SJ280	--	2,450	6	McKechnie et al. 2014:Table S1
45SK43	Weaverling Spit	14,800	25	McKechnie et al. 2014:Table S1

[1]All fish samples from 1/8” (3.18 mm) mesh size or smaller.

The abundance of herring in coastal sites in Washington State is reason to expect herring in most of the encountered assemblages. As mentioned above, recovery of small bodied fish, like herring, is known to be limited with the use of larger than 1/8’’ screens (Gobalet 1989, Stewart et al. 2003, Densmore 2009, and Zohar and Belmaker 2005). Given the known abundance of herring in the Salish Sea, and the presence of herring remains in the archaeofaunal record, it seems likely that herring is likely to be encountered at many, if not most, of the sites found in coastal Washington.

The Anderson Creek site (45KP233) contained just 38 specimens that could be identified as herring (<1% of the total assemblage NISP). While this is a miniscule fraction of the total NISP, these specimens were mostly recovered from the 1/16” screen (the 25% sample from DR3). Other midden sites in the Salish Sea display a great deal of variation in herring NISP, both within Puget Sound and outside the Sound (Table 10). The highest proportion of herring in Puget Sound sites is 80% at Burton Acres Shell Midden, while three of the seven sites yielded <1% herring (Duwamish #1, Anderson Creek and Qwu?gwes). Some of this variation may be due to screen-size bias, but the Burton Acres Shell Midden and Bay Street Shell Midden fish included no 1/16” samples yet had 80% and 43% herring respectively, while the Anderson Creek fish included <1% herring for the site overall and only 2% herring with the addition of the 1/16” sample in DR3. Variation in herring abundances in North Pacific archaeological sites appears common for both the Northwest Coast (McKechnie et al. 2014) and Kodiak Archipelago in Alaska (Partlow 2015), and do not appear to be simply a result of recovery methods. This topic will be discussed in a bit more detail below.

Fragmentation at 45KP233

Basic taphonomy of the site was discussed in the report (Partlow and Holstine 2017). As is typical for fish assemblages, there is a low proportion of burned remains. Of more interest here is the degree of breakage to the fish assemblage, which is quite different than fish assemblages on Kodiak Island with which Dr. Partlow is familiar. What are the breakage trends at the Anderson Creek site, what do those tell us, and how typical are they of sites in Puget Sound?

One role of breakage is fragmentation and its effect on quantification. Fragmentation in archaeological sites has long been known to cause problems with representativeness of NISP. This is because NISP can vary with both taxonomic abundance, and the degree of fragmentation at the site (Cannon 2011:3). Bones broken into many pieces are counted separately, artificially inflating the total NISP. Cannon (2011:7) explains that NISP should go up as fragmentation increases, but that as this pattern reaches high degrees of fragmentation, that the NISP should decrease with the decrease in average specimen size. This is due to the declines in proportion of identifiable specimens with increases in fragmentation rates. Some investigators recognize the difference between fragment counts and identified fragment counts as number of specimens (NSP) as opposed to number of identified specimens (NISP); see Grayson (1991).

The high degree of fragmentation at the Anderson Creek site made identification of the less distinctive taxa quite difficult. Fish represent 64% of the total assemblage and salmon remains constituted 70% of the identified fish taxa at the site, but the vast majority of those remains were vertebral fragments. Only 16 complete (centrum more than 50% complete) salmon vertebrae were found in the entire assemblage, compared to 1,584 vertebrae fragments (16/1,600=1% complete). Contrast that to the vertebrae identified as flatfish (Order Pleuronectiformes): 178 complete vertebrae were identified, and only 166 vertebrae fragments (178/344= 52% complete). This is more likely a function of the distinctive features of salmon remains, rather than the lack of flatfish vertebrae fragments. While salmonid remains are almost certainly still the most abundant taxa present at the site, they may be over-represented compared to other species because their remains are so distinctive. Another species that could be over-represented, due to distinctiveness, is that of the Pacific Spiny Dogfish (*Squalus suckleyi*): There were only 12 complete centra found but 106 centrum fragments (12/118=10% complete). One species that did not fit this trend was herring; 97% of the herring vertebrae found were complete (37/38). This could be due to the size of complete vertebrae, and that when broken they are simply too small to confidently identify.

Overall, the fish assemblage at the Anderson Creek Site is very fragmented. Of the fish specimens identified to order or better at 45KP233 (3,420), only 479 (14%) were complete. Of the 9,594 fish specimens identified to class, only 148 (2%) of them were complete. Another measure of fragmentation is specimen size. Of the total 9,594 fish remains, 9540 of them (99.4%) were less than 1 cm in length, with only 52 (0.5%) between 1 and 2 cm in size, and 2 specimens from 2-3 cm in size.

