Report of the 2015 University of Montana Investigations at *Temyiq Tuyuryaq*, the Old Togiak Site (GDN-00203), Bristol Bay, Southwest Alaska

Edited by

Anna Marie Prentiss and Kristen D. Barnett

Department of Anthropology, The University of Montana, Missoula MT 59812

Conducted in Collaboration with the Togiak Traditional Council and the Togiak Community**,** the Bristol Bay Native Corporation, Cook Inlet Regional, Inc. and the Bristol Bay Native Association

Sponsored by the National Science Foundation (PLR-1339445) and the University of Montana

Acknowledgements

This research was funded by an EAGER grant (PLR-1339445) from the Arctic Social Sciences Program of the National Science Foundation and time and space for laboratory research was provided by the University of Montana (UM). We thank Anna Kerttula for her work at NSF to help facilitate the project. We thank John Douglas for use of his lab. This research was carried out as a collaborative partnership with the Togiak Traditional Council and Togiak Community, the Bristol Bay Native Corporation, Cook Inlet Regional, Inc. and the Bristol Bay Native Association. We thank in particular Togiak Traditional Council members 2012 to present, Helen Gregorio, Teo Pauk, Francesca Kamkahpak, Pete Abraham, Francisca Demoski, and Tiel Smith. Field research was assisted by interns Brianna Aspelund and David Clark along with UM graduate student, Ethan Ryan. We thank Hans Reed and the staff of North Pacific Seafoods for logistical help while in the field. We also thank the USFWS Togiak National Wildlife Refuge for logistical aid in developing the project. Our UM lab team included Dougless Skinner, Sarah Nowell, and Nathaniel Perhay. We thank our funded and unfunded collaborators including Thomas Foor, Steven Sheriff, Owen Mason, Cynthia Zutter, Natasha Lyons, and the staff at DirectAMS. Finally we thank Francisca Demoski for editorial comments regarding appropriate local Yup'ik names.

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Chapter One
Introduction

(Anna Marie Prentiss)

The Togiak Archaeological and Paleoecological Project (TAPP) was designed to be a long-term archaeological and paleoecological study of Yup'ik Eskimo village establishment and growth, traditional subsistence variability, and technology in the context of climate change during the past 1000 years. With a research focus on *Temyiq Tuyuryaq*, the Old Togiak archaeological site (Kowta 1963), the project seeks to contribute towards an enhanced understanding of the ancient history of the Bristol Bay Yup'ik people from the early Thule (ancestral Yup'ik) period through developments during the early Colonial period (e.g. Dumond 2009; Shaw 1998; VanStone 1967). It doing so it is also expected to contribute to a deeper scientific understanding of relationships between human predation pressure, changing climate regimes and variability in key prey populations, especially emphasizing salmon (e.g. Finney et al. 2002) and several species of pinnipeds (e.g. Betts et al. 2011; Hill 2011; Rick et al. 2011). While there has been extensive research into late Holocene cultural and ecological developments on the Alaska Peninsula, the eastern Aleutians, and Kodiak Island (Betts et al. 2011; Davis and Knecht 2010; Fitzhugh 2003; Jordan and Maschner 2000; Lech et al. 2011; Maschner 1999; Maschner et al. 2009a, 2009b; Maschner and Hoffman 2003; West 2009), there have been virtually no modern archaeological studies of these processes in the northern Bristol Bay area. Consequently, our understanding of long term culture change and human and climate impacts on populations of fish and sea mammals is very poorly developed in this area.

The archaeological record of the north Bristol Bay area is extensive with frequent large and complex villages generally dating to within the past 2500 years whose occupants are generally considered to be ancestral to today's Yup'ik people (Ackerman 1964; Bailey 1992; Bundy 2007; Dumond 2003, 2009; Kowta 1963; Larsen 1950; Ross 1971; Schaaf et al. 2007; Shaw 1998; Staley 1992). One such village, now known as *Temyiq Tuyuryaq*, the Old Togiak site, is about 75 by 180 meters in extent and consists of one large mound stretching approximately 130 meters in length adjacent to three smaller mounds. The site is located on an accreting sand spit (Mason, Appendix D) featuring a sequence of beach ridges dating to the past 1500 years. Depressions across several of the beach ridges and the mounds reflect an array of late-dating house structures and cache pits, in addition to some illicit modern excavations. Excavations at *Temyiq Tuyuryaq* in 1960 (Kowta 1963) focused on the large mound and revealed deeply stratified deposits (at least four meters) that included indicators of house structures, clay-lined cache pits, possible outdoor activity areas, and shell midden material. Clearly the *Temyiq Tuyuryaq* mounds accumulated through many occupation events leaving complex stratigraphic records. Artifacts recovered during excavations suggested to Kowta (1963) that the site was occupied by the Yup'ik people primarily during the late pre-colonial period or ca. 1000 to 1700 AD. However, a detailed, chronometrically dated stratigraphic sequence was not established. Kowta (1963) excavated approximately "200 cubic yards" in a single block within the large mound during the summer of 1960, working primarily alone. Recovery of artifacts and faunal remains was accomplished without use of screens. Despite this and his reliance upon a "selective" approach to collecting faunal remains, Kowta still recovered 4070 stone, bone, ivory, antler, and wood artifacts, 622 mammal bones (including marine and terrestrial taxa), 462 bird remains, and an unreported quantity of fish and invertebrates.

Kowta (1963) described the mounds as middens yet also described layers containing cache pits and complex distributions of wooden planks and other items. His profiles depict buried depressions that appear to be small housepits. Consequently, it is clear that the *Temyiq Tuyuryaq* mounds actually represent "house-mounds" with some midden fill similar to that recognized in Bering Strait and northern Alaskan contexts (e.g. Csonka 2003; Ford 1959; Stanford 1976), but on a very large scale. Kowta's dissertation research indicates that the archaeological record of this village formed in a manner somewhat similar to the village mounds or "tells" of the Near East (e.g. Mellaart 1967; Kenyon 1960; Kuijt et al. 2011; Moore et al. 2000; Rollefson et al. 1992) whereby the mounds accumulated as the consequence of cycles of household construction, use, abandonment, and subsequent new construction. It also appears that new living surfaces may have been created by filling voids between houses and in old house depressions with midden material and other sediments. If *Temyiq Tuyuryaq* is effectively a stratified village with excellent preservation of organic materials it opens the possibility of addressing a wide array of archaeological research questions linked to village history and socio-economic and political change associated with the Thule phase in Southwest Alaska. Given these parameters we expected this research, if fully developed, to also impact wider discussions concerning village establishment (Bandy and Fox 2010), household archaeology (Douglas and Conlin 2012; Hoffman 1999), village socio-economic change (Prentiss et al. 2007, 2012), and subsistence intensification (Betts et al. 2011; Broughton 1994; Butler and Campbell 2004; Janetski 1997).

This study represents the first season of what could become a long term project designed to test a variety of hypotheses regarding Thule period (ancestral Yup'ik) village histories and paleoecology in the Bristol Bay area. Over the long term, this work offers a test of hypotheses linking climate change to village demographics, foraging strategies, and social relationships (e.g. Maschner et al. 2009a). Consequently, it furthers archaeological understanding of the Thule phenomenon in general and impacts current discussions regarding the ancient history of the Yup'ik people (Dumond 2009). Most specifically, the research developed under this grant focuses on developing a thorough stratigraphic understanding of the site through mapping, geophysics, coring, radiocarbon dating, and paleoecological studies. The research is pursued in a collaborative relationship between The University of Montana and the Togiak Community and Bristol Bay Native Corporation, the contemporary descendants of the original site occupants. In the long term, we expect the project to permit development of comprehensive understanding of cultural and ecological processes drawing upon both scientific and traditional knowledge (e.g. Frink 2009; Krupnik and Ray 2007).

This report provides results of the 2015 field investigations and subsequent lab studies at *Temyiq Tuyuryaq*, the Old Togiak site. In the next chapter we review field and lab procedures, site spatial organization, cultural and geological stratigraphy, radiocarbon dating, and faunal and botanical remains. The latter include macrobotanicals and pollen samples. We close with conclusions that reflect on hypotheses proposed in this chapter, paleoecological patterns, and finally with recommendations for future research.

Goals of the 2015 Field Season and Associated Lab Studies

The 2015 field season of the Togiak Archaeological and Paleoecological Project offers contributions in three critical areas: Yup'ik archaeology, village archaeology, and archaeological geophysical studies.

Yup'ik Archaeology. Archaeological study of *Temyiq Tuyuryaq* is designed to permit our team to examine processes behind the historical development of traditional Yup'ik cultural traditions, the rise of large villages in the eastern Bering Sea, subsistence intensification processes particularly associated with fish and sea mammals, technological evolution, and impacts of climate change. Yup'ik culture history has been approached from archaeological and ethnohistorical standpoints. Dumond (2009; see also Shaw 1998) has offered the primary archaeological contributions to understanding the long term culture history in the Bristol Bay area. Ethnohistorical research was conducted by VanStone (1967) in association with excavations of Colonial period sites (VanStone 1968, 1970). However, a range of questions remain unanswered regarding the development of a range of practices from technologies to social and ritual traditions (e.g. Fienup-Riordan 1994).

Village Archaeology. The frequent presence of well-preserved large villages with dozens to hundreds of house depressions and radiocarbon dates spanning the last several millennia (e.g. Maschner 2004) places the North Pacific/eastern Bering Sea region as one of the world's preeminent places to study the evolution of village life. Village development and subsistence intensification has been intensively studied in the eastern Aleutians, both the Upper and Lower Alaska Peninsula, and on Kodiak Island (e.g. Dumond 1981; Hoffman 1999; Fitzhugh 2003; Knecht 1995; Maschner 1999; Maschner and Hoffman 2003; Maschner and Jordan 2008; Maschner et al. 2009a; Partlow 2000). Archaeologists of these areas have developed an increasingly sophisticated understanding of relationships between dynamics of climate change, landscape and resource variability, human predation practices, and aspects of cultural variation (Betts et al. 2011; Jordan and Maschner 2000; Maschner et al. 2009b; West 2009). Modern research on such questions has not happened yet in the northern Bristol Bay area and consequently, there is little archaeological literature concerning late Holocene interactions between human groups and favored prey populations, especially salmon, seals, and walrus (e.g. Crockford and Frederick 2011; Hill 2011). Also largely missing throughout the larger region are long-term studies that examine in detail specific village histories with combined landscape level and detailed household research. This kind of research permits archaeologists to address the decisions made at individual and group levels impacting demography, technological evolution, inter-village interactions, and social change (Cameron and Duff 2008; Clark et al. 2010; Kuijt 2000; Peterson and Shelach 2010; Prentiss et al. 2008, 2012; Rollefson 2000; Schachner 2010). The stratified house-mounds at *Temyiq Tuyuryaq* offer an opportunity to examine long term village history in order to study these kinds of problems. Given the potential complexity of household and midden sediments, this initial phase of research focused on mapping, geophysics, dating, and geoarchaeology is considered critical.

Archaeological Geophysics Studies. This research provided the chance for our team to develop and refine geophysical and geoarchaeological approaches to the complex stratigraphic contexts at *Temyiq Tuyuryaq*. Previous research at the Bridge River site in British Columbia established the utility of magnetometry, electrical conductivity, and ground-penetrating radar (GPR) for identifying buried cultural features within complexly stratified contexts (Cross 2010; Prentiss et al. 2008, 2012). This research joins a number of others in contexts featuring multiple earthen-roofed housepits (e.g. Hodgetts et al. 2011; Kvamme 2003, 2008; Kvamme and Ahler 2007; Urban et al. 2012) in demonstrating the utility of geophysical studies for mapping buried distributions of cultural materials. However, significant challenges remain for using geophysics to reconstruct deeply stratified settlements of this nature where there may be multiple living surfaces within one mound (Thompson et al. 2011). These challenges preclude the sole use of any single technique. Multi-method approaches provide multiple data sets that image different subsurface changes in physical processes as aptly demonstrated by thumbing through any issue of *Archaeological Prospection* (e.g. Berge and Drahor 2011a, 2011b; Casana et al. 2008; Schmidt and Fazeli 2007). Building on the recent nearby experience of Urban et al (2012) and our results from Bridge River (Cross 2010; Prentiss et al. 2008, 2012) and Yellowstone National Park (Sheriff et al. 2010; Sheriff and MacDonald, 2011) we expected that magnetic exploration would provide site layout, feature locations, and 3D source geometry. We had planned for a second field season in which other techniques including electrical resistivity and ground-penetrating radar would be explored. However, due to funding issues this was not possible. Thus future work at the site could benefit from application of these additional techniques. Subsequent investigation of specific complex areas, or those with the highest potential rewards, with high resolution (500 MHz) ground penetrating radar could provide refined images and detailed depth structure. Following Monaghan and Peebles (2010), we followed geophysical research with targeted coring, sediment studies, and radiocarbon dating.

Hypotheses

Village archaeology (e.g. Bandy and Fox 2010) offers the opportunity to examine interrelated hypotheses regarding aspects of village evolution, subsistence stability and change in relation to local ecologies, and associated social trajectories that can range from persistence of older patterns to the emergence of new forms of organization. Village evolution studies encompass a host of related hypotheses regarding the emergence, growth, and abandonment of settlements (Bandy 2010; Clark et al. 2010; Prentiss et al. 2007, 2008; Prentiss and Kuijt 2004). Explanatory models often look to relationships between ecological conditions, resource procurement technologies, and demographic growth (and decline) (e.g. Mason 1998), though other factors such as defense (Chatters 2004) may also play a significant role. Clearly related to village history is the second critical area of village research: subsistence change. Demographic growth and decline is most typically predicated on subsistence economy which can vary over time in three potential ways. Subsistence strategies may vary with prevailing local ecologies and will thus be characterized by simple increase or decrease in patterns of usage for critical food resources, or may trend towards true intensification and extensification/diversification (Boserup 1965; Broughton 1994; Chatters 1995; Morrison 1994). Explanatory hypotheses for subsistence change tend to focus on articulations between demographic change, local ecological conditions, and technological variables, though they may also consider social factors (Butler and Campbell 2004; Chatters 1995; Lourandos 1991). Finally, social change may occur during the long term history of villages. One possibility is that strong traditions persist to varying degrees despite change in aspects of local resource ecology and political alignments with surrounding groups (Panich 2013). In contrast social change in many contexts may refer to increases in degrees of social complexity, for example, ranked society in the greater Pacific Northwest and North Pacific regions (Maschner and Hoffman 2003), or concomitant decline and collapse in social structure (Kuijt and Prentiss 2004; Prentiss et al. 2012). Explanatory hypotheses for social change in village societies are highly diverse spanning ecology, demographics, Darwinian processes, evolutionary psychology, and social theory (Ames 2008; Prentiss et al. 2012).

The TAPP was designed to test hypotheses regarding village evolution, foraging and ecology, and social change via survey/mapping, geophysical research, and excavations at *Temyiq Tuyuryaq*. Given that prior to this project there was not yet a detailed radiocarbon chronology at the site and given also the lack of prior knowledge regarding spatial variability in occupation patterns, it was not appropriate to propose specific detailed hypotheses. However, it was appropriate to consider the major hypotheses that link major aspects of village evolution to patterns of climate change in the last millennium. It is well known that the period of ca. AD 900 to 1250/1300 was associated with a pattern of global warming widely recognized as the "Medieval Warm Period" (MWP) subsequently followed by the generally cooler "Little Ice Age" (LIA) (Betts et al. 2011; Hu et al. 2001; Jordan 2009). Arctic scholars have recognized portions of the MWP as times of high climate variability and generally low primary productivity in marine environments that had adverse impacts on human groups in many regions including the eastern Bering Sea and adjacent Gulf of Alaska (Maschner et al. 2009a, 2009b). Maschner et al. (2009a) point out a major shift in atmospheric circulation spanning ca. AD 800-1350 that led to oceanic warming, low primary productivity, declines in salmon stocks, and some sea mammal populations, especially Stellar sea lions. In the Aleutians and Kodiak Island areas, loss of Stellar sea lions also meant loss of critical material (hides) for manufacture of boats, a necessary tool for food acquisition in a maritime economy. Maschner et al. (2009a) suggest that there was a significant decline in number and size of villages in the eastern Aleutians, Alaska Peninsula, and Kodiak Island during this time that also permitted populations of Yup'ik speakers to move into the Pacific region including Kodiak Island, where they are eventually recognized as the Alutiiq people and associated with the Koniag phase. By AD 1400-1450, the Little Ice Age had begun, associated with rising marine productivity and increasing salmon and sea mammal populations (Maschner et al. 2009a). Villages around the region responded with rapid growth, a range of technological enhancements, and a variety of social changes that included the appearance of social ranking with ascribed status as indicated by differential house size and associated wealth, evidence for long distance exchange (especially in elite households), and development of feasts and other rituals, as facilitated by the actions of emergent elites under optimal resource conditions (Maschner and Hoffman 2003).

It has not been clear if the MWP had the same impact on northern Bristol Bay or Kuskokwim Delta groups of the early Thule phase. It does appear likely that populations of the earlier Norton phase were indeed impacted as indicated by abandonment of Norton villages throughout the region by ca. AD 1000 (Dumond 2000, 2009; Shaw 1998). The appearance of Thule villages with its concomitant suite of Asian inspired technologies after ca. AD 1000 suggests to Dumond (2009) that Thule groups with advanced technologies derived from the Bering Strait were better able to cope with ecological changes of the MWP than earlier Norton peoples or the southern presumably Aleut–related groups. This is potentially indicated by the lack of interruption in the MWP radiocarbon chronology at Brooks Camp in the Naknek drainage of the upper Alaska Peninsula across the Norton to Thule phase transition (Dumond 2009). Social and ritual traditions developed in the north would have been transported into the Bristol Bay region during this time where they may have blended with some older (Norton) traditions. Investigation of *Temyiq Tuyuryaq* permits initial testing of these alternative scenarios.

In more formal terms, (Hypothesis 1) the Maschner et al. (2009a) ecological collapse hypothesis suggests that during the MWP, villages in the Bering Sea and North Pacific regions should decline in size, typically leading to abandonment. This should be accompanied by a break-down in markers of household social status and regional trade connections. It should be accompanied by a subsistence regime shifting from a focus on a wide spectrum of fish (herring, salmon, and cod), sea mammals, and terrestrial mammals to a more narrow emphasis on salmon and terrestrial mammals. Under this scenario, *Temyiq Tuyuryaq* was not occupied prior to ca. AD 1400. However, once the Little Ice Age resource conditions developed, the *Temyiq Tuyuryaq* village was not only occupied but rapidly developed into a large winter village with multiple houses of varying sizes and a range of outdoor activity zones and middens. Predation should have focused on salmon, though herring and sea mammals should be important. Indicators of inter-household wealth and status differentiation should be increasingly developed in correlation with demographic expansion within the village and establishment of regional networks. Correspondingly, evidence for exchange and feasting should be most evident during peak resource conditions and demographic packing.

An alternate hypothesis (Hypothesis 2) suggests that while MWP conditions adversely impacted southern (eastern Aleutians and lower Alaska Peninsula) and earlier Norton phase groups in the Kuskokwim Delta and Bristol Bay areas, groups possessing Thule period innovations in boats, weaponry, wood-working tools, houses, pottery, and likely, alternate food acquisition strategies (e.g. new approaches to seal, walrus, and whale hunting derived from Bering Strait) were less affected and indeed took advantage of the sparsely occupied MWP landscape at ca. AD 1000-1200 to establish many new villages like *Temyiq Tuyuryaq*. As MWP conditions were replaced by those of the LIA, Thule phase groups grew rapidly as characterized by a rapidly expanding *Temyiq Tuyuryaq* winter village and intensification of salmon, herring, seals, walrus, toothed whales, and terrestrial mammals. Traditional social practices as documented in Yup'ik ethnographies (Nelson 1899; Fienup-Riordan 1983, 1994) developed and included male-female residential and activity dichotomy, long-distance exchange, feasting and give-away ceremonies, and limited wealth-based ranking. These traditions would be maintained regardless of short-term variability in resource conditions or minor demographic fluctuations. However, late population packing and competition (Dumond 2005) may have resulted in warfare, an intensification of some rituals, exchange networks, and competitive social relationships.

Overview of Research Methods

Testing the alternate hypotheses required a range of research activities and collaborations between field archaeologists and specialists in artifact analysis, geoarchaeology, archaeometry, zooarchaeology, and paleoethnobotany. The 2015 field season and subsequent lab work focused on a careful examination of the site to assess impacts from tidal action and illicit digging, development of a new map for the site, an exploratory geophysical investigation, development of site stratigraphic and local paleoecological history, and radiocarbon dating.

First, the site was inspected for past and current impacts in particular from rising sea level and human actions. Geoarchaeological investigations provided the best data in this regard and are detailed by Mason (Appendix D). However, we also observed routine ongoing illicit digging for artifacts by local people. Second, the site was mapped using a Trimble GeoExplorer 2008 Series GPS system providing the project with an up to date digital map and establishing a formal grid system to facilitate geophysical investigations and coring. Third, an essential component of the 2015 field season was to acquire geophysical data for the site (Sheriff, Appendix C). Finally, a program of sediment coring was initiated to extract material for radiocarbon dating and paleoecological analysis.

Geophysical investigations are a critical part of modern archaeological research, especially where deposits are extensive and complex as they are in many northern environments (Eastahaugh and Taylor 2011; Hodgetts et al. 2011; Horsley and Dockrill 2002; Prentiss et al. 2008, 2012; Urban et al. 2012). Geophysical studies were directed by Dr. Steven Sheriff and emphasized total field magnetic mapping of the site to delineate boundaries as well as the layout of pithouses and other site features (Appendix C). The goal of the geophysical research was to develop applicable methods and to delineate features with total field magnetics. Eventually these results could be used to site 2D electrical resistivity lines, and combine the results to provide 3D models to visualize deeply buried features that can guide excavation. This work is also expected to eventually provide the framework for more detailed investigation with ground penetrating radar (GPR). The ultimate combination of the three methods is expected to eventually guide excavation, yield enhanced site interpretation, and provide the site layout while helping to protect finite archaeological resources. Further, the site stratigraphy is complex and multiple geophysical methods are typically the optimal approach for site reconnaissance as well as overcoming the pitfalls of any particular method (e.g. Urban et al. 2012).

Magnetic exploration is the most commonly applied geophysical tool in archaeological prospection (e.g. Aspinall et al. 2008; Sheriff and MacDonald 2011; Prentiss et al. 2008). Geophysical exploration at Togiak began with total field magnetics, a particularly effective tool for identifying and mapping shallow and deeply buried features. Magnetic gradiometry is also common, but total field sample intervals are wider allowing more efficient field time and simple calculations yield the magnetic gradients from the total field (Pedersen et al., 1990). Thus it provides equivalent results with faster acquisition in the field. The team used standard acquisition techniques employing a Geometrics G-858 Cesium magnetometer for gridded observations and a GEM systems proton precession magnetometer base station for diurnal corrections. Line spacing was one meter with a sampling frequency of 10 Hz. (see Sheriff et al., 2010 and Sheriff and MacDonald 2011). Data processing, edge detection (Cheney et al. 2011; Sheriff et al. 2010), and inversion for 3D source structure with the methods of Sheriff et al. (2010) to delineate site boundaries and locate internal features. As above, while application of electrical resistivity was a part of the original plan, this was not possible given limitations of a single field season.

Surface mapping and geophysical investigations were followed by percussion coring to derive stratigraphic data, paleoecological samples, and radiocarbon dating materials. Archaeological sampling by percussion coring can be a very cost effective way to identify broad trends in site stratigraphy, to explore geoarchaeological questions regarding site formation, collect ecological data (e.g. pollen, shell, and macrobotanicals), and to derive multiple samples for radiocarbon dating from deeply buried deposits (Chatters 1990; Martindale et al. 2009). This project sampled with 30 cores all mounds and a series of likely cultural features off mounds but dispersed along beach ridges at *Temyiq Tuyuryaq* that are investigated with geophysical instruments. Two approaches to site sampling were undertaken. First, we followed an approach effectively used by Martindale et al (2009) on deep shell mounds on the northern British Columbia coast for collection of deep samples from mounds at *Temyiq Tuyuryaq*. Second, we used the coring procedure to test anomalies identified by the geophysical investigations.

To facilitate collection of cores, we used a percussion corer (JMC Environmentalist's Subsoil Probe) capable of deriving cores from at least 5 m of deposits. The coring device uses an impact driven system to hammer a driving tube into the sediments. A co-polyester liner is used to remove the core from the driving tube. Once standard depth is achieved, the tube is removed and sample extracted. Then a new sample tube is inserted and the driving tube reinserted at the depth reached by the first to drive further and extract the next sample. Thus, multiple intact cores can be acquired for collection, transport, and analysis. Paleoecological and dating samples were derived from the cores in stratigraphic order. Given the narrow width of the cores (about 2 cm), we did not expect recover many artifacts. Dominant materials recovered were botanical items and faunal remains but several small fragments of pottery were also recovered.

An important goal of the project is to build a preliminary paleoecological model for the Togiak area spanning the occupation period of the site. This is critical to define the local effects of regional climate change and was initiated through integrated analysis of multiple data sets. First, a geoarchaeological assessment of the site and its associated geomorphological context will was undertaken by Owen Mason (Appendix D). Mason's study draws upon observations and data obtained from site sediments and non-cultural sediments adjacent to the site to understand landscape formation associated with the spit which underlies the mounds. Dr. Mason focuses on sedimentary structures, lithological identification, granulometry in order to infer geomorphic processes, delineating storm surge, wind, colluvial and soil formation. The delineation of abandonment surfaces are an essential part of the research. Limited offsite soil probes and shovel tests in adjacent marshes and alluvial deposits supplemented on-site stratigraphic observations and involve linking spit, deltaic and river evolution. Modern beach and coastal processes are documented by defining modern depositional facies (elevation, vegetation communities), both shore-parallel and along shore. Driftwood accumulations were observed for comparison with regional data. Sequential aerial photography was analyzed to establish depositional processes and to document erosion, including the mapping of beach ridge and spit systems in the northern Bristol Bay region. Preliminary chronometric estimates for storm and sea level history were obtained from AMS ^{14}C ages.

Second, paleobotanical samples were derived from the cores. While it is expected that variations in the marine environment should have been most critical to *Temyiq Tuyuryaq* residents, MWP warming could have enhanced terrestrial productivity at the same time marine conditions deteriorated, changing the importance of terrestrial resources. Changes in the terrestrial ecosystem and its impact on *Temyiq Tuyuryaq* residents were addressed in a preliminary way through pollen and macrobotanical analyses. Several pollen samples derived from the best dated and deepest cores on the site will be analyzed by Cynthia Zutter (Appendix F). This pollen record will be used to reconstruct terrestrial ecology in the village and its immediate vicinity (Birks and Gordon 1985; Howe and Webb 1983). Macrobotanical remains were collected from core samples via flotation procedures and analyzed by Dr. Natasha Lyons (Appendix G) with a primary goal of identifying food species, household features, and architectural materials, along with reconstructing site formation processes (Lennstrom and Hastorf 1995; Lepofsky 1996; Lepofsky et al 2001; Lyons and Orchard 2007).

Third, zooarchaeological studies were conducted by graduate student Dougless Skinner with supervision from Anna Prentiss and Kristen Barnett emphasizing assessment of site occupation patterns focusing in particular on predation behavior (Appendix E). Given the limited nature of core sampling, zooarchaeological studies focused on fish and shellfish with the goal of testing predation hypotheses (e.g. salmon should be a keystone resource through the period of occupation under general hypotheses) and developing a preliminary assessment of stability or change in the marine ecosystem. Interestingly, a wider variety of bird and mammal remains were also recovered. Faunal data were not adequate for isotopic analysis.

Radiocarbon dating was conducted at DirectAMS (Seattle, WA) and relied upon standard AMS dating techniques, considering appropriate calibration and source material issues (e.g. Dumond and Griffin 2002; Gerlach and Mason 1992; McGhee 2009). We ran 40 dates (Appendix B) from a variety of source contexts and using materials focusing exclusively on grass to control for source bias while constructing a detailed site occupation chronology (e.g. Martindale et al. 2009).

An important part of the project is the establishment of "community driven" research questions and appropriate methods. This is being accomplished by permitting community members to tell their own stories. This effort is ongoing and has not been completed as of the writing of this report. However descendent voices were a key element in all aspects of the project.

Report Outline

The report includes an overview of all major results (Chapter Two) that include mapping, cores and dating, section profiles, geophysics, geoarchaeological assessment, faunal remains, macrobotanical analysis, pollen studies, and artifacts recovered. Chapter Three provides conclusions and recommendations. Appendices include maps and photos (Appendix A) along with radiocarbon data (Appendix B) and reports for geophysics (Appendix C), geoarchaeology (Appendix D), zooarchaeology (Appendix E), pollen analysis (Appendix F), and macrobotanical studies (Appendix G).

Chapter Two

Summary of Archaeological and Paleoecological Studies at *Temyiq Tuyuryaq*, the Old Togiak Site, for the 2015 Field Season

(Anna Marie Prentiss, Kristen D. Barnett, Sarah Nowell, Ethan Ryan, Brianna Aspelund, and David Clark)

In this chapter we review major archaeological and paleoecological findings of field research in 2015 and subsequent lab studies. We begin with a review of site spatial organization and mound stratigraphy. We follow with a discussion of lab procedures, radiocarbon dating results. Then, we review findings from lab studies detailed in the appendices of this report. Conclusions are discussed in Chapter Three.

Site Spatial Organization

A major goal of the 2015 field season at *Temyiq Tuyuryaq*, the Old Togiak site, was to collect new data on spatial positions of natural and cultural features across the site (Appendix A). Spatial data were gathered using a Trimble GPS unit. The extent of the site perimeter was first recorded on foot using the trace feature, followed by recording of the landing strip/road found in the northern part of the site. The datum and site grid were then recorded as point data by averaging 100 different measurements taken by the GPS of a single point. Identifiable house pits were then recorded by taking centroid measurements, perimeter measurements, and two transects through each pit. GPS points were also taken at each location that a core sample was taken. Finally, point data were taken every five steps while walking transects through the site, spaced 10 meters apart to gather elevation data. *Temyiq Tuyuryaq* is located on a northwest trending sand spit in the northwestern portion of Bristol Bay, Alaska (Mason, Appendix D). Field investigations in 2015 identified 14 beach ridges across the sand spit containing 67 mapped cultural depression features considered to be likely housepits. Housepit features occur in two size classes. The most common were small housepits rarely exceeding 3 meters in diameter from rim crest to rim crest. A smaller set of quite large features, some in excess of ten meters in rim crest to rim rest diameter, were also recognized. Nearly all housepits had recognizable entrance tunnels and many had attached smaller depressions that were likely atriums used for cooking or storage (Fienup-Riordan 1994, 2007; Nelson 1983). Size distinctions likely reflect the presence of the larger *qasgi* or men's houses and the much smaller *enet* or sod houses used by women and children (Fienup-Riordan 1994, 2007). Spatially, housepits are located on beach ridges and house mounds in two areas of the site, here termed north and south (Appendix A). The south portion of the site includes four mounds. The largest, termed Mound 1, is approximately 120 meters in length and trends northwest/southeast along the beach axis. The other three are approximately round in shape and are found on the northeast/east side of Mound 1 and are labelled Mounds 2-4 north to south.

Mound Stratigraphy

Kowta (1963) excavated a large block near the apex of Mound 1 establishing the presence of a sequence of deposits extending to approximately four meters depth. Kowta was not concerned with defining details within the stratigraphic sequence though it was evident to him and from a quick review of his profiles that multiple occupation strata were present. Mound 1 has suffered from extensive illicit digging by local artifact hunters. We took advantage of cuts into the beach side of Mound 1 to profile eight short sections with the goal of gaining some perspective on mound stratigraphy beyond what Kowta described from his excavation. Photographs and profile maps are provided in Appendix A. All mound sediments were described as clays and loams. Substrate below the mound strata are made up of frozen beach sand.

Profile Section A reflects a single occupation surface located directly below the tundra vegetation surface. A single pit feature, about 50 cm wide, is evident. The feature lacks evidence for house posts and it is not oxidized but rather consists of layers of clay ranging from oily clay to clay containing matted vegetation (grass; *canek*). Given these patterns it is possible that this could reflect a storage pit used on multiple occasions and gradually filled in. Profile Section B appears to have two occupation surfaces though it is possible that the lower (stratum H) is a floor while the upper strata (Strata C, D, and E) reflect a roof remnant. Two narrow pit features are evident within stratum H likely reflect post-holes. Profile Section C appears to reflect a single occupation surface marked the presence of wooden posts in vertical positions. Profile Section D is complex with multiple strata. It is possible that three occupation surfaces are present as indicated by organic clay horizons including wood, rock and bone (strata E, G, and J). However, only one of these was clearly an occupation surface. Stratum G is thicker than the others and contains what appears to be a shallow basin-shaped hearth feature containing wood, rock, and bones. Profile Section E has two clear occupation surfaces. Stratum B is a thick sandy zone capped by wood fragments and bisected vertically by a feature containing sandy loam and wood fragments. The latter feature is likely a thick post hole though it is also possible that it could represent the margin of a wider feature. Stratum H is a thick layer of wood and clay that resembles a wooden house floor. Profile Section F has eight distinct horizontal beds, three of which may be occupation surfaces. Stratum D includes a clear hearth pit feature with rock, fire-cracked rock, charcoal, and wood. Profile Section G is located at the southeast end of Mound 1 and sits at the base of the mound stratigraphic sequence. There are four cultural strata above the beach sand substrate but only one has abundant cultural material in the form of wood reflecting the possibility of an occupation surface or even house floor. Profile Section H is complex with at least two occupation surfaces. Each of strata C and D include wood items reflective of house beams or floor materials.

Profile Sections A-F and H are located high on the side of Mound 1 and could likely reflect the last occupations associated with the mound. In contrast, Profile Section G is at the base of the mound and reflects the earliest occupants. Thus, we have indicators of stratified occupations surfaces early and late in the mound sequence. The middle strata from Mound 1 were not clearly evident on the exposed sections and thus, we were unable to examine these contexts. Combining the profiles with results of coring and considering Kowta's profiles, it is very clear that Mound 1 has a long and complex sequence of occupations that likely include outdoor activity areas but also house floors and roof deposits.

Geophysical Investigations

Geophysical investigations were conducted by Steven Sheriff (Appendix C) with a focus on using Total Field Magnetic Intensity observations to identify anomalies that could represent cultural features. A study area was defined as a set of contiguous grid blocks centered on Mound 1 and adjacent beach ridges with obvious cultural depressions to the northwest. The datum point for the grids was at the apex of Mound 1 on its southeast end adjacent to Kowta's (1963) original excavation area. A 20x20m grid was also established in a northeastern portion of the site away from the most prominent beach ridges and lacking obvious cultural depressions on the surface. Study of this space was conducted to provide a baseline understanding of geophysical patterns in the absence of evidence for human occupation. Results as detailed by Sheriff in Appendix C were complicated by the hummocky nature of the tundra surface and by the presence of frequent metal artifacts (stove parts, wash basins, etc. [see photos in Appendix A]). However, it was also possible to image housepits and possibly also other cultural features such as cache pits and hearths. Strongly positive anomalies judged likely not associated with metallic artifacts were used as a guide for placement of cores. As noted below, this strategy was highly successful for acquisition of cultural and paleoecological materials from our coring operation. It also raises the strong possibility that while challenging in this context, geophysics can be useful for identifying cultural features and should be integrated into feature archaeological investigations at this site and elsewhere in arctic coastal contexts.

Lab Procedures Regarding Cores

Thirty core samples were collected during the 2015 field season of the Togiak project, each measuring two centimeters in diameter. Each core is one meter in length with the exception of three cores that measure two to four meters each. A number of soil samples were also collected from the profiles of selected sections along the beach front.

All samples that were collected from *Temyiq Tuyuryaq* were analyzed under sterile conditions. The laboratory space itself was cleaned using a solution of isopropyl alcohol and anti-bacterial dish liquid initially and on a weekly basis. Each analyst took measures to protect samples from contemporary contaminants such as hair and other particulates that could potentially have originated from skin and clothing. These measures included laboratory coats, nitrile gloves and restrictions on wearing long hair down while working with samples. Given the nature of the types of testing that will be conducted on particular samples, these measures were deemed necessary in order to ensure the integrity of all specimens.

Many specific protocols were developed throughout the period in which laboratory analysis was conducted. Adaptive procedures were necessary due to the fact that detailed prior knowledge regarding the types of artifact and ecofact that would be recovered in the coring samples were not possible. Among the early tasks, it was necessary to design numbering systems and broad categories by which to sort the contents of core and soil samples. Each of the broad categories was color coded and grouped according to proposed testing strategies. This is described further below.

Each core was opened from bottom, or deepest section to the top, or section nearest the surface. This was executed by using scalpels in order to ensure clean incisions that (1) did not contaminate the sample with small shreds of plastic tubing and (2) did not drag materials from one potential stratum to the next, thus mixing materials. Each core sample was then examined for soil changes, charcoal bands or burn features, artifact or fauna concentrations and other anomalies that were visible both under normal vision and under 50-100X magnification. Any charcoal bands were removed and immediately packaged in foil and small petri dishes. Considering the fact that core samples were mainly placed according to geophysical anomalies within housepits, charcoal bands and concentrations of burned material were considered to be likely anthropogenic in nature. Because of this, samples from anthropogenic soil horizons in each core approximately two to three centimeters in thickness were collected in petri dishes separately in order to be sent for pollen analysis.

After charcoal/burn features and pollen samples were marked for collection, each clear soil change was marked. As the first core samples were dissected, it became clear that the clay content in core samples was very high, which prevented the immediate extraction of many intact specimens. The solution to this issue was a change in protocol that involved the flotation of all individual core-strata. After each sample underwent flotation, the extraction of larger and more complete specimens in higher quantities was possible. In the case of these flotation samples, heavy and light fractions were dried separately when they could be separated. Flotation samples were numbered for each core from bottom to top such that "1" was the deepest flotation sample within each core sleeve and so on.

Soil samples that were collected from profiles along the beach front (Appendix A) were floated and analyzed as one sample. A separate numbering system was implemented and specimens from soil samples were recorded separately from the core samples. Specimens were still separated according to the same broad artifact and ecofact categories as core samples. In addition, some specimens such as large sections of wood were too large for petri dishes and bottles and therefore bagged separately from other wood samples. Any sterile soil from core samples or soil profile samples was also bagged separately in the event that they could potentially contribute to ecological or other types of inquiry in the future.

The broad categories of artifact and ecofact were color coded in the lab for labeling and established as the following: charcoal, fauna, wood, grass/small twigs/seeds, sections of intact woven grass mat and lithics. Throughout the process of analysis, other materials were collected separately which include: hair, samples that have been potentially identified as linoleum and samples of burnt wood and fauna covered in a blue mineral substance that has been potentially identified as hydrohalite (pending chemical analysis). The handling of each of these types is described in turn below:

Charcoal. All charcoal was wrapped in foil and sealed into small petri dishes. Specific dating samples were selected in a way that allowed for the representation of all areas of the site that were selected for coring while also considering core depth associated with deep cores.

Fauna. In samples with moderate to higher amounts of fauna, more than one bottle or petri dish was used in order to separate shell fragments from other types of faunal material. Faunal samples were analyzed in the laboratory by one analyst dedicated to this purpose. All faunal material was analyzed according to standard zooarchaeological procedures, while also applying Yup'ik language terminology to identifiable taxa (see Skinner, Appendix E).

Wood. All wood specimens were collected separately from other botanical specimens in core and soil samples. Any samples that contain burned specimens of wood were coded accordingly in the event that they should be separated later. The implications for fully understanding wood samples at *Temyiq Tuyuryaq* were considered to be potentially limited due to the fact that it was not possible to distinguish whether many wood samples came from local trees or driftwood that might have washed ashore. Because of this, no wood samples have been selected for dating or other analysis other than identification at this time.

Grass/Small Twigs/Seeds. Specimens of grass, small twigs and seeds were collected together. All of these specimens were analyzed by the same individual outside of the University of Montana (Lyons, Appendix G), therefore combining the samples was considered practical.

Grass is seasonal in the region where *Temyiq Tuyuryaq* is located and is considered significant. Small twigs were included with these samples because unlike driftwood, smaller twigs may be identified and provide more information. A variety of seeds were also recovered from core and soil samples and thus included. All burned samples were marked accordingly. In some cases, special notes were made to indicate whether or not a sample contained burned seeds.

<u>Woven Grass Mat.</u> In many samples, intact sections of woven grass mat were recovered from core and soil samples. Each fragment of woven mat was collected and contained separately from other types of artifact. The importance of collecting woven grass mats is obvious and the cultural significance of these materials will be further described in following discussion.

<u>Lithic artifacts</u>. Due to the nature of the samples that were collected, the majority of lithic artifacts were very small in size. Lithic artifacts were identified as such in the event that some element of flake anatomy, e.g. initiation was visible. Very few specimens that required further cleaning and analysis were kept for further verification, either as lithic debitage or fire-cracked rock. For lithic specimens that showed clear identifiable features, additional notes were made regarding preliminary classification.

<u>Hair.</u> In some samples, individual hair specimens that were reasonably distinguishable from contemporary contaminants were collected in separate containers. The majority of these hair samples lacked pigmentation. In almost every case, the root of the hair was either absent or will require examination under higher magnification in order to attempt identification. Great care was taken with hair samples and every necessary consideration made pending the results of identification. Ultimately, taxonomic identification was not possible.

<u>Potential Linoleum.</u> One core sample contained small fragments of green material. Under 100X magnification, they appeared to be plastic in nature. Dr. Kelly Dixon from University of Montana was consulted and proposed that pending further examination, the fragments could potentially be linoleum. The specimens were collected separately and await a positive identification. Pending the conclusion of laboratory analysis, the potential linoleum fragments were only found in one particular core.

<u>Potential Fragments Containing Hydrohalite.</u> During the course of analysis, a limited number of core samples contained material from burn features, specifically fauna and wood, which appeared to be coated in a blue substance. Initially, this substance was believed to be mold. However, examination under higher magnification shows that the blue material has a mineralized appearance that is uncharacteristic of mold. Research is currently underway to determine the identity of the substance. Pending chemical analysis, it remains unidentified. Specimens that contain this substance were collected separately and placed in containers according to the broad artifact/ecofact categories (i.e. the fauna contained separately from wood).

Radiocarbon Dating

A critical component of our research at *Temyiq Tuyuryaq* was to develop an initial radiocarbon chronology of site occupations. To accomplish this, decisions were required regarding sample context and sample material. As described above, cores were dissected to identify likely occupation strata recognized as organic rich horizons within sequences of low organic clay, loam, or sand. Dating samples were chosen from those horizons. Sampled core horizons were coded as core number followed by an additional number designating the horizon. Most cores has a single major occupation horizon (thus, coded 3.1, 11.1, etc.), though within any single major occupation horizon there could be one to several specific stratigraphic layers potentially reflecting house floor, roof, hearth, and other feature contexts. However, several cores had multiple major occupation horizons (as, for example, coded 28.1, 28.2, 28.3, etc.). Next, specific sample materials were chosen for dating. Arctic coastal environments offer many challenges for choice of optimum radiocarbon dating samples (e.g. Arundale 1981; Dumond and Griffin 2002; Gerlach and Mason 1992; Ledger et al. 2016; McGhee 2009; Morrison 1989). Sea mammal remains and all materials soaking up sea mammal oil may be subject to marine reservoir effect which can alter dates by hundreds of years. Some terrestrial materials can also be a challenge. Park (1994) describes the "terrestrial reservoir effect" a suite of processes by which plant materials or herbivore bone collagen take non old carbon due to slow decay in arctic soils, variable ^{14}C fractionation in different plants, and differential associations between materials with varying ages at death (e.g. "old wood" problems). Grass has often been held as a useful material for dating given its short life and limited likelihood for non-cultural transport. Coastal tundra grass was also commonly used by Yup'ik people for a variety of technologies (Fienup-Riordan 2007). Coastal rye grass (*Elymus arenarius*) is ubiquitous on the Old Togiak spit and is present within the cultural horizons of most cores taken from *Temyiq Tuyuryaq*. Faunal remains were highly fragmentary and inconsistent between cores. Charcoal and wood fragments were also inconsistently represented. Wood fragments also have a higher risk for unknown taxa, non-cultural transport, and uncontrolled co-association with other materials. Therefore, while recognizing there was still some possibility of contamination from marine mammal fat or other materials, grass was a logical choice for maintaining consistency between samples. Thus, all radiocarbon dates were run on grass, many appearing to be small pieces of woven artifacts. Radiocarbon dating was accomplished by DirectAMS using the AMS procedure (Appendix B). Forty samples were submitted for dating and of those, three were rejected out of hand due to either modern or Pleistocene date ranges. The remaining 37 dates are provided in Table 2.1. Each sample was calibrated using Bayesian procedures (Appendix B) in OxCal 4.2 (https://c14.arch.ox.ac.uk/oxcal.html).

Table 2.1. Radiocarbon data. Row 1: UM lab sample numbers, Row 2: core numbers, Rows 3-5: calibrated (95% confidence) high, low, and mean; Rows 6 and 7: Uncalibrated mean and error.

Sample#	C286	C020	C362	C386	C350	C346	C270
Core	17.1	3.1	15.1	23.1	11.1	17.1	19.1
Calibrated High	1915	1938	1925	1919	1919	1930	1919
Calibrated Low	1706	1681	1690	1694	1693	1682	1693
Calibrated Mean	1811	1810	1808	1807	1806	1806	1806
uncal mean	12	117	96	75	77	111	89
uncal error at 1 sd	22	23	23	22	24	22	20

C382	C287	C025	C337	C039	C383	C231	C048
22.1	24.1	6.1	15.1	10.1	13.1	28.3	1.1
1927	1927	1926	1935	1918	1800	1799	1799
1685	1660	1662	1650	1664	1528	1527	1521
1806	1794	1794	1793	1791	1664	1663	1660

103	187	181	204	170	249	256	265
24	22	21	22	21	22	22	27

C240	C062	C146	C001	C213	C115	C047	C114
28.1	1.1	29.1	1.2	28.1/28.2	29.1	1.1	29.1
1643	1644	1642	1641	1635	1634	1624	1614
1492	1483	1486	1485	1464	1453	1446	1436
1568	1564	1564	1563	1550	1544	1535	1525
321	326	330	332	348	358	382	412
20	26	22	21	21	25	22	21

C110	C330	C003	C084	C068	C247	C124	C400
29.2	11.1	1.2	30.1	1.1	28.2	30.2	9.1
1458	1456	1448	1445	1438	1425	1406	1400
1419	1416	1411	1404	1322	1316	1297	1296
1439	1436	1430	1425	1380	1371	1352	1348
455	460	484	501	532	555	605	614
23	24	25	25	26	22	28	22

C123	C263	C029	C195	C334	C125
30.2	30.2	7.1	28.3/28.4	15.1	30.2
1392	1380	1290	1275	989	768
1281	1264	1260	1220	778	659
1337	1322	1275	1248	884	714
654	706	728	778	1128	1307
25	23	21	22	25	26

Appendix B provides details regarding radiocarbon dates including DirectAMS output and subsequent calibrations in OxCal. Given the probabilistic nature of radiocarbon dating accuracy is increased at the expense of wider error distribution ranges. Figure 2.1 is a plot of 37 calibrated dates at 95% confidence interval. This means that there is only a 5% chance of error at this range. Results indicate three broad time periods here termed, *Temyiq Tuyuryaq/*Old Togiak I, II, and III. Dating and cores for each time period are summarized as follows:

Temyiq Tuyuryaq/Old Togiak I (mean date range of 1248-1439 CE and max [95% confidence] standard deviation range of 1220-1458 CE) is reflected in the following cores/samples: 28.3/28.4, 7.1, 30.2 (three 30.2 dates) 9.1, 28.2, 1.1, 30.1, 1.2, 11.1 and 29.2. Summarizing, we have these earliest dates in cores 1, 9, 11, 28, 29, and 30.

Temyiq Tuyuryaq/Old Togiak II (mean date range of 1525-1568 CE and max [95% confidence] standard deviation 1436-1800 CE) is reflected in cores/samples 29.1, 1.1, 28.1/28.2, 1.2, 29.1, 1.1 (three dates), 29.1, 28.1, 28.3, and 13.1. Summarizing, this group includes cores 1, 13, 28, 29.

Temyiq Tuyuryaq/Old Togiak III (mean date range 1791-1811 CE; max [95% confidence] standard deviation 1664-1915 CE) is reflected in these cores/samples 10.1, 15.1, 6.1, 24.1, 22.1, 19.1, 17.1 (two samples), 11.1, 23.1, 15.1, and 3.1. Summarizing, this group includes cores 3, 10, 11, 15, 17, 19, 22, 23, and 24.

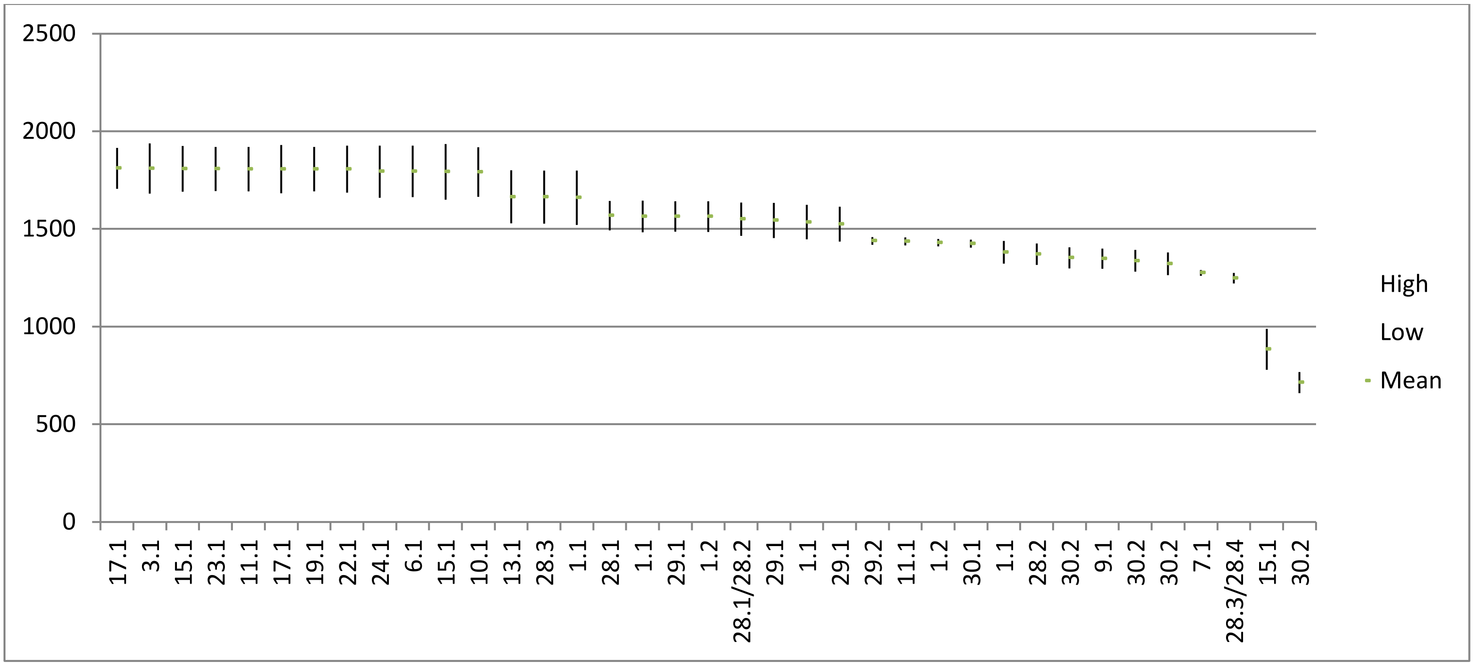

Figure 2.1. Plotted calibrated (with Bayesian modeling) radiocarbon dates at 95% confidence interval.

Figure 2.2 provides a plot of the same dates at the lowest possible confidence interval down to the one sigma level of 68%. This means that the chance of error ranges up to 32% but many error ranges on individual dates drop to narrower widths. The result is effectively the same as the 95% confidence interval range though the boundaries between the inferred periods are less distinct. Two samples (core samples 15.1 and 30.2) pre-date all others but later dates were also derived from approximately the same stratigraphic contexts and thus given the range of the other 35 dates we consider it unlikely that these two accurately reflect occupation dates. Further, artifacts recovered by Kowta (1963) and those observed by this team in beach and illicit excavation contexts do not reflect any other than the Thule period (or post-1000 BP ancestral Yup'ik). Occupations pre-dating 1000 B.P, would normally reflect the earlier Norton period (Dumond 2009).

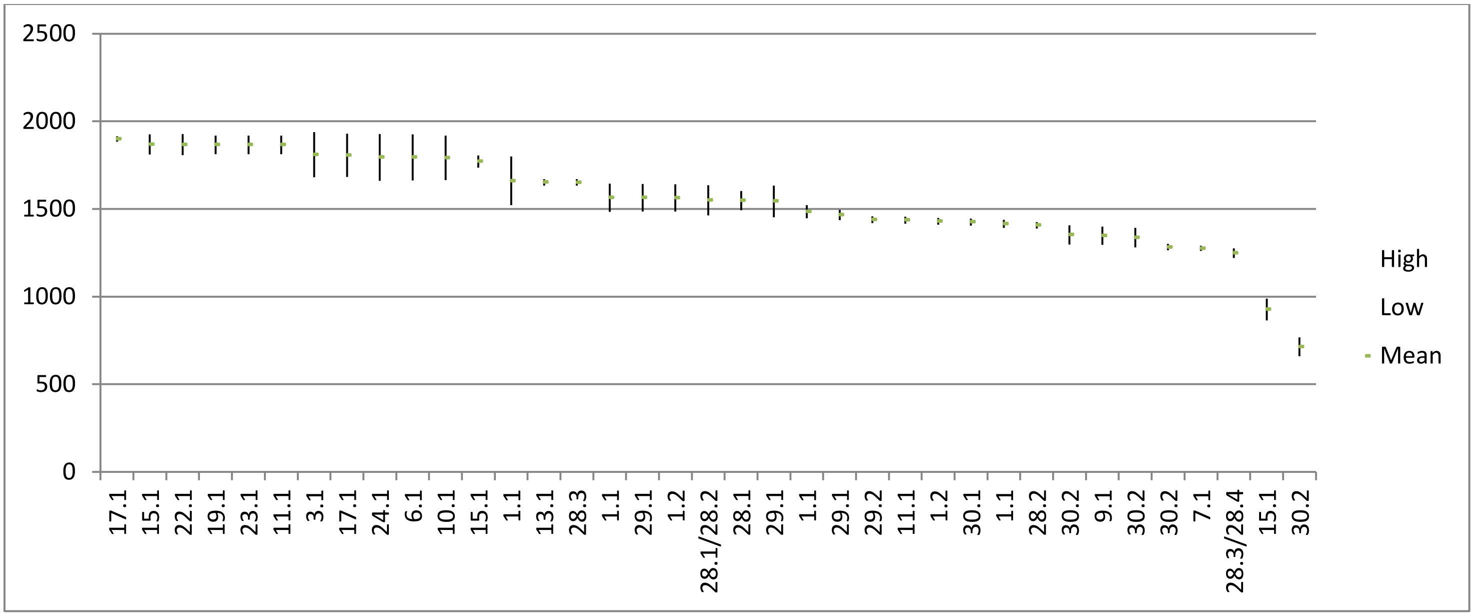

Figure 2.2. . Plotted calibrated (with Bayesian modeling) radiocarbon dates at 68-95% confidence interval.

Togiak community members requested that we present the dates in 50 year increments presumably reflecting theoretical generations using the site. Figure 2.3 provides a summary of numbers of dates plotted by 50 year periods. These results also generally support an argument that three major time periods are presented presuming that the 1650-1699 C.E. period groups with the earlier (ca. 1500-1600 C.E.) dates as evident when we examine error ranges in Tables 2.1 and 2.2. Overall, these results suggest relatively continuous occupation of *Temyiq Tuyuryaq* since ca. 1250 C.E. but with the possibility of relatively short periods of vacancy ca. 1450-1500 and 1700-1750 C.E. Spatially it would appear that the earliest occupations occurred in what are now the lower strata of Mound 1. Later occupations accumulated sediment on the mounds and simultaneously added house structures along beach ridges to the north and northwest (see Mason Appendix D). The pattern of later dates appearing generally in more northern portions of the site is illustrated in Figure 2.4.

