ZOOARCHAEOLOGICAL ANALYSIS AT 49-RAT-32: HISTORICAL ECOLOGY AND MARITIME SUBSISTENCE IN THE LATE ALEUTIAN PERIOD

By

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Abstract

This thesis utilizes a zooarchaeological collection from 49-RAT-32 on Amchitka Island in the Western Aleutians to examine Unangax̂ subsistence strategies, and human/environment interactions from 620 ± 20 to 320 ± 20 years B.P. The materials used for this analysis were recovered from primary and secondary fill overlaying the House 1 floor. Paleoecological records within this region are limited and conflict with each other, but the cool and wet conditions of the Little Ice Age 600-100 years B.P, or C.E. 1350-1850 are believed to be in effect during the deposition of the fill materials. Marine mammal, fish, and sea urchin remains were analyzed to understand subsistence practices, seasonality, and land/seascape use. The relative abundance of the exploited taxa and fork lengths of marine fishes were analyzed to identify potential resource stress and change over time. Atka mackerel dominates the faunal assemblage and Pacific cod are present in very low frequencies, both of which make 49-RAT-32 unique when compared to other Aleutian assemblages. Atka mackerel, Pacific cod, and Irish lords are larger in size than their modern counterparts, with the large size of Pacific cod indicating deep sea fishing practices. The size differentials in Atka mackerel and Irish lords may reflect differences in ocean conditions. This analysis of fauna from 49-RAT-32 does not indicate the presence of human-driven resource depression, in fact, fish sizes were increasing, and diet breadth was shrinking. The opposite pattern from what would be expected if humans were overfishing. The data from this analysis increase our understanding of resource utilization and landscape use during the Late Aleutian Period, and provides baseline information for future studies analyzing changes in fish size over time.

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Chapter 1: Introduction

This thesis focuses on understanding past human-environmental relations based on the analysis of the archaeofaunal assemblage from the fill deposits at House 1 of 49-RAT-32 on Amchitka Island in the Western Aleutians of Alaska. House 1 was occupied between 550 ± 30 and 330 ± 30 years B.P (Rogers et al. 2016), with the fill deposit dating from 620 ± 20 to 320 ± 20 years B.P. These dates correspond to the Little Ice Age (LIA) period between 600-100 years B.P, (Cronin et al. 2003) and the Late Aleutian period (Davis and Knecht 2010). Based on climate proxy data for the Western Aleutians, the fill deposits accumulated during a period of moderate cooling (Causey et al. 2005). It has been proposed that the LIA witnessed one of the most productive marine ecosystems in modern history (Maschner et al. 2009).

Amchitka Island is the southernmost island in the Rat Island group. It is one of the only islands in the archipelago to receive extensive archaeological survey, with more than 120 sites having been mapped, tested, and described (Funk 2011). It also contains the only non-chieftain household in the Western Aleutians to be fully excavated. Amchitka Island preserves the earliest known sites in the Rat Islands, with five occupations across four sites ranging between 4780 ± 270 to 3520 ± 130 years B.P (Funk 2011).

The analysis of faunal remains from archaeological sites is uniquely suited for providing data on the nature of past human interactions with their environment (Rick and Erlandson 2008). Archaeological sites with preserved faunal deposits offer unique avenues to understand both human impacts on the environment, and human responses to climate change. However, it is important to keep in mind that faunal deposits reflect cultural choices; they are not inherently a direct representation of the local environment. At the same time, it is appropriate to assume that a range of the local fauna would have been collected and deposited at a site.

The deposits analyzed in this thesis can be characterized as fill deposits within House 1. As will be discussed later, this fill is likely composed of redeposited midden material overlaying a primary deposited midden. The nature of the deposit makes it more likely that skeletal elements will be encountered whole, as trampling and other activities occurring within an active household would not be expected.

1.1 Research Problem

Over the past several decades, researchers have identified a global crisis among marine ecosystems (Jackson et al. 2001). Until recently, many archaeologists and modern researchers thought of marine fauna as an inexhaustible resource (discussed by Erlandson and Rick 2010 and Hutchings and Reynolds 2004). However, many species have experienced drastic population declines, changes in growth rates, and shifts in community structure (Daly and Brodeur 2015; Hunter et al. 2015; Hutchings and Reynolds 2004; Johnson 2016; Ruttenberg 2001; Uusi-Heikkilä et al. 2015). Some of these effects can be traced to anthropogenic changes, including over-exploitation, habitat loss, pollution, and the introduction of invasive species (Altieri et al. 2012; Baudron et al. 2013; Beeton 1970; Riley et al. 2008; Sarmiento et al. 2004).

In face of the recent realization of the dire conditions faced by fisheries all over the world, archaeological research serves a key role, as it can speak to human impacts upon marine environments within the past (Erlandson and Rick 2010; Lyman 1996). These impacts are not limited to modern times; past human populations have also deleteriously impacted marine ecosystems around the world (Anderson 2008; Braje et al. 2007; Butler 2001; Corbett et al. 2008; Kirch 2004; Quitmyer 2003; Reitz et al. 2008; Steadman et al. 1984). However, some prehistoric hunter-gatherers lived in a sustainable relationship with their environments, with little adverse impact on their environments (Butler and Campbell 2004; Campbell and Butler 2010; Etnier 2007; Perdikaris and McGovern 2008).

Due to the issues and risks associated with modern harvesting practices and climate change, it is increasingly important to contextualize present-day marine systems within a long-term framework that considers past human activities. Human and environmental systems are interconnected, having dynamic and diverse composition and structures. Within this analysis, historical ecology is utilized to contextualize prehistoric marine resource exploitation at 49-RAT-32.

Zooarchaeological research in the Aleutians has occurred since the 1960s (Lippold 1966). However, unequal attention to specific cultural periods across the chain has left large gaps in coverage over both time and space. As of 2016, only 20 faunal assemblages in the Aleutian Islands had been analyzed or quantified (Morrison 2016), though a few more have since been published (Krylovich et al. 2019; Vasyukov et al. 2019). The analysis of faunal remains from 49-

RAT-32 contributes to our understanding of Late Aleutian Period subsistence practices in the Western Aleutians and the Rat Island group. As argued by Rick and Erlandson (2008:10) “temporal changes in the average size or age of individuals from a particular fish or shellfish species are one of the simplest, most common, and valuable measures used by archaeologists to reconstruct shifts in human predation pressure and impacts in marine or aquatic ecosystems." However, regression techniques aimed at exploring fish length and weight have only five sites have utilized (Maschner et al. 2008; Orchard 2005; Orchard and Crockford 2010). Within the Western Aleutians, this method has only been applied to one species (Pacific cod) from two sites (ATU-003 and ATU-061) (Orchard and Crockford 2010). Estimating the sizes of fish harvested allows for more detailed conclusions to be drawn in regard to fishing practices and environmental health. The potential impacts of specific harvesting methods on fish populations can also be assessed.

49-RAT-32 is an exceptional site for understanding resource availability and fishery ecologies before the advent of industrial exploitation during the historic period (beginning in 1741 C.E). Analysis of the fauna from 49-RAT-32 adds to a growing body of literature on Unangax̂ subsistence strategies in the Western Aleutians. Faunal analyses can address anthropological problems relating to past diets, changes in subsistence strategies over time, and potential resource depression. Archaeological studies also provide context to understand changes within present-day marine systems through a long-term research framework that considers human activities.

Based on the current understanding of paleo-climate models in the Western Aleutians, the LIA represents a time of moderate cooling (Morrison 2016). This cooling is linked to greater ecosystem productivity and should produce a signature distinct from that during warmer time periods. As will be discussed in more detail in Chapter Three, a greater abundance of copepods and zooplankton during cooler periods should have supported larger marine mammal and fishery populations as cooler oceans are better able to bring deep ocean nutrients into the photic zone (Bopp et al. 2001; Sarmiento et al. 1998; Sarmiento et al. 2004; Schmittner 2005). However, some fishes, such as cod and flatfish, may increase in size but decrease in overall frequency during periods when sea surface temperatures were warmer (Maschner et al. 2009).

1.2 Thesis Organization

The following chapters present information on the physical environment and culture history, of the region, the theory guiding the research, and the materials and methods of the analysis. Chapter Two includes key background information and a discussion on the physical environment and culture history. The theory guiding the research questions, and the resulting expectations are discussed in Chapter Three. Chapter Four includes a discussion of the excavation at 49-RAT-32, and the materials and methods used in the faunal analysis. Chapter Five presents the results of the faunal analysis. Chapter Six discusses those results and the issues that arose when applying the data to the research questions. The last chapter summarizes the findings from this analysis and presents the conclusions and possible directions for future studies.

Chapter 2: Background

2.1 Physical Environment

2.1.1 *Setting*

The Aleutian Island chain is the longest volcanic island chain in the world (Corbett et al. 2010). The region stretches nearly 1,118 miles from the tip of the Alaska Peninsula to the Near Islands (Corbett et al. 2010). The Eastern Aleutians comprise the area between Port Moller on the Alaska Peninsula to the Islands of the Four Mountains (Davis and Knecht 2010), while the Central Aleutians consist of the Andreanof and the Delarof Island groups (Black 1984). The Rat Island and Near Island groups combine to form the Western Aleutians (Funk 2011). Today, no area of the United States is more isolated or more sparsely populated than the Western and Central Aleutians (Corbett et al. 2010). The Rat Island group (Figure 2.1) consists of ten islands: the largest and southernmost of these is Amchitka Island. Amchitka is the location of 49-RAT-32, a late prehistoric to early historic village site. Amchitka is 42 miles long and one to four miles wide, with an area of approximately 74,240 acres. The island is located about 1,340 miles west-southwest of Anchorage, Alaska, and 870 miles east of the Kamchatka Peninsula in eastern Russia (Cook et al. 1972). Elevations range from sea level to more than 1,100 feet above sea level (Powers et al. 1960). The coastline is rugged; sea cliffs and grassy slopes surround the island. Vegetation on the island is low-growing, with meadow-like tundra grasses at lower elevations (Amundsen 1977). The lowest elevations seen on Amchitka occur in the eastern third of the island, which is characterized by numerous shallow lakes and heavily vegetated drainages. Like most of the islands in the Aleutians, Amchitka has no trees. The central portion of the island has higher elevation and fewer lakes than the eastern third, while the westernmost three miles of the island consists of a windswept rocky plateau with sparse vegetation (Cook et al. 1972; Merritt 1977).

49-RAT-32 is located on the Pacific Ocean coastline, approximately 23 kilometers from the eastern tip of the island (Cook et al. 1972) (Figure 2.2). The site is situated on a bluff rising 15 to 18 meters above sea level and overlooks a small cove protected by a reef approximately four hundred meters offshore. Dating of the site, taken from House 1, indicate that it was occupied from at least 550 ± 30 to 330 ± 30 calibrated years B.P (Cal. yrs B.P: Rogers et al.

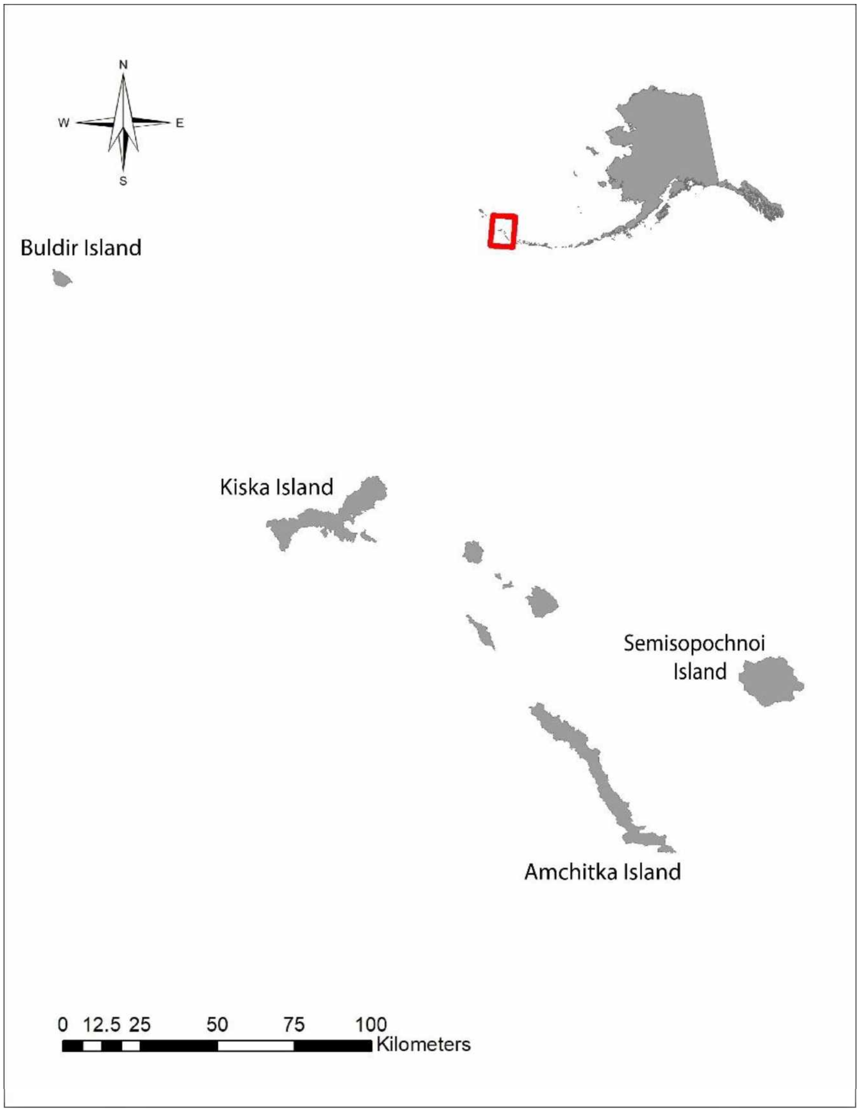


Figure 2.1 Location of the Rat Island Group

2016). This is consistent with dates obtained by Cook et al. (1972) wherein the upper levels of the household were dated to 335 ± 100 Cal. years BP. However, new radiocarbon dates obtained as part of this analysis indicate that the fill deposits from House 1 are at least partially redeposited. The new dates, which will be discussed in more detail in Chapter Four, span from 620 ± 20 to 320 ± 20 Cal. years BP. This includes the Late Aleutian and early historic periods for the region. The Late Aleutian period dates to 1000-200 Cal. BP, although it is worth noting that these dates were generated from sites in the Eastern Aleutians (Davis and Knecht 2010). 49-RAT-32 has experienced significant erosion due to its position on an actively eroding bluff, but currently consists of two middens along with multiple household depressions (Cook et al. 1972).

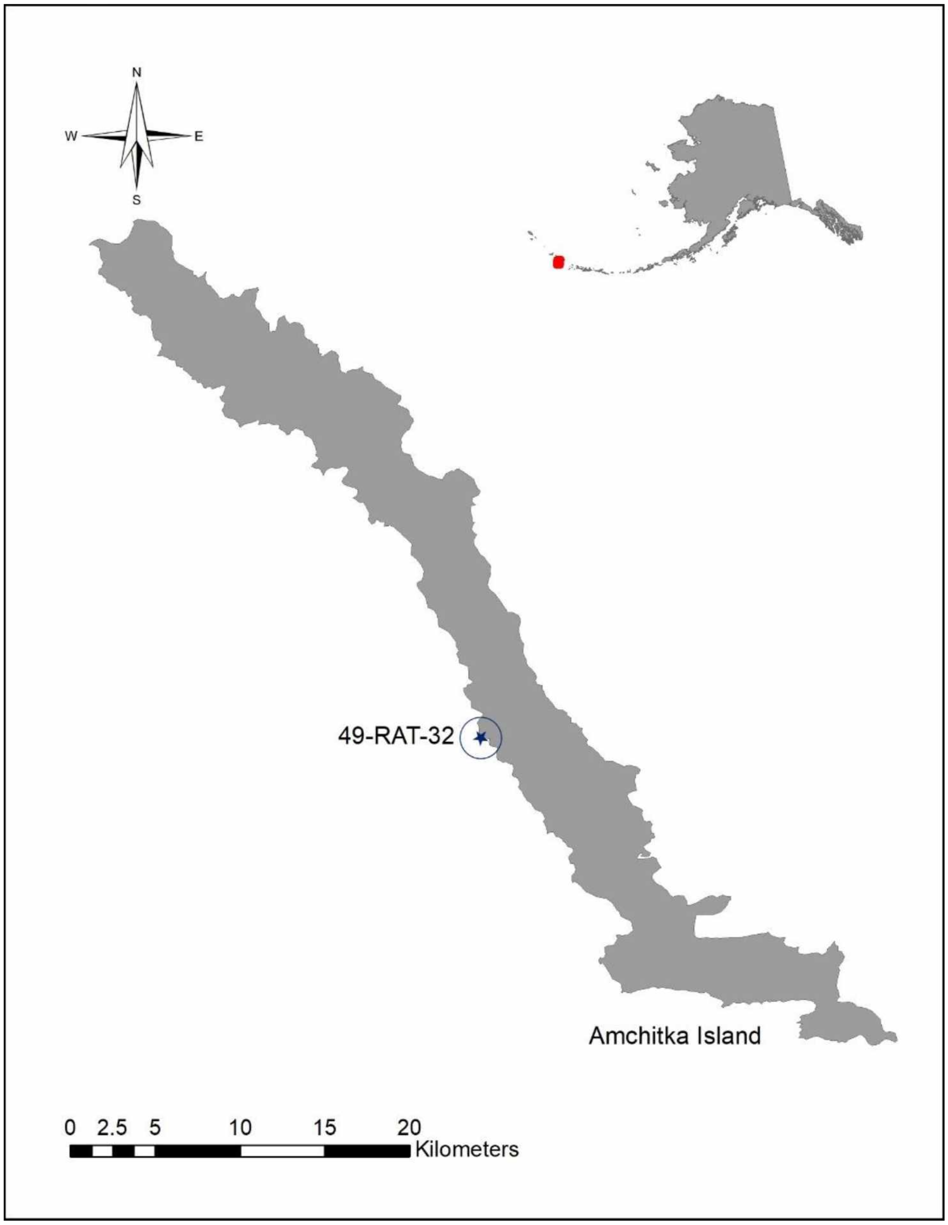


Figure 2.2 49-RAT-32 Location

Additionally, this site contains one of the only households (House 1) in the Western and Central Aleutians to be fully excavated.

2.1.2 *Physical Geology*

The Aleutian Islands are the emergent peaks of a submarine volcanic arc rising from the Aleutian Ridge. The islands mark the presence of a subduction zone between the North American continental plate and the Pacific oceanic plate. The Rat Island group, located along the northeast edge of a segment of the Aleutian Ridge, is a part of great fault block tilted southwestward toward the Aleutian Trench. This large tilted block is composed of rocks that are greatly deformed by block faulting. As attested by frequent earthquakes, the region is still structurally unstable, but no recent earth movement has been sufficient to form visible scarps or other features (Powers et al. 1960).

Most of the littoral zone on Amchitka Island is typified by a rock bench that averages 15 meters wide and is covered with seaweed. Seaward, the bench is truncated by a steep cliff that extends as much as nine meters below water. Landward, the bench terminates against the base of a cliff that ranges from 15 to hundreds of meters high (Powers et al. 1960).

2.1.3 *Climate*

The Aleutian climate is maritime, with cool, wet summers and mild winters. Temperatures rarely fall below -12°C or rise above 15°C (Corbett 1991; Merritt and Fuller 1987). Weather is largely controlled by large scale pressure systems and associated weather fronts. Warm, moist air from the Pacific Ocean collides with the cool, arctic air to form a near continuous cloud cover, fog, and high winds.

Aleutian weather has commonly been described as inclement (Cook et al. 1972; Veltre and Smith 2010). During the excavation of 49-RAT-32, the official report and the field notes describe the weather as being “a near constant annoyance” (Cook et al. 1972:3). The most violent storms occur in early winter (November and December). Hurricane force winds (120 kph) occur on all of the islands in the Aleutians from two to fifteen times a year (Beaudet 1960). In addition, katabatic winds, called williwaws, can build up on windward mountain slopes, then pour down the lee slope at hurricane speeds. They occur suddenly and without warning, primarily on mountainous islands with precipitous shores (Beaudet 1960; NOAA 1987). However, fog and high or sudden winds would have the most dangerous weather conditions for the prehistoric habitants of the Aleutians. Drawn out periods of these conditions could leave hunters landbound and unable to effectively hunt and gather marine resources. These conditions could eventually lead to hunger and starvation if unabated for long stretches of time. If hunters were at sea during these periods, they could be in danger of capsizing, getting lost, or dying. If a hunter dies, especially in a low population center, then their dependents could suffer great hardships (Corbett 1991).

Despite the risks of inclement weather, the Aleutians are known for their generally predictable seasonal winds and storm cycles (Funk and Hornbeck 2014). These have the potential to hinder, as well as facilitate, travel and hunting in the region. Winds blow at an average of 30-40 kph and can come from any direction in any season. In the Rat Island group, the predominate wind patterns are as follows: winter winds flow to the west, spring to the northwest, summer to the northeast, and fall to the east (Funk and Hornbeck 2014).

2.1.4 *Oceanography*

Ethnographically, Unangax̂ diet is almost entirely marine-resource dependent (Lantis 1984; Turner 2008). Aleutian waters are resource rich and one of the world's most productive fisheries; this is due to their geographic placement and the nature of the ocean currents. Specifically, it is based on their sub-marine topography, current flow, winds and the mixing of waters and nutrients from the Pacific Ocean and Bering Sea (Ladd et al. 2005).

Circulation in the North Pacific is dominated by the eastward flowing Subarctic Current, but the Aleutian region is a complex mix of Pacific Ocean and Bering Sea currents and eddies. Two major sea currents pass through the Rat Islands. (Figure 2.3). These are the Aleutian North Slope Flow and the Alaskan Stream, which together form a clockwise-like transport system of marine waters around the Rat Islands (Funk and Hornbeck 2014). The Alaskan Stream, to the south, is narrow and swift and flows westward. A portion of this current then turns north on the east side of Amchitka Pass and in the pass west of the island group. The Aleutian North Slope Flow, on the other hand is slower and sporadic. This current sends waters southward on the west side of passes. Small (10 km) eddies are sometimes present in the Amchitka Pass or in areas of significant bathymetric drop-off (Funk and Hornbeck 2014). Tides are diurnal with episodes of extreme low tides.

The mixing of the Pacific Ocean and the Bering Sea is the main driver of the rich marine waters in the area. The warmer waters of the Pacific Ocean move northward through the straits between the islands to produce complex mixing with Bering Sea water. This results in upwelling and the spread of nutrients in the area. Amchitka Pass, which is deep and wide, provide extensive habitat for a multitude of species. Westward from Amchitka Island, the Rat Island group (Kiska, Rat, and islands in between) is characterized as having small islands and wide passes, some of which contain deep canyons (Hunt and Stabeno 2005).

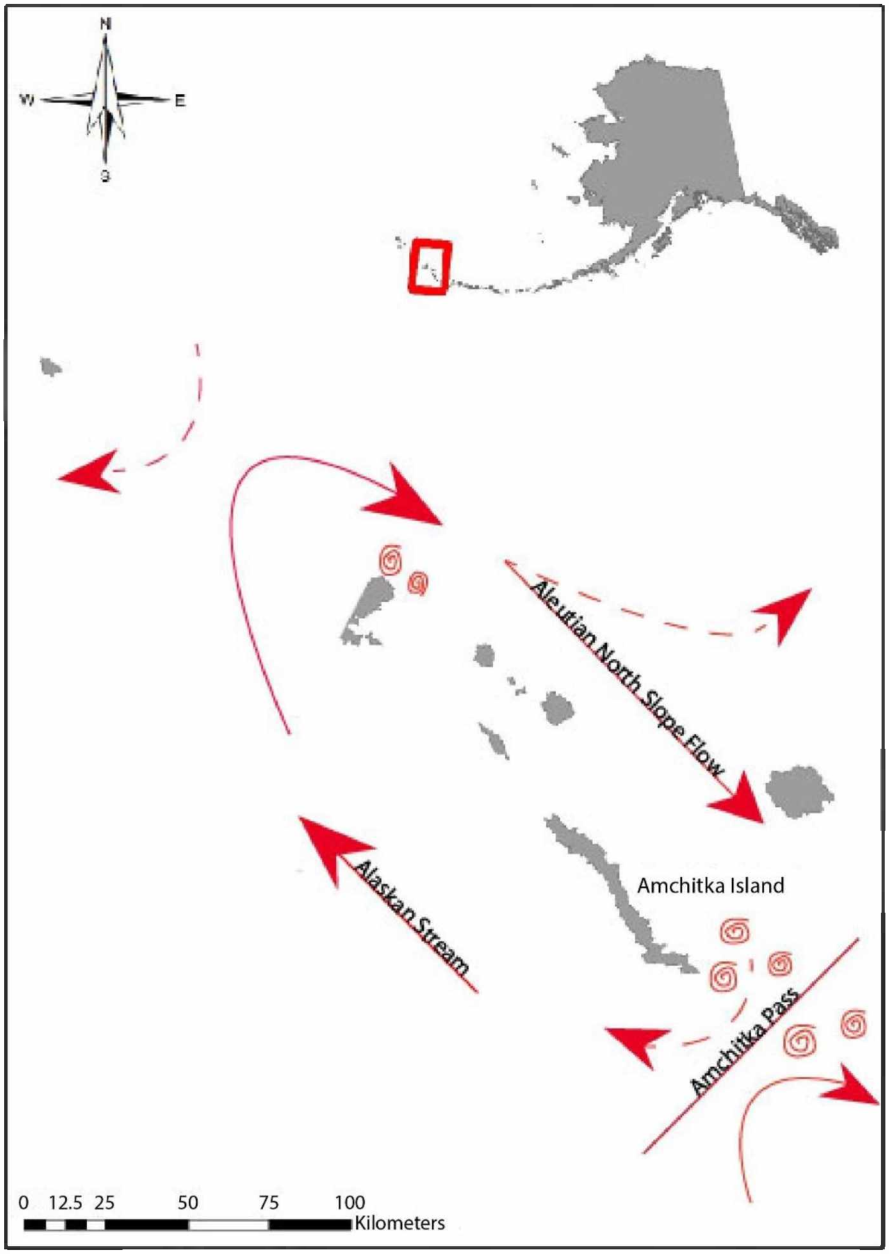


Figure 2.3 Marine Currents in the Rat Islands

2.2 Ecology

2.2.1 *Vegetation*

The vegetation in the Aleutians is dominated by tundra. Dwarf shrubs and forbs, including crowberry and willow, occur at higher elevations, while lower, more protected areas support mesic graminoid herbaceous meadows dominated by bluejoint (*Calamagrostis canadensis*) and a variety of other herbs (Shacklette et al. 1969). Graminoid herbaceous communities occur in coastal areas, while bogs support low scrub communities to develop thick peat deposits (Gallant et al. 1995). There are 14 main terrestrial habitats on Amchitka (Shacklette et al. 1969); these are as follows: strand, dune, sea cliff, *Empetrum* heath, bog, marsh, lake, pool, stream, ruderal, discontinuous heath, solifluction, alpine meadow, and inland bedrock. A complete list of these habitats and the corresponding prominent vegetation community can be found in Appendix A. Overall, tall grasses and shrubs dominate at higher elevations, while at lower elevations herbaceous meadows are the dominant plant communities.

2.2.2 *Marine Mammals*

Marine mammals are the only mammals native to most of the Aleutian Islands. The two exceptions to this rule are the red fox and lemming, endemic only to the easternmost islands of Umnak, Unalaska, Akutan, and Akun islands (Bailey 1993). Marine mammals known to inhabit the Aleutian Islands (at least seasonally) include sea otters (*Enhydra lutris*), harbor seals (*Phoca vitulina*), sea lions (*Eumetopias jubatus*), fur seals (*Callorhinus ursinus*), porpoises (*Phocoenidae*), and whales (*Cetacea*). Many of these marine mammals, such as harbor seals, sea lions, porpoises, and sea otters, would have been in the Aleutians year-round. However, some species are only present in the region during the spring and fall months; modern populations of fur seals are present during their migrations to and from the Pribilof Islands. The greatest diversity of marine mammals would have been available during the summer months. At this time sea lions are in their rookeries, and some baleen whales are migrating through and feeding in the island passes (Morrison 2016). See Appendix B for a list of marine mammals known to occur in the archipelago.

2.2.3 *Birds*

The Aleutian Islands are known throughout the world as a birding hot spot, with upwards of 40 million individuals nesting on Alaska Maritime Refuge lands. This region provides critical habitat for nesting seabirds and others that come to these islands annually. Dozens of bird species would have been available to residents of the Aleutian Islands, bird families including *Alcidae* (auk), *Anatidae* (ducks and geese), *Diomedeidae* (albatross), *Phalacrocoracidae* (cormorant), *Procellariidae* (shearwaters), and *Laridae* (gulls) were commonly hunted and utilized in the Aleutian Islands (Crockford 2012; Crockford and Frederick 2007; Crockford et al. 2005; Yesner 1977). Birds were an important raw material; bird skins and feathers were used for clothing, bird bones were used for tools such as awls and needles, and feathers were used for fletching and decorative uses (Corbett 2016). Although bird bones are present at 49-RAT-32, avian remains were not analyzed as part of this thesis.

2.2.4 *Fish*

Fishery resources around Amchitka (and the Aleutians more generally) are abundant and diverse. The region around Amchitka Island is characterized as a shallow-water bridge joining temperate Asia and North America, which results in a distinct ichthyofauna (Simenstad et al. 1977). Although deep-water species common to the Aleutians are distributed throughout the North Pacific basin, the Aleutian fauna present in nearshore and intertidal waters are characterized predominantly by North American forms. This predominance appears to be a result of the Alaskan Stream, which disperses the pelagic eggs, larvae, and juveniles of indigenous species (Simenstad et al. 1977). This mechanism is termed a “filter-bridge” by Wilimovsky (1964), in that it not only inhibits the eastward expansion of Asiatic species, but also limits the westward expansion of North Pacific species. This bridge is further accentuated by Amchitka Pass, which, as described previously, is a major point of exchange between the North Pacific Ocean and Bering Sea water masses (McAlister 1971). The extensive, wide littoral benches and the broad sublittoral shelf on the Pacific Ocean side of the island provide suitable habitat for large populations of littoral and inner sublittoral fishes (Simenstad et al. 1977).