Fragmentation in the mammal assemblage at the site is broadly similar. Breakage is even more common than in the fish assemblage, as all 4,328 mammal specimens show signs of breakage and none are complete. They are also broken into small pieces, but not quite as small as the fishes. For fragment size, 3,457 (80%) were less than 1 cm in length, 612 (14%) were between 1 and 2 cm in size, 139 (4%) were from 2-3 cm in size, and the remaining specimens (2%) were 3-11 cm in size. Naturally these fragments are larger than the fish since mammal bones are larger when complete.

A question about this very broken fish bone assemblage at Anderson Creek is how does it compare to other sites in the Salish Sea and North Pacific? Dr. Partlow's gut impression was that this site was much more fragmented than similar sites in the Kodiak Archipelago. Table 11 summarizes fragmentation of salmonid vertebrae for selected sites in both regions. This table shows marked differences between Kodiak Archipelago sites and sites of the Salish Sea. The Kodiak Archipelago sites have mostly complete vertebral centra (complete centra compose 59-89% of centrum NISP), while the Salish Sea sites are much more fragmented (complete centra compose only 1-22% of centrum NISP). The Anderson Creek Site has the least complete (or most fragmented) salmonid vertebrae of the seven sites in Table 11, and stands out in this very low proportion of complete vertebrae. However, given the small number of Salish Sea sites to compare with in Table 11, and the range of variation in the Kodiak Archipelago, it appears to follow the pattern for Salish Sea shell midden sites.

Within the Anderson Creek site, another question is whether the fragmentation was different from the shell midden (Layer 6) than the pre-shell midden (Layer 7). When comparing pre-midden and midden components of 45KP233, 19% (150/800) of the fish vertebral centra in Layer 7 were observed to be complete, while 16% were complete in Layer 6. This variation is small enough to discount differential preservation, and is more likely to be a function of the sample size available in the Layer 7 sample, which had significantly fewer fish remains than Layer 6.

Table 11. Salmonid Vertebral Centrum Completeness at Sites from Salish Sea and Alaska[1]

Site	NISP	MNE	MNE/NISP	Reference
Kodiak Archipelago Sites:				
AFG-012	1,620	1,437	0.89	Partlow 2000, p.c. 2017
AFG-015 (Settlement Point) Midden only	2,269	1,826	0.80	Partlow 2000, p.c. 2017
KAR-001 Midden + house floors	9,062	6,094	0.67	West 2009: Table 4.26
KAR-031 (Old Karluk) Midden + house floors	2,810	1,646	0.59	West 2009: Table 4.26
Salish Sea Sites:				
45KI248/45KI429 (West Point Sites)	2,096	227	0.11	Wigen 1995:A5-14
45KP233 (Anderson Creek) 1/8” and larger	1,182	16	0.01	This thesis
1/16” and larger	1,614	16	0.01	This thesis
45SJ24 (English Camp) Operation D	3,488	784	0.22	Kopperl 2011:156

[1]All reported assemblages are 1/8” screened samples. Comparable data were not available from several other Salish Sea sites, namely the Bay Street Shell Midden (Lewarch 2002), Burton Acres Shell Midden (Butler and Kopperl 2002), Qwu?gwes (Croes et al. 2007), Tse-whit-zen (Mollenhoff 2013).

Layer Comparison and Seasonality

Fauna recovered from the seven different natural layers at the site are similar but not identical. To provide a comparison of taxa identified in each layer, Table 12 lists rank order for the six taxonomic groups most common at the site. Hoofed mammals (Order Artiodactyla) are consistently in the top two ranked taxonomic orders throughout the site. Only two layers had a taxonomic order other than hoofed mammals in the top ranked position: Layer 2 and Layer 6. Both of these were where salmon (Order Salmoniformes) took the top position. Flatfishes (Order Pleuronectiformes) are ranked third in nearly every layer, except when their NISP is tied for 2nd, and tied for 3rd. The other taxonomic orders at Anderson Creek appear almost interchangeably between ranks 4, 5, and 6, throughout the site.