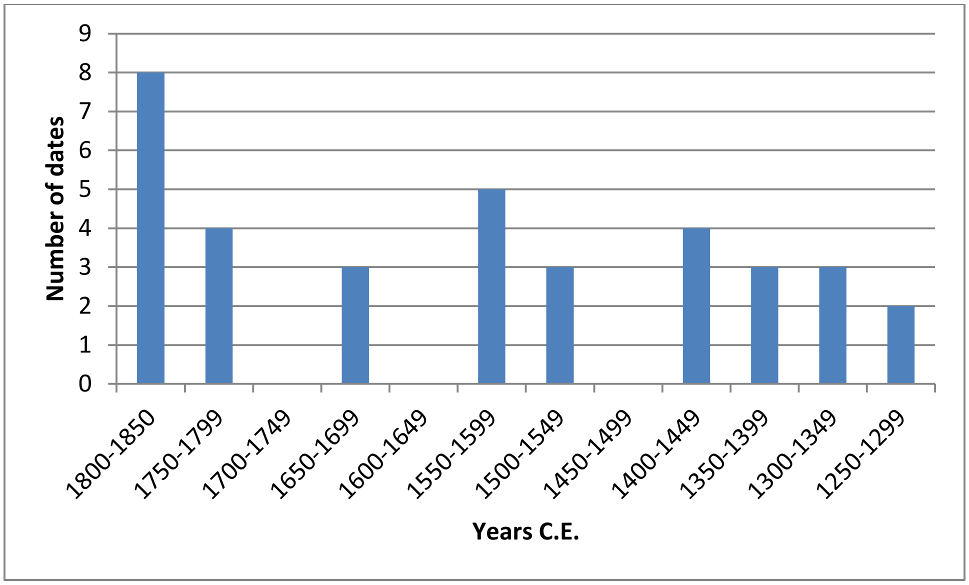

Figure 2.3. Counts of calibrated radiocarbon date mean points by 50 year interval.

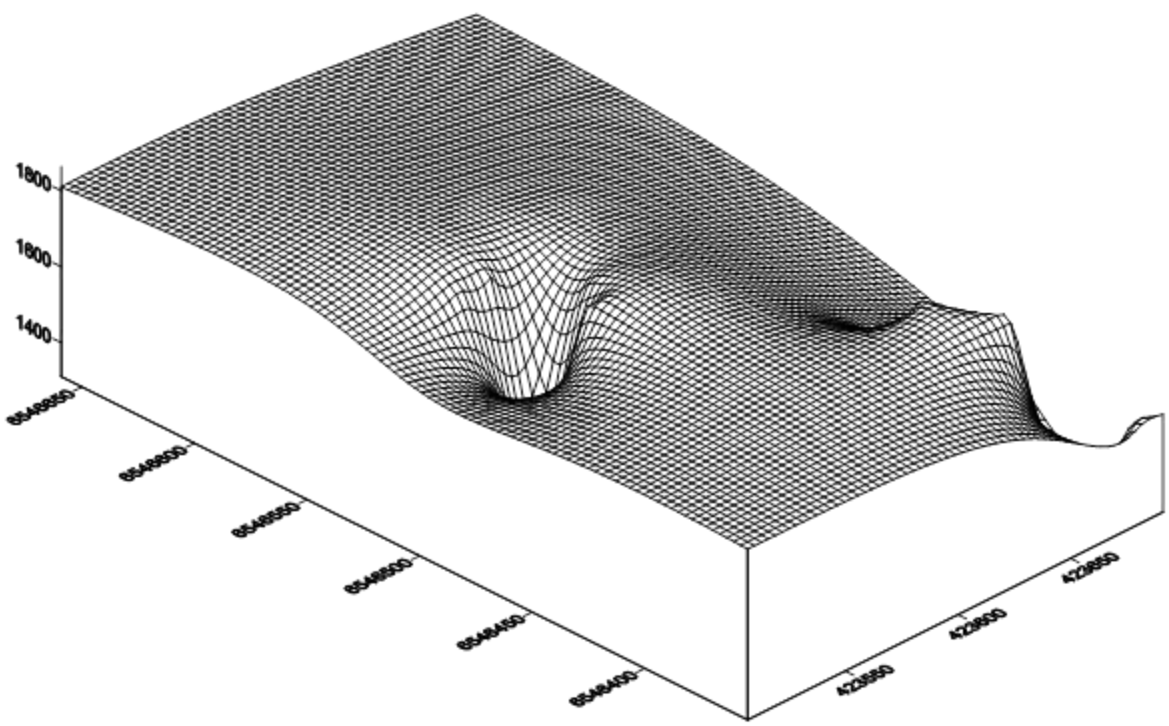

Figure 2.4. Topographic map plotting radiocarbon ages in years C.E. (deeper is older) by spatial position on *Temyiq Tuyuryaq*.

While we are able to recognize approximately three periods in which dates cluster and a general pattern of older to younger across the landscape we are not yet able to reconstruct details of village size in terms of numbers of houses over time. The latter will require a more intensive geophysics and excavation program than was possible in our single field season in 2015. Next, recent research by Ledger et al. (2016) suggests that grass may not be the most highly reliable material for dating. These authors conclude that caribou bone collagen remains the best arctic dating material. However, that material was not available to us in these investigations and our distribution of dates is internally consistent with our expectations from previously recovered artifacts as well as the geomorphology of the Old Togiak spit (Mason, Appendix D). While obviously the site would benefit from further dating using caribou collagen we suggest that our patterns are likely to be relatively accurate. Future research with this data set will include statistical testing of significance of break points between visually evident date clusters.

Geoarchaeology

Owen Mason (Appendix D) conducted a geoarchaeological study of *Temyiq Tuyuryaq* focused on in particular on assessing formation of the Old Togiak spit and considering challenges faced by the original occupants and potential future impacts to what remains of the site today. Mason argues that the spit accreted from sand moved by currents within Togiak Bay. Drawing from our radiocarbon sequence most rapid and substantial growth occurred during the period post-dating 1000 C.E. and in particular during the Little Ice Age (post-1300 C.E.). While recommending further testing Mason suggests that evidence for effects of major storms in less obvious than that of beach ridge systems in northwestern Alaska. It is likely that *Temyiq Tuyuryaq* was well positioned for avoiding the worst impacts of Bering Sea storm systems. However, this does not mean that the site has not been impacted by erosion, even if at a lower rate than beaches farther north. From an examination of aerial photographs, Mason estimates that the site is losing approximately 100 cm per year since 1985 from erosion. At that rate (and excluding effects of illicit artifact digging) the portions of the site along the beach front on the southwest side (this includes the mounds and associated beach ridges) will be entirely gone within 25 years. For past occupants it is unclear if high tides or storms impacted houses located on the beach fronts. As noted by Mason this is a topic for further investigations.

Zooarchaeology

Dougless Skinner (Appendix E) conducted a zooarchaeological study of faunal remains recovered from the 30 cores extracted from *Temyiq Tuyuryaq*. She recorded 4303 faunal specimens including 1491 Osteichthyes, 457 Mammalia, 37, Avies, and 2116 Mollusca. While there is not enough of a sample to discuss change over time it is interesting to note that a total of 2338 (54%) came from earliest dated contexts (*Temyiq Tuyuryaq*/Old Togiak I), 352 (8%) from Old Togiak II contexts, and the remaining 1613 (38%) from *Temyiq Tuyuryaq*/Old Togiak III contexts. Individual taxa represented included *neqa* (salmon [*Onchorynchus sp.*]), *kayutaq* (sculpin [Scorpaeniformes]), *caqig* (starry flounder [*Platichthys sp.*]), *atgiaq* (pacific cod [*Gadus sp.*]), *iqallugpik* (dolly varden [*Salvelinus sp.*]), *cukilek* (stickleback [*Gasterosteidae*]), *seturrnaq* (tomcod [*Microgadus sp.*]), *iqallugpik* (herring [*Clupea sp.*]), a variety of very fragmentary small mammal remains (that could include *ugnaraq* [voles], *qayeqeggliq* [hares], *uugnar* [lemmings], *tevyuliq* [muskrat], *narullgiq* [weasels], *angyayaagaq* [shrews], *imarmiutaq* [mink], and *qanganaq* [squirrel], highly fragmentary medium mammal remains (that could include *kaviaq* [fox], *terikaniaq* [wolverine], *tertuli* [lynx], or *angaqurta* [domesticated dog]), a variety of Mullosca particularly dominated by *qapilaaq* (blue mussel [*Mytilus edulis*]), and finally Avies remains including *anipa* (snowy owl [*Bubo scandiacus*]), *payig* (merganser [*Mergus merganser*]), and Great Blue Heron (*Ardea herodias*). Great Blue Heron is particularly interesting in this context as it is not found in the Togiak area today. When these results are considered along with the findings of Kowta (1963), it is clear from species representation that year-round occupations could have occurred at the site. This assumes the likelihood that some if not many species were procured at more distant localities (offshore, elsewhere along the coast, and upriver) and transported to the village (e.g. Fienup-Riordan 1986, 2007). Illustrating the high degree of organic preservation in the *Temyiq Tuyuryaq* sediments, our lab team identified feathers attached to some Avies specimens and 25 hairs collectively from cores 3.1, 9.1, 11.1, 15.1, 16.1, 17.1, 24.1, 26.1, 28.1, 29.1, 28.1/.2, 28.3/.4, and 29.1/.2. With permission from the Togiak community several hairs were tested for preserved ancient DNA but unfortunately none would amplify. Nonetheless, it is evident that *Temyiq Tuyuryaq* has remarkable potential to shed light on traditional hunting and animal processing behavior spanning the Thule or Ancestral Yup'ik to historic Yup'ik periods.

Pollen Analysis

Pollen analysis was conducted by Cynthia Zutter (Appendix F) drawing upon 16 samples from eight cores emphasizing in particular cores 1.1, 10.1, 29.1, 29.2, and 30.2. This permitted consideration of pollen from a date range spanning ca. 1300-1900 CE. *Taperrnat* (grass; *Gramineae*) is consistently the dominant taxon followed by cuukvaguaq *(alder*; *Alnus*). Significantly lower quantities of herbs (some herbs could be classified as "mousefood" or *anlleq*; *Cyperaceae*), *uqviaq (willow*; *Salix*), *elnguq (birch*; *Bertula*), *melngut neqait* (heather; *Ericaceae*), *kevraartuq* (pine; *Picea*), *naunerrluk* (wormwood; *Artimisia*), *avngulek* (cottonwood; *Populus*), and thistle (*Circium*) were also recorded. Zutter recognizes that since samples derived from contexts likely modified by human actions that pollen profiles do not provide a direct indicator of wider ecological conditions. Nonetheless she notes that the grass dominated pollen profile indicates an open landscape with abundant grasses, herbs and low shrubs as would be typical of cold conditions during the Little Ice Age (LIA). She notes it is possible during the LIA (ca. 500-700 CE) that alder may have been briefly more common in the area than today. However, she also notes that the high alder profiles could reflect sampling as for example affected by the presence of alder plants growing in the village and contributing excess pollen to a particular location.

Paleoethnobotany

Natasha Lyons conducted a paleoethnobotanical analysis of macrobotanicals (plant remains visible without a microscope) recovered from core samples at *Temyiq Tuyuryaq* (Appendix G). Sixty-seven spot samples were derived from nine cores (1, 3, 4, 7, 9, 10, 28, 29, 30) permitting a preliminary assessment of macrobotanical remains from contexts spanning ca. 1300-1900 CE. Lyons notes that while overall species diversity is low a number of important taxa were recognized. Food plants recovered include *kavlakuaraq* (crowberries), *aqevyik* (cloudberries, *puyuiaarpak* (red raspberry), *elquaq* (algae [bladderwrack]), and *ciruneruat* (lichen). None showed evidence of cooking and consequently it is possible that some entered the archaeological record via non-cultural processes. Recovered plants used for technological purposes include lichen, kelp, bark, grass stems, and moss. Several medicinal plants were recovered including wormwood and red raspberry. Lyons suggests that the presence of these plants could indicate occupation of the site during the warm season, while noting that a number could have also been stored for cold season use. Lyons also recognizes that outcomes of the macrobotanical study matches key aspects of the pollen study in pointing human use of an environment dominated by grasses and low shrubs. Finally, she points out that this study is particularly significant in that while well-known ethnographically, many plant species described herein (all berries, wormwood, mosses, lichens, algae), have never been documented in the archaeological record of this region.

Artifacts

A limited number of artifacts were recovered from the cores and these include lithic debitage, two lithic tools, and several very small ceramic sherds. The lithic debitage (flakes from making chipped stone tools) collection included 26 artifacts (Table 2.3) from cores 4, 9, 27, 28, 29, and 30 with the majority deriving from core 28.2. Given debitage from this set of cores we can suggest that lithic tools were produced and modified throughout the Thule or Ancestral Yup'ik period but not clearly during the Historic Yup'ik period. However, given very limited sampling this hypothesis is subject to further evaluation. A variety of data were collected from the lithic debitage including lithic raw material (slate, basalt, or crypto-crystalline silicate [chert]), presence or absence of thermal alteration, size (small 1-4 cm^2; extra-small <1 cm^2), Sullivan and Rozen typology (or flake completeness approach [Prentiss 1998; Sullivan and Rozen 1985] that includes complete flakes, proximal fragments, medial-distal fragments, non-orientable fragments, and split flakes), cortex cover on dorsal face (tertiary flakes are those lacking dorsal cortex), interpretive flake type (retouch flakes are small and removed from tool margins for maintenance or resharpening purposes though they can also be spontaneously removed during use), and flake initiation (fracture mechanics terms: cone, bend or wedge). Results in Table 2.3 demonstrate a consistent pattern of small to extra-small slate, basalt, and chert flakes, occasionally identifiable as retouch with bend initiations. Given the small bore size for the cores it is not surprising that all flakes are very small. But this does suggest that among other things lithic reduction included tool maintenance though some of the flakes could have been produced as byproducts of heavy tool use (e.g. chopping or adzing wood with a slate celt [one was observed in contexts associated with illicit digging -- Appendix A).

Table 2.3. Lithic debitage data. Therm_Alt=thermal alteration; SM = small; XSM=extra–small; SRT=Sullivan and Rozen typology; t=tertiary cortex; rf=retouch flake; b=bend initiation; CCS=crypto-crystalline silicate; pl grn=pale green.

Spec_ID	Core	Material	Therm_Alt	Size	SRT	Cortex	Type	Initiation
C259	28.2	slate	n	Xsm	md	t		
C259	28.2	slate	n	Xsm	md	t		
C259	28.2	slate	n	Xsm	md	t		

C259	28.2	slate	n	Xsm	p	t	rf	b
C259	28.2	slate	n	Xsm	md	t		
C259	28.2	slate	n	Xsm	md	t		
C259	28.2	slate	n	Xsm	md	t		
C259	28.2	dark_ccs	n	Xsm	md	t		
C259	28.2	slate	n	Sm	s	t	rf	b
C259	28.2	slate	n	xsm	md	t		
C259	28.2	slate	n	xsm	md	t		
C259	28.2	slate	n	xsm	md	t		
C087	9	ltgrey_ccs	n	xsm	p	t	rf	b
C086	30	basalt	n	xsm	p	t	rf	b
C086	30	basalt	n	xsm	md	t		
C405	27	sandstone	n	sm	md	t		
C202	28.3	transp_ccs	n	xsm	md	t		
C191	28.4	slate	n	xsm	md	t		
C191	28.4	slate	n	xsm	md	t		
C191	28.4	basalt	n	xsm	md	t		
C228	28.2	pl grn ccs	n	sm	md	t		
C060	4	slate	n	xsm	md	t		
C226	28.3	slate_shale	n	xsm	p	t	rf	b
C226	28.3	slate	n	xsm	md	t		
C499	13	slate_shale	n	xsm	md	t		
C150	29.2	basalt	n	Xsm	md	t		

Two small lithic tools were recovered from undated contexts. Both are chipped triangular objects, one made on slate and the other basalt. Each has lateral retouch on one margin that could represent use-wear. One (basalt) also includes damage in the form of rounding to its distal tip suggesting use as a punch or drill.

Three additional classes of artifacts were recovered from the cores. These included very small fragments of items woven from grass, extra-small (<1 cm^2) ceramic sherds (Yup'ik; not European), and fire cracked rock. Fienup-Riordan (2007) documents many uses for woven grass including (but not limited to) mats, baskets, bedding, boot liners, curtains, fans, harnesses, mitten liners, twine, and clothing. Kowta (1963) described Thule tradition ceramics from his excavations and large sherds of the same items are common in contexts of illicit artifact digging on Mound 1. One tiny glass shard was recovered from an undated context. This is likely intrusive from later times though in 19th century contexts glass could have been used. Fire-cracked rock, used in cooking and heating was recovered in small numbers in a number of cores.

Table 2.4. Other artifacts.

Core	Woven Grass	Ceramics	Glass	Fire-Cracked Rock
6.1				1
9.1	1			

11.1				1
13.1		1		
14.1		3		1
15.1				2
16.1	1		1	
17.1	1			
19.1				1
22.1		2		
24.1				4
26.1		2		
28.1	5			
28.1/28.2				1
29.1/29.2	1			

Summary

The 2015 field season of the Togiak Archaeological and Paleoecology Project focused on generated an array of multidisciplinary data. Field activities focused on mapping the site, profiling exposed sections of Mound 1, collecting core samples, facilitating and collecting geophysical data, and collecting initial geoarchaeological data. Lab research focused on dissecting cores and extracting materials for radiocarbon dating and analysis. Subsequently we ran 40 AMS radiocarbon dates of which 37 were in or near the expected range (13^{th} to 19^{th} centuries). We collected macrobotanical data for paleoethnobotanical analysis and submitted soil samples for pollen studies. We identified an unexpectedly large sample of faunal remains that included elements from shellfish, fish, birds, and mammals. We also collected a small inventory of lithic, ceramic, and grass artifacts from the cores. Results of these studies detailed in the appendices confirm a lengthy Thule (Ancestral Yup'ik) and Historic Yup'ik occupation sequence across the site with oldest materials located in the southern area within and adjacent to the four house mounds. Geoarchaeological research opens many new questions regarding landform evolution and challenges to the original occupants. However, this research does suggest that the Old Togiak spit formed most intensively during the past 700-800 years and while still accreting is also being eroded on its lateral margins. Erosion is severe enough that even without effects of illicit digging for artifacts the southern portion of the site could be entirely eroded away in the next 100 years. Paleoecological studies point to an ancient landscape that was in many similar to that of today. Pollen and macrobotanicals implicate a grassy-tundra with limited low shrubs of a variety of species. However, different from today, alder bushes may have been more common at some specific times during the Little Ice Age of ca. 1500-1700 CE. Faunal and floral remains provide direct insight into foraging activities by *Temyiq Tuyuryaq* residents. Sampling is not adequate to address change over time. However, it is clear that annual cycles much like that described in the ethnographic record were practiced within this community. Artifacts recovered in cores and identified in back dirt from illicit digging are consistent with radiocarbon dates pointing to Ancestral and Historic Yup'ik occupations. Additional conclusions and recommendations are briefly discussed in the next chapter.

Conclusions and Recommendations

(Anna Marie Prentiss)

At the initiation of this project we proposed two alternative macro-scale hypotheses regarding human occupation patterns in the northern Bristol Bay area as might be manifested at *Temyiq Tuyuryaq*, the Old Togiak site. The first followed from Maschner et al. (2009) that the Bristol Bay area was not exempt from ecological instability associated with the Medieval Warm Period (MWP) of ca. 800-1400 CE that led to abandonments of many large villages in the eastern Aleutians and Gulf of Alaska. We hypothesized that if this were the case then Norton period villages would have been abandoned early in this time and later replaced by Thule period groups closer to ca. 1400 CE or at the end or the MWP and the beginning of the Little Ice Age (LIA). We projected that if similar to the southeastern Bering Sea the new groups would have focused to a greater degree on salmon harvest coupled with select sea mammals compared to more diversified diets of earlier times. We offered a counter-hypothesis that despite ecological challenges, Thule period groups with enhanced technologies and foraging strategies perhaps derived from the Bering Strait region directly followed the Norton groups and established permanent villages perhaps as early 1000 CE, which then remained stable through the MWP and grew more rapidly during the more productive LIA. Enhanced technologies and foraging strategies would have permitted groups to maintain a diversified diet including fish, terrestrial game, and sea mammals. Both hypotheses expect Yup'ik subsistence cycles, inter-group relations, and ritual traditions to develop throughout the lifespan of the village though the initial manifestations of many Yup'ik traditions would appear much earlier in the latter hypothesis.

Not all aspects of these hypotheses could be tested with the results of the 2015 field season as ultimately this would require extensive excavation data permitting assessment of variation in household occupations over time. However, drawing from our data and that of Kowta (1963) it is possible to draw some preliminary conclusions. First, 35 of our 40 radiocarbon dates fall in the range of ca. 1220-1920 CE (drawing from 95% confidence intervals). Of these, the first major concentration of dates are in the range of ca. 1320-1420 CE and thus on the transition from the MWP to the LIA. As illustrated by Maschner et al. (2009) (drawing data from Finney et al. [2002]), salmon productivity was substantially elevated (compared to the period pre-dating 800 CE) after ca. 1300 CE. If our dates are confirmed by future investigations using alternative dating materials it suggests that first major occupations of *Temyiq Tuyuryaq* came as salmon productivity increased during the early LIA. This, therefore, tentatively confirms the major prediction of the first hypothesis that there was an occupation gap during much of the MWP between the last Norton period occupants and those of the Thule period. Slightly later dates were identified at the Nunalleq site in the Kuskokwim Delta to the west (Ledger et a. 2016). Dumond (1981) acquired six dates from Thule period materials at Brooks Camp. While four of those dates are within the same range as ours two others seem slightly earlier. However, Dumond's date of 845+/-100 BP calibrates to a highest probability range (.994) of 767-1446 CE with a mean of 1107 CE while his other date of 880 +/-65 BP calibrates at the highest probability range (.976) to 890-1316 CE with a mean of 1103 CE (both at two sigmas using Calib 7.1). Thus, at two sigma calibrations, Dumond's dates have wide error ranges that substantially overlap with our early dates. Given these comparisons we suggest that our earliest Thule period dates are in line for what we would expect of earliest Ancestral Yup'ik (Thule period) occupants of northern Bristol Bay likely during the 13th and early 14th centuries.

The next question concerns whether the LIA had a recognizable effect in the *Temyiq Tuyuryaq/*Old Togiak area. Put differently, the colder climate of the LIA impact plant and animal distributions in our study area. While our data are not yet adequate to address fish, bird, and mammal distributions our pollen and macrobotanical data converge on the conclusion that shrubs were likely relatively uncommon. If that was the case then this may have been tundra adapted to colder conditions between the 13th and 19th centuries and thus clearly impacted by the LIA. Obviously, this conclusion is highly preliminary and subject to further testing in the future.

A major contribution of our study is demonstration that *Temyiq Tuyuryaq* residents harvested cloud berries, crow berries, and red raspberries along with a range of other plant food sources. We also show that fishing was intensive likely from earliest occupation dates. These conclusions conform to hypothesis one predictions that marine productivity was critical to early Thule period occupants but also show that plant foods were essential as documented in ethnography. Kowta's (1993) inventory of faunal remains confirms that seals were important to diets throughout the entire sequence. Kowta's excavation levels 6-11 have only sparse numbers of whales, walrus, and bearded seal while upper levels have these items in relative abundance. On surface inspection this suggests that only seals were critical (along with fish) during the earliest occupation. However, there is also reason to suspect that sampling bias could be affecting this outcome as Kowta's sampling frame was much narrower in the deeper strata. The latter conclusion is further supported by the distribution of land mammals which is comparatively sparse in levels 6-11 compared to later levels. Clearly, further analysis needs to be conducted with Kowta's collected faunal remains, particularly in reference to sampling issues.

Inherent to our alternative hypotheses are predictions regarding the development of Yup'ik socio-cultural traditions outside of subsistence behavior. Our data are not adequate at this time to conduct those studies as this would require substantial excavation. Combining our data from profile sections with Kowta's excavation results it is clear that Mound 1 and likely that of Mounds 2-4 are house mounds, essentially multiple layers of human living surfaces that included houses and undoubtedly a variety of other features. Our profile sections depict wooden floors, house posts, and probably cache pits and hearths. Given the remarkable level of preservation, the *Temyiq Tuyuryaq* mounds could provide a wealth of archaeological data to reconstruct *Tuyuryaqmiut* cultural traditions associated with family life, ritual, exchange, and other processes during the past 700 years.

Temyiq Tuyuryaq is now under significant threat. Two agents are causing rapid loss of site material, namely erosion from storms and winter ice and illicit artifact digging. As noted by Mason (Appendix D), since 1985 the site is losing about 100 cm of its width on average per year due to erosion (in reality most erosion occurs during brief drastic stormy periods) and projecting from that number we can predict that in as little as 30 years all of the south portion of the site including all mounds and beach ridges with high numbers of house depressions (about 150 by 30 meters or 4500 square meters x 2 meters of average depth, thus about 9000 cubic meters) could be gone (assuming loss of 300 cubic meters on average per year (1m x 150m x 2m). However, it is likely that 30 years over-estimates the time before the site is destroyed. During the three weeks that our field team worked on *Temyiq Tuyuryaq*, a group of dedicated artifact collectors removed an estimated nine cubic meters of sediment from the beach side margin of Mound 1. If the illicit diggers removed three meters per week for 26 weeks per year, the site would lose 78 cubic meters per year. This means that in about 115 years the illicit diggers would completely destroy this portion of the site. If we combine the impact of illicit digging and sea level rise and associated erosion it could mean loss of as much as 378 cubic meters per year and this means total loss of this critical part of the site in 24 years. This figure is merely a crude projection based upon a number of assumptions regarding rates of erosion and illicit digging. It may be an over-estimate but it may also underestimate the rate of site loss. There is good reason to believe that this is actually an underestimation given the interactive effects of illicit digging enhancing the effects of erosion by encouraging slumping of unstable mound sediments (as witnessed by our field team) during high tide or storm surge events.

Given the inevitable loss of one of the region's most precious archaeological localities, I can offer several thoughts for the Togiak Community to consider. First, the community needs to consider if archaeological heritage is worth preserving and/or being recovered via archaeological research. It is not an exaggeration to say that this site offers an extraordinary record of ancestral Yup'ik and more specifically, Tuyuryaqmiut history. Unfortunately, neither is it an exaggeration to say that this record is being rapidly lost and will be entirely gone in the next 20-50 years. Second, while it will probably be hard if not impossible to slow the adverse effects of sea level rise, the community could take steps to reduce the impact of artifact collecting. This would require a concerted effort that would likely include education, signage, and site visits. Third, even with proactive efforts to reduce illicit digging, the site will still be lost to erosion (as combined with effects of human activities). Thus, a final option to consider is archaeological excavation.

A major archaeological excavation could be possible with funding, for example, from the National Science Foundation, and should be developed in such a way that community members are employed in the field and lab operation and younger generations educated by exposure to the field and lab work. Research questions for such a project should be substantially driven by community interests. All recovered materials should be ultimately curated in Togiak and presumably made available for community research and education efforts. Methodological approaches to such a research project could build on the advanced studies outlined in this report. Indeed, many of the research directions initiated here could be much further expanded in a larger scale effort. Finally, ongoing research in community history and potentially ethnoarchaeology should be woven into any larger scale archaeological efforts.

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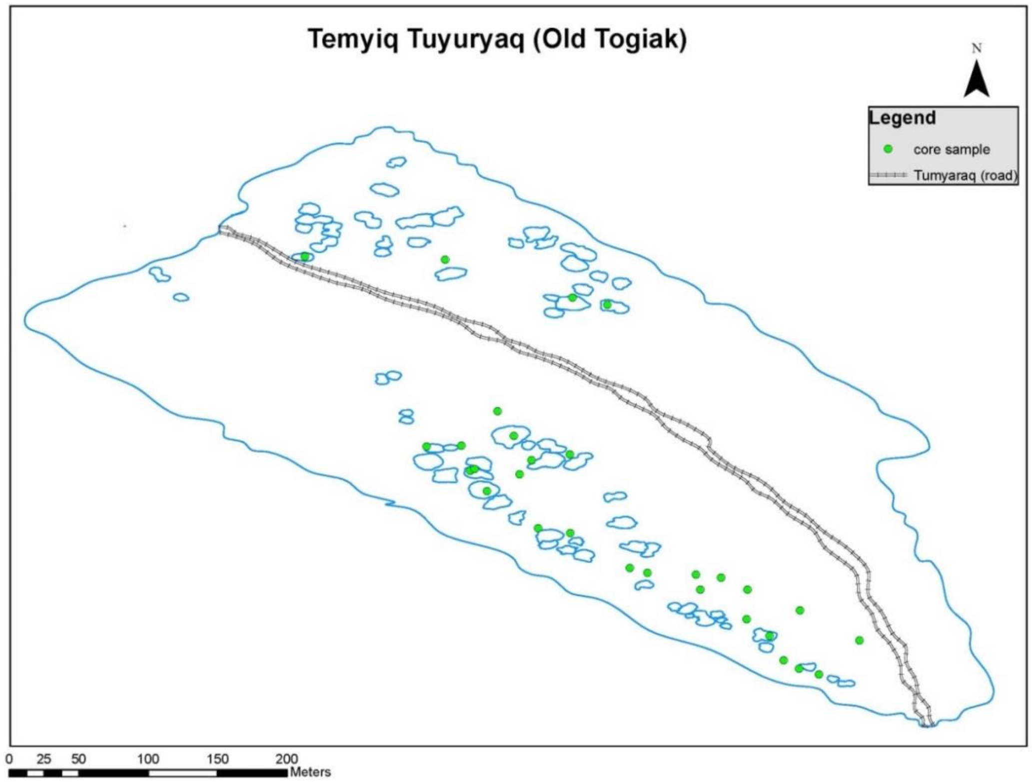
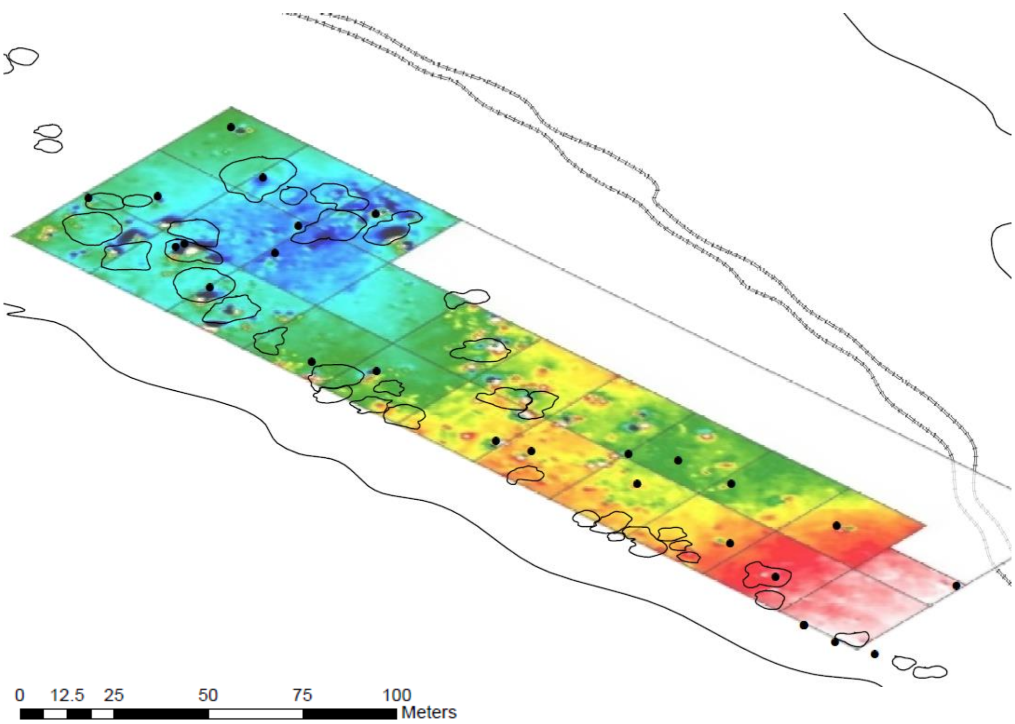
Appendix A

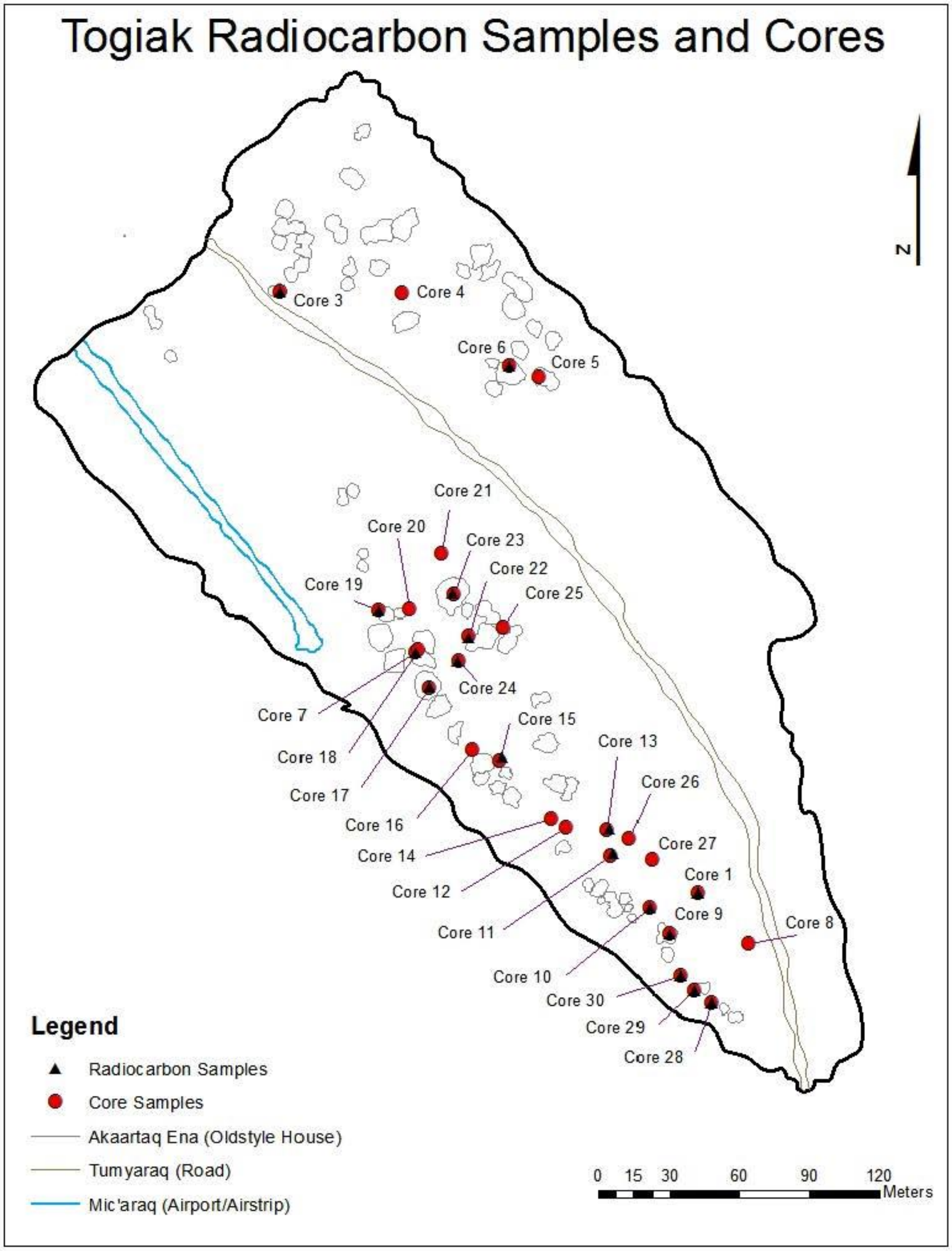
Maps and Photographs



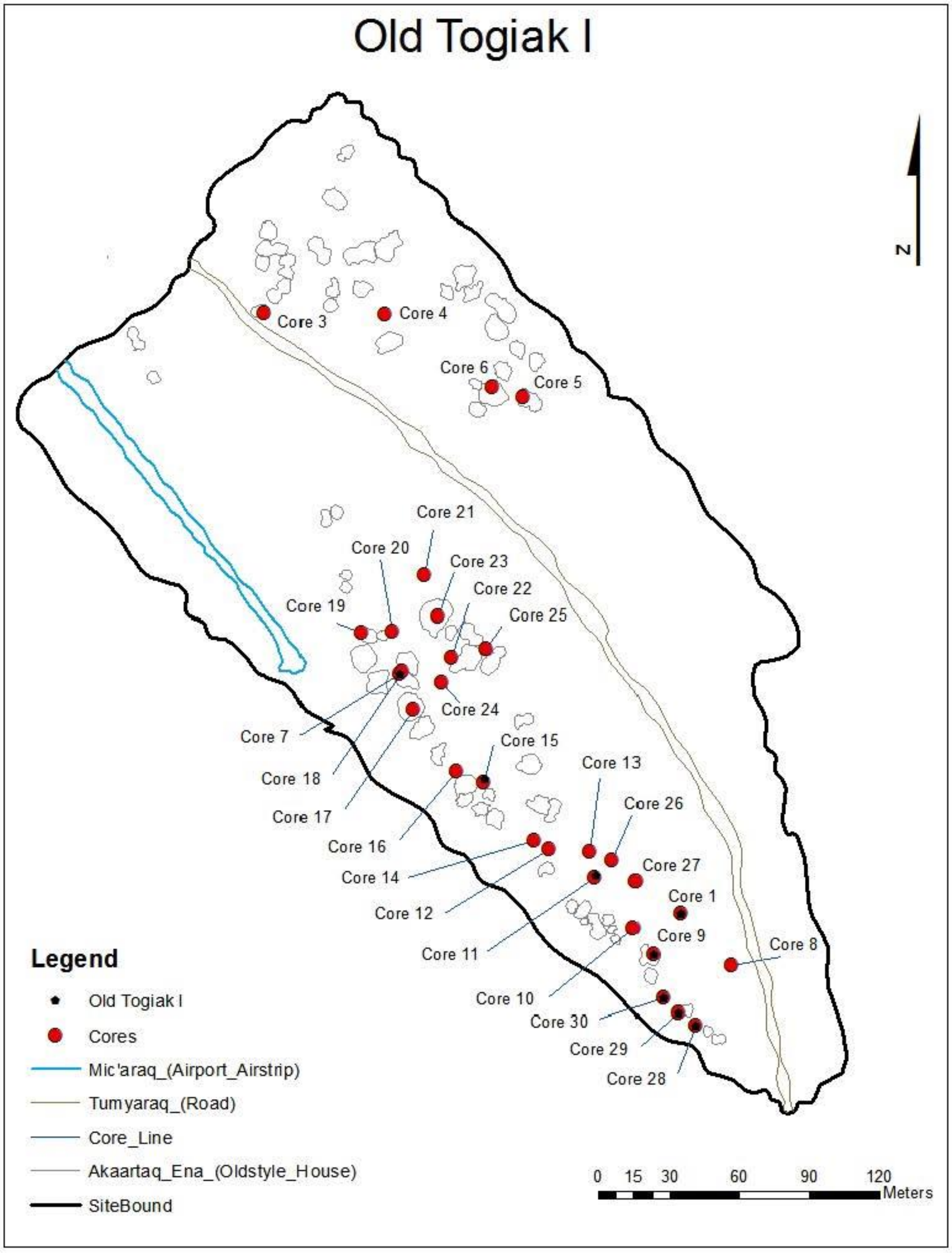
Surface map of *Temyiq Tuyuryaq*, the Old Togiak site showing major cultural depressions and core locations.



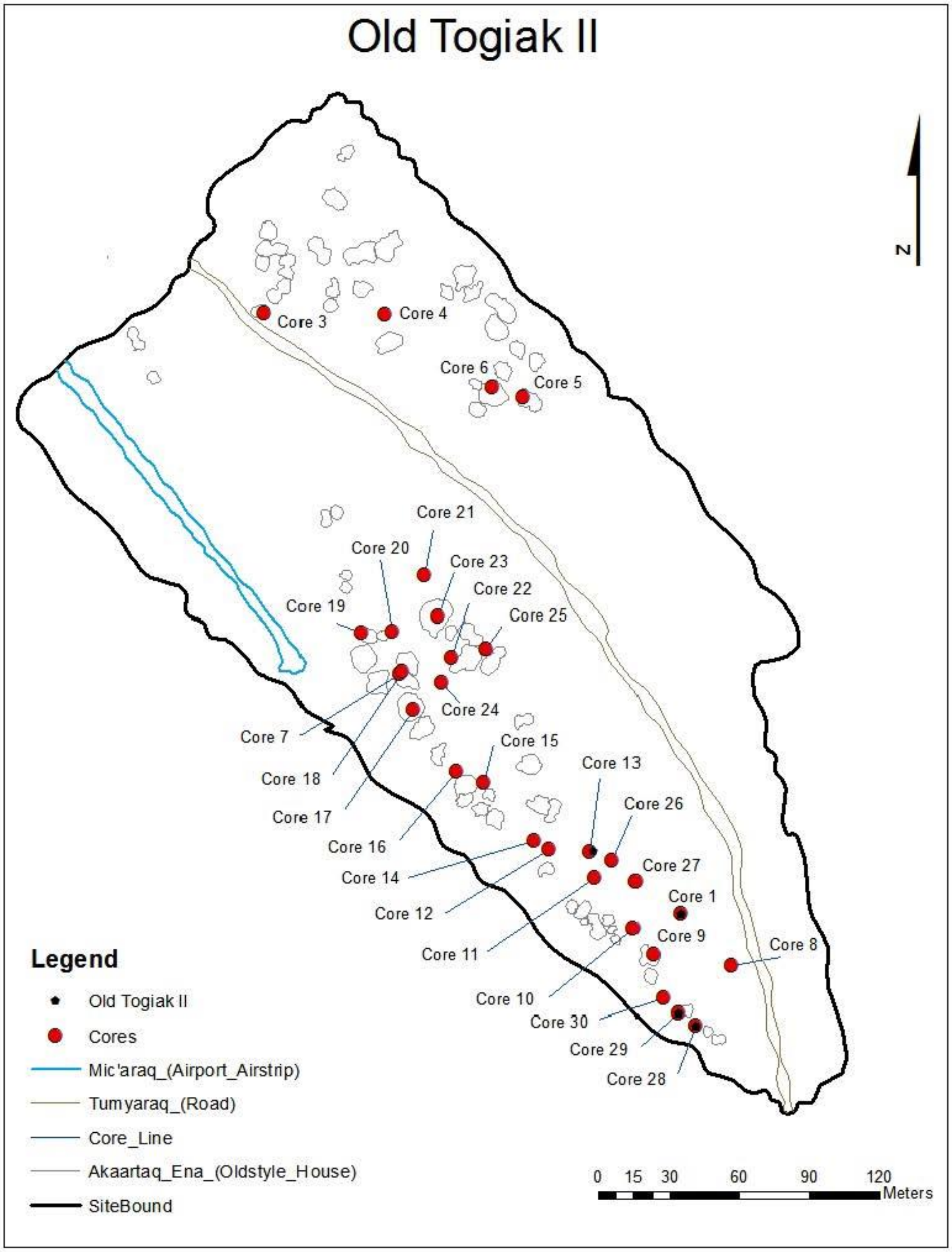
Magnetometry map southern portion of site including mounds and beach ridges with cultural depressions. Also present are core positions for this locality.



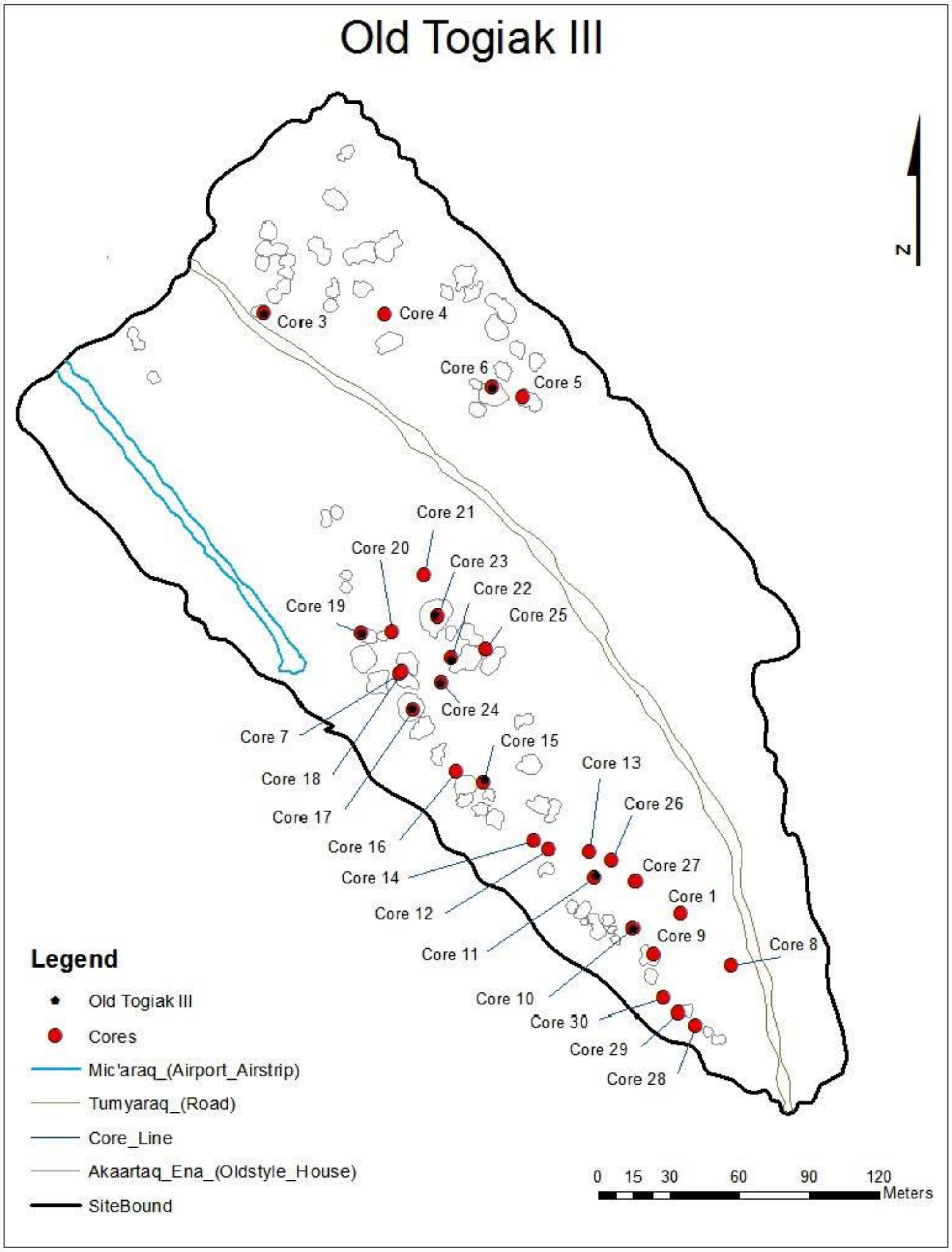
Map of *Temyiq Tuyuryaq*, the Old Togiak site showing core locations. Cores 9, 10, 28, 29, and 30 are on Mound 1. Core 1 is on Mound 2. Core 8 is on Mound 3. Mound 4 is to the SE of the Core 28 area near the intersection of the road and the beach line.



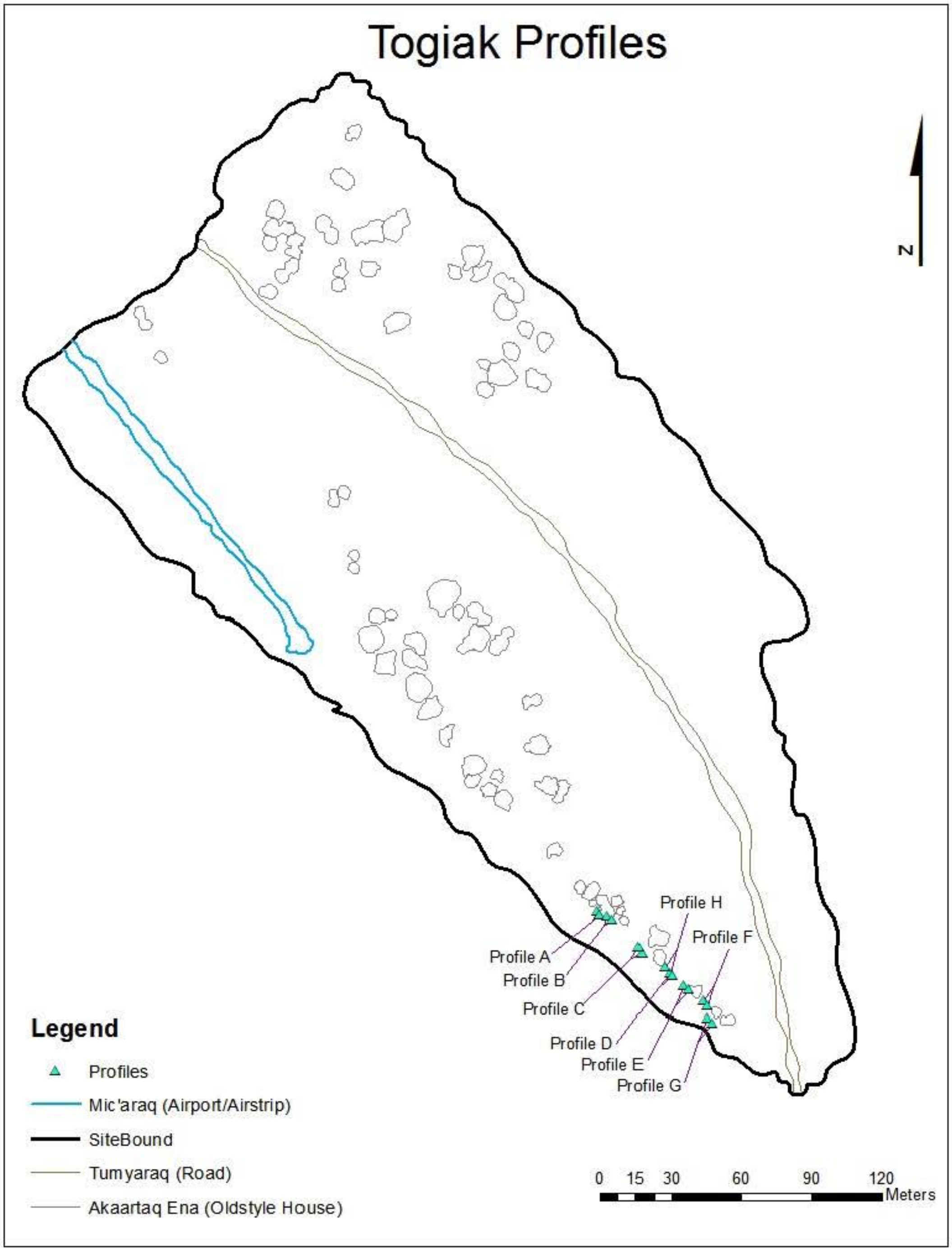
Map of *Temyiq Tuyuryaq*, the Old Togiak site showing core locations with TT/OTI dates.



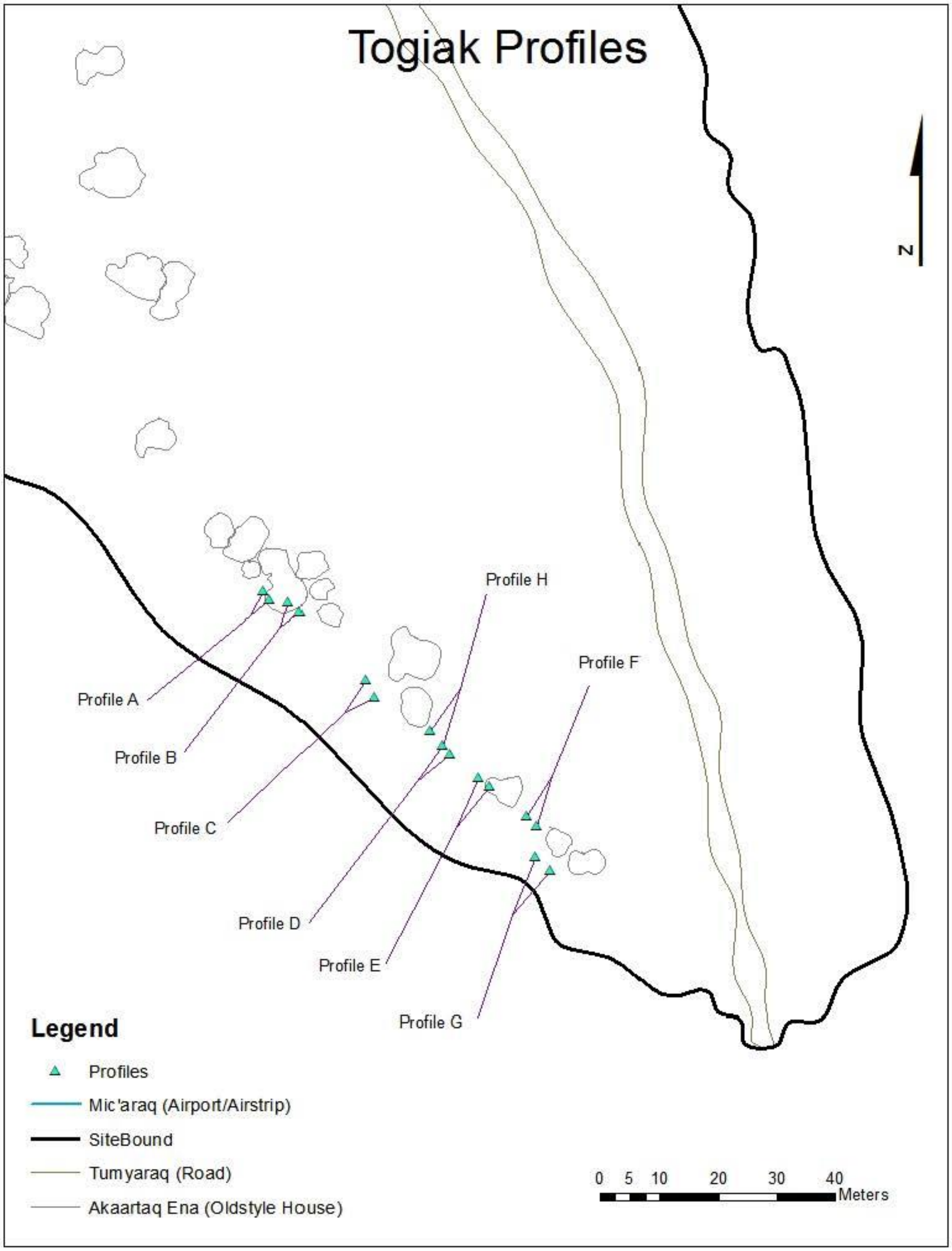
Map of *Temyiq Tuyuryaq*, the Old Togiak site showing core locations with TT/OTII dates.