Fishery resources located around Amchitka are better known than in other areas of the archipelago because of the U.S. Atomic Energy Commission (AEC) activities that occurred here. Simenstad et al. (1977) provides the most complete list of fish found in the waters around Amchitka; between 1967-1972, 90 species of fish were documented in nearshore and offshore environments. A complete list of these species can be found in Appendix C, taxa identified at 49-RAT-32 are marked with an asterisk.

2.3 Culture History

2.3.1 *Region*

The Unangax̂ region extends from Port Moller on the Alaska Peninsula westward to Attu Island at the far western end of the Aleutian archipelago. This region also includes the Shumagin Islands south of the Alaska Peninsula and the Pribilof Islands to the north of the eastern Aleutians. Unangax̂ lived and hunted throughout most of this region; only the Pribilof Islands appear to have been uninhabited prior to Russian contact (Veltre and Smith 2010).

2.3.2 *The Unangax̂*

Sustained contact between European populations and the Unangax̂ began with the arrival of the vessel *Sv. Evdokiia* under Mikhail Nevodchikov, which landed off the second of the big islands (suspected as being Agattu) in September 1745. At this time, the Unangax̂ occupied most of the islands in the Aleutian archipelago (Berkh 1974). While the appearance of similar tools and equipment for a maritime based economy led some to paint a picture of cultural homogeneity across the Aleutian chain, this is not the case (Corbett 1991). The Unangax̂ were divided culturally, linguistically, and politically. The Near Islanders spoke a dialect of Western Aleut, now referred to as Attuan. The now extinct Rat Islanders may have spoken a closely related dialect, Atkan, though almost nothing is known of it (Bergsland et al. 1990). Those who lived in the eastern Aleutians spoke a dialect referred to as the "eastern dialect".

Early ethnographies of the people of the Aleutians are rare and there are no robust early sources describing the lifeways of people living in the westernmost sections of the island chain. The Western Aleutians was the first area in Alaska to be affected by Russian contact. This contact began the longest and arguably harshest history of foreign contact among any indigenous people in Alaska (Veltre and Smith 2010). Ethnographic accounts post-date sizeable changes to the Unangax̂ way of life as a result of Russian and American colonization. In 1840, Father Ivan Veniaminov published the most detailed and extensive ethnographic account of the Eastern Unangax̂. Most generalizations about Unangax̂ traditional culture since Veniaminov are based on his work. Ethnographic data presented in Jochelson (1925, 1966), Lantis (1970), Laughlin (1980), Liapunova (1987, 1996), and Turner (2008), are strongly biased toward the eastern islands. In his ethnography, Veniaminov recognized regional cultural differences within the group and included a short section on the Atkans by Father Netsvetov, and no ethnography exists for the Near Islands (which are no longer inhabited). By 1834, only twenty-seven villages remained in the archipelago from what once was hundreds. A little more than 80 years after contact, the Unangax̂ population had been reduced into only a few villages, located primarily near the sources of furs (Hrdlička 1945) (Figure 2.4). Battles between the Russians and Unangax̂, forced labor, and introduced diseases all played a role in population decline. So too, did resettlement and consolidation into artels, associations of laborers for collective work such as sea mammal hunting (Jones 1980).

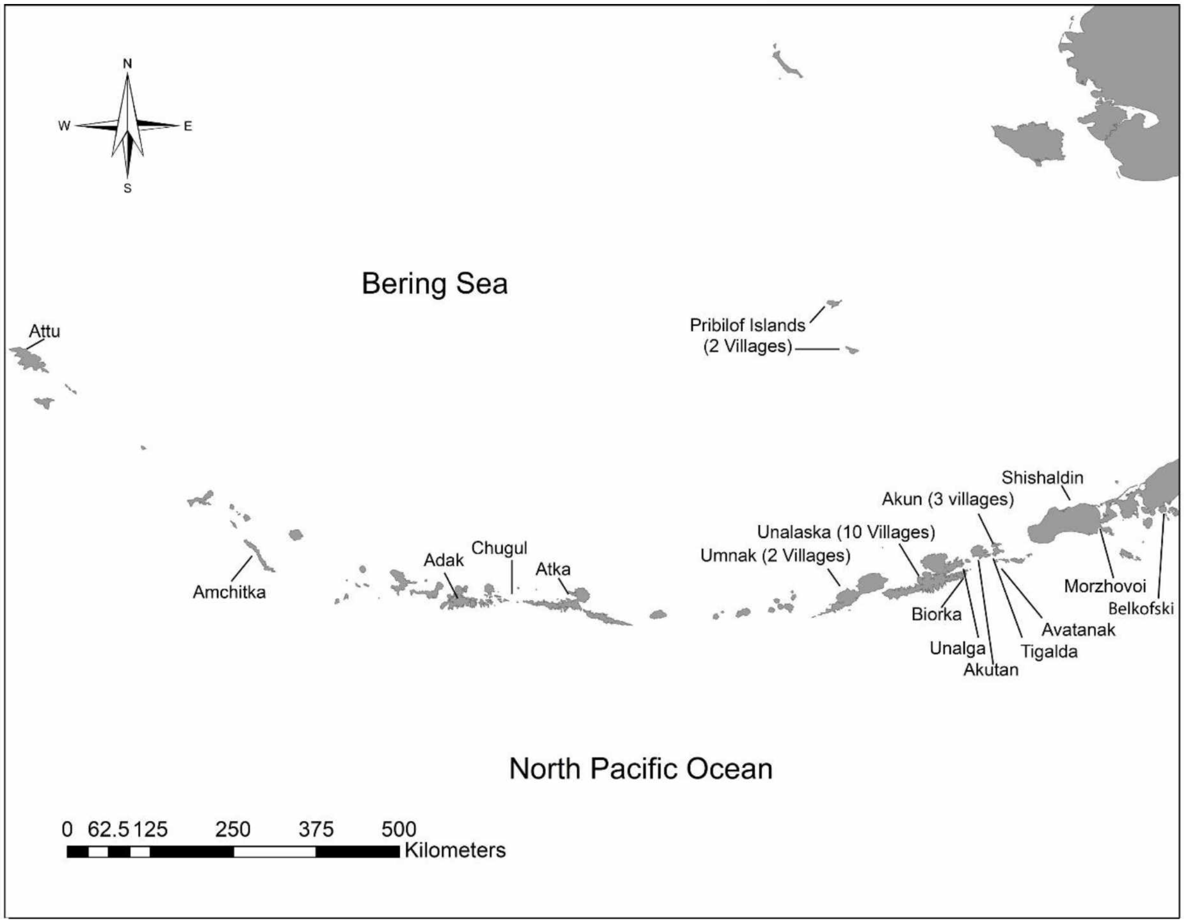


Figure 2.4 Locations of Villages Known to be Occupied between 1827-1831 (Adapted from Reedy-Maschner 2010)

2.3.3 *Social Organization and Politics*

Prior to the consolidation of the Unangax̂ people following Russian contact, the Unangax̂ people occupied small, scattered settlements. It is commonly stated that most prehistoric households in the Aleutians housed several communal based nuclear families (Lantis 1984; Maschner 1999, 2003), otherwise referred to as nuclear-satellite longhouses. However, while communal longhouses are known to exist in the eastern Aleutians, the westernmost known example is on Adak Island in the central Aleutians. There is no record of nuclear-satellite prehistoric households in the Rat or the Near Island groups (Corbett et al. 1997). Families in a household were generally patrilineally related, with avuncular relationships also being strong (Lantis 1984).

Social ranking existed in the Western Aleutians, but in a more attenuated form than in the Eastern Aleutians. Existing ethnographies of the people of the Aleutian chain are based on the Fox Islands in the Eastern Aleutians. Because of the supposed isolation of the Western Aleutians, the people have long been viewed as less culturally sophisticated than those to the east. Leadership was organized on kinship lines, with a headman for each kin group and likely for each village. Headmen and their families formed the upper class. Dual leadership was common, consisting of a chief and a second chief. Usually, but not always, the second chief inherited the position when the chief died. The common people made up the majority, and there was an underclass of dependent relatives consisting of widows and orphans who relied upon the chief for support (Corbett 2011). Lantis (1970) and Black (1984) offer differing views on how descent and inheritance operated. According to Lantis (1970), descent was matrilineal, though she indicated that many early sources on the Unangax̂ are not clear on the form of descent. However, Black (1984) argues that descent and inheritance were reckoned patrilineally, with lineage heads and their families forming the upper class of chiefs and better men who functioned as a chief's assistant. Overall, Black (1984) argues that Lantis failed to consider all of the available sources and argues that descent and inheritance were reckoned patrilineally.

Seniority and status were very important in the Aleutians, with high status assigned to those who were successful hunters (Lantis 1984; Dall 1870). Lantis (1984) also states that since both polyandry and polygyny were permitted, it is not surprising to find that both levirate and sororate systems were also acceptable (Veniaminov 1984). In levirate systems, the brother or another male within the same kin group is obliged to marry his brother's widow. In sororate systems, a sister or another woman within the same kin group is obliged to marry her sister's widow. Matri-patrilocality (a family's residence with or near either the women's or man's parents) was the most common form of residence, though this was not strictly enforced (Lantis 1984; Veniaminov 1984). Families consisted of a man and as many wives as he could support. Commoners could have as many as three; chiefs could have four. The Near Islands reportedly did not prohibit brother-sister marriages, but this could simply be a lack of restrictions on marriage between parallel cousins (Black 1984).

2.3.4 *Burial Practices*

Burial practices can provide information on world views and ideologies. Throughout the archipelago, Unangax̂ practiced a wide variety of burial techniques, including cave burials, mummification, burial houses, burials in abandoned houses, above-ground sarcophagi, sod-covered mounds called umquans, and in extended and flexed burials in rooms off communal houses (Aigner and Veltre 1976; Hrdlička 1945; Jochelson 1925; Knecht and Davis 2008; West et al. 2003; Weyer 1929). Not all of the burial practices seen in the Aleutians were practiced across the entirety of the archipelago. Most of these practices have not been observed in the Western Aleutians; the most complex burials seen in the Western Aleutians are one known burial cave and the interment of several individuals in small, house-like structures (Corbett 1991; Corbett et al. 2001; West et al. 2003).

2.3.5 *Warfare*

Feuding and warfare appear to have been common prior to Russian contact, with raiders being known to travel long distances for revenge, captives, and glory (Veniaminov 1984). Specifically, raiding involved taking material goods, wives, and captives for slaves (Corbett et al. 1997). While little is known of the relations between the Rat Islanders and the Near Islanders, relations with people further to the east were decidedly belligerent. At the time of Russian contact, the Near Islanders were under military pressure from the Central Unangax̂; Russian traders in the Andreanov Islands rescued and repatriated several children captured by the Atkans (Berkh 1974; Black 1984). The taking of wives and captives for slaves is believed to have promoted an increase in the homogeneity of language and culture along the chain, as the captives became integrated into the captors' villages and introduced their own cultural background (Corbett 1997; Misarti and Maschner 2015).

Households in the Aleutians are often characterized as being placed in areas that were amenable for hunting and gathering but also for protection from raiders (Maschner and Reedy-Maschner 1998). This includes high vantage points and places with limited watercraft access. Additionally, the social-political boundaries of the Unangax̂ seem to have played a significant part in warfare. Specifically, social boundaries existed between villages, but the boundary effect preferencing defensible areas are most prominent on the island and island-group peripheries (Maschner and Reedy-Maschner 1998).

2.3.6 *Settlements and Households*

Houses, or barabaras, were large rectangular, semisubterranean structures with "stall-like living spaces strung along the sides for…several nuclear families, with a long common space in the center under the large roof hole for entrance and light" (Veniaminov 1984:262). Trenches separate the common areas and personal living spaces, with much of the working and sleeping occurring in the latter. While households in the eastern Aleutians are generally large, the households west of Adak Island are smaller in overall dimensions and are single family based without the stall-like living apartments. Along the westward portion of the archipelago, two types of residential structures have been observed: chieftain and regular houses. "Regular" houses range in size from 4 and 9 meters in maximum length, with chieftain households being larger than that (Corbett et al. 2001). While hearths in households are reported ethnographically and archaeologically, the Unangax̂ in the Western Aleutians supposedly rarely lit fires in the houses; instead they heated the structures with lamps on pedestals (Corbett et al. 2010).

Variations in settlement patterns are seen throughout the volcanic chain (Hoffmann 1999). However, villages were generally located near streams that empty into bays, and near headlands which could function as a good vantage point for both marine mammals and enemies (Black and Liapunova 1988). Villages were also generally located on the Bering Sea coasts due to the greater abundance of resources on this coast. However, sites on Amchitka Island do not follow this mode, as there are an equal number of recorded sites on the northern and southern coasts of the island (Funk 2011). Jochim (1976) considered proximity to resources to be the most important criteria in selecting site location. His prediction that sites would be located closer to resources that were less mobile (rookeries and reefs) and less clustered (waterfowl, fish) has largely been upheld. Veniaminov (1984:258) additionally adds that "a majority of villages are at present, and were formerly also, on the north side of the islands on the Bering Sea, as it is more abundant in fish, driftage, and especially whales." Veniaminov reports that villages were essentially self-sufficient and relied on resources located immediately adjacent to the settlement. According to McCartney (1984), three marine habitats were favored by the Unangax̂: onshore shallow areas for netting fish or fishing with lines from the shore, deeper offshore areas for line fishing from boats and marine mammal hunting, and marine or lake waters for hunting waterfowl. A variety of researchers (Haggarty et al. 1991; Yesner 1977) have predicted that site location would depend on the diversity and density of local resources, with permanent settlements exhibiting the greatest variety of resources. During the summer, people were less sedentary, camping where they found food and taking shelter in rock clefts or in lean-tos during bad weather. Kul'kov reported that people sheltered in pits covered with mats, slept under baidarkas (skin sewn light weight watercraft), and built structures of baidarkas, paddles, and poles covered with skins (Liapunova 1996).

2.3.7 *Material Culture*

Unangax̂ material culture is outlined by Lantis (1984), who emphasizes the quality of Unangax̂ basketry and clothing (Veniaminov 1984). The Unangax̂ kayaks, called baidarkas since Russian contact, were the primary means of transportation, and when combined with harpoons, lances, bird darts, fish spears and composite fishhooks, provided the means for hunting and fishing (Jochelson 1966; Lantis 1984; Laughlin 1980; Veniaminov 1984). As noted by Laughlin and Aigner (1975), procurement of fish involved deep sea fishing by boat and line fishing from shore. The Unangax̂ people also possessed bows and arrows, though Lantis (1984) indicates that they were not used in kayaks and primarily saw use in warfare, with some terrestrial hunting in the far eastern Unangax̂ territories.

Unangax̂ material culture is rich and varied. It includes decorated utilitarian objects, carved and painted bentwood visors, wooden bowls, grass baskets, and ceremonial items such as whalebone masks. However, some of these cultural materials rarely appear in the archaeological record for the Rat or Near Islands (Corbett et al. 1997). Some of the practices not seen in the Western Aleutians include some burial practices, bentwood hunting hats, masks, and the use of some raw materials such as obsidian and dentalium, which are exotic trade goods and are extremely rare or nonexistent (Corbett et al. 1997). However, there is the presence of iron in sites in the Rat Island group (Corbett et al. 1997). This is significant because it has been used to argue for trade relations with Asia (McCartney 1984). However, Corbett et al. (1997) propose that the iron most likely derives from the scavenging of Japanese or Chinese shipwrecks. This is supported by the tight control the Rat Islands had over iron due to its rarity in neighboring island groups (Corbett et al. 1997; Hatfield 2010).

Clothing in the Aleutians relied principally upon marine mammals and birds. Tailored clothing was produced in the form of birdskin, sea mammal skin parkas, and waterproof gut outer parkas (kamleikas) (McCartney and Veltre 1999). These provided protection against the cool and wet Aleutian climate. The fine sewing of garments made it possible to produce clothing that was well decorated as well as warm (McCartney and Veltre 1999). Bird skins were used to make parkas where the water-repellant feathers were turned to the outside in wet weather and to the inside in dry weather.

2.3.8 *Subsistence*

Prehistoric subsistence practices of the Unangax̂ appear to be almost exclusively maritime based. This is emphasized in virtually every source. Jochelson (1966) provides an ethnographic list of food resources, indicating that the most important fish species taken were halibut (*Hippoglossooides*), Pacific cod (*Gadus macrocephalus*), pink salmon (*Oncorhynchus gorbuscha*), chum (*Oncorhynchus keta*), Coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), Chinook (*Oncorhynchus tshawytscha*), flounder (*Pleuronectidae*), herring (*Clupea harengus*), Atka mackerel (*Pleurogrammus monopterygius*), goletz (*Salmo malma*), and shark (*Seminasus microcephalus*), the latter of which was not reportedly eaten, but utilized as a source of oil and skin. Historically, the Unangax̂ also heavily relied on oil as a food source, with Veniaminov stating that “the main food of the Unangax̂ is fat [zhir-oil, blubber] of any [sea] animal except the sperm whale” (1984:277). The strong maritime dependence is clearly seen in archaeological assemblages from across the Aleutians (Corbett et al. 2010; Crockford et al. 2005; Lefèvre et al. 1997; Lefèvre et al. 2011; Morrison 2016). The ethnographic record suggests that if hunting and fishing were unsuccessful-or if regular subsistence activity was inhibited by inclement weather conditions-edible roots were dug, or seaweed and shellfish were collected from the beach (Jochelson 1966; Lantis 1984). In reconstructing the prehistoric Unangax̂ diet, Laughlin (1980) estimates that marine mammals and fish each contributed 30 percent of calories, birds and eggs contributed 20 percent, shellfish contributed 15 percent, and plants contributed less than 5 percent, with these values varying from 5-10 percent annually.

Fishing was an important part of Unangax̂ culture. Fish were able to be dried and stored in sea lion stomachs that could be used throughout the year (Johnson 2002). However, the preservation of fish could prove to be complicated and risky due to the inclemency of the weather. Food preparation was generally minimal. Fish or meat procured in the winter or summer was eaten primarily raw, though it was occasionally cooked (Jochelson 1966). The exception to this is the consumption of Pacific cod. Veniaminov (1984) states that it can be very harmful raw, with one common way of amending it is to cook it in a soup.

Fish were caught in nets, weirs, fishing lines from shore, and with barbed spears (Johnson 2002). Anadromous fish were caught using weirs and nets, though pelagic fishes such as Irish Lords were caught with hooks and lines from shore. Fishing lines were made from animal sinew and seaweed and could be up to 150 fathoms long; these were twice as strong as modern hemp cords (Johnson 2002). Fishing spears were used for a variety of fish but were used especially to capture Atka mackerel during their spawning season (Turner 1886). During their spawning season, people would travel in two-holed baidarkas to the spawning grounds. They would make jerking movements with a barbed spear of at least 12 ft in length; using this method, one could harvest a couple hundred pounds of mackerel in only a few hours (Turner 1886).

2.4 Archaeological Studies & Interpretations in the Aleutians

2.4.1 *Early Studies & Ideas*

Some of the first archaeological and anthropological work in Alaska took place in Unangax̂ territory in southwest Alaska. Archaeological deposits in this region are typically well preserved; this is due in part to deposition with shellfish and the lack of terrestrial carnivores to impact the assemblages.

Interpretations of the prehistory of the Aleutian Islands are primarily based on the work of three early scholars in the region. These are Dall (1877), Jochelson (1925) and Hrdlička (1945). The work conducted by these individuals led to the establishment of two major ideas that have affected all other work to come after them. Some of this work also created controversy, such as that of Hrdlička. The controversy associated with Hrdlička relates to his procurement or "looting" of Unangax̂ burials without the consent of descendent communities. One of the most prominent ideas to originate from these early studies is that the Aleutian Islands were populated from the east to the west, with the occupation of the region having considerable time depth, dating as far back as the early Holocene (Aigner 1976). A main driver behind the assertion of a considerable time depth is the idea of cultural isolation due to the geographic placement of the Aleutian Island chain (Corbett et al. 1997; Laughlin 1975; McCartney and Veltre 1999). This isolation effect is a core principle in Aleutian archaeology in terms of understanding past peoples and potential social change. Additionally, the isolation effect is of primary concern in understanding and analyzing population movements and changes in artifact representation across space and time. These issues continue to be at the forefront of archaeological research in the area.

2.4.2 *Population Continuity or Replacement 1000 Years BP?*

An important and hotly debated topic in the study of Aleutian archaeology relates to potential population changes that occurred across the chain around 1000 years BP, and the question of continuity throughout the sequence. In addressing societal changes that occur throughout the sequence of Aleutian archaeology, there have been differing opinions on the degree of continuity. Dall (1877) proposed a 3-period chronology, while Jochelson (1925) proposed an uninterrupted sequence. Additional interpretations include McCartney's (1984) "dual-tradition" model and Laughlin (1980) arguing for continuity. Current interpretations vary, but most generally agree with Laughlin's (1980) interpretation of continuity, while acknowledging that incursions and excursions of people and cultural elements occurred (Davis and Knecht 2010; Davis et al. 2016)

In 1945, Hrdlička noted a change in cranial vault form in burials in Unalaska, Umnak, and the Kagamil Islands after 1000 B.P. He concluded that these individuals and the burial contexts in which they are found in represented a distinct population living in the Aleutians known as Paleo- and New-Aleut groups. While Hrdlička argues for population replacement from another genetically distinct group of people, others, such as Misarti and Maschner (2015), argue that genetic and isotopic differences are based not on population movements, but on the beginnings of social complexity. This social complexity is proposed to be the result of the differential access to higher status foods and increased regional interactions and suspected warfare in the region.

2.4.2 *Maritime Economy*

Archaeologists have proposed that precontact subsistence patterns were driven by the needs of a maritime based economy. The prevailing theme is that the Unangax̂ focused their lives on the sea and the coast, with most of the raw materials and food originating from marine mammals, birds, pelagic and anadromous fish, and marine invertebrates (McCartney and Veltre 1999). In the absence of significant terrestrial fauna and given the limited plant foods available, the abundant and diverse fish, birds, marine mammals, and marine invertebrates provided the basis for human subsistence.

2.4.3 *Archaeology in the Western Aleutians*

There is a disparity in terms of the intensity of archaeological research as one moves west along the Aleutian chain. The Eastern Aleutians and the Alaska Peninsula have been the subject of the most research, while relatively little work has been conducted in the Western Aleutians (Corbett et al. 2010). The geographic distance between these areas, and the relatively short duration of amenable conditions for archaeological work are partially to blame. More recently, scholars such as Corbett, Causey, Funk, Hansen, Hatfield, Lefèvre, and West have attempted to increase our understanding of the archaeology of the Central and Western Aleutians and how it relates to the rest of the island chain.

The Rat Islands are located in the easternmost section of the Western Aleutian region; archaeological data indicates that the Unangax̂ have lived in this region for at least 6,000 years (Desautels et al. 1971). The earliest dates of occupation in the Rat Islands originate from Amchitka Island, with five occupations across four sites, dating to 4780 ± 270 to 3520 ± 130 years B.P (Funk 2011). Research in the Rat Islands has been uneven. Early researchers primarily focused on the Near Islands or the Central Aleutian island groups, and those who studied the Rat Islands focused on the most prominent village middens (Bank 1953, 1977; Dall 1877; Guggenheim 1945; Hrdlička 1945; McCartney 1974a, 1974b, 1977). Over the last 60 years, archaeological research has largely been related to activities requiring federal compliance: this includes the AEC survey and excavations on Amchitka Island in the 1960s and 1970s, and the

United States Bureau of Indian Affairs (USBIA) Alaska Native Claims Settlement Act (ANCSA) 14(h)(1) investigations in the 1980s and 1990s, which occurred throughout the island group (Cook et al. 1972; Desautels et al. 1971; Harrington 1987; Merritt and Fuller 1977; Sense 1969; Turner 1970; Warter 1970). Given that Amchitka Island was used by the AEC as an underground testing location for nuclear devices, the island was subjected to a greater degree of research than other islands in the Rat Island group. Amchitka was the first island in the Aleutians to be completely surveyed, with 86 sites recorded there. Only 20 other sites have been recorded elsewhere in the Rat Islands (Funk 2011). This bias has led researchers to define Amchitka as the main regional population center of the island group. With the regional population center believed to be at Amchitka Island, it was inferred that the other Rat Islands were primary resource extraction centers (Funk 2011).

Archaeologists working in the Aleutians have often relied upon three main assumptions about the Rat Islands. First is that there were relatively few people who lived in the Rat Islands; this is based on the low number of known prehistoric and contact-era sites in addition to Russian observations of the low populations (Black 1984). Second, that the Unangax̂ had little impact on the terrestrial and marine ecological systems due to long-held assumptions about the generally low impact of Native Americans on North American landscapes (Anderson 2005; Corbett et al. 2001; McCartney 1977). Third is a simplistic, time compressed view of Rat Islands history (driven by a lack of systematic and comparable data sets). Based on these assumptions, it was proposed that the Rat Islands were populated from a founder population, experienced a cultural shift (as did all other Aleutian groups) ~1,000 years ago, and then had contact with the Russians, with the resulting fallout (Funk 2011). However, recent research demonstrates the complexity and ubiquity of Unangax̂ landscape use in the Rat Islands. Current research indicates that there were higher population densities on Kiska, Rat, and Amchitka Island as compared to other islands in the Rat Island group, indicating that this region is more complex than previously thought (Funk 2011).

2.4.4 *Limiting Factors*

Several factors have limited the study and understanding of Aleutian prehistory. These include military activities, vandalism of sites, geographic isolation, and climactic conditions which are not amenable to surveys and testing. World War II was extremely damaging and destructive to Aleutian archaeological heritage. Military activities such as bombings and construction throughout the archipelago not only disturbed archaeological sites that were already known, but also those that had not yet been discovered. Pot-hunting was also common in the archipelago (and on Amchitka) during this time, as recorded in detail by Paul Guggenheim (Guggenheim 1945). These activities and others led McCartney to comment that "archaeologists working for hundreds of years could not alter and damage the number of sites that WWII forces did in five years" (U.S. Fish and Wildlife Service 1972: 36). Apart from wartime effects on the Aleutian archaeology, another factor hindering research in the area is its geographic isolation. It is difficult and expensive for archaeologists to access sites in the Western Aleutians. Once one arrives to the island, it is difficult to find sites that are in good condition. Finally, earlier excavations in the region did not employ modern techniques which makes meta analyses complicated, as the results of early excavations are often not comparable due to differences in excavation techniques. (Dall 1877; Hrdlička 1945; Quimby 1948).

2.5 Background Summary

The prehistory of the Western Aleutians has been the subject of relatively sporadic scholarly interest, particularly as compared to the Eastern Aleutians. The Western Aleutians were also the location of the first Russian contact. This contact forever changed life in the Aleutians, making the archaeological deposits at 49-RAT-32 an important site for understanding local interactions in the Late Aleutian period. The material analyzed at this site derive from fill deposits and likely reflect the contribution of multiple families. It is a rare site that has both escaped vandalism and destruction, and preserves a large amount of materials that were recovered with modern excavation methods. Overall, this site incorporates a window of time during the end of the Late Prehistoric period, where Unangax̂ lived and flourished before the severe population crashes brought about by Russian activities, including the resettlement of indigenous people into artels and consolidated villages.

Chapter 3: Theoretical Framework

Within this analysis I draw from historical ecology in order to address subsistence, landscape and seascape use, seasonality, processing, and potential resource stress at 49-RAT-32. In this chapter, I will provide a brief overview to historical ecology, which was critical in developing the research questions and expectations that guide this study.

3.1 Historical Ecology

3.1.1 *Background of Historical Ecology*

Historical ecology is a research program concerned with the interactions between humans, the environment, and the consequences of these interactions to understanding past and present cultures and landscapes (Balée 2006). Historical ecology utilizes four main tenants. The first is that basically all environments on Earth have been impacted by humans (Kidder and Balée 1998; Redman 1999). The second is that humans are not predetermined to lessen or augment species diversity (Crumley 2001; Hayashida 2005). The third is that all societies, whether defined by socioeconomic, political, and cultural criteria, impact landscapes in different ways (Balée 2006). Finally, humans interact with landscapes in a broad variety of historical and ecological contexts that may be studied as an integrative phenomenon (Balée 1998; Egan and Howell 2001; Rival 2006; Sutton and Anderson 2004). As it exists today, historical ecology takes a somewhat different approach than that proposed by Julian Steward in the 1950s (Steward 1955). Steward proposed that cultures in similar environments would tend to formulate similar responses to environmental challenges. Steward's approach thus focuses primarily on the impacts of the environment on human adaptation, whereas historical ecology focuses more on human effects on the landscape. Proponents of historical ecology argue that social, economic, cultural, and environmental conditions can all impact the relationship between the landscapes they occupy. Overall, historical ecology is an interdisciplinary field that bridges the life sciences and social sciences with a goal of understanding the consequences of past human interactions with the environment.

Historical ecology frameworks have been applied in many coastal settings. The primary purpose of historical ecology is to place human decision-making, and the consciousness that drives it, at the center of analyses of the human-environment relationship (Gragson 2005). Specifically, it is the assessment of the situation and the resulting choices made by humans that links them to their environment. Overall, the strengths of historical ecological data are that they provide information on the long-term evolutionary and ecological history of plants and animals, help identify the species that are endemic (native) to a particular region, and allow for an understanding how these populations have responded to both climatic and anthropogenic forces in deep time. Many historical ecology studies focus on reconstructing past ecological conditions and their implications for present and future ecosystem management (Balée 2006). However, researchers from differing disciplinary backgrounds agree that the basic form of historical ecology is concerned with the historical interconnectedness of nature and human culture (Szabó 2015).