Table 12. Comparison of Commonly Identified Orders by Layer at 45KP233

		Six Most Common Taxonomic Orders[1]					
Layer	NISP Sum	Hoofed Mammal	Dogfish Sharks	Salmon	Rockfishes, Sculpins	Perches	Flatfishes
2A	108	NISP 36 Rank 2	NISP 12 Rank 4	NISP 40 Rank 1	NISP 1 Rank 5.5	NISP 1 Rank 5.5	NISP 18 Rank 3
3A	21	NISP 17 Rank 1	NISP 0 Rank 4.5	NISP 4 Rank 2	NISP 0 Rank 4.5	NISP 0 Rank 4.5	NISP 0 Rank 4.5
4A	82	NISP 64 Rank 1	NISP 0 Rank 5	NISP 9 Rank 2.5	NISP 0 Rank 5	NISP 0 Rank 5	NISP 9 Rank 2.5
5	1,183	NISP 661 Rank 1	NISP 15 Rank 5	NISP 416 Rank 2	NISP 31 Rank 4	NISP 4 Rank 6	NISP 56 Rank 3
6	2,362	NISP 892 Rank 2	NISP 62 Rank 4	NISP 948 Rank 1	NISP 61 Rank 5	NISP 46 Rank 6	NISP 353 Rank 3
7A	2,196	NISP 1,380 Rank 1	NISP 38 Rank 5	NISP 597 Rank 2	NISP 0 Rank 6	NISP 41 Rank 4	NISP 140 Rank 3

[1]each order includes all specimens identified in the order, so for example Hoofed Mammal (Order Artiodactyla) includes deer, elk, DSPG, *Bos/Bison*, and Size Class IV-VI mammals. Ranks follow rank-order rules, so that ties are divided evenly between ranks (e.g., two tied for 5th place are each 5.5 [(5+6)/2], or four tied for 3rd place are each 4.5 [(3+4+5+6)/2].

Another topic of interest to archaeologists is whether the faunal remains at the site can inform our understanding of season of site occupation. Unfortunately, the Anderson Creek site has little evidence to bear on this question. Some of the best lines of evidence available at other sites are not available at 45KP233, such as fetal mammalian remains, juvenile mammal mandibles, juvenile seals, or migratory birds.

The presence of certain fish species could provide evidence of site season if the fish are only available in some seasons or are typically caught in certain seasons by native peoples. For 45KP233, the salmon appear to be fresh caught instead of eaten as dried winter stores based on the presence of teeth as well as vertebrae, implying whole fish rather than just dried trunks (see Hoffman et al. 2000). This only eliminates winter, however. The presence of herring could indicate spawning season, known to be late January to mid-April (West et al. 2008). Other species found at Anderson Creek are available year-round, and so do not provide useful data to determine season.

Conclusions

This analysis has shed valuable light on both the impact of fine screen sampling, and my own analytical short-comings. The Anderson Creek site is typical for a site of its age and location. As expected, there were a great deal of salmon remains, and the presence of many other locally available species that could be gathered without significant additional energy expenditure. Small bodied fish present in the assemblage were shown to be underrepresented in the >1/8” fraction, but no species that was present in the 1/16” fraction was absent from the 1/8” and larger samples.

In order to better quantify the results of the 1/16’ screen samples, there are several things that could be replicated with more certainty in future works. First, hours spent sorting faunal remains from the bulk sample would be counted more precisely, and would all have been done by the same means (using the nested sieves sped up the rate of processing exponentially, versus sorting by hand as done for the earlier part of the sorting). Second, the time spent doing data entry for the 1/16” sample should have been counted separately from that of the rest of the assemblage. This would have given a much more complete picture of time investment required with the use of 1/16” screen.

I have a suggestion to future undertakings of this nature. I highly recommend the use of nested geological-sediment sieves during sorting of 1/16” screen matrix as a means for saving time and money. Their use easily doubled the speed at which I was able to differentiate bones from the rest of the bulk sample (roots, twigs, pebbles, sand, and broken shell).

This study brought up several research questions that might be addressed in the future. As noted earlier in this chapter, there is significant variation in the abundance of herring and the fragmentation of salmon vertebrae at Salish Sea Sites. Why? Some of the differences may be methodological, but this seems unlikely to explain the pattern. For herring, it could be differences in natural abundance near sites, season of site occupation, site age, or other factors. For fragmentation, it could be differences in bone preservation, cooking and preparation techniques, recovery methods, or some other taphonomic factors. These and other questions are ripe for more investigation.

Further investigation could include testing the proposed hypotheses. To test the herring natural abundance hypothesis, for example, one could compare site locations with modern herring spawning locations. To test the herring season hypothesis, for example, one could compare site season to modern spawning herring season. To test the fragmentation preservation hypothesis, for example, one could examine possible variables affecting preservation at Kodiak and Puget Sound sites, such as soil pH, rainfall, or sediment texture.

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