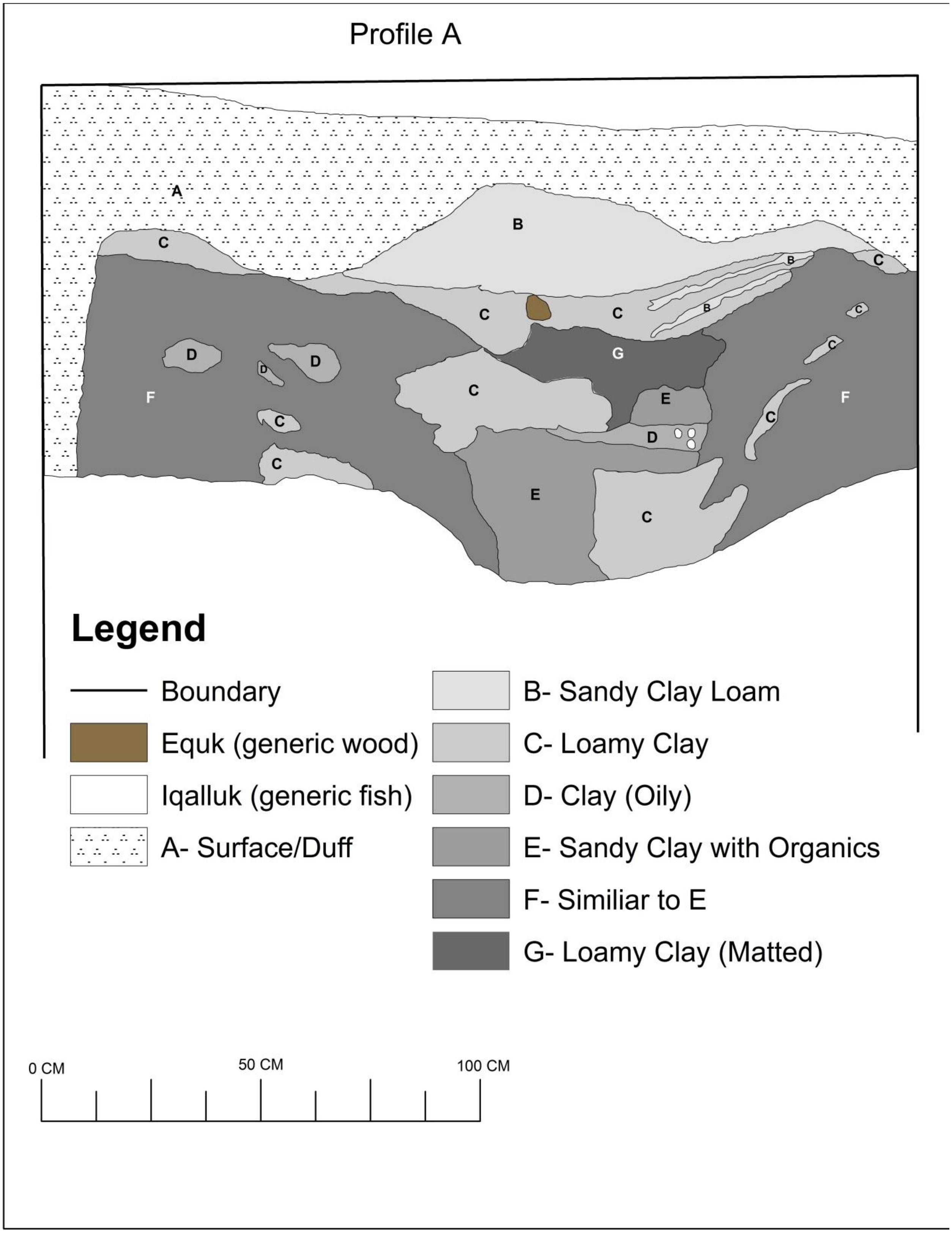
Map of *Temyiq Tuyuryaq*, the Old Togiak site showing core locations with TT/OTIII dates.



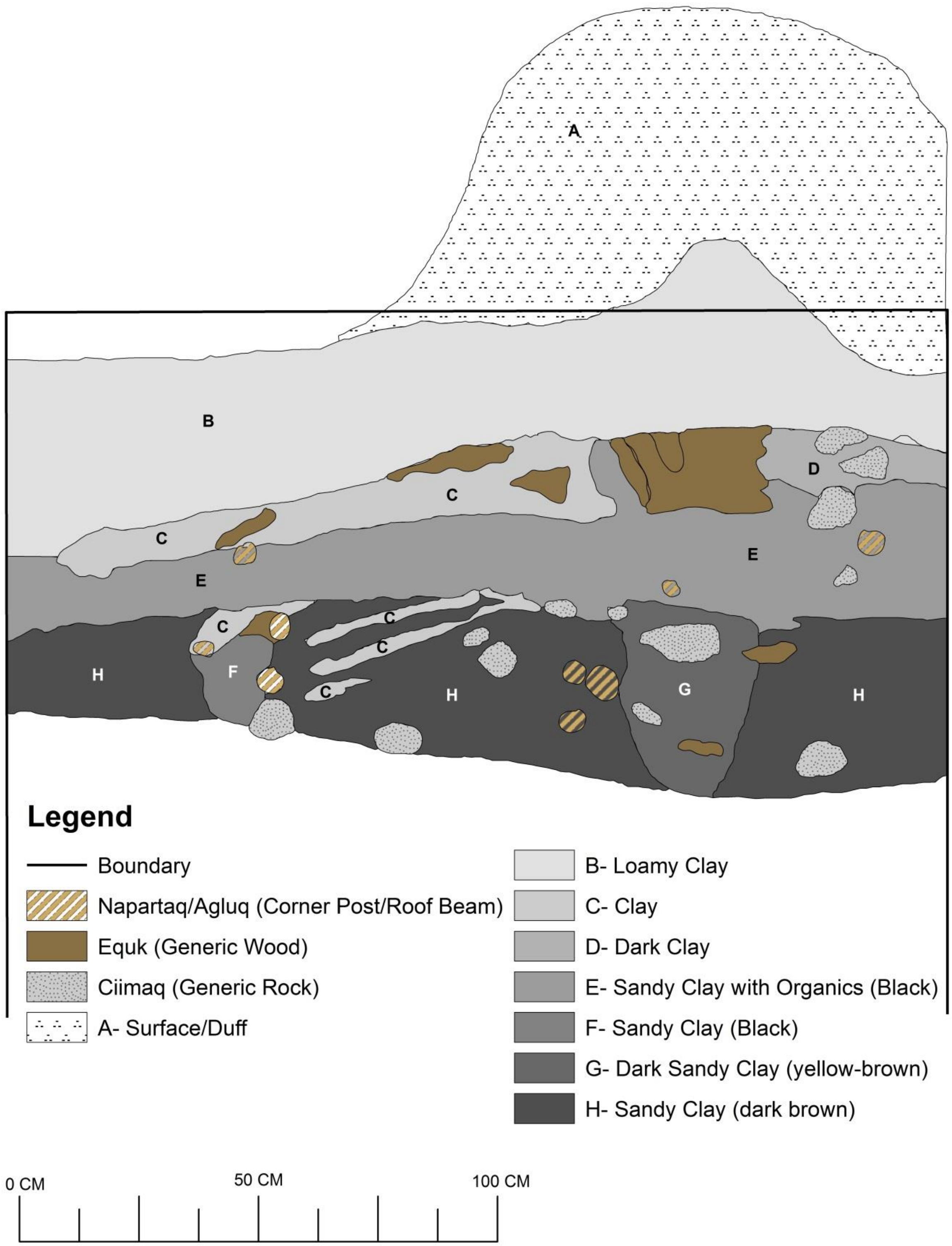
Map of *Temyiq Tuyuryaq*, the Old Togiak site showing locations of profiled Mound 1 sections.



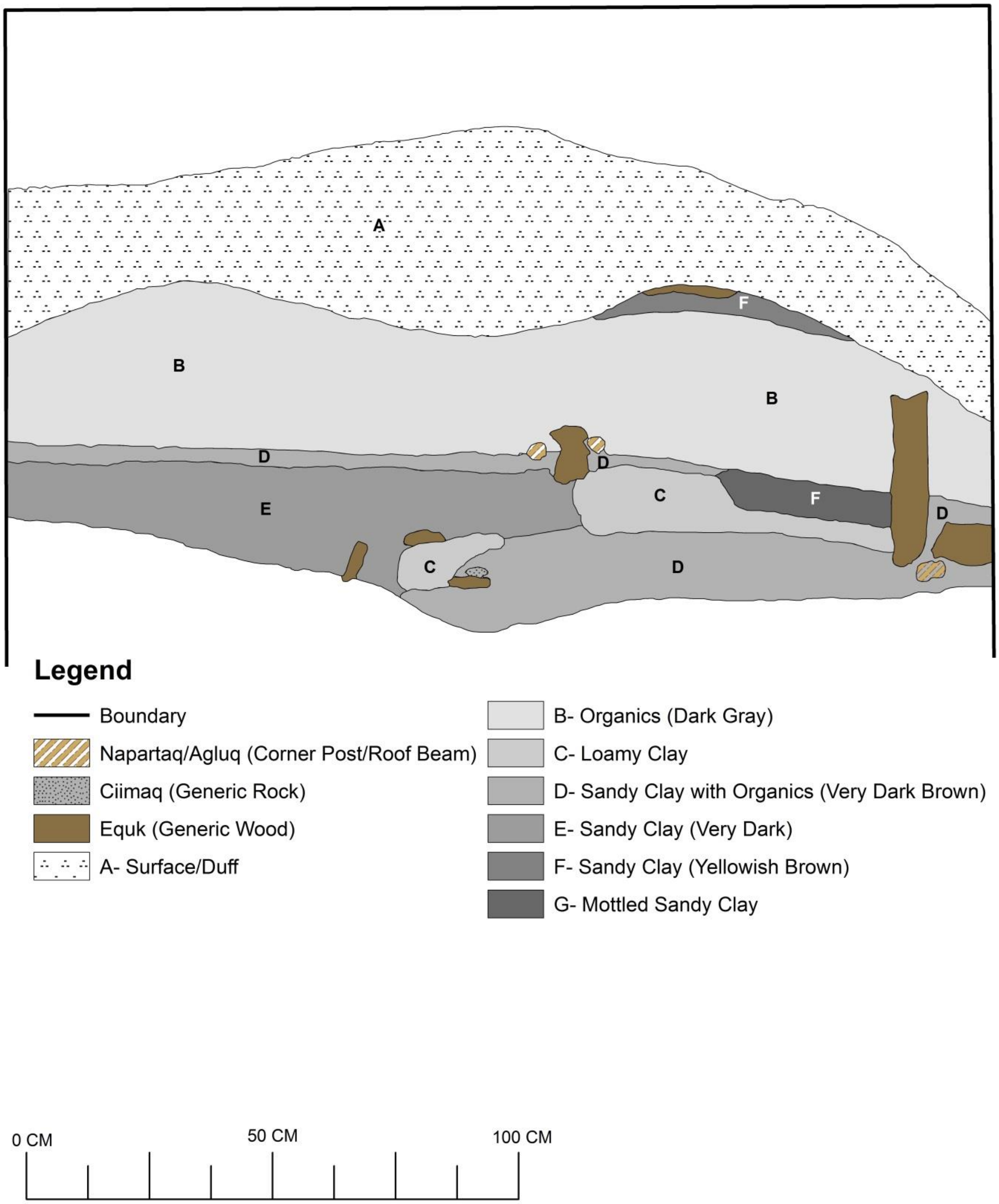
Map of *Temyiq Tuyuryaq*, the Old Togiak site showing locations of profiled Mound 1 sections.


Profile A
A
B
C
F
D
G
E
Legend
Boundary
Equk (generic wood)
Iqalluk (generic fish)
A- Surface/Duff
B- Sandy Clay Loam
C- Loamy Clay
D- Clay (Oily)
E- Sandy Clay with Organics
F- Similiar to E
G- Loamy Clay (Matted)
0 CM
50 CM
100 CM

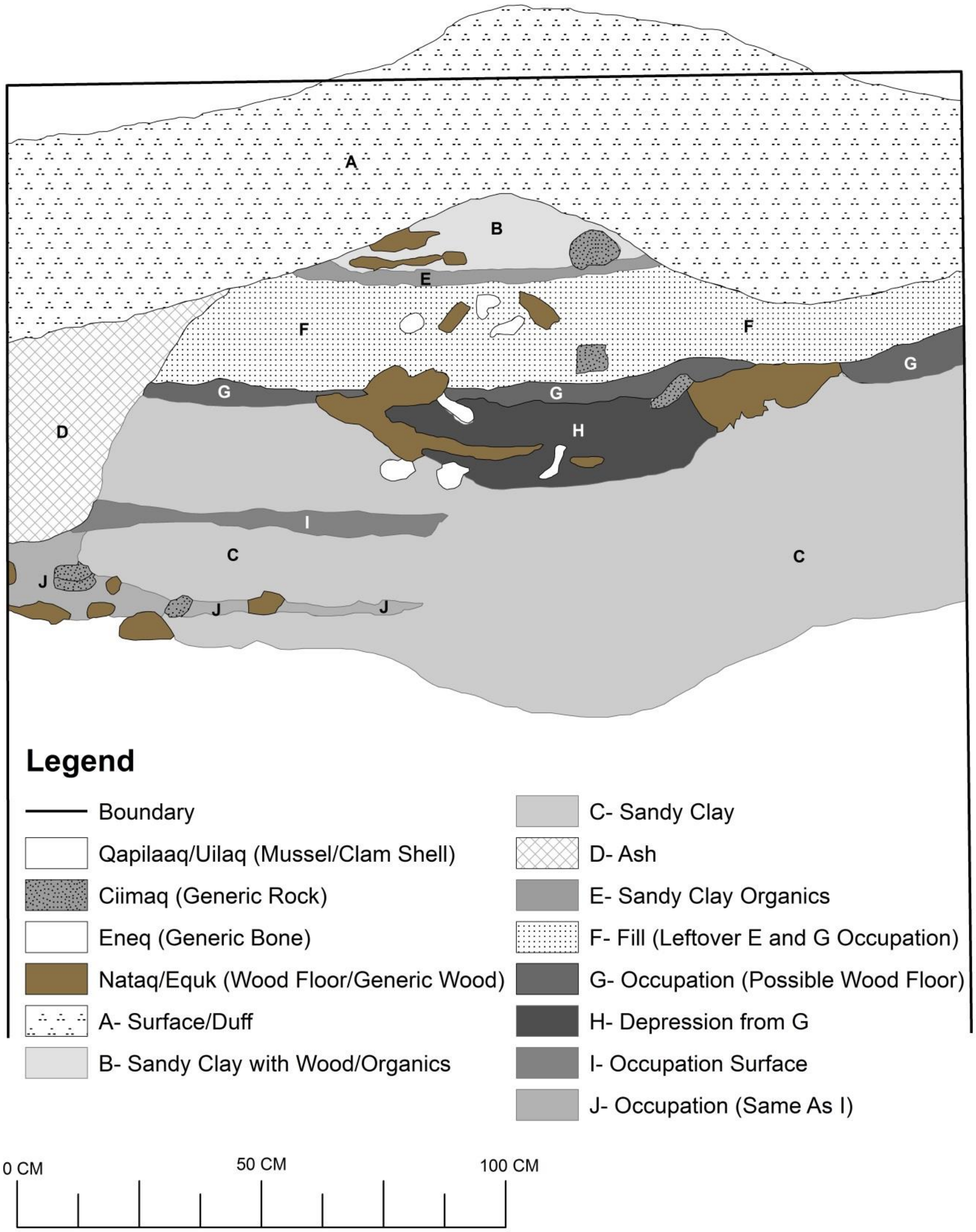
Profile B


A
B
C
D
E
F
G
H
Legend
Boundary
Napartaq/Agluq (Corner Post/Roof Beam)
Equk (Generic Wood)
Ciimaq (Generic Rock)
A- Surface/Duff
B- Loamy Clay
C- Clay
D- Dark Clay
E- Sandy Clay with Organics (Black)
F- Sandy Clay (Black)
G- Dark Sandy Clay (yellow-brown)
H- Sandy Clay (dark brown)
0 CM
50 CM
100 CM

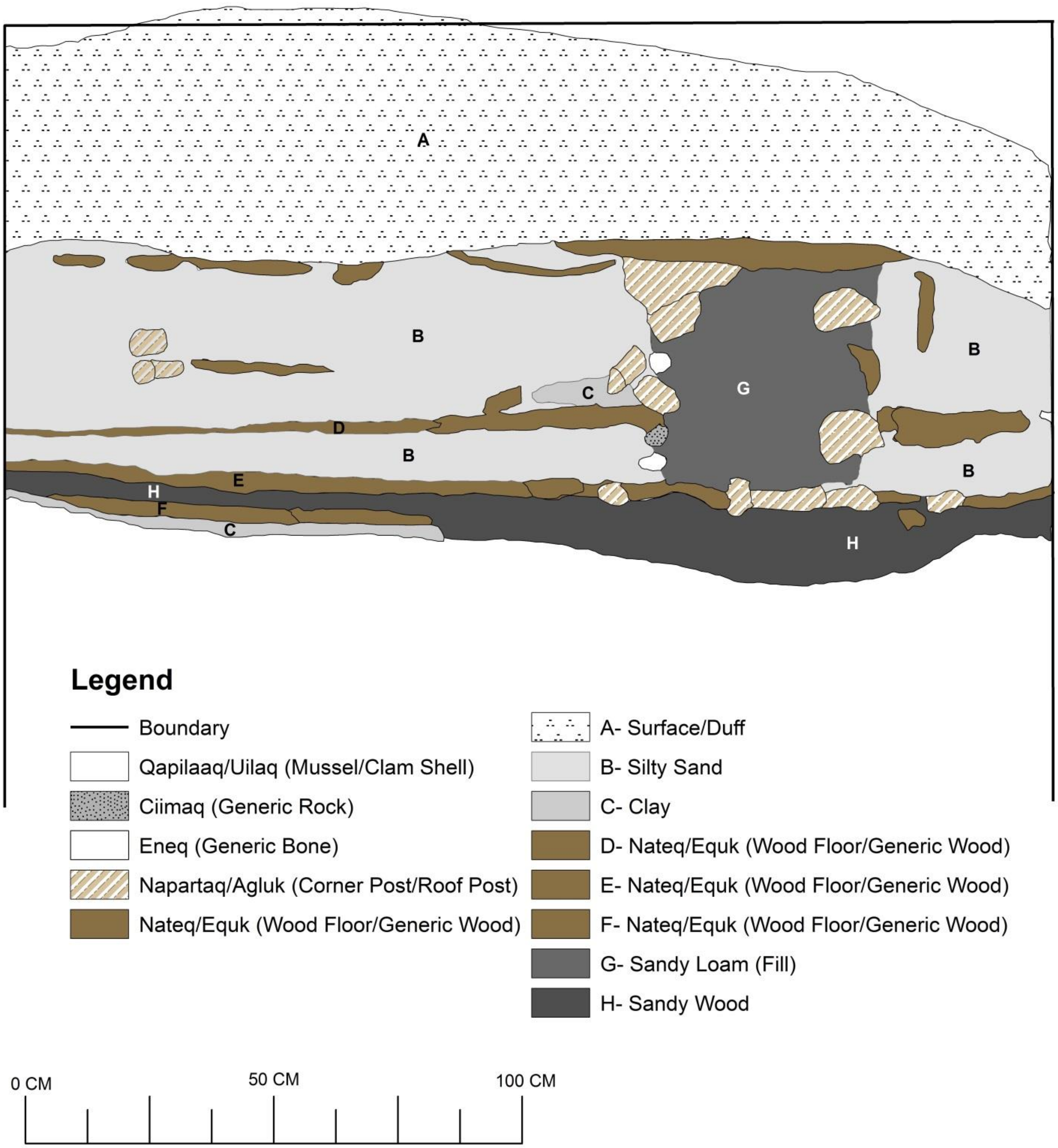
Profile C


A
B
B
F
D
D
C
F
D
E
C
D
Legend
Boundary
Napartaq/Agluq (Corner Post/Roof Beam)
Ciimaq (Generic Rock)
Equk (Generic Wood)
A- Surface/Duff
B- Organics (Dark Gray)
C- Loamy Clay
D- Sandy Clay with Organics (Very Dark Brown)
E- Sandy Clay (Very Dark)
F- Sandy Clay (Yellowish Brown)
G- Mottled Sandy Clay
0 CM
50 CM
100 CM

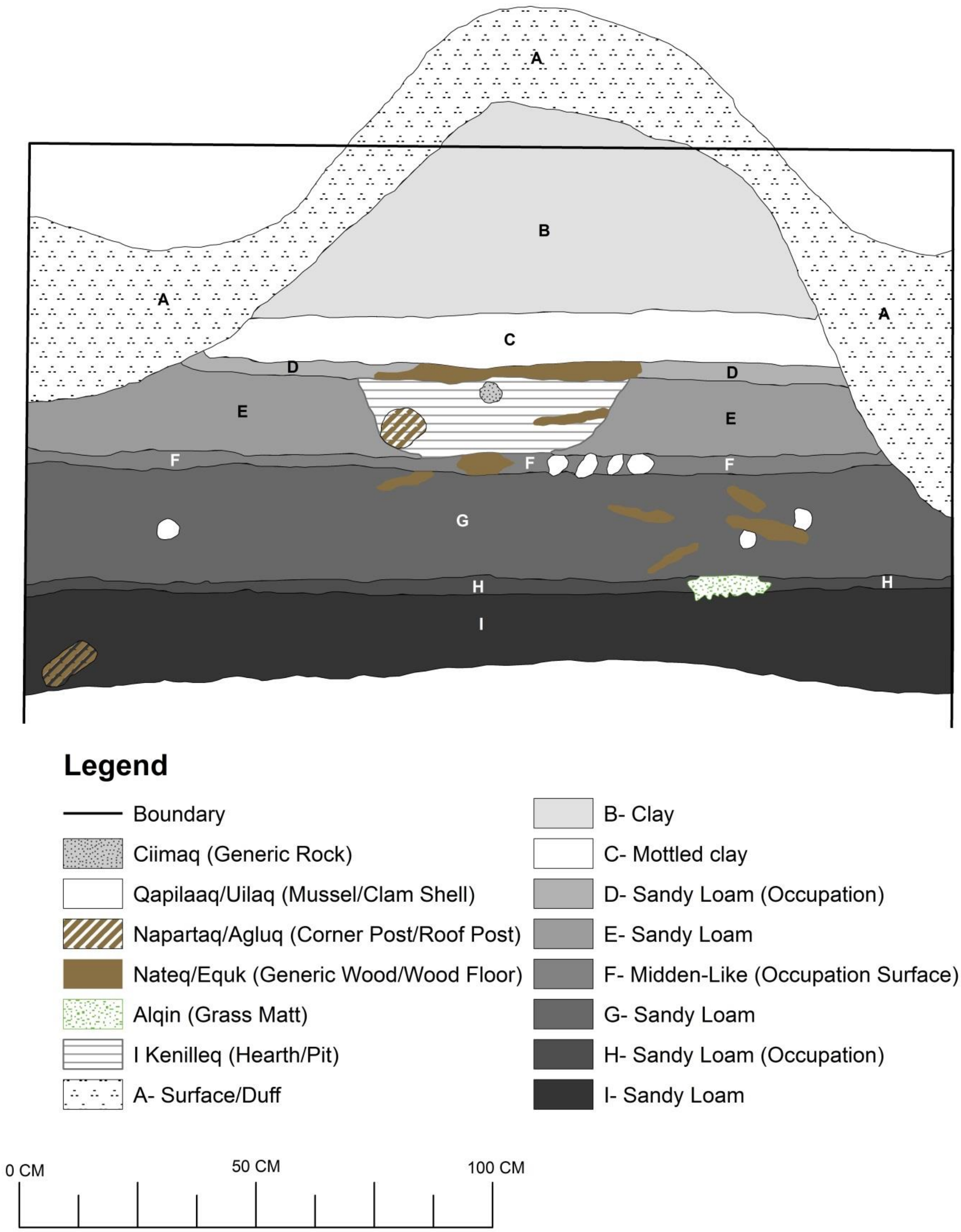
Profile D


A
B
E
F
F
G
G
G
H
D
I
C
C
J
J
J
Legend
Boundary
Qapilaaq/Uilaq (Mussel/Clam Shell)
Ciimaq (Generic Rock)
Eneq (Generic Bone)
Nataq/Equk (Wood Floor/Generic Wood)
A- Surface/Duff
B- Sandy Clay with Wood/Organics
C- Sandy Clay
D- Ash
E- Sandy Clay Organics
F- Fill (Leftover E and G Occupation)
G- Occupation (Possible Wood Floor)
H- Depression from G
I- Occupation Surface
J- Occupation (Same As I)
0 CM
50 CM
100 CM

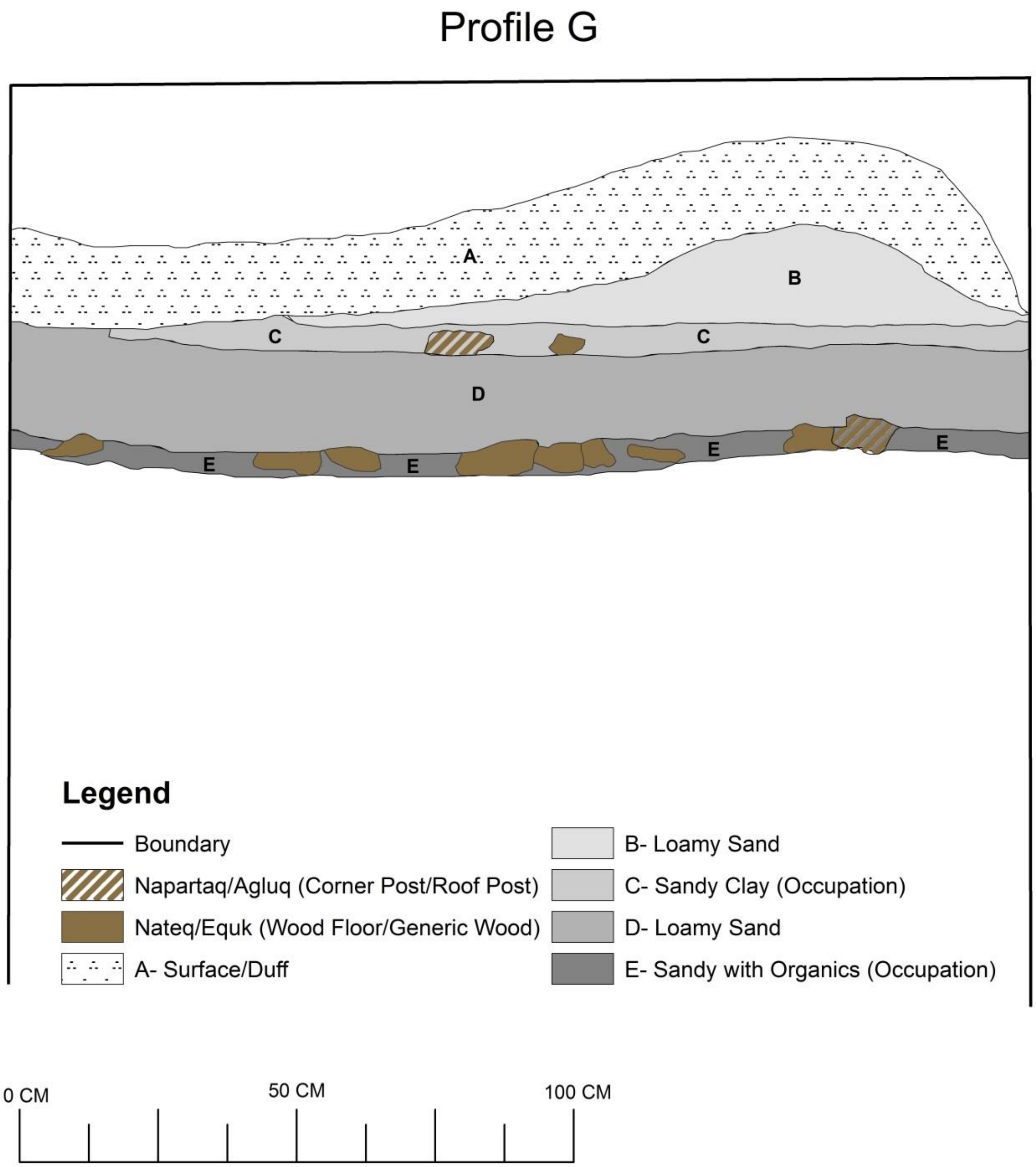
Profile E


A
B
B
C
G
D
B
B
B
H
E
F
C
H
Legend
Boundary
Qapilaaq/Uilaq (Mussel/Clam Shell)
Ciimaq (Generic Rock)
Eneq (Generic Bone)
Napartaq/Agluk (Corner Post/Roof Post)
Nateq/Equk (Wood Floor/Generic Wood)
A- Surface/Duff
B- Silty Sand
C- Clay
D- Nateq/Equk (Wood Floor/Generic Wood)
E- Nateq/Equk (Wood Floor/Generic Wood)
F- Nateq/Equk (Wood Floor/Generic Wood)
G- Sandy Loam (Fill)
H- Sandy Wood
0 CM
50 CM
100 CM

Profile F

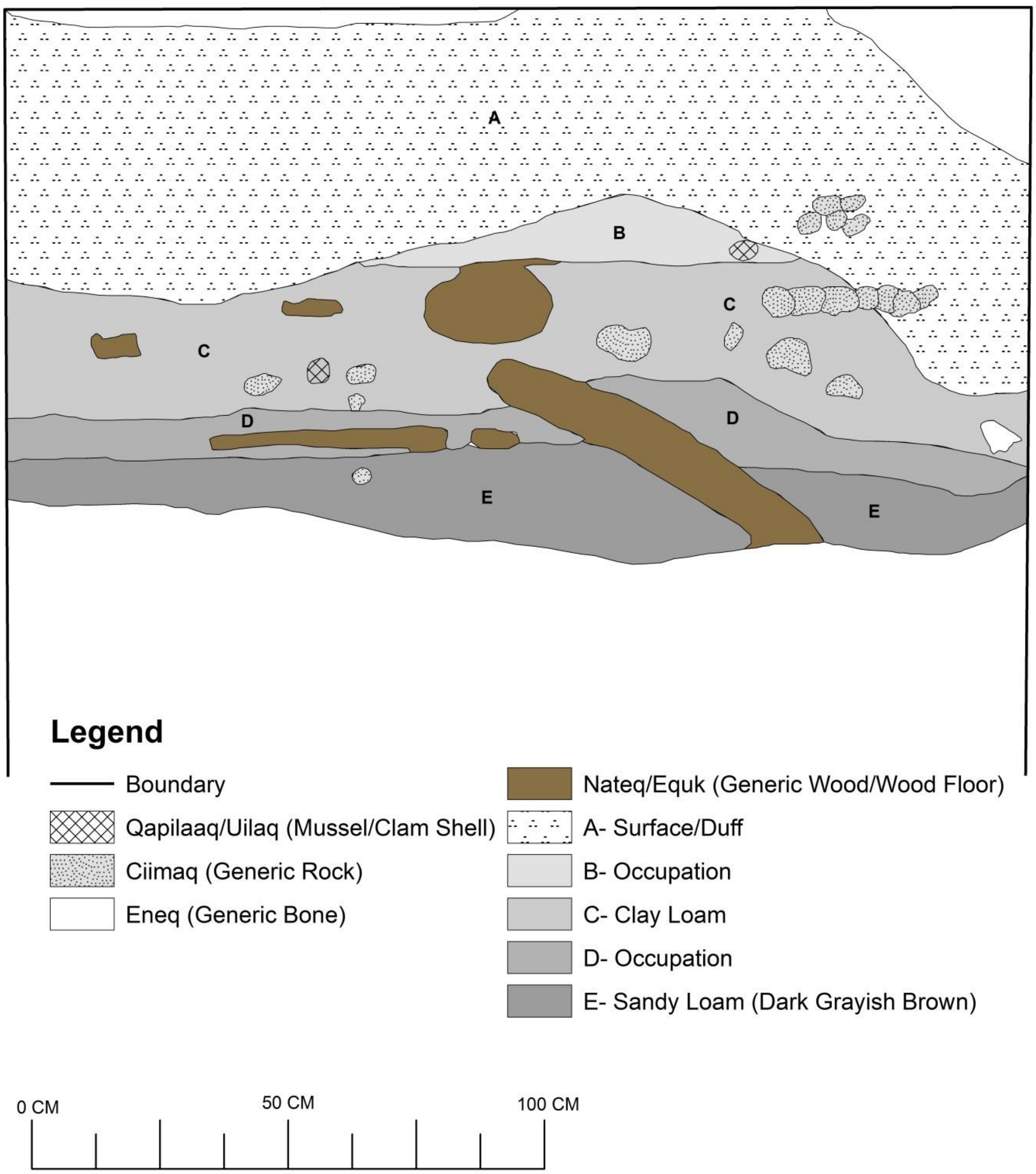


A
B
A
A
C
D
D
E
E
F
F
F
G
H
H
I
Legend
Boundary
Ciimaq (Generic Rock)
Qapilaaq/Uilaq (Mussel/Clam Shell)
Napartaq/Agluq (Corner Post/Roof Post)
Nateq/Equk (Generic Wood/Wood Floor)
Alqin (Grass Matt)
I Kenilleq (Hearth/Pit)
A- Surface/Duff
B- Clay
C- Mottled clay
D- Sandy Loam (Occupation)
E- Sandy Loam
F- Midden-Like (Occupation Surface)
G- Sandy Loam
H- Sandy Loam (Occupation)
I- Sandy Loam
0 CM
50 CM
100 CM



Profile G
A
B
C
C
D
E
E
E
E
Legend
Boundary
Napartaq/Agluq (Corner Post/Roof Post)
Nateq/Equk (Wood Floor/Generic Wood)
A- Surface/Duff
B- Loamy Sand
C- Sandy Clay (Occupation)
D- Loamy Sand
E- Sandy with Organics (Occupation)
0 CM
50 CM
100 CM

Profile H


Legend
Boundary
Qapilaaq/Uilaq (Mussel/Clam Shell)
Ciimaq (Generic Rock)
Eneq (Generic Bone)
Nateq/Equk (Generic Wood/Wood Floor)
A- Surface/Duff
B- Occupation
C- Clay Loam
D- Occupation
E- Sandy Loam (Dark Grayish Brown)
0 CM
50 CM
100 CM


View of the Old Togiak spit facing southwest from Twin Hills


View of salt marsh on north side of *Temyiq Tuyuryaq*, Old Togiak site; view facing approximately north.

View of beach ridges on north/northwest side of *Temyiq Tuyuryaq*, the Old Togiak site; view facing N/NW.

Interns collecting data in northern portion of *Temyiq Tuyuryaq*; view facing approximately southeast.


Beach ridges with housepits on north side of *Temyiq Tuyuryaq*. View approximately north.


Interns collecting data from large housepit on north side of *Temyiq Tuyuryaq*. View facing approximately west.

Beach on south side of *Temyiq Tuyuryaq*, Old Togiak site. View facing approximately southeast.

East side of Mound 1 (largest mound) illustrating damage from illicit digging and erosion. Note also datum stake on apex of mound. View facing approximately north.

Large housepit on beach ridge on south portion of *Temyiq Tuyuryaq*. View facing approximately north.

Small housepit on beach ridge in south portion of *Temyiq Tuyuryaq*. View facing approximately northeast.


Large housepit on beach ridge on south portion of *Temyiq Tuyuryaq*. View facing approximately north.


Historic artifact (wash basin) in south portion of *Temyiq Tuyuryaq*.


Historic artifact (stove part) in south portion of *Temyiq Tuyuryaq*.


Ethan Ryan and Kristen Barnett collecting a core sample on Mound 1 (large mound). View facing southeast.


Damage from illicit digging on Mound 1. View facing approximately north/northeast.


Damage from illicit digging on Mound 1. View facing approximately northeast.


Damage from illicit digging on Mound 1. View facing approximately northeast.


Damage from illicit digging on Mound 1.


Interns collecting data on Mound 1. View facing northwest.


Profile A. View facing northeast.

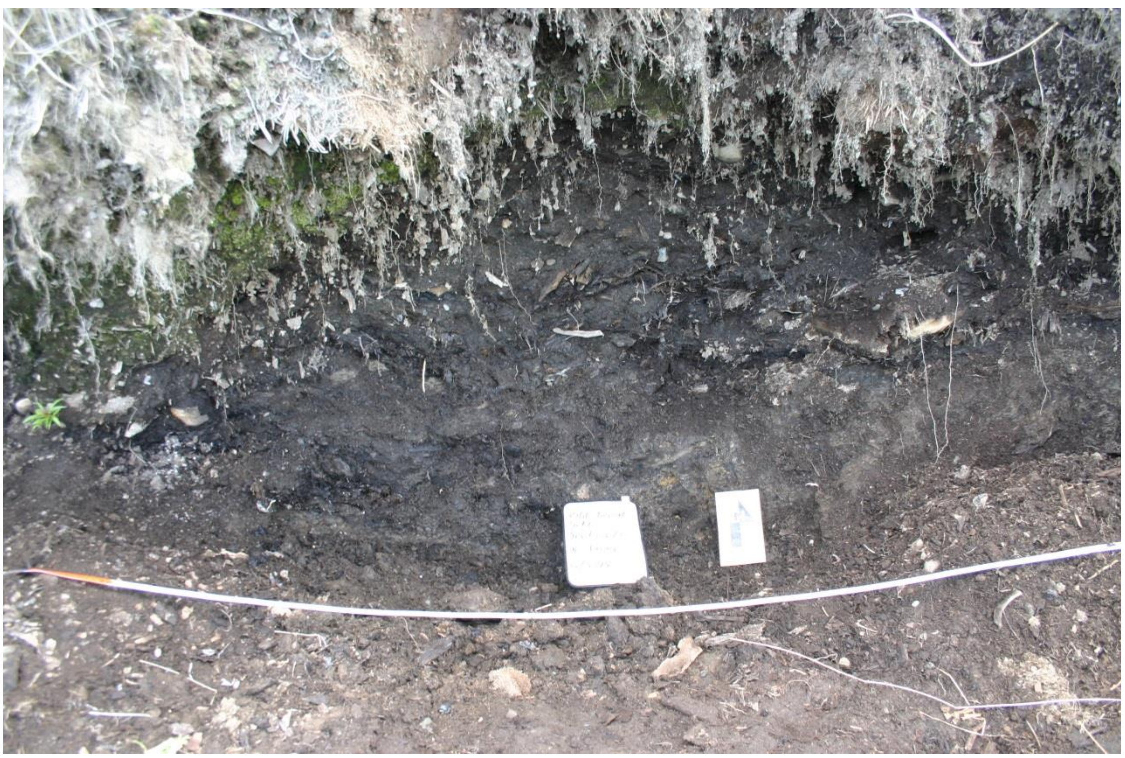
Profile A (close-up). View facing northeast.


Profile B. View facing northeast.


Profile C. View facing northeast.

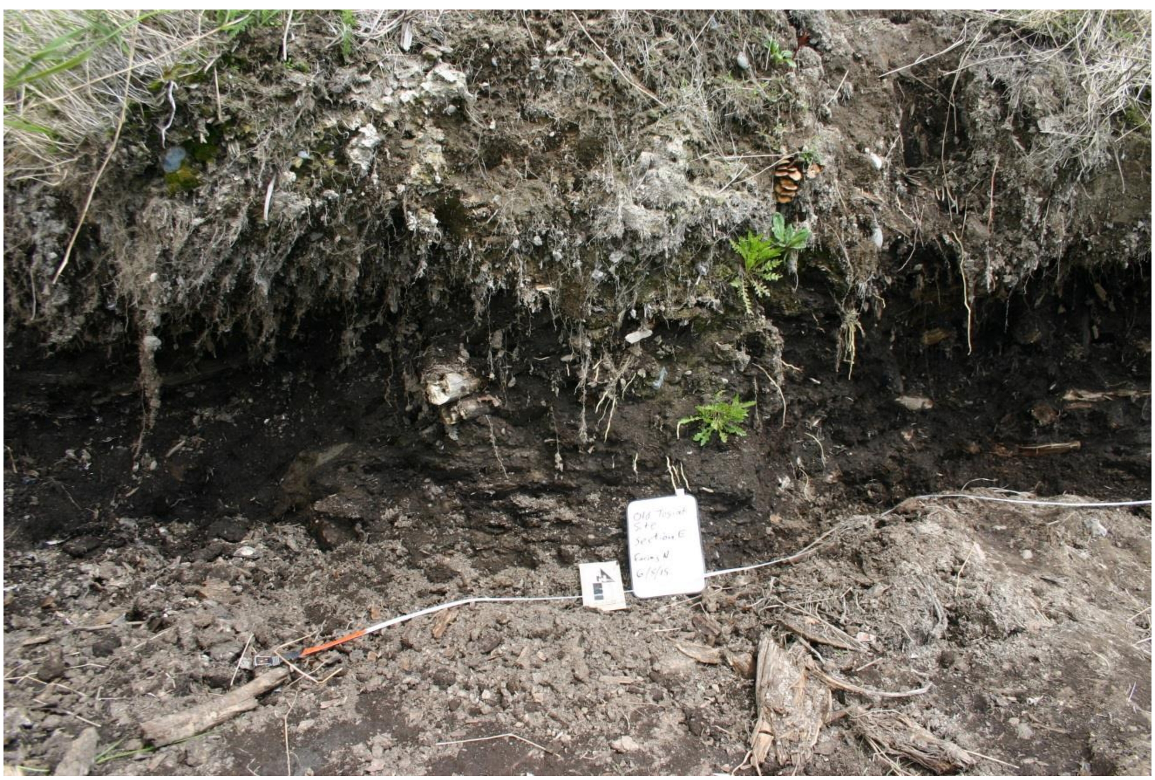
Profile C (Close-up). View facing northeast.

Profile D. View facing northeast.



Profile D (Close-up). View facing northeast.


Profile E. View facing northeast.


Profile E (Close-up). View facing northeast.


Profile F. View facing northeast.

Profile F (close-up). View facing northeast.

Profile G. View facing northeast.

Profile G (Close-up). View facing northeast.

Profile H. View facing northeast.

Artifacts exposed by illicit excavators (note harpoon fragment on right).


Faunal remains exposed by illicit excavators (claw core from a bear).


Artifact exposed by illicit excavators (Thule style [ancestral Yup'ik] pottery rim sherd).


Pottery (left) and slate artifacts (right) exposed by illicit excavators.


Wooden bucket base exposed by illicit excavators.


Artifact exposed by illicit excavators (Thule style [ancestral Yup'ik] pottery rim sherd).

Antler and slate artifacts uncovered by illicit excavators.


Artifacts uncovered by illicit excavators (note polished slate adze in middle).


Faunal remains (marine mammal mandible) uncovered by illicit excavators.

Large scapula with two drilled holes (likely a shovel blade) uncovered by illicit excavators.

Artifact exposed by illicit excavators (sharpened wooden shaft).

Appendix B

Radiocarbon Dates

DirectAMS | Radiocarbon Dating Services

Dr. Ugo Zoppi
Director, Accelerator Mass Spectrometry Lab

22 January 2016

Anna Prentiss
University of Montana
Dept. of Anthropology
Missoula, MT 59812

Dear Anna,

Your samples submitted for radiocarbon dating have been processed and measured by AMS. Following results were obtained:

DirectAMS code	Submitter ID	$\delta(^{13}C)$	Fraction of modern		Radiocarbon age	
		per mil	pMC	1σ error	BP	1σ error
D-AMS 014534	C084	-20.0	93.95	0.29	501	25
D-AMS 014535	C123	-20.3	92.18	0.29	654	25
D-AMS 014536	C125	-18.0	84.98	0.27	1307	26
D-AMS 014537	C048	-16.9	96.76	0.32	265	27
D-AMS 014538	C115	-19.1	95.64	0.30	358	25
D-AMS 014539	C062	-19.6	96.02	0.31	326	26
D-AMS 014540	C034	-18.7	6.127	0.062	22432	81
D-AMS 014541	C022	-20.5	NDFB			
D-AMS 014542	C110	-22.6	94.49	0.27	455	23
D-AMS 014543	C003	-27.1	94.15	0.29	484	25
D-AMS 014544	C146	-20.3	95.97	0.26	330	22
D-AMS 014545	C124	-23.7	92.74	0.32	605	28
D-AMS 014546	C114	-20.3	95.00	0.25	412	21
D-AMS 014547	C025	-20.8	97.77	0.26	181	21
D-AMS 014548	C020	-20.6	98.56	0.28	117	23
D-AMS 014549	C001	-22.1	95.95	0.25	332	21

NDFB = Not Distinguishable From Background

All results have been corrected for isotopic fractionation with $\delta^{13}C$ values measured on the prepared graphite using the AMS spectrometer. These $\delta^{13}C$ values provide the most accurate radiocarbon ages but cannot be used to investigate environmental conditions.

Best regards,

Ugo Zoppi

550 17th Avenue, Suite 550, Seattle WA 98122
Tel (206) 258-8857 – Fax (206) 281-5916 – www.directAMS.net

DirectAMS | Radiocarbon Dating Services

Dr. Ugo Zoppi
Director, Accelerator Mass Spectrometry Lab

21 March 2016

Kristen Barnett
University of Montana
Dept. of Anthropology
Missoula, MT 59812

Dear Kristen,

Your samples submitted for radiocarbon dating have been processed and measured by AMS. Following results were obtained:

DirectAMS code	Submitter ID	$\delta(^{13}C)$	Fraction of modern		Radiocarbon age	
		per mil	pMC	1σ error	BP	1σ error
D-AMS 015403	C263	-22.2	91.58	0.26	706	23
D-AMS 015404	C068	-24.2	93.59	0.30	532	26
D-AMS 015405	C337	-20.0	97.50	0.27	204	22
D-AMS 015406	C382	-26.3	98.73	0.30	103	24
D-AMS 015407	C386	-27.7	99.07	0.27	75	22
D-AMS 015408	C400	-23.7	92.64	0.26	614	22
D-AMS 015409	C301	-24.3	100.11	0.26	Modern	
D-AMS 015410	C286	-24.5	99.85	0.27	12	22
D-AMS 015411	C270	-18.7	98.90	0.25	89	20
D-AMS 015412	C240	-24.2	96.09	0.24	321	20
D-AMS 015413	C330	-22.3	94.43	0.28	460	24
D-AMS 015414	C247	-21.8	93.32	0.25	555	22
D-AMS 015415	C029	-14.1	91.34	0.24	728	21
D-AMS 015416	C195	-22.3	90.77	0.24	778	22
D-AMS 015417	C334	-29.7	86.90	0.27	1128	25
D-AMS 015418	C287	-23.7	97.70	0.26	187	22
D-AMS 015419	C213	-21.3	95.76	0.25	348	21
D-AMS 015420	C047	-21.6	95.36	0.26	382	22
D-AMS 015421	C383	-24.5	96.95	0.27	249	22
D-AMS 015422	C362	-29.8	98.81	0.28	96	23
D-AMS 015423	C039	-25.7	97.91	0.26	170	21
D-AMS 015424	C231	-26.5	96.86	0.26	256	22
D-AMS 015425	C350	-26.0	99.05	0.29	77	24
D-AMS 015426	C346	-18.2	98.63	0.27	111	22

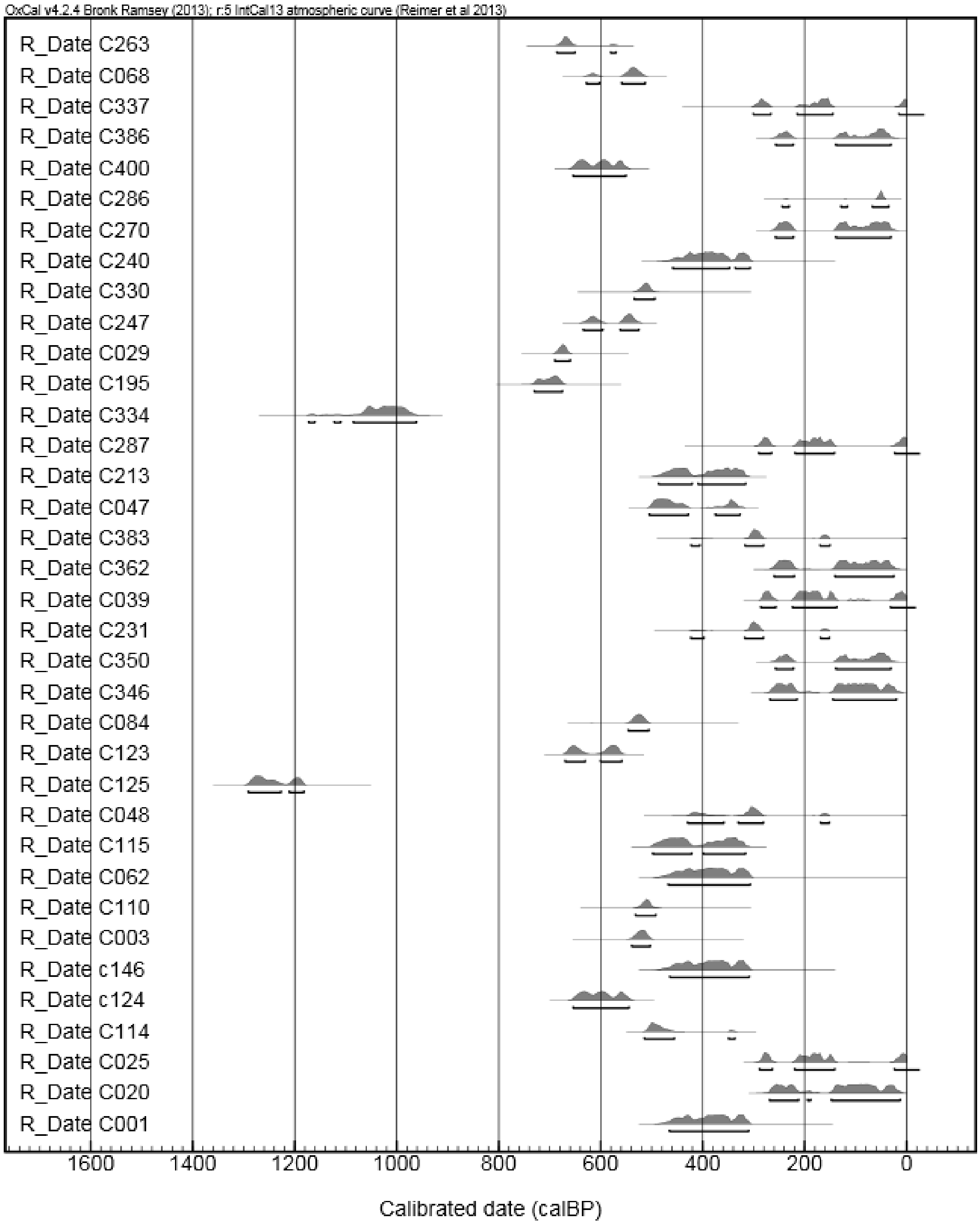
550 17th Avenue, Suite 550, Seattle WA 98122
Tel (206) 258-8857 – Fax (206) 281-5916 – www.directAMS.net

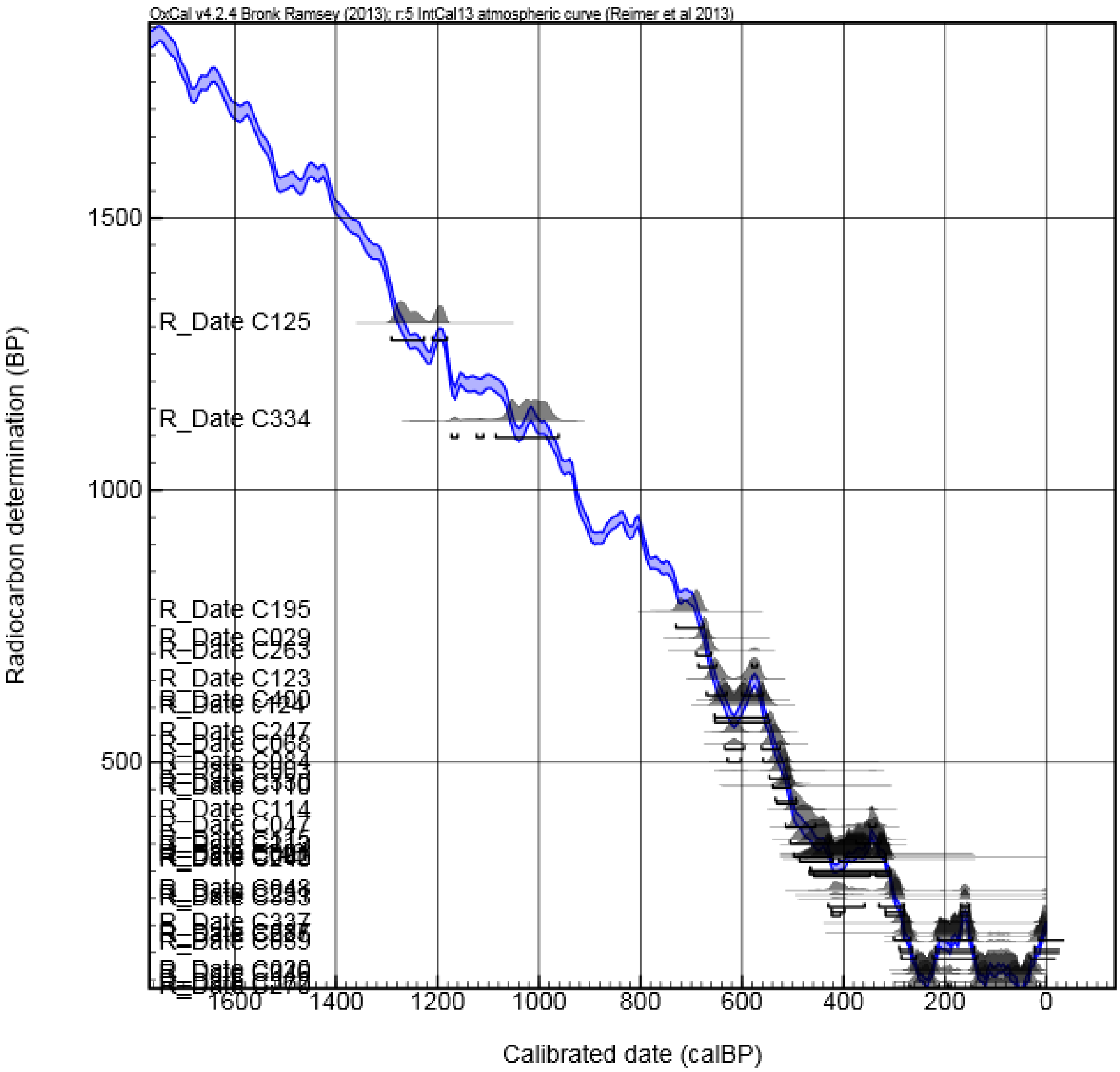
All results have been corrected for isotopic fractionation with $\delta^{13}C$ values measured on the prepared graphite using the AMS spectrometer. These $\delta^{13}C$ values provide the most accurate radiocarbon ages but cannot be used to investigate environmental conditions.