Archaeologists are interested in reconstructing key aspects of prehistoric human lifeways such as subsistence patterns and settlement organization. Understanding that humans impact their environment is necessary in order to begin to analyze this impact. Until recently, many archaeologists considered the oceans to be an inexhaustible resource (see discussion in Erlandson and Rick 2010). This perspective has several roots. First is the tendency to minimize the impacts that preindustrial people had on their environments and demonize modern industrial advancements. Some have also assumed that prehistoric peoples were not sophisticated or numerous enough to significantly alter their environments (see discussions in Kay and Simmons 2002; Kirch 2005; Krech 1999). Zooarchaeology is uniquely suited for understanding human impacts on their environments through the analysis of animal remains. Analyzing faunal remains can help infer past climate conditions, potential resource depression, and human decision making. In utilizing a historical ecology approach, archaeologists can increase their understanding of human-environment interaction in marine ecosystems. However, an understanding of environmental processes and their impacts on marine food webs is crucial. Understanding the predominate climactic regimes that were active during the time when a site was occupied is critical to developing one’s expectations and interpretations of their data.

Human decision making is the product of a multitude of variables. In Julian Steward’s multilinear approach this decision making is a result of the environment. Specifically, humans formulate similar responses to specific challenges. In the Aleutians, this would be interpreted as the result of their geographic isolation and climate where resources are temporally and geographically clustered (Veltre and Veltre 1983). Unangax̂ reacted to this environment through their utilization of semi-permanent settlement practices and a wide range of resources. Overall, following Julian Steward's approach, Unangax̂ decision making is predicated by their environment.

3.1.2 *Historical Ecology in the Aleutians and Southwest Alaska*

Within the Aleutians, historical ecology frameworks have been utilized to identify human decision making and their signatures in shellfish, marine mammal, and fish stocks (Corbett et al. 2008; Laughlin 1980; Orchard 2001, 2003; Palmisano and Estes 1977; Simenstad et al. 1978; West 2009). Foci include the potential for resource competition between sea otters and humans for urchins. Overhunting of sea otters either for subsistence or the cash economy (the fur trade) could lead to barren "desert" regions with high urchin numbers. Corbett et al. (2008) analyzed faunal remains from selected sites from Amchitka and Attu Islands. These analyses indicate that sea otters were rare in most sites, while large sea urchins were common. In conjunction with isotopic analyses, this finding led researchers to assume that there was a lack of sea otters near archaeological sites. The lack of sea otters would have had a large impact on nearshore ecosystems. In the absence of their primary predator, sea urchins would have increased their population numbers and devastated kelp-based communities. Without kelp in these nearshore areas, marine life that depended on kelp for their habitat would suffer. The result could have forced people to travel further away from settlements to find resources that were not impacted by the resulting imbalance.

Additional studies analyzing human activity and impacts on the landscape in southwest Alaska include Dunne et al. (2016) and West (2009). Dunne et al. (2016) focused on the roles and impacts of human hunter-gatherers on North Pacific marine food webs based on an archaeological site in the Sanak Archipelago. In contrast, West (2009) analyzed how humans responded to climate change and changes in resource availability on Kodiak Island from 650-140 Cal. B.P. While West was unable to connect changes in fishing strategy to salmon ubiquity or changes in the climate, a change in fishing strategy was observed. Dunne et al. (2016) were specifically interested in human impacts on the environment. They argued that although humans were positioned to have strong effects on ecology, the arrival and presence of Unangax̂ people in the Sanak Archipelago does not appear to be associated with any long-term extinctions. This finding is also supported by Causey et al. (2005). Causey proposes that the chance for extinctions decreases when an invading omnivorous, super-generalist consumer (humans) focused strong pressures on smaller fractions of its possible resource base. However, while this research focuses on the macro scale of the human effect on resources, it does not analyze how specific species reacted to human hunting behavior. Overall, both of these studies focus on resource availability and the processes that effect their availability. While they each take different approaches, they both shed light on the possible effects of resource change over time in coastal settings.

Overall, while people would have had differential impacts on their landscapes and seascapes, Causey et al. (2005) propose that there are no major human derived shifts, declines, or species extinctions of seabirds for nearly 3,000 years in the Western Aleutians. However, research in the Lower Alaskan Peninsula suggests that there was an ecosystem collapse during a transition in climate around AD 1000-1200 (Maschner 2016; Maschner et al. 2009). This period is notable for having lower overall marine productivity than earlier and later time periods. This period is known as the Medieval Climactic Anomaly and is associated with warmer temperatures and changes in marine water circulation (Maschner et al. 2009).

Historical ecology focuses on human behavior and the reconstruction of past environments, and is based on the understanding that cultural groups affect their landscapes in dissimilar ways. Historical ecology studies have painstakingly attempted to isolate and identify human and non-human signatures, and to elucidate issues or concerns in modern ecology (Rick and Erlandson 2008). The potential for historical ecology from an archaeological perspective is that it not only helps elucidate the processes occurring at archaeological sites, but it also increases the otherwise shallow focus of modern ecological studies that are based on recent observations that rarely span more than a few decades (Rick and Erlandson 2008).

3.2 Research Questions

This project aims to understand how inhabitants of 49-RAT-32 interacted with their landscapes and to identify subsistence practices in place prior to the historic period. Landscape use and the intensity of resource extraction will be analyzed through a traditional zooarchaeological study that also utilizes skeletal element lengths of fish and a consideration of butchery patterns to understand possible environmental impacts and cultural practices.

Research questions investigated within this project include:

1. What subsistence activities were occurring at 49-RAT-32? Few zooarchaeological analyses exist for the Aleutian Islands, especially for the western region. This question will be investigated by analyzing the taxonomic representation and frequencies of species through time. Species will be assigned to their preferred habitats to understand landscape and seascape use. Taxonomic data will also be explored in relation to seasonality of site use. These methods will allow for a greater understanding of subsistence activities and landscape use during the Late Aleutian Period in the Western Aleutians.

2. Is there evidence for resource depression during the accumulation of the fill deposit at House 1 of 49-RAT-32? This question is foundational to understanding human decision-making processes and understanding if human activities impacted their environment. Strategies for addressing this will be discussed later in this chapter and Chapter Four.

3. What processing activities are evidenced at this site? This question will be analyzed through the identification and quantification of the recovered skeletal elements. The ratio of cranial bones to post-cranial elements provide insight into butchering practices and can potentially speak to the season of occupation. A high appearance of cranial elements should reflect consumption of freshly caught fish as opposed to the consumption of stored foods (Hoffman et al. 2000). This basic model derives from salmon processing practices, but it is believed to affect all fish equally. Faunal assemblages dominated by post-cranial elements indicate sites where stored fish were consumed and discarded, whereas assemblages dominated by cranial elements indicate sites where fish were caught and/or processed for storage (Boehm 1973; Butler 1993; Matson and Coupland 1995; Matsui 1996; Partlow 1998). A comparison of the ratio of cranial to post-cranial elements can inform on butchery practices through time and identify if there was stability or change during the site's occupation.

3.3 Research Goals and Expectations

In addressing these research questions, this project will identify how inhabitants at 49-RAT-32 interacted with their environments prior to the historic period. Within this analysis there are three primary goals. These are to generally characterize and understand subsistence, identify change over time, and to identify if resource stress was present.

3.3.1 *Subsistence Practices*

Few zooarchaeological studies exist from the Western Aleutians; this analysis will assist in understanding subsistence practices of Late Aleutian Period prehistory. Taxonomic frequencies, meat weight contributions, landscape use, seasonality, and butchery practices will be analyzed. Taxonomic frequencies will be analyzed through time in order to identify if there were changes in exploitation of particular species. Additionally, taxonomic frequencies will be paired with modern ecological data in order to better understand how prehistoric peoples utilized their landscapes and seascapes. Taxonomic appearance and frequency will also be analyzed to understand seasonality. Based on modern behaviors and archaeological data the most likely time frame of habitation will be determined.

3.3.2 *Change Over Time and Resource Stress*

This analysis seeks to determine whether there was change over time in the intensity of the exploited resources at 49-RAT-32, and if this change resulted in measurable stress upon fish stocks. A consideration of meat weight contributions and fish fork length data will help flesh out and assist in identifying patterns within the taxonomic data. Estimated meat weights and fork lengths for fish will be calculated utilizing Orchard's (2001) published regression equations for skeletal elements. The regression equations allow for the estimation of fork length and meat weight for a variety of North Pacific fishes through time. These include Pacific cod (*Gadus macrocephalus*), Irish lords (*Hemilepidotus sp.*), Atka mackerel (*Pleurogrammus monopterygius*), rockfish (*Sebastes sp.*), and rock or kelp greenling (*Hexagrammos sp.*). As previously discussed, the analysis of fish fork lengths over time is important because "changes in the average size or age of individuals from a particular fish or shellfish species are one of the simplest, most common, and valuable measures used by archaeologists to reconstruct shifts in human predation pressure and impacts in marine or aquatic ecosystems" (Rick and Erlandson 2008:10). If fish sizes decrease through time, this could be interpreted as a possible signature of human overexploitation, as fish become mature earlier in their life cycles to adjust to this predation (Uusi-Heikkilä et al. 2015). However, a reduction in size could also reflect climate change. Additionally, understanding fish lengths has the potential to reflect specific subsistence activities such as deep-sea fishing for Pacific cod (Orchard and Crockford 2010).

While changes in meat weight contributions and fish sizes can be used as a line of evidence for resource stress, human and environmental signatures need to be identified and discussed. Diet breadth is another measure used to identify the presence of resource stress. An increase in diet breath or increases in “famine” foods could indicate times of increased resource stress. Diet breadth will be evaluated using taxonomic data, where I will use normalized values to account for the differing number of bones present in different species.

3.4 Non-Human vs. Human Signatures

3.4.1 *The Effect of Climate Regimes on Marine Resources*

In order to better understand human-environment relationships and identify human-driven changes in animal and plant resources, one first needs to evaluate the impacts of non-human agents. Climactic conditions are well known to affect marine and terrestrial resource distribution and availability (Carscadden and Nakashima 1997; Causey et al. 2005; Corbett et al. 1997; Maschner et al. 2008; Morrison 2016; Schmittner 2005). In the Aleutians, prehistoric subsistence relies almost entirely upon the marine environment. Warm and cold periods such as the Late Medieval Climactic Anomaly and the Little Ice Age have differing influences on the marine environment (Maschner et al. 2009; Morrison 2016). When surface waters are cold, it becomes easier for deeper water to rise to the surface, bringing nutrients to sunlit areas where phytoplankton can metabolize them. When surface waters are warm, they becomes less dense than the colder waters where the nutrients are loading. This cold water is trapped below this layer because ocean layers are not mixing due to the changes in relative densities and the amount of energy now required to mix these layers (Bopp et al. 2001; Sarmiento et al. 1998; Sarmiento et al. 2004; Schmittner 2005). This ultimately reduces biotic density and the available food resources for animals, as nutrients are being condensed in deep, colder waters. This condensing of nutrients means they are unable to be utilized by certain organisms, which could have stark consequences for humans and other animals (Doney 2006; Marinov et al. 2010; Schmittner 2005; Steinacher et al. 2010). This slows the growth rate and ultimately lowers the maximum size parameters for many fish such as salmon and others (Carscadden et al. 1997; Daly and Brodeur

2015; Pyper and Peterman 1999). Specifically, if the general climate in the region was getting warmer, one should expect to see smaller fish sizes over time, reflecting adaptation to lower oxygen levels, increased metabolisms, and a decrease in overall marine productivity (Carscadden et al. 1997; Daly and Brodeur 2015; Pyper and Peterman 1999; Uusi-Heikkilä et al. 2015). However, some fishes, such as cod and flatfish, are known to increase in size but decrease in overall abundance during periods when surface waters are warmer (Maschner et al. 2008). Conversely, within time periods of colder ocean temperatures, there is an increase in marine productivity and oxygen levels that results in larger fish sizes and stocks for most species (Baudron et al. 2013).

While nutrient mixing may be reduced during warmer climate periods, storms also become stronger and more prevalent. The turbulence caused by storms are one potential mechanism for mixing nutrients upwards during warmer climactic regimes (Palter 2015). However, storms and their resulting nutrient upticks are relatively short lived. This short-lived nutrient bloom has important implications for animals and humans. When storms are not present during warmer climactic regimes there is a shortfall of nutrients for biotic communities. Overall, storms are associated with an approximately tenfold increase in surface nutrient concentrations during the storm, followed by two short-lived bursts of nutrients after the storm (Palter 2015). However, it is still ultimately unknown how long these nutrient bursts stay in the water column where organisms can capitalize upon their presence. Current research indicates that these events are limited, with initial results indicating an average period of ten days (Palter 2015).

House 1 at 49-RAT-32 dates to between 639-517 to 473-308 calibrated years B.P (Rogers et al. 2016). During this time period, the Little Ice Age (LIA) was in full effect. The LIA is known for cooler global temperatures and dates to c. 1350-1850 C.E. in North America (Cronin et al. 2003). Throughout the Aleutians and the Gulf of Alaska, these dates also align with cooler temperatures (Causey et al. 2005). However, in the Aleutians this cooler period would have resulted in fewer storms and the weather would not be as dominated by the cool and wet conditions observed today (Causey et al. 2005). Given this, it is expected that the House 1 fill deposits formed during a period of high marine productivity. Some expectations that can be drawn from the environmental component are: 1) overall average fish sizes should be larger than during times when there are warmer ocean temperatures (such as the present); 2) Pacific cod should have larger populations but smaller sizes (Freitas et al. 2015; Johnson 2016); 3) there may be different habitat and species distributions than observed in modern times; and 4) fish sizes should be relatively constant over time as the fill deposits formed within the LIA, a relatively stable period of high marine productivity.

3.4.2 *Human Signatures*

A multitude of lines of evidence can speak to human impacts on the environments. Fish fork length can be used to understand an individual's total length, which is indicative of the age of fish. At the population level, this can inform on the health of a specific fish stock. If human fishing within a highly productive marine environment resulted in overexploitation, then the record should show a transition to a wider diet breadth wherein lower ranked foods were utilized, and fish lengths should decrease as fish become mature earlier in their life cycle (Uusi-Heikkilä et al. 2015).

Human technology can also impact subsistence practices. Within the Aleutians, hunting practices can result in an assemblage that is not representative of a natural death assemblage. Fish were caught using spears, weirs, hook and line, and nets (Johnson 2002). Nets would be the most likely to produce a death assemblage that would favor older individuals, as the smaller and younger fish could theoretically make it through the gaps in the mesh. However, net sizes in use at 49-RAT-32 are currently unknown. Nets, along with weirs, were commonly used for anadromous spawning fish, such as salmon in brackish and freshwater streams and rivulets. Hooks were made of wood, ivory, or animal bone, depending on the type of fish being procured. It is not expected that the use of hook and line technology would favor a specific age or size class as it is an opportunity-based catchment system. However, the size of the hook can result in size selection, as smaller fish can't fit their mouth around large hooks, whereas larger fish could and would be drawn to larger sizes of bait. In many experimental studies, increasing hook and bait sizes have been shown to decrease the catch efficiency of smaller individuals and increase efficiency of larger individuals (Herrmann et al. 2018; Patterson et al. 2012; Ruttenberg 2001). However, contradictory results are present as well (Nicolaides et al. 2002; Penaherrera and Hearn 2008). Specific hook and bait sizes have the potential to cause resource stress and a shift to smaller average fish sizes, as continually removing larger individuals from the population has the potential to change key life history traits. Fishing spears were long and traditionally made out of wood with a potential barbed bone section comprising the terminal end. In the catchment of Atka mackerel (*Pleurogrammus monopterygius*) in the Central Aleutians, a fishing spear averaging 12 ft long was traditionally used (Turner 1886). If this technology was in use, one may see a specific size range being procured as Atka mackerel vertically stratify themselves based on their maturation and age. The youngest and most immature fish are in the upper layers with increasing maturation and age as one move further down the water column. Fish continue to grow throughout their life so the largest and most mature fish would be encountered in the lowest levels.

Overall, human and non-human stresses can impact marine and terrestrial ecosystems. While non-human and human signatures can be difficult to parse apart from one another, understanding how these forces impact environments are fundamental to making informed interpretations. Because the LIA was in effect throughout the deposition of the fill deposit at House 1, if marine resources show a decrease in average fork length and if diet breadth was increasing, this would be a strong indication that human activity is driving the changes.

3.5 Impact on Future Aleutian Studies

This research adds to our understanding of Late Prehistoric subsistence practices in the Western Aleutians. Taxonomic and metric data will allow for an evaluation of hunting pressures and butchery practices. This study also provides baseline data for future studies analyzing changes in fish sizes over time, and for studies of fishing practices in the Aleutians. In the next chapter, I will discuss the excavation of 49-RAT-32 and the methods used to address the research questions.

Chapter 4: Materials and Methods

Data were gathered to more clearly understand how Unangax̂ at 49-RAT-32 interacted with their environment. In this chapter, I describe the materials and methods utilized for this analysis, beginning with a discussion of the excavations at 49-RAT-32.

4.1 Excavation

4.1.1 *49-RAT-32 Setting*

49-RAT-32 (Figure 4.1) was excavated in the summer of 1971 through salvage efforts by an archaeological field crew from the University of Alaska, which spent eight weeks at the site (Cook et al. 1972). The crew consisted of Dr. John P. Cook as the principle investigator, two graduate students who served as co-assistants—E. James Dixon, Jr. and Charles E. Holmes—and three other anthropology students: Terry Dickey, William Evans, and Steve Behnke (Cook et al. 1972). Given the site's location on an eroding bluff and its proximity to the impending Cannikin subsurface nuclear test (scheduled for the fall of 1971), the site was selected for excavation. The Cannikin test resulted in the largest subsurface nuclear test in U.S. history at 5 megatons or 21 petajoules. The original excavation plan called for a 2 m wide trench that would transect the long axis of the site, but this trench was never completed because the site proved to be deeper, larger, and more complex than expected (Cook et al. 1972). The final extent of the excavation comprised 24 units, each of which was 2 m^2. Thirteen of these units were part of the trench; the remaining 11 units were associated with House 1, which was excavated in its entirety. The average depth to bedrock was 1.25 m, though some areas contained more than two meters of deposits. As discussed, previous radiocarbon dating of the stratigraphic levels observed within House 1 bracket 550 ± 30 to 335 ± 100 years B.P (Rogers et al. 2016). However, radiocarbon dating conducted as part of this analysis (described in more detail below) indicate that the fill deposits date to 620 ± 20 to 320 ± 20 years B.P (Table 4.1).

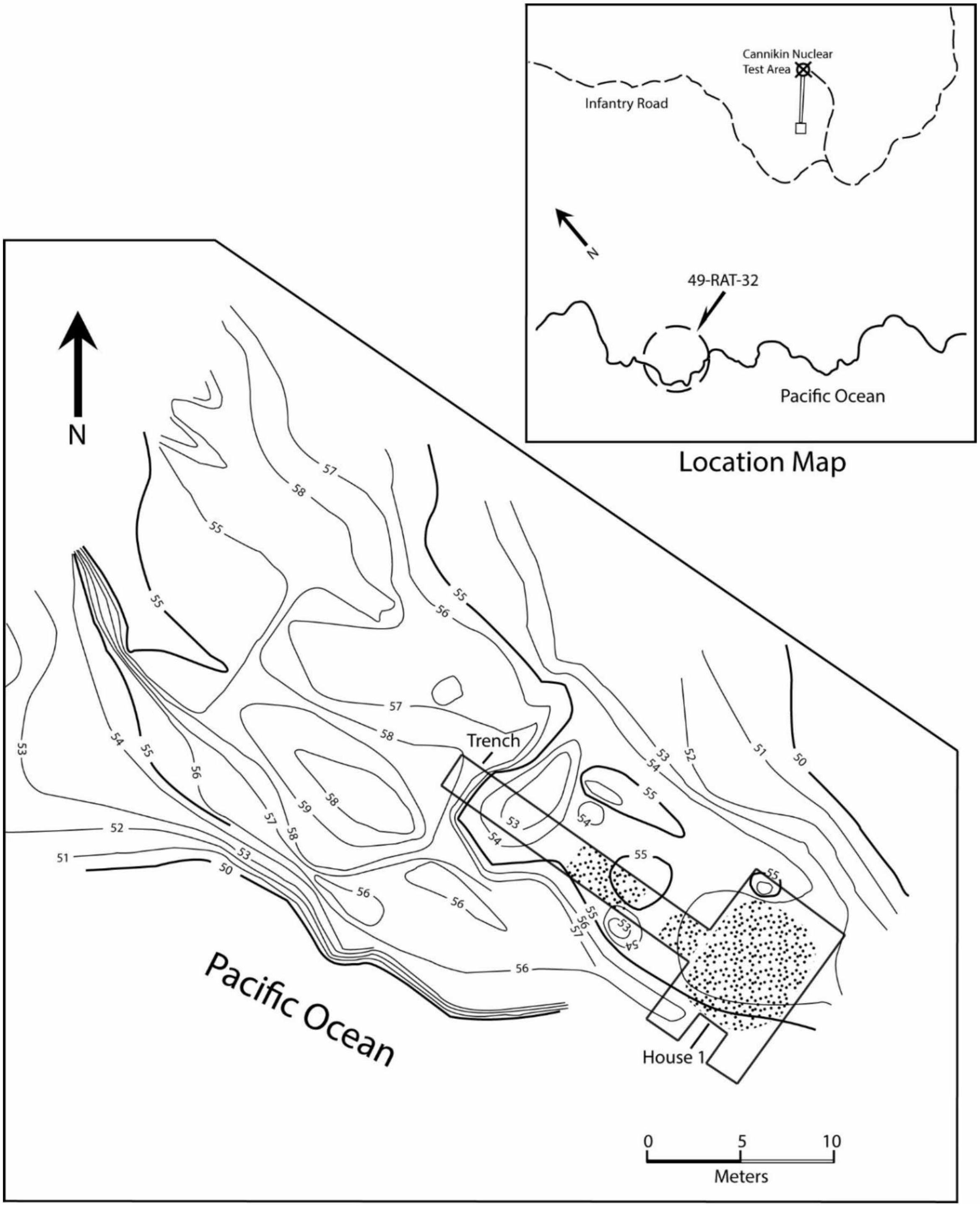


Figure 4.1 Site Excavation Extent (Adapted from Cook et al. 1972; Contour Intervals are in Feet)

Table 4.1 Radiocarbon Dating of 49-RAT-32

Lab #	**Sample ID**	**Depth (cm)**	**Material**	**δ^{13}C (‰)**	**^{14}C age (BP)**	**Cal yr BP - 2σ range**	**Cal yr BP – median (mean) age**	**Cal AD/BC - 2σ range**	**Cal yr AD/BC – median (mean) age**	**Reference**
House 1 – Upper fill										
UGAMS# 45300	UA71-026-4417	0-5	Charcoal	-22.01	620±20	656-553	599 (604)	AD 1294-1397	AD 1352 (1346)	This study
UGAMS# 45299	UA71-026-3710	15-20	Charcoal	-19.74	610±20	653-550	602 (603)	AD 1298-1400	AD 1348 (1347)	This study
Combined[1]	—	*0-20*	*Charcoal*	—	*615±15*	*654-552*	*600 (604)*	*AD 1297-1398*	*AD 1351 (1346)*	—
House 1 – Lower fill										
UGAMS# 45298	UA71-026-3670	25-30	Charcoal	-26.08	360±20	495-319	432 (409)	AD 1456-1632	AD 1518 (1541)	This study
UGAMS# 45301	UA71-026-4418	50-55	Charcoal	-25.39	320±20	458-307	386 (383)	AD 1492-1643	AD 1564 (1567)	This study
UGAMS# 45297	UA71-026-3376	55-60	Charcoal	-28.55	350±20	488-316	390 (399)	AD 1462-1635	AD 1561 (1551)	This study
Combined[2]	—	*25-60*	*Charcoal*	—	*343±12*	*472-317*	*377 (390)*	*AD 1479-1634*	*AD 1574 (1560)*	
House 1 – Floor										
Beta-455422		90-100	Charcoal		330±30	473-308	388 (390)	AD 1477-1643	AD 1562 (1560)	Rogers et al. (2016)
Beta-455421		90-100	Wood		550±30	639-517	555 (573)	AD 1311-1434	AD 1396 (1377)	Rogers et al. (2016)
Combined[3] *- House 1 floor (average)*	—	*90-100*	*Charcoal and wood*	—	*442±22*	*525-480*	*506 (504)*	*AD 1425-1470*	*AD 1445 (1446)*	—
Combined[4] *- House 1 lower fill and floor (except Beta-455421)*	—	*25-100*	*Charcoal*	—	*342±11*	*470-361*	*376 (389)*	*AD 1481-1634*	*AD 1575 (1561)*	—
RAT-032 midden										
NOSAMS 128361	UA71-026-0708	Top of N48W68	Charcoal	-26.8	250±15	309-156	296 (281)	AD 1641-1794	AD 1654 (1669)	Rogers et al. (2016)
NOSAMS 128360	UA71-026-0759	Middle of N48W68	Charcoal	-22.67	715±15	683-659	671 (670)	AD 1267-1291	AD 1280 (1280)	Rogers et al. (2016)
NOSAMS 128359	UA71-026-0806	Bottom of N48W68	Charcoal	-22.49	2200±15	2308-2150	2242 (2230)	359-201 BC	293 (281) BC	Rogers et al. (2016)
1972 radiocarbon ages										
GX-2449	—	House 1 hearth	Charred vegetable material	-26.08	<200	—	—	—	—	Cook et al. (1972)
GX-2450	—	House 1	Grass and wood chips	-25.39	335±100	544-0	380 (361)	AD 1406-1950	AD 1571 (1589)	Cook et al. (1972)
GX-2505	—	House 1 hearth	Charcoal	-28.55	495±90	661-318	525 (516)	AD 1289-1633	AD 1426 (1434)	Cook et al. (1972)
GX-2503	—	Level 7	Charcoal	—	1865±135	2147-1424	1801 (1805)	198 BC to AD 527	AD 149 (145)	Cook et al. (1972)

[1] Statistically similar ages (T=0.1; df=1; χ^2=3.8; p=<0.75183).

[2] Statistically similar ages (T=2.2; df=2; χ^2=6.0; p=<0.138011).

[3] Statistically different ages (T=26.9; df=1; χ^2=3.8; p=<.00001).

[4] Statistically similar ages (T=2.3; df=3; χ^2=7.8; p=0.512521).

4.1.2 *Collection and Sampling Methods*

During the excavation of 49-RAT-32, each excavator was assigned a 2 m^2 unit that was then divided into 1 m^2 quadrants for more precise spatial control when mapping features and recording provenience data for artifacts and bulk samples (Cook et al. 1972). The excavation began with 5-cm thick arbitrary levels to establish vertical control within House 1's fill (Figure 4.2). Units that were excavated using arbitrary 5-cm levels included N48W54, N48W52, and N48W50. All other units were excavated stratigraphically. An effort was made to collect all of the faunal remains encountered (Cook et al. 1972). This involved dry and wet screening samples with a ¼" (6 mm) screen, with some use of a 1/8" (3 mm) screen (Cook et al. 1972). Flotation was also occasionally used to separate the roots from the house fill and floor matrices. However, neither the field notes nor the main report on the excavation (Cook et al. 1972) specify which or how many of the units were fine-screened. During the initial sorting stage for this analysis, I determined that the materials from N48W54 were recovered with an 1/8" screen, as most of the bones for this study went through the ¼" mesh screen used during this process.

After the eight weeks spent excavating at 49-RAT-32, the material from the site was transferred to the University of Alaska Museum (now, the University of Alaska Museum of the North [UAMN]) for curation. Over the last 48 years, the 49-RAT-32 faunal material has seen little in the way of analysis. Mike Etnier, Affiliate Research Associate at the Department of Anthropology at Western Washington University, analyzed portions of the fauna from midden deposits recovered from the trench, but his results have yet to be published. This thesis project is the only other study focusing on marine resources from 49-RAT-32.

The eleven units excavated from House 1 provide abundant faunal material for analysis. Most of the fauna excavated from House 1 derives from one unit - N48W54 (Figure 4.3) - with relatively sparse material in the other units. One possible reason why the fauna seems to be mostly from this unit is that widespread deposition and redeposition of material within House 1 did not occur after it was abandoned. After selecting this unit for analysis, every bag of fauna with provenience information was sorted by taxa (fish, birds, mammals, shellfish). The sample from N48W54 comprises 62 bags of fauna. Table 4.2 shows the distribution of fauna by quadrant and stratigraphic layer. Given the sheer quantity of material in this unit, additional subsampling was required. The southwest quadrant of N48W54 was chosen for further study because it contains the most complete chronological record. From this quadrant, material was analyzed using 10 cm levels in order to address small sample size concerns in individual 5 cm layers. The southwest quadrant also provides a large enough sample such that bias from under-sampling is not expected.