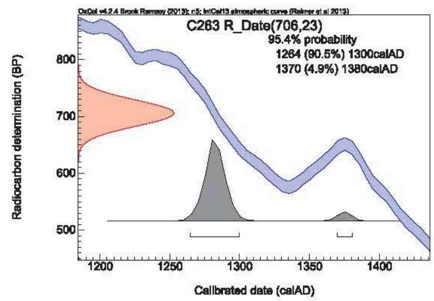
Best regards,

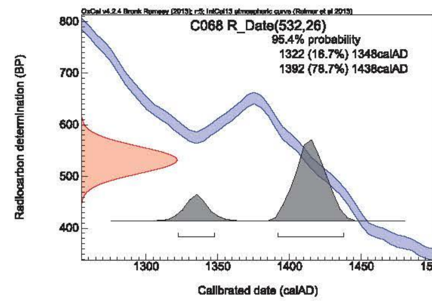
Ugo Zoppi

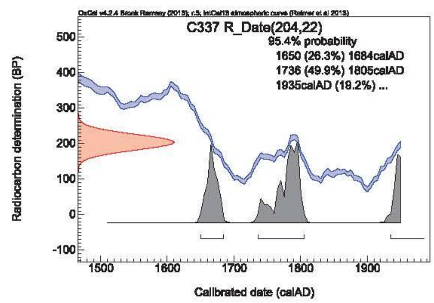
550 17th Avenue, Suite 550, Seattle WA 98122
Tel (206) 258-8857 – Fax (206) 281-5916 – www.directAMS.net

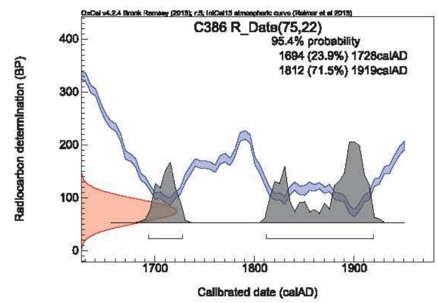

OxCal v4.2.4 Bronk Ramsey (2013); r:5 IntCal13 atmospheric curve (Reimer et al 2013)
R_Date C263
R_Date C068
R_Date C337
R_Date C386
R_Date C400
R_Date C286
R_Date C270
R_Date C240
R_Date C330
R_Date C247
R_Date C029
R_Date C195
R_Date C334
R_Date C287
R_Date C213
R_Date C047
R_Date C383
R_Date C362
R_Date C039
R_Date C231
R_Date C350
R_Date C346
R_Date C084
R_Date C123
R_Date C125
R_Date C048
R_Date C115
R_Date C062
R_Date C110
R_Date C003
R_Date c146
R_Date c124
R_Date C114
R_Date C025
R_Date C020
R_Date C001
1600
1400
1200
1000
800
600
400
200
0
Calibrated date (calBP)

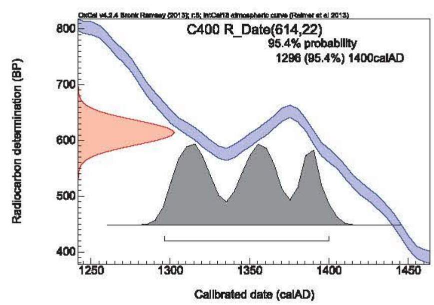

OxCal v4.2.4 Bronk Ramsey (2013); r:5 IntCal13 atmospheric curve (Reimer et al 2013)
Radiocarbon determination (BP)
1500
1000
500
R_Date C125
R_Date C334
R_Date C195
R_Date C123
R_Date C247
R_Date C114
1600
1400
1200
1000
800
600
400
200
0
Calibrated date (calBP)

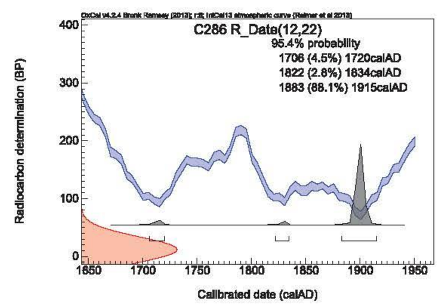

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C263 R_Date(706,23)
95.4% probability
1264 (90.5%) 1300calAD
1370 (4.9%) 1380calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

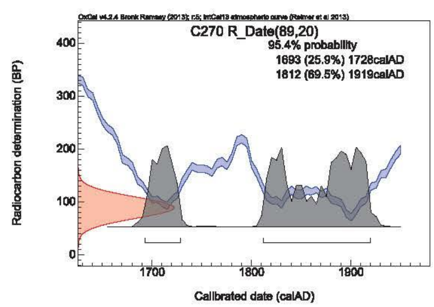

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C068 R_Date(532,26)
95.4% probability
1322 (16.7%) 1348calAD
1392 (78.7%) 1438calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

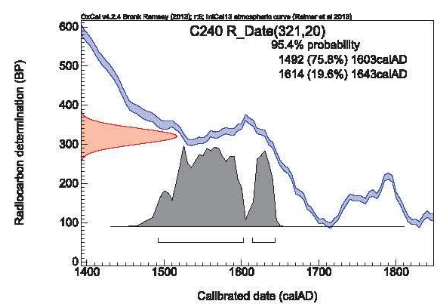

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C337 R_Date(204,22)
95.4% probability
1650 (26.3%) 1684calAD
1736 (49.9%) 1805calAD
1935calAD (19.2%) ...
Radiocarbon determination (BP)
Calibrated date (calAD)

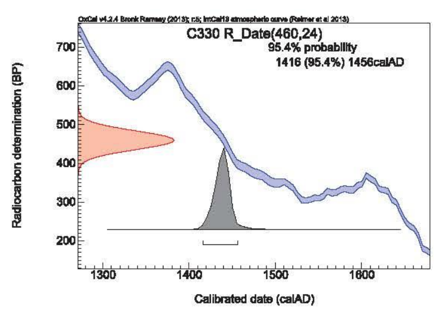

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C386 R_Date(75,22)
95.4% probability
1694 (23.9%) 1728calAD
1812 (71.5%) 1919calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

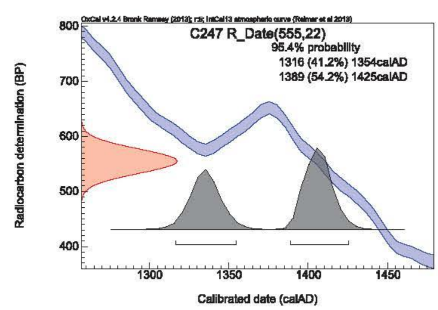

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C400 R_Date(614,22)
95.4% probability
1296 (95.4%) 1400calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

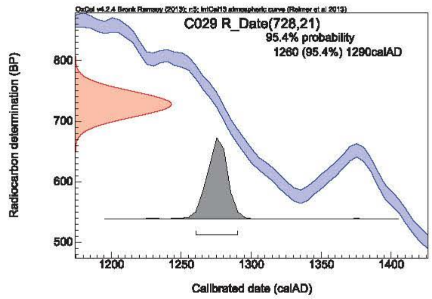

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C286 R_Date(12,22)
95.4% probability
1706 (4.5%) 1720calAD
1822 (2.8%) 1834calAD
1883 (88.1%) 1915calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

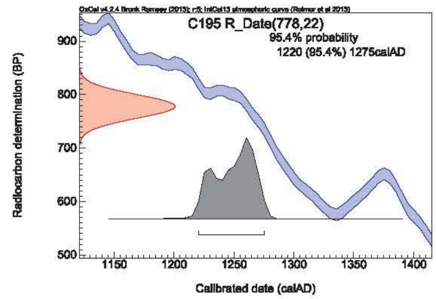

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C270 R_Date(89,20)
95.4% probability
1693 (25.9%) 1728calAD
1812 (69.5%) 1919calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

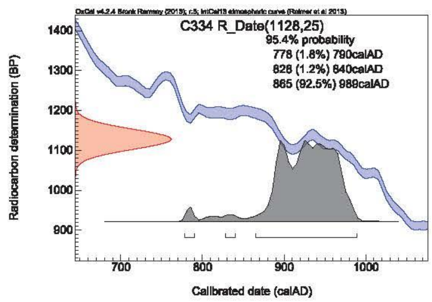

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C240 R_Date(321,20)
95.4% probability
1492 (75.8%) 1603calAD
1614 (19.6%) 1643calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

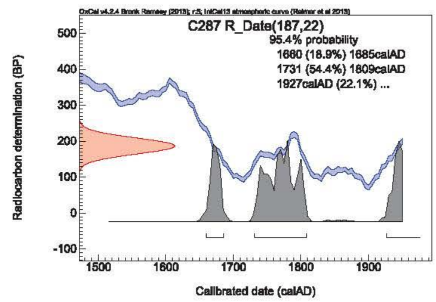

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C330 R_Date(460,24)
95.4% probability
1416 (95.4%) 1456calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

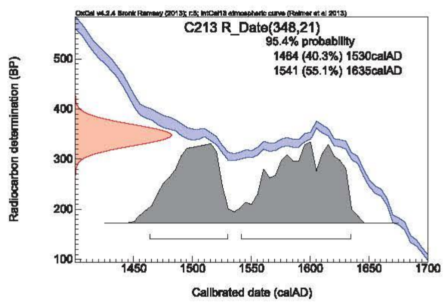

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C247 R_Date(555,22)
95.4% probability
1316 (41.2%) 1354calAD
1389 (54.2%) 1425calAD
Radiocarbon determination (BP)
Calibrated date (calAD)

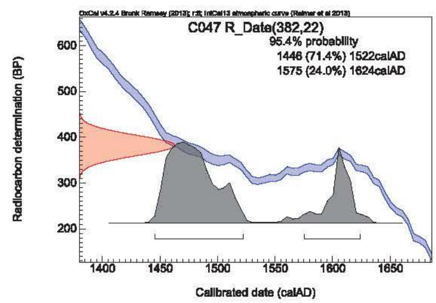

OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C029 R_Date(728,21)
95.4% probability
1260 (95.4%) 1290calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C195 R_Date(778,22)
95.4% probability
1220 (95.4%) 1275calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C334 R_Date(1128,25)
95.4% probability
776 (1.8%) 790calAD
828 (1.2%) 840calAD
865 (92.5%) 989calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C287 R_Date(187,22)
95.4% probability
1660 (18.9%) 1685calAD
1731 (54.4%) 1809calAD
1927calAD (22.1%) ...
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C213 R_Date(348,21)
95.4% probability
1464 (40.3%) 1530calAD
1541 (55.1%) 1635calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C047 R_Date(382,22)
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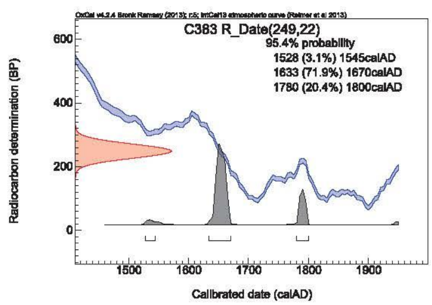
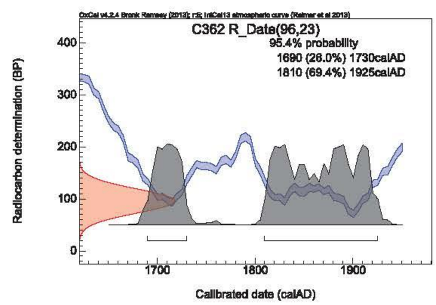
1446 (71.4%) 1522calAD
1575 (24.0%) 1624calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C383 R_Date(249,22)
95.4% probability
1528 (3.1%) 1545calAD
1633 (71.9%) 1670calAD
1780 (20.4%) 1800calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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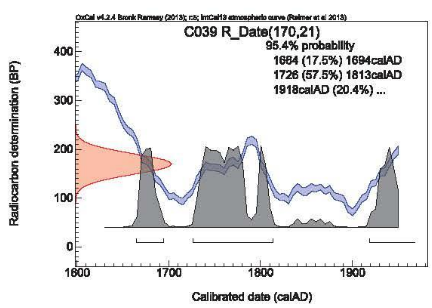
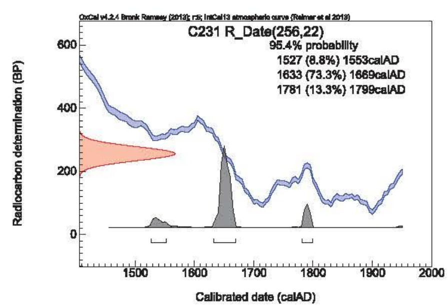
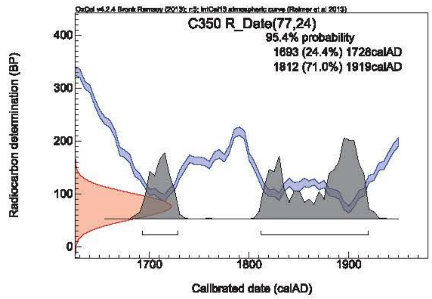
C362 R_Date(96,23)
95.4% probability
1690 (26.0%) 1730calAD
1810 (69.4%) 1925calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C039 R_Date(170,21)
95.4% probability
1664 (17.5%) 1694calAD
1726 (57.5%) 1813calAD
1918calAD (20.4%) ...
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C231 R_Date(256,22)
95.4% probability
1527 (8.8%) 1553calAD
1633 (73.3%) 1669calAD
1781 (13.3%) 1799calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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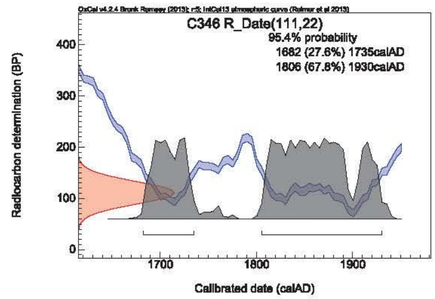
C350 R_Date(77,24)
95.4% probability
1693 (24.4%) 1728calAD
1812 (71.0%) 1919calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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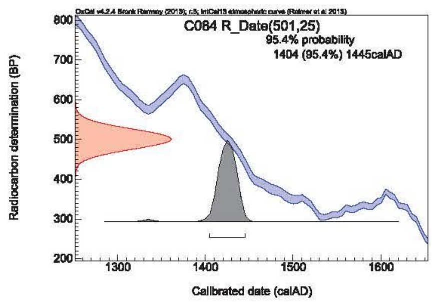
C346 R_Date(111,22)
95.4% probability
1682 (27.6%) 1735calAD
1806 (67.8%) 1930calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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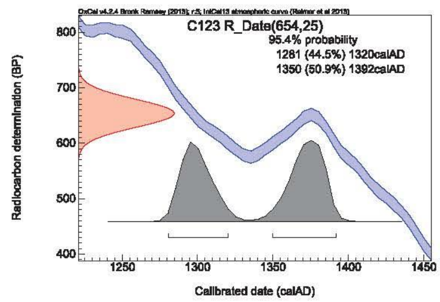
C084 R_Date(501,25)
95.4% probability
1404 (95.4%) 1445calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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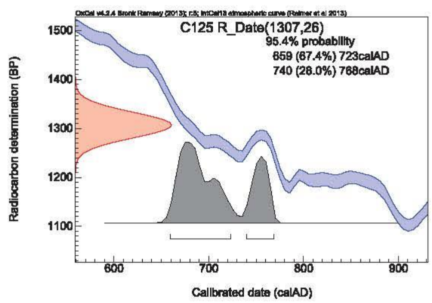
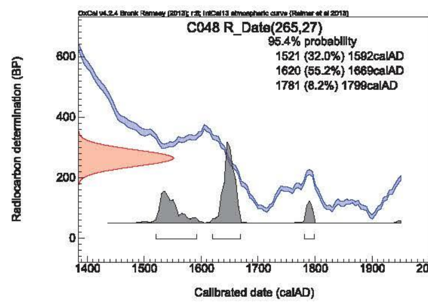
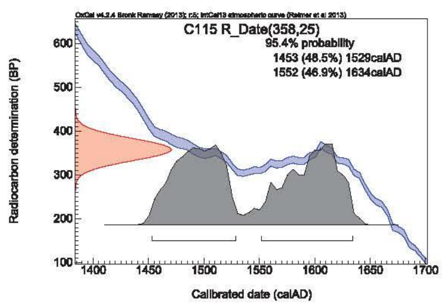
C123 R_Date(654,25)
95.4% probability
1281 (44.5%) 1320calAD
1350 (50.9%) 1392calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C125 R_Date(1307,26)
95.4% probability
659 (67.4%) 723calAD
740 (28.0%) 768calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C048 R_Date(265,27)
95.4% probability
1521 (32.0%) 1592calAD
1620 (55.2%) 1669calAD
1781 (8.2%) 1799calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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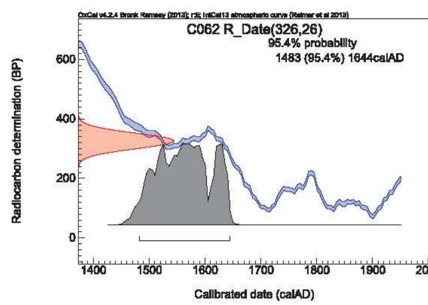
C115 R_Date(358,25)
95.4% probability
1453 (48.5%) 1529calAD
1552 (46.9%) 1634calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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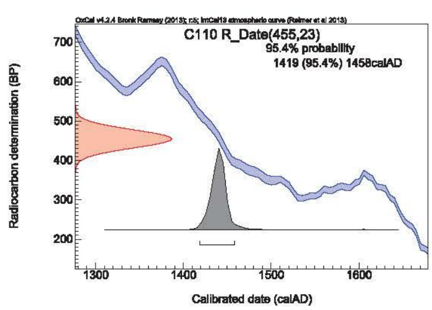
C062 R_Date(326,26)
95.4% probability
1483 (95.4%) 1644calAD
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
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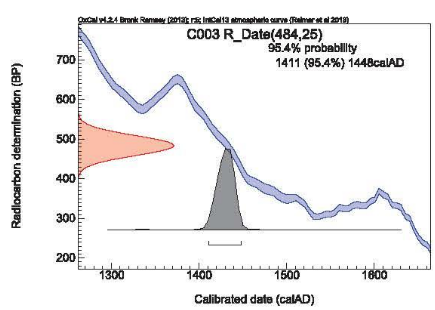
95.4% probability
1419 (95.4%) 1458calAD
Radiocarbon determination (BP)
Calibrated date (calAD)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95.4% probability
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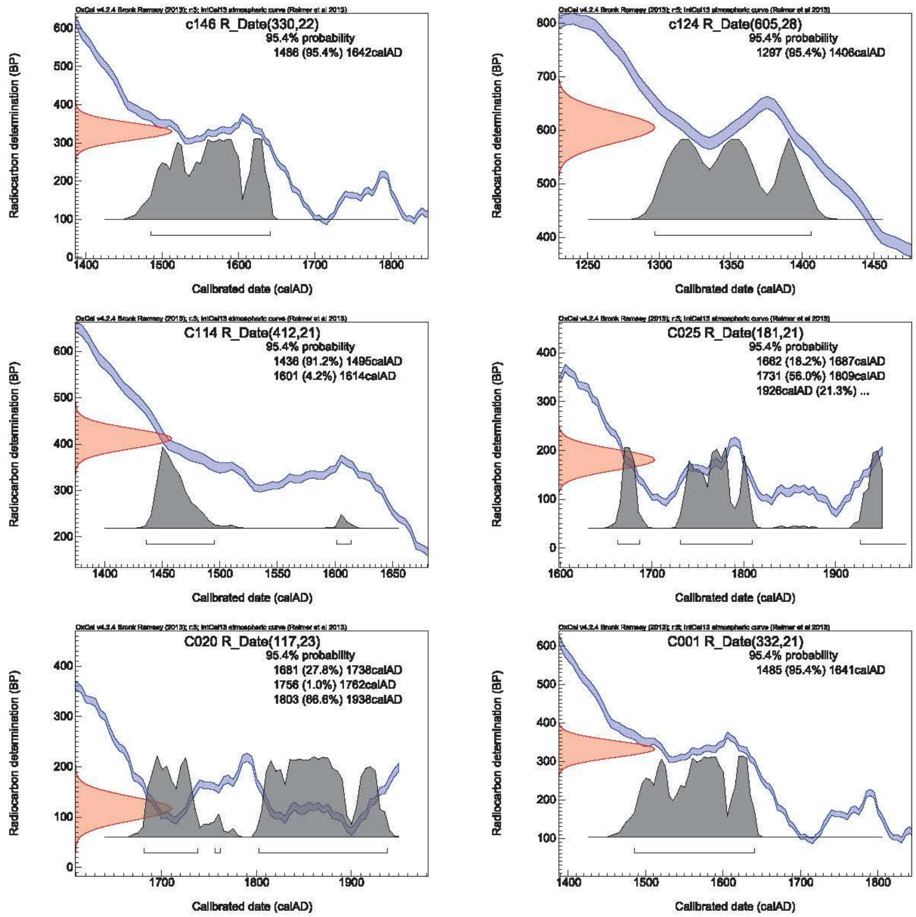
Radiocarbon determination (BP)
Calibrated date (calAD)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c146 R_Date(330,22)
95.4% probability
1486 (95.4%) 1642calAD
Radiocarbon determination (BP)
Calibrated date (calAD)
OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
c124 R_Date(605,28)
95.4% probability
1297 (95.4%) 1406calAD
Radiocarbon determination (BP)
Calibrated date (calAD)
OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C114 R_Date(412,21)
95.4% probability
1436 (91.2%) 1495calAD
1601 (4.2%) 1614calAD
Radiocarbon determination (BP)
Calibrated date (calAD)
OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C025 R_Date(181,21)
95.4% probability
1662 (18.2%) 1687calAD
1731 (56.0%) 1809calAD
1926calAD (21.3%) ...
Radiocarbon determination (BP)
Calibrated date (calAD)
OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C020 R_Date(117,23)
95.4% probability
1681 (27.8%) 1738calAD
1756 (1.0%) 1762calAD
1803 (66.6%) 1938calAD
Radiocarbon determination (BP)
Calibrated date (calAD)
OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
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95.4% probability
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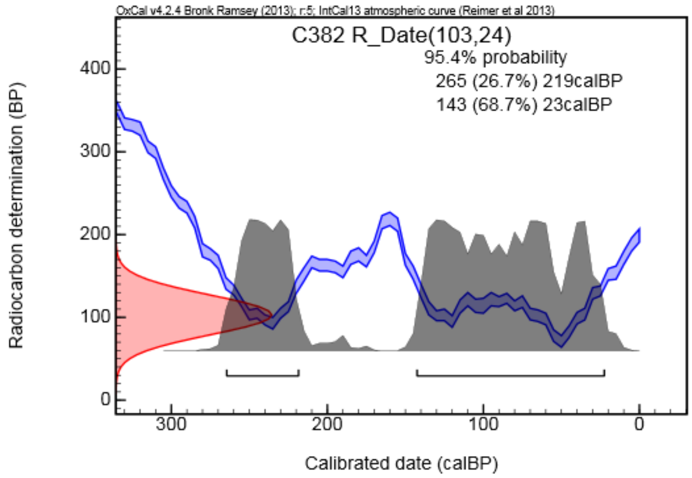
Radiocarbon determination (BP)
Calibrated date (calAD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
C382 R_Date(103,24)
95.4% probability
265 (26.7%) 219calBP
143 (68.7%) 23calBP
Radiocarbon determination (BP)
400
300
200
100
0
300
200
100
0
Calibrated date (calBP)

Appendix C
Geophysics Report (Steven Sheriff)

Total Field Magnetic Investigation at the Togiak Archaeological Site, Alaska: June, 2015

Prepared by:

Steven D. Sheriff
Professor Emeritus
Department of Geosciences
University of Montana
Missoula, MT

Introduction and Goals

The total field magnetic investigations in this report are from field work west of Twin Hills, Alaska and near the Togiak Cannery. The general goal was magnetic surveying of a known archaeological site to determine site layout and guide locations for subsequent coring operations. They would also be useful for guiding excavations in the future.

Summary

We completed total field magnetic observations in 25 contiguous 20x20 meter grids as well as 5 isolated grids. Within the 20x20 meter grids we acquired magnetic intensity (TMI) observations at 10 Hz while walking bidirectional transects spaced one meter apart using a Geometrics G858 Cesium vapor magnetometer while holding the sensor roughly 30 cm off the ground. The data, not diurnally corrected due to shipping problems in the Dillingham USPS office, were processed and filtered to isolate magnetic sources in the upper one to two meters.

Much of the archaeological site hosts metal objects and debris generally aligned with beach ridges and correlated with visible pit houses. Thus, occupation of those pit houses overlaps the modern era. The high amplitude, high gradient anomalies overwhelm any potential magnetic signal from more subtle features. Regardless, we were able to image some circular anomalies not associated with visible features and determine

Contents

Table of Figures

Field Procedures and Data Acquisition

Grid Locations

We collected the majority of the total field magnetic intensity (TMI) data discussed in this report within 20x20 meter grids whose corners we established in the field. We first set a SE-NW 220 meter long baseline from a datum on the high mound and then set 20x20 meter grids along that line to the northwest followed by second and third rows to the northeast. We measured each grid side with standard tape measures and verified that the diagonals were equivalent (28.3m). Errors along sides and across diagonals were typically less than two or three decimeters. We then used a 2008 Trimble GeoExplorer handheld GPS unit to measure each corner location, averaging observations over about five minutes. Figure 1 shows the layout, grid numbering, and preliminary total field magnetic intensity results from all the grids; here, and throughout the report, all TMI amplitudes are in nanoteslas (nT).

We also collected data over five grids not inthis main set off the baseline. We discuss those and the main grids in individual sections for each grid.

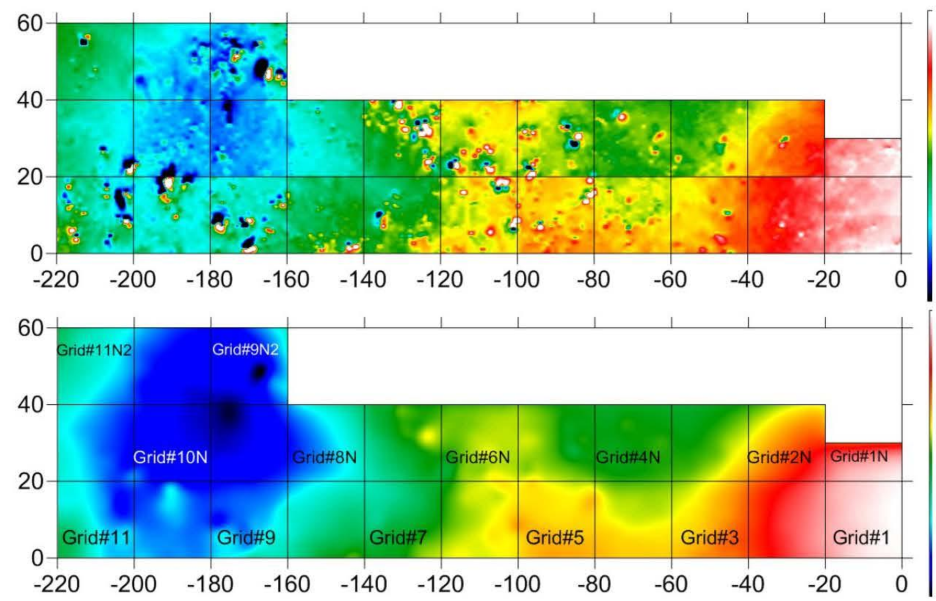


Figure 1. Upper image is the total magnetic intensity observations after being decorrugated. Lower image is the same after upward continuation to 3 meters showing the geologic scale variation of magnetic observations in the field area.

Magnetic Data Acquisition and Processing

Within the 20x20 meter grids established for magnetic observations we acquired total field magnetic intensity (TMI) observations at 10 Hz while walking bidirectional transects spaced one meter apart using a Geometrics G858 Cesium vapor magnetometer while holding the sensor roughly 30 cm off the ground. We guided those 20 meter transects with a combination of tape measures, human guidance, and makeshift pylons at each end of the line. We use one-meter line spacing because analyzing the power spectra for the total magnetic intensity (TMI) of a randomly magnetized layer shows line spacing can be twice the separation of the source and sensor while keeping aliasing of shorter wavelength components sufficiently small to still allow accurate modeling and inversion. Dipole targets require half that line spacing but our targets of interest for this archaeology study are spatially broader than small dipole sources. Our line spacing is a bit greater than expected for those practitioners who use vertical gradient magnetometers as the magnetic gradient falls off faster with height than the total field (1/r^4 versus 1/r^3) thereby necessitating closer measuring intervals for the gradient. In any case, the vertical gradient, if desired, is easy to calculate given the total field (e.g. Pedersen, 1991).

Bidirectional acquisition at walking speed in a grid is very time efficient but adds some noise to the data when compared to static observations at measured grid points. The noise issues are particularly true and problematic for the Togiak Archaeological Site. The site, covered in tall grass forming humps nearly a meter tall, is pockmarked by abundant holes, pits, and troughs up to a meter deep (Figure 2). Among

Figure 2. Overview of the site from the mound looking north, cannery is to the left.

these features are the archaeologic pit houses which can be two to three meters deep and many meters wide (Figure 3). Obviously in these conditions walking at a uniform speed with a constant separation of the sensor from the ground is not possible. Given these conditions for acquisition, it is startling how consistent and informative the resulting data are despite the loss of subtle anomalies.

Typically high data density (10 Hz sampling) along transects more than makes up for the added noise. In this study, it does not make up for all the acquisition noise but it still helps. That is one reason we kept acquisition lines to 20 meters long. Following acquisition, we filter the vast majority of noise with techniques typical for aeromagnetic and ground magnetic data acquired in the energy and minerals exploration industry. Usually we also use a recording Proton Precession base station magnetometer for measuring and removing small daily changes in the geomagnetic field. These diurnal corrections assist in merging contiguous grids into a single map and remove noise from fluctuations in the geomagnetic field. Because the USPS failed to deliver our base station magnetometer, magnetic observations in this report are not corrected for diurnal variations. Consequently, to aid making a mosaic of the grids with smooth edge joins, we removed a least squares best fit cubic polynomial from each grid before analyzing the

Figure 3. Ethan collecting magnetic data as he crosses one of the house pits in representative field conditions.

combined results. For the analysis and discussion of individual grids each was processed independently.

Our TMI observations, typically gridded by kriging with about 0.25 meter spacing, include features at three dominant scales. First, there is experimental noise resulting from acquisition and attendant effects of historic debris and recent cultural features on and near the surface; the linear components of this noise which are highly correlated with acquisition are typically termed corrugation or herringbone.

Corrugation from acquisition can be significant in high magnetic gradient environments and is typical in ground and airborne magnetic surveys where one acquires observations at relatively high spatial frequency along more widely spaced transects. Yet, this approach requires less surveying and grid setup and allows acquisition at walking speed as compared to surveying each acquisition point. Despite the usual efforts to keep the Cesium magnetic sensor a constant distance from the ground and walk at a consistent pace pits, the rough surface, grass clumps, trenches, and channels along with wind combine to interfere with the operator and impact the distance of the sensor from the ground and vary rates of walking while acquiring TMI observations at 10 Hz. This manifests as linear magnetic anomalies in the direction of acquisition. We use a common technique [Urquhart, 1988] for decorrugation filtering as elaborated on in Sheriff et al. [2010]. The anomalies from the metal debris and artifacts within the grids cannot be removed and their high amplitudes and breath obscure more subtle anomalies.

The second and third scales of magnetic anomalies in this type of study are deeper geologic sources and shallow, potentially interesting sources at the archaeological and/or environmental scale. Unfortunately, as is particularly evident in this study, the latter shallow sources include many galvanized wash tubs, cast iron wood stoves or their remains, along with various kettles and pots. In this study we analyze and compare results after separating these sources into equivalent layers using differencing of upward continuations following Jacobsen [1987]. Upward continuation is a mathematical calculation yielding the magnetic field as if it had been collected at a higher elevation further from source. The successive application of filtering to remove corrugation and then separating the TMI observations into equivalent layers yields magnetic maps ready for interpretation. Various methods of image enhancement, edge detection, and depth estimates follow this filtering.

It is a combination of the above techniques and processes, used in an iterative and experimental process that leads to the final results and interpretations in this report. The final interpretations and presentations for each discussed data set are representative results for those data that yielded the most informative results. Innumerable intermittent steps and experiments are omitted from this report. All of the results, as presented, have been decorrugated and filtered several different ways. In some cases extreme outliers from the super high magnetic intensity sources in some of the areas have also been filtered from the data to yield more informative maps. Color scales are regularly adjusted to encompass the first or second standard deviations of amplitudes around the mean for best visualization and to highlight subtle highlight anomalies obscured by the preponderance of huge signals from historic metal items.

Results

Reference Grid from outside the recognized archaeological site

Figure 4 shows the processed results from a 20x20 meter grid we collected north of the recognized site next to the secondary road north of camp. As we only did one such grid, we cannot call it representative but it does provide a bit of insight into what the measured magnetic field is like outside the site and on somewhat easier ground for data acquisition. I also processed this grid the same as for all the individual grid discussions below. First, I decorrugated the data, upward continued it 0.25 meters to allow for bobbing of the sensor, and then subtracted an upward continuation of 2.0 meters to isolate anomalies from sources in the upper meter or so. After doing so, the range of data in this grid is 12.3 nT in the order of what we would expect in undisturbed ground with somewhat noisy acquisition. Many of the subsequent grids have a range of ten to twenty times that amount or more; those huge ranges are from historic metal artifacts in the area and swamp subtle anomalies we would hope for in an archaeological survey. The parallel dashed lines in the grid represent the acquisition lines with one meter spacing as we

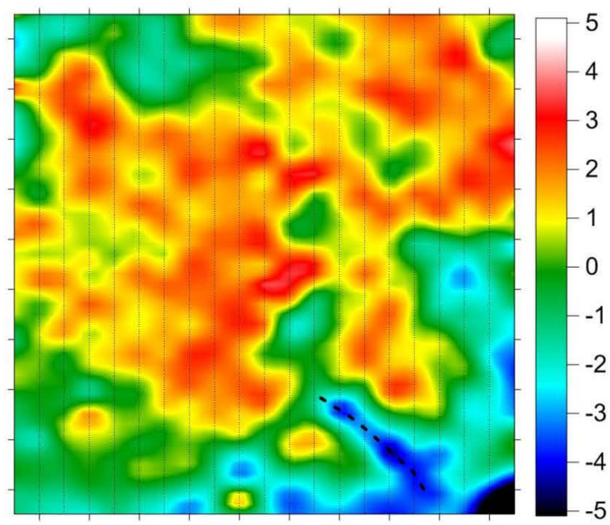


Figure 4. 20x20 meter grid of an equivalent magnetic layer outside the contiguous grids and not in the area of known archaeological disturbance; scale in nT, note the small range.

used in all subsequent grids. Anomalies that are supported by more than one survey line are very unlikely to be noise from acquisition. Two features are worth noting. First, there is a deep magnetic low in the southeast corner which is likely from leaving the tape measure too close to the grid corner. Second, the magnetic low marked by the dashed line in the figure is probably from a slight soil change probably from an old drainage feature. The latter is the sort of thing we would regularly see given better acquisition conditions than available at the site.

Test Grids on Recognized House Pits

The first recognized house pit we collected data over, delineated House Pit#1, was very apparent on the main mound with a rim and deep hole in the center. Figure 5 shows two images of the magnetic results as processed to highlight sources in the upper meter or so. What is immediately apparent is a very high amplitude magnetic anomaly, marked by "A" on the left image, caused by a near-surface metal source. The image on the right shows the same results on a 3D rendition to give a sense of scale of the anomaly from the metal. Those high amplitude anomalies, common throughout the grids collected at the archaeological test site, obscure any potential subtle anomalies we would regularly expect to see. In this case the magnetic high makes the circular anomaly expected from the house pit difficult to detect.

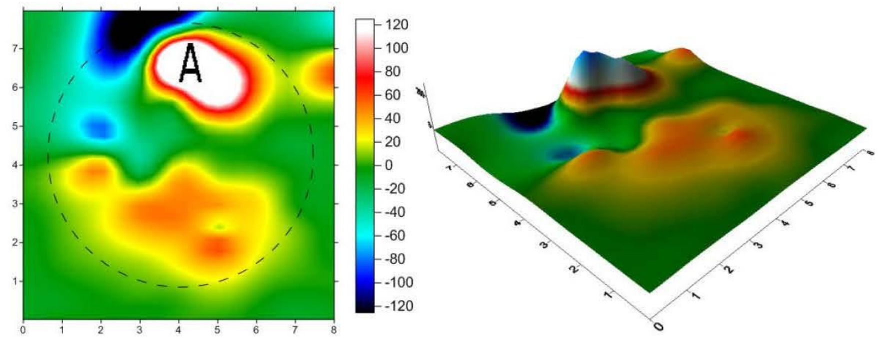


Figure 5. Magnetic results over a known house pit, House Pit#1.

We collected a 24x12 meter grid of total field magnetic data over House Pit#2 (Figure 6), located

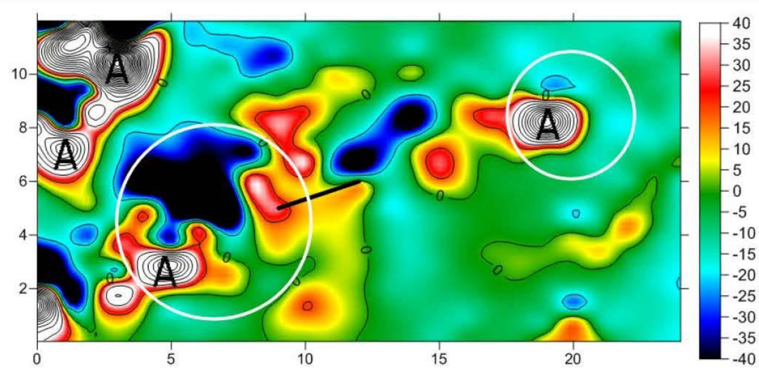


Figure 6. Circles show perimeters of house pits in the grid for House Pit#2.

northeast of our camp. The grid covered one big house and one small one as shown by the white circles superposed on the image; the solid black line marks the entrance to the house. Again, high amplitude magnetic anomalies from metals sources ("A") dominate the data obscuring the anomalies expected from the pit houses and their rims.

House Pit#3 (Figure 7) also shows two major high amplitude magnetic anomalies in the left image (marked with "A") that are coincident with the rim of the house pit as shown by the dashed circles on

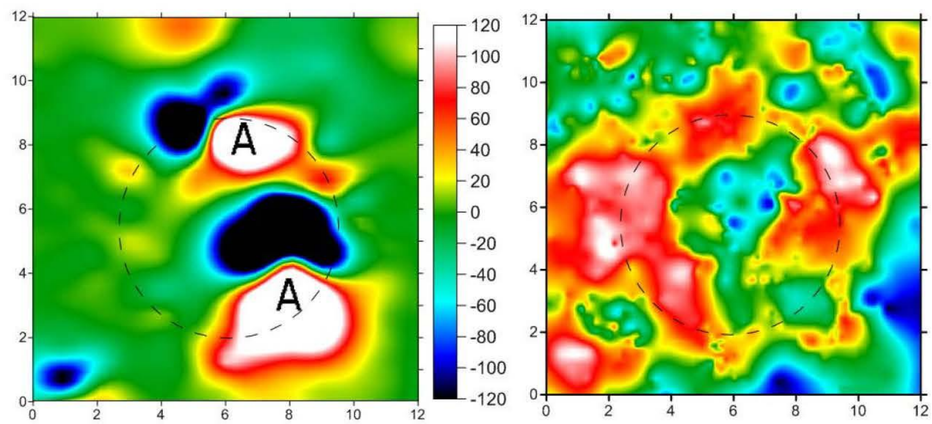


Figure 7. Magnetic results on House Pit#3. Left image is the equivalent layer (sources in upper meter or so), right image is enhanced by using Euler depth analysis.

the images. The left image shows the equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters enhancing anomalies from the upper meter or so. The right hand image is an accentuation of those data using an edge and depth estimation technique that helps bring out the circular shape of the house pit.

House Pit#4 (aka camp house) was a 10x10m collection of data over a known house pit close to camp. We collected this grid twice (Figure 8), once with the sensor about 0.3 meters above ground (left image) and again with the sensor about 2.0 meters above ground (right image).As expected the data acquired at 2.0 meters is much smoother and has a much lower range (48 nT) than that closer to the ground whose range was 1,150 nT showing most of the magnetic source creating high amplitude and steep gradient anomalies is near surface; this is true throughout the study area.

Isolating the near-surface sources by differencing the grids yields Figure 9 in which "A" marks the sources for the high amplitude anomalies. A general circular arrangement mimicking the pit house is discernable.

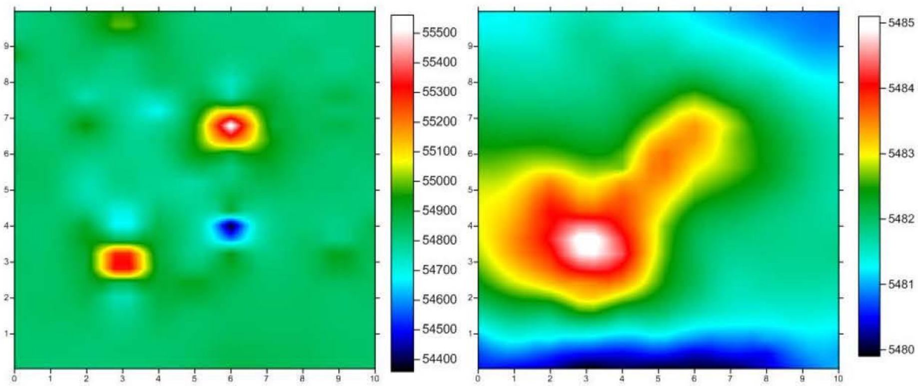


Figure 8. Magnetic results from House Pit#4 collected twice; left at ~0.3 m above ground, right at ~2.0 m above ground.

These results over known and readily observable pit houses gave us some indication of what anomalies from the pit houses would look like at this archaeologic site and the prevalence of obscuring sources (washtubs, tea kettles, wood stoves, etc.) which would make detection of subtle anomalies difficult. We also gained empirical insight into successful processing and filtering techniques used throughout the analysis of the main grids.

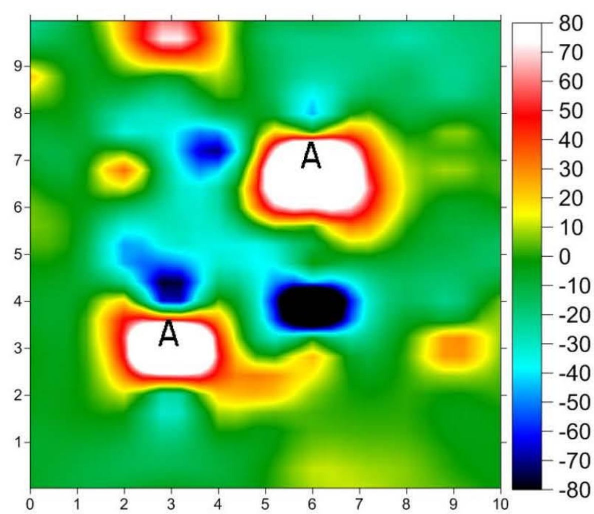


Figure 9. Equivalent magnetic layer for House Pit#4 accentuating shallow sources and circular form.

Anomalies and Features Apparent on the Combined Grids

Isolating the nearer surface features by subtracting an upward continuation of two meters from the decorrugated data upward continued 0.25 meters yields some interesting results which are not apparent on the ground (Figure 10). Qualitatively, these sources would be in the upper meter or two. On Figure 10, the diagonal lines show a general linear arrangement of high amplitude anomalies whose sources are almost certainly historic ferromagnetic artifacts associated with living quarters; these would be the washtubs, water kettles, stove parts and the like we discovered in the field. Their linear arrangement is probably correlated with the beach ridges. The dashed circles are potentially more interesting archaeological sources in that their radii are much larger than the visible house pits at the site an example of which is marked with the bold red circle (Figure 10). One can imagine more (or fewer) of these circular sets of anomalies but it is unlikely all are imaginary and, given the local surface and soil situation, they are unlikely to be geologic in nature; only excavation would tell.

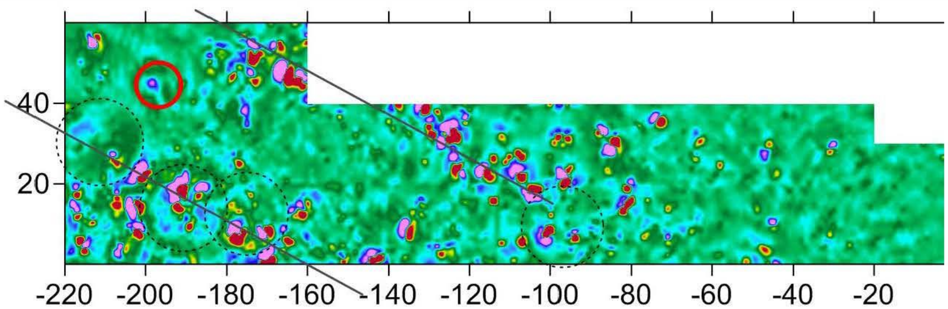


Figure 10. Equivalent magnetic layer for shallow sources in the combined grids; range is 646 nT.

A shaded relief map of the east end of the site complex shows some interesting radial anomalies roughly centered on the top of the mound (Figure 11). Given the noise inducing acquisition conditions, the fact the anomalies cross contiguous grids, and their concentric nature they are neither acquisition nor processing artifacts. Perhaps they represent soil differences accumulated during building out of the midden or drainage terraces of some sort; again only excavation would tell.

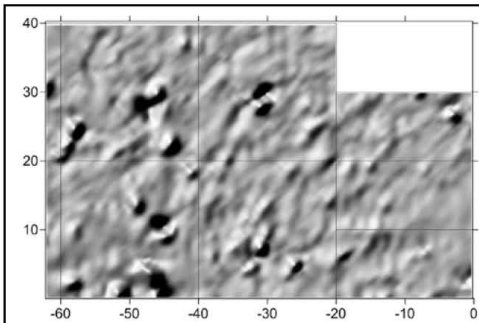


Figure 11. Raised relief highlighting radial anomalies around the mound.

Anomalies and Features Apparent on Individual Grids

Grid#1 and Grid #1_north

Figure 12 shows the processed results for Grid#1 and Grid#1_north. These equivalent layers have ranges of 19.3 nT for Grid#1 and 34.9 nT for Grid#1_north. The alternating highs and lows are contributors to the previously discussed radial anomalies around the mound. In the northeast (dashed circle in the upper right) there is a hint of a circular anomaly that we found interesting because it is largely off the mound and nothing is apparent on the surface. Thus, Grid#1_north starts in the center (Y=10m) of Grid#1 to overlap that circular anomaly and continues 20m north from there. We expected the anomaly to continue and collected overlapping grids in this first occasion to assess the reliability of our acquisition in this rough topography. What we found in Grid#1_north (Figure 12) is that the arcuate feature in Grid#1 is truncated by another circular feature in Grid#1_north. Also, merging Grid#1 and Grid#1_north which overlap by 10 meters shows the same anomalies and results are consistent across the grid boundaries. Thus, despite the rough topography and challenging acquisition conditions the data are robust at the presented scale.

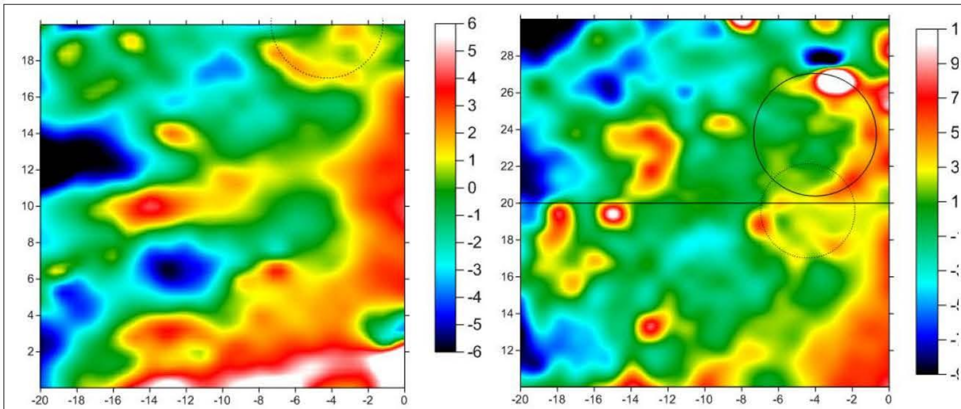


Figure 12. Grid#1 (left) and Grid#1_north (right) equivalent layers; scale in nT.

Grid#2

Figure 13 shows the processed results for Grid#2, an equivalent layer from the upper one to two meters or so constructed by differencing the decorrugated data with an upward continuation of two meters. The range of these data is 35.8 nT. "A" in the south center of the grid marks a classic dipole anomaly from what is most likely a reversely magnetized piece of metal, a magnetic high flanked by lows. There is also an indication of a circular feature occupying the upper right quarter of the grid. The radius of that feature is larger than that of visible house pits in the site but approaching those marked on the mosaic of all the grids (Figure 1).

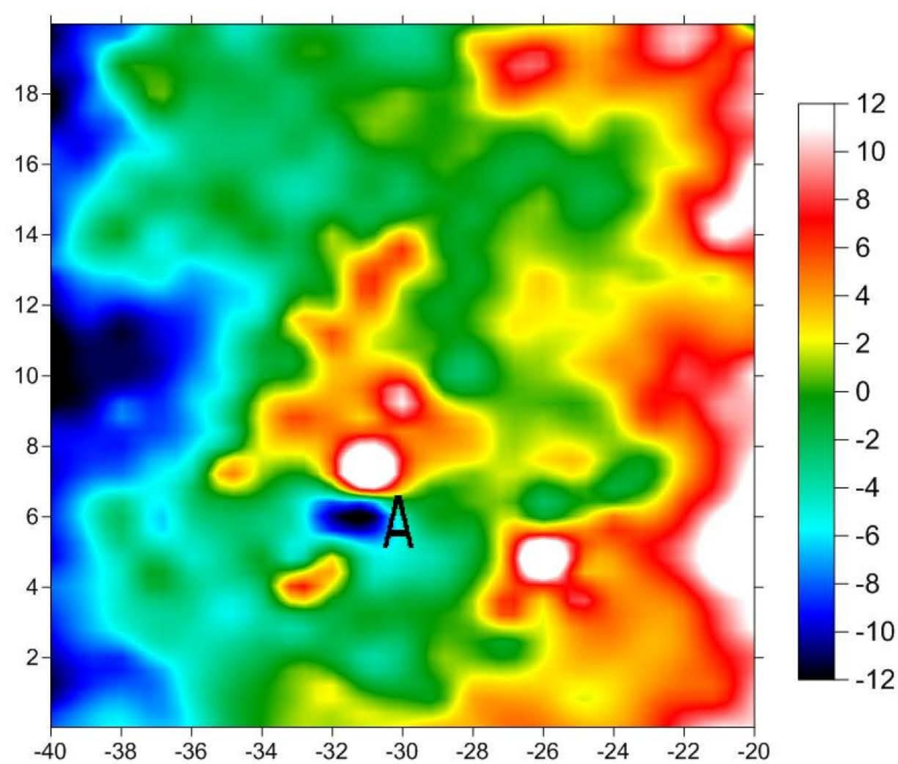


Figure 13.Grid#2 equivalent layer constructed by difference upward continuations to 0.25 meters and 2.0 meters; all subsequent equivalent layers are constructed similarly.

Grid#2_north (north being the designation for the next row of grids north of the baseline)

Figure 14 shows the processed results for Grid#2_north (second row north of baseline), an equivalent layer, with a range of 87.3 nT, produced by differencing the decorrugated results with an upward continuation of two meters. There is one high amplitude magnetic anomaly ("A") near the center of the grid, likely from a metal source. Also visible in Grid#2_north is a general radial pattern shown by the dashed arc about the southeast corner that contributes to the radial anomalies shown and discussed with Figure 11.

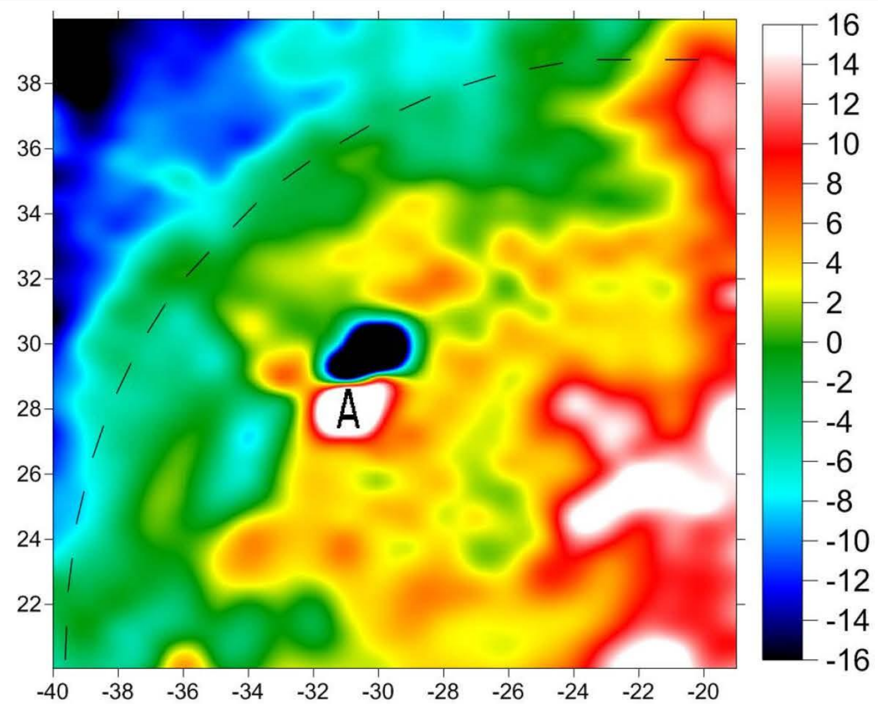


Figure 14. Shallow equivalent layer for Grid #2_north.

Grid#3

Figure 15shows the processed results for Grid#3, an equivalent layer from the upper one to two meters or so with a range of 91.5 nT. There is nothing of particular interest in Grid#3. It is west of the area with arcuate anomalies concentric around the mound. The only features of note, marked by "A" in the figure, are near surface metal sources with normal magnetization; the dipole lows are north of the highs.

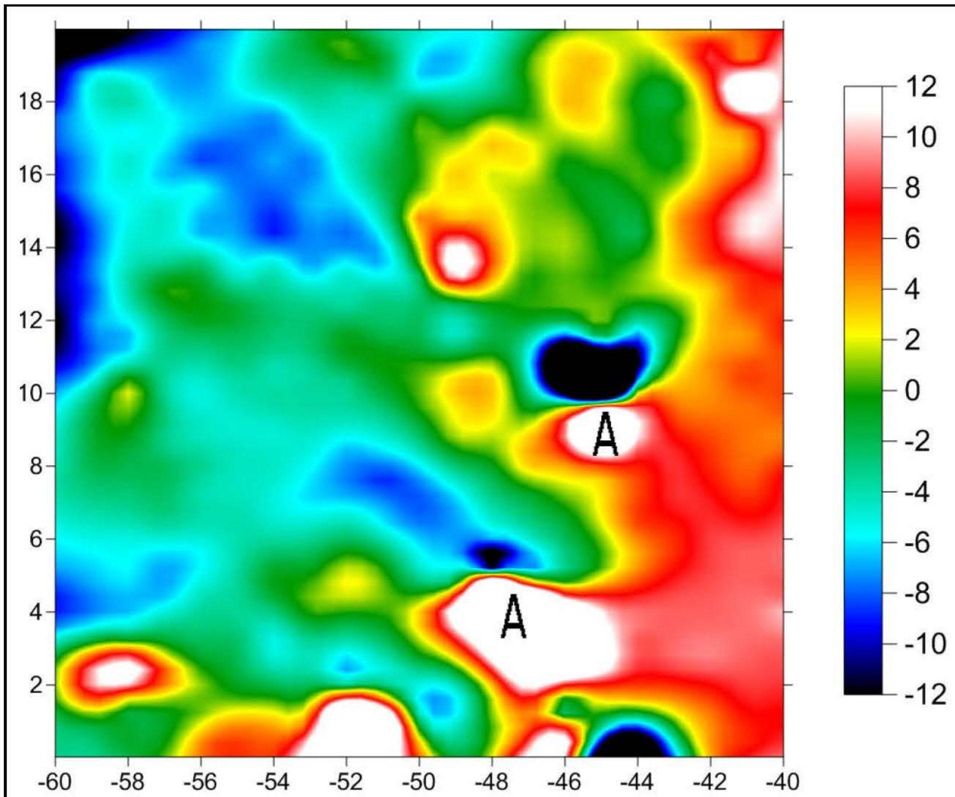


Figure 15. Shallow equivalent layer for Grid#3.

16

Grid#3_north

Figure 16 shows the processed results for Grid#3_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; its range is 63.4 nT. As per the convention, "A" marks metal sources for the high amplitude anomalies. Also visible in Grid#3_north is a general radial pattern shown by the dashed arc, that is the distal part of the radial anomalies shown and discussed with Figure 11.

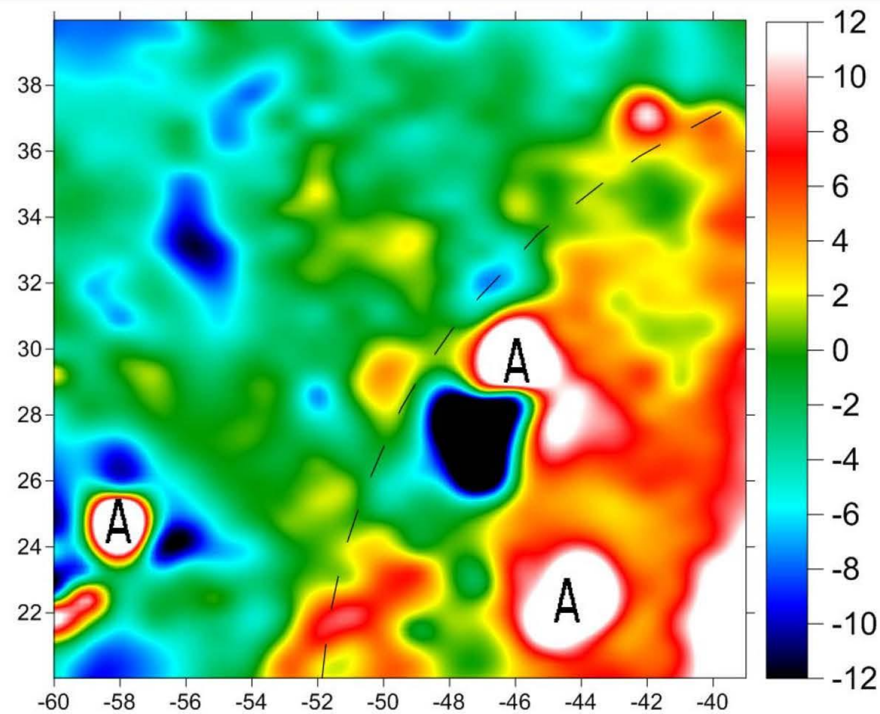


Figure 16. Shallow equivalent layer for Grid#3_north.

Grid#4

Figure 17 shows the processed results for Grid#4, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 168.3 nT. This isolates features near the surface and biases strongly against deeper, likely geologic, sources. On grid#4 there are a couple likely metal sources (marked with "A") as well as a fairly large scale circular feature in the north half of the grid (dashed arc). This circular feature is on the same scale as those larger ones marked in Figure 1 and is also apparent, though not marked, on that image. Fiddling with color scales, calculating various equivalent layers, and other image enhancement techniques makes features either more or less noticeable relative to their neighbors depending on local amplitudes.

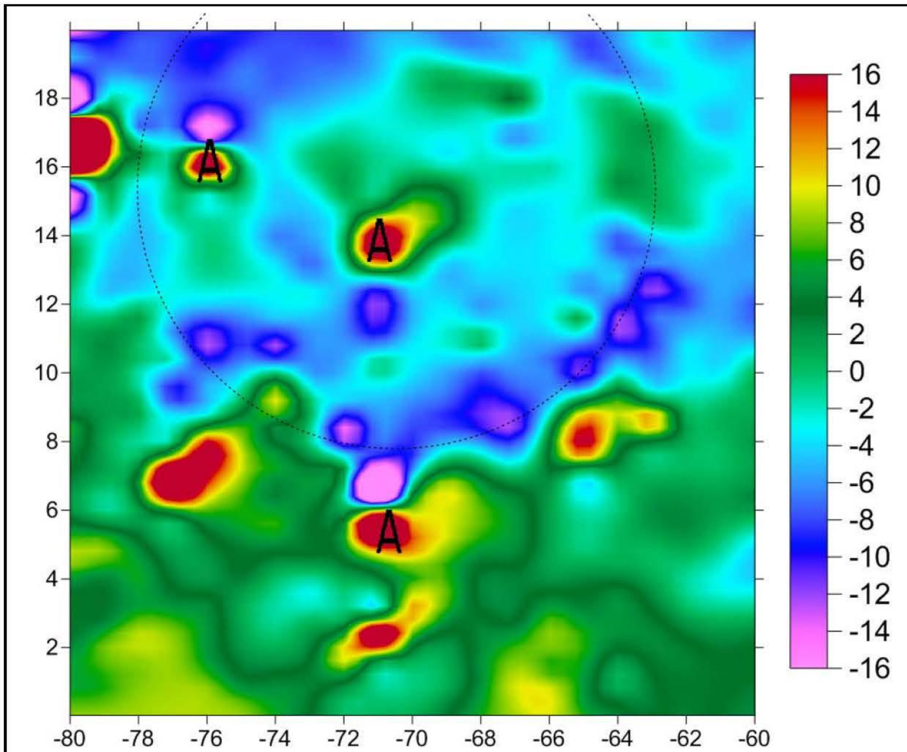


Figure 17. Shallow equivalent layer for Grid#4.

Grid#4_north

Figure 18 shows the processed results for Grid#4_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 149.7 nT. This grid has a few randomly distributed high amplitude magnetic anomalies ("A") as well as a number of smaller ones. Consequently there is little opportunity to discern subtle anomalies from sources preceding the use of metal washtubs and such modern conveniences. However, there is an interesting circular arrangement of anomalies shown by the dashed line around a couple of the high amplitude anomalies. Excavation across that circle, if it is not an archaeological feature measured in the field, could be interesting.

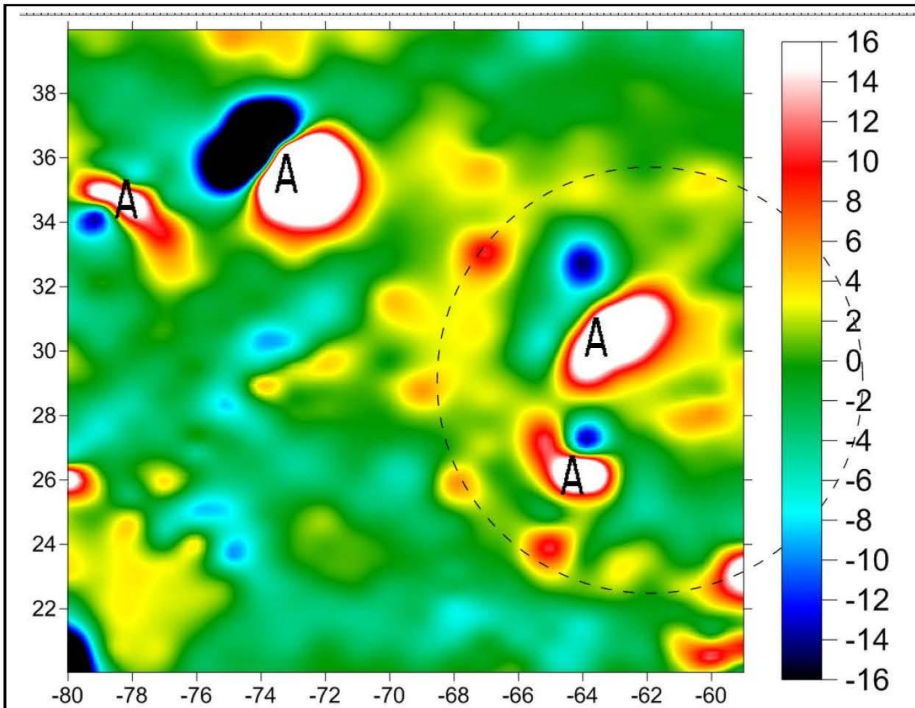


Figure 18. Shallow equivalent layer for Grid#4_north.

19

Grid#5

Figure 19 shows the processed results for Grid#5, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 319 nT. As is true throughout the area there are several metal sources manifesting in dipolar anomalies ("A"'s in the figure). There is also a circular anomaly shown by the dashed circle which is about the size of the visible house pits at the site. That circle also shows up with edge detection.

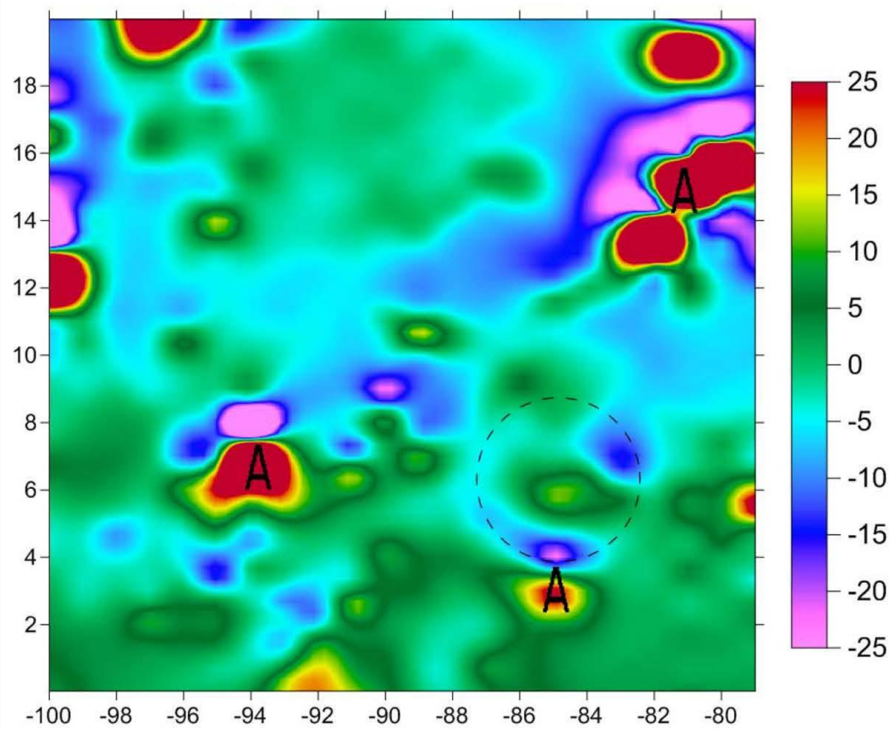


Figure 19. Shallow equivalent layer for Grid#5.

Grid#5_north

Figure 20 shows the processed results for Grid#5_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 509.9 nT (huge). Aside from the all too common high amplitude magnetic anomalies from historic metal sources, one can sketch in a speculative circular feature (dashed circle on the image) ringing one of the concentrations of metal sources. In the field we frequently found galvanized washtubs within circular house pits, this may be one of those cases.

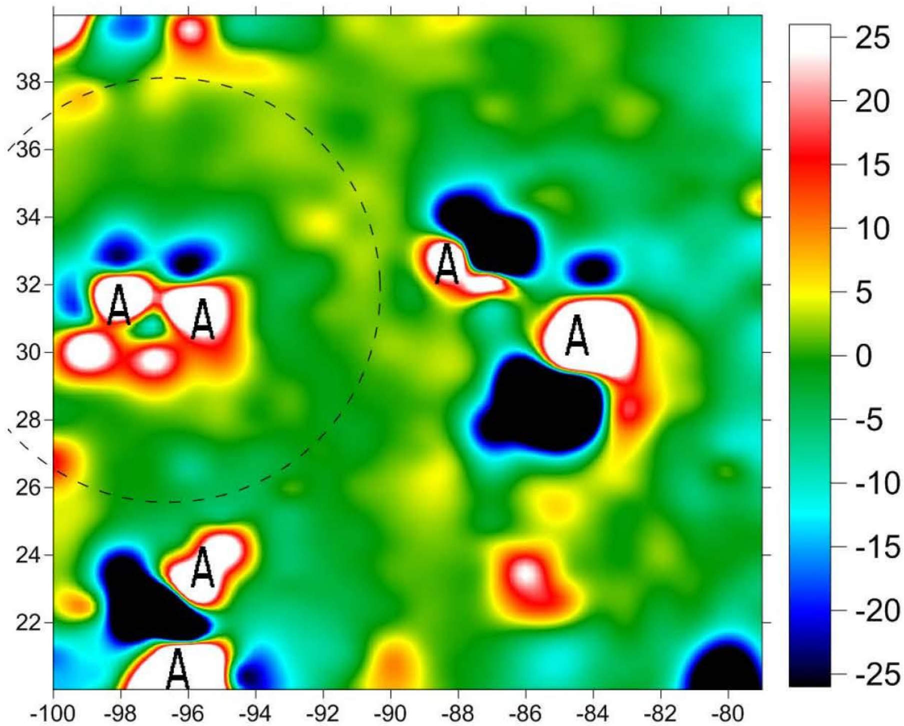


Figure 20. Shallow equivalent layer for Grid#5_north.

Grid#6

Figure 21 shows the processed results for Grid#6, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 550.1 nT. The isolated high amplitude anomalies in Grid#6 are all most likely from metal sources. Those marked with "A" are certainly so as the lows associated with the magnetic highs are displaced south of the highs indicating a remanent magnetization. The anomaly marked "B" is a more classic metal dipole source with a high flanked by lows to the north and south. There is also a hint of a pit house sized circular anomaly in the center of the south third of the grid, the magnetic highs around it could be metal sources but they have less well defined associated magnetic lows.

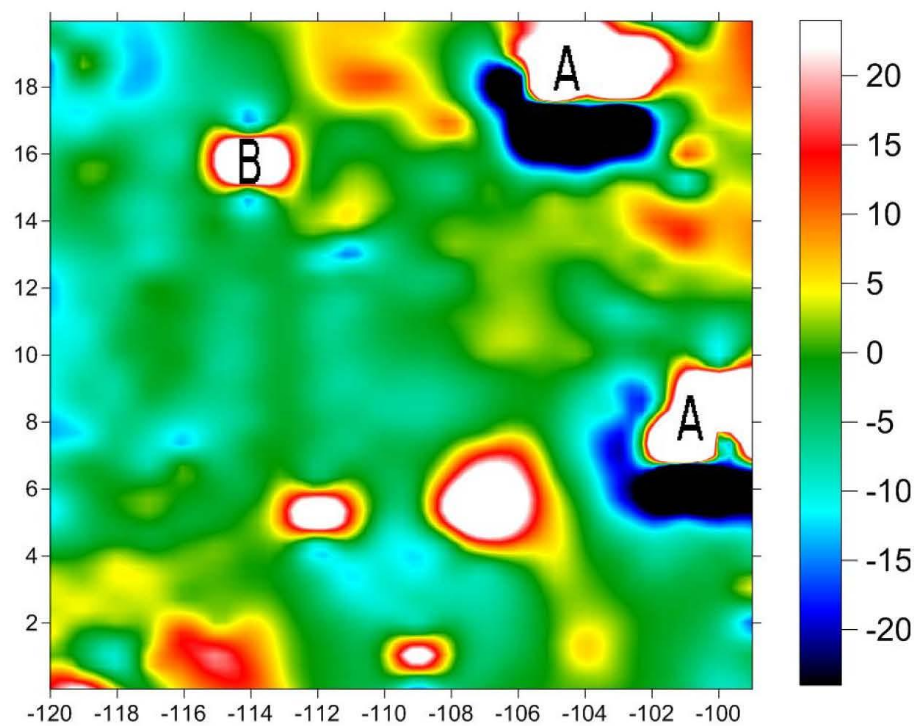


Figure 21. Shallow equivalent layer for Grid#6.

Grid#6_north

Figure 22 shows the processed results for Grid#6_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 366.6 nT. There are several large amplitude magnetic anomalies in this grid, those marked with "A" are from relatively shallow sources, those with "B" somewhat deeper. In both cases the most likely sources are historic metal.

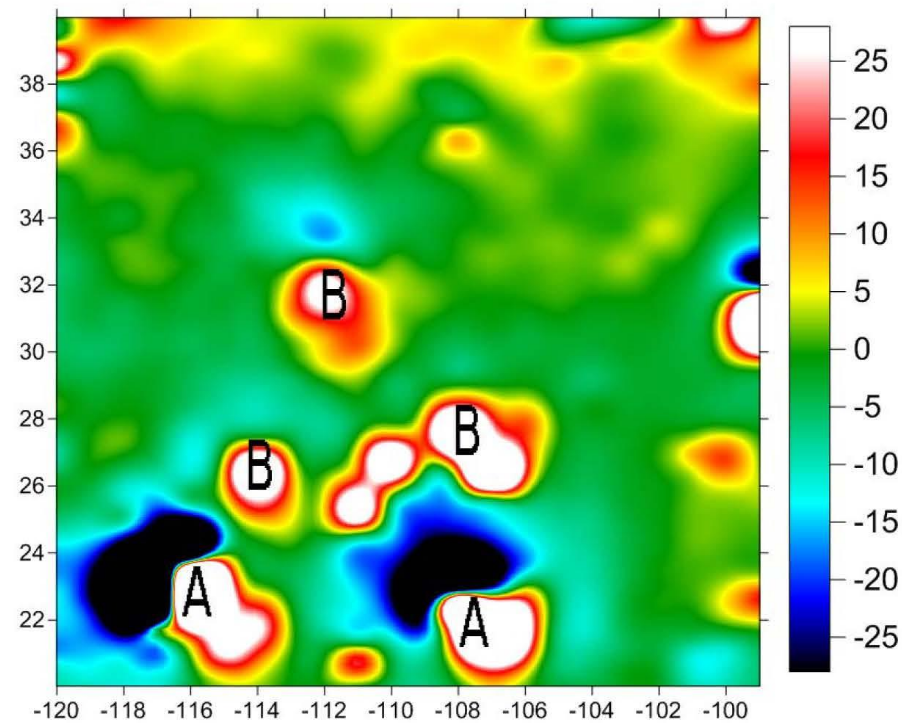


Figure 22. Shallow equivalent layer for Grid#6_north.

23

Grid #7

Figure 23 shows the processed results for Grid#7, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 169.2 nT. There are isolated magnetic highs with associated lows indicative of metal sources indicated by "A". There is also a radial anomaly shown by the dashed circle, again the sort of source which could only be confirmed with excavation and careful investigation of the soil and stratigraphy. The dashed line at the south edge of the circle partly defines that circle but is also associated with the magnetic high ("A") south of it. The magnetic lows on the dashed line are near-linear with a greater radius of curvature than the circle; they may be from a local trench.

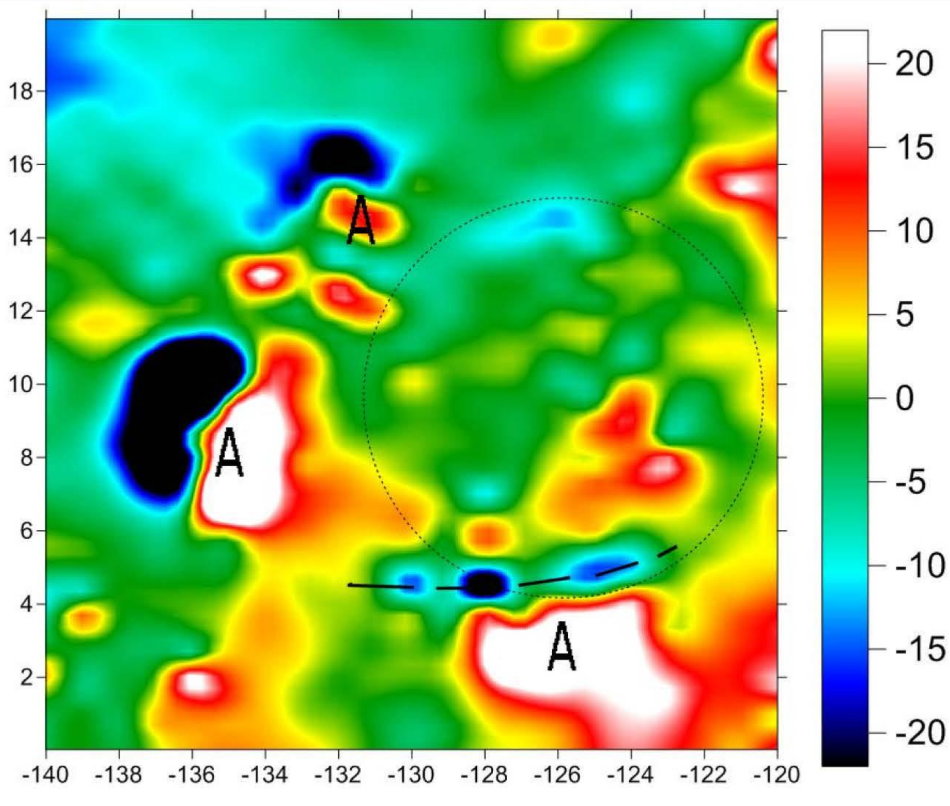


Figure 23. Shallow equivalent layer for Grid#7.

Grid#7_north

Figure 24 shows the processed results for Grid#7_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 394.1 nT. Distributed (and plentiful) magnetic highs, several of which are marked with "A", dominate the northeast half of this grid and are major contributors to the long trend of such shown in Figure 1. In addition to those sources one can conjecture the possibility of a magnetic low, possibly from a trench, leading to a subtle (maybe real) circular anomaly as shown with the dashed line and circle, respectively. It will be interesting to see if these correlate with one of the archaeological features

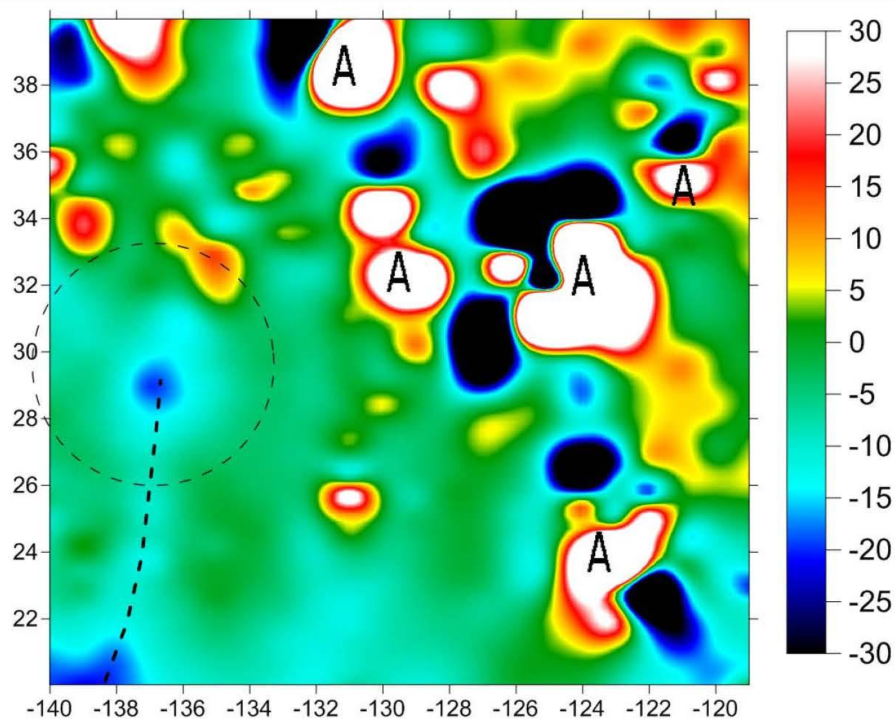


Figure 24. Shallow equivalent layer for Grid#7_north.

mapped in the field.

Grid#8

Figure 25 shows the processed results for Grid#8, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 233.3 nT. There are isolated magnetic highs with associated lows indicative of metal sources indicated by “A”. More curious is the vague circular feature shown by the dashed circle. Larger than most of the visible house pits it is on the scale of those indicated on Figure 1 and, once highlighted by the dashed circle, can easily be imagined in Figure 25.

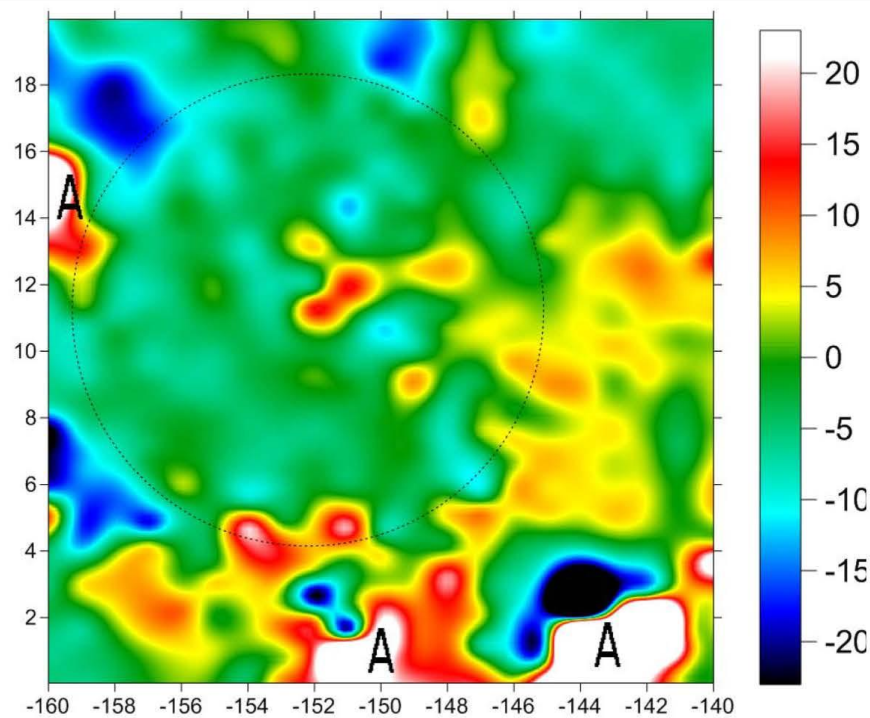


Figure 25. Shallow equivalent layer for Grid#8.

26

Grid#8_north

Figure 26 shows the processed results for Grid#8_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 79.4 nT. The isolated magnetic highs likely have metal sources; they generally align from the

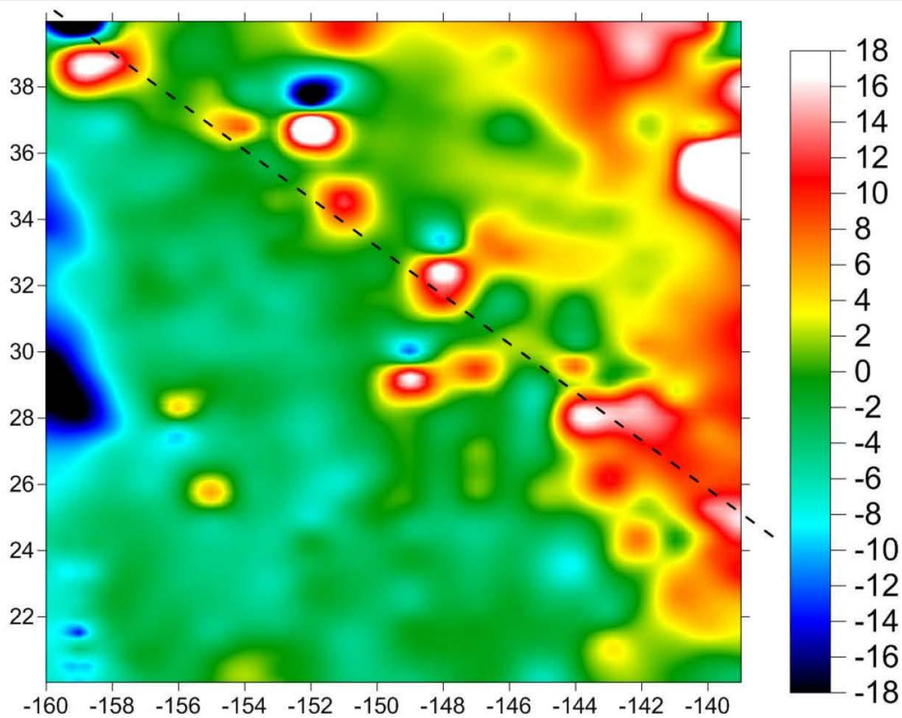


Figure 26. Shallow equivalent layer for Grid#8_north.

upper left to lower right as seen on the mosaic of all the grids (Figure 1).

Grid#9

Figure 27 shows the processed results for Grid#9, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is a staggering 568.2 nT. There are isolated magnetic highs with associated lows likely from metal sources as indicated by "A". The magnetic highs have exceptional amplitude, the range in this grid is 568 nanoteslas (nT). Meanwhile we hope for archaeological anomalies on the order of nT or at most 10's of nT. These high amplitude anomalies from metal sources swamp any subtle signal. The dashed circle is the same as that discussed earlier (Figure 1) where it is somewhat more apparent on the mosaicked grids.

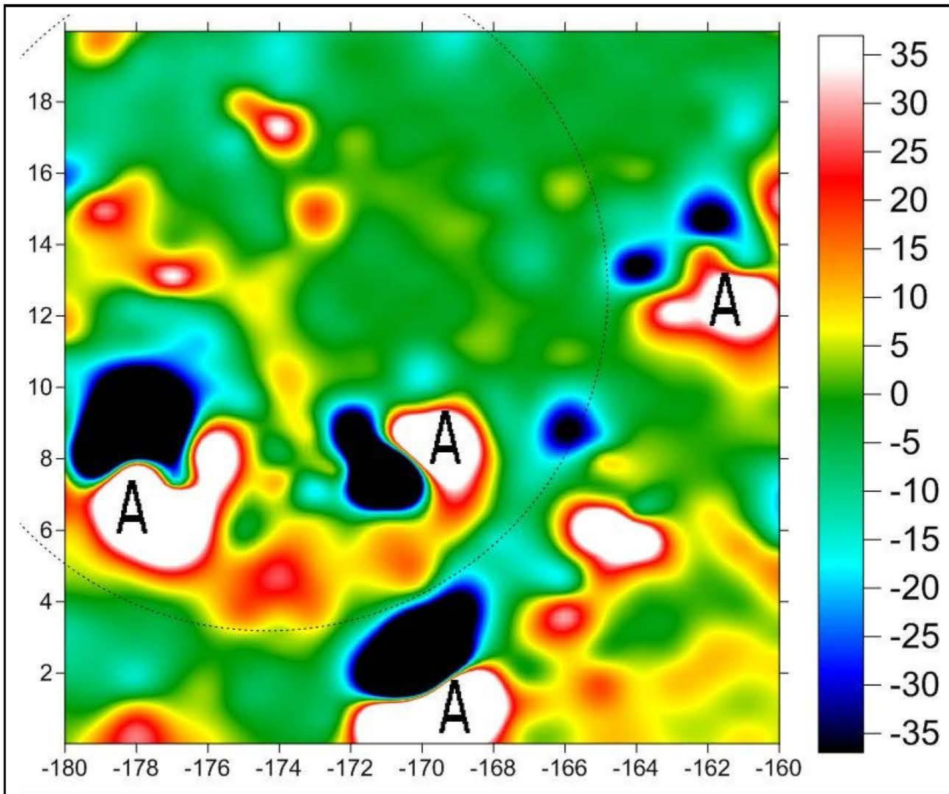


Figure 27. Shallow equivalent layer for Grid#9.

Grid#9_north

Figure 28 shows the processed results for Grid#9_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 86.4 nT. The "A" marks the metal source for the large magnetic high in the southwest and there appears to be smaller such sources distributed around the grid. Of potential interest is the rectangular anomaly in the northwest corner marked by the dashed white line. That deep magnetic low has high gradient sides and lacks an associated magnetic high, all of which is suggestive of modern construction. One guess for its origin is a backfilled, machine-dug trench. However, that trench does lead to a deep house pit.

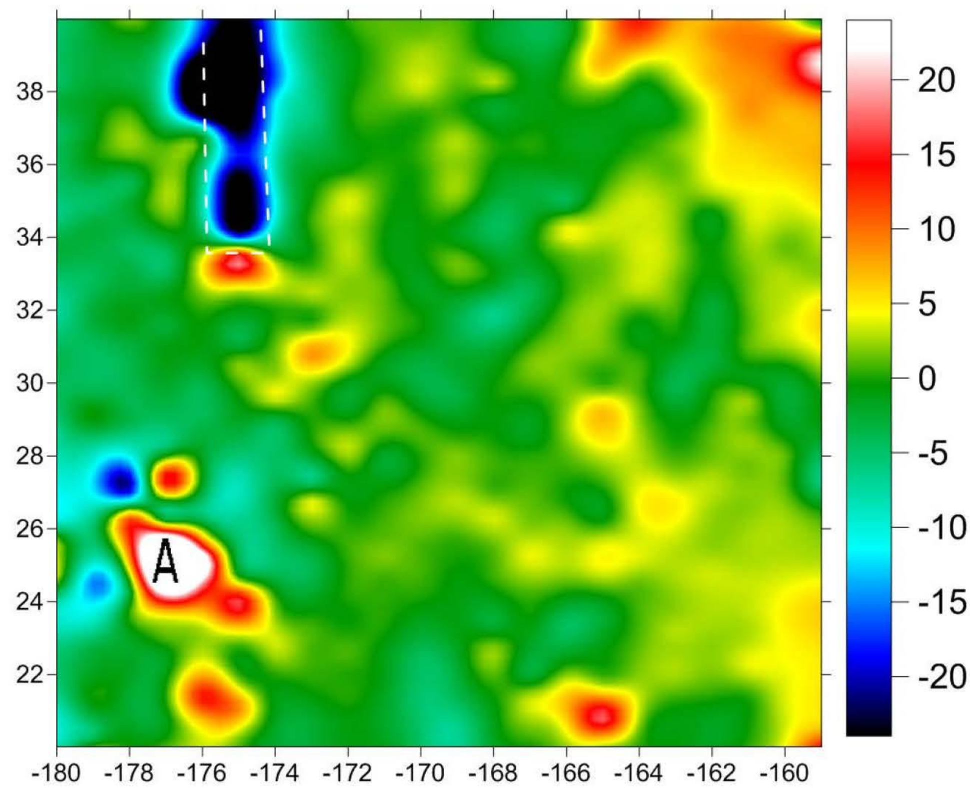


Figure 28. Shallow equivalent layer for Grid#9_north.

Grid#9_north_2 (the second row north of the baseline as seen in Figure 1)

Figure 29 shows the processed results for Grid#9_north_2, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 501.0. High amplitude magnetic anomalies from near surface metal sources dominate the observations in this grid. "A" marks the highest, though there are several smaller ones as well. Potential subtle features are obscured.

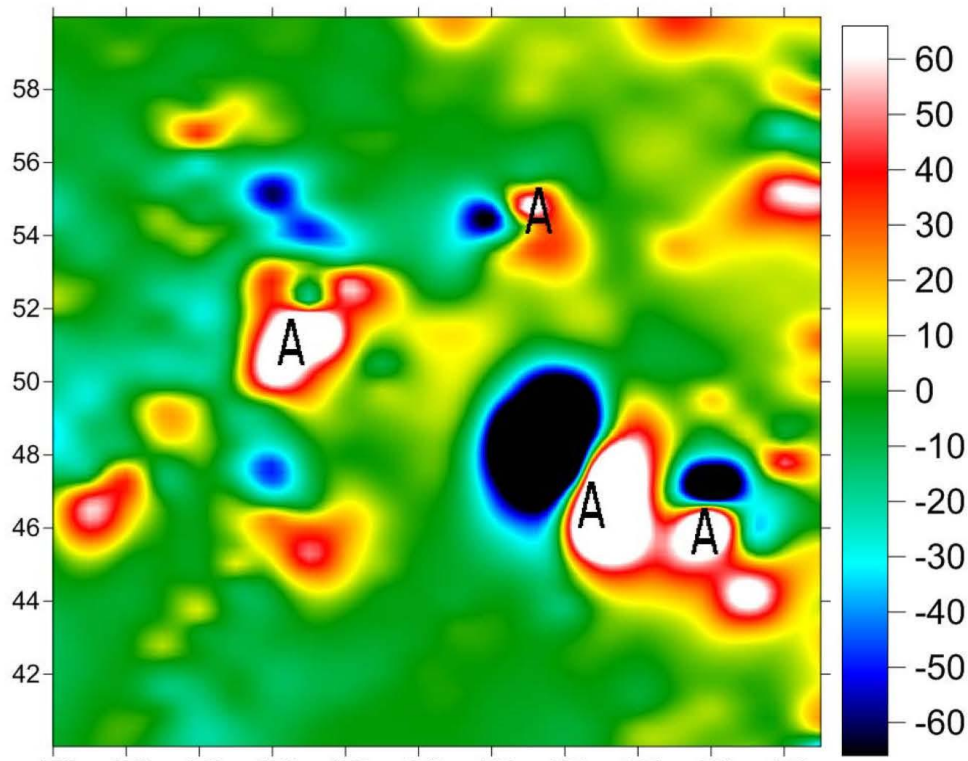


Figure 29. Shallow equivalent layer for Grid#9_north_2.

30

Grid#10

Figure 30 shows the processed results for Grid#10, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 543.2 nT. Grid#10 includes a portion of the circular feature noted in an earlier section Figure 1) though that feature is more apparent on the composite image. The high amplitude anomalies in the north center of Grid#10 are indicative of near surface metal sources and lay along the northwest trending line of sources shown on Figure 1.

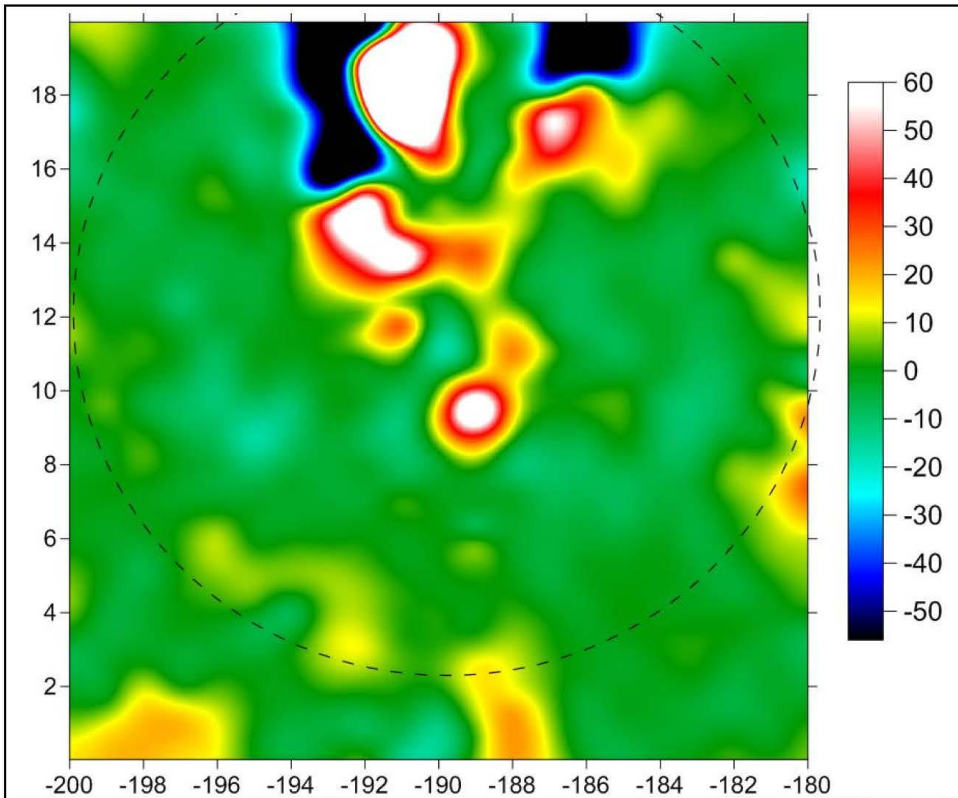


Figure 30. Shallow equivalent layer for Grid#10.

Grid #10_north

Figure 31 shows the processed results for Grid#10_north (second row north of baseline), an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 250.6 nT. There is little of note or interest in Grid#10_north which is mostly dominated by several small magnetic highs due to metal sources and a large magnetic low on the south edge that continues from Grid#10 to the south.

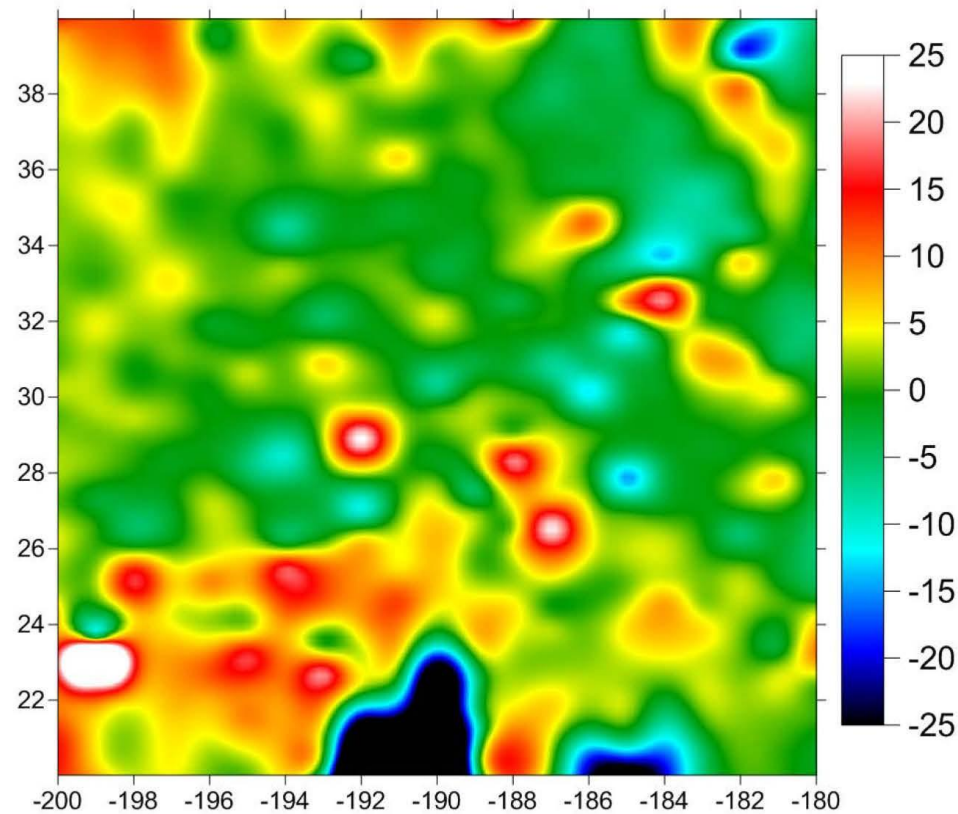


Figure 31. Shallow equivalent layer for Grid#10_north.

32

Grid#10_north_2 (the second row north of the baseline)

Figure 32 shows the processed results for Grid#10_north_2, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 89.9 nT. As with many other grids, Grid#10_north_2 contains many high amplitude magnetic anomalies from historic metal sources. Grid#10_north_2 also, as marked on the image with dashed circles, contains two circular features. The southwestern of those two also has a magnetic low (dashed line on the image) that marks the entry trench to the circular house pit which was visible in the field.

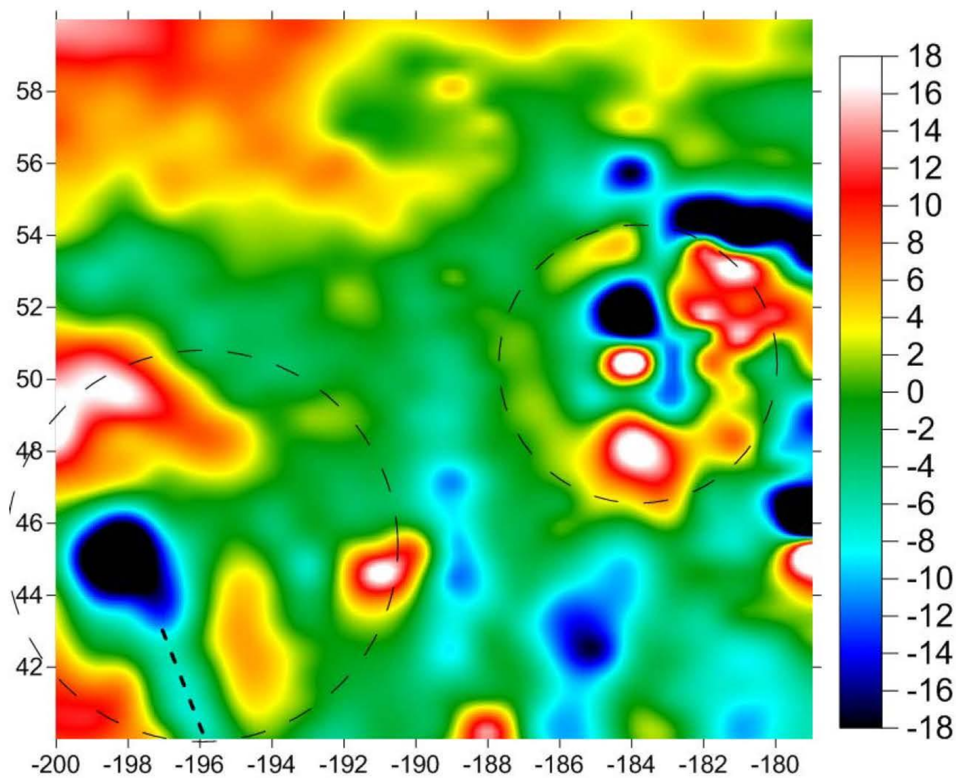


Figure 32. Shallow equivalent layer for Grid#10_north_2.

Grid#11

Figure 33 shows the processed results for Grid#11, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters. There is little in the way of pattern in Grid#11 which is dominated by the high amplitude point source anomalies, the larger of which are marked by “A”, characteristic of historic metal artifacts as are present in most of the grids. Though those sources could likely be recovered with minimal pawing at the ground there is little to guide, or recommend, excavation in this grid. There is a vague circular arrangement of some of the magnetic highs (dashed circle) but there are so many such anomalies that that may be happenstance; excavation would tell.

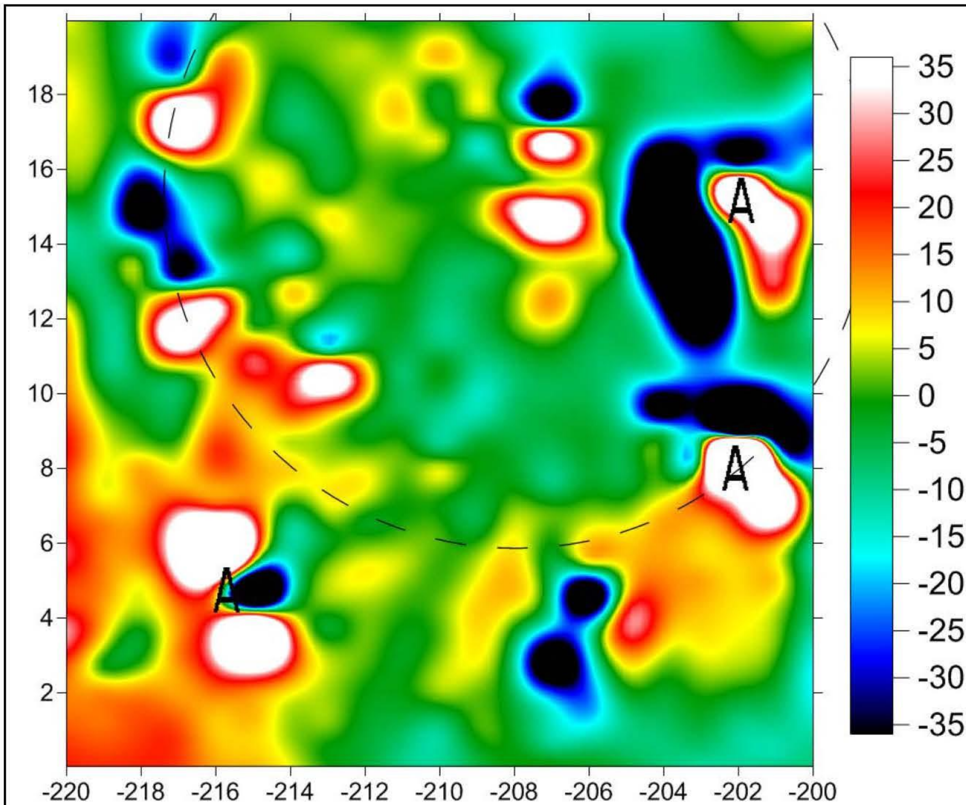


Figure 33. Shallow equivalent layer for Grid#11.

34

Grid#11_north

Figure 34 shows the processed results for Grid#11_north, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 935.7 nT (largest of all grids). The two highest amplitude anomalies with their flanking lows to the north ("A") are from metal sources. After acquisition, we found a galvanized washtub at about (-201, 22) which explains the southeast magnetic high. The dashed arc marks a magnetic low which is cut by several transects during acquisition of the magnetic data. That low could well be from a trench or old pit house entrance.

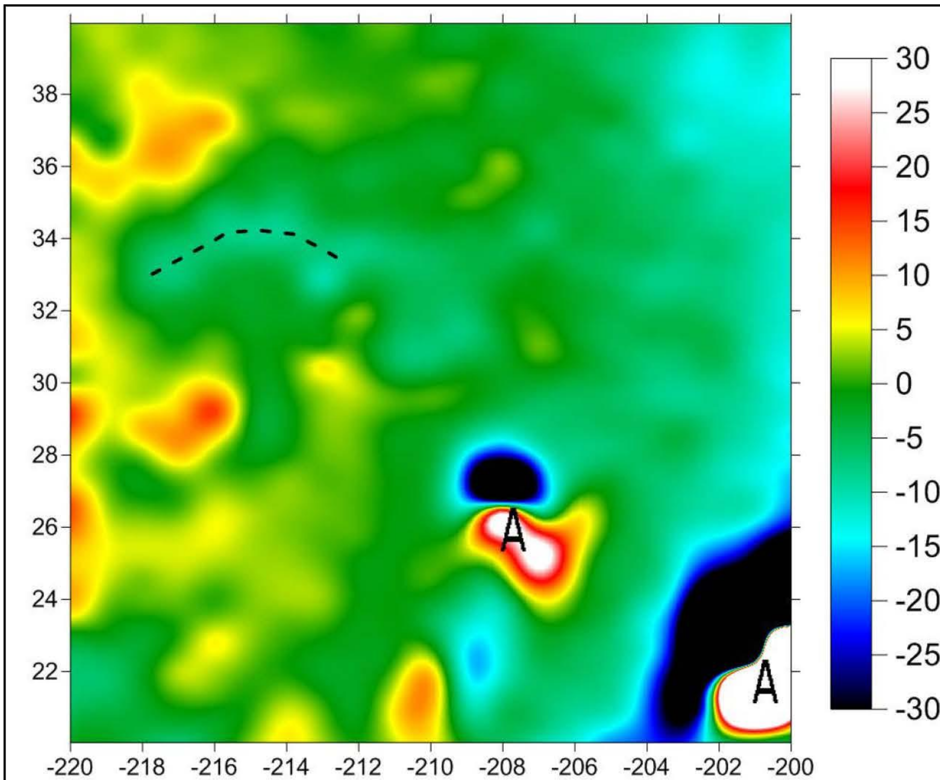


Figure 34. Shallow equivalent layer for Grid#11_north.

Grid#11_north_2 (the second row north of the baseline)

Figure 35 shows the processed results for Grid#11_north_2, an equivalent layer produced by differencing the decorrugated results with an upward continuation of two meters; range is 335.2 nT. There is a large metal source ("A") in the northwest quadrant and a couple smaller ones south of that. Other than that the only notable feature is in the southeast corner where there is an arcuate anomaly which is the western portion of a house pit largely in Grid#10_north_2 (Figure 32).

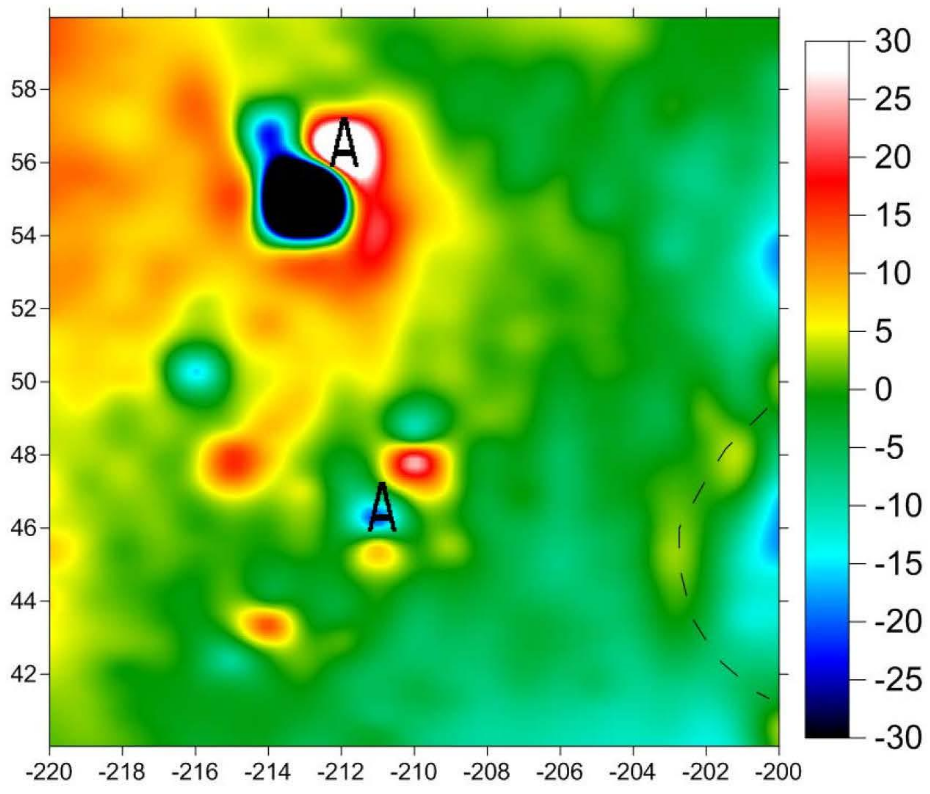


Figure 35. Shallow equivalent layer for Grid#11_north_2.

36

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Pedersen, L.B., 1991, Relations between potential fields and some equivalent sources, Geophysics, 56, 961-971.

S.D. Sheriff, 2010, Matched Filter Separation of Magnetic Anomalies Caused by Scattered Surface Debris at Archaeological Sites. Near Surface Geophysics, v. 8, #2, p. 145-150.

Urquhart, T., 1988. Decorrugation of enhanced magnetic field maps. 58th Annual International Meeting, SEG, Expanded Abstracts, 371–372.

Glossary of lesser known terms used in the report.

Corrugation - Artificial anomalies oriented with or perpendicular to survey lines that result from errors in leveling, gridding, survey locations, etc. Decorrugation filtering removes these artifacts.

Equivalent layers (or equivalent sources) - fictional layers, below the observation surface, where the distribution of magnetization produces the observed magnetic field. A single layer containing gravity or magnetic sources that yield the same gravity or magnetic field as observed.

Filtering - The attenuation of components of a signal based on some measurable property. Usually implies that the measurable property is frequency, performed mathematically with Fourier transformation.

High gradient – A large first derivative or rate of change of the magnetic field with respect to distance or, in the case of vertical gradient, the vertical. Shallow sources create high gradient anomalies.

Longer wavelength signals – those of lower spatial frequency and typically related to deeper sources.

Low gradient - A small first derivative or rate of change of the magnetic field with respect to distance or, in the case of vertical gradient, the vertical. Deep sources create low gradient anomalies.

Magnetic gradiometry – technique of measuring the vertical gradient of the total magnetic field. This discriminates against deeper sources.

Matched filtering - A filter that maximizes the output in response to a signal of particular shape. The elements of a matched filter are the elements of the signal in reverse order. Used where the waveform of the signal is known, as in removing a random distribution of magnetic sources from a particular depth.

Noise - Any unwanted signal or a disturbance that does not represent part of a message from a specified source.

Sources – The material, or change in material, at depth that causes a magnetic anomaly.

Spatial frequency – measurement of 1/wavelength of Fourier components of a signal.

Spatial frequency domain – Amplitude versus spatial frequency response of the Fourier transform.

Total field magnetometry – measurement of the strength of the magnetic field at a spot (compare magnetic gradiometry).

Upward continuation - Calculation of the potential field at an elevation higher than that at which the field is known.

Wavelength - The distance between successive similar points on two adjacent cycles of a wave, measured perpendicular to the wavefront.

Appendix D
Geoarchaeology Report (Owen K. Mason)

Geoarchaeology of the Old Togiak Spit
and Implications for Prehistory

by

Owen K. Mason

Report to the Togiak Archaeology and Paleoecological Project
conducted by the
Department of Anthropology, University of Montana, Missoula

National Science Foundation

12 January 2017

Geoarch Alaska
220 W Sky Dr
Boise, ID 83702

Geoarchaeology of the Old Togiak Spit and Implications for Prehistory

Owen K. Mason

Introduction

The goal of the geomorphology subcomponent of the Togiak Archaeological and Paleoecological Project (TAPP) project sought "[t]o provide contextual data for past climates and storm history of the northern Bristol Bay region." The Old Togiak site lies atop a small northwest trending spit that is exposed to southwesterly winds and waves, and is just barely above storm tides. Bristol Bay is the eastern compartment of the Bering Sea, and is subject to subarctic forcing that includes seasonal pack ice for over half the year and is also marked by the onslaught of intense storm surges. Although northern Togiak Bay is comparatively restricted in orientation, storm surges are likely occurrences every 10 to 50 years and very likely posed a challenge for prehistoric residents. The program of preliminary research in June 2015 involved both field and archival efforts, with observations on the modern beach as well as aerial photographic interpretation. To contextualize the study, the available literature for Bristol Bay geography and geology was reviewed and synthesized in this report.

The following research report is preliminary and offers the author's hypotheses for the coastal geomorphology and storm history of the Togiak region. Only a substantial increase in data will bolster and support these observations. First, the configuration of beach ridges atop the spit was mapped from aerial photographs. Second, sequential aerial photographs were compared to generate relative rates of coastal erosion. Finally, the extant literature was reviewed in order to describe the wave climate of Togiak Bay and to outline the history of storms, as known and reported. Contrary to expectation, the study area is not among the most storm-sensitive or erosion threatened regions of western Alaska. Suggestions for subsequent research are presented in the conclusions.

Methods

The geological and geomorphic data base for the Togiak Bay region is limited, mostly assembled in the 1970s, with few data obtained during the recent decades. Bathymetric data are available from NOAA charts while precise sedimentary data are rudimentary and offer little spatial resolution.