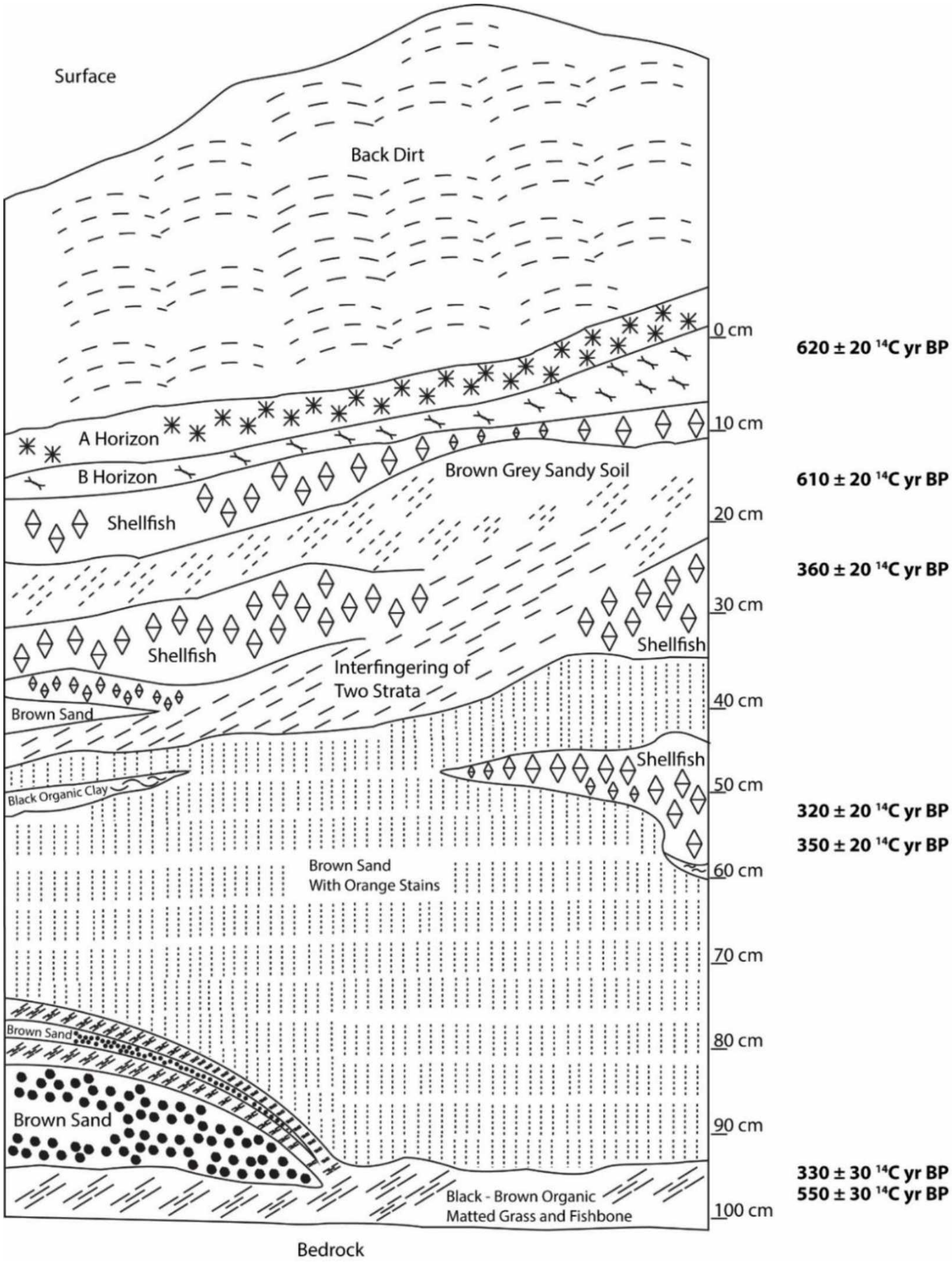


Figure 4.2 N48W54 Stratigraphy Profile of the Southwest Quadrant's West Wall (Adapted from Field Notes from the Excavation of 49-RAT-32)

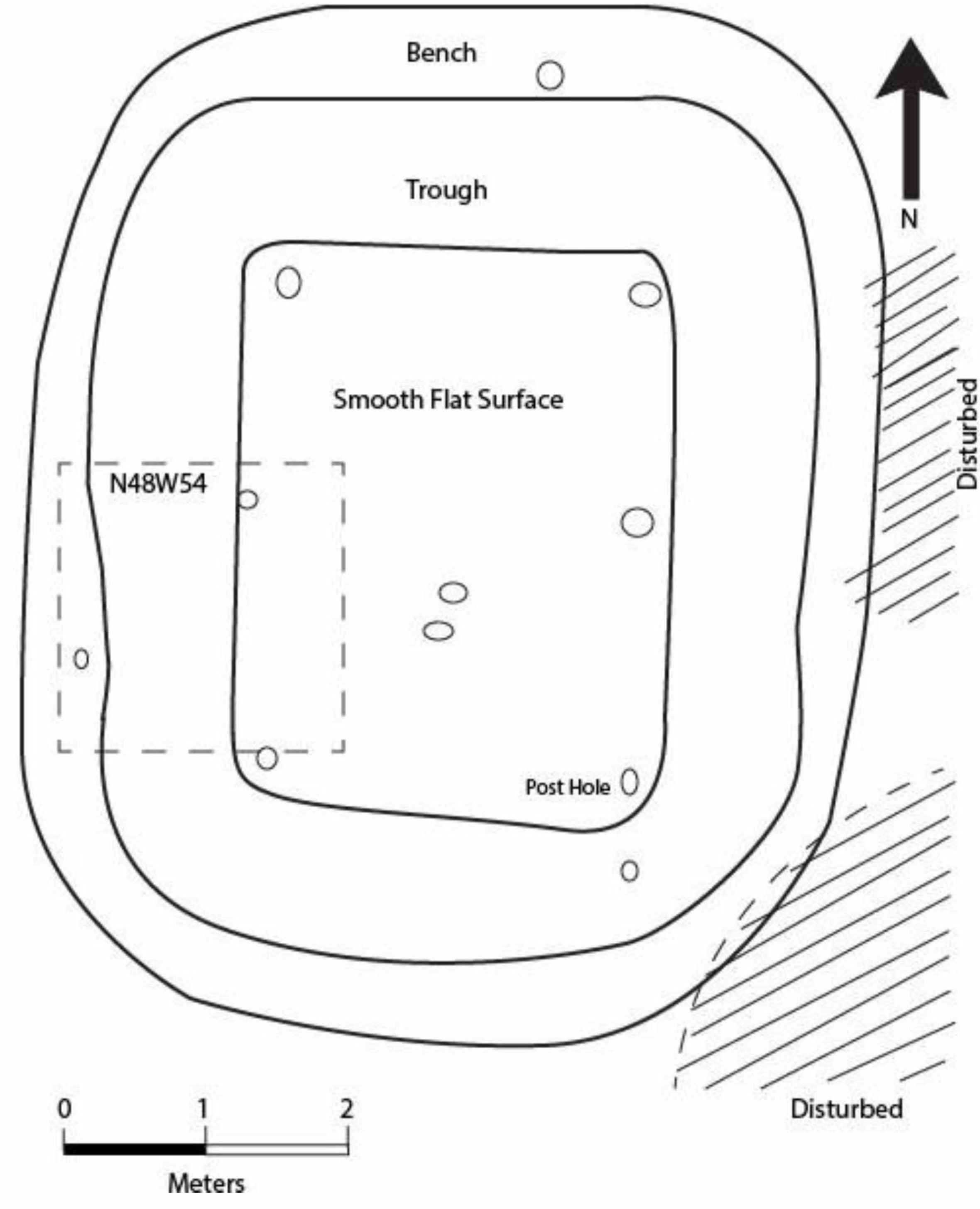


Figure 4.3 House 1 Floor Plan Highlighting the Location of N48W54 (Adapted from Cook et al. 1972)

Table 4.2 N48W54 Inventory: Numbers Represent the Counts of Bags Associated with Each Level and Quadrant

Depth (cm)	SW Quad	NW Quad	NE Quad	SE Quad	Multiple or Unknown Quadrants
0-5	2	3	1	1	1
5-10	0	0	1	1	2
10-15	2	0	6	1	2
15-20	2	0	3	2	1
20-25	3	1	1	4	2
25-30	1	4	2	3	0
30-35	1	0	0	0	2
35-40	2	0	0	0	0
40-45	0	1	0	0	0
45-50	1	0	1	0	0
50-55	1	0	0	0	1
55-60	0	0	1	1	0
Total	15	9	14	13	11

4.1.3 *House 1 Fill Deposits/New Radiocarbon Dates*

This analysis focuses on the fill deposits associated with House 1 at 49-RAT-32; no floor deposits are included because materials below 60 cm were unable to be located in the museum collection. Fill deposits are similar to midden deposits in that they are both refuse of subsistence activities. Due to the erosion that took place at 49-RAT-32 prior to the excavation, the original site extent is ultimately unknown. However, the Central and Western Aleutians are dominated by single family households with small overall populations (Bouchet et al. 2001). Given this, the fill deposits analyzed in this study likely reflect the activities of a small number of families.

Fill deposits are expected to contain more intact specimens, as compared to deposits from household living surfaces, as the latter may be restricted to selective parts of animals from processing and cooking. Fill deposits also would have been covered more quickly and been less heavily impacted by trampling or burning associated with household activities. The greater degree of preservation observed within these deposits assists in the identification process and element measurements.

As part of this project, five new radiocarbon dates were obtained from the fill deposits (Table 4.1). These dates were produced by the University of Georgia Center for Applied Isotope Studies and Oxcal v4.3 statistical program (Ramsey 2009) was used for calibration. The new radiocarbon dates indicate that the fill was deposited between 656-553 and 495-307 Cal B.P. Notably, the stratigraphic sequence of deposition is reversed. Specifically, the upper deposits (0-10 cm) date to 620 ± 20 years B.P, and 50-60 cm deposits date to 320 ± 20 years B.P. In the Rat Island group of the Western Aleutians, many houses were dug into previously existing middens (Funk 2011; Johnson and Wilmerding 2001). According to Johnson and Wilmerding (2001), 90% of known households in the Rat Islands were dug into previously existing middens. If House 1 was used as a receptacle for redeposition of old midden material, either during the construction of a new house or for another reason, then a sequence of older materials overlying younger materials would be expected, as this process would produce a profile where the oldest material would be the last to be deposited. Based on the dates and the stratigraphy, the fill deposits in House 1 represent redeposited material on top of primary fill.

4.2 Identification Methods and Data Classes

The marine mammals, fish, and urchin remains were identified following standard zooarchaeological methods (Reitz and Wing 2008) and were weighed with an Ohaus Scout Pro SP2001 scale that measured specimens to a tenth of a gram. Birds and bird eggshells were not analyzed but were separated and set aside for future analysis. The invertebrates from this excavation were predominantly urchin (>95%). Urchin remains were not counted individually, rather, they were bulk weighed by layer. However, urchin ossicles were separated from the other elements and placed in their own bags. Some limpets were recovered, but their overall numbers are small, and these were not analyzed as part of the current study. Marine mammals and fish were identified using physical comparative collections from the UAMN and from the Department of Anthropology at the University of Alaska Fairbanks. The Idaho Virtual Museum (https://virtual.imnh.iri.isu.edu/Osteo) was also used to assist in the identification process when necessary. Following Driver (2011), all specimens that could be identified to a skeletal element were termed as 'identifiable' and were sided and assigned portion codes when possible. In coding mammalian remains, Stiner's (2004) system for portion codes was used. The fauna was identified to the most inclusive taxonomic category possible followed by more specific identification where feasible. While the author completed all identifications, Emily M. Sippel provided laboratory assistance in the form of sorting, weighing, and data entry.

Primary data classes collected for this analysis include taxonomic identification, degree of epiphyseal fusion, skeletal element, portion recovered, specimen weight, metric data, and taphonomic variables such as burning. Secondary data recorded during analysis include minimum number counts, meat weights, and estimated fish fork lengths.

4.3 Quantification of Species

4.3.1 *Number of Identified Species*

The number of identified species (NISP) is one of the most basic quantitative units in zooarchaeology. It simply reflects the number of bones or bone fragments in an assemblage that can be identified to a specific taxon and element. However, Grayson (1973; 1981) outlines several potential issues with this method. First, NISP can be affected by butchery patterns because differential accumulation or processing of skeletal elements by taxa can occur. Second, skeletal element counts vary across species, which can bias taxonomic frequency data. Third, the use of NISP assumes that all specimens were equally affected by post-depositional destruction. NISP data may also be biased based on screen size, in that small animals may be underrepresented. The possible interdependence of specimens is also problematic. As defined by Lyman (2008), a specimen indicates any individual skeletal element whether it is complete or not. Depending on the fragmentation of specimens through various taphonomic processes, an analyst could be counting the same individual more than once. Overall, fragmentation and interdependence can inflate the relative importance of certain taxa over others.

Despite these issues, NISP remains one of the most useful means of quantifying the relative abundances of taxa within a site (Grayson 1984; Lyman 2008). Unlike some other measures, NISP is additive, and the extent of many of the other issues can be evaluated via an understanding of the taphonomic processes that have affected the site and the recovery methods used during the excavation.

Bones that were able to be refitted were counted as a single specimen. Certain fish elements, such as branchiostegal rays, ribs, and spines, were only bulk weighed and not counted individually or assigned to species. This is because they are rarely diagnostic to species/genus and because they occur in varying quantities across species. Fish bones that could not be identified to element or species were bulk weighed and labeled "unidentifiable fish." All other specimens were weighed and coded individually.

4.3.2 *Normalized NISP*

Given that taxonomic frequency data may be skewed by raw NISP counts I will also use normalized NISP (nNISP) values, which correct for the number of bones in the skeleton for each taxon. Because fish spines, branchiostegal rays, and ribs were not counted or assigned to taxa during the initial identification process, these elements were not included when calculating nNISP. Expected counts for cranial elements were generated from Cannon (1987), and the average number of vertebrae was taken from the National Oceanic and Atmospheric Administration (NOAA) Stomach Examiner's Tool under their Resource Ecology and Fisheries Management Division website (https://access.afsc.noaa.gov/REEM/SET/Vert.php). Normalized data were also used to analyze the ratio of post-cranial to cranial elements; these data can help identify specific butchery processes such as drying for storage (Hoffman et al. 2000). Table 4.3 presents the number of skeletal elements for the relevant taxa.

Table 4.3 Fish nNISP Values

Species	**Cranial**	**Post-cranial**	**Total**
Pacific cod	111	81	192
Atka mackerel	111	86	197
Greenling	111	83	194
Irish lords	111	65	176
Rockfish	111	54.5	165.5

4.3.3 *Minimum Number of Individuals*

The term “MNI” refers to the minimum number of individuals necessary to account for all the specimens of a given taxon (Grayson 1979; Reitz and Wing 2008; White 1953). MNI is estimated based on the identification of overlapping elements and, when applicable, age. For this analysis MNI is calculated at the most inclusive taxonomic level. The sample includes multiple species within a single family, such as Irish lords and non-Atka mackerel greenlings. These species are very similar in their form and shape, and while some elements could be identified to species, in order to be conservative, MNI was based on the combined sample such that all Irish lords have a single MNI count, as do the non-Atka mackerel greenlings.

MNI is a standard zooarchaeological quantification method, but this measure can also be problematic. Use of MNI can skew the relative importance of some taxa over others. Consider a hypothetical sample with an MNI of 20 greenling and five Pacific cod. While greenling dominates the sample, Pacific cod are much larger. Simply relying on MNI can provide in an incomplete understanding of a given prey’s importance to the diet. Another issue with MNI is that it is affected by aggregation. Lyman (2008:58) defines an aggregate as “an assemblage or collection of faunal remains, the boundaries of which are chosen by the analyst, whether those boundaries correspond to stratigraphic boundaries or arbitrarily and artificially bounded excavation/collection units.” MNI must be calculated independently for each layer and the values are not additive. The choice of how to aggregate layers can thus shape the results. Another issue with MNI is that it is subject to identification biases. Some elements, such as vertebrae, are more readily identifiable than others. As such, the taxa represented by these elements may be incorrectly perceived as being more significant to the subsistence economy than animals with less distinctive/identifiable elements. For instance, although skates and rays have dermal structures (denticles) that can preserve, they have a cartilaginous skeleton that does not often preserve. Another issue with MNI is the assumption that the entire individual was utilized at the site; ethnographic data tell us this is often not the case. Looking at fish in particular, people are known to process carcasses off-site, throwing waste bones into the water (Hoffman et al. 2000). All of these factors can bias studies of taxonomic representation; as such, it is best to utilize multiple quantification measures, like NISP, MNI, and nNISP.

4.3.4 *Age Determinations*

In this analysis, age of death was estimated for marine mammals based on the degree of post-cranial epiphyseal fusion. The codes used in the analysis include fused (3), fusing (2), or unfused (1). Age of death could not be established for shellfish or fish as these faunal classes do not preserve similar structures. When mammals are immature, a cartilaginous plate separates the shaft (diaphysis) of the element from the ends of the element (epiphyses). When maturity is reached and growth is completed, these cartilaginous plates ossify. However, environmental conditions can influence the actual age at which fusion is completed (Reitz and Wing 2008). Elements that show signs of incomplete fusion are often identified as juveniles; while fused elements are interpreted as adults. However, not all elements fuse at the same age. The use of data to identify juveniles is best for elements that fuse early in the maturation sequence. Tooth eruption and wear data can be more reliable indicators of age than post-cranial fusion, but a lack of teeth in this collection prevented this form of analysis (Ohtaishi 1980; Steele 2005, 2006).

4.4 Fork Length, Meat Weight, and Statistical Measures

4.4.1 *Estimated Fork Length*

Equations used to estimate fish fork length and weight follow Orchard (2001). A consideration of fish size and potential changes in size over time are crucial to understanding if humans depressed fish populations and in evaluating climate change. Orchard (2001) used seventeen different skeletal elements to generate regression equations for estimating live meat weight and fork length. These elements are the vomer, dentary, angular, articular, premaxilla, quadrate, interhyal, epihyal, basihyal, hyomandibular, hypohyal #2, inferior pharyngeal, pharyngobranchial #2, hypobranchial #3, atlas, penultimate vertebra, and otoliths. The regression equations used within this analysis can be found in Appendix D. However, there are discrepancies in the naming conventions used for some bones between this analysis and Orchard's. Within Orchard's analysis, two bones (angular and articular) did not follow the naming conventions used in the reference collections I utilized. Specifically, bones called the articular in Orchard (2001) were labeled as angulars, and bones labeled as angular in Orchard (2001) are labeled as retroarticulars.

Archaeological fish elements were chosen in such a way as to prevent measuring two elements from the same individual. For each taxa, the element that made the greatest contribution to the MNI was chosen for measurements. Additionally, only those specimens with complete measurable features were analyzed. Measurements were recorded with digital calipers and recorded in millimeters. Weights are listed in grams. These measurements are useful in identifying potential resource depression, diet contribution, climactic conditions, and cultural activities. The equations derive from a regression-based approach, as this method provides the most accurate method for estimating the original live size of archaeological fish specimens (Casteel 1976). The same measurements used to calculate average fork-length were also used to calculate fish weight.

4.4.2 *Meat Weights*

Calculation of meat weight values relies on MNI counts; consideration of meat weight can compensate for some issues associated with MNI. Meat weight refers to the quantities of meat that a specific taxon might contribute to the diet. Estimates for fish are based on the regression equations produced by Orchard (2001). However, archaeological remains of Irish lords (*Hemilepidotus* sp.) within this and Orchard's analyses are larger on average than the small modern collection Orchard used to generate the regression equations. Because these equations are not completely reliable, I made use of the maximum known length and weight of modern Irish lords. Specifically, the average weight per centimeter of fork length of the modern individuals was multiplied by the estimated lengths of Irish lords generated from the estimated fork length equations (Orchard 2001). For marine mammals, the average usable meat weights for adult and adolescent individuals originate from Yesner (1988).

Following Vellanoweth et al. (2000), the recorded dry shell weight for urchin is multiplied by a conversion factor to estimate the meat weight. One can more accurately identify the relative importance of shellfish in the diet by doing this conversion.

4.4.3 *Statistical Measures*

Multiple statistical measures were used in this analysis; all tests utilized a 0.05 sigma level for determining significance. Tests used in this analysis include chi-square (χ^2), and the non-parametric Wilcoxon rank-sum test. χ^2 tests were used to explore changes in taxonomic frequency data between levels. The Wilcoxon rank-sum test, a nonparametric comparison for each pair of layers, was applied to explore changes in fork lengths of different fish species over time. Only layers with more than five specimens were included in this analysis. The programs utilized to perform these tests were JMP for the non-parametric Wilcoxon rank-sum test, and Social Science Statistics (https://www.socscistatistics.com/) for χ^2 analysis.

4.5 Taphonomy

Some taphonomic data were recorded during this analysis. Bones can be intentionally burned during processing or disposal, or unintentionally after discard. Burned specimens result from the carbonization of bone collagen and are identified by their black color (Lyman 1994).

Carnivore and rodent damage were not expected because terrestrial mammals are not native to the region west of Umnak Island (Bailey 1993; Buskirk and Gipson 1980; Murie 1959), with the exception of red fox (*Vulpes vulpes*) and domesticated dog (*Canis lupus familiaris*), which have been documented in prehistoric levels on Carlisle Island within the Four Mountains Island group (Krylovich et al. 2019; Vasyukov et al. 2019). However, rats and foxes only arrived at regions west of Umnak Island during historic times. Foxes were introduced for the fur trade and rats were introduced as unintentional passengers on visiting ships.

4.6 Summary

For analytical purposes, the fauna is divided into three distinct categories bony fishes, marine mammals, and urchin. Taxa are assigned to their respective habitats to understand landscape/seascape use. Additionally, MNI, meat weights, and frequency data are compared for an in-depth analysis of subsistence practices. Patterns of skeletal element abundance are analyzed to provide evidence of cultural practices, such as storage and butchery decisions.

Zooarchaeological analyses are often influenced by sampling, aggregation, and quantitative biases. The methods used in this analysis aim to limit these biases. The resulting data allow for the reconstruction of specific aspects of the subsistence economy from the Western Aleutians within the framework of historical ecology.

Chapter 5: Results

In this chapter, I will present data on change over time in the taxa represented at 49-RAT-32, while also providing data on fish fork lengths, meat weights, processing, and taphonomy.

5.1 Identified Taxa

As discussed in the previous chapter, faunal material was subsampled due to the immense volume of material from the N48W54 unit. The total vertebrate NISP for the southwest quad of N48W54 is 13,130; as shown in Table 5.1, the assemblage is taxonomically diverse. Of the identified taxa, marine mammals were present in notably small quantities, only contributing 15 bones across the entire sample. Conversely, marine fishes dominate the assemblage, with *Hexagrammidae* comprising the majority of the total sample.

5.2 Results

5.2.1 *Analyzed Deposit*

The analyzed deposits originate from 0-55 cm below the A horizon. This deposit is fill and does not include the house floor, which was in the 90-100 cm range. The fill was radiocarbon dated to 656-553 to 458-307 Cal. years B.P. The frequency and distribution of faunal remains varied horizontally and vertically within N48W54. Faunal remains within the SW quad were prevalent in the 0-30 cm range, but they became sparser as depth increased. The NISP for each 10 cm level is presented in Figure 5.1 to illustrate the differences in the quantity of the recovered faunal remains in the SW quad.

As mentioned, 13,130 specimens were identified. Of the total NISP, 99.89% (13,115) are attributed to fish and 0.11% (15) are attributed to marine mammals. Bones were largely intact, which proved helpful in identifying the fauna.

5.2.2 *Recovered Fish*

Fish bones unable to be identified to species or an element were placed into a bulk bag and given an identifying number. The total weight of identified fish bones is 2,032.2 g and non-identified fish bones weighed 778.3 g. The total weight directly correlates with the NISP results, in that the 20-30 cm layer has the largest weight and the 50-60 cm layer has the smallest total weight. See Appendix E for data on weight of fish bones by level.

Table 5.1 Taxa Identified in the SW Quad of N48W54

Scientific Name	Common Name	NISP	MNI
Gadiforms			
Gadidae			
cf. Gadus macrocephalus	Gadid, prob. P. cod	8	-
Gadus macrocephalus	Pacific Cod	259	13
Perciformes			
Scorpaenidae			
Sebastes sp.	Rockfish sp.	616	26
Hexagrammidae			
Pleurogrammus monopterygius	Atka Mackerel	8,570	154
Hexagrammos sp.	Greenling sp.	1,771	47
Hexagrammos lagocephalus	Rock Greenling	65	-
Cottidae			
Myoxocephalus polyacanthocephalus	Great Sculpin	15	5
Hemilepidotus sp.	Irish Lord sp.	1,397	63
Hemilepidotus jordani	Yellow Irish Lord	412	-
Pleuronectiformes			
Pleuronectidae			
Hippoglossus stenolepis	Pacific Halibut	1	1
Salmoniformes			
Salmonidae			
Oncorhynchus sp.	Salmon sp.	1	1
Carnivora			
Otariidae			
Callorhinus ursinus	Northern Fur Seal	1	1
Eumetopias jubatus	Steller Sea Lion	2	1
Phocidae			
Phocas sp.	Seal	9	2
Phoca Vitulina	Harbor Seal	1	1
Marine Mammal	Unidentifiable	2	-
Cassiduloida			
Echinidae			
Strongylocentrotus sp.	Sea Urchin	N/A	N/A
Total Sample		13,130	315

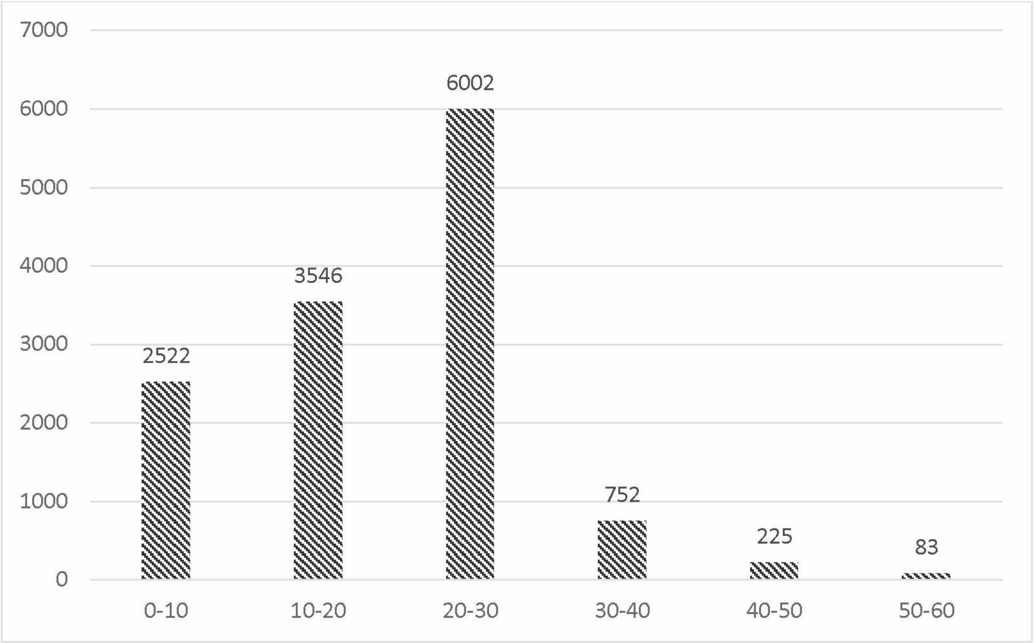


Figure 5.1 NISP for Each 10 cm Level (Increasing in Depth from Left to Right)

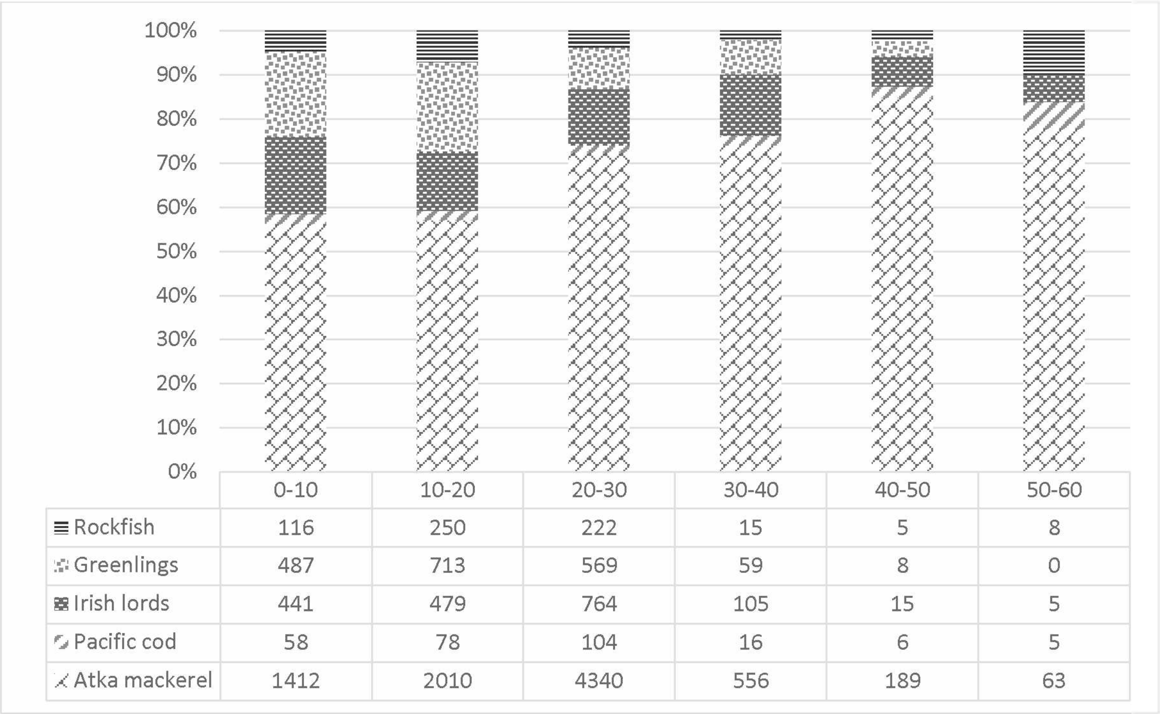
Table 5.2 presents a summary of fish NISP by stratigraphic level with reference to the habitat distributions of the identified taxa. Habitat such as demersal and epipelagic refer to the ocean floor and parts of the ocean where enough light penetrates for photosynthesis respectively. Figure 5.2 presents the taxonomic frequency data in graphic form, focusing on the five most common taxa, while Figure 5.3 presents the same data corrected for the differing number of elements present in the analyzed fishes.

Of the identified fish remains, most were only identified to the genus or family level due to the number of closely related species and the lack of a complete comparative collection. Atka mackerel (*Pleurogrammus monopterygius*) is the most abundant species in every level. Atka mackerel are then followed by other greenlings (rock and kelp) (*Hexagrammos* sp.) and Irish lords (*Hemilepidotus* sp.). While Atka mackerel are considered a type of greenling, the skeletal differences between them and other greenlings allowed for Atka mackerel to be identified to the species level. All future references to greenlings refer to non-Atka mackerel varieties. Rockfish (*Sebasates* sp.) and Pacific cod (*Gadus macrocephalus*) are the next most prevalent species. Finally, there are rare species represented by only a few specimens. These include great sculpin (*Myoxocephalus polyacanthocephalus*), salmon (*Orcorhynchus* sp.), and Pacific halibut (*Hippoglosus stenolepis*). Salmon and Pacific halibut are each represented by a single specimen.

The rank order for MNI is largely consistent with the NISP data, the only difference being that greenling and Irish lords switch places in the MNI data.

Table 5.2 Fish Distribution and NISP by 10 cm Layers

Family/Species	**Common Name**	**Distribution**	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**
Gadidae								
Gadus macrocephalus	Pacific Cod	Demersal	58	76	103	16	1	5
cf Gadus macrocephalus	Gadid, prob. P. cod	Demersal	0	2	1	0	5	0
Scorpaenidae								
Sebastes sp.	Rockfish	Reefs, Subtidal, and Demersal	116	250	222	15	5	8
Hexagrammidae								
Pleurogrammus monopterygius	Atka Mackerel	Subtidal	1412	2010	4340	556	189	63
Hexagrammos sp.	Greenling	Reefs	487	713	569	59	8	0
Cottidae								
Myoxocephalus polyacanthocephalus	Great Sculpin	Intertidal	0	10	0	1	2	2
Hemilepidotus sp.	Irish Lord	Subtidal	441	479	764	105	15	5
Pleuronectidae								
Hippoglossus stenolepis	Pacific Halibut	Epipelagic	1	0	0	0	0	0
Salmonidae								
Oncorhynchus sp.	Salmon	Epipelagic	0	1	0	0	0	0
Total			**2515**	**3541**	**5999**	**752**	**225**	**83**



	0-10	10-20	20-30	30-40	40-50	50-60
≡ Rockfish	116	250	222	15	5	8
Greenlings	487	713	569	59	8	0
Irish lords	441	479	764	105	15	5
Pacific cod	58	78	104	16	6	5
Atka mackerel	1412	2010	4340	556	189	63

Figure 5.2 Relative Frequency of Fish (Pacific Halibut, Salmon, and Great Sculpin are not Included Due to Low Sample Numbers)

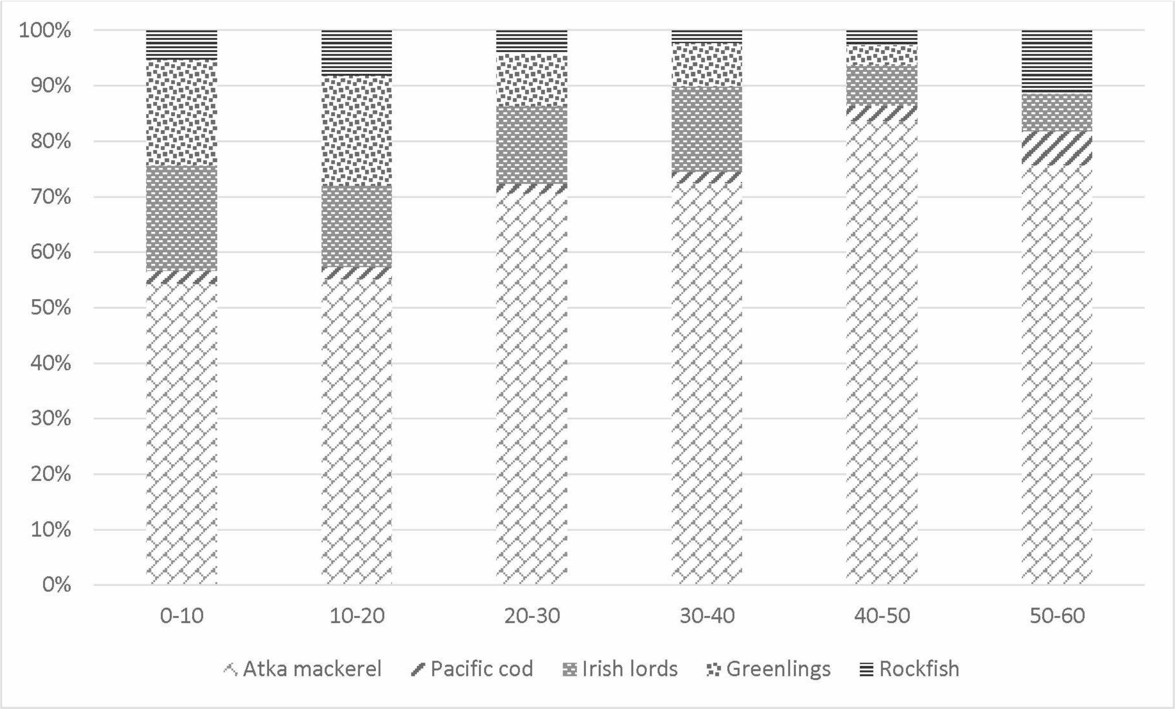


Figure 5.3 Relative Frequency of Fish Based on Normalized NISP (Pacific Halibut, Salmon, and Great Sculpin are not Included Due to Low Sample Numbers)

The fish assemblage is dominated by Atka mackerel. The total NISP for Atka mackerel is 8,570 or 65.35% of the total NISP for fish. Atka mackerel are found along the Aleutian Islands in subtidal environments during their spawning season of July – September (ADF&G n.d.b). Outside of this time period, they are found in the demersal zone on the continental shelf. Atka mackerel are typically identified as being semi-demersal to acknowledge the migration from the shelf edge to shallow coastal waters for spawning. In the capture and procurement of Atka mackerel, these fish are most easily captured during their spawning season when they are closer to the surface and can be exploited with mass capture methods. Hook and line technology are required when Atka mackerel are on the continental shelf, which is not as efficient as mass capture techniques.

The second and third most abundant fish are greenling and Irish lords. Greenling are found in every level except the 50-60 cm level. The total NISP for greenling is 1,836 or 14% of the fish assemblage. Greenling habitat in this region (rock and kelp varieties) are reefs. Irish lords are found in every level. The total NISP for Irish lords is 1,809 or 13.79% of the fish assemblage. Habitat for Irish lords is subtidal for both the red and yellow varieties.

Rockfish and Pacific cod account for 4.7% (NISP= 616) and 1.97% (NISP= 259) of the total fish NISP. Given the number of rockfish native to the Western Aleutians, it was difficult to identify these specimens to the species level. Identifications are limited by the near ubiquitous shape and form of their skeletal elements and the size of the available comparative collections. Although they make up a small proportion of the total assemblage, rockfish and cods, most of which are likely Pacific cod, were found in every layer. Rockfish are found in reefs, subtidal, and demersal zones with cods, specifically Pacific cod, being demersal.

Rare or incidental fish species include Pacific halibut, salmon, and great sculpin. Pacific halibut and salmon are each represented by a single element and are both epipelagic species. Great sculpin only contributed 15 specimens; these are found in the intertidal zone.

Of the identified fish remains, an overwhelming percentage of taxa occur in nearshore environments. Only 261 (1.99%) specimens are regularly found in the demersal or epipelagic zones. Ethnographically, Atka mackerel are known to be exploited during their spawning season when they are in subtidal zones, but are not known to be a subsistence focus outside of this time period (Turner 1886). Given this, I suspect they were not collected from the demersal zone. This will be discussed in more detail in Chapter 6.

5.3 Statistical Measures

5.3.1 *Changes in Taxonomic Frequency Over Time*

In order to explore changes in the frequency of different fish taxa between levels, a χ^2 test was performed for the five most common taxa recovered; χ^2 value is 551.472 and the p-value is <0.001, indicating significant changes in taxonomic frequency over time. In order to explore what is driving this result, adjusted standardized residuals were generated, these are presented in Table 5.3. Adjusted standardized residuals are a measure of the strength of the difference between the observed and expected values. These can be con be considered a rough equivalent of a Z-score, where values greater than +1.96 indicate that the observed frequency is significantly greater than the expected frequency (at an alpha of 0.05), and values less than -1.96 indicate that the observed frequency is significantly less than the expected frequency (Nolan and Heinzen 2011).

Table 5.3 Chi-square Test Results

Depth (cm)	**Pacific cod**	**Atka mackerel**	**Greenlings**	**Irish lords**	**Rockfish**
0-10	0.94	-5.74	7.18	5.03	-0.22
10-20	0.71	-6.24	9.82	-0.39	6.49
20-30	-1.65	6.62	-9.40	-2.24	-3.54
30-40	0.18	2.92	-4.51	0.13	-3.43
40-50	0.68	3.57	-4.16	-2.85	-1.70
50-60	2.61	1.37	-3.37	-1.85	2.14

When analyzing the adjusted standardized residuals, some trends are found in the data. Few species show consistency in exploitation over time. Pacific cod is the only taxa where most of the observed frequencies are similar to the expected values. When looking at Atka mackerel and other greenlings, there is an inverse relationship, in that when Atka mackerel occur in lower frequencies than expected, greenlings occur in higher frequencies than expected (and vice versa). This type of relationship is not expected to occur among a single pair of taxa within a larger group.

In order to further explore the inverse relationship shown in Table 5.3, the frequency of Atka mackerel and greenlings were analyzed with a χ^2 test (Table 5.4). When using an alpha level of 0.05, statistically significant difference in frequency were found between many levels. For Atka mackerel and greenlings, significant differences were found between the 10-20 cm and 20-30 cm level, and between the 30-40 cm and 40-50 cm level. Atka mackerel increase in frequency from the 30-40 cm and 40-50 cm level, with a sharper increase from the 20-30 cm to 10-20 cm level. Greenlings show significant changes in the same levels; however, they decline in frequencies. These tests are not fully independent. However, they illustrate the inverse relationships observed between these closely related taxa. Potential explanations for this pattern will be discussed in Chapter 6.

Table 5.4 χ^2 for Atka Mackerel and Greenling Versus all other Taxa

Atka Mackerel	**0-10 vs 10-20**	**10-20 vs 20-30**	**20-30 vs 30-40**	**30-40 vs 40-50**	**40-50 vs 50-60**
X^2	0.23	242.897	0.849	9.687	2.672
p	.6315	**< .001**	.3568	**.0019**	.1021
Greenlings	**0-10 vs 10-20**	**10-20 vs 20-30**	**20-30 vs 30-40**	**30-40 vs 40-50**	**40-50 vs 50-60**
X^2	0.55	217.141	2.128	4.990	NA
p	.4578	**< .0001**	.1446	**.0255**	NA

5.3.2 *Fish Lengths*

The equations generated by Orchard (2001) were used to calculate estimated fork lengths and weights for the identified taxa. Of the recovered taxa, Orchard included regression equations for all species but salmon, Pacific halibut, and great sculpin. The nonparametric Wilcoxon test was used to analyze the variation in fork length over time. Only layers with more than five specimens were included in the statistical analysis. Figure 5.4 displays the estimated fork lengths for Atka mackerel, greenlings, Irish lords, and rockfish with box and whisker plots. Modern population size averages (also based on fork length) are displayed with a dashed line; modern values are based on the following sources: 35.9 cm (Lauth et al. 2010) for Atka mackerel, Rooper and Haldorson (2000) for greenlings, and 34.9 cm (TenBrink and Buckley 2013) for Irish lords. Since there are many different species for rockfish and data are most often reported in terms of maximum length, I used the smallest maximum length for rockfish (based on Hart 1973). Pacific cod are not displayed given that the total sample had only five measurable elements. Table 5.5 presents the sample sizes, means, and standard deviations for the analyzed taxa. The raw data for this analysis is found in Appendix F.

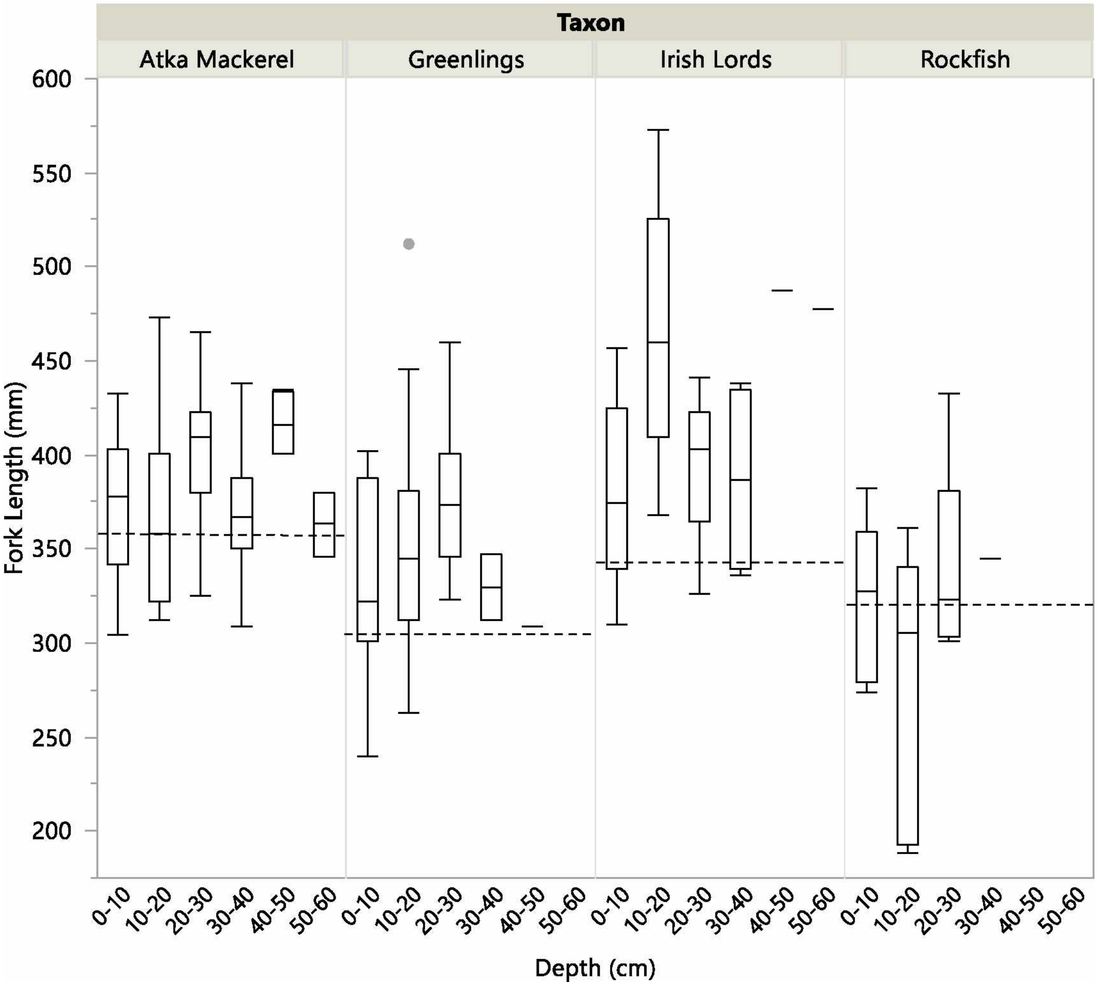


Figure 5.4 Fork Length Box and Whisker Plots (Outliers Shown as Circles)

Results of the statistical analysis are presented in Table 5.6. Atka mackerel and greenlings both show a significant shift in size over time. Notably the Atka mackerel from the 20-30 cm layer are significantly different in size (larger) than these from the layers above and below it. Atka mackerel are also large in the 40-50 cm layer, but the sample size was not large enough for statistical comparison. As compared to Rooper and Haldorson's (2000) modern daata, greenlings are also shown to be larger than modern populations. Another finding is that Irish lords are relatively stable in size through time. The only layer that does not follow this general trend is the 10-20 cm level, in that Irish lords from this layer are significantly larger than those in the other deposits.

The relative lack of measurable elements in the deeper portions of the deposit, i.e. the 30-40 cm, 40-50 cm, and the 50-60 cm levels, is somewhat problematic. While the sample sizes for Atka mackerel are above the five-specimen threshold for analysis in the 30-40 cm level, all other analyzed taxa recovered from the layers between 30-60 cm are represented by four or fewer specimens. These small sample sizes impact the ability to statistically analyze changes in fork length over time. This issue is compounded for rockfish and Pacific cod. Pacific cod is represented by only five measurable elements across the entire sample, with only one layer having even two specimens. The rockfish samples are slightly more robust, with an average of five specimens per layer; however, only one measurable specimen was found in the 30-40 cm layer, with no specimens from the lowest levels. Because of these low sample sizes, the results of statistical comparison would not be reliable.

Table 5.5 Sample Sizes, Fish Length Means, and Standard Deviations

Depth (cm)	**Sample Size**	**Mean (mm)**	**Standard Deviation**
Pacific Cod			
0-10	1	979.63	-
10-20	1	1089.29	-
20-30	2	707.25	192.605
30-40	1	731.13	-
Atka Mackerel			
0-10	21	368.894	37.1603
10-20	17	365.066	48.8585
20-30	54	401.331	30.2435
30-40	10	369.417	35.2124
40-50	4	416.533	17.1862
50-60	2	363.320	24.0459
Greenlings			
0-10	11	332.215	56.6792
10-20	21	352.074	59.5220
20-30	20	377.404	36.3875

Table 5.5 (Continued)

Depth	**Sample Size**	**Mean**	**Standard Deviation**
30-40	2	329.523	25.4233
40-50	1	308.682	-
Irish Lords			
0-10	13	380.980	46.9096
10-20	8	466.201	68.1612
20-30	21	393.054	35.2272
30-40	4	386.694	51.5698
40-50	1	487.634	-
50-60	1	477.630	-
Rockfish			
0-10	5	321.058	43.4128
10-20	5	274.132	77.6128
20-30	5	337.884	54.3547
30-40	1	344.528	-

Table 5.6 Pair-wise Comparisons of Fork Length Using the Wilcoxon Method

Level (cm)	Level (cm)	Atka Mackerel p-value	Greenling p-value	Irish lord p-value
0-10	*10-20*	0.6596	0.5783	**0.0082**
0-10	*20-30*	**0.0006**	**0.0349**	0.4460
0-10	*30-40*	0.8823	-	-
10-20	*20-30*	**0.0020**	0.0567	**0.0078**
10-20	*30-40*	0.4978	-	-
20-30	*30-40*	**0.0075**	-	-

5.4 Marine Mammals

Within this analysis, marine mammals contribute only 15 bones (0.11%) of the total NISP. Of these 15 specimens, three species are identified. These are *Callorhinus ursinus* (northern fur seal) *Eumetopias jubatus* (Stellar sea lion) and *Phoca vitulina* (harbor seal). A breakdown of the NISP by level is presented in Table 5.7.

Table 5.7 Marine Mammal NISP by Level

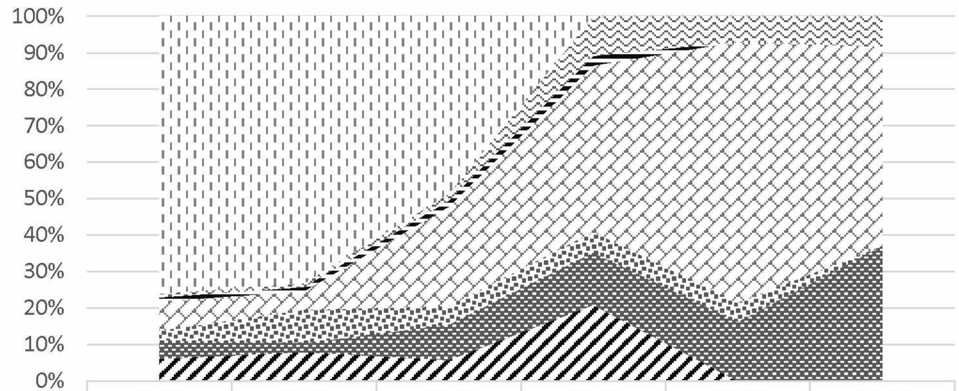
Family/Species	Common Name	0-10	10-20	20-30	30-40	40-50	50-60
Otariidae		0	0	0	0	0	0
Callorhinus ursinus	Northern Fur Seal	0	1	0	0	0	0
Eumetopias jubatus	Stellar Sea Lion	2	0	0	0	0	0
Phocidae		0	0	0	0	0	0
Phoca vitulina	Harbor Seal	0	1	0	0	0	0
Cf. *Phocidae*	Phocid, prob. Harbor Seal	5	3	1	0	0	0
Unidentifiable		0	0	2	0	0	0
Total		**7**	**5**	**3**	**0**	**0**	**0**

Of these specimens, five bones were unfused – all are metacarpals. This lack of fusion indicates that the individual(s) may range from zero to five years of age, which could indicate sexually reproductive adults. The overall skeletal element breakdown for marine mammals is as follows: six specimens are from the flippers, one is a long bone fragment, two are rib fragments, four are teeth/cranial fragments, and two are spongy bone fragments. Initial identification indicates a general preference for flippers based skeletal elements, but the low sample size complicates interpretations.

5.5 Meat Weights

The utilization of meat weight data in zooarchaeology relies on MNI and serves as one means of compensating for some issues associated with NISP and MNI measures. Meat weight refers to the quantity of meat contributed by a given taxon. Meat weight analysis assumes that the entire animal was present. This assumption is potentially problematic for marine mammals, which are much larger than individual fish. Meat weights are also potentially problematic for marine fish, as the values are generated from element lengths. This means that fish with few or no measurable skeletal elements will be underrepresented. Inclusion of marine mammals can also skew the results, as they are so much larger than other taxa present in the study. Laughlin's (1980) analysis of Unangax̂ data indicates that marine mammals and fishes should contribute

30% of the diet, although these percentages may vary by ± 10% in any given year. Within this analysis, the complete diet is not being analyzed, only the contribution of urchin, fish, and marine mammals. As presented in Figure 5.5, marine mammals and marine fishes do not contribute similar proportions of the total meat weight. However, it is known that food sharing activities existed, at least within extended family households, and potentially within an entire community (Veltre and Veltre 1983). Ethnographically, food sharing occurred for both marine mammals and fish collected with nets and weirs (Veltre and Veltre 1983). As stated by Veniaminov (1984:56): “From time immemorial it has been the custom of the Aleuts, when there is a shortage of food, to divide among themselves all that is obtained. For example, he who has caught some fish divides them among all who are in need and not only does he not take a larger share than the rest, but not infrequently he gets less than the others.”



	0-10	10-20	20-30	30-40	40-50	50-60
Marine mammals	168580	181550	90775	0	0	0
Sea urchin	2179.08	2557.04	3400.17	2602.62	367.87	193.26
Rockfish	2426.57	2929.5	3054.78	629.72	0	0
Atka mackerel	17745.57	12453.75	50830.53	10976.75	3788.6	1273.59
Greenlings	5,931.94	22740.08	9397.84	1391.31	275.91	0
Irish lords	11,261.71	6064	18191.99	3465.14	866.29	866.29
Pacific cod	13,522.49	19791.33	10757	5024.44	0	0

Figure 5.5 Analyzed Fauna Meat Weights (g)

In analyzing the meat weight data from 49-RAT-32, it is obvious that when treating the remains as if they reflect complete carcasses, marine mammals overwhelm the diet (48.69% to 76.06%). Despite the quantity of sea urchin recovered in these deposits, they are a relatively minor component of the diet. Urchin comprises a maximum 10.8% of the total meat weight, and this occurs in the 30-40 cm layer where marine mammals are absent. Urchin fluctuate between 1-

6.8% of the total meat weight in the other layers. Atka mackerel appear to be a relatively minor resource when compared to the marine mammals, despite contributing 65.35% of the total NISP. When marine mammals are not present, Atka mackerel contribute the majority of the meat weight. In order to better evaluate changes in the dietary importance of the analyzed fish and urchin taxa, marine mammals were removed from the study (Figure 5.6).

In analyzing the meat weight data without marine mammals, changes in the contribution of other taxa are more obvious. Rockfish and urchin are relatively stable over time with rockfish contributing 2.6-4.6% and urchin 3.6-10.8% of the total. Irish lords are more variable, contributing 16.3% and 30.7% of the meat weight in the lowest two layers, but 9.1-21.2% of the meat weight in other layers. Pacific cod, though small in overall NISP, contributes a sizeable portion of the meat weight; this reflects the large size of the recovered individuals. Pacific cod range between 11.2% and 29.7% of the total meat weight (again this is without marine mammals). Greenlings are also variable through time, ranging from 5.2% of the meat weight in 40-50 cm layer to 34.2% in the 10-20 cm layer. Atka mackerel shows the greatest variation through time. In the lowest four levels, Atka mackerel contribute 45.2-71.5% of the meat weight. In the 10-20 cm level, there is a sharp decline in the contribution of Atka mackerel (to 18.7%), with the 0-10 cm level slightly rebounding (33.4%).

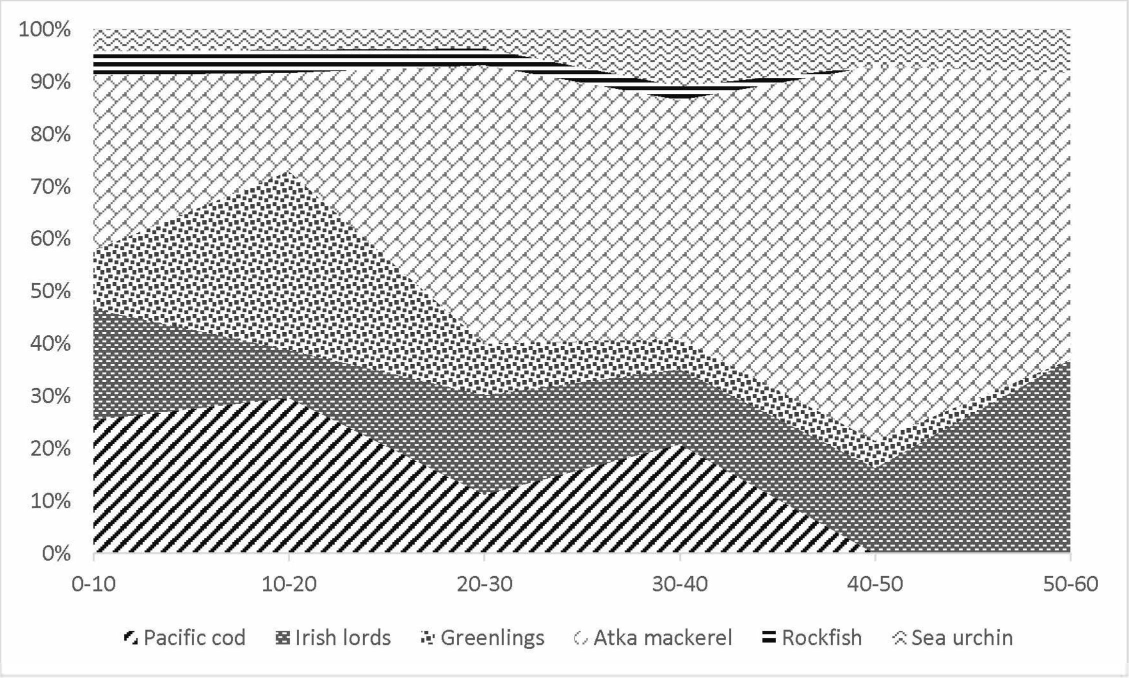


Figure 5.6 Fish and Urchin Meat Weights

The basic takeaway from the meat weight data is that for most of the analyzed species, dietary contribution was not consistent over time. Atka mackerel, the single largest contributor to the NISP, experienced a gradual increase through time with decreasing reliance on other species. Overall, meat weight data help provide context to the MNI data. While marine mammals contribute a large portion of the analyzed meat weight, it is not known how processing or sharing activities affected its consumption. These and other issues will be discussed further in Chapter 6.

5.6 Butchery and Storage

Butchery and storage practices were analyzed by comparing the ratio of cranial to post-cranial skeletal elements, based on normalized NISP. This ratio may provide insight into butchering practices and seasonality, as high levels of cranial elements can reflect on-site butchery and consumption of freshly caught fish that would be most easily accessible from Spring to Fall, as opposed to the consumption of stored foods (Hoffman et al. 2000). Figures 5.7 to 5.12 presents the skeletal data for the five most common taxa; each figure represents one ten-centimeter level.

In the analysis of fish cranial and post-cranial ratios, there is general consistency across species. In nearly every case, there are more post-crania, than cranial remains. In the few cases where there are more cranial remains, such as for Irish lords and rockfish from the 50-60 cm level, it is almost always when there are low sample sizes, making these data less reliable.