The fieldwork in June 2015 focused on examining both past and modern beach processes. On the active beach, shore perpendicular and shore parallel trenches were excavated by TAPP. The surface sediments of the beach were recorded, along with elevational observations about tide and storm effects. Lithological and granulometric observations follow from the strata within the trenches and by the placement of 1 m^2 grids at intervals parallel to the beach. Four aerial photographs were obtained from AeroMap (Anchorage, AK) in order to estimate erosion rates and to gauge the effects of the wave climates of the last 70 years of record.

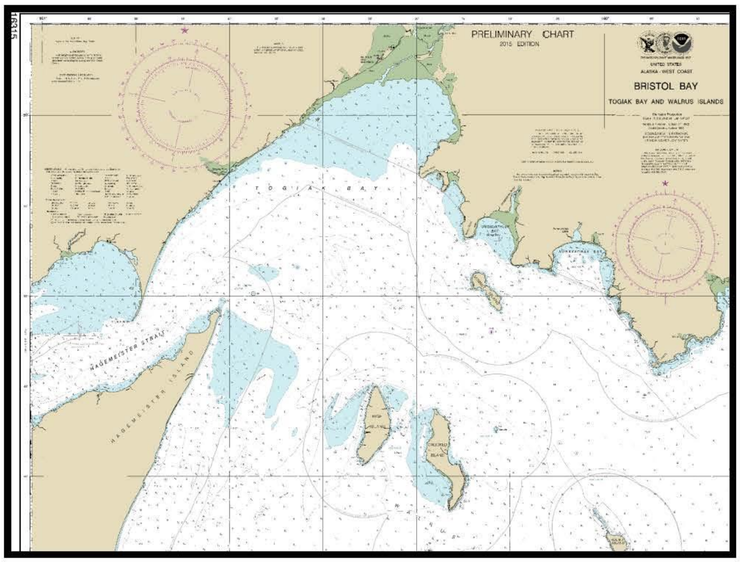
Several project goals could not be met. The research design envisioned obtaining sea level and storm history records by placing a series of soil probes in the area landward of the site. The marsh landward of the Old Togiak site consists of slightly oxidized unconsolidated clay that lacked macroscopic evidence of stratigraphy and lacked any recognizable organic beds. Opportunity did not permit Dr. Mason to visit any natural river or delta exposures in the immediate region, owing to the lack of a skiff or other navigable craft.

An important goal of the TAPP project involved a paleoecological model for the Togiak area spanning the occupation period of the site, the last 2000 years. The goal is to define the local effects of regional climate change and will be accomplished through integrated analysis of multiple data sets, of which the geoarchaeological data are one part. This report represents the geoarchaeological assessment of the site and its associated geomorphological context. The study draws upon both Dr. Mason's field observations as well as the data obtained by the TAPP team in a series of cores across the Old Togiak site (Fig. 1), supplemented by stratigraphic sections drawan by Dr. Prentiss along the eroding site margin landward of the beach. TAPP obtained 41 age estimates on AMS ^{14}C assays from within 17 of the 30 cores placed in the Old Togiak mound. The resultant chronometric data extend over 1500 years, although samples cluster within the last 300 years. Basal ages from the cores provide limiting ages on beach ridge formation of the OT spit.

Fig. 1. Oblique view of Old Togiak Spit showing a modern cannery foreground. The Old Togiak site lies in the background, covered by beach grass.

Site Setting and Geological Background

The small, 2 km long sand and gravelly Old Togiak (OT) spit recurves northwest to northeast along the eastern shore of Togiak Bay at 59° 3′ 6″ N, 160° 19′ 49″ W. The OT spit is comprised of between 10 and possibly 15 laterally continuous arcuate beach ridges that enclose an oval-shaped tidal marsh to the landward (Fig. 1, 2). The spit has formed at the bay mouth, as long shore currents encountered open water. The entire package of ridges issued perpendicularly to a northerly angle from a single node at the farthest southern limit of the spit. The spit's orientation leads to the inference that waves from the south and southwest produced the current configuration of the ridges. In general, the entire spit lies than 2 m above sea level, although the mound of the Old Togiak site attains a height of up to 4 m.



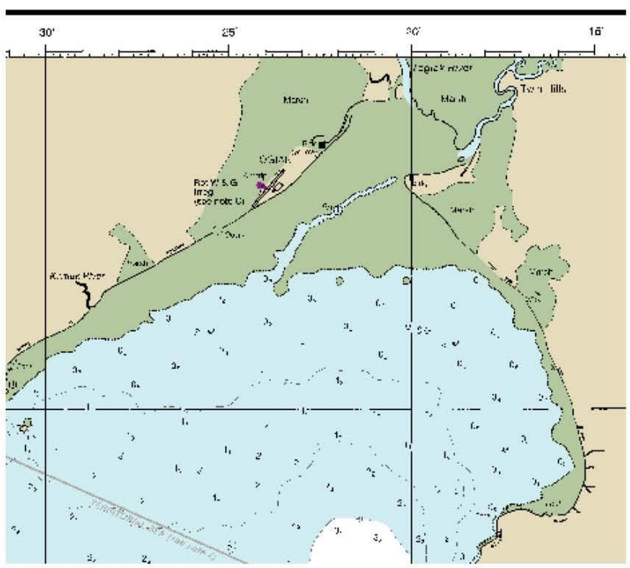


Figure 2a, 2b Bathymetry of Togiak Bay, Upper: US Coastal Pilot NOAA chart 16315, northwest corner, detail below of inner Togiak Bay, showing mapping of nearshore to Old Togiak spit as subtidal.

The bay offshore from OT spit is extremely shallow, termed as not navigable by the NOAA in the Coastal Pilot and the shallow deltaic sediments are mapped as above water, with the same pattern as the marsh (cf. Fig. 2a, 2b). The bathymetric chart for Togiak indicates the entire upper bay is virtually exposed at MLLW, with only a narrow channel off the Cannery on the OT spit. To the southwest, about 200 m Togiak Bay water depths are only between 40 and 80 cm (0.2 and 0.4 fathoms) at MLLW. At high tide, water depth is substantially greater, approaching nearly 7 m in depth.

Geologic Setting

Bristol Bay represents the surface expression of the North Aleutian sedimentary basin that lies north of the Aleutian arc (Walker et al. 2003). A complex array of tectonic processes over millions of years produced the subsiding basin, that is now filled with several kilometers of sediment. The North Aleutian basin underwent extension during the Eocene (30 Mya), followed by subsidence (Bond et al. 1988) and the effects of deltaic sedimentation in the subsequent epochs, from the Miocene (22 Mya) to the Holocene (10,000 yrs BP to the present).

Continuing from the northwest, across the Togiak River valley, structurally, the Togiak Bay lies within a series of down-warping grabens cut by a number of short faults (Hoare and Coonrad 1978, 1980), most prominently the Hagemeister fault, that directly underlies, the OT spit (Fig. 3). The fault underlies, possibly defines the Togiak River and continues offshore to the eastern margin of Hagemeister Island, about 15 km offshore, to the southwest. The Hagemeister fault marks an upthrown aspect on west hills of the valley, composed of deformed Mesozoic volcanic rocks—part of a "widespread (originally) marine unit" composed of "mafic and pillow basalts, andesitic flows, tuffs and breccias…[i]nterbedded with … tuffaceous siltstone, tuffaceous cherts…and argillite" (Hoare and Coonrad 1978:Plate 2). The lower, eastern margin of the Togiak River valley is underlain by the comparatively thin (<20 m thick) basaltic flows of the Togiak basalt forms the eastern margin of the lower Togiak River valley and delta. In the lower valley, near the coast, the Togiak basalt is overlain by Quaternary glacial and alluvial sediments

Fine grained sediments compose the landforms in the immediate countryside including the bluffs east of the Old Togiak spit. The floodplain alluvium is described by Hoare and Coonrad 1978, pl. 2, above) as "sand, gravel and boulders intertonguing with mud and overlain by silt near the coast. Beach deposits are chiefly sand and small pebbles, include[ing] boulders near sea cliffs." Continuing along the southeast, shore parallel dunes occur landward of beaches for limited stretches of the coast, especially near high sediment point sources such as small creek or river mouths.

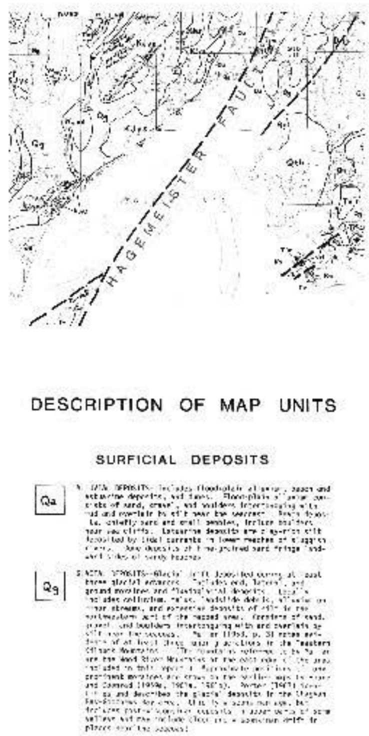


Figure 3. Quaternary geological map of the Togiak Bay area (Hoare and Coonrad 1980, with key for surficial deposits in vicinity of OT spit.

Quaternary History

The northern Bristol Bay is fronted by the southwesterly trending Ahklun Mountains, which repeatedly witnessed glaciations during the last several hundred thousand years (Porter 1967, Kaufman et al. 2001) as well as the last high stand of sea level around 125,000 years ago. The last 200,000 years of Quaternary history of the upper Bristol Bay region were reconstructed by Kaufman et al. (2001) by employing several stratigraphic sections cut along the 15 to 20 m high bluffs along the margins of Togiak Bay. A key section marks the sequence from the last Interglacial, Oxygen Stage (OS) 5e, to the subsequent early Wisconsin glaciation, OS 5d. Initially, at the base of the Togiak bluffs, about 4 m of laminated sandy silt of marine origin reflects the OS 5e high stand of sea level. Following this datum, a series of peaty silts were interbedded with tephra dated less than 100,000 years ago. Subsequently at 8 m ASL, the section records a vesicular flow of the Togiak basalt (Hoare and Coonrad 1980) dated by TL to ca. 70,000 yrs BP (Kaufman et al. 2001:193). Subsequently, the basalt was capped by >7 m of poorly sorted silty gravel of diverse lithology that contains subrounded, faceted, and striated clasts. This diamicton serves as evidence of a glacial expansion from the north (Kaufman et al. 2001:193). This sedimentary amalgam, termed "ice contact drift," forms the modern surface, that is marked by amorphous, pock marked ponds interspersed with odd shaped linear and hummocky landforms.

Sediments

The sedimentary cover of the Bering Sea shelf served Sharma (1972, 1974, 1975) as a type section for a graded shelf that responds to variable intensity of wave climates and is increasingly fine across the shelf, to the south---with the northern bays as an exception. In general, silt and clay are less likely to be deposited at depths less than 100 m because of continual wave induced turbulence (Sharma 1975:44-45). Conversely, the fines are transported southward to deeper areas and the sorting (dispersion around mean sediment size) is improved. All three of the shallow bays (Kvichak, Nushagak, Togiak) are poorly sorted, the result of bluff erosion of sandy gravel glacial sediments (Kaufman et al. 2001) and the input of fines, silts and sands, from the "point sources" of the various rivers (Sharma 1975). The shelf atop the northern perimeter of the sea is floored locally by poorly sorted gravelly sand and silt (Sharma 1975) as a result of the erosion of diamicton-rich bluffs. Such eroded gravelly sand is prevalent on the shelf southeast of the OT spit and this material is subject to littoral transport to form the OT beaches and beach ridges.

No data, such as grab samples, sediment cores, etc. are available to this researcher to describe the sediments in the tidal flat immediately offshore from the Old Togiak spit. The closest approximation is probably the sedimentary composition of the marsh landward of the spit that consists of massive clayey silt.

Oceanographic Parameters

The study area, the north northwest-trending Old Togiak spit, lies at the northern margin of Bristol Bay, within a smaller embayment, the funnel shaped Togiak Bay, and at its west by Hagemeister Strait (Fig. 4). Connected to the Togiak River drainage at its northern limit, Togiak Bay is a shallow, wide, southwest trending water body, backed by the marsh river valley and higher mountains on its western boundary. Togiak Bay is further restricted and partially sheltered by Hagemeister Island at its western limit and a series of small, rocky islets on its eastern limit, the Walrus Islands. However, the breakwater effects of the three Walrus Islands are limited due to their narrow north/south orientation. In addition, the narrow passes between the Walrus Islands might even heighten coastal currents, a subject that should pursued with knowledgeable local informants and oceanographers.

Study Area: Northern Bristol Bay

Figure 4. Study area showing the major water bodies that affect the Old Togiak spit, which lies opposite from Togiak. Note the sheltering effects of the Walrus and Hagemeister Islands to the south. The tidal gauge at Platinum offers the closest approximation of tidal fluctuations at Old Togiak.

Bristol Bay is the southeastern compartment of the Bering Sea, opening to the west from the southwest trending Alaska Peninsula. The embayment is, at its maximum ca. 500 km from north to south and roughly 350 km west to east. Located at the north margin, the Old

Togiak spit is exposed to the maximum amount of fetch across Bristol Bay from a very restricted portion of the compass, about 190° to 220.° Because of its location, no storms can produce elevated seas from nearly 3/4^{ths} of the compass. Despite this restricted exposure, Old Togiak spit does witness the effects of the major storms since the storm systems across the Bering Sea preferentially generate southwest winds and swell.

Currents and Sea Ice

The OT spit preserves evidence of the long-term northwesterly current along the eastern margin of Togiak Bay. In the absence of transient storm systems, long shore and tidal currents across Bristol Bay, generally track in a counter-clockwise direction, from the easterly direction. In western Togiak Bay, the situation is more complex, as read from various prograding beach ridge and spit systems along Hagemeister Strait and Island. Northern Bristol Bay lies within a zone with a narrow band of perennial shorefast and more extensive pack ice cover, persisting for six to eight months per year (LaBelle et al. 1983). The development of sea cover varies with tidal regime and coastal currents as well as larger scale forcings such as the El Nino/Southern Oscillation and the degree and persistence of winter storms (Niebauer and Day 1989).

Transient Fluctuations in Sea Level: Tides, Storms and Eustasy

Togiak Bay is subject to substantial variations in tide level. Although no station is maintained in the bay, its tide levels seem comparable to the Platinum station in Kuskokwim Bay, 50 km to the west. Platinum's highest tides vary are ca. 3 m above MLLW (La Belle and Wise 1983:Fig. 3a). Thus, the tides within Togiak can be characterized as macro-tidal, a circumstance that has several geomorphic consequences. First, the tidal range is so considerable that it largely precludes deltaic sedimentation of the Togiak River. A second consequence is that sea ice is less likely to remain stable. Finally, the considerable tide range damps the effects of storm surges; the timing of storm surge elevation is critical since a storm surge at low tide that produces a 3 m sea level elevation, attains a water plane that might be several meters below high tide. Conversely, a storm at high tide could lead to significant flooding.

Wind Speed and Direction

The Cape Newenham station (Fig. 4) provides the closest approximation for the wind climate that affects Togiak Bay (Fig. 5). During Fall, winds exhibit comparatively little preferred orientation, with southwesterly winds common only 10% of the time in September, and even less in October to December (Brower et al. 1977, reproduced in La Belle and Wise 1983:248-251). Wind energy in Togiak Bay reflects a polarity between fall and winter dominated by northerly and easterly winds while southerly winds are stronger and more common in summer (July to August) at Cape Newenham, accounting for nearly 20% of winds. In more recent records (Figs. 5a, 5b), from 1991-2002, southerly winds prevailed about 13% of the time in July (https://weatherspark.com/averages/32934/7/Cape-Newenham-Alaska-United-States)

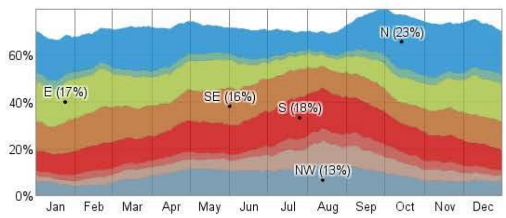


Figure 5a. Cape Newenham wind direction shows the fraction of time spent with the wind blowing from the various directions over the entire year. Values do not sum to 100% because the wind direction is undefined when the wind speed is zero.

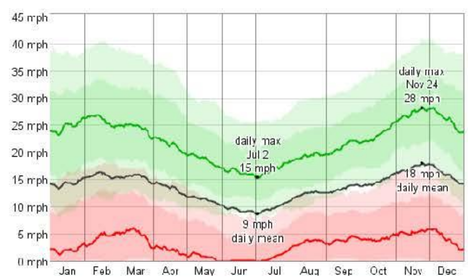


Fig. 5b Average wind speed at Cape Newenham, 1991-2002. Note that maximum winds occur in November when the most prevalent winds are from the north. Summer winds, more likely southerly, are generally much weaker, less than 15 mph, although a small fraction are up to 25 mph.

Sea Level History

No specifically local records for relative sea level history are available for the Togiak Bay or Bristol Bay reagion. The entire region was subaerial during the Late Pleistocene glaciation, as discussed below. Ice limits mapped by Kaufman et al. (2001) place the shore south of Togiak on Hagemeister Island and are tens of meters below present sea level. Some measure of isostatic rebound is to be expected for the early Holocene, but its parameters remain uncertain. The record may be broadly similar to the southern Alaska Peninsula, where Jordan (2001) encountered emergent shorelines responding isostatically, dated by peat, to the early Holocene and observed that relative sea level fell since then, with a major episode of coseismic subsidence around 2,000 years ago. The Alaska Peninsula is, of course, more seismically active than Bristol Bay so that its record may not be applicable. The late Holocene transgression can be approximated by examining marsh records from northern Alaska (Mason and Jordan 2002) and offshore paleoclimatic studies (Katsuki et al 2006). For purposes of this research, it is assumed that no more than 50 to 75 cm of eustatic sea level elevation has occurred during the last 2000 years.

Storm History in Bering Sea since the Little Ice Age

Despite catastrophist global change expectations based on theoretical calculations repeatedly issued during the last 20 years, Bering Sea storm intensity and magnitude was greater during the Little Ice Age (AD 1300-1900) based on 19th century historic accounts and inferences from coastal landforms and proxy records (Mason and Jordan 1993, Mason et al. 1996, Mason 2008). The prevailing trend is one that associates heightened storm intensity during cold climates, based on the greater tropical to arctic contrast during cold periods (O'Brien et al. 1995, Mayewski et al. 2004). In the most catastrophic case, the Revenue Cutter U.S.S. Bear, captained by Hooper (1886) reported storm surges that ravaged the Yukon delta inland for distances of over 20km. Farther north, in the Chukchi Sea, an 1893 storm surge at Point Hope elevated sea level over 4 m while at Nome, ferocious storms repeatedly pummeled the coast from 1898 to 1913 (Mason et al. 1996).

The historic record of storm for the entire Bering Sea region is the subject of several collations. The effort of Wise et al. (1981) produced evidence for 89 storms from 1898-1980 across the entire western and northern coasts of Alaska. On a local scale, Mason et al. (1996) detailed 60 storms from newspapers printed in Nome from 1898 to 1993. More recent efforts extend the time frame and vary form a western Alaska perspective from 1954-2004 (n=52, Chapman et al. 2009) and a local approach by Terenzi et al. (2014) on the Yukon Delta, counting only 39 storms. Nonetheless, in the YK delta, fierce storms in 2005 and 2011 extended nearly 30 km inland and resulted in a 3 to 3.5 m elevation of sea level, comparable to the Bering Sea storm of record in 1974 (Terenzi et al. 2014). The record in the southern Bering Sea is known with less certainty, and the susceptibility of the region to storm surges is probably less than farther north, owing to the region's restricted orientation in regard to maximum wave fetch. Only two of the six storms documented by Wise et al. (1981) co-occur with those within the YK delta (Terenzi et al. 2014:Table 1); one in November 1978 and another in November 1979. This circumstance is unsurprising, considering that the Bristol Bay area is sheltered to some extent from the northwest.

Table 1. Mid to late 20th century storms across Bristol Bay (Wise et al. 1981)

1956, September 13
1964, October 26 to 27. Sea level elevated ca. 1 m at Clark's Point in Nushagak Bay
1978, October 23 to 24, Sea level elevated ca. 2 m along north shore of Bristol Bay
1979, November 8 to 10. Sea level documented at 1 m above at Safety Sound, Nome
1979, November 14 to 15.
1980, August 17 to 18. "10 ft [3.05 m] tides at Clark's Point"

Mathematical Calculations of Maximum Storm Surge Height

Storm surge prediction involves a complex set of atmospheric and oceanic equations that can infer the air and sea conditions that produce elevated sea surfaces (Chapman et al. 2009). In addition to the length of the storm, the principal variables are fetch, wind speed, ice cover, tidal regime, and atmospheric pressure. Models incorporate historical data in order to predict recurrence interval, so that with increasing time depth, recurrence intervals can be more closely approximated. A first approximation by Wise et al. (1981:22) suggested that a surge of about 2.4 m produced by 45-53 kmph winds should occur once every 8 years while a hundred year storm follows winds of 66 to 75 kmph and results in a surge elevation of 3.65 m.

Incorporating data from the last 30 years, an updated simulation of eastern Bering Sea storm surges by Chapman et al. (2009) indicated that the 50 yr surge should reach 2.4±0.57 m at Cape Newenham and a hundred year surge would extend 2.97±0.62 m above sea level. Every ten years, a surge of 1.16±0.18 should be expected (Chapman et al. 2009:Table 4-17, p. 32). The range of elevation events is between 0.98 to 1.34 m every ten years, between 1.86 and 3 m, every 50 years and between 2.35 and 3.59 m every 100 years. The fairly wide standard deviation for the long intervals reflects the high likelihood that a storm will occur at nearly any time.

Old Togiak Erosion Rates since 1950 Based on Aerial Photogrammetry.

The available aerial photography for the OT spit provides a series of images separated by 10 to 20 years that is extremely useful in characterizing its erosion history over the last 70 years. Aeromap Alaska (in Anchorage) archives aerial photographic negatives for the Old Togiak area, with images from 1952, 1962, 1972, 1983, 1991 and 2005, while google-earth offers a downloadable image from 28 February 2010 (Fig. 6 to 8). The TAP project contracted Aeromap to supply images from 1952, 1972, 1983 and 1991. This series of aerial photographs allows the extrapolation of erosion rates between the five guideposts; consequently, rates can be approximated for the decades between 1952 and 1972, between 1972 and 1983, and subsequently between 1983 and 1991 and then the 19 years between 1991 and 2010 (Table 2). The two end points, 1952 and 2010, are presented in Fig. 6, with the intervening years in Fig. 7 and with the Old Togiak site detailed in Fig. 8.

The sequence of photos indicates that for the two decades after 1952, the spit was comparatively stable.[1] After 1972, the terminus of the spit shows that a significant sediment body was deposited just southwest of the spit recurve. This sediment represents material eroded updrift, including the Old Togiak spit—as apparent in sequential measurements (Table 2). Further, the level of commercial development is evident form the photographs. In 1952, the spit had no traces of modern construction, but the successive development of fish processing facilities (cannery, storage, housing, dump sites) can be readily tracked in the sequence of images.

[1] Distances across the Old Togiak site were measured by both hand and computer assisted ruler at a consistent bearing (205°) from a readily definable point at the northeast margin of the marsh/beach ridge contact. Adjustments for variable scales were made. This rough and ready method should be followed by more sophisticated data analyses.

Table 2. Aerial Photographs available for the Old Togiak spit [Source: Aeromap, Inc., S. Sparks, 2016, pers. comm.] Images in bold employed in this study. The 2010 image downloaded from google.earth.

Date of Photograph	Distance on ground	Distance A-A'	Photograph Scale	Pixel dimensions
4 Sept 1952	**1 cm = 414 m**	**165 m**	**1:41.400**	**60.1 cm**
6 July 1962	1 cm = 30 m	—	1:3,000	4.5 cm
7 July 1972	**1 cm = 48 m**	**168**	**1:4,800**	**6.1 cm**
10 June 1983	**1 cm = 120 m**	**163**	**1:12,000**	**15.2 cm**
27 August 1991	**1 cm = 60 m**	**154.7**	**1:6,000**	**3.81 cm**
3 October 2005	1 cm = 96 m	—	1:9,600	12.1 cm
28 Feb 2010	**1 cm = 410 m**	**137 m, 161 bch**	**1:41,400**	—

Old Togiak Spit, Aerial Photographic Comparison1952-2010

Fig. 6. Aerial Photographs of the Old Togiak Spit, 1952 and 2010. Note that the site, at the southwest margin lies on a bulge that has witnessed over 20 m of erosion in the last 65 years.

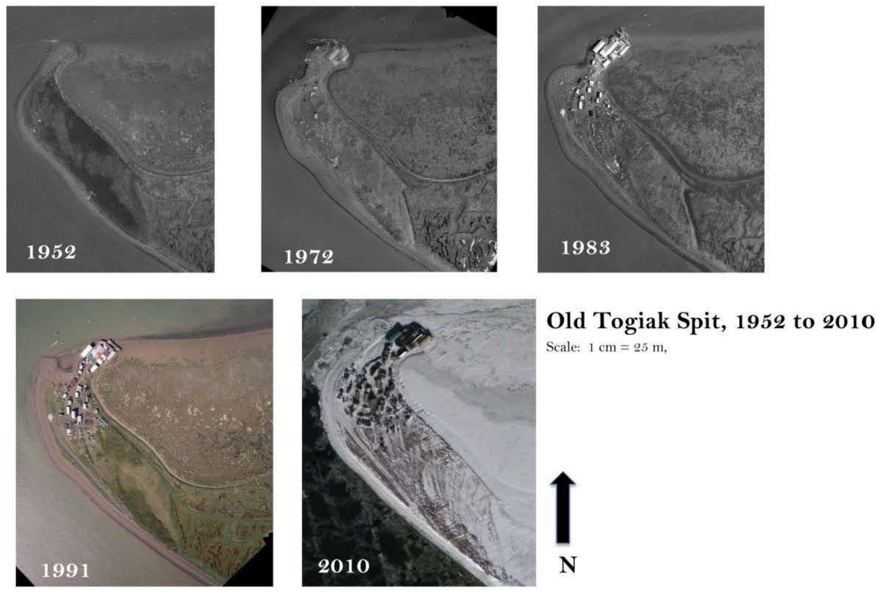


Figure 7. Old Togiak spit: Sequential aerial photographs (cf. Table 2), reflecting landform changes since 1952.

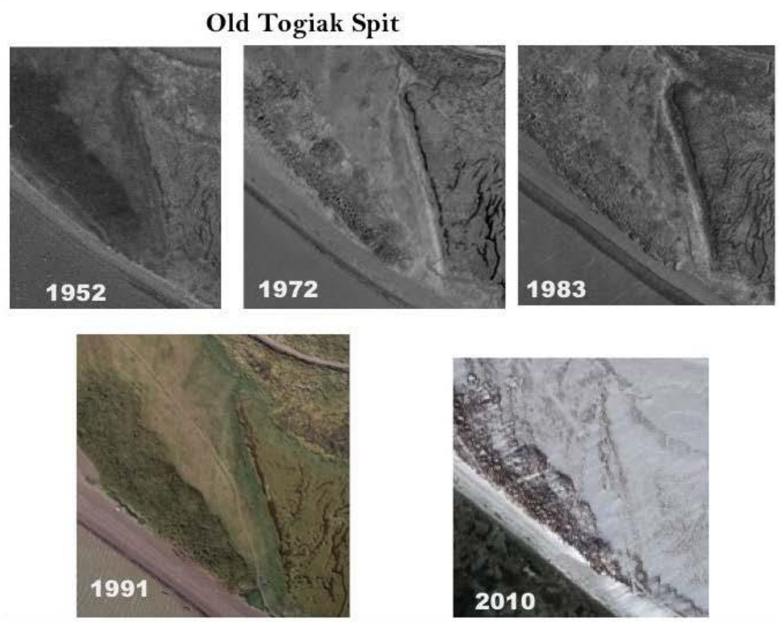


Figure 8. Sequential detailed images of the Old Togiak site (lower left), showing the site at different intervals, from 1952 until 2010. Since 1983, erosion has intensified.

The aerial photograph sequence (Figs. 6, 7, 8; Table 2) records that a major shift in the rate of erosion occurred during the last 30 years. From 1952 until 1983, the Old Togiak site did not witness appreciable erosion. After 1983, a major acceleration in erosion rate occurred, with over 25 m eroded, an annualized rate of between 93 and 100 cm. This shift parallels the major shift around 1980 in erosion rates documented at south-facing coast lines in the Chukchi Sea (Manley et al. 2006, Gorokhovich and Leiserowiz 2011). This shift may be related to global scale, systemic factors such as El Nino Southern Oscillation or the Pacific Decadal Oscillation; topics to be addressed in further research.

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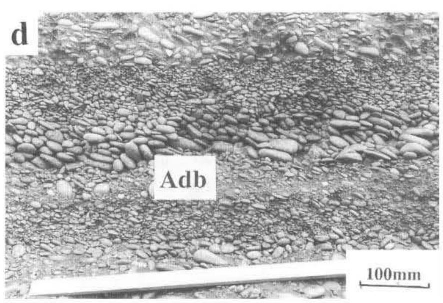
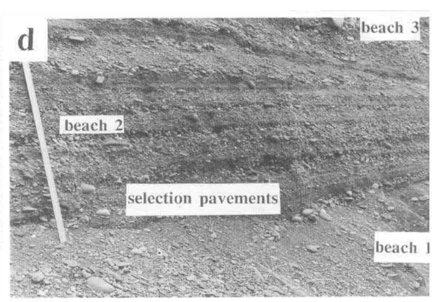
Geomorphology of the Old Togiak Spit

Considerations in Interpretation: Gravel Facies

Unconsolidated gravel beds are notoriously difficult to examine and comprehend, although scholarly attention has increased in the last 20 years (Anthony 2009:289ff, Austin and Masselink 2006, Collinson et al. 2006). Especially relevant is the early research by Bluck (1967) and a later synthesis (Bluck 1999) that provides detailed beach and storm process inferences in relation to the stratigraphic expression of beach facies, shows the down-profile re-circulation of finer matrix, easily mistaken for a cessation of sedimentation or the operation of subaerial processes, such as wind deposition (Fig. 9a, 9b). Both air and water play a role in modifying gravel beaches during and after deposition (Anthony 2009:298). Hydrodynamic properties differ in the uprush and downrush phases wave attack: Larger clasts (granules to cobbles) are stranded on the beach ridge crest at the maximum up thrust of waves, while fine sediments (granules to sand) are drawn down the shoreface by backwash (Anthony 2009:299). Typically, the size of pebble to cobble clasts typically precludes the formation of bedforms common in sand; i.e., ripples will not form in clasts with the diameter of ripples (Collinson et al. 2006:140). Thus, bedforms are not noticeable to trace specific flow conditions, although "as a general rule, the larger and coarser the sediments, the stronger the flow" (*ibid.*,141). The onshore movement of larger gravel clasts, especially cobbles, requires storm energy (Bluck 1967:135); "the net landward movement during normal [i.e., fair-weather] sea conditions is small…and mainly confined to disc shaped pebbles."



(a)



(b)

Figure 9a, 9b. Gravel beds serve as proxy records of hydrodynamic processes (Bluck 1999). (a) At left: example of an assemblage of disks and blades, segregated by particle size under the influence of wave or current activity—from right to left (Bluck 1999:Fig.

4d); (b) At right: Gravel selection pavements interbedded with sand sheets, foreshore of beach ridge (Bluck 1999:29d). Selection pavements accumulate on the lower beach as clast reject zones (Bluck 1999:29)

The fabric of gravel beds (Figs. 9a, 9b) can provide instructive clues about wave energy and location on the beach relative to stratigraphic position (Collinson et al. 2006:150ff); typically imbrication, the down-dip of flat surfaces, follows the direction of transport. If flat clasts lack a preferred orientation, then either high current viscosity or a rapid flow prevented its development (Collinson et al. 2006:148). Clast shape and dimensions provide recent and deep history of clasts that are frequently subject to gouging and tool marks if under glaciers (e.g., Gale and Hoare 1991:103ff). Further, most gravel clasts likely travel no more than hundreds of kilometers before deposition (*ibid.*:156). In its final stages on beaches, "discoidal particles [may be] kept in suspicion by wave turbulence and are deposited highest on the beach" while "…spherical particles may accumulate at the bottom of the beach" as these particles rapidly settle out of suspension" (Gale and Hoare 1991:113). Sand beds within gravels are particularly informative: Sand beds can refer to the presence of swash and backwash of the shoreface (Hart and Plint 1989:Fig. 2) while sand at the lower contacts of gravel beds is typically an indicator of wave induced percolation through the gravel matrix (Bluck 1999:Fig. 16, Collinson et al. 2006:145) or forms part of overwash fans descending from storm deposits at the ridge crest. Cross beds are distinctive features of sandy overwash fans (Fig. 10).

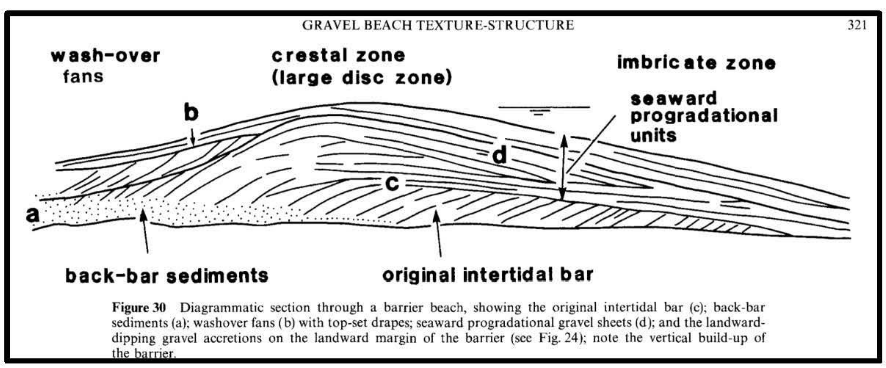


Figure 10. Diagram of an ideal barrier beach showing the facies related to storm deposition (Bluck 1999:Fig. 30, p. 321). Wash-over fans are often composed of sand.

Well-dated sequences of beach ridges allow historical reconstruction of sea level, storm history and paleo-wave climates (Tamura 2012). If regional correlations are available, it is possible to infer broader patterns of climate change (Mason and Jordan 1993), and even the course of a single storm, as exhibited by firm chronometric constraints by Mason (2008, 2009, Rinck and Mason (2015). In a singular case across northwest Alaska where a significant storm surge, >3m ASL, occurred during the 5th century AD and implaced a storm berm, often capped by driftwood, from Deering and Kotzebue over 1000 km to Point Barrow (Mason 2008, 2009, unpublished; Rinck and Mason 2015).

Field Observations based on of the 2015 Season at Togiak

Old Togiak Beach Transect

The Old Togiak beach is wide, comparatively steep and, in its lower third, reflective, in total, rising ca. 4 m across 40 m (Fig. 11). The steepness of the beach indicates that wave energy is damped and deposition is not, in general, favored. The steepest portion of the beach lies 15 m landward of the tidal flat surface at MLLW. A drift line of algal and small wood, including twigs and sticks, marks the elevation of the middle beach between ca. 1.6 and 2.0 m above MLW. The sedimentary cover of the beach varies between poorly sorted pebbles (1-3 cm L), granules and very coarse sand in the lower beach to increasingly bimodal in the upper beach where the matrix is mostly fine to medium sand with sporadic cobbles over 10 cm in length. The lower beach is covered by extensive areas that contain a thin veneer of fine to medium sand; these are generally lower than the debris lines associated with higher tidal phases and likely reflect the wave backwash that carries finer sediments (see above).

A shovel probe (OM 15-01) and three successive stratigraphic profiles (OM 15-02 to 15-04) portray the sedimentary changes along the transect from lower to middle to upper beach (Fig. 11). To a depth of 1 m, several gravel beds, dominated by large pebbles to cobbles, each 5 to 10 cm in thickness, were traceable perpendicular across the beach, separated by fine sand beds.

Figure 11. Beach transect at Old Togiak. View to northwest. Beach width is ca. 40 m, Location of detailed profiles, illustrated, bar represents 20 cm in depth.

A shovel probe in the lower beach **OM 15-01** exemplifies a single swash sedimentation event (Fig. 11). The surface sediments of **OM 15-01** are predominantly subrounded to rounded pebbles, most are 1 to 3 cm length, with the largest 6 to 8 cm in length, nearly imbricate, with a bed thickness of 2 to 4 cm with comparatively little matrix. Below the surface bed, a graded bed extends to ca. 9 cm, and reveals a very poorly sorted lower facies that is mostly granules and very small pebbles that grades upward into very coarse sand. At ca. 10 cm bs, several cobbles, 20 by 15 cm, were buried by the upper finer beds.

OM 15-02, located on the middle to lower beach at 15 m landward (Fig. 11) revealed three clast supported pebbly beds between 4 and 5 cm length. The three gravel beds, G1 to G3, occurred below 40 cm (G1), from 28 to 18 cmbs (G2) and from 10 cm to surface. Two graded coarse to fine sand beds were interbedded between the gravels; these represent phases of less intense wave energy. Notably, extensive surface areas of the lower beach were covered by fine sand. It is likely that comparatively little time is represented in the stratigraphy of OM 15-02, possibly just three or four tidal cycles or heightened swash during strong waves, with the waning phase producing the finer graded sand bed. As discussed above, higher wave energies are required to mobilize larger clasts. The open treliss work of pebbles allows the fine sand to accumulate below (cf. discussion above). The long term preservation of diurnal tide or infrequent storm beds is unknown, but is associated with only a few of the total tidal onshore flow is associated with higher energy waves. After all, on an annual base, the number of tides is within the hundreds so that not every tidal period is represented.

The upper beach extends between 25 and 40 m from the swash zone of MLLW, and is composed of a lower storm beach and an upper storm beach. Two trenches were excavated during the 2015 field season.

Fig. 12. Old Togiak upper beach transect and trench profile, OM 15-04

A 1 m deep profile on the Lower Storm Beach (Fig. 12), **OM 15-03**, revealed five gravel beds below 20 cm thick surface cover dominated by a matrix supported fine to medium. Gravel bed **G1**, the lowest, extends from about 80 to 60 cm below surface, and dips eastward, landward. G1 is clast supported; with most between 4 and 5 cm dia., and is increasingly matrix supported, with medium to coarse sand in its upper portion. G2 and G3 are composed of slightly smaller clasts, with the lower 6 to 8 cm thick clast supported G2, dipping from 52 to 62 cm bas at its base. G 3 is a discrete and imbricated bed of moderately well sorted 1 to 3 cm ovoids, with little matrix. The intervening sand beds, S 2 to S 4 are generally massive, composed of predominantly medium to coarse sand, with few if any larger clasts. The uppermost S 4 is slightly bedded, possibly indicative of eolian influences.

Located in the upper storm beach (Fig. 12, 13), OM 15-04 lies between 40 and 42 m E of MLLW. Four prominent gravel beds extend across OM 15-04, clustered between 75 and 42 cm bs (Fig. 13). Two mid level gravel beds between 60 and 40 cm, G3 and G4, are predominantly composed of small pebbles (1-3cm length) have a small fraction of larger clasts, 8 cm in length. A series of granule and sand beds separates the two gravel beds. In the upper 40cm, fine to medium sand, S4, contains three thin (1cm thick) granule beds, with a small fraction of pebbles in the middle bed.

Old Togiak OM 15-04 W wall

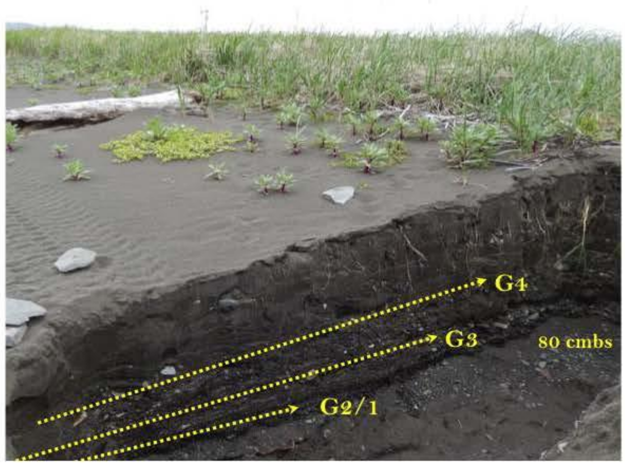


Figure 13. W wall of stratigraphic section OM 15-04, indicating major storm gravels, cf. detailed profile of N wall in Fig. 14.

Profile **OM 15-04b** (Fig. 14) describes the North wall of the upper beach trench that lies beneath the boundary of grass cover. To the landward, northern direction, the stratigraphic sequence is both compressed and shows a shift in clast size and bedding. In the profile, the upper sand S4 is massive, compressed to a 20 cm thickness, and lacks the very thin coarse sand beds. The middle sands (S2 and S3) are wider and thinly bedded, although the lower beds alternate between coarse and fine sands. .The middle and lower Gravel beds G4 and G3 are marked by fewer larger pebbles or cobbles. The OM 15-04b section represents the farthest limit of storm effects, landward of the crest where hydrodynamic forces were strongest; further trenching should be undertaken to complete facies descriptions of the beach ridge system at Old Togiak.

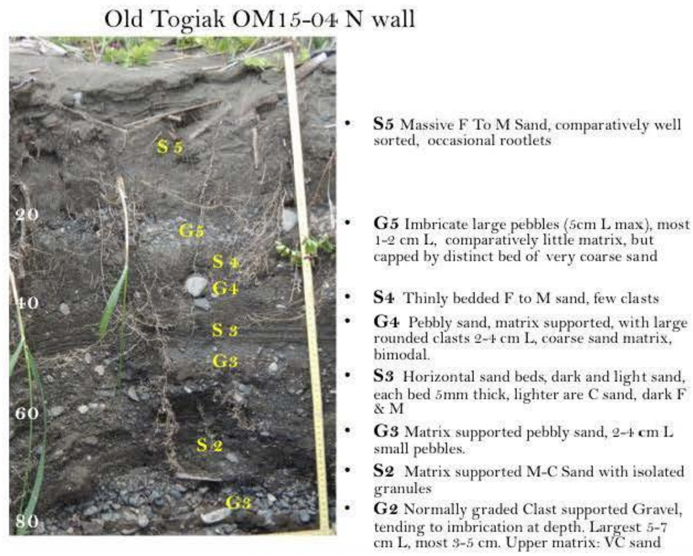


Fig. 14. Storm beach stratigraphy exposed in N wall of section OM 15-04b

Establishing the Elevation of Storm Effects at Old Togiak

A geomorphic transect perpendicular to the Old Togiak beach enabled an estimate of the local tidal range and established that the Platinum gauge (stn# 9465396) serves as a closer marker than the Dillingham gauge (stn#9465374). A hand level elevation placed high tide at 3.2 m above the swash, within flotsam and jetsam deposited by high tide. As Recorded at Noon and 1530 ADT, falling tidal regime, probably near low tide at 1530. At 1556 pm the gauge Platinum, AK recorded a +0.21 m low tide tide] Field observations established that the Togiak mean High Tide berm was at 3.2 m above mean water level, ca. 3.4 m above MLLW. The crest of the storm berm was still higher, ca. 4.30 m above MLLW, although another storm berm likely occurs farther inland and is higher, possibly about 5 m above MLLW. The largest drift logs were generally about 20 cm wide and 1 m in length.

The amount of driftwood on the storm beach is incredibly low (Fig. 15) and lacks the large timbers so common farther north; this is unsurprising, considering that Bristol Bay lies far south of the Yukon River. The source of wood on the Togiak Bay beaches should be further researched, but is likely local, from the Nushagak, the upper Togiak River. Of course, cultural factors could also be a factor, if local people are collecting wood. Conceivably, wood from the Kuskokwim River may be entrained by sea ice and eventually onto the Old Togiak spit.

Fig. 15. View northwest of stratigraphic section OM 15-04 at the upper storm beach of the Old Togiak spit. The surface is covered by rippled sand and isolated occurrences of drift logs (25 to 30 cm dia.) and tabular cobbles between 10 and 15 cm in dia.

Old Togiak Marsh Stratigraphy

An extensive marsh lies landward of the earliest Old Togiak beach ridges (Fig. 16a). Several tidal channels at least 50 cm deep drain the marsh to the north and likely consist of a massive clay that seems unconsolidated and treacherous for human footfalls. No effort was undertaken to traverse the tidal channels. Several soil probes were placed along the southern margin of the marsh, within 10 m of the slope break contact with the oldest beach ridge of the OT complex. The soil probe only penetrated 20 cm below surface and reached stiff resistance that reflects a frozen surface on June 10, 2016, considerably prior to the likely maximum depth of thaw that occurs three months later in September. The soil probe OM 15-05 consisted of massive, mottled and oxidized silty clay (Fig. 16b).

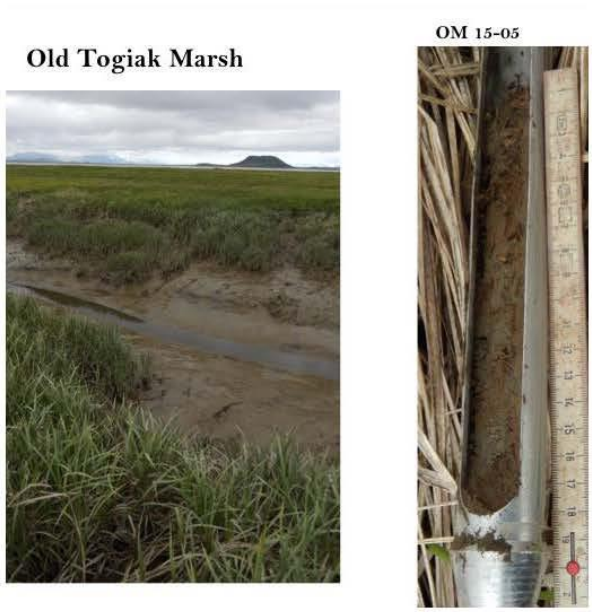


Fig. 16a, b. A tidal marsh lies landward of the oldest Old Togiak beach ridges (a), view to north with tidal channel ca. 75 cm deep, impassable to pedestrians. At right (b), a soil probe (OM 15-05) reveals a matrix of mottled, oxidized clayey silt, that lacks macrofossil concentrations or beds and that was frozen at only 20 cm below surface. Scale represents depth below surface, to point of resistence

Defining the Depositional History of Old Togiak Spit

Spit progradation occurs as decelerating long shore currents transport clastic sediments encounter a shallow water body, a circumstance that leads to deposition (Antonson et al. 2006, Davis and Fitzgerald 2004, Friedman and Sanders 1978, Hine 1979). A huge surfeit of sediment eventually produces a spit platform, if sea level changes are minimal and sediment supply swamps tidal forces (Friedman and Sanders 1978). The resultant surface of the spit platform is repeated subject to the addition of recurved berms or swash bars that parallel the position of the incoming waves that are refracted along shore (Hine 1979). The growth of the spit also reflects a constellation of factors relating to persistent longshore currents and sediment supply. In the case of Old Togiak, sediment is available from two sources: shelf sediments and updrift bluffs. Intense storms affect sediment supply by increasing the reach of waves to mobilize sediments onshore and to erode updrift glacigenic bluffs. Reflecting this type of geomorphic history, Old Togiak spit has a cover of superimposed storm-deposited beach ridges that appear on aerial photographs, most prominently the snow-covered February 2010 image posted on google.earth (Fig. 17).

Defining beach ridges across the Old Togiak spit requires several assumptions, in that the late 20th century cannery and its associated structures and debris occupy over a fourth of the spit surface. For the oldest, eastern portions of the spit, the trend of beach ridges is readily apparent. However, in the western portion, the trend of beach ridges is obscured by roads, debris and structures. Thus, it must be assumed that the topographic expression of ridges is preserved, even by the trend of aligned structures. Likely, the ridges offered more stable building sites, so that their alignment is a proxy for the continuation of beach ridges observed in un-built areas. Ridges enumeration follows the precedents of Giddings (1963:2) for Kotzebue Sound, and starts with the most recent, successively older. Sets of ridges that reflect commonalities in wave climate are labeled by Roman numerals (i.e., I, II and III).

Three different phases of development are evident in the pattern of Old Togiak beach ridges, as ridge orientation reflected on itself and shifted slightly to the north. The earliest set of ridges, forming **Unit I**, includes six composite ridge sets, from OT 14 to OT 9. Ridges OT 14, 13 and 12 are low and composed of several smaller ridges, with wide swales separating these ridge sets. Ridge OT 11 curves slightly to the northeast, while ridges OT 10 and 9 are oriented slightly to the northwest. Ridge OT 8 is markedly wider than any other the other ridges, a circumstance which implies its long persistence as a shore front ridge. The sequence of ridges following OT 8 is notable by the narrowness of ridges and swales, OT 5 to 1, as well as in the recurve of the ridges. The process of sediment addition can be sporadic, as documented by a slug of material evident in the 20th century aerial photographs between 1972 and 1991.

Old Togiak Spit

Figure 17. Depositional Units of the Old Togiak Spit, inferred from aerial photograph. Upper limiting archaeological ^{14}C ages are available from Unit II.

Geomorphic or direct age assignments for the emplacement of the beach ridges could not obtained during this project, owing to the intractable nature of the deposits and the grass cover. Nonetheless, the archaeological coring project did produce over 37 of 40 ^{14}C ages that provide limiting ages on beach ridge formation. All of those ^{14}C ages were obtained from ridge OT 8, which forms Unit II of the OT spit depositional sequence. Nearly all of the ages from the OT cores are less than 800 years old; in fact, only two derive from deposits may be between 1300 and 1100 years old. The older of the two samples implies that ridge OT 8 was stabilized prior to **AD 630-786** (1307±26 BP) (D-AMS 14536)—however, several other ages from the same stratigraphic level are only 700-800 years old: **AD 1333±42** (654±25 BP, D-AMS 014535) and **AD 1278±07** (706±23 BP, D-AMS-015403).[2] Thus, OT ridge 8, may have formed

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[2]: The context of the early samples may be equivocal, as commented by Dr. Prentiss, the TAPP, PI: "This might be over-interpreted. The two dates falling during that ca 1000-1500 BP period come from sample contexts with more recent dates (both cores 15.1 and 30.2). While there are clearly some old pieces of grass in these samples the greater preponderance of data point earliest occupations no older than about 800 BP." From a geologic perspective, the possibly older grass may represent an older surface and still provide a solid reference point on landform evolution.

as early as the 7th century AD, based on geological considerations, but the first cultural occupations did not occur for several centuries later. Alternatively, older grass was possibly incorporated into cultural levels. From these contrasting perspectives, only very tentative relative age assignments are possible for the earlier Unit I and the succeeding younger ridges of Unit III. The preceding Unit I certainly formed prior to AD 1200 but possibly much earlier prior to the 7th century AD. Very likely spit deposition commenced during the first centuries AD. Unit II formed prior to AD 700 or at least by AD 1200. The precise timing of the progradation associated with each ridge of Unit III cannot be yet inferred, but the entire set of ridges certainly were added following the 11th century AD, and most likely occurred during the Little Ice Age, that is to say, in the last several centuries, from AD 1300 onward.

The circumstance that the Old Togiak site remained viable as a settlement for the succeeding centuries is informative about the both the wave climate and the formation processes that underpinned the Old Togiak spit. First, some centuries of stasis, i.e., fewer storms must have occurred in the earliest centuries. In general, the spit was not eroding, but accreting. Further, the Old Togiak site must represent a zone of sediment bypassing; i.e., longshore transport continued to the north and west of the site.

Comparisons and Correlations with other Beach Ridge Complexes of Western Alaska

The OT spit is oriented to a direction open to southwesterly fetch similar to several other Alaska beach ridge complexes; most prominently Point Hope (PH), Cape Krusentern (CK), Sisualik (S) Point Spencer (PS) and Cape Nome (CN) (Mason and Jordan 1993, Mason 2015). Unfortunately, most of those complexes are only tentatively dated by geological (i.e., non-cultural samples). Three of those complexes contain most or exclusively ridges younger than the last 2000 years (PH, S, PS and CN), and spit growth was extremely rapid at the southwest facing Sisualik, Pt. Spencer and Cape Nome complexes. Correlations with these complexes are farther afield and further discussion will be deferred in favor of more local records, from southwest Alaska.

Several spits and prograding series of beach ridges occur in the general region of Hagemeister Island and westward to Good News Bay (Fig. 4). Hagemeister Island has two narrow beach ridge forelands attached at its northwest and northeast aspects, with a series of a over a dozen beach ridges on its northern margin (Fig. 18). Archaeological limiting ages from

XHI-061 on the 12th ridge landward (Bailey 1991), indicating a late Norton occupation occurred during the 13th century AD. This small foreland is oriented to the northwest, at a direction similar to that of the OT spit, parallel to the trend of Hagemeister Strait. The northwest Hagemeister foreland has two depositional units, similar, but not necessary correlative with the northeast foreland that is oriented to the southeast, but is as yet undated.

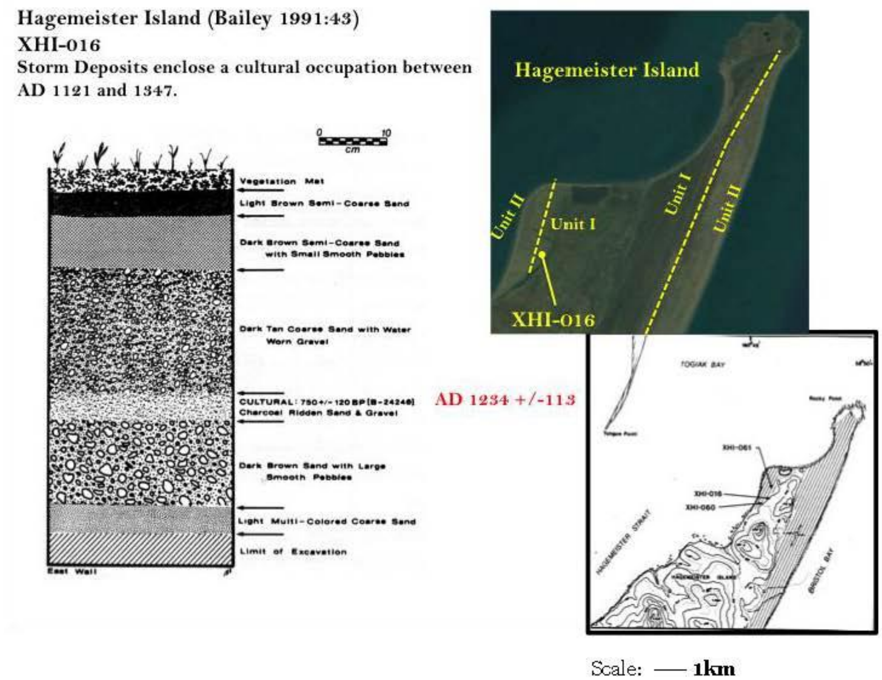

Figure 18. Beach ridge foreland along the northwest margin of Hagemeister Island (Bailey 1991; google-earth image, upper right). A southwesterly wave climate through Hagemeister Strait led to the formation of two sets of beach ridges. One of the older ridges, the 12th, bears a 13th century occupation that both caps a storm prior and provides a lower limiting age on a storm that followed the occupation.

On the mainland coast along Hagemeister Strait to Cape Newenham, there are several small prograding landforms, with three small bays on the eastern shore of Kuskokwim Bay bearing mainland attached barriers and/or spits, from south to north: Nanvak, Chagvan (Fig. 19a,b and c) and Good News Bay. The twin spits of Good News Bay were explored by Larsen

(1952) in the late 1940s and contain an extensive undated Norton settlement that may provide an upper limiting age of spit formation in the area.

Figure 19a. South-trending spit and north-facing foreland at the mouth of Chagvan Bay.

Chagvan Bay – South, foreland

Figure 19b A close-up of the south Chagvan bay barrier/beach ridge complex, with radiocarbon ages obtained by Ackerman (1964:7) from several excavated house. The archaeological upper limiting ages on the foreland indicate that progradation was rapid in the last 1500 years. A Norton community lay atop the low bluff, dated to 1800 to 1200 ^{14}C yrs BP. Note that the sequence broadly parallels that of the Old Togiak spit, despite the circumstance that the complex is oriented to the northwest.