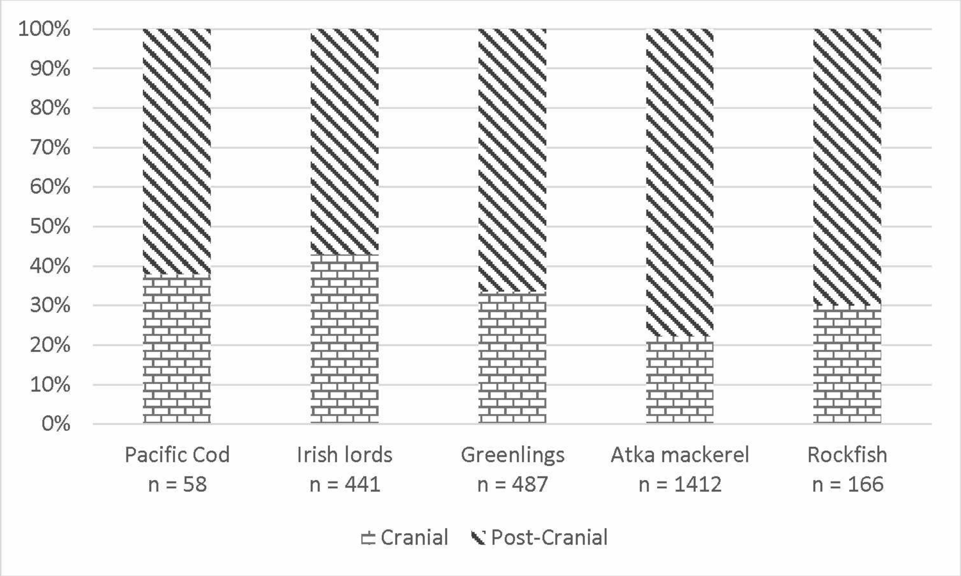


Figure 5.7 Skeletal Element Ratios (0-10 cm)

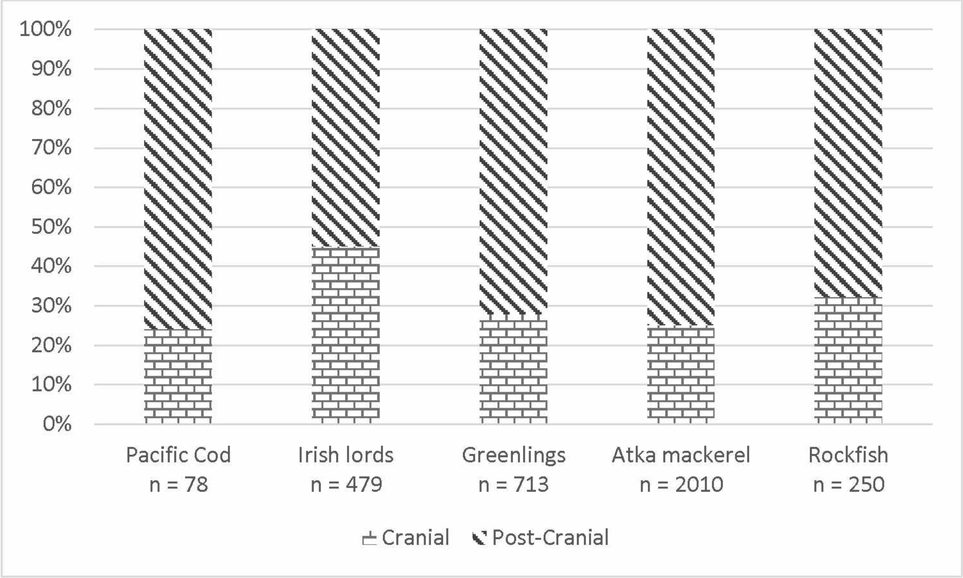


Figure 5.8 Skeletal Element Ratios (10-20 cm)

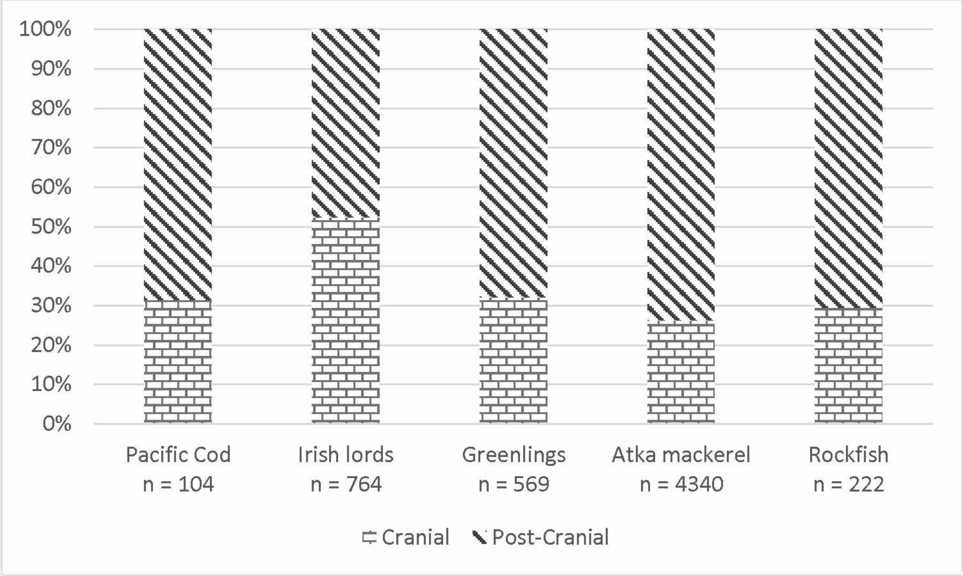


Figure 5.9 Skeletal Element Ratios (20-30 cm)

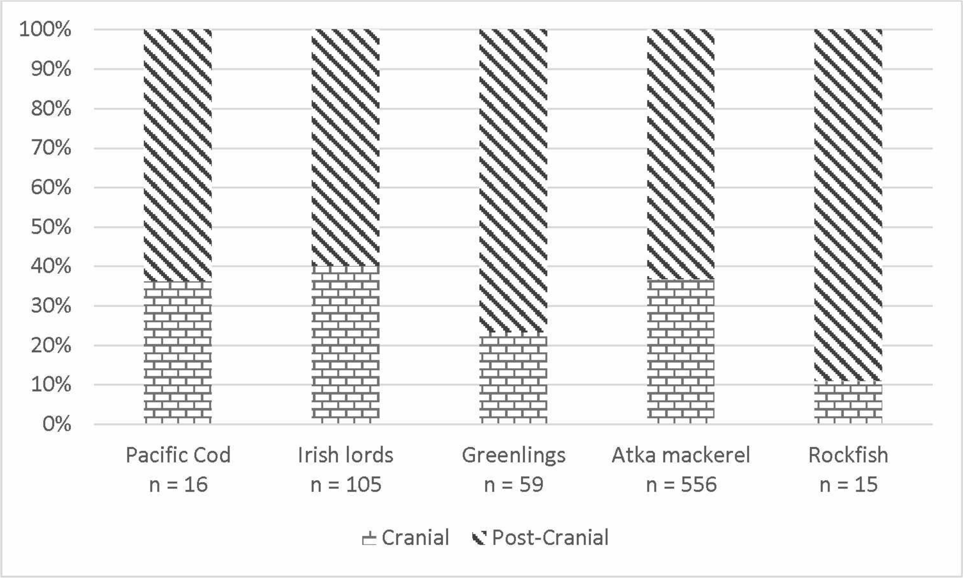


Figure 5.10 Skeletal Element Ratios (30-40 cm)

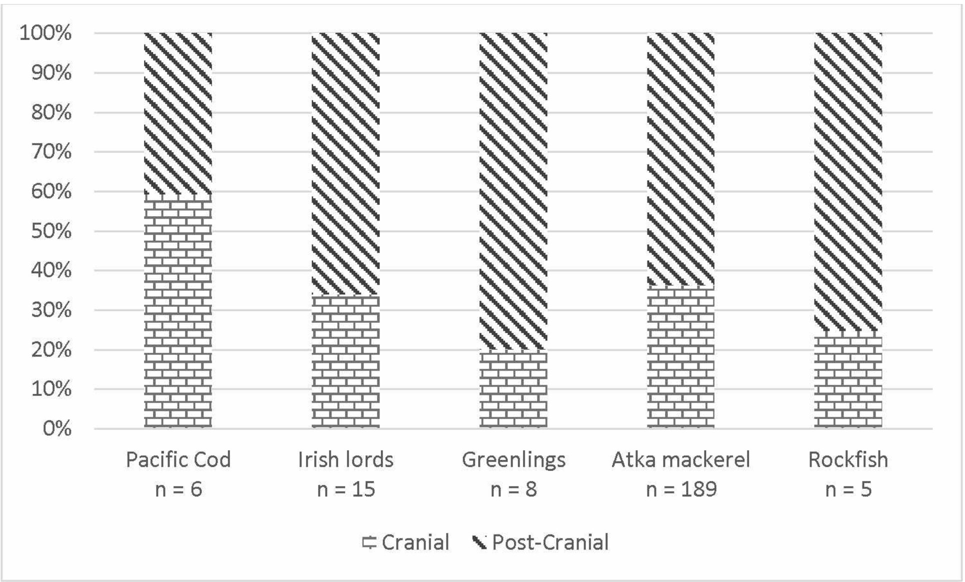


Figure 5.11 Skeletal Element Ratios (40-50 cm)

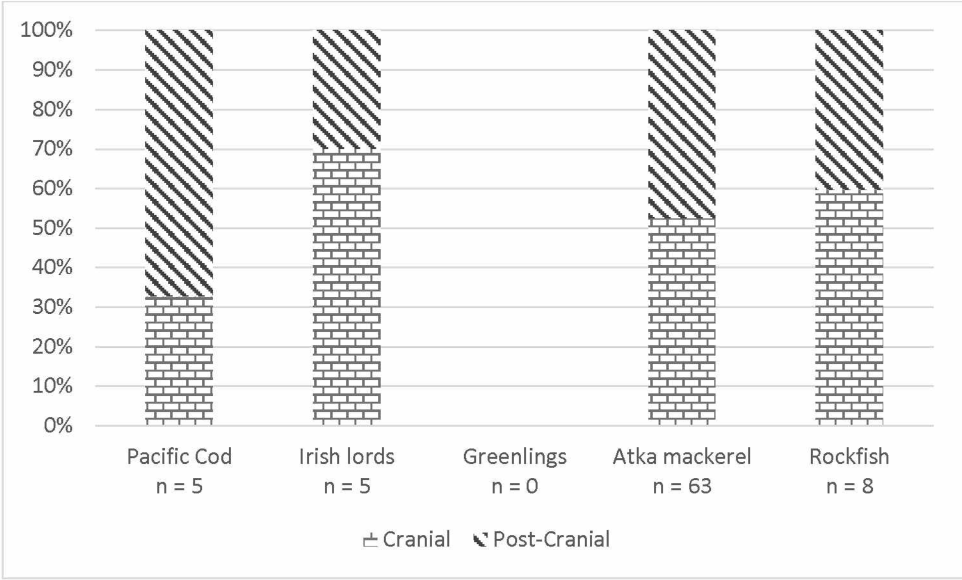


Figure 5.12 Skeletal Element Ratios (50-60 cm)

5.7 Taphonomy

Specimens were only examined using the naked eye, meaning that cut marks and other forms of surface damage may have been missed. The only taphonomic signature detected on fish bones was burning, although only 50 bones were burned, and all of these were from the 30-40 cm layer. Of these burned bones, all but two are Atka mackerel vertebra, the other two belong to greenlings and consist of a quadrate and a vertebra. No marine mammal bones were burned, and one marine mammal bone had root etching (from the 10-20 cm level). No carnivore or rodent damage was observed.

5.8 Interlude to the Discussion

The next chapter will integrate the results presented in this chapter with the research questions identified in Chapter Two. Goals include characterizing subsistence through taxonomic representation and meat weights, evaluating the nature of landscape and seascape utilization, reconstructing seasonality through the ecology of the represented taxa, skeletal element frequency and processing activities. Finally, I will discuss change over time in the identified taxa and evaluate how human hunting pressures and climate may have impacted marine ecology.

Chapter 6: Discussion

In this chapter, I will discuss the results of the current study and revisit the research questions. I will be focusing on changes in fish size, butchery practices, season(s) of site occupation, landscape and seascape use, and taphonomic processes.

6.1 Faunal Analysis and Identification

6.1.1 *Sample Context*

The analyzed deposits from House 1 range in age from 656-553 to 458-307 Cal. yr B.P, where the youngest layers are the deepest stratigraphically, and the oldest are the highest stratigraphically. The House 1 faunal assemblage was extraordinarily rich, requiring the remains to be sampled. The total sample of identified fauna was quite large (NISP = 13,130) despite the fact that I only analyzed material from the southwest quadrant of N48W54. The southwest quad was chosen because it had the largest quantity of faunal remains and contained the most complete chronological sequence. However, it was lacking fauna from every 5 cm level, which is part of the reason the material was analyzed using 10 cm levels. The deepest levels (40-50 cm and 50-60 cm) had the fewest overall bones, which may reflect depositional processes. If non-faunal bearing material was falling into the house pit during primary deposition, this could explain why these layers are not as dense with faunal material.

The preservation of the material at 49-RAT-32 is excellent. Many fragile fish bones were complete. Because the specimens were recovered from a fill deposit, they were likely covered more quickly and not subjected to the same anthropogenic taphonomic processes as deposits from a house floor, including trampling. Dating of the fill deposit indicates that the deposition occurred over a few hundred years (656-553 to 458-307 Cal. yr B.P). Specifically, the upper fill (0-20 cm) formed over a short period of time with an average age of 654-552 Cal. yr B.P. The lower fill (20-60 cm) similarly formed in a short period of time, with an average age of 472-317 Cal. yr B.P. Only 50 fish bones were identified as being burned/calcined. All of the burned fish were from the 30-40 cm layer. No marine mammal bones were identified as being burned. The general lack of burning/calcination is not unexpected. While hearths are reported ethnographically and archaeologically in the Aleutians, Corbett et al. (2010) proposed that people rarely lit fires in houses, instead heating structures with lamps on pedestals.

Given the size of the fish sample, it is not expected that expanding the number of analyzed units would have significantly altered the results. Of the fish remains, the five main taxa contribute 99.87% of the NISP. The taxonomic data presented here are also consistent with Etnier's findings from the midden (Michael Etnier, Western Washington University, unpublished data provided to author). Overall, while the sample size is robust for marine fishes, marine mammals have a low NISP (15) this limits my ability to evaluate the role of marine mammals hunting at 49-RAT-32. An increase in the sample size may assist in fleshing out the history of marine mammal use at the site.

6.1.2 *Comparative Material*

In analyzing the fauna from 49-RAT-32, three comparative collections were used: the UAMN, UAF Anthropology Department, and the Idaho Virtual Museum. Generally speaking, there was sufficient comparative material to identify the fauna. However, several issues were encountered when identifying particular marine fishes. The primary issue was a lack of physical comparative specimens for great sculpin (*Myoxocephalus polyacanthocephalus*). While the Idaho Virtual Museum included great sculpin, only certain elements were available. Additionally, while physical and digital collections for rockfish (*Sebastes* sp.) were available, multiple species from the Western Aleutians were not available. Despite these issues, the materials could be identified to at least the family level.

6.2 Season(s) of Site Occupation

The available sample can aid in determining the season(s) of site occupation. The presence of northern fur seal may suggest an early summer or fall occupation, given the timing of their migration to and from the Pribilof Islands. However, Crockford (2012:132) proposes that "locally breeding fur seals were present throughout the Aleutians, from at least 6,000 years ago until the late pre-contact period." This proposition is further supported by Yesner and Knecht (2003), who identified rookery-age pups in archaeological assemblages in the Aleutian Islands. The presence of these rookeries would expand the window for fur seal exploitation. All other marine mammals represented within the sample could have been locally available year-round.

A few of the marine mammal specimens were unfused. More specifically, three distal metacarpals belonging to *Phocidae* sp. were unfused. Storå (2000) presents the expected age at fusion for skeletal elements belonging to seals. Because metapodials can fuse quite late, the age at death can only be placed between zero to five years, meaning these specimens could derive from sexually mature individuals. While the fusion of postcranial elements ultimately does not help in determining seasonality, marine mammals congregate and are more noticeable during the spring and summer, with pups appearing in spring and early summer at rookeries.

All of the identified fish species are present year-round in the Aleutian Islands. However, Atka mackerel, greenlings, halibut, and cod are more commonly found nearshore during their spawning seasons, which span from late spring through early fall. After spawning, they retreat to deeper waters, where they remain through the winter (Mecklenburg et al. 2002). Turner (1886) reported that people in the Central and Western Aleutians would fish for Atka mackerel from summer to early fall. These fish were commonly dried and stored for winter consumption and were important because of their high fat content. When they are not spawning, Atka mackerel are traditionally found on the continental shelf. Being the predominant fish exploited at 49-RAT-32, the fact that Atka mackerel congregate in large numbers during their spawning period, and because they are relatively difficult to access outside of this time period, the data here suggest a summer to early fall season of occupation.

Sea urchin are also present in the Aleutian Islands year-round. However, urchin reproduce between March and September and often congregate during this period (ADF&G n.d.a). Urchin gonads (the edible portion) begin filling in during late summer; this process continues into the winter when spawning occurs (James and Siikavuopio n.d.). Ethnographically, urchin was primarily gathered by women by hand in shallow pools, but were also gathered using three-pronged (*itu-s)* and four-pronged (*chuniigasi-s,* or *chuhniyaquusi-x*) spears (Bergsland and Dirks 1990; Jochelson 1925; Veniaminov 1984). Storms could deposit 3 to 4 ft thick piles of urchin on the beaches (Turner 2008). Given that the edible portion of urchin is more substantial from late summer to winter, urchin data are also consistent with a summer to fall occupation.

While avian remains were not included in this analysis, eggshell was ubiquitous; specimens were separated into their own bags for future analysis. The presence of bird eggshells indicates at least a late spring to early summer occupation as egg harvests occur primarily in May and June (Fall et al. 1998).

The overall pattern of the recovered faunal remains suggests that inhabitants at 49-RAT-32 occupied the site from at least spring through fall, and potentially occupied the site year-round. Inhabitants exploited a diverse array of locally available resources, most of which were abundant in the region during late spring and summer.

6.3 Exploited Habitats

6.3.1 *Intertidal and Nearshore*

Of the exploited taxa, most occur primarily in intertidal and nearshore environments. The extensive urchin deposits indicate that inhabitants were utilizing the intertidal zone. Although limpet specimens were not quantified, they were present in low frequencies. These taxa live in rocky habitats with outcrops. No bivalves, such as cockles, were encountered during the sorting process. The lack of bivalves may indicate a lack of appropriate habitat near the site for those animals, as they require a low energy environment. In contrast, urchin can exist in high energy environments.

The ubiquitous presence of greenlings and Irish lords, and the lack of sea otters, are indicative of a mature kelp forest during the site's occupation. While there are differences in the overall frequency of greenlings and Irish lords through time, the overall percentage of individuals associated with a mature kelp forest ecosystem is consistent over time. The lack of sea otters in the deposit may explain the large quantity of urchin, as sea otters are a primary consumer of and competitor for urchin. The consistent contribution of urchin meat to the diet (based on meat weights) suggests that urchin populations were stable over time.

Marine mammals utilized at this site include sea lion, harbor seal, and fur seal. These animals are traditionally found nearshore, though they have the ability to go into pelagic waters. Despite the low sample size for marine mammals (especially sea lions), the ethnographic record suggests they were very important to people in the Aleutian Islands. The relative lack of marine mammals within the House 1 fill at 49-RAT-32 is thus perplexing. Marine mammals occur in generally higher frequencies in other Aleutian sites (Crockford 2012; Davis 2001; Desautels et al. 1971; Knecht and Davis 2004; Lefèvre et al. 1997; Morrison 2016). Not only are they integral as a food resource, but for clothing and the construction of boats (which are themselves crucial for subsistence). Potential explanations for the relative lack of marine mammal remains are off-site processing or a lack of rookeries near the site.

Atka mackerel and rock/kelp greenling (*Hexagrammidae*) are very prevalent at 49-RAT-32. In comparison to other archaeological studies in the region, the focus on Atka mackerel is unique (Crockford 2012; Lefèvre et al. 1997; Lefèvre et al. 2011; Orchard 2001). While it is currently the most abundant marine fish species in the Aleutian Islands by biomass (Yang 1999), it is typically a minor component in zooarchaeological deposits. Apart from an archaeological site on Buldir (49-KIS-08) in the Rat Islands, Atka mackerel do not contribute more than fifty percent of the NISP in other published samples from the Aleutians. Rock/kelp greenling are also prevalent at 49-RAT-32, though in comparable frequencies to that at other sites (Lefèvre et al. 1997; Lefèvre et al. 2011; Orchard 2001).

The absence of Pacific herring (*Clupea pallasii*) within the 49-RAT-32 assemblage is notable. Pacific herring is an important food resource for local seabirds (Trapp 1979) and they are known to spawn in the Western Aleutians (North Pacific Fishery Management Council 1982). The absence of this species can be attributed to a couple of variables. It is not expected to relate to screen size, as 3 mm screens were consistently used and are sufficient for the recovery of small bones. A more likely factor is the site's location next to a high energy beach. Pacific herring spawn in low-energy shallow areas along shorelines in late spring (late April to mid-May) (Hay 1985). If there was no suitable spawning habitat close to the site, it is not unreasonable to assume that Pacific herring were not exploited by the local people. As discussed above, the lack of bivalves also suggests a lack of a low-energy environment near the site.

6.3.2 *Offshore*

While offshore habitats were exploited, demersal or epipelagic fish only contribute a small percent of the analyzed marine fish (NISP = 261 or 1.99% of the marine fish sample). Pacific cod was the only demersal or epipelagic fish consistently present throughout the deposit. Salmon and Pacific halibut are each represented by a single specimen.

The near absence of salmon at 49-RAT-32 is not surprising. Ethnographically, Unangax̂ established fish camps near streams where they spawned during the autumn spawning seasons. If this were the case, most of the bones were likely left at the spawning site. 49-RAT-32 is not located near a spawning stream, and given the season of occupation suggested by the fauna, people were present at the site when salmon would have been spawning elsewhere.

Cod often dominate faunal collections recovered from Aleutian sites (Crockford et al. 2004; West et al. 2003), although this is not always the case (Lefèvre et al. 1997). The low frequency of cod at 49-RAT-32 deserves some consideration, given its general prevalence in other Aleutian assemblages. Cod are primarily bottom dwellers and require hook and line techniques to catch them. This makes them more difficult to exploit than more easily accessible fish. The presence of more abundant and easier to catch fish, such as Atka mackerel, may thus account for the relatively low frequency of cod. Additionally, the bathymetric drop off on the southern (Pacific Ocean) coastline is not as rapid as it is on the northern (Bering Sea) coastline (Powers et al. 1960). Pacific cod prefer relatively deep waters, which are closer to shore and more easily accessible on the northern coastline than on the southern coastline where the site is located. This difference may also account for the relatively low frequency of cod.

During the summer months, Pacific cod migrate into shallower waters of 20-165 m (Alverson 1960), but very large fish appear to remain relatively deep (50-200 m, Vinnikov 1996). The specimens reported here (Chapter 5) were quite large (57.1-108.9 cm) with some reaching the upper limits and even surpassing the maximum size reported for contemporary Pacific cod. Hart (1973) suggests that modern cod range up to 100 cm, while Vinnikov (1996) suggesting that cod can reach up to 118 cm in the Bering Sea. Vinnikov (1996) reports that the average size of modern cod ranges from 30-60 cm – all but one of the specimens at 49-RAT-32 exceed the average size of modern cod. However, it is relevant to note that Pacific cod from the Aleutian Islands are slightly larger on average than those found along the Pacific Northwest or the Bering Sea (Wilimovsky et al. 1967). It is also relevant to note that the lifespan of cod in colder northern waters is longer. This change in water temperature may partially account for the larger size of the cod in this analysis. In any case, given the large body size of the Pacific cod recovered at 49-RAT-32, it would appear that the inhabitants at the site were fishing at depths at or exceeding 50 m.

Whale bones were not encountered during the analysis. However, during the excavation of House 1, whale bone was identified as building material used in the construction of the structure (Cook et al. 1972). The presence of whale bones in archaeological sites is always difficult to interpret because it is normally impossible to identify bones as food refuse versus bone used as a raw material (Lefèvre 2011). Black (1987) points out that there are no historical references to whaling in the Central and Western Aleutians; however, the utilization of drift whales for material and subsistence is mentioned.

6.4 Fish Exploitation and Variation in Body Size

Fish bones comprise the majority of the analyzed collection, and the analysis of temporal changes in the average size of fish species is a valuable measure for reconstructing shifts in marine or aquatic ecosystems. Because of this, understanding the history of the area is crucial in interpreting the data. Of the species exploited, *Hexagrammidae*, specifically Atka mackerel, were dominant throughout the sequence. Few taxa showed consistency in their frequency through time. The only taxon to not experience a marked increase or decrease in exploitation is Pacific cod, where it remained a small portion of the NISP. As described in Chapter 3, a change in body size (based on fork length) can potentially speak to human behavior (overexploitation) and climate change. Based on the radiocarbon dates, the LIA (600-100 years B.P) may have been in full effect during the occupation of the site, with temperatures fluctuating on a centennial scale (Morrison 2016). However, some contradictory data exist regarding how the LIA impacted the Aleutians. Savinetsky et al. (2012) propose that on Adak in the central Aleutians, the period between ca. 600 to 300 B.P. was actually one of warming. The data used in this analysis are oxygen isotopes from barnacle plates. However, in the Western Aleutians, Causey et al. (2005) noted an increase in abundance of offshore feeding piscivorous birds from archaeological assemblages, which are thought to be associated with cooler periods. Additionally, pollen cores from Sanak Island in the Eastern Aleutians suggest the area was “cold and wet” between 670-120 cal. B.P (700-100 B.P; Maschner et al. 2009). While there may be differences in local conditions across the chain during the LIA, the local signature for the Western Aleutians appears to be a cooler climate, which is normally associated with increased marine productivity and larger average fish sizes.

6.4.1 *Atka Mackerel Fork Lengths and Frequency*

Atka mackerel experienced an overall increase in relative abundance over time. In the 40-50 and 20-30 cm layers, Atka mackerel exploitation significantly increased from earlier levels. Fork lengths also changed during this time. While fork lengths increased from the 30-40 cm to the 40-50 cm layer, the change in size is not significant at the $\alpha = 0.05$ level and the small sample size in the 40-50 cm layer is problematic. However, the change between the 10-20 cm and 20-30 cm layers is significant with a p-value of 0.002. At this time, there is a sharp increase in exploitation and body size. Apart from the increase in size and frequency, there is a significant decrease in size at the 30-40 cm level from the 20-30 cm level (p = 0.0075). This decrease in size is not associated with a change in frequency and could represent hunting pressures, that is, with high harvesting pressures they may have become stressed, resulting in smaller fork lengths.

As discussed, occupation of 49-RAT-32 overlaps with the LIA, suggesting cooler than average ocean temperatures and a decrease in storminess. Changes in Atka mackerel frequency and size could be the result of climactic conditions favoring marine productivity. As the climate became more amenable for Atka mackerel, humans responded by increasing their exploitation of them. However, human hunting pressure may have caused stress on the population as frequency levels are consistent, but sizes decreased in the 30-40 cm level. Ethnographic data suggest that Atka mackerel were traditionally hunted by placing a spear into the water with a high fish density, where the spear was jerked up and down to gig any fish that may come along (Turner 1886). Families were reported to recover a couple hundred pounds of fish in a few hours utilizing this approach (Turner 1886). If this technology was in use at 49-RAT-32, one may see a specific pattern in the fork lengths as Atka mackerel vertically stratify themselves based on their maturation and age, with the immature fish at the top of the column with older and more mature fish on the bottom. The effect observed with this method over time could be a reduction in body size as this technology targeted individuals in the lower levels of the column. However, the general trend observed here is that fish sizes largely increased through time, which occurred parallel to increases in the relative frequency of the species.

Historically, Atka mackerel have different growth histories based on their location within the Aleutian Island chain (Lauth et al. 2010; Rand et al. 2010). Specifically, Atka mackerel west of 174°W have a smaller mean size at age than those to the east of this longitude (McDermott and Lowe 1997; Rand 2010). This east-to-west size cline in the Aleutian Islands is proposed to be the result of food quality, rather than quantity or ocean temperatures (Rand et al. 2010). Around Amchitka Island, Atka mackerel eat more copepods and fewer euphausiids than mackerel populations east of Seguam Pass (Rand et al. 2010). Copepods are considered lower quality food than euphausiids as they are not as calorically dense. According to Lauth et al. (2010), the average fork length of females and nonbreeding and breeding males west of 174°W ranged between 35.6 and 36.7 cm, with the maximum size recorded at 43 cm. Those to the east of this point ranged in sizes between 38.8-39.4 cm with a maximum size of 45 cm. Historically, the maximum known size for Atka mackerel is 45 cm (NOAA 2010). In this study, two individuals exceed this value, with fork lengths of 47.3 cm and 46.5 cm. Many individuals are close to the 45 cm mark. The mean fork length for every layer except one exceeds the modern means recorded by Lauth et al. (2010). Even in the 10-20 cm level, the mean fork length is 36.5 cm, which is on the high end of the mean range for modern populations in this region. The estimated biomass of Atka mackerel in the Aleutian Islands is at or near historic, post-1977 highs (ADF&G n.d.b). Atka mackerel in Alaskan waters were landed exclusively by the distant water fleets of the U.S.S.R., Japan, and the Republic of Korea from 1970-1979 (Lowe et al. 2018). However, Atka mackerel only became a reported species group in the Bering Sea and Aleutian Islands (BSAI) Fishery Management Plan in 1978 (Lowe et al. 2018). Atka mackerel are not classified as being overfished or nearing an overfished condition. The changes in average size between modern and archaeological populations are not expected to solely be the result of modern/historic commercial fishing, though fisheries of Atka mackerel have been operating since the 1970's. Rather, they are also likely to be the result of changes in climate from the LIA to the modern day. As discussed above, at least some fish in the LIA were expected to be larger than their modern counterparts due to a combination of factors including increased marine productivity and lowered metabolisms from colder oceans.

6.4.2 *Greenling Fork Lengths and Frequency*

Multiple greenling species are found in the Aleutians, including *Hexagrammos lagocephalus, H. decagrammus, H. octogrammus, H. superciliosus,* and *H. stelleri* (Hart 1973; Eschmeyer et al. 1983). According to Eschmeyer et al. (1983), these fish range in size from 28-61 cm. No individuals within this analysis exceeded the maximum size range for modern greenling, but average fork lengths are larger than modern populations (303 mm). Within the assemblage from 49-RAT-32, greenlings show changes in body sizes that track the changes in frequency evidenced among Atka mackerel. Specifically, Atka mackerel and other greenlings both have maximum mean sizes in the 20-30 cm layer. Both of these peaks are then followed by a decrease in average size. However, greenlings and Atka mackerel experience inversion in frequency. When Atka mackerel exploitation increases, greenling correspondingly decrease.

Additionally, while Atka mackerel frequency and fork length increase concurrently, greenlings decreased in frequency at the same time they increased in fork length. These trends are suggestive of increasing marine productivity and a reduction of population stress for greenlings.

6.4.3 *Irish Lords Fork Lengths and Frequency*

Irish lords (*Hemilepidotus sp.*) are an interesting though complicated subset of the faunal assemblage. Based on ethnographic data and their presence and frequency at archaeological sites, Irish lords were widely utilized by prehistoric people in the Aleutians (Orchard 2001; Turner 1886). However, at present there are no commercial fisheries and few sport fishermen who target these fishes. As a result, there are few comparative specimens with known size and weight. As was the case for Orchard (2001), the Irish lords from 49-RAT-32 are larger than the limited comparative specimens he had access to. While this indicates that fork lengths and meat weights are not precise indicators of body size, they should be accurate in analyzing relative changes in size and meat yields. Within this taxa, body size appears relatively constant through time. The only level to show a distinctly different pattern is where Irish lords are significantly larger than in other layers (10-20 cm). However, it is interesting to note that fish sizes from the 40-60 cm layers are also large, although the sample sizes were too small to statistically evaluate. The size increase from the 0-10 cm layer is associated with a significant decrease in exploitation. However, there is also a sharp decrease in exploitation at the 20-30 cm layer, highlighted by a co-current decrease in size. Among the analyzed Irish lords, two individuals are larger than the maximum recorded size of modern yellow Irish lords (52.2 cm; TenBrink and Buckley 2013).

6.4.4 *Pacific Cod Fork Lengths and Frequency*

Pacific cod were present in each analyzed layer; however, they were present in low numbers and only a few elements could be measured. In fact, estimated fork length and weight could only be calculated for five specimens. As such, it is not appropriate to address changes in body size over time. However, all but one of the specimens at 49-RAT-32 exceed the average size of modern cod (30-60 cm). This may be due in part that Pacific cod are the focus of a well-established commercial fishing fleet, which may have impacted their overall sizes, leading modern populations to be smaller (Maschner et al. 2008; Orchard and Crockford 2010).

6.4.5 *Rockfish Fork Lengths and Frequency*

Rockfish were another uncommon species encountered in the analysis (NISP = 616 or 4.7% of the fish assemblage). Rockfish were not found to have changed significantly in size over time. However, their low sample sizes make interpretations problematic as there were five or fewer specimens per layer. Rockfish are particularly susceptible to overexploitation in comparison to other fish species (Frid et al. 2016). This is due to their fecundity (production of offspring) and the fact that offspring quality increases with maternal size or age (Frid et al. 2016). Rockfish are a slow-growing, late-maturing, and long-lived species. This combination makes it relatively easy to overexploit. Rockfish are a very diverse and abundant taxon in the Aleutians. Eschmeyer et al. (1983) report that eleven species of rockfish occur within the Aleutians, with the maximum size range between 32-96 cm. Hart (1973) analyzed nine species from the Aleutian Islands and found that the maximum size range these species spanned 32.4-71 cm. Rockfish within this analysis range in size between 18.78-43.29 cm. Because of the wide range of taxa present in the Aleutians, it is not unusual that all of the specimens fall below the maximum known fork lengths, as available comparative collections and skeletal element similarities made more specific identification impossible. However, about half of the analyzed specimens do reach the lower range of the published maximum size range for rockfish.

6.4.6 *Atka Mackerel Versus Greenlings*

In the analysis of the relative frequency data, I found that Atka mackerel and greenlings show opposing patterns. In cases where Atka mackerel were present in higher than expected frequencies, greenlings were present at lower than expected frequencies (and vice versa). These layers that showed statistically significant shifts in frequency also showed significant changes in fish size. Between the 10-20 and 20-30 cm levels, both Atka mackerel and greenlings are getting larger, but Atka mackerel increase in abundance while greenlings decrease. A possible explanation for this pattern relates to the fishing technology utilized. Greenlings share many ecological habitats with other fish procured at 49-RAT-32. If one was to argue that environmental degradation precipitated the decline in greenling abundance, then one would expect shrinking fork lengths, and other taxa that rely upon the same habitat should also decline in abundance. However, fish lengths are increasing, and other species found in the same habitat (Atka mackerel and Irish lords) show an increase or consistency in exploitation. A change in fishhook sizes may cause the observed trend. As stated in Chapter Three, changes in fishhook sizes have the potential to visibly effect fish communities. If fishhooks were increasing in size, then smaller fish would have a harder time being hooked, increasing the proportion of larger individuals recovered at the site. Additionally, when one focusing on procuring large fish, there are comparatively fewer of those individuals than smaller ones. Overall, while it is not well understood why there is an inversion in Atka mackerel and greenling exploitation, which are closely related species, a change in fishhook sizes could possibly account for the larger individuals and decreasing abundances of greenlings.

6.4.7 *Summary of Measurements and Abundance*

When evaluating the body size data across all analyzed taxa, some trends are apparent. *Hexagrammidae* (Atka mackerel and greenlings) constitute the majority of the analyzed fauna. Both of these taxa show an increase in size through time. However, as discussed above, while greenlings decrease in their overall frequency, Atka mackerel shows an increase in frequency across the deposits. This pattern could reflect a more amenable climate, with people choosing to focus their attention on spawning mackerel. Specifically, if size-selective harvesting was causing deleterious changes in key life-history traits, this would lead to lower maximum body size and poorer reproductive output (Uusi-Heikkilä et al. 2015). Apart from the decrease in size at the 30-40 cm layer for Atka mackerel, and potentially for greenlings (sample size), both of these taxa increase in size over time. This increase in size is not supportive of long-term overexploitation. However, the decrease in size for Atka mackerel in the 30-40 cm layer could represent human derived population stress, as the overall frequency of taxa are consistent with the surrounding layers. Since climate is believed to have oscillated on the centennial scale in the Aleutians during the LIA (Morrison 2016), this oscillation is not necessarily expected to have occurred as the deposition from the 20-30 cm to the 50-60 cm level spans a relatively short period of time.

Irish lords are generally consistent in their overall size, though experience a sharp increase in size in at the 10-20 cm level. Despite this, Irish lords stay largely constant in their overall size while experiencing decreased exploitation through time. For Pacific cod and rockfish, there appears to be no major change in fork lengths through time. However, the small sample sizes precludes rigorous analysis for these species. Cod use is stable through time, and the size of the recovered individuals suggests deep sea fishing. While rockfish experience significant changes in their levels of exploitation, they do not appear to correspondingly change in fork length that would be suggestive of overexploitation.

Overall, while Atka mackerel is consistently the largest contributor to the NISP and MNI, exploitation levels largely increased through time. People appear to have increased their focus on these fishes, decreasing their diet breath and reliance on previously exploited species such as greenlings and Irish lords. Rockfish saw variable use over time, though it remained a small portion of the overall sample. Within 49-RAT-32, stress on Atka mackerel may be observed in the 30-40 cm level, but the taxonomic data do not suggest an expansion of dietary breadth at this time, as would be expected with resource stress.

6.5 Diet and Meat Weights

The analysis of meat weights and the relative importance of different taxa to the overall diet raises a number of issues. Marine mammals comprise the majority of the meat weight whenever they are present, despite only having an NISP of 15. These 15 bones represent three species with an MNI of 5 (based on 10 cm levels). For this analysis, the whole individual is assumed to have been utilized at the site. However, when viewed in this way, all other resources become minor in comparison. Overall, it is difficult to evaluate the contribution of fish, marine mammal, urchin, and other resources to a family's diet because of meat sharing, processing, and differential preservation. However, marine mammals would have been an important and an integral component of the diet, even though the total NISP is low.

For fish remains, the meat weight data provide a sense of how important different species were to the diet. At 49-RAT-32, although Atka mackerel contributes the most to the NISP and has the highest MNI, they were not the most important food source in terms of meat weight in every level. While Atka mackerel contribute a significant portion of the meat weight in the oldest layers (highest stratigraphic layers), there is a general increase in the reliance on this species over time. Conversely, Pacific cod make up a small contribution to the NISP and MNI, but the individuals present in the analysis are large, some reaching and surpassing 1 m in length. When present, they contribute 11-29% of the total fish meat weight. Other species of importance are Irish lords and greenlings. While it is hard to accurately assign meat weights to Irish lords for the reasons stated above, the available data indicate that they were a consistently important resource for the inhabitants of 49-RAT-32. Turner (1886) reported that Irish lords were one of the preferred fishes for people of the Aleutians, not only for their taste but also because they rarely had pests or issues such as diseases that were more common in other species. Greenlings were also important for past peoples, though experienced decreased use when Atka mackerel harvests increased. Finally, though rockfish were present, they did not provide much in the way of the overall meat weight or NISP.

In Aleutian sites, urchin deposits are often thick and rich, signifying that these were an intensively exploited and an important resource (Corbett et al. 2008; West et al. 2012). Historically, despite the nutrients that sea urchin provides, they have been commonly seen as a famine food as they are a reliable resource to fall back on. When marine mammals are not included, urchin provide 3.5-6.9% of the meat weight, with one layer (30-40 cm) at 10.8%. Urchin are easy to exploit and often appear on beaches, tide pools, and in the intertidal areas, where they can be gathered by hand or spear by the young and old. If the assumption that shellfish were more intensively exploited during famines holds, then the 30-40 cm layer may reflect this event. This layer shows a significant decrease in Atka mackerel fork length at the same time when urchin exploitation reaches its peak. Shellfish are traditionally understood as an important and reliable resource that see increased use during times of hunger (Birket-Smith 1971; Braje and Erlandson 2009; Eells 1985), despite the risks associated with paralytic shellfish poisoning (Lantis 1984). When analyzing meat weight data for changes in marine fish exploitation in this layer, only Pacific cod see an increase.

Overall, meat weight data provide insight into the importance of specific resources to the diet. Using meat weights attempts to circumvent issues associated with NISP and MNI values, which may bely the actual importance of some resources. Within this analysis, meat weight data contributes to the interpretation that diet breadth was decreasing over time, though the number of species represented remains constant. Additionally, although Atka mackerel is an important resource, its importance is not as large as one would assume when relying on the NISP and MNI values alone. Finally, although rare in overall abundance, meat weight data suggest marine mammals served as an integral role in subsistence, in the form of raw materials as well as fat and protein necessary in the diet.

6.6 Body Part Profiles

Skeletal element profiles can speak to human processing decisions and behaviors. For fish remains, skeletal elements were classified as cranial or post-cranial elements and then compared against one another. The results suggest that butchery practices remained constant across species and over time. In normalizing the values, more post-crania than cranial elements are represented. This is not unusual, as fish heads are often removed at the site of capture or in an area specified for processing (Hoffman et al. 2000). However, despite the fact that there was a greater ratio of post-crania to cranial bones, there was still a substantial number of cranial bones present at the site. This supports localized procurement, as cranial bones are often rare in areas where fishing activities are not happening or when fishing happens far away from the site. On average, Atka mackerel had the lowest ratio of cranial to post-cranial elements. This may suggest that they were dried, as Atka mackerel have a high fat content that makes it ideal for winter use. Ethnographically, fish heads were removed from the body of the fish that was to be dried; the remaining trunk was then placed on a stake to air dry for later consumption (Turner 1886).

The relative lack of marine mammal bones is not expected to be the result of post depositional processes, particularly given the excellent condition of the fish bones, which are much more fragile. Rather, it is likely that processing decisions ultimately determined the discard pattern for these bones. All of the recovered bones are small, increasing their relative transportability. Ethnographic sources on sea lion use and butchery suggest different reasons why some bones may be more prevalent than others (Haynes and Mischler 1991). There are many recipes that utilize whole flippers that do not involve de-fleshing the bones first. Additionally, the skin of the flippers is reported to be used to create shoes that have greater grip for slippery surfaces (Haynes and Mischler 1991). Overall, the small sample of marine mammal bones makes the data difficult to interpret, but the high rate of flipper bones may suggest that activities focusing on those elements may have been occurring nearby.

6.7 Summary

A primary issue encountered during this analysis was the low sample for the lower-most levels (40-60 cm). Future work should focus on expanding the identified sample from these layers. The second issue encountered during this analysis is relatively minor, but it does impact future interpretations of the material from 49-RAT-32. The records left behind by the original excavators make it difficult to directly compare material from the arbitrary 5 cm layers to those following natural stratigraphy. Additionally, based on radiocarbon analysis of the fill deposit at House 1, these deposits are stratigraphically positioned in reverse order, likely due to a combination of primary deposition of material after the house was abandoned, followed by redeposition activities. This further complicates comparison to material from other units.

The general trend observed in these layers suggest that diet breadth was shrinking with an increase in reliance on Atka mackerel over time. Changes in climate could have favorably impacted Atka mackerel populations, resulting in people increasing their exploitation of these relatively easy to exploit fishes. The LIA is recorded to have oscillated on the centennial scale so the changes in exploitation and fork lengths between 0-20 cm and 20-60 cm may represent climate change. However, oceanic conditions are hard to characterize, and these may have played a role. Some of the data suggests a small window during which diet breadth may have increased, as the deposits from 20-30 to 30-40 cm show decreasing Atka mackerel fork lengths, and an increasing reliance of urchin.

Chapter 7: Conclusions

Historical ecology postulates that where humans are present, they impact their environments (Balée 1998). This impact is documented throughout the world (Grayson 2001), and is keenly felt in coastal, especially island, environments (Rick and Erlandson 2008). During the Late Aleutian period in the Western Aleutians, people exploited the resources around them. In the construction of semi-subterranean households and the formation of shell middens, the physical environment was impacted. Beyond this physical impact, people may have impacted their environments through a multitude of hunting and fishing practices (Corbett et al. 2008).

The zooarchaeological data from 49-RAT-32 indicate that large numbers of fish were taken from nearshore environments, with a minor, though important, component of the diet deriving from taxa from pelagic environments. The faunal remains suggest a site occupation from at least spring through fall, with people potentially occupying the site year-round. Inhabitants here may have placed some stress on Atka mackerel populations as fork lengths decreased and urchin use increased in the 30-40 cm level, a level which also saw an increase in urchin use. As the LIA is believed to have fluctuated on the centennial scale, changes in fish sizes and frequency from earlier levels could reflect this change. Specifically, there is a at least a 55-year hiatus between the 10-20 cm and 20-30 cm levels. The changes evidenced between these layers suggests a decreasing diet breadth and an increase in average fork lengths among some species of fish.

Apart from identifying that eggshells and bird bones are present in the deposits, the importance of avian resources to the diet is unknown. Marine mammals were also present and utilized at this site, but the relative importance of marine mammals to the diet is also difficult to understand, in part because it is not possible to reconstruct processing and meat sharing activities. However, it can be established that marine mammals would have been an important and an integral component of the diet, even though the total NISP (15) is low.

Invertebrate exploitation also occurred at this site, and meat weight data suggests that the degree of urchin exploitation was largely stable over time; urchins comprising a relatively small portion of the overall diet. Invertebrates recovered during analysis are found in high energy beach areas, with low energy species such as bivalves being absent from the site. This indicates that the local beach environment was a high energy area.

The samples of Pacific cod, Atka mackerel, greenlings, and Irish lords include individuals that are larger than modern populations. Atka mackerel are currently not classified as being overfished nor reaching an overfished condition, so the size difference is not expected to reflect modern size reductions driven by human activity (ADF&G n.d.b). Rather, the larger sizes at 49-Rat-32 are likely to be the result of changes in climate from the LIA to the modern day, as higher marine productivity is believed to have occurred during this time. This distinction is important because Atka mackerel are an important food source for many different kinds of fish, seabirds, and marine mammals. They are particularly important for the western stock of Steller sea lions, which has experienced a >80% population decline in the last 30 years (Atkinson et al. 2008). Greenlings are not a commercially harvested fish, and like Atka mackerel, the larger sizes are likely to be the result of changes in climate. However, changes in size of Pacific cod between the Late Aleutian Period and modern times are not expected to be because of the change in climate. Rather, Pacific cod are the focus of a well-established commercial fishing fleet which has likely driven their overall size decrease (Orchard and Crockford 2010). The changes observed in sizes between modern and archaeological samples of Irish lords are difficult to analyze because of the Irish lords used to generate the regression equations are known to be small.

Within the archaeological sample, Atka mackerel increased in size over time while also increasing in frequency. A possible explanation for this trend is a change in climate that promoted an increase in size. Other species that show an increase in average fork lengths are greenlings, with Irish lords being relatively constant in size over time. Not much is known about modern Irish lord populations as they are not targeted for commercial fisheries or sport fishermen. Although greenlings increased in size whenever Atka mackerel showed a significant increases in frequency, greenlings showed a decline in exploitation.

This study has generated sizeable data about Late Aleutian subsistence economies, but additional research is needed. More paleoclimate data is needed as conflicting interpretations exist for the region (Causey et al. 2005; Savinetsky et al. 2012). Climate and weather systems are dynamic along the Aleutian chain; the climate experienced at one end of the volcanic chain may not be the same as that experienced in other portions of the chain. This is important for future understandings on how the environment affected people, as well as how people impacted the environment.

It is increasingly important to contextualize present-day marine systems within a long-term framework that considers human activities and the impacts of climate on marine resources. This research builds upon our knowledge of Aleutian marine environments and their reactions to both anthropogenic, and climactic forces. At present, not many analyses in the Aleutians, focus on changes in fish sizes over time. As documented, these data are "one of the simplest, most common, and valuable measures used by archaeologists to reconstruct shifts in human predation pressure and impacts in marine or aquatic ecosystems" (Rick and Erlandson 2008:10). It is thus important to analyze and consider this type of data. Future analyses should expand upon Orchard's (2001) regression equations for calculating fish length and weight to other fish taxa. Larger comparative specimens of Irish lords of known length and weight are needed to more accurately assess changes in this species through time. While Irish lords are not commercially gathered or necessarily sought after by sport fishermen today, prehistorically these fish were widely utilized (Orchard 2001). Increasing these comparative samples will increase the accuracy and precision of interpretations for this taxa.

This project has not identified evidence for significant human-derived resource depression during the Late Aleutian Period. However, additional work is needed to increase the robusticity of these findings: Within the site, larger samples from the deepest deposits will allow a better understanding of change over time. As a whole, the analysis of the fauna from 49-RAT-32 contributes to our knowledge base on Western Aleutian subsistence practices as well as how humans impacted their landscapes and seascapes – it also provides key baseline data for broader analyses of changes in fish size over time.

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Appendices

Appendix A

Plant Communities (Shacklette et al. 1969)

Terrestrial Habitats	**Vegetation Community**
Strand	a. Honckenya-Senecio community
Dune	a. Poa-Deschampsia-Festuca
	b. Elymus
Sea cliff	a. Eurhynchium-Pucainellia-Caloplaca
	b. Potentillea-Draba-Sawifraga
	c. Xanthoria-Ramalina
	d. Elymus-Ligusticum-Anemone
Empetrum heath	a. Empetrum-Ccwese-Iichen
	b. Cladonia-Carew meadow
	c. Moss mound
	d. Organic bird-perch mound
	e. Streamside
	f. Peat-bank
	g. Frost-scar
Bog	a. Sphagnum bog
	b. Philonotis-Pamassia
	c. Scapania-Nardia-Marsupella
Marsh	a. Wet sedge-meadow
	b. Caltha-Claytonia
Lake	a. Hippuris-Ranunculus
	b. Isoetes-Ranunculus-Limosella
Pool	a. Juncus-Eriophorum
	b. Subularia-CaMitriche
	c. SiphulOrScapama
Stream	a. Fontinalis-Ranunculus

Buderal	a. Calamaffrostis
	b. Lupinus-Amica
	c. Equisetum-Sagina-Ceratodon
Discontinuous heath	a. Salix-Empetrum
	b. Andreaea-Schistidium-Rhaoomitrium
Solifluction	a. Fell-field
	b. Solifluction terrace
Alpine meadow	a. Snow-bed
	b. Alpine meadow
Inland bedrock	a. Low-altitude bedrock
	b. High-altitude bedrock

Appendix B

Marine Mammals (U.S. Fish and Wildlife Service n.d.)

Cetacea	
Gray whale	*Eschrichtius robustus*
Blue whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealus*
Minke whale	*Balaenoptera acutorostrata*
Humpback whale	*Megaptera novaeangliae*
Sperm whale	*Physeter catodon*
Baird's beaked whale	*Berardius bairdii*
Stejneger's beaked whale	*Mesoplodon stejnegeri*
Cuvier's beaked whale	*Ziphius cavirostris*
Killer whale	*Orcinus orca*
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
Dall porpoise	*Phocoenoides dalli*
Carnivora	
Sea otter	*Enhydra lutris*
Northern fur seal	*Callorhinus ursinus*
Steller sea lion	*Eumatopias jubatus*
Walrus	*Odobensus rosmarus*
Harbor seal	*Phoca vitulina*
Northern elephant seal	*Mirounga angustirostris*

Appendix C

Marine Fishes (90) Collected at Amchitka, 1967 Through 1972 (Simenstad et al. 1977; taxa identified during the analysis are marked with an asterisk)

Scientific Name	***Common Name***
Order Petromyzonidae	
Family Petromyzonidae	Lampreys
Entrosphenus tridentalus	Pacific lamprey
Order Squaliformes	
Family Ptilichyidae	Mackerel sharks
Lamna ditropis	Salmon shark
Order Rajiformes	Skates
Family Rajidae	
Raja binoculata	Big skate
Raja parmifera	Alaska skate
Raja trachura	Roughtail skate
Order Salmoniformes	
**Family Salmonidae*	Salmons and trout
Oncorhynchus gorbuscha	Pink salmon
Oncorhynchus keta	Chum salmon
Oncorhynchus kisutch	Coho salmon
Oncorhynchus nerka	Sockeye salmon
Oncorhynchus tshawytscha	Chinook salmon
Salvelinus malma	Dolly Varden
Family Bathylagidae	Deepsea smelts
Bathylagus milleri	Stout blacksmelt
Bathylagus stilbius	California smoothtongue
Family Gonostomatidae	Lightfishes
Cyclothone microdon	Veiled anglemouth
Family Chauliodontidae	Viperfishes
Chauliodus macouni	Pacific viperfish
Order Myctophiformes	

Family Alepisauridae	Lancetfishes
Alepisaurus ferox	Longnose lancetfish
Family Myctophidae	Lanternfishes
Diaphus theta	California headlightfish
Electrona arctica	Bigeye lanternfish
Lampanyctus regalis	Pinpoint lampfish
Stenobrachius leucopsarus	Northern lampfish
Tarletonbeania crenularis	Blue lampfish
Order Gadiformes	
Family Gadidae	Codfishes
Arctogadus borisovi	Toothed cod
*Gadus macrocephalus	Pacific cod
Theragra chalcogramma	Walleye pollock
Family Macrouridae	Grenadiers
Coryphaenoides acrolepis	Roughscale rattail
Coryphaenoides filifeza	Filamented rattail
Order Gasterostciforms	
Family Gasterosteidae	Sticklebacks
Gasterosteus aculeatus	Threespine stickleback
Order Perciformes	
Family Trichodontidae	Sandfishes
Trichodon trichodon	Pacific sandfish
Family Bathymasteridae	Ronquils
Bathymaster cacruleofasciatas	Alaskan ronquil
Bathymaster signatus	Searcher
Ronquilus jordani	Northern Ronquil
Family Stichaeidae	Priclebacks
Alectrias alectrolophus	Stone cockscomb
Anaplarchus purpurescens	High cockscomb
Chirolophis nugator	Mosshead warbonnet
Gymnoclinus cristulatus	Trident prickleback

Phytichthys chirus	Ribbon prickleback
Poroclinus rothrocki	Whitebarred prickleback
Family Pholidae	Gunnels
Pholis dolichogaster	Stippled gunnel
Pholis laeta	Crescent gunnel
Family Ptilichthydae	Quillfishes
Ptilichthys goodei	Quillfish
Family Zaproridae	Prowfishes
Zaprora silenus	Prowfish
Family Ammodytidae	Sand lances
Ammodytes hexapterus	Pacific sand lance
**Family Scorpaenidae*	Scorpionfishes
Sebastes aleutianus	Rougheye rockfish
Sebastes alutus	Pacific ocean perch
Sebastes babcocki	Redbanded rockfish
Sebastes ciliates	Dusky rockfish
Sebastes polyspinis	Northern rockfish
Sebastes proriger	Redstripe rockfish
Sebastes alascanus	Shortspine thornyhead
Family Anoplopomatidae	Sablefishes
Anoplopoma fimbria	Sablefish
**Family Hexagrammidae*	Greenling
*Hexagrammos decagrammus	Kelp greenling
*Hexagrammos lagocephalus	Rock greenling
*Pleurogrammus monopterygius	Atka mackerel
Family Cottidae	Sculpins
Blepsias cirrhosis	Silverspotted sculpin
Clinocottus acuticeps	Sharpnose sculpin
Clinocottus embryum	Calico sculpin
Enophrys diceraus	Antlered sculpin
Gymnocanthus galeatus	Armorhead sculpin

Gymnocanthus pistilliger	Threaded sculpin
*Hemilepidotus hemilepidotus	Red Irish lord
*Hemilepidotus jordani	Yellow Irish lord
Hemitripterus bolini	Bigmouth sculpin
Icelus canaliculatus	Blacknose sculpin
Malacocottus kincaidi	Blackfin sculpin
*Myoxocephalus polyacanthocephalus	Great sculpin
Nautichthys probilouius	Eyeshade sculpin
Radulinus asprellus	Slim sculpin
Triglops forficate	Scissortail sculpin
Triglops pingeli	Ribbed sculpin
Triglops scepticus	Spectacled sculpin
Family Agonidae	Poachers
Agonus acipenserinus	Sturgeon poacher
Aspidophoroides bartoni	Aleutian alligatorfish
Hypsagonus quandricornis	Fourhorn poacher
Pallasina barbata	Tubenose poacher
Sarritor leptorhynchus	Longnose poacher
Family Cyclopteridae	Lumpfishes and snailfishes
Aptocyclus ventricosus	Smooth lampsucker
Careproctus gilberti	Smalldisk snailfish
Careproctus phasma	Spectral snailfish
Crystallichthys cyclospilus	Blotched snailfish
Eumicrotremus orbis	Pacific spiny lumpsucker
Lethotremus muticus	Docked snailfish
Liparis callyodon	Spotted snailfish
Liparis megacephalus	Bighead snailfish
Nectoliparis pelagicus	Tadpole snailfish
Polypera greeni	Lobefin snailfish
Order Pleuronectiformes	
Family Pleronectidae	Righteye flounders

Astheresthes stomias	Arrowtooth flounder
Glyptaocephalus zachirus	Rex sole
Hippoglossoides elassodon	Flathead sole
*Hippoglossus stenolepis	Pacific halibut
Lepidopsetta bilineata	Rock sole
Reinhardtius hippoglossoides	Greenland halibut

Appendix D

Utilized Regression Equations

Fork length (FL) regression equations for Atka mackerel (*Pleurogrammus monopterygius*) comparative specimens. Regression formulae take the following form: $FL = \alpha + \beta X$, where X represents the skeletal measurement in question. FL and X are in millimeters. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Dentary	1	60.33	12.13	0.959	91
Dentary	2	121.57	48.77	0.886	91
Dentary	3	47.55	24.29	0.959	91
Articular	1	29.83	11.65	0.965	91
Articular	2	47.09	28.94	0.945	91
Articular	4	108.37	75.98	0.936	91
Quadrate	3	113.56	65.31	0.931	91
Atlas	1	65.89	61.13	0.969	91
Atlas	2	43.68	54.22	0.968	91
Atlas	3	22.83	146.56	0.734	91

Results of weight (Wt) regression for Atka mackerel *(Pleurogrammus monopterygius)* comparative specimens. Regression formulae take the following form: $Wt = \alpha X^{\beta}$, where X represents the skeletal measurement in question. X is in millimeters and Wt. is in grams. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Dentary	1	0.05	2.96	0.950	96
Dentary	2	12.78	2.45	0.905	96
Dentary	3	0.24	3.07	0.948	96
Articular	1	0.01	3.25	0.943	96
Articular	2	0.36	3.11	0.924	96
Articular	4	31.75	2.48	0.942	96
Quadrate	3	23.68	2.46	0.935	96
Atlas	1	6.92	2.85	0.955	96
Atlas	2	2.60	3.09	0.956	96
Atlas	3	27.44	3.69	0.793	96

Results of fork length (FL) regression for Greenling (*Hexagrammos* sp.) comparative specimens. Regression formulae take the following form: $FL = \alpha + \beta X$, where X represents the skeletal measurement in question. FL and X are in millimeters. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Dentary	2	51.82	46.20	0.879	20
Dentary	3	19.19	27.07	0.978	20
Articular	1	9.55	14.66	0.974	20
Articular	3	25.68	72.60	0.952	20
Quadrate	3	35.69	71.84	0.940	21
Quadrate	4	0.83	25.92	0.989	21

Results of weight (Wt) regression for Greenling (*Hexagrammos* sp.) comparative specimens. Regression formulae take the following form: $Wt = \alpha X^{\beta}$, where X represents the skeletal measurement in question. X is in millimeters and Wt. is in grams. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Dentary	2	4.27	2.89	0.976	21
Dentary	3	0.38	3.00	0.992	21
Articular	1	0.03	3.25	0.995	21
Articular	3	7.75	3.07	0.987	21
Quadrate	3	10.90	2.89	0.989	22
Quadrate	4	0.15	3.21	0.995	22

Results of fork length (FL) regression for Irish Lord (*Hemilepidotus* sp.) comparative specimens. Regression formulae take the following form: FL = α + βX, where X represents the skeletal measurement in question. FL and X are in millimeters. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Quadrate	3	39.27	67.52	0.968	7
Quadrate	4	5.67	17.41	0.988	7
Premaxilla	1	50.11	11.07	0.968	7
Premaxilla	3	-59.63	40.24	0.920	7
Epihyal	2	-26.28	152.17	0.919	6

Results of fork length (FL) regression for Rockfish (*Sebastes* sp.) comparative specimens. Regression formulae take the following form: FL = α + βX, where X represents the skeletal measurement in question. FL and X are in millimeters. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Dentary	3	40.91	14.54	0.898	31
Articular	1	99.98	6.35	0.879	33
Articular	2	75.14	10.72	0.908	33
Articular	4	96.03	61.25	0.824	33
Atlas	2	59.45	41.91	0.911	31

Results of weight (Wt) regression for Rockfish (*Sebastes* sp.) comparative specimens. Regression formulae take the following form: $Wt = \alpha X^{\beta}$, where X represents the skeletal measurement in question. X is in millimeters and Wt. is in grams. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	*α*	*β*	*r-squared*	*n*
Dentary	3	0.11	2.89	0.931	29
Articular	1	0.07	2.55	0.918	31
Articular	2	0.16	2.60	0.930	31
Articular	4	26.16	2.35	0.896	31
Atlas	2	4.67	2.62	0.980	29

Results of fork length (FL) regression for Pacific cod (*Gadus macrocephalus*) comparative specimens. Regression formulae take the following form: FL = $\alpha + \beta X$, where X represents the skeletal measurement in question. FL and X are in millimeters. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	α	*B*	*r-squared*	*n*
Dentary	1	20.85	10.43	0.981	25
Quadrate	3	105.19	56.88	0.956	25
Quadrate	4	35.25	17.92	0.963	25

Results of weight (Wt) regression for Pacific cod (*Gadus macrocephalus*) comparative specimens. Regression formulae take the following form: $Wt = \alpha X^{\beta}$, where X represents the skeletal measurement in question. X is in millimeters and Wt. is in grams. n is the number of comparative specimens used to generate the equation within Orchard (2001).