Chagvan Bay North Barrier Spit

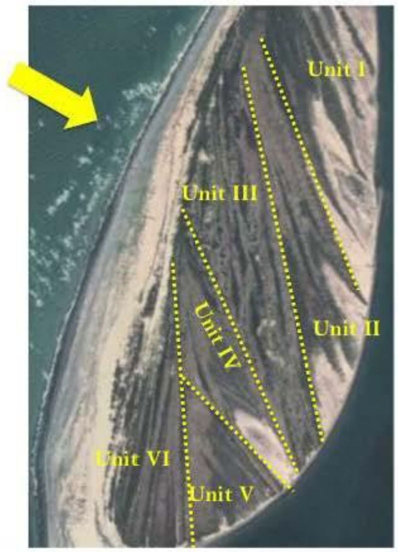

Figure 19c. The south-trending north Chagvan Bay barrier; the arrow indicates the present wave climate and oblique approach of waves that produces deposition and longshore transport. The five sets of beach/dune ridges are oriented at slightly differing angles, but generally reveal that a progradational regime prevailed during the last hundreds to thousands of years. Unit II is marked by frost cracks; a circumstance that indicates some antiquity. The sequence is, as yet, undated, to the knowledge of the author.

Aerial photographs from google-earth reveal considerable complexity for a south-trending barrier spit (Fig. 19c) at the mouth of Chagvan Bay (Fig. 19a) and a small foreland on the southern approach to the bay (Fig. 19b). The south trending barrier spit is composed of five discrete sets of beach ridges, several of which are cross cut by erosional conformities; note, especially the transverse relationship of Units V/IV and the abrupt shift in ridge orientation between sets of ridges (Units VI/V and Units IV/III. Based on correlations with other west and northwest Alaska beach ridges (Mason and Jordan 1993), it is expected that Unit II is over 2000 years old, Unit I is older than 2000 years BP and the succeeding Units III to VI are the results of wave climates and heightened storms of the last two millennia. Unit V likely precedes the Little Ice Age.

Stratigraphic Inferences on the Old Togiak site: Evidence of Sea Level and Storms?

Research by Kowta (1962)

In 1960, Kowta (1962:48,55) established that the Old Togiak mound extended about 4 m above sea level. Kowta's huge block excavation encountered sterile sand 3.35 m below the highest surface, at approximately MHW, with his excavation continuing another 30 cm into sterile, presumably beach deposits. Kowta's (1962:61) stratigraphic profiles indicate that entire mound lies unconformably atop a dark organic mat that covered beach sand (Fig. 20). Quite notably, shell beds lay directly atop the surface of the sand (*ibid.*). It remains unclear whether shell beds are definitively cultural or non-cultural in origin. Quite significantly, cultural pits were excavated into the sterile sand, extending from above and through the presumed vegetation mat.

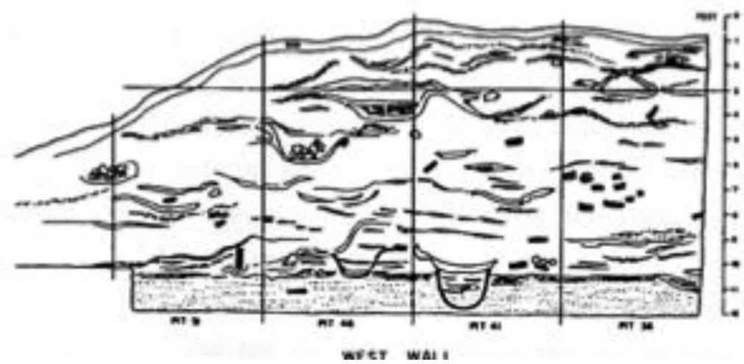

Figure 20. Stratigraphic profile of the West Wall of Kowta's excavation. Note the sterile beach deposits between 10 and 12 m below surface. A dark band marks an organic bed that Kowta interpreted as a former stable peat surface. Note the pit excavated into the sterile beach sand.

Stratigraphic Relations observed by the TAPP project.

The TAPP project drafted eight short profiles (<1m) along 50 m of eroding bluff margin of the Old Togiak site (Fig. 21). The profiles were drawn with the aim of defining cultural stratigraphy and providing the context of cultural features (wood, bone or shell). The schematic profiles indicate the primacy of human agents in depositing clayey or sandy loam or in excavating pits. The series of profiles indicates that storms did not overtop the site during occupations, if one assumes that shells were cultural in origin. This finding may be significant, if substantiated by further research.

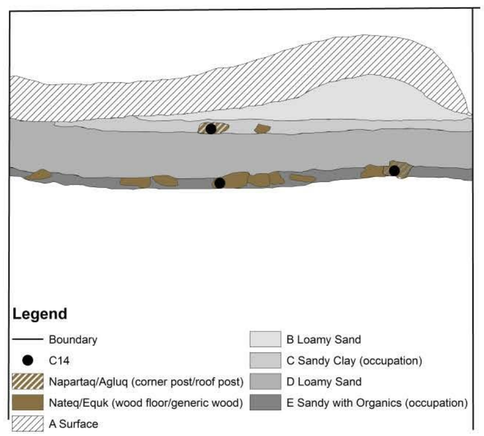

Figure 21. TAPP Profile G along the south margin of the Old Togiak site. Cultural features are emphasized.

Conclusions

A provocative and, perhaps surprising geoarchaeological perspective emerges from the Old Togiak archaeological site, by employing the 2015 research and resultant synthesis. First. the base of the site lies at the limit of Mean High High Water, a circumstance which would lead one to imagine that repeated flooding was persistent threat to prehistoric inhabitants. Stratigraphic evidence from both the TAPP project and Kowta's efforts show little or no direct impact from storms within the Old Togiak midden. Hence, the currently available data do not support that supposition. Nonetheless, further research is necessary to validate this conclusion. However, the relative position of sea level at the time of initial occupation remains undetermined; if sea level history in northwest Alaska is any guide (cf. Mason and Jordan 2002), then sea level was substantially lower, possibly by 50 cm,, at the time of the initial occupation of the Old Togiak site, which Kowta (1962) established was atop sterile beach sand—like many of its contemporary sites in Alaska

The TAPP project obtained several radiocarbon ages that indicate that the earliest occupation is no more than 1200 to 1500 years old, confirming the supposition of its first excavator, Kowta. Perhaps slightly more surprising is the circumstance that the Old Togiak mounds occupied the same locale for the last millennia—in spite of the fact that substantial spit growth occurrence to the northwestward. In fact, many spits (cf. Shepard and Wanless 1977) across western Alaska record the same basic pattern: long shore currents bypass a critical node and result in stasis in the middle of the spit.

The persistence of the Old Togiak site and the infrequency of storm overwash are perhaps unsurprising when the 20th century record is examined. Storm surges in Bristol Bay are of lesser magnitude and frequency than farther north. Consequently, the erosion of the site is less intense and less frequent than many places farther north—a circumstance that is also not surprising, considering the protected nature of Togiak Bay. Aerial photogrammetric comparisons showed that average erosion rates are within the range of Kotzebue Sound, for the last 30 years (Manley et al. 2006).

Finally, a tentative depositional history of the Old Togiak spit revealed its formation preceded the first centuries AD and witnessed a spike in growth during the Little Ice Age. Spit growth tracks heightened sediment supply, derived from bluff erosion updrift. The Old Togiak spit record is paralleled locally by beach ridge records at Hagemeister Island and Chagvan Bay. Comparisons with other Alaskan beach ridge complexes confirm that this is a proxy climate signal of variable storminess (Mason and Jordan 1993)—that is linked to cold climates.

Recommendations

The present report on the geoarchaeological and paleoclimatology of the Old Togiak represents only an initial assessment of the potential for further research at the locality. The Old Togiak spit is one of many similar landforms in southwest Alaska and, like most, it contains evidence of human occupation for the last two millennia. To improve understanding of the region, an extensive program of coring and dating will be required.

First, owing to the depth of fine unconsolidated marsh sediments, the use of auger or gravity driven cores will be essential in obtaining detailed records of both sea level rise and storm history. It is possible that Oakfield soil probes will have some use if undertaken during the period of maximum thaw during September.

Second, a more regionally extensive investigation would improve and verify any local records. Any future research should include research at Hagemeister Island and examine the beaches and dunes south of the Old Togiak spit.

Third, it is essential to excavate a trench from the beach to a point at the base of the Old Togiak site, with the aim of establishing the limit of sterile beach deposits underlying the site, verifying the work of Kowta (1962).

Fourth, oral history and ethnohistorical research should be undertaken to elucidate the storm history of the 19th and 20th centuries. It is noteworthy that few of the small regional newspapers (i.e., *Tundra Drums* and so on) have uploaded their previous issues (previous to 2000) on line—a circumstance that requires researchers to pursue traditional archival methods (ie., Mason et al. 1996). within the precincts of libraries and other institutions. Quite importantly, the online storm records stored in NOAA historic folders are singularly thin in time depth, with few data listings prior to the 1970s. Further, a similar effort will likely uncover data within the records of missionaries, ethnographers and Native elders. One likely source is the ANCSA records maintained by the Bureau of Indian Affairs in Anchorage.

Finally, it is a pressing need that a local sea level and storm record be produced from the marshes around northern Bristol Bay.

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Appendix E
Faunal Report (Dougless Skinner)

Togiak Archaeological and Paleoecological Project 2015 (TAPP)
Faunal Analysis

Dougless Skinner

Department of Anthropology
University of Alaska Fairbanks

Introduction:

The people of the Old Togiak Village participated in a seasonally-based subsistence strategy, which relied heavily on knowledge of Bristol Bay and surrounding interior regions. The Old Togiak Village was likely occupied on a year-round basis with potential logistical camps along the river and interior in order to target various resources. The major subsistence focus was on sea mammal hunting and anadromous fishing—both conducted in the immediate vicinity of the village (Kowta 1963, Fienup-Riordan 1982, Togiak Wildlife Refuge).

In the winter, aggregated village members lived in the housepits at the Old Togiak Village consuming the year's storage. Storage items generally included *issuriq* (seal) and *asveq* (walrus) meat and fat, smoked and dried fish, and frozen mammals. Ethnographically, in times of scarcity parkas, boots, mittens, etc…made from fish scales and seal skins were additionally consumed (Fienup-Riordan 1982). Often in the late winter there were hunting forays for sea mammals who lived on and under the ice including *issuriq* (seal), *asveq* (walrus), *assigarnaq* (beluga whale), and *uginaq* (sea lions). However, most sea mammal hunting was conducted in the spring and early fall depending upon sea ice and winter weather conditions. Land mammals such as *kaviaq* (fox), *nullutuyaq* (hare), *paluqtaq* (beaver), and *imarmiutaq* (mink) were trapped and hunted for their warm pelts, and ice fishing was conducted for *iqalluaq* (smelt), *iqallugpik* (dolly vardens), *paassataq* (arctic char), and *talaariq* (rainbow trout) (Togiak National Refuge).

In early the spring, fish camps were constructed along the confluence of the Bristol Bay and Togiak River for drying and smoking fish. The first major runs of fish were *cuukvak* (pike), *iqalluaq* (smelt), and *manignaq* (burbot). They were typically caught using traps and seining/netting. It was also peak spawning season for herring, the roe picked from the sea weed.

Early spring also brought the commencement of migratory fowl, which moved to the bay to feed and lay eggs. The fowl often filled the gap between scarcity and abundance every spring as the people awaited fish and sea mammal hunting. According to the U.S. Fish and Wildlife Service, "more than a million ducks and half a million geese bred in [Southwestern Alaska] annually" (Fienup-Riordan 2007; 197). Birds were hunted using a variety of methods included using nets, bolas, spears, slings, and arrows (Fienup-Riordan 2007).

After the break-up of the ice, during the spring and summer months, salmon began to swim from ocean to river— first *taryaqvak* (king), then *qakiiyaq* (coho), *kangitneq* (chum), *sayak* (sockeye), and lastly *amaqaayak* (pink). Ethnographically fish were cooked, boiled, wind dried or smoked in Central Yup'ik societies. *Kiaqtag* were cut into strips, the tail and head saved, while just the meat smoked. The skins and scales were saved to make clothing, while heads and tails were saved. *Qakiiyaq, kangitneq, sayak,* and *amaqaayak* were all halved, tail and head still attached and hung to dry in the summer wind or smoked. Sometimes, if the rains were too severe, whole fish were placed into pits and left to ripen in the permafrost. Salmon were typically fished with dip nets as they swam from the Bering Sea into the Togiak River (Fienup-Riordan 1982).

Land mammals were hunted chiefly during the late summer and fall when stored fat and pelts were prime for the winter. Possible logistical camps could have been constructed in the interior to hunt *tuntu* (caribou) and *tuntuvak* (moose) during the rutting season, and even *kegluneq* (wolves) or *ungungssit* (bears) as they prepared for hibernation. Small mammals were hunted year-round near the village including *avcellngaq* (voles), *negluneq/ciriiq* (hares), *uugnar* (lemmings), *tevyuliq* (muskrat), *narullgiq* (weasels), *angyayaagaq* (shrews), *imarmiutaq* (mink), and *qanganaq* (squirrel) Ethnographically, small mammals were hunted with bolas and slings, but most often trapped and netted (Fienup-Riordan 2007, Togiak National Refuge).

Along the coast there were the last of the fall and winter fishing for *iqallugpik* (dolly varden), *paassataq* (arctic char), *seturrnaq* (tomcod), *iqalluaq* (smelt), and *cagiq* (flounder) (Fienup-Riordan 2007, Togiak National Refuge). *Taqukaq* (seal) and *asveq* (walrus) harpooning was conducted as well during the time when their fat and grease content was highest for winter, and the last of the fowling was accomplished before the birds migrated for the winter (Togiak National Refuge).

Methodology:

All faunal materials were recovered from the Togiak Archaeological and Paleoecological Project (TAPP) 2015 season, by a collection of cores; each core was two centimeters in circumference and had varying lengths depending on the depth of the permafrost. The cores were then floated according to anthropogenic layers and analyzed in laboratory facilities at the University of Montana, Missoula. The fauna was identified to most discrete taxonomic class possible. Every bone was identified to taxon (Mollusca, Osteichthyes, Mammalia, or Aves), species, element type, side (left/right), end (proximal/distal), and relative age (juvenile/subadult/adult) (Cannon 1979; Gilbert 1990). Major resources utilized in the identification of faunal remains were University of Montana's Phillip L. Wright Zoological Museum, the Idaho State University's Virtual Zooarchaeology of the Arctic Project website, and U.S. Fish and Wildlife Service's Togiak National Wildlife Refuge website.

Fragments of mammalian species were classified according to relative size: small, medium, and large. Small mammals included small-sized rodents such as mice and martens through larger-sized animals such as rabbits. Medium mammals included beaver through seal or coyote mammals. Large mammals were considered caribou or walrus and up. Fragments of Aves were also classified according to relative size: small, medium, and large. Small Aves included the artic tern through green-winged teal. Medium Aves included mallard duck through trumpeter swan. Large Aves included bald eagle and up. Fragments of Osteichthyes were also classified according to relative size: small, medium, or large. Small Osteichthyes included three-spine stickleback through rainbow trout. Medium Osteichthyes included Bering cisco through sockeye salmon. Large Osteichthyes included large king salmon and up. Mollusca species were also identified by small, medium and large if the shell could be positively identified. Small mollusks included blue oysters through Pacific razor clam. Medium mollusks included Pacific oyster through cockle, while large mollusks include horse clam and up.

The specimens were then classified to type, which included: cortical, cancellous, calcine, shell, scale, ligament, antler, enamel, or ivory. Fragments were further categorized into fracture type: irregular, transverse, oblique, or spiral. Spiral and oblique fractures indicated marrow and grease production, while transverse fractures indicated a break of a less fresh specimen (Church and Lyman 2003; Gilbert 1990; Outram 2001; Binford 1978, 1981). Irregular fractures included all others and indicated cleaning or trampling activities. Human modifications were also noted and included: cut marks, chopping marks, scraping, sawing, and abrasion (Gilbert 1990; Lyman 1978; Reitz and Wing 2008). Burning was categorized by color and texture including charred black to completely calcined white. Stages of burnt bone revealed how fauna was processed and cooked and included brown, brown/black, black, grey, blue, grey/white, and white (Shipman et al. 1984). To understand the relationship of the bone preservation and the environment, weathering was also assessed according to Behrensmeyer's (1978) five stage model. Weathering values ranged from 0 to 5, where 0 signified no weathering and 5 signified the bone as unrecognizable due to cracking and complete exfoliation. If fragments couldn't positively be identified, yet retained characteristics (shape and diagnostics) of species, fragments were classified as comparable. There were three types of comparable fragments: mild, moderate, and high. Mildly comparable retained the same shape with some diagnostic characteristics. Moderately comparable retained same shape and many diagnostic characteristics. Highly comparable retained shape and diagnostic characteristics, but weren't positively identified due to fragment comparing favorably to more than one species or to extensive weathering. Comparable fragments were noted in the "comments" section of the analysis, and if the fragments were highly comparable, the Yup'ik name was also given. Lastly, if a fragment was positively identified to species or element it was noted whether that species or element had high or low caloric or cultural utility compared to other available fauna.

Faunal Remains:

The faunal assemblage offers a total of 4303 remains across the 30 core samples according to core and flotation sample number.

Table 1: Total counts of taxon according to core.

Core	N	Osteichthyes	Mammalia	Aves	Mollusca
1	1	1			
3	10				
4	416	165	35	11	138
6	29	5	24		
7	1				
9	342	140	65		135
10	155	41	18		96
11	868	207	11	4	604
12	1	1			
13	11	11			

14	42	25	6		
15	77	51	3		19
16	97	58	6		23
17	223	193	3	1	
18	441	51	18		377
19	4		3	1	
20	1		1		
21	4	4			
22	14			7	7
24	29	17	1	7	
26	22	20			1
27	4	1			2
28.1	1	1			
28.2	340	167	42		113
28.3	119	29	47		34
29.1	41	7	29		5
29.2	835	224	86	5	519
29.4	2	1			1
30.1	129	68	23	1	37
30.2	44	3	36		5

Core 1:

Core 1 (Table 2) had a total of one faunal remains found in float 3. It was a Basipteryium of a medium-sized Osteichthyes. The Basipteryium was burned brown/black and irregularly fractured.

Table 2. Core 1 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
1	1		1			

Core 3:

Core 3 (Table 3) contained a total of ten faunal remains all found in float 1. Six remains were weathered fragments of either Mammalian or Aves bone small/medium sized and burnt grey/white. The remaining four faunal remains were too heavily fragmented and burnt black for the taxon to be identified.

Table 3. Core 2 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
3	10	10				

Core 4:

Core 4 (Table 4) contained ten Aves, 138 Mollusca, 37 Mammalia, 67 Mammalia/Aves, 164 Osteichthyes in floats 1, 2, 3 and soil sample 1.

Float 1 contained 24 mammalian fragments, five Mollusca, one Aves and nine Osteichthyes. Four of the Mollusca were positively identified as *qapilaaq*/ *Mytilus edulis* shell. One resilifer of a bivalve Mollusca was also identified. One medial portion of a medium-sized mammalian long bone was identified; the fragment was burnt black, had a spiral fracture, and contained a cut mark perpendicular to the side. The spiral fracture and burn suggests that the bone was broken for grease production. There was also one small Mammalia long bone identified burnt grey and broke transversely. Of the Aves there was no positive identification of species nor element.

Float 2 contained five Aves, 12 Mammalia, 67 Mammalia/Aves, 152 Osteichthyes. Of the Aves no species were positively identified, but a proximal coracoid and a piece of vertebra both medium-sized compared highly with *civtulgaq* (arctic tern) three rodent species were identified from one proximal long bone, and two ribs, both were small, unburnt, and transversely broken. Two *seturrnaq* (sculpin) small cranial fragments were identified from the Osteichthyes. One fragment was a basipteryium, while the other was a post temporal fragment both were unburnt, which suggests the crania was not cooked nor used for grease production. Of the other fragments there were a total of small: five crania pieces (also unburnt) two dentary, one caudal vertebra, one vertebra, and two rays. Small/medium: 56 crania, 13 rays, 29 spines. Large: one vertebra. All were unburnt.

Float 3 contained one Ave, four Mollusca, one Mammalia, and four Osteichthyes. There was one unburnt rib fragment of unidentifiable Aves. The Mollusca was identified as *qapilaaq* (blue mussel) shell fragments. One postcleithym was also identified as *taalariq* (rainbow trout). One Osteichthyes vertebra, one dentary, and one jaw fragment were unidentifiable to species.

Table 4. Core 4 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
4	416		164	37	10	138

Core 6:

Core 6 (Table 5) contained a total of 24 Mammalia and five Osteichthyes. Of the Mammals, one third metatarsal of a *cenkag* (river otter), medium, burnt grey and fragmented was identified. There was also one unidentifiable small Mammalian dentary fragment. Of the Osteichthyes there were one small spine and 4 small cranial fragments. Both unburnt.

Table 5. Core 6 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
6	29		5	24		

Core 7:

Core 7 (Table 6) contained one unidentifiable fragment. The fragment was small, cancellous, and unburnt.

Table 6. Core 7 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
7	1	1				

Core 9:

Core 9 (Table 7) contained 342 fragments from floats 2 and 3.

Float 2 contained 34 Mammalia remains, 133 Mollusca, and 27 Osteichthyes. 12 of the remains were identified as *paluqtaq* (beaver) vertebral discs. The discs were burnt brown and broken irregularly. There were also five rodent ribs, burnt brown/black and spirally fractured, suggesting that they were broken purposefully. The ribs compare highly with *uugnar* (lemming). 126 fragments of the Mollusca were positively identified as *qapilaaq* (blue mussel). None of the Osteichthyes were identifiable to species, but identified were one caudal vertebra, one vertebra, 12 spines, one neutral spine, six crania. All were burnt brown/black, minus the vertebra, and had irregular fractures. The caudal vertebra compared highly with *taalriq* (rainbow trout).

Float 3 contained 30 Mammalia, two Mollusca, and 113 Osteichthyes remains. None of the mammal remains were identifiable to species, but there was one proximal and medial long bone. Both long bones were small and burnt brown/black. The medial long bone had shell attached to it perhaps from burning and cooking activities. The proximal long bone was burnt and had polishing, possibly from tool usage. There were two *caqiq* (starry flounder) vertebrae identified. One was a thoracic and the other a caudal vertebra, both juvenile and probably washed upon the shore and scavenged rather than fished. There were also 45 medium to large fish cranial fragments, 12 small vertebrae, 39 small spines all burnt brown/black. One small caudal vertebra, unburnt, compared moderately with rainbow trout. Lastly, two fragments of fish dentary remains were identified, both small-sized and unburnt enamel.

Table 7. Core 9 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
9	342	3	140	64		135

Core 10:

Core 10 (Table 8) contained 155 specimens: 18 Mammalia, 96 Mollusca, and 41 Osteichthyes in float 1 and 2.

Float 1 contained 17 Mammalia, 50 Mollusca, and 30 Osteichthyes. There were no species identified for mammal. The only element identified was one mammal dentary enamel, burnt brown and showing signs of wear. No species were identifiable for the Mollusca, and the only element recovered was shell. Three of the Osteichthyes remains were identified to *neqa* (salmon); one a precaudal vertebra, one thoracic vertebra, and one premaxilla. The precaudal vertebra was *igallugpik* (dolly varden), burnt brown/black and was not fragmented. The thoracic vertebra, neither burnt nor fragmented, compared highly with *amaqsaq* (pink salmon). The premaxilla was identified as *sayak* (sockeye salmon). Also identified were 12 small spines burnt brown and black, one unidentifiable, unburnt vertebra, and three blackened spines or ribs.

Float 2 contained one Mammalia, 46 Mollusca, and 11 Osteichthyes remains. The mammal was unidentifiable to species, but was identified as a superior articular process of a lumbar vertebra of a medium-sized mammal. The articular process compared very highly with *tevyuliq* (muskrat). The Mollusca were identified as *qapilaaq* (blue mussel) and *uilaq* (native littleneck clam) shell. The remains of both species were unburnt and were irregularly fractured, signifying possible trampling or cleaning activities. Of the Osteichthyes, there was one indeterminate medium vertebra, two small dentaries, seven spines, burnt brown/black, and one articular process burnt brown/black. The small dentaries compared moderately with smelt, while the small articular compared moderately with salmon.

Table 8. Core 10 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
10	155		41	18		96

Core 11:

Core 11 (Table 9) contained 11 Mammalia, 4 Aves, 609 Mollusca, 207 Osteichthyes, and 37 indeterminate fragments in floats 1 and 2.

Float 1 contained seven Mammalia, 30 Osteichthyes, and 25 indeterminate fragments. The seven small mammal fragments were caudal vertebrae fused together and compared highly with rodent; mice or voles. The fusion of the vertebrae was possibly a result of Ankylosing Spondylitis, which was an effect of arthritis in older animals. Of the Osteichthyes there was one vertebra, eight crania, one mandibular arch, four rays, one rib, and 15 spines. The vertebra, mandibular arch and rib were all small-sized, irregularly and transversely fractured and burnt brown black. The rays and spines were the fragments of a medium-sized fish, both irregularly broken and burnt brown. Seven indeterminate fragments were medium-sized, irregularly broken, and burnt brown, while 18 indeterminate fragments were not identified to size, but were calcined white.

Float 2 contained four Aves, four Mammalia, 609 Mollusca, 177 Osteichthyes, and 12 indeterminate fragments. The Aves were not identified to species, but one remain was of a medial long bone, and one of a rib. Both Aves were small-sized, transversely broken, and unburnt. The other two Aves were also small-sized, transversely fractured, and unburnt. The four Mammalia were rodent caudal vertebrae. The vertebrae were fused together possibly a result of Ankylosing Spondylitis. The vertebrae were transversely fractured and burnt brown. 118 of the Mollusca was identified to *qapilaaq* (blue mussel); 2 fragments from the hinge area which connected the two shells of the bivalve, and 116 shell fragments. 17 fragments were identified as *uiluq* (Pacific littleneck clam); four hinge fragments and 13 shell fragments. Lastly, 11 Pacific razor clam shell fragments were identified. There were 458 unidentifiable Mollusca fragments, 9 from resilifer remains, the connecting ligament on a bivalve shell, and then 449 shell pieces.

Of the Osteichthyes identified there was one *cagiq* (flounder), five *iqallugpik* (Pacific herring), four *seturrnaq* (tomcod), and 16 *neqa* (salmon). The thoracic vertebra of the flounder was small-sized, transversely fractured, and burnt black. There was one precaudal vertebra and five caudal vertebra of pacific herring all small-sized, not fractured, and unburnt. The five thoracic vertebra were also small-sized, not fragmented, and unburnt. The Salmonids were all medium-sized, one basipteryium, one thoracic vertebra, and 14 unidentifiable vertebrae. The basipteryium was obliquely fractured and unburnt, the thoracic vertebra transversely fractured and burnt brown, while the 14 vertebrae were irregularly fractured and burnt brown/black. Also present are two small-sized haemal/nueral spines transversely fractured and burnt brown, 56 small ribs/spines burnt brown, 46 medium ribs/spines transversely fractured and burnt brown, 23 small/medium crania irregularly fractured and unburnt, one small quadrate transversely broken and burnt brown, eight medium rays transversely broken and burnt brown, four small thoracic vertebrae irregularly fractured and burnt black, and 12 small vertebrae; two irregularly fractured and unburnt, three not fractured and burnt black, and seven burnt brown. One of the medium-sized haemal spines and six ribs compared highly with *neqa* (salmon), while four of the vertebrae compared highly with *seturrnaq* (tomcod).

Table 9. Core 11 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
11		37	207	11	4	609

Core 13:

Core 13 (Table 10) contained 11 Osteichthyes in floats 1 and 2.

Float 1 contained nine Osteichthyes; one a caudal vertebra from *seturrnaq* (tomcod), and one vertebra from *neqa* (salmon). The seturrnaq caudal vertebra was small, not fractured and unburnt, while the *neqa* was small/medium cancellous bone, unburnt and irregularly fractured. Float 1 also contained five spines transversely broken and unburnt and two small/medium-sized indeterminate fragments.

Float 2 contained two Osteichthyes; one small *neqa* (salmon) vertebra irregularly fractured and unburnt, and one small rib obliquely fractured and burnt brown.

Table 10. Core 13 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
13	11		11			

Core 14:

Core 14 (Table 11) contained six Mammalia, 25 Osteichthyes, and 11 indeterminate fragments in float 1, 2, 3, and 4.

Float 1 contained two Mammalia, seven Osteichthyes, and one indeterminate fragment. The two mammals were small/medium-sized, cancellous bone, irregularly fractured, and burnt black. Five Osteichthyes were medium-sized crania, irregularly fractured and burnt brown, while two Osteichthyes were small/medium-sized spines transversely fractured and burnt brown/black. The indeterminate was small-sized, irregularly fractured and burnt brown/black.

Float 2 contained two Mammalia, five Osteichthyes, and six indeterminate fragments. The two mammals were unidentifiable small/medium-sized, irregularly fractured and burnt brown/black. One Osteichthyes was the caudal vertebra of a medium-sized *neqa* (salmon) irregularly fractured and unburnt. Another Osteichthyes element was a small-sized caudal vertebra that compared slightly with tomcod. Lastly, there was three small rays, irregularly fractured and burnt brown. The six indeterminate fragments were highly burnt and weathered.

Float 3 contained one Mammalia, 13 Osteichthyes, and 4 indeterminate fragments. The mammal fragment was a small-sized proximal long bone that compared slightly with lemming, it was transversely broken and burnt black. The 13 Osteichthyes were small-sized cranial fragments irregularly broken and unburnt. One indeterminate was small, irregularly broken and burnt brown/black, while the other three were highly weathered and too burnt to describe much.

Float 4 contained one Mammalia fragment. The fragment was small/medium-sized, irregularly fractured and burnt brown.

Table 11. Core 14 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
14	42	11	25	6		

Core 15:

Core 15 (Table 12) contained three Mammalia, 19 Mollusca, 51 Osteichthyes, and four indeterminate fragments in float 1,2,3,4, and 5.

Float 1 contained one Mollusca fragment of a resilifer, the ligament that connects the bivalve shells, irregularly fragmented and unburnt.

Float 2 contained three Mollusca and seven Osteichthyes. The three Mollusca are unidentifiable shell irregularly fragmented and unburnt. One Osteichthyes was the remains of a scale. The scale was medium-sized and unburnt, possibly from a Salmonids. The remainder were 3 small-sized cranial remains, irregularly fragmented, one ultimate vertebra of a small-sized fish, transversely fragmented and burnt brown, and two small fragments irregularly broken and burnt brown.

Float 3 contained three Mammalia, 11 Mollusca, and 26 Osteichthyes fragments. The three Mammalia fragments were small and unidentifiable, irregularly fragmented and burnt brown/black. The 11 Mollusca were small-sized shell unidentifiable remains, irregularly broken and unburnt. Of the Osteichthyes, none were identifiable to species; however, there was one small-sized ultimate vertebra irregularly broken and burnt brown, one small and complete precaudal vertebral burnt brown, one small and complete vertebral process burnt brown, five small-sized cranial remains irregularly fragmented and burnt brown, three small rays irregularly fragmented and burnt brown, 15 small-sized spines transversely fragmented and burnt brown. The ultimate vertebra also compared highly with *tataariq* (rainbow trout).

Float 4 contained four Mollusca and eight Osteichthyes remains. Three of the Mollusca remains were small-sized irregularly fractured resilifer remains. The last fragment was one shell irregularly fragmented and unbroken. One Osteichthyes was a small-sized *neqa* (salmon) vertebra, which compared moderately with *tataariq*. The remaining Osteichthyes were unidentifiable to species, but contained five small-sized cranial remains irregularly fragmented and burnt black, and two small-sized spines transversely fragmented and unburnt.

Float 5 contained ten Osteichthyes and four indeterminate fragments. None of the Osteichthyes were identifiable to species, but there were four medium-sized cranial remains, irregularly fragmented and burnt brown/black, five small-sized cranial remains, irregularly fragmented and burnt brown/black, and three fragments burnt black. The four indeterminate fragments were small-sized, irregularly broken, and burnt black.

Table 12. Core 15 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
15	77	4	51	3		19

Core 16:

Core 16 (Table 13) contained six Mammalia, 23 Mollusca, 58 Osteichthyes, and ten indeterminate fragments in float 1,2, and 3.

Float 1 contained 23 Mollusca and 50 Osteichthyes. The remains of two Mollusca were unidentifiable resilifer, irregularly fragmented and unburnt. The remaining 21 Mollusca were unidentifiable shell, irregularly fragmented and unburnt. 11 of the Osteichthyes were identifiable; one dentary remains was an *manignaq* (burbot) irregularly broken and burnt black, four thoracic vertebrae from *sayak* (sockeye salmon), 2 complete and 2 irregularly fragmented, all burnt brown/black, and three caudal vertebrae from *seturrnaq* (tomcod) burnt brown. Of the unidentifiable species there were two small/medium-sized maxilla fragments which compared highly with *manignaq* (burbot), five medium rays transversely fragmented and burnt brown which compared moderately with sockeye salmon, three medium ribs transversely fragmented and burnt brown that also compared moderately with sockeye salmon, two small atlas vertebrae irregularly fractured and burnt brown which compared moderate with tomcod, one caudal vertebra burnt brown which also compared with tomcod, one small dentary burnt brown, one small mandibular arch irregularly fragmented and burnt brown, 11 small/medium-sized spines transversely fragmented and burnt brown, three small vertebrae complete burnt brown, and 11 unidentifiable elements burnt brown.

Float 2 contained six Mammalia, eight Osteichthyes, and ten indeterminate fragments. Of the Mammalia only one fragment was identifiable to element, one small-sized caudal vertebra unburnt. There were four medium *neqa* (salmon) vertebrae irregularly fragmented and unburnt. The remaining Osteichthyes were three small-sized spines, transversely broken and unburnt, and one small/medium-sized crania irregularly fractured and burnt brown. All the indeterminate fragments were irregularly broken and burnt; two were burnt grey/blue, seven brown, and one was calcined white.

Table 13. Core 16 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
16	97	10	58	6		23

Core 17:

Core 17 (Table 14) contained three Mammalia, one Aves, 193 Osteichthyes, and 26 indeterminate fragments from float 2, 3 and 4.

Float 2 contained 193 Osteichthyes all unidentifiable to species, but were identified as large cranial elements irregularly broken and unburnt. Compared mildly with king or silver salmon and halibut.

Float 3 contained one Aves and 23 indeterminate fragments. The Aves was unidentifiable to species, but was a small-sized proximal long bone, transversely fragmented and calcined white. The 23 indeterminate fragments were unidentifiable to element; there were five small-sized remains transversely fractured and burnt grey and 18 medium-sized remains transversely fractured and burnt grey/white.

Float 4 contained three Mammalia and three indeterminate fragments. The Mammalia were small-sized irregularly fractured and calcined white. The indeterminate fragments were all irregularly broken; one remain was burnt grey/blue and two were burnt black.

Table 14. Core 17 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
17	223	26	193	3	1	

Core 18:

Core 18 (Table 15) contained three Mammalia, 377 Mollusca, 51 Osteichthyes, and ten unidentifiable fragments in float 1. One mammal fragment was fused together caudal vertebrae and compared highly with rodent; mice or voles. The fusion of the vertebrae was possibly a result of Ankylosing Spondylitis, which is an effect of arthritis in older animals. The other two mammal fragments were small/medium-sized both burnt, one brown and the other grey blue. 97 shell fragments were *uilaq* (Pacific razor clam), and 5 other shells were *qapilaaq* (blue mussel). The remaining 261 shell fragments were unidentifiable; there were also 15 resilifer unidentifiable shell remains. Of the Osteichthyes there was one *sayak* (sockeye salmon) seven *neqa* (salmon) and 41 unidentifiable remains. The *sayak* was a parasheriod fragment burnt brown and obliquely fractured. Three *neqa* fragments were medium/large rays, burnt brown and irregularly fractured. The remaining four *neqa* were medium vertebrae burnt brown and irregularly fractured. Of the 41 unidentifiable fragments there was one small thoracic vertebra, unburnt and transversely fragmented, three fragments of unburnt dermis, six small/medium unburnt cranial remains irregularly fragmented, one medium unburnt dentary, three small unburnt rays, 14 small ribs transversely fractured and unburnt, one small scapula irregularly fragmented and burnt brown, ten small/medium-sized spines transversely fragmented and unburnt, and lastly one vertebra irregularly broken and unburnt. The ten unidentifiable fragments were all small-sized, irregularly fragmented, and burnt brown/black.

Table 15. Core 18 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
18	441	10	51	3		377

Core 19:

Core 19 (Table 16) contained three Mammalia and one Aves fragment in float 2. None of the Mammalia fragments were identified to species, but one was a medium-sized medial long bone, which due to its size and curvature was deduced to that of *kaviaq* (fox), *terikaniaq* (wolverine), *tertuli* (lynx), or *angaqurta* (domesticated dog). The remaining two fragments were medium/large-sized cancellous bones that could have been part of the same animal as the medial long bone. However, the cancellous bones were burnt brown and grey where the medial long bone was unburnt. The Aves remain was also unidentifiable to species and element, it was medium-sized, irregularly fragmented, and unburnt. The remains, however, did have black polishing, and could have been used as a tool.

Table 16. Core 19 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
19	4			3	1	

Core 20:

Core 20 (Table 17) contained one fragment of Mammalia from float 4. The fragment was unidentifiable to species or element. It was a cancellous bone, irregularly fractured and burnt black.

Table 17. Core 20 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
20	1			1		

Core 21:

Core 21 (Table 18) contained four Osteichthyes remains from float 2. The remains were unidentifiable to species, they were all cranial fragments irregularly fractured, and unburnt.

Table 18. Core 21 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
21	4		4			

Core 22:

Core 22 (Table 19) contained seven Aves and seven Mollusca remains from floats 2 and 3. The seven Aves were small, irregularly fractured, and burnt calcined white. Five of the Mollusca were identified as *qapilaaq* (blue mussel) shell, irregularly fractured and unburnt. The remaining were one shell fragment and one resilifer fragment.

Table 19. Core 22 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
22	14				7	7

Core 24:

Core 24 (Table 20) contained one Mammalia, seven Aves, 20 Osteichthyes, and one unidentifiable fragment from floats 1 and 4.

Float 1 contained one Mammalia and one Osteichthyes. The Mammalia was a fragment of a small-sized unidentifiable to species vertebra. It was transversely fragmented and burnt brown. The Osteichthyes was a small-sized vertebra which compared moderately with *talaariq* (rainbow trout).

Float 4 contained seven Aves, 19 Osteichthyes and one unidentifiable fragment. All Aves were unidentifiable to species and element; they were medium-sized and unburnt. 18 Osteichthyes remains were cranial fragments, irregularly fractured and unburnt. One of the Osteichthyes remain was a small-sized dentary burnt brown. The unidentifiable piece was a fragment of an enamel piece with cortex together. It was small-sized, irregularly fractured and unburnt.

Table 20. Core 24 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
24	29	1	20	1	7	

Core 26:

Core 26 (Table 21) contained one Mollusca, one Osteichthyes, and one unidentifiable fragment from float 3. The Mollusca was a resilifer fragment, irregularly fractured and burnt black. The Osteichthyes was a small-sized spine, transversely fractured and burnt brown. The unidentifiable fragment was medium-sized, irregularly broken and burnt calcined white.

Table 21. Core 26 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
26	3		1			1

Core 27:

Core 27 (Table 22) contained one Mollusca, one Osteichthyes, and one unidentifiable fragment from float one. The Mollusca fragment was irregularly fractured shell. The Osteichthyes was a medium-sized ray irregularly fractured and burnt black. The unidentifiable fragment was small-sized, irregularly fractured and calcined white.

Table 22. Core 27 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
27	3	1	1			1

Core 28.1:

Core 28.1 (Table 23) contained one Osteichthyes from float 11. The bone was unidentifiable to species, but was a medium-sized cranial ray, transversely fractured and unburnt.

Table 23. Core 28.1 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
28.1	1		1			

Core 28.2:

Core 28.2 (Table 24) contained 42 Mammalia, 113 Mollusca, 167 Osteichthyes, and 26 unidentifiable fragments from float 6,7,8,9 and 10.

Float 6 contained 37 Mammalia, 44 Mollusca, 84 Osteichthyes, and four unidentifiable fragments. The Mammalia were 37 fragments of cervical and caudal vertebra from a small-sized mammal. The vertebrae were transversely broken and burnt brown. They also had some fusion due to arthritis. Four of the Mollusca were identified as *qapilaaq* (blue mussel) shell, irregularly fragmented. The remaining Mollusca were 29 unidentifiable shell fragments, ten unidentifiable resilifer fragments, and one shell fragment that compared moderately to littleneck clam. Of the Osteichthyes there were three sayak (sockeye salmon) remains. Two were dentary fragments burnt black, and one was a thoracic vertebra burnt brown. The remaining Osteichthyes were: one small-sized caudal vertebra burnt brown, seven small/medium cranial fragments irregularly fractured and unburnt, nine small/medium ribs transversely fractured and burnt brown and black, seven small/medium rays transversely and obliquely fractured burnt black, 53 small/medium spines transversely fractured and burnt brown and black, and five medium vertebrae transversely broken and burnt brown. The unidentifiable fragments were three small/medium-sized remains, burnt brown and black.

Float 7 contained 3 Mammalia, 11 Mollusca, and 11 Osteichthyes. None of the Mammalia was identified to species or element. Two remains were medium-sized, irregularly fractured and burnt grey/white, and one remain was small-sized, transversely fragmented and unburnt. Nine Mollusca were resilifers, irregularly fragmented and unburnt; the remaining two Mollusca were shell, irregularly fractured and unburnt. One Osteichthyes remain was the cyloid scale of a *neqa* (salmon), medium-sized and unburnt. The remaining were, six small-sized crania irregularly broken and unburnt and two small/medium-sized spines, irregularly fractured and burnt one black and one white.

Float 8 contained two Mammalia, six Mollusca, 13 Osteichthyes, and two indeterminate fragments. The Mammalia was the remains of two *avcellngaq* (lemmus) claws small and burnt black. The six Mollusca were the remains of *qapilaaq* (blue mussel) shell irregularly broken and unburnt. The Osteichthyes were all indeterminate to species, but two remains were medium-sized epipleural spines transversely fractured and burnt black, four medium-sized rays irregularly fractured and burnt black, two medium-sized vertebrae burnt black, and five fragments small/medium-sized transversely broken and burnt black. The two indeterminate fragments were small-sized.

Float 9 contained 28 Mollusca and 41 Osteichthyes. 25 of the Mollusca were shell fragments irregularly broken and unburnt, while three were resilifer remains irregularly broken and unburnt. None of the Osteichthyes were identifiable to species, but there were three caudal vertebrae small-sized and irregularly fragmented, six small/medium-sized cranial fragments irregularly fragmented, two small-sized dentary remains irregularly fragmented and burnt brown, three medium spines irregularly broken and burnt black, one small vertebra irregularly fragmented and burnt black, and one medium-sized vertebral process irregularly fractured and burnt black.

Float 10 contained 24 Mollusca, 45 Osteichthyes, and 11 indeterminate fragments. The Mollusca had 16 shell fragments irregularly broken and unburnt and eight resilifer fragments irregularly broken and unburnt. 17 of the Osteichthyes were identified to salmonids; one medium-sized basipteryium transversely fractured and burnt brown, two medium-sized caudal vertebrae irregularly broken and burnt brown, two medium-sized proximal ribs transversely/obliquely fractured and burnt brown, nine medium-sized vertebrae irregularly broken and burnt brown, one medium-sized vertebra irregularly broken and unburnt, and two large-sized anal fin spines transversely and obliquely fractured and burnt brown/black. The remaining were unidentifiable to species: nine small/medium-sized crania irregularly fractured and burnt brown, six small/medium rays irregularly broken and burnt brown/black, 10 spines small and medium transversely broken and burnt black, and three small-sized vertebrae irregularly fractured and burnt black. There were 11 indeterminate small/medium-sized fragments, ten cortex bones and one cancellous remains, all irregularly broken and burnt black, and then nine medium-sized fragments calcined white.

Table 24. Core 28.2 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
28.2	348	26	167	42		113

Core 28.3:

Core 28.3 (Table 25) contained 47 Mammalia, 34 Mollusca, 29 Osteichthyes, and nine indeterminate fragments from floats 1, 2, 3, 4, 5, and 8.

Float 1 contained one Mammalia fragments medium/large-sized cancellous transversely broken and burnt black.

Float 2 contained 15 Mammalia, one Mollusca 12 Osteichthyes, and eight indeterminate fragments. None of the Mammalia could be identified to species; there were however two small/medium long bones identified transversely/obliquely fractured and burnt brown. The other mammal fragments included three large fragments irregularly fractured and burnt brown, nine medium/large fragments calcined white, and one medium/large-sized cancellous fragment unburnt. The Mollusca remains were one resilifer irregularly fractured and unburnt. No Osteichthyes were identified to species, however there were seven small/medium-sized cranial fragments irregularly fractured and unburnt, three medium-sized spines transversely fractured and burnt brown, and two small-sized spines transversely fractured. The indeterminate fragments were four small/medium fragments irregularly fractured and burnt black and four irregularly fractured and burnt black fragments.

Float 3 contained one Osteichthyes small/medium-sized cranial fragment.

Float 4 contained five Mammalia, four Osteichthyes, and one indeterminate fragment. The Mammalia were unidentifiable to species, two remains were medium/large-sized cancellous fragments burnt brown/black and the remaining three were small-sized transversely fractured and burnt blue/white. The Osteichthyes consisted of one small-sized crania fragment, one small-sized ray transversely fractured, and three small-sized ribs transversely fractured. The unidentifiable remain was one small-sized proximal long bone transversely fractured. The bone at one point was broken and fused back together through time. The animal was an adult when hunted.

Float 5 contained 16 Mammalia, 33 Mollusca, and 11 Osteichthyes. None of the Mammalia was identified to species or element, 14 remains were large-sized cancellous bone, irregularly fractured and burnt brown, one medium/large-sized fragment irregularly fractured, and one medium/large-sized fragment irregularly fractured and burnt black. One Mollusca remain was identified as *uiluq* (native littleneck) clam shell irregularly fractured. There were 25 other unidentifiable shell remains irregularly fractured and seven unidentifiable resilifer fragments. Of the Osteichthyes there was one small/medium-sized cranial fragments irregularly fractured, seven small-sized spines transversely fractured, and three small-sized vertebrae transversely fractured.

Float 8 contained ten Mammalia vertebral discs, medium-sized, irregularly fractured and unburnt.

Table 25. Core 28.3 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
28.3	119	9	29	47		34

Core 29.1:

Core 29.1 (Table 26) contained 29 Mammalia, five Mollusca, and seven Osteichthyes in floats 1, 2, 6, 7, and 11.

Float 1 contained five small-sized Mollusca shells.

Float 2 contained 24 Mammalia fragments. 23 of the Mammalia were small-sized cervical and caudal vertebrae, transversely broken and burnt black. They were also fused together from arthritis. One Mammalia fragment was a small-sized medial long bone, transversely broken and burnt black.

Float 6 contained five Mammalia and two Osteichthyes. The Mammalia were small/medium-sized, four cancellous bones and one cortex, all obliquely fractured and burnt brown/black. Both Osteichthyes were small-sized vertebra.

Float 7 contained one Osteichthyes small-sized ray, irregularly fractured.

Float 11 Contained two Osteichthyes medium-sized dentary remains transversely fractured.

Table 26. Core 29.1 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
29.1	41		7	29		5

Core 29.2:

Core 29.2 (Table 27) contained five Aves, 86 Mammalia, 519 Mollusca, 224 Osteichthyes, and one unidentifiable fragments from float 1,2, and 3.

Float 1 contained four Mammalia, 13 Mollusca, and eight Osteichthyes. The four Mammalia were not identified to species or element, they were medium/large-sized irregularly fractured and burnt grey/white. The 13 Mollusca were shell irregularly broken and unburnt which compared moderately with native littleneck clam. Of the Osteichthyes there was one small-sized precaudal vertebra irregularly fractured and compared moderately with uiluq (native littleneck) clam, four medium-sized epiplueral spines transversely fractured and burnt brown/black, one medium-crania irregularly fragmented, and two small-size spines transversely fractured and burnt brown/black.

Float 2 contained 5 Aves, 69 Mammalia, 338 Mollusca, 182 Osteichthyes, and one indeterminate fragment. Three Aves were the remains of *payig* (merganser) were identified, two proximal and medial ribs transversely broken and unburnt and one cervical vertebral process transversely fragmented. The remains were identified also as an adult male. The remaining two Aves were not identified to species or element, they were medium-sized and irregularly fractured. None of the Mammalia was identified to species, ten of the remains were medial long bones small/medium and nine irregularly fractured and three spirally fractured. The remaining mammal remains were 19 small-medium sized irregularly fractured, three small-medium-sized cancellous bone, nine small/medium-sized irregularly fractured and burnt blue/white, three small/medium-sized irregularly fractured and burnt brown/black, 28 medium-sized fragments irregularly fractured and 13 burnt grey/white, while 15 were burnt black.

102 of the Mollusca were *qapilaaq* (blue mussel) shell irregularly fractured, while 21 Mollusca were uiluq (butter clam) shell. The remaining were unidentifiable to species; 192 shells were irregularly fractured and unburnt, 15 resilifers were irregularly fractured and nine burnt brown, six had resilifier and shell still together, and three were shell irregularly fragmented and

burnt brown/black perhaps from roasting. Of the Osteichthyes 11 were *sayak* (sockeye salmon); one angular transversely fractured and burnt brown/black, one caudal vertebra, one cleithrum irregularly fractured and burnt brown, six dentary remains, one neural spine and arch transversely fractured, and one suborbital transversely fractured and burnt brown. Also identified were seven caudal vertebrae of an atgiaq (pacific cod) not fragmented and unburnt, and one prootic of a Gadidae, which was of the cod family. The remaining Osteichthyes were unidentifiable, there were 24 cranial remains irregularly fractured and compared highly with *atgiaq* (pacific cod), seven small-sized vertebrae irregularly fractured that compared highly with Cukilek (three-spined stickleback), three precaudal vertebrae that compared moderately with dolly varden, five small/medium-sized crania irregularly fractured, burnt brown/black and covered in an oily substance, three small thoracic vertebrae irregularly fragmented and attached to a woven grass mat perhaps from cooking, three small vertebrae irregularly fragmented and burnt brown, one small caudal vertebra, five small/medium cranial fragments irregularly fragmented and burnt brown/black, four medium-sized postcleithum fragments irregularly fractured, nine small/medium-sized rays irregularly fragmented and burnt brown, one medium rib transversely fragmented, one medium sphenotic transversely fragmented and burnt brown/black, 87 small/medium spines transversely fractured and 36 burnt brown/black, three small-sized thoracic vertebrae, 3 small/medium vertebrae irregularly fractured, and four small-sized vertebral spines transversely fractured. Lastly, the indeterminate fragment was medium and transversely fractured.

Float 3 contained 13 Mammalia, 168 Mollusca, and 34 Osteichthyes. None of the Mammalia were identifiable they were all medium/large-sized, 10 were cortex bone 3 were cancellous, the cancellous bone was burnt brown and white. 16 of the Mollusca were uiluq (butter clam), three hinges transversely fractured and burnt black and 13 shell fragments irregularly fragmented and burnt black. Two remains were *qapilaaq* (blue mussel) shell unburnt. The remaining were unidentifiable, there were 145 shell fragments irregularly fractured and 3 were burnt brown, three hinge remains transversely/irregularly fractured and burnt black, and two resilifer remains irregularly fractured. None of the Osteichthyes were identifiable to species, but there were eight medium-sized cranial remains irregularly fractured, 16 rays small/medium-sized irregularly fractured and burnt brown, five small/medium-sized ribs transversely fragmented and burnt brown/black, four small/medium vertebrae transversely fractured, and one medium-sized cycloid scale.

Table 27. Core 29.2 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
29.2	835	1	224	86	5	519

Core 29.4:

Core 29.4 (Table 28) contained one Mollusca and One Osteichthyes. The Mollusca was a small-sized *uiluq* (native littleneck clam) shell irregularly fragmented and burnt black. The Osteichthyes was a medium-sized ray transversely fragmented and burnt brown.

Table 28. Core 29.4 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
29.4	2		1			1

Core 30.1:

Core 30.1 (Table 29) contained one Aves, 23 Mammalia, 37 Mollusca, and 68 Osteichthyes in float 1 and 2.

Float 1 contained six Mammalia, four Mollusca, and 17 Osteichthyes. The six Mammalia were the remains of a medium/large-sized mammal irregularly fractured and burnt brown/grey. One Mollusca shell was identified to *qapilaaq* (blue mussel) irregularly fractured. The remaining Mollusca were two small-sized resilifer and one shell irregularly fractured and burnt black. Of the Osteichthyes there were two small-sized caudal vertebrea transversely broken and burnt black, five small/medium-sized cranial fragments irregularly fractured, one small ray irregularly fractured, and nine small/medium spines transversely fractured and burnt brown/black.

Float 2 contained one Aves, 17 Mammalia, 33 Mollusca, and 36 Osteichthyes. The Aves remains was identified as a Great Blue Heron, which didn't have an associated word in the "Yup'ik Eskimo Dictionary" (Jacobson 1984). Recovered was a distal tibotarsus that was transversely fractured. None of the Mammalia were identifiable to species, but there was a small proximal rib obliquely fractured and burnt brown which compared moderately with a marten, two small-sized distal carpals or tarsals, five small/medium-sized medial longbones transversely and obliquely fragmented and two were burnt black, six small/medium cancellous fragments irregularly fractured, and one medium/large irregularly fractured remain.

Of the Osteichthyes there were three neqa (salmon) remains; one small vertebra burnt black and two small precaudal vertebrae, which compared moderate with *iqallugpik* (Dolly Varden). The remaining Osteichthyes were 15 small/medium-sized cranial remains irregularly fractured and burnt brown/black, three small/medium rays irregularly fractured, 13 small/medium spines transversely fractured and burnt brown/black, one caudal vertebra transversely fractured and compared highly with *seturrnaq* (tomcod), one small-sized basipteryium transversely fractured, two small/medium caudal vertebrae transversely fractured, two small-sized ribs transversely fractured, ten small/medium vertebrae irregularly fractured, and one small-sized vertebral spine transversely fractured.

Table 29. Core 30.1 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
30.1	129		68	23	1	37

Core 30.2:

Core 30.2 (Table 30) contained 36 Mammalia, five Mollusca, and three Osteichthyes in float 1, 2, and 3.

Float 1 contained seven Mammalia all small/medium irregularly fragmented remains, six burnt grey/white and one brown.

Float 2 contained two Mammalia and one Mollusca. The Mammalia were two fragments of a small/medium-sized crania irregularly fragmented and burnt brown. The Mollusca was the remains of a shell irregularly fragmented.

Float 3 contained 26 Mammalia, four Mollusca, and three Osteichthyes. The Mammalia were medium/large remains irregularly fragmented and burn black. One Mollusca was a resilifer remain irregularly fragmented and the remaining three remains were unidentifiable shell. The Osteichthyes were two medium-sized cranial remains, irregularly fragmented and one medium-sized spine irregularly fragmented.

Table 30. Core 30.2 fauna.

Core	N	Unidentifiable	Osteichthyes	Mammalia	Aves	Mollusca
30.2	44		3	36		5

Summary:

The faunal assemblage was dominated by Osteichthyes; primarily *neqa* (salmon). There were occasions of *seturrnaq* (sculpin), *caqig* (starry flounder), *atgiaq* (pacific cod), *iqallugpik* (dolly varden), *cukilek* (stickleback), *seturrnaq* (tomcod), and *iqallugpik* (herring). Axial elements such as thoracic vertebra, precaudal vertebra, caudal vertebra, and vertebral fragments were present, as well as cranial, pelvic, and pectoral elements. All elements were present in the assemblage possibly due to the close proximity of the fishing source. In ethnographic resources, Yup'ik butchering activities included all elements of the Osteitchthyes, fillets and heads were utilized for food, winter storage, and feasting activities. The smaller the fish the more often the tail and head would be left attached during drying and smoking processes and often the heads and tails of larger fish like *neqa* (salmon), particularly *caauryaq* (coho) and *amagaayak* (pink) were saved for feeding domesticated dogs during the scarce winter months (Fienup-Rodian 1998).

Mammalia was dominated by small-sized remains which could have included *avcellngaaq* (voles), *negluneq/ciriiq* (hares), *uugnar* (lemmings), *tevyuliq* (muskrat), *narullgiq* (weasels), *angyayaagaq* (shrews), *imarmiutaq* (mink), and *qanganaq* (squirrel). Small mammal elements recovered were mainly proximal/medial long bones and caudal/cervical vertebra. Caudal/cervical vertebrae had the lowest utility of the small mammals and were also fused together possibly due to arthritis or anthropomorphic cooking processes. The lack of identification of larger mammals was doubtless due to sample-size rather than a lack of larger mammals. Large fragments in the assemblage were dominated by irregularly fractured cancellous bone, indicating grease and marrow processing activities.