Bone	*Measure #*	α	β	*r-squared*	*n*
Dentary	1	0.01	3.11	0.986	30
Quadrate	3	1.46	3.15	0.985	30
Quadrate	4	6.57	2.81	0.973	30

Appendix E

Total Weight of Identified and Unidentified Fish Bones

Depth	Unidentified (g)	Identified (g)
0-10	199.6	602
10-20	209.5	739.1
20-30	324.6	1250.8
30-40	33.7	153.8
40-50	7.3	31.7
50-60	3.6	18.8
Total	778.3	2796.2

Appendix F

Raw Data of Specimens Used to Estimate fish Fork Length and Weight Per Layer

ID #	Depth (cm)	Taxon	Element	M1 (mm)	M2 (mm)	M3 (mm)	M4 (mm)	Measure Used	Fork Length (mm)	Fish Wight (g)
KMS-11145	0-10	Gadus macrocephalus	Quadrate	-	-	16.3	52.7	4	979.634	13522.48875
KMS-7460	0-10	Hemilepidotus sp.	Quadrate	-	-	6.2	24.8	4	437.438	943.4937276
KMS-7461	0-10	Hemilepidotus sp.	Quadrate	-	-	5.3	20.2	4	357.352	770.7592174
KMS-7462	0-10	Hemilepidotus sp.	Quadrate	-	-	5.7	23.4	4	413.064	890.922355
KMS-7463	0-10	Hemilepidotus sp.	Quadrate	-	-	5.2	21.5	4	379.985	819.5754921
KMS-7464	0-10	Hemilepidotus sp.	Quadrate	-	-	5.1	18.9	4	334.719	721.9429428
KMS-7465	0-10	Hemilepidotus sp.	Quadrate	-	-	6.5	25.3	4	446.143	962.2692179
KMS-7466	0-10	Hemilepidotus sp.	Quadrate	-	-	4	Inc	3	309.35	667.2254917
KMS-7467	0-10	Hemilepidotus sp.	Quadrate	-	-	4.9	19.4	4	343.424	740.7184331
KMS-8824	0-10	Hemilepidotus sp.	Quadrate	-	-	6.1	20.5	4	362.575	782.0245116
KMS-11037	0-10	Hemilepidotus sp.	Quadrate	-	-	4.9	18.9	4	334.719	721.9429428
KMS-11038	0-10	Hemilepidotus sp.	Quadrate	-	-	Inc	22.8	4	402.618	868.3917667
KMS-11039	0-10	Hemilepidotus sp.	Quadrate	-	-	Inc	21.2	4	374.762	808.3101979
KMS-11040	0-10	Hemilepidotus sp.	Quadrate	-	-	Inc	25.9	4	456.589	984.7998062
KMS-7456	0-10	Hexagrammos sp.	Quadrate	-	-	4.9	Inc	3	387.706	933.2017016
KMS-7457	0-10	Hexagrammos sp.	Quadrate	-	-	4.6	12.4	4	322.238	485.2604185

KMS-7458	0-10	Hexagrammos sp.	Quadrate	-	-	Inc	9.2	4	239.294	186.1444898
KMS-8817	0-10	Hexagrammos sp.	Quadrate	-	-	5.1	Inc	3	402.074	1208.660438
KMS-8818	0-10	Hexagrammos sp.	Quadrate	-	-	4.5	11.7	3	358.97	841.8033753
KMS-8819	0-10	Hexagrammos sp.	Quadrate	-	-	4.9	12.9	3	387.706	1076.696173
KMS-11031	0-10	Hexagrammos sp.	Quadrate	-	-	4.8	12.8	3	380.522	1014.410355
KMS-11032	0-10	Hexagrammos sp.	Quadrate	-	-	Inc	12.1	4	314.462	478.55211
KMS-11033	0-10	Hexagrammos sp.	Quadrate	-	-	3.9	Inc	3	315.866	556.6769156
KMS-11034	0-10	Hexagrammos sp.	Quadrate	-	-	2.9	8.5	3	244.026	236.45947
KMS-11035	0-10	Hexagrammos sp.	Quadrate	-	-	3.7	Inc	3	301.498	478.1118199
KMS-7047	0-10	Pleurogrammus monopterygius	Atlas	5.6	6.5	2.7	-	1	408.218	853.0736399
KMS-7048	0-10	Pleurogrammus monopterygius	Atlas	Inc	5.8	2.3	-	2	358.156	2467.98504
KMS-7049	0-10	Pleurogrammus monopterygius	Atlas	Inc	Inc	2	-	3	315.89	354.147998
KMS-7050	0-10	Pleurogrammus monopterygius	Atlas	Inc	5.7	2.8	-	2	352.734	2306.137963
KMS-7051	0-10	Pleurogrammus monopterygius	Atlas	5.5	6.1	2.5	-	1	402.105	810.3717829
KMS-7052	0-10	Pleurogrammus monopterygius	Atlas	5.2	6.1	2.7	-	1	383.766	690.6534329
KMS-7053	0-10	Pleurogrammus monopterygius	Atlas	5.2	6.5	2.4	-	1	383.766	690.6534329
KMS-8972	0-10	Pleurogrammus monopterygius	Atlas	4.6	5.7	2.2	-	1	347.088	535.7546076
KMS-8973	0-10	Pleurogrammus monopterygius	Atlas	5.7	6.4	2.6	-	1	414.331	987.0733649
KMS-11332	0-10	Pleurogrammus monopterygius	Atlas	Inc	Inc	2.6	-	3	403.808	932.4719168
KMS-11333	0-10	Pleurogrammus monopterygius	Atlas	5.2	6.2	2.2	-	1	383.766	759.828578

KMS-11334	0-10	Pleurogrammus monopterygius	Atlas	5.6	6.4	2.8	-	1	408.218	938.5166277
KMS-11335	0-10	Pleurogrammus monopterygius	Atlas	4.1	5.2	2.1	-	1	316.523	385.9580345
KMS-11336	0-10	Pleurogrammus monopterygius	Atlas	3.9	4.2	1.7	-	1	304.297	334.6880641
KMS-11337	0-10	Pleurogrammus monopterygius	Atlas	5.4	6	2.5	-	1	395.992	846.1128874
KMS-11338	0-10	Pleurogrammus monopterygius	Atlas	4.2	5.1	2.3	-	1	322.636	413.3962875
KMS-11339	0-10	Pleurogrammus monopterygius	Atlas	6	5.9	Inc	-	1	432.67	1142.449884
KMS-11340	0-10	Pleurogrammus monopterygius	Atlas	4.6	5.8	2.7	-	1	347.088	535.7546076
KMS-11341	0-10	Pleurogrammus monopterygius	Atlas	5.1	6	2.8	-	1	377.653	718.9208785
KMS-11342	0-10	Pleurogrammus monopterygius	Atlas	4.7	6.1	2.5	-	1	353.201	569.6196854
KMS-11343	0-10	Pleurogrammus monopterygius	Atlas	4.4	4.8	2.2	-	1	334.862	472.0045905
KMS-6977	0-10	Sebastes sp.	Atlas	6.2	6.4	6	-	2	327.764	556.3948571
KMS-8839	0-10	Sebastes sp.	Atlas	3.9	5.4	5.2	-	2	285.854	165.1604856
KMS-8840	0-10	Sebastes sp.	Atlas	4.5	5.1	4.4	-	2	273.281	240.2888764
KMS-11234	0-10	Sebastes sp.	Atlas	6.3	6.6	6.4	-	2	336.146	580.2152244
KMS-11235	0-10	Sebastes sp.	Atlas	7.4	7.7	8	-	2	382.247	884.5125234
KMS-0472	10-20	Hemilepidotus sp.	Premaxilla	28.7	Inc	13.2	-	1	367.819	793.3350998
KMS-0473	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	14.7	-	3	532.633	1148.816277
KMS-0474	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	12.7	-	3	452.053	975.0162767
KMS-0475	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	14	-	3	504.43	1087.986277
KMS-0476	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	15.7	-	3	572.923	1235.716277

KMS-0477	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	13.1	-	3	468.169	1009.776277
KMS-0478	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	11.5	-	3	403.705	870.7362765
KMS-7692	10-20	Hemilepidotus sp.	Premaxilla	Inc	Inc	12.1	-	3	427.879	922.8762766
KMS-6558	10-20	Hexagrammos sp.	Angular	26.9	-	6.2	5.5	1	403.904	1329.891361
KMS-6559	10-20	Hexagrammos sp.	Angular	21.4	-	4.3	4.2	1	323.274	632.3623695
KMS-6560	10-20	Hexagrammos sp.	Angular	17.3	-	3.9	3.9	1	263.168	316.7897272
KMS-0394	10-20	Hexagrammos sp.	Angular	22.8	-	Inc	Inc	1	343.798	776.9794053
KMS-0395	10-20	Hexagrammos sp.	Angular	18.3	-	-	-	1	277.828	380.2658248
KMS-0396	10-20	Hexagrammos sp.	Angular	Inc	-	6.7	Inc	3	512.1	1288.489584
KMS-0397	10-20	Hexagrammos sp.	Angular	20.8	-	-	-	1	314.478	576.5368798
KMS-0398	10-20	Hexagrammos sp.	Angular	20.5	-	-	-	1	310.08	549.9475899
KMS-0399	10-20	Hexagrammos sp.	Angular	22.6	-	-	-	1	340.866	755.0464708
KMS-0400	10-20	Hexagrammos sp.	Angular	23.1	-	-	-	1	348.196	810.7000305
KMS-0501	10-20	Gadus macrocephalus	Quadrate	-	-	17.3	Inc	3	1089.214	19791.32722
KMS-6581	10-20	Pleurogrammus monopterygius	Dentary	Inc	7.2	Inc	Inc	2	472.714	1610.628835
KMS-1087	10-20	Pleurogrammus monopterygius	Dentary	Inc	6.4	Inc	-	2	433.698	1206.901397
KMS-0835	10-20	Pleurogrammus monopterygius	Dentary	21.6	4.1	10.5	-	1	322.338	445.608132
KMS-0836	10-20	Pleurogrammus monopterygius	Dentary	Inc	5	Inc	-	2	365.42	659.1850731
KMS-0837	10-20	Pleurogrammus monopterygius	Dentary	Inc	5.7	11.3	-	3	322.027	410.3572051
KMS-0838	10-20	Pleurogrammus monopterygius	Dentary	24.5	5.6	12.9	-	1	357.515	646.9960274

KMS-0839	10-20	Pleurogrammus monopterygius	Dentary	Inc	6	12.9	-	3	360.891	616.1999409
KMS-0840	10-20	Pleurogrammus monopterygius	Dentary	24.7	5.3	12	-	1	359.941	662.754959
KMS-0841	10-20	Pleurogrammus monopterygius	Dentary	31.5	7	13.1	-	1	442.425	1361.348269
KMS-0842	10-20	Pleurogrammus monopterygius	Dentary	Inc	Inc	12.6	-	3	353.604	573.2562722
KMS-0843	10-20	Pleurogrammus monopterygius	Dentary	Inc	4	Inc	-	2	316.65	381.5731722
KMS-0844	10-20	Pleurogrammus monopterygius	Dentary	22.2	4.6	10.6	-	1	329.616	483.2532781
KMS-0845	10-20	Pleurogrammus monopterygius	Dentary	27.7	5.8	11.5	-	1	396.331	930.4865948
KMS-0846	10-20	Pleurogrammus monopterygius	Dentary	Inc	4.3	10.9	-	3	312.311	367.3758386
KMS-0847	10-20	Pleurogrammus monopterygius	Dentary	Inc	5.5	11	-	3	314.74	377.821602
KMS-0848	10-20	Pleurogrammus monopterygius	Dentary	Inc	5.1	12.1	-	3	341.459	506.2468438
KMS-0849	10-20	Pleurogrammus monopterygius	Dentary	Inc	5.8	Inc	-	2	404.436	948.2643816
KMS-0811	10-20	Sebastes sp.	Dentary	38.8	7.8	19.2	-	3	320.078	562.5138709
KMS-0812	10-20	Sebastes sp.	Dentary	35.9	7.3	18.2	-	3	305.538	481.9466839
KMS-0813	10-20	Sebastes sp.	Dentary	Inc	8.9	22	-	3	360.79	833.6701137
KMS-0814	10-20	Sebastes sp.	Dentary	Inc	6.8	10.1	-	3	187.764	87.87826124
KMS-0815	10-20	Sebastes sp.	Dentary	Inc	7.9	10.7	-	3	196.488	103.8273579
KMS-7923	10-20	Hexagrammos sp.	Quadrate	-	-	4.8	Inc	3	380.522	1014.410355
KMS-7924	10-20	Hexagrammos sp.	Quadrate	-	-	4.3	Inc	3	344.602	738.1597059
KMS-7925	10-20	Hexagrammos sp.	Quadrate	-	-	4.1	9.9	3	330.234	643.2382235
KMS-7926	10-20	Hexagrammos sp.	Quadrate	-	-	4.3	Inc	3	344.602	738.1597059

KMS-0516	10-20	Hexagrammos sp.	Quadrate	-	-	3.4	8.7	3	279.946	374.4558055
KMS-0517	10-20	Hexagrammos sp.	Quadrate	-	-	4.6	10.4	3	366.154	897.008651
KMS-0518	10-20	Hexagrammos sp.	Quadrate	-	-	3.6	9.9	3	294.314	441.7135533
KMS-0519	10-20	Hexagrammos sp.	Quadrate	-	-	4.6	11.1	3	366.154	897.008651
KMS-0520	10-20	Hexagrammos sp.	Quadrate	-	-	5.4	13	3	423.626	1425.753557
KMS-0521	10-20	Hexagrammos sp.	Quadrate	-	-	4.8	12.1	3	380.522	1014.410355
KMS-0522	10-20	Hexagrammos sp.	Quadrate	-	-	5.7	12.7	3	445.178	1666.8819
KMS-12043	20-30	Gadus macrocephalus	Quadrate	-	-	12.8	45.1	4	843.442	8383.39682
KMS-12044	20-30	Gadus macrocephalus	Quadrate	-	-	7.5	29.9	4	571.058	2373.605765
KMS-12027	20-30	Hemilepidotus sp.	Quadrate	-	-	5.6	Inc	3	417.402	900.2788256
KMS-12028	20-30	Hemilepidotus sp.	Quadrate	-	-	Inc	18.4	4	326.014	703.1674526
KMS-12029	20-30	Hemilepidotus sp.	Quadrate	-	-	5.7	22.8	4	402.618	868.3917667
KMS-12030	20-30	Hemilepidotus sp.	Quadrate	-	-	6.1	23.1	4	407.841	879.6570608
KMS-12031	20-30	Hemilepidotus sp.	Quadrate	-	-	6.7	25	4	440.92	951.0039237
KMS-9368	20-30	Hemilepidotus sp.	Quadrate	-	-	6.5	23.2	4	409.582	883.4121589
KMS-9369	20-30	Hemilepidotus sp.	Quadrate	-	-	5	21.8	4	385.208	830.8407862
KMS-9370	20-30	Hemilepidotus sp.	Quadrate	-	-	Inc	24.2	4	426.992	920.9631393
KMS-9371	20-30	Hemilepidotus sp.	Quadrate	-	-	6.7	24.2	4	426.992	920.9631393
KMS-9372	20-30	Hemilepidotus sp.	Quadrate	-	-	Inc	21.4	4	378.244	815.820394
KMS-2824	20-30	Hemilepidotus sp.	Quadrate	-	-	6.6	24.5	4	432.215	932.2284335

KMS-2825	20-30	Hemilepidotus sp.	Quadrate	-	-	6	23.5	4	414.805	894.677453
KMS-2826	20-30	Hemilepidotus sp.	Quadrate	-	-	Inc	19.7	4	348.647	751.9837272
KMS-12032	20-30	Hexagrammos sp.	Quadrate	-	-	4.3	10.8	3	344.602	738.1597059
KMS-12033	20-30	Hexagrammos sp.	Quadrate	-	-	4.4	11.7	3	351.786	788.8687147
KMS-12034	20-30	Hexagrammos sp.	Quadrate	-	-	4.2	Inc	3	337.418	689.6312727
KMS-12035	20-30	Hexagrammos sp.	Quadrate	-	-	4.5	11.7	3	358.97	841.8033753
KMS-12036	20-30	Hexagrammos sp.	Quadrate	-	-	4.2	Inc	3	337.418	689.6312727
KMS-9363	20-30	Hexagrammos sp.	Quadrate	-	-	4.9	17.8	3	387.706	1076.696173
KMS-9364	20-30	Hexagrammos sp.	Quadrate	-	-	4.2	11.1	3	337.418	689.6312727
KMS-9365	20-30	Hexagrammos sp.	Quadrate	-	-	5.5	Inc	3	430.81	1503.400432
KMS-2815	20-30	Hexagrammos sp.	Quadrate	-	-	Inc	14.1	4	366.302	732.9673183
KMS-2816	20-30	Hexagrammos sp.	Quadrate	-	-	4.9	13.9	4	361.118	700.1140091
KMS-13002	20-30	Pleurogrammus monopterygius	Angular	33.4	12.3	4.5	Inc	1	418.94	895.7277255
KMS-13003	20-30	Pleurogrammus monopterygius	Angular	Inc	Inc	Inc	2.9	4	328.712	445.1339967
KMS-13004	20-30	Pleurogrammus monopterygius	Angular	27.8	10.2	3.4	3.5	1	353.7	493.3391563
KMS-13005	20-30	Pleurogrammus monopterygius	Angular	Inc	11.5	4.2	4.1	2	379.9	716.2634402
KMS-9604	20-30	Pleurogrammus monopterygius	Angular	29.2	11.3	3.5	3.8	1	370.01	578.7543486
KMS-9605	20-30	Pleurogrammus monopterygius	Angular	32	12.3	3.2	Inc	1	402.63	779.3587749
KMS-9606	20-30	Pleurogrammus monopterygius	Angular	29.9	10.4	4.6	3.8	1	378.165	625.0738953
KMS-9607	20-30	Pleurogrammus monopterygius	Angular	27.1	9.7	3.8	2.9	1	345.545	454.0986339

KMS-9608	20-30	Pleurogrammus monopterygius	Angular	32.6	11.2	4	4.2	1	409.62	827.8605739
KMS-9609	20-30	Pleurogrammus monopterygius	Angular	33.5	13.2	3.7	4.5	1	420.105	904.4730331
KMS-9610	20-30	Pleurogrammus monopterygius	Angular	Inc	12.9	4.3	4.2	2	420.416	1023.850389
KMS-9611	20-30	Pleurogrammus monopterygius	Angular	31	12.1	4.3	4.2	1	390.98	702.9517314
KMS-9612	20-30	Pleurogrammus monopterygius	Angular	Inc	13.2	Inc	Inc	2	429.098	1099.733429
KMS-9613	20-30	Pleurogrammus monopterygius	Angular	32.6	12.5	4.1	4	1	409.62	827.8605739
KMS-9614	20-30	Pleurogrammus monopterygius	Angular	28.5	11.5	3.9	Inc	1	361.855	534.8669892
KMS-9615	20-30	Pleurogrammus monopterygius	Angular	33.4	12.3	4.4	4.1	1	418.94	895.7277255
KMS-9616	20-30	Pleurogrammus monopterygius	Angular	29.3	10.3	3.6	3.8	1	371.175	585.2208171
KMS-9617	20-30	Pleurogrammus monopterygius	Angular	Inc	Inc	Inc	3.8	4	397.094	870.1758963
KMS-9618	20-30	Pleurogrammus monopterygius	Angular	34.1	13.1	4	4.5	1	427.095	958.1902154
KMS-9619	20-30	Pleurogrammus monopterygius	Angular	33.5	12.8	3.5	4.3	1	420.105	904.4730331
KMS-9620	20-30	Pleurogrammus monopterygius	Angular	29.6	12	4	3.6	1	374.67	604.9201636
KMS-9621	20-30	Pleurogrammus monopterygius	Angular	29.3	11.2	4	3.5	1	371.175	585.2208171
KMS-9622	20-30	Pleurogrammus monopterygius	Angular	30.8	11.5	4.1	3.8	1	388.65	688.3191123
KMS-9623	20-30	Pleurogrammus monopterygius	Angular	30.6	11.3	4.1	3.9	1	386.32	673.8987271
KMS-9624	20-30	Pleurogrammus monopterygius	Angular	34.2	12.9	3.8	4	1	428.26	967.3526922
KMS-2722	20-30	Pleurogrammus monopterygius	Angular	Inc	12.9	3.7	Inc	2	420.416	1023.850389
KMS-2723	20-30	Pleurogrammus monopterygius	Angular	34.6	13.8	3.7	4.2	1	432.89	1004.609593
KMS-2724	20-30	Pleurogrammus monopterygius	Angular	Inc	13	4	4	2	423.31	1048.736363

KMS-2725	20-30	Pleurogrammus monopterygius	Angular	29	10.1	3.3	3.5	1	367.65	565.9701065
KMS-2726	20-30	Pleurogrammus monopterygius	Angular	Inc	Inc	Inc	4.4	4	442.682	1251.717625
KMS-2727	20-30	Pleurogrammus monopterygius	Angular	33.4	Inc	3.6	4.3	1	418.91	895.7277255
KMS-2728	20-30	Pleurogrammus monopterygius	Angular	27.3	Inc	3	2.8	1	347.845	465.0810057
KMS-2729	20-30	Pleurogrammus monopterygius	Angular	34	11.1	4	4.1	1	425.9	949.0879957
KMS-2730	20-30	Pleurogrammus monopterygius	Angular	32.7	12.2	Inc	3.3	1	410.755	836.1423027
KMS-2731	20-30	Pleurogrammus monopterygius	Angular	32.5	Inc	3.6	3.8	1	408.425	819.6358075
KMS-2732	20-30	Pleurogrammus monopterygius	Angular	33.2	12.3	3.6	3.8	1	416.58	878.4130356
KMS-2733	20-30	Pleurogrammus monopterygius	Angular	Inc	Inc	3.5	4.3	4	435.084	1182.348486
KMS-2734	20-30	Pleurogrammus monopterygius	Angular	33.7	13.1	3.7	4.4	1	422.405	922.1406728
KMS-2735	20-30	Pleurogrammus monopterygius	Angular	33.3	11.8	3.8	4.4	1	417.745	887.0411328
KMS-2736	20-30	Pleurogrammus monopterygius	Angular	32	12.2	4	4.3	1	402.6	779.3587749
KMS-2737	20-30	Pleurogrammus monopterygius	Angular	Inc	Inc	Inc	4.7	4	465.476	1474.166091
KMS-2738	20-30	Pleurogrammus monopterygius	Angular	33.4	12.1	4	4.6	1	418.91	895.7277255
KMS-2739	20-30	Pleurogrammus monopterygius	Angular	30.9	12.3	4.1	4.1	1	389.785	695.6087849
KMS-2740	20-30	Pleurogrammus monopterygius	Angular	Inc	Inc	3.7	3.6	4	381.898	760.9812067
KMS-2741	20-30	Pleurogrammus monopterygius	Angular	29.2	Inc	3.2	3.7	1	369.98	578.7543486
KMS-2742	20-30	Pleurogrammus monopterygius	Angular	Inc	11.5	3.4	4	2	379.9	716.2634402
KMS-5341	20-30	Pleurogrammus monopterygius	Angular	33	-	-	-	1	414.28	861.3314492
KMS-5342	20-30	Pleurogrammus monopterygius	Angular	32.5	-	-	-	1	408.455	819.6358075

KMS-5343	20-30	Pleurogrammus monopterygius	Angular	34.9	-	-	-	1	436.415	1033.195813
KMS-5344	20-30	Pleurogrammus monopterygius	Angular	34.4	-	-	-	1	430.59	985.8593016
KMS-5345	20-30	Pleurogrammus monopterygius	Angular	33.7	-	-	-	1	422.435	922.1406728
KMS-5346	20-30	Pleurogrammus monopterygius	Angular	25.3	-	-	-	1	324.575	363.1965327
KMS-5347	20-30	Pleurogrammus monopterygius	Angular	31.2	-	-	-	1	393.31	717.7983085
KMS-5348	20-30	Pleurogrammus monopterygius	Angular	35.2	-	-	-	1	439.91	1062.340299
KMS-13016	20-30	Sebastes sp.	Angular	37.1	23.6	-	3.9	2	328.132	107.7255472
KMS-13017	20-30	Sebastes sp.	Angular	Inc	Inc	-	5.5	4	432.905	1437.110161
KMS-9631	20-30	Sebastes sp.	Angular	36.1	23.1	-	3.6	2	322.772	103.0767368
KMS-2780	20-30	Sebastes sp.	Angular	34.3	Inc	-	3.4	1	304.28	575.5698631
KMS-2781	20-30	Sebastes sp.	Angular	35.1	21.1	-	3.6	2	301.332	443.8685418
KMS-5660	20-30	Hemilepidotus sp.	Quadrate	-	-	4.9	Inc	3	370.118	798.2937273
KMS-5661	20-30	Hemilepidotus sp.	Quadrate	-	-	6.2	23.5	4	414.805	894.677453
KMS-5662	20-30	Hemilepidotus sp.	Quadrate	-	-	4.5	Inc	3	343.11	740.0411782
KMS-5663	20-30	Hemilepidotus sp.	Quadrate	-	-	4.3	18.7	4	331.237	714.4327467
KMS-5664	20-30	Hemilepidotus sp.	Quadrate	-	-	5.6	22.2	4	392.172	845.8611784
KMS-5665	20-30	Hemilepidotus sp.	Quadrate	-	-	5	20.3	4	359.093	774.5143155
KMS-5666	20-30	Hemilepidotus sp.	Quadrate	-	-	Inc	22.1	4	390.431	842.1060803
KMS-5667	20-30	Hemilepidotus sp.	Quadrate	-	-	6.4	24.7	4	435.697	939.7386296
KMS-12037	20-30	Hexagrammos sp.	Quadrate	-	-	4.8	12.2	3	380.522	820.7337274

KMS-12038	20-30	Hexagrammos sp.	Quadrate	-	-	4	Inc	3	323.05	696.7745114
KMS-2817	20-30	Hexagrammos sp.	Quadrate	-	-	5	Inc	3	394.89	851.7235313
KMS-2818	20-30	Hexagrammos sp.	Quadrate	-	-	4.5	Inc	3	358.97	774.2490214
KMS-2819	20-30	Hexagrammos sp.	Quadrate	-	-	5.3	Inc	3	416.442	898.2082373
KMS-9361	20-30	Hexagrammos sp.	Quadrate	-	-	5	Inc	3	394.89	851.7235313
KMS-9362	20-30	Hexagrammos sp.	Quadrate	-	-	5.9	Inc	3	459.546	991.1776493
KMS-5657	20-30	Hexagrammos sp.	Quadrate	-	-	5.1	Inc	3	402.074	867.2184333
KMS-5658	20-30	Hexagrammos sp.	Quadrate	-	-	5.4	Inc	3	423.626	913.7031393
KMS-5659	20-30	Hexagrammos sp.	Quadrate	-	-	4.8	Inc	3	380.522	820.7337274
KMS-4990	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4.4	Inc	3	351.786	758.7541194
KMS-4991	30-40	Pleurogrammus monopterygius	Quadrate	-	-	3.8	Inc	3	308.682	665.7847074
KMS-4992	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4.6	Inc	3	366.154	789.7439234
KMS-4993	30-40	Pleurogrammus monopterygius	Quadrate	-	-	5.6	Inc	3	437.994	944.6929433
KMS-4994	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4.6	Inc	3	366.154	789.7439234
KMS-4995	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4.3	Inc	3	344.602	743.2592174
KMS-4996	30-40	Hemilepidotus sp.	Quadrate	-	-	5.1	19.7	4	348.647	751.9837272
KMS-4997	30-40	Hemilepidotus sp.	Quadrate	-	-	5.9	Inc	3	437.638	943.9251002
KMS-4998	30-40	Hemilepidotus sp.	Quadrate	-	-	5.7	Inc	3	424.134	914.7988256
KMS-4922	30-40	Hexagrammos sp.	Dentary	Inc	6.4	Inc	-	2	347.5	912.6158346
KMS-4923	30-40	Hexagrammos sp.	Dentary	21.9	7.8	10.8	-	3	311.546	478.69056

KMS-5237	30-40	Sebastes sp.	Atlas	6.5	6.8	6.3	-	2	344.528	629.7234629
KMS-4727	30-40	Gadus macrocephalus	Dentary	68.1	-	47.9	-	1	731.133	5024.438307
KMS-4693	30-40	Hemilepidotus sp.	Quadrate	-	-	4.4	Inc	3	336.358	725.4780409
KMS-4694	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4.5	Inc	3	407.455	957.8212808
KMS-4695	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4.1	Inc	3	381.331	761.7807353
KMS-2533	30-40	Pleurogrammus monopterygius	Quadrate	-	-	4	Inc	3	374.8	716.8846424
KMS-2534	30-40	Pleurogrammus monopterygius	Quadrate	-	-	3.7	Inc	3	355.207	591.7768057
KMS-0056	45-50	Hemilepidotus sp.	Premaxilla	29.5	Inc	13.6	Inc	3	487.634	1051.75961
KMS-0275	45-50	Hexagrammos sp.	Quadrate	-	-	3.8	10.4	3	308.682	516.417668
KMS-0199	45-50	Pleurogrammus monopterygius	Angular	34.1	13.5	4.5	4.3	1	427.095	958.1902154
KMS-0200	45-50	Pleurogrammus monopterygius	Angular	32.1	12.3	3.8	4	1	403.795	787.3020011
KMS-0201	45-50	Pleurogrammus monopterygius	Angular	Inc	Inc	4.4	4.3	4	435.084	1182.348486
KMS-0202	45-50	Pleurogrammus monopterygius	Angular	Inc	12.2	Inc	Inc	2	400.158	860.7590036
KMS-0348	50-55	Hemilepidotus sp.	Epihyal	Inc	3.3	Inc	-	2	477.63	1030.182355
KMS-0386	50-55	Pleurogrammus monopterygius	Dentary	Inc	5.7	13.7	-	3	380.323	741.2136061
KMS-0387	50-55	Pleurogrammus monopterygius	Dentary	26.6	5.3	12.3	-	3	346.317	532.3777958