Mollusca made up a large portion of the assemblage. Elements recovered were shell and resilifer, the ligament that held bivalve shells together. Mollusca was dominated by *qapilaaq* (blue mussel), which would have been easily collected along the beach during low tide. All the shell was irregularly broken, probably due to trampling and cleaning activities.

Aves made up the smallest number of the assemblage; identified were the remains of *anipa* (snowy owl), *payig* (merganser), and great blue heron. *Anipa*, called the "ghost of the tundra" by most Yup'ik groups were ethnographically utilized for mask and fan feather dances. They were generally only consumed on rare occasions or starvation times. The *anipa* identified was spirally fractured indicating possible anthropomorphic modification, and there was a small white down feather wedged in the break. *Payig* was a common water fowl which migrated to southern Alaska during the spring. It would have been an easy target for a well-aimed bola, sling, bird spear, or bird net. The great blue heron was somewhat of a shock to see in the collection, as the Old Togiak Village was farther north than its normal nesting area. Perhaps the great blue heron's presence indicated a change in ecology during the time, trading, or an isolated incident of the heron flying far north.

Taphonomy:

Relative Size

Relative-size (Table 31) referred to the size of the species (refer to the Methodology section for a list of relative sizes). Relative size—small, medium, large, small/medium, and medium/large aided in the identification process of fauna. Relative-size also indicated a range of possible animal types even when the taxon or species were unidentifiable. The majority of the species were in the small range, with larger amounts in core 4, 9, 11, and 29.2. Small species mainly consisted of small fish such as *seturrnaq* (sculpin), *iqallugpik* (dolly varden), *cukilek* (stickleback), *seturrnaq* (tomcod), or *iqallugpik* (herring). All shell identified as blue mussel was relatively small-sized, and most of the Mammalia was identified as small-sized. Core 9, 11, and 29.2 were located on the bottom of mound one, closer to the bay, whereas core 4 was located across the modern road. The cores in the mound closer to the ocean were radiocarbon dated later than the housepits behind the road. Perhaps this points to the continuity of the site over the last 1,000 years.

Table 31. Relative-Size of Fauna by Core.

Core	Small	Medium	Large	Small/Medium	Medium/Large	Total
1		1				1
3				2		2
4	175	18	2	205	315	715
6	5	20		4		29
7	1					1
9	255	27		45		327
10	46	14		7	1	68
11	243	172		22		437
12	1					1
13	8			3		11

14	20	6		7		33
15	50	4				54
16	25	27		3	1	46
17	18	3	193			214
18	4	114			3	121
19		1	1		2	4
20	1					1
21	4					4
22	7					7
24	22	7				29
26	20	1				21
27	1	1				2
28.1	1				1	2
28.2	111	77	2	47		237
28.3	21	14	17	14	16	82
29.1	14	23		3		40
29.2	241	93		101	45	480
29.4	1	1				2
30.1	33	4	1	56	9	103
30.2		9		28	1	38

Fracture Patterns

Fracture pattern distribution across the site (Table 32) may reveal patterns of processing and discarding faunal resources. Spiral, oblique, and irregular fractures may indicate increased faunal processing and marrow or grease production. Irregular breaks may also indicate cleaning or trampling activities, while transverse fractures generally indicate an unintentional break in a less fresh specimen. The assemblage was dominated by irregular fractures due to marrow and grease production or cleaning and trampling activities. The large-sized specimens, which made up less of the assemblage, with irregular breaks were possibly utilized for grease and marrow production, while the small-sized fauna were probably trampled or cleaned. Transverse remains were primarily Osteichthyes ribs, spines, and rays, and small-sized Mammalia long bones. The transverse fractures were not culturally modified rather breaks from natural causation. Oblique fractures were mainly found on medium-sized long bone and may have indicated cooking processes, such as, boiling. Spiral fractures are very uncommon, but rather than a lack of grease and marrow production at the village, it undoubtedly indicates a lack of samples from the small cores.

Table 32. Fracture Patterns of Fauna by Core.

Core	Complete	Irregular	Transverse	Oblique	Spiral	Total
1		1				1
3		1				1
4	5	219	56			282
6	1	22	3		1	27
7		1				1
9	13	295	33			346
10	2	141	12			501
11	8	774	116	7		905
12			1			1
13	1	4	5	1		11
14	1	37	4			42
15	3	51	21			75
16	4	47	24			75
17		204	19		2	225

18		408	32	1	5	447
19		3	1			4
20		1				1
21		4				4
22		7	7			14
24		24	5		3	32
26		1	1			2
27		4				4
28.1	1					451
28.2	4	206	120	5		845
28.3		89	26			168
29.1		2	27	5		34
29.2	11	686	121			
29.4		1	1			2
30.1	3	84	39	1		127
30.2		44				44

Burning Stages

Distribution of burnt fauna (Table 33) can indicate faunal butchery and processing patterns as well as other taphonomic process such as cooking. Most common in the assemblage was unburnt bone, which could indicate that butchering activities where happening away from cooking hearths. It also indicates that during cleaning activities fauna was not placed near to fires rather bones were moved elsewhere after consumption. However, due to lack of provincial information burning could be from other outside factors.

Table 33. Burning Stages by Core.

Core	Unburnt	Brown	Brown/Black	Black	Grey	Grey/Blue	Blue	Grey/White	White	Total
11										1
3	18	15	5	3		1				42

4	33	49	7	1	2	2		3	97
6	405	25	10			1			441
7	4								4
9	6			1				7	14
10	18	2		1				1	22
11	2			1				1	4
12		1		1					2
13	193			2		19		9	223
14	28	7		3			6		44
15	1								1
16	7	4							11
17	369	17	10		2	14		4	416
18	178	17	119	25		1		1	342
19	148	60	8	120			2	2	340
20	73	23	2	9			3	1	119
21	12		5	24					41
22	184	8	43	4					129
24	679	44	62	23			26	1	835
26	1		1						1
27	10		1				1		10
28.1	6				2	19		2	29
28.2	112	8	29	6					155
28.3	849	100	89	4			3		868
29.1	26	31	13	7					77
29.2	2			1	1				4

29.4			1	1
30.1	27	2		29
30.2	1			1

Weather Stages

Weathering can be an indicator of the general level of processing activities or environmental stress the bone received while exposed. The majority of the faunal remains were stage 3 weathering (Table 34). This may indicate that the overall effects of weathering, whether from environmental or processing factors, were not overly intensive and the acidity of the soil not averse to faunal preservation. The higher counts of fauna with stage 4 and 5 weathering were located in shallower cores (minus core 30.2) and may have been exposed longer to the elements. The 26 remains at stage 5 weathering in core 30.2 may indicate heavier processing activities during that time.

Table 34. Weather stages by core.

Core	Weather2	Weather3	Weather4	Weather5	Total
1			1		1
3		1		1	2
4		299	119		348
6		27	2		29
7			1		1
9		226	97	16	339
10		126	28	1	155
11		774	79	15	868
12		1			1
13		8	1	2	11
14	13	9	6	14	42
15		29	48		77

16		63	28	7	98
17		218	5		223
18		411	30		441
19		3	1		4
20		1			1
21			4		4
22		13	1		14
24		3	25	1	29
26		21	1		22
27		3	1		4
28.1	1				460
28.2		223	116	1	878
28.3		68	43	8	173
29.1		11	30		41
29.2		689	146		835
29.4			2	1	3
30.1		84	43	2	129
30.2		8	10	26	44

Cultural or Natural Modifications:

Evidence of cultural modification is extremely limited (Table 35), almost nonexistent, due to the small sample size. The only two modifications found were cut marks and polish. Two faunal remains looked polished possibly from tool usage. The majority of the cut marks were found on medial long bones and were probably a result of butchering processes on smaller mammals.

Table 35. Cultural modifications by core.

Core	Cut Marks	Polish	Total
4	1		1
6	1		1
9		1	1
19		1	1
29.2	3		3
30.1	1		1

Discussion:

The faunal recovered from the cores taken at Old Togiak Village during the 2015 field season revealed aspects of seasonality and continuity. The faunal remains suggest that Osteichthyes were the main focus and seasonally specific. The Osteichthyes recovered were *neqa* (salmonid), *seturrnaq* (sculpin), *caqig* (starry flounder), *atagiaq* (pacific cod), *iqallugpik* (dolly varden), *cukilek* (stickleback), *seturrnaq* (tomcod), and *iqallugpik* (herring). According to the Togiak National Wildlife Refuge, *iqallugpik* spawning peaked in the spring followed by the *neqa* and *iqallugpik* runs for the summer. The *neqa* and *iqallugpik* runs flowed into the fall when spawning was peaked especially for *sayak*, of which were found in the analysis. According to the Alaska Fisheries *atagiaq* and *seturrnaq* would have been found spawning in the water right off shore in the winter months and stayed until summer.

The Mammalia remains suggested extensive small mammal hunting, although the sample size restricts research to mainly small and medium-sized mammals. However, there were large sea and terrestrial mammal subsistence, as seen through Kowta's excavations in the 1960's (Kowta 1963). Small mammals were hunted year round when available and could have included *avcellngaq* (voles), *negluneq/ciriiq* (hares), *uugnar* (lemmings), *tevyuliq* (muskrat), *narullgiq* (weasels), *angyayaagaq* (shrews), *imarmiutaq* (mink), and *qanganaq* (squirrel). Recovered from the excavation were small rodent caudal and cervical vertebrae which compared highly with *avcellnaq*. *Avcellnaq* would have been available year-round, their caches under the ground, easily accessible during the fall months. Also identified were *uugnar* (lemming), which lived in the tall grasses, sedges, and willows. *Uugnar* were possibly also trapped in the fall months when their pelts were thickest and they were fat for winter (Fienup-Riordan 1982).

Two medium-sized mammals were also uncovered; *cenkaq* (river otter) and *paluqtaq* (beaver). *Ceniq'aq* would have been hunted using aquatic traps along the river banks during the fall months when the pelts were soft and bodies were fat for winter (Fienup-Riordan 1982). *Cenkaq* remained active in both the winter and summer months, and could be killed along with seals and fish in winter ice holes (Fienup-Riordan 1982). Another mammalian remains worth mentioning, although not positively identified, was that of a medium-sized medial long bone. The fragment was deduced to that of *kaviaq* (fox), *terikaniaq* (wolverine), *tertuli* (lynx), or *angaqurta* (domesticated dog). *Kanqilngq*, *terikaniaqm* and *niutuayaq* were trapped during the fall and winter hunting seasons, and den for the winter normally near water (National Park Services).

The Aves recovered in analysis were few; however the birds which migrate to the area were plentiful and possibly not represented well in the core samples. Of the three species identified they were all seasonally available. According to the Cornell lab of Ornithology the great blue heron was found in either freshwater or seawater areas along North America and Canada. They normally lived in swamp or wetland environments with a large body of water nearby often accompanied by trees in the close distance. They, on occasion, are also found in grassland environments. Herons nest in the spring in trees 1 or 2 miles from large bodies of water; however, they will nest on the ground if the area has enough shelter. They are both migratory and sedentary birds. They will migrate if the area isn't productive during the winter. They have been known to live year round along the coast of British Colombia and south east Alaska. If conditions get too cold, they will migrate to the warmer waters of Mexico and Central America. There was not an associated Central Yup'ik word found in the Jacobson's Yu'pik language dictionary for the great blue heron.

The *payig* (merganser) migrated to the north in the early spring and lived there through late summer to feed from the fish and breed (The Cornell Lab of Ornithology). *Anipaq* (snowy owl) lived in the spring and early summer breeding months on tundra grasslands frequently near beach dunes bereft of trees. They were ground hunters they particularly were interested in *uugnar* (lemming). According to traditional knowledge and experiences of Yup'ik cultural area, *anipaq* was rescue food during starving times and its feathers were also used in traditional mask and feather fan dances (*Alaskan Native Knowledge Network*, University of Alaska Fairbanks).

Faunal remains recovered from the Old Togiak Village advocated for high seasonality at Togiak. The remains suggested that there were enough resources live in the village on a year-round basis, with possible logistical camps located along the river and in the interior. The main focus was on fish, which from the remains recovered, spanned all four seasons. They supplemented in the spring and summer with Aves, and had a possible focus on land and sea mammals in the fall and winter. Utilizing the faunal analysis provided a broader understanding of the expansive knowledge of the faunal seasonality by the Yup'ik people of the Old Togiak Village.

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Appendix F
Pollen Report (Cynthia Zutter)

Pollen Analysis of Temyiq Tuyuryaq (OLD TOGIAK Village), Bristol Bay, SW Alaska

Cynthia Zutter, Ph.D.

MacEwan University.

Prepared for: Togiak Community and University of Montana.

January, 2017

Introduction

The following pollen analysis creates a preliminary reconstruction of the palaeoecology of the Old Togiak site and its surroundings as part of the Togiak Archaeology and Paleoecology Project (TAAP) (Prentiss 2015). The TAPP program is focussed on contributing towards an enhanced understanding of the ancient history of the Bristol Bay Yup'ik people from the early Thule period through and during the early Colonial period. Change to terrestrial ecosystem can impact a variety of plant resources and is addressed in the types and abundance of different pollen types. Pollen analysis of samples from archaeological matrix can provide a general signature of the localized site environment, often including a variety of plant species (i.e. anthropogenic) that thrive in highly disturbed zones of indicating human occupation (Pearsall, 2000).

Background

Environment of area

The Old Togiak site is located in a climatic transition zone, between the subarctic and cold marine regions that are part of the Bristol Bay lowland ecoregion. This coastal locale has July average temperatures of 12 °C however winters are still influenced by arctic weather and can range from −43 to −1 °C. This lowland ecoregion has rolling terrain, formed from moraine deposits with well drained soils and is north of the current treeline (Viereck 1977). Dwarf scrub communities, dominated by alder and low lying Ericaceae bush are widespread, but large areas of wetland communities occur and lakes are scattered throughout the lowlands (https://hort.purdue.edu/newcrop/cropmap/ecoreg/descript.html#112)

A variety of palaeoecological studies have been done in the local region, specifically at Lone Spruce pond (Kaufman et. al., 2011) which is approximately 100 km north of Togiak and at Grandfather lake and Ongivinuk lake in the Ahklun mountains (Hu et. al., 1995). Together these studies document the last 13,000 years of vegetation and climate change in this region of SW Alaska. After deglaciation, herb tundra is replaced by birch shrub tundra communities. By ca. 7400 years ago alder arrives and by 4000 BP spruce becomes established in the highland regions (Hu et al., 1995). Since 2000 BP, alder shrub tundra, with a variety of grasses and herbaceous plants dominate the vegetation in the low lying areas. Temperature reconstruction for the last millennium, based on chironomid midge species in the Lone Spruce pond suggest that low average summer temperatures occurred during the 8th 9th and 18th centuries AD while the 13th C. AD represents the warmest interval during the pre-modern Holocene period (Kaufman et al 2009).

The archaeological record of Bristol Bay, SW Alaska is extensive with frequent large and complex village generally dating to within the past 2500 years. One such village, now known as the Old Togiak site, is located on the north side of Bristol Bay. This large residential site was intensively occupied by the Bristol Bay Yup'ik and is about 75-180 m in extent and consists of one large mound stretching approximately 130 m in length adjacent to at least six other somewhat smaller mounds (Prentice 2015). The site was occupied from approximately 1200-1860 AD (Kowta 1963), representing Thule and late pre-contact phases (Barnett, pers. comm.) The Togiak villagers lived in sod roof houses, repeatedly re-built over time, creating a variety of rich organic, deeply stratified mounds which contain remnants of house structures, middens and possible outdoor activities.

Methods

Auguring of the mounds at the Old Togiak site was carried out in the summer of 2015 with a JMC percussion augur to explore the contents of the mounds and to create a sequence of living floors in the site. A total of 32 cores were collected from the site. The cores were approximately 2 cm diameter and ranged in length from 500 cm to over two meters. The cores were divided longitudinally and analyzed under a dissecting microscope. Natural layers were separated from cultural layers and pollen samples were isolated from the cultural matrix.

Sixteen pollen samples were subsampled from 8 separate cores, selected from strata that co-occurred with highly organic cultural lenses within the cores. Ten of these pollen samples were collected from four different cores (#1,10,29 and 30; see attached map) recovered in the SW area of the site. All of the pollen samples contained abundant amounts of well preserved pollen and other microscopic materials, including charcoal and wood fragments and various spores. Only one of the pollen samples, #111 from core 29.2, was sub sampled from a cultural lens that was directly above the palaeoethnobotanical sample C160.

Sixteen pollen samples, 1-3 g dry weight, were processed using a 10% sodium hydroxide to break down organic materials, and soaked in hydrofluoric acid to dissolve silicates and acetolysis to remove cellulose (Moore, Webb and Collinson, 1991). Total pollen counts ranged between 250-700 grains per sample, in order to get a relatively consistent pollen sums and a representative number of plant taxa (Birks and Birks, 1980:165). A standard Leitz transmitted light microscope was used to pollen analysis and pollen identification was aided by published keys (Moore, Webb and Collinson, 1991) and the extensive pollen reference collection of the Palaeoenvironmental Laboratory, University of Alberta. Botanical nomenclature follows *Flora of Alaska and Neighboring Territories*, (Hulten, 1968).

Results

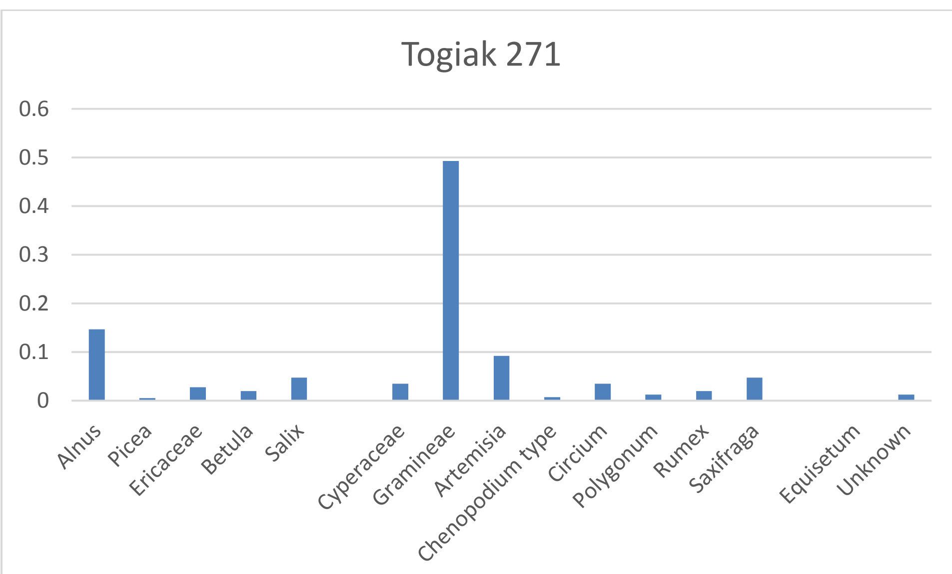
Gramineae pollen is by far the most common pollen in all samples, from a high of 70% in samples #217 and #116, to a low of 25% in sample #108. Other herb species that are ubiquitous throughout all the samples include *Artemisia* (wormwood) pollen which from a high of 17% in sample #380, but averages around 10% in most samples and *Circium* (thistle) that varies from 5-

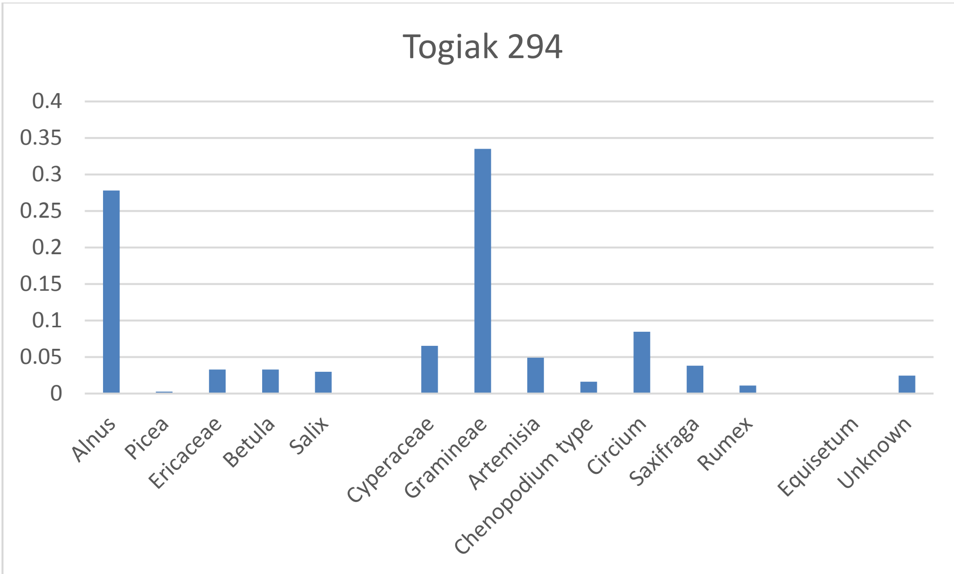
10%. Pollen from Cyperaceae taxa, *Saxifraga*, *Polygonum* and other herb species are found in low amounts.

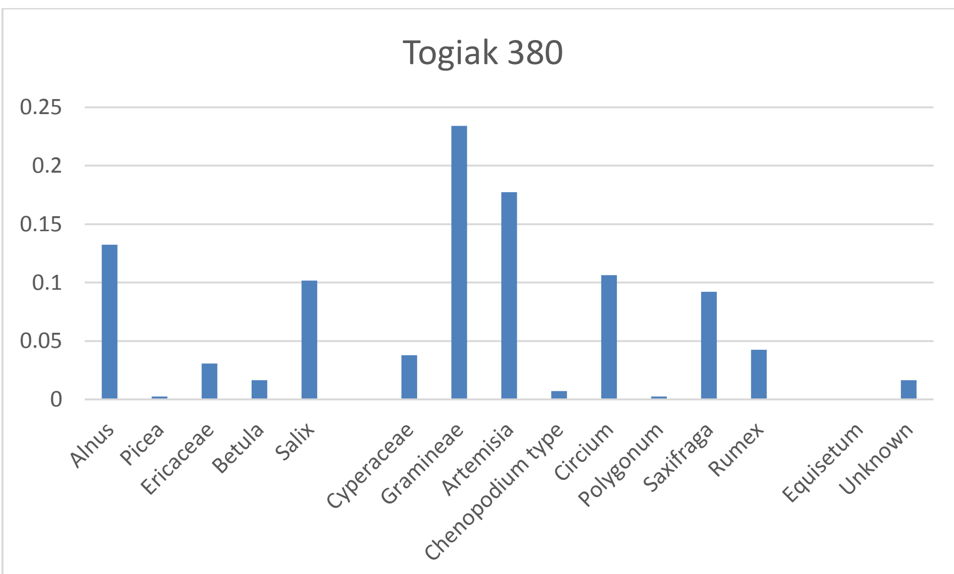
The most common tree pollen is represented by *Alnus* (Alder) taxa averaging between 15% and 35%, and only in sample #108 is the *Alnus* pollen percentage more abundant than Gramineae. Other pollen from woody species include *Salix* (willow) and Ericaceae (*Vaccinium*, *Empetrum*, etc.) taxa that average between 5-10%. *Picea* (spruce) pollen was rare and *Betula* (birch) pollen was in low abundance (less than 5%).

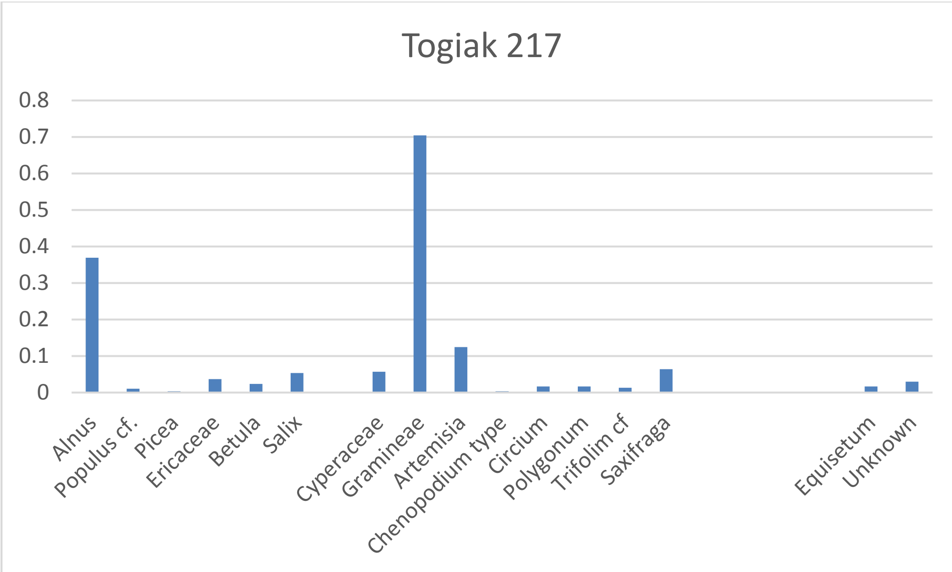
Sample #111, from the core 29.2, had an average amount of Graminea, *Artemisia*, *Alnus* and Ericaceae pollen. These taxa are also represented in the palaeoethnobotanical sample C160, from core 29.2 collected directly below the pollen sample. In fact, sample C160 had the highest concentration of macro-botanicals in all of samples, including Gramineae (grass) stems, *Artemisia* (wormwood) and *Empetrum nigrum* (crowberry) seeds (Lyons 2016).

The four pollen diagrams displayed below represent samples #271, 294, 380 and 217, and were subsampled from cores that did not have any associated dates. The pollen percentages are similar to those from dated core samples, with the exception of sample 217 that has the highest percentage of Gramineae pollen (ca. 70%).

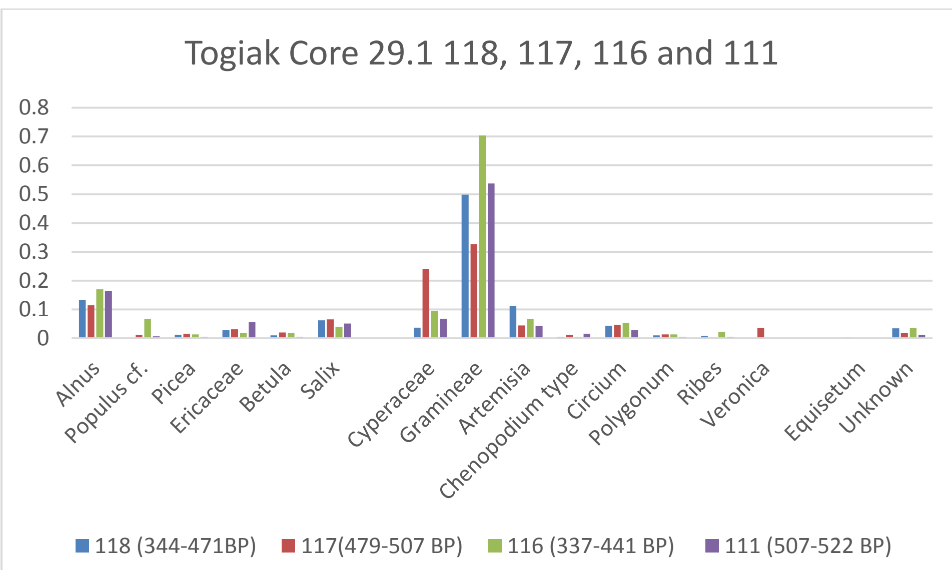



Togiak 294
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Alnus
Picea
Ericaceae
Betula
Salix
Cyperaceae
Gramineae
Artemisia
Chenopodium type
Circium
Saxifraga
Rumex
Equisetum
Unknown

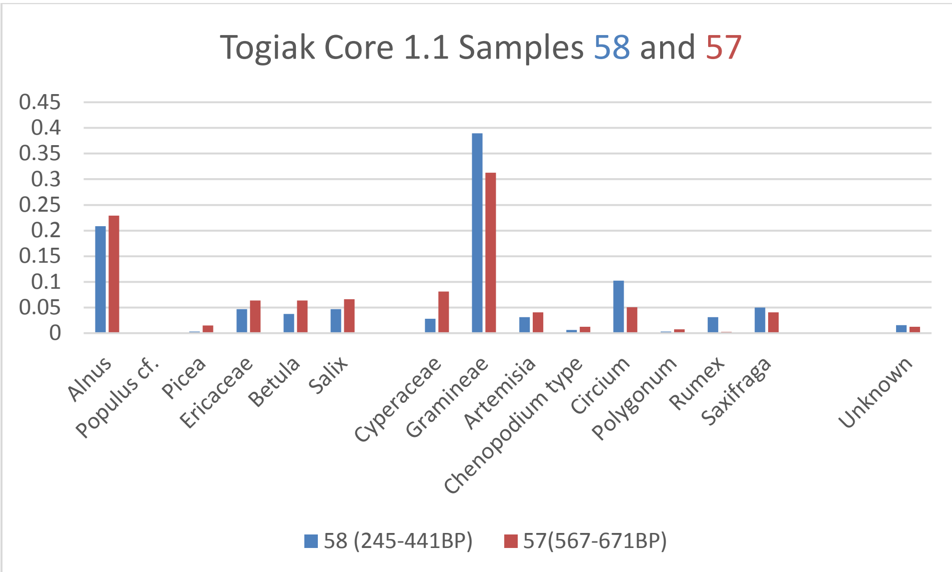

Togiak 380
0.25
0.2
0.15
0.1
0.05
0
Alnus
Picea
Ericaceae
Betula
Salix
Cyperaceae
Gramineae
Artemisia
Chenopodium type
Circium
Polygonum
Saxifraga
Rumex
Equisetum
Unknown



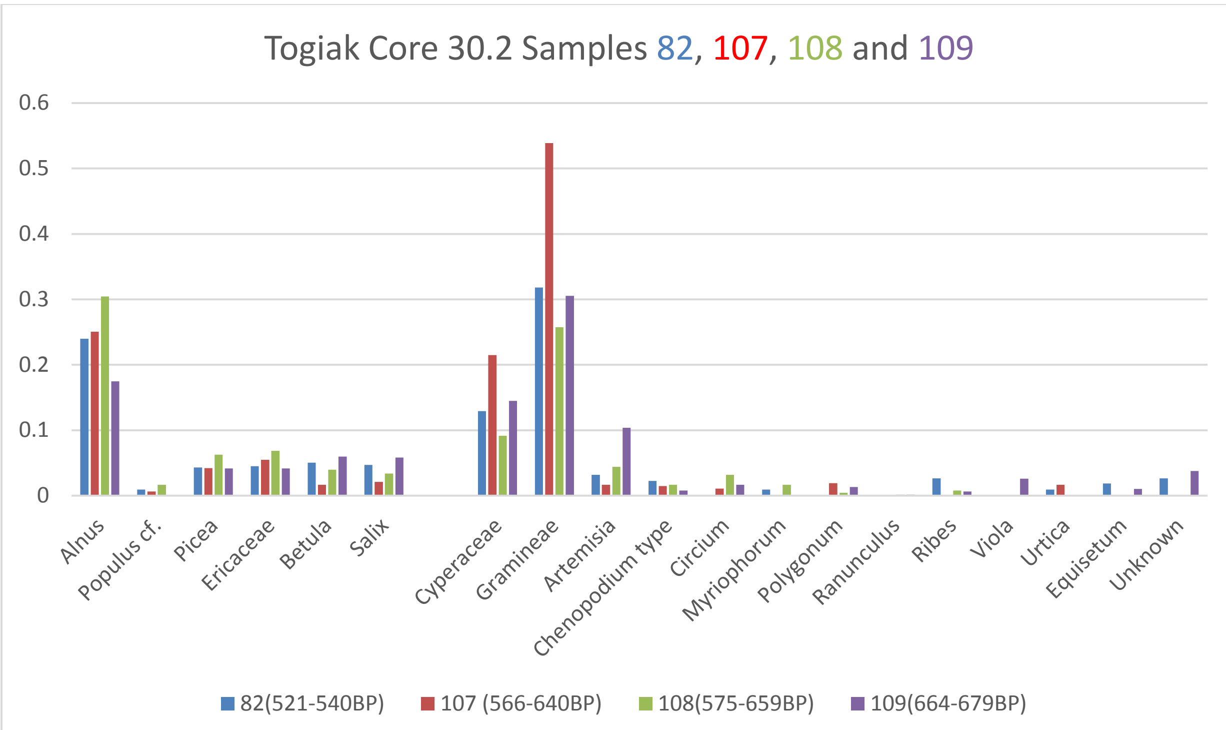
Pollen samples #118, 117, 116 and 111 were collected in sequence from core 29.1/29.2 representing 344-522 BP. Generally, the tree pollen is low, with *Alnus* less than 20% suggesting that the vegetation is open, with few shrubs. Grasses are abundant between the 337-441 BP while Cyperaceae taxa (sedges) rise to over 20% from 479-507 BP.



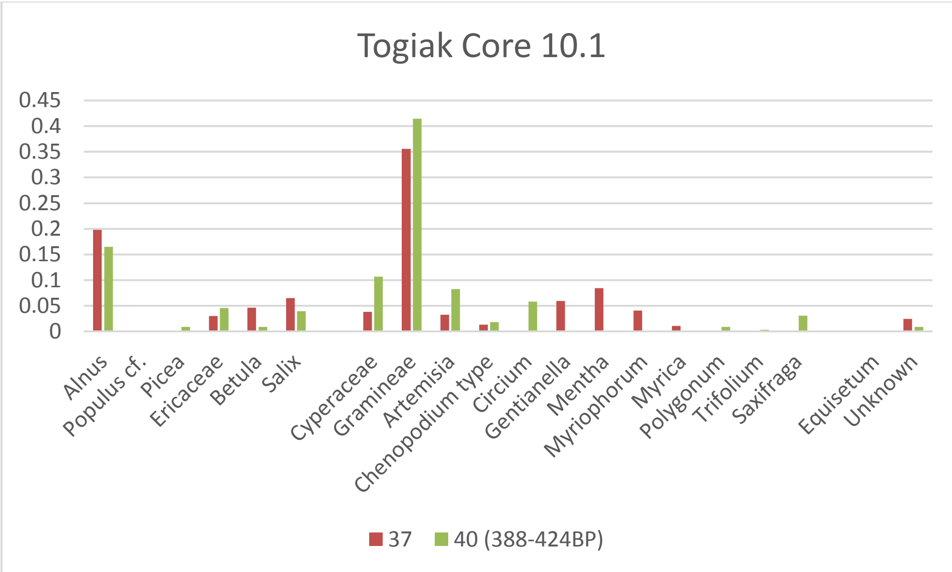
Samples #58 and 57 from core 1.1 have similar pollen percentages that span 245-671 BP. *Alnus* pollen is over 20% and dominates the shrub type pollen while grass pollen averages 38% and 31% respectively.



These four samples from Core 30.2 represent years 521-679 BP. Sample #108 is unique with a higher percentage of *Alnus* than Gramineae pollen while in the sample #109, there is a diversity of pollen types, including Cyperaceae, *Artemisia* with low numbers of *Alnus*.



Similar to Core 1.1, the pollen percentages from 10.1 are representative of the general pollen percentages from all samples. *Alnus* percentages are close to 20% while Gramineae pollen ranges from 35-40%.



Discussion

The general trend represented by all of the pollen samples from the Old Togiak site suggest an open landscape consisting of mainly grasses and various herbs, with alder shrubs and various other low lying berry bearing bushes. This open vegetation community dominated by grasses and herbs is comparable to other pollen studies from contemporary archaeological sites in the Naknek river area from SW Alaska completed by Heusser (1963). Further, the prominent grass profiles in all of these Old Togiak samples suggests that human activities contribute to maintaining a camp clear of shrubs and trees.

An open grassland is the case in all but sample #107 (575-659 BP) where a high alder percentage suggests that there was a more shrub dominated site during this time. However, sample #57 (567-671 BP) is contemporary with sample #107 but has much lower shrub and higher grass percentages. Consequently, sample #107 may be an anomaly, perhaps an alder shrub growing nearby the sod house contributed an over abundance of pollen in this specific area.

It should also be noted that there is a close correlation between the macro and micro botanical samples from the Old Togiak site. Samples from Core 29.2 (#111 pollen, C160 macro-botanical) represent both include Gramineae, *Artemisia*, *Alnus* and Ericaceae plant remains. Ethnobotanical studies from the Yup'ik communities report that each of these plants are used currently by the Yup'ik (Jernigan n.d :102) and their presence in the archaeological matrix suggest that they were likely important as part of the economy at Old Togiak in the past.

Pollen analysis of samples from archaeological sediments can provide a general signature of the localized environment but due to the human disturbance factors that occur on archaeological sites, reconstructing highly specific climate reconstructions is limited. Consequently, these pollen results can not provide a precise climate picture from the 14th-18 C., but the fact that shrubs were not growing in abundance at the Old Togiak site suggests that perhaps both cooler LIA conditions (Loso et al, 2006) and clearing activities by those living at the site combined to create the grassy open locale. This preliminary study supports further work with micro and macro botanicals to enhance the understanding the ancient history of the Yup'ik peoples in the Bristol Bay region.

Acknowledgements. Many thanks to Kristen Barnett for providing me with the opportunity to participate in this compelling research and to Kristen and Anna Prentiss for assistance and guidance with the site and project information.

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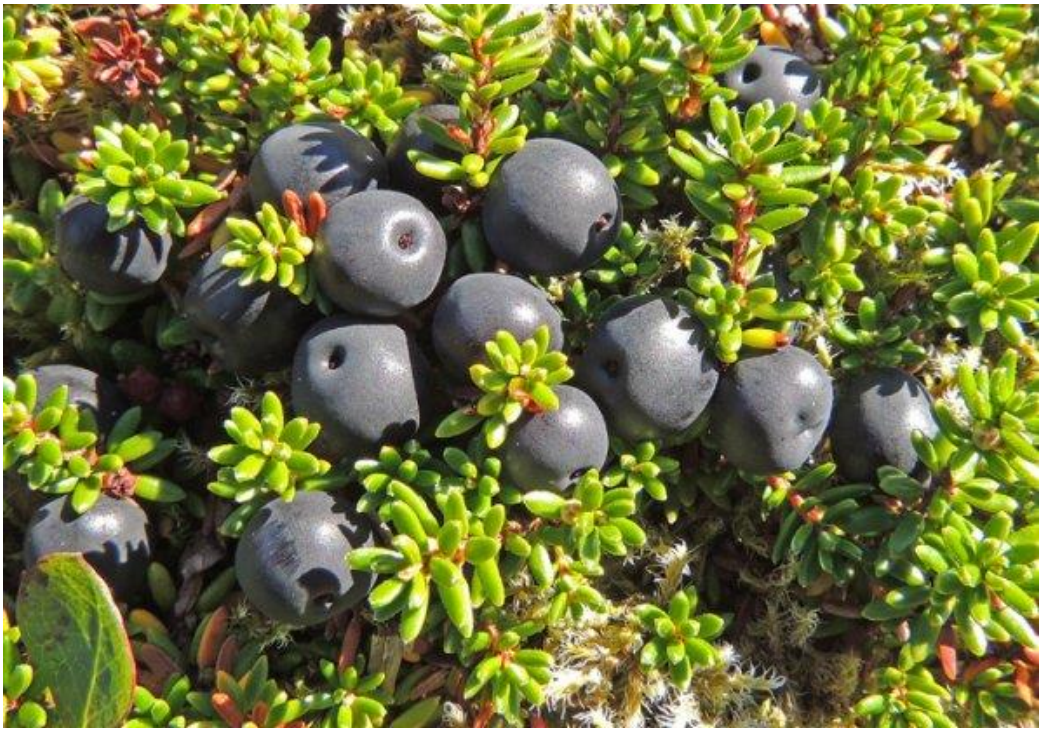
Appendix G
Macrobotanical Report (Natasha Lyons)

Palaeoethnobotanical Analysis of Temyiq Tuyuryaq (Old Togiak Village), Bristol Bay, Alaska



Crowberry heath, www.naturebob.com

Natasha Lyons, PhD

ursus-heritage.ca

natasha@ursus-heritage.ca

Prepared for: Togiak Community & University Montana

November 2016

Table of Contents

Introduction

This report presents a palaeoethnobotanical analysis of the village site at Old Togiak, known as Temyiq Tuyuryaq in Yupi'k, located on the north side of Bristol Bay, in southwestern Alaska. This large residential site was intensively occupied by Bristol Bay Yup'ik from approximately 1200 to ca 1860 AD (Barnett, pers. comm.), representing the Thule and late pre-contact phases of this region (Kowta 1963). The Togiak villagers appear to have lived in sod roof houses that were repeatedly re-built over time, generating a tell-like stratigraphy in parts of the site that has been well-preserved and is rich in organics. The site consists of different types of habitation and related structures. At the southwest end of the site, close to the shoreline, is a large mound stretching 130 meters in length adjacent to at least six other somewhat smaller mounds (Prentiss 2015). The mounds are deeply stratified—some as much as four meters—and contain remnants of house structures, clay-lined cache pits, possible outdoor activity areas, and shell midden material. Moving northeast towards a marshy area, the houses are shallower surface constructions.

The program of coring using a JMC percussion augur was intended to test these house mounds, determine the scale of the site, and conduct an initial exploration of the contents of the sequence of house floors. Sixty-nine spot samples extracted from 10 of 32 cores were analysed for the present palaeoethnobotanical study of the Old Togiak site. This analysis represents the first study of archaeobotanical macroremains from any archaeological site in Bristol Bay, and one of only a handful in the whole of Alaska. The goals of this analysis are therefore general and exploratory. I sought to provide a holistic study of ancient plant-people relationships on this site by combining ethnographic, ethnobotanical, ecological, traditional and contemporary knowledge of plants amongst Yup'ik peoples with the archaeobotanical data. I also sought to integrate our findings with other data sets to create a large sense of the nature and scope of the lives lived by ancient Togiak residents.

This report is organized as follows. I begin with a review of Alaskan ethnobotany and palaeoethnobotany, providing a generalized summary of the annual plant cycle of Yup'ik peoples. I then consider the palaeoenvironmental and site formation factors affecting plant preservation and distribution at the Old Togiak village. In the methods section, I describe the processing, sorting, identification and analysis procedures for all samples. In the results section, I present an inventory of the Togiak plant assemblage that gives the Yup'ik term and describes the ecology and ethnobotany of plant taxa represented. A limited quantitative analysis looks at the ubiquity and abundance of taxa in the archaeobotanical assemblage, in addition to discussions of site-level taphonomy, ancient site use, and seasonality. In the discussion, I compare the pollen and macroremains data from Togiak, place the assemblage in a broader picture of the fledgling field of Alaskan palaeoethnobotany, and identify gaps and suggest prospects for further study.

A note on terms is in order here. Palaeoethnobotany is the study of past human-plant interactions, while archaeobotany refers to the analysis of archaeological plant remains (Hastorf and Popper 1988:2). These terms are often used interchangeably in the literature. Plant macroremains are those visible to the naked eye, while microremains require high level magnification (Pearsall 2000:6-9). This analysis deals with macroremains such as seeds, charcoal, buds, leaves, stems, petals and the like; plant microremains take the form of starches, pollen, and phytoliths.

Alaskan Ethnobotany & Palaeoethnobotany

Yup'ik Annual Plant Round

Alaska has a rich tradition of ethnobotany in Alaska Native communities (eg., CAFF 2006; Floyd 2001; Garibaldi 1999; Jernigan n.d.; Jones 2010; Russell 1995). Plant knowledge remains resonant in contemporary communities and is actively being passed on to succeeding generations through land-based activities such as berry-picking and beach grass harvesting, as well as being documented in both analog and digital forms. These ethnobotanies record myriad uses of plant life by Alaska Native peoples, from foods, technologies, and medicines, to bedding, regalia, and charms. The following summary of the Yup'ik annual plant round is primarily derived from Ann Fienup-Riordan's volume *The Nelson Island Eskimo* (1983), which places plant harvesting within a larger subsistence and ritual cycle followed by Nelson Island families. Clarifications of Yup'ik and Latin names are from Jernigan (n.d.). I focus on food and technological plants, which consumed the greatest economic output among women, children, and Elders. While the phenology of plants and the parallel timing of local harvests may vary across the Yup'ik landscape, the essence of this seasonal round would have been familiar to traditional Togiak village residents.

Spring is *Up'nerkaq* in Yup'ik, meaning 'to get ready to prepare' for the season of light and harvesting ahead (Fienup-Riordan 1983:65). As the snow melts, the plants from the last growing season are exposed for harvest, such as *ayut* (Labrador tea, *Ledum palustre*), *tan'gerpii*t (crowberry, *Empetrum nigrum*), and *uingiaraat* (bog cranberry, *Oxycoccus microcarpus*) (Fienup-Riordan 1983:68). Warmth comes in May, bringing greens such as *allngiguat* (marsh marigold, *Caltha palustris*) and *kapuukaq* (buttercup, *Ranunculus pallasii*) as well as roots of buttercup and *mecuqelugaq* (wild parsnip, known as sea lovage in English; *Ligusticum scoticum)* (Fienup-Riordan 1983:88; Jernigan n.d.:64, 74). June brings preparation for the herring season. *Taperrnat* (referred to as beach grass, rye grass, and dune grass; *Elymus mollis* and *Elymus arenarius*) is harvested en masse to be used to braid the drying herring and line the cache pits (Fienup-Riordan 1983:92). *Elquat*, the herring eggs that attach to seaweed, are collected in bushels in the later spring (Fienup-Riordan 1983:90).

Summer brings wide-ranging gathering of plant greens, berries, and other parts, as well as eggs and shellfish. Early summer greens include *ikituut* (wild celery, *Angelica lucida*), *angukaq* (wild rhubarb, *Polygonum alaskanum),* and *anuqtuliar* (yarrow, *Achillea millefolium)*; *ikituu*t and *anuqtuliar* are also well known medicinals (Fienup-Riordan 1983:116; Jernigan n.d.:97-101). *Mecuqelugaq* (wild parsnip) roots are enjoyed fresh with seal oil. *Taperrnaq* (beach grasses, including *Elymus arenarius*, also called rye grass*)*, *aatunaq* (sour dock, *Rumex arcticus), iitallret* (pond grasses), and willow leaves (*Salix* spp.) were harvested en masse and stored in seal oil. *Akutaq* is a delicacy, a mixture of greens, seal oil, milk, and sugar (Fienup-Riordan 1983:118). *Melqruuaq* (cotton grass, *Eriophorum* spp.) was also harvested for use as stuffing, medicine, and food (Jernigan n.d.:58-9).

When the cotton grass is ready, it signals that the *naunraat* (cloudberries, *Rubus chamaemorus*) are also ripe. Starting in late July or early August, berry-picking may carry on for several social weeks on the marshy flats, with families assembling 100 pounds of *naunraat* in good conditions (Fienup-Riordan 1983:122-3). The berries could be stored layered in *quagcit* (wild spinach) in grass baskets, or in a gunny-sack, stored beneath the water of the pond, or in seal guts buried in pits. *Akutaq,* Eskimo icecream, would be made throughout the winter, whipping cloudberries together with salmon eggs or fish livers and seal oil (Jernigan n.d.:47-8). Later in August, willow ash was made in large quantities to be chewed with tobacco. At this time, both *tan'gerpiit* (crowberries) and *curat* (blueberries, *Vaccinium uliginosum*) were harvested in the hills, as well as *naucetaat iinrut*, medicinal plants, such as *caiggluk* (wormwood, *Artemisia tilesii), qaltaruat* (leaves for chewing with ash), and *palurutaq* (mushrooms, *boletacia*) (Fienup-Riordan 1983:124).

The final gathering of the growing season is for *utngungssaq*, 'mouse food', gathered from rodent burrows. This includes the edible roots and underground stems of *iitaat* (sedges, *Carex* spp.) and cotton grass. Beach grass is once again gathered en masse after first frost, to be used for basket-making, boot insoles, mats, and other domestic manufactures through the winter (Blue 2007; Fienup-Riordan 1983:126-7). *Tayarat* (mare's tail, *Hippuris tetraphylla)* is also harvested after first frost in brackish ponds by skimming the surface with a rake; the plant is eaten cooked as a green vegetable (Jernigan n.d.:69).

Palaeoethnobotany in Alaska

Despite the richness of the ethnobotanical record in Alaska, and its ongoing documentation by Alaska Native communities, palaeoethnobotanical analyses are incredibly rare. Though plants preserve extremely well in northern conditions, most archaeological studies of diet and subsistence focus on sea mammal and terrestrial hunting and fishing. The handful of palaeoethnbotanical studies conducted to date in Alaska are summarized here. Lepofsky and Winant examined archaeobotanical remains left by Qikertarmuit at Three Saints Harbor on Kodiak Island, a site occupied from the late 18th to early 19th centuries by Russian traders. This analysis yielded very high densities of red elderberries (*Sambucus racemosa*) and especially salmonberries (*Rubus spectabilis*) and low frequencies of *Rumex* species and a single geranium family member; the investigators assessed that berries were being used to make a drink, possibly an alcoholic one (Crowell 1997:115). Claire Alix (2009, 2016) has analysed ancient wood use across the North American Arctic, determining both the diversity of taxa collected by ancient Inuit and the range of their uses. Northern Alaskan Thule assemblages, for instance, are dominated by spruce (*Picea* spp.) and willow (*Salix* spp.) (Alix 2009:186-7). Investigators have also studied the historic adoption of gardening practices—particularly the growing of potatoes and other root foods—by Unangan (Aleut) and Tlingit communities alongside the continuation of native plant use (Moss 2005; Veltre 2011). Finally, I conducted an analysis with Dana Lepofsky at Cape Addington Rockshelter, a site excavated by Madonna Moss on the Prince of Wales Archipelago in southeast Alaska. We identified fifteen taxa, including edible plants such as crabapple (*Pyrus fusca*), red elderberry, bearberry

(*Arctostaphylos uva-urs*i, also known as kinnikinnick), sea thrift (*Armeria maritima*) and what is probably salmonberry (*Rubus* cf. *spectabilis*) (Lepofsky et al 2001, 2004). Other taxa were primarily charred and uncharred wood, including Douglas-fir, transported to the Archipelago on drift currents from central British Columbia (Lepofsky et al 2003).

These studies show both the relative richness and utility of palaeoethnobotanical analyses in Sub-arctic and Arctic regions. Apart from Alix's work, all studies to date have focused on sites at the southern extent of Alaska, where the biodiversity is greater, and all are conducted at coastal sites. Palaeoethnbotany has great promise further north (and in interior sites) because of the wide-ranging use of plants by all Alaska Native groups in addition to the high preservation potential of tundra landscapes.

Preservation & Palaeoenvironment

The palaeoenvironment of Alaska is known at a relatively macro-level based on geological, pollen, and botanical collections. Vegetation patterns are comprised of a combination of Asian species via the Bering Land Bridge and North American species. During warmer intervals of geologic time, such as the Hypsithermal Interval of 6-4000 years ago, the treeline, characterized by spruce forests, ranged further north than present distributions (Hulten 1968:xvi). Togiak, located on the north shore of Bristol Bay, is currently located north of the treeline. The site is located on a small lowlying peninsula that extends west into Bristol Bay. At the tip of the peninsula is a cluster of large buildings that house a fish cannery. From the air, a large number of house mounds and beach ridges are visible southeast of the cannery.

Pollen diagrams from the Togiak site indicate a high proportion of scrubby alder (*Alnus viridis*), in addition to lower and relatively even proportions of willow (*Salix* spp.), cottonwood (*Populus* spp.), birch (*Betula* spp.), ericaceous shrubs, and white spruce (*Picea glauca*) (Zutter 2016, and following). Among non-arboreal plant taxa, grasses and sedges dominate, followed by low levels of wormwood (*Artemisia tilesii*), knotweed (*Polygonum* spp.), gooseberry (*Ribes* spp.), buttercup (*Ranunculus pallasii*), violet (*Viola* spp.), and thistle (*Cirsium* spp.) pollen. Trace percentages of stinging nettle (*Urtica gracilis),* myrica gale *(Myrica gale),* mint *(Mentha spp.),* water milfoil *(Myriophyllum sibicirum)*, and pink family (Caryophyllaceae) pollen are present. Kristen Barnett (pers. comm.) notes a diversity of tundra plants and beach grasses growing on site. These include fireweed (*Epilobium angustifolium*), ferns, crowberries (also called blackberries, *Empetrum nigrum*), caribou lichen (or reindeer lichen), labrador tea (*Rhododendrom groenlandicum*), dwarf dogwood (*Cornus suecica)*, lowbush cranberry (*Vaccinium oxycoccus* or *V. vitis-idaea)*, cloudberry (also known as salmonberry), beach greens, sour dock (*Rumex arcticus)*, bog blueberry (*Vaccinium uliginosum)*, wild chives (*Allium schoenoprasum*), horsetail (*Equisetum* spp.), stinkweed (also known as wormwood), wild celery (*Angelica lucida)*, and kelp.

Climate change is affecting this part of the coast and the rate of permafrost thaw, but not to the extent seen further north on the Alaska and Yukon North Slopes bordering the Arctic Ocean and Beaufort Sea. Permafrost presently keeps the Togiak deposits frozen for a good part of the year, with summer inducing partial thawing of exposed and surficial site deposits. Preservation varies across site. At the east end of the site, preservation has been impacted by factors including subsistence digging and looting, exposure from excavations by Kowta (1963), and shoreline erosion. At a larger scale, some parts of the site have been destroyed by construction of the cannery, local roads, and the airstrip. The cores collected on site for this analysis were not affected by these factors, however, and appear to have good depositional integrity.

Methods

Old Togiak village, Temyiq Tuyuryaq, is located on the Twin Hill side of Togiak Bay on the north coast of Bristol Bay, Alaska. Geomagnotometry was used to map the sub-surface features of the site, which in turn was used to guide core sampling. A total of 32 core samples was collected from the site. Each core is approximately 2 cm in diameter and provides a stratigraphic and occupational sequence. The cores were later sliced lengthwise and analysed under 60-100x resolution using a dissecting scope. Cores were sectioned into natural and cultural layers and the cultural layers separated from the matrix via standard bucket flotation using a 1/16" screen. The light and heavy fractions were separated into their constituent parts, including lithics, fauna, plant macroremains, and pottery. Pollen was extracted from sediment samples.

Sixty-seven spot samples extracted from ten cores are represented in the palaeoethnobotanical analysis (after two were found to be non-viable). The plant macroremains include uncharred seeds, stems, moss, lichen, algae, wood, charcoal flecks, rootlets and bark. Larger wood and charcoal was separated for another analysis. All macroremains derived from the cultural layers and tabulated in this analysis are uncharred—with the exception of charcoal flecking--and considered archaeological. Each sample was sorted into its constituent parts using a dissecting microscope (6-30x). Type specimens were viewed and photographed using a dino-lite digital microscope (>100x).

A range of resources were used for identifications including the Ursus reference collection, seed volumes, Alaska and Western Arctic plant guides, lists, and floras, digital seed databases, as well as valuable aid from Kristen Barnett (Black and Fehr 2002; Burt 2000; Bojnanský and Fargašová 2007; Cappers 2006; Eflora BC; Hulten 1968; Jernigan n.d.; Lévesque et al. 1988; MacKinnon et al 2009; Martin and Barkley 1961; Montgomery 1977; Porsild 1957; US Fish and Wildlife Service 1997; USDA Plant Database n.d). Plant taxa were identified according to the most certain level of confidence. A '*cf.*' before any part of a designation means that the identification is uncertain but probable. A '?' before any part of a designation indicates that the identification is possible. The phytogeography of the species is also considered in cases where multiple species of a single genus, which are not anatomically distinguishable, are present in the study area. Morphological criteria used for seed identifications include dimension, shape, and surface characteristics (as per Montgomery 1977: 2-3). The term 'seed' is used in a generic sense to represent all botanical fruiting structures such as drupes, capsules, berries, endocarps, achenes, etc.

There are a number of factors that limited the identification of certain classes of macroremains. Uncharred wood was the most abundant constituent of samples, but was present as fibrous fragments too small for identification. Charcoal occurred as flecks too small for identification. Grasses were compressed stems lacking seeds and inflorescences that might help identify them. Macroremains such as rootlets and twigs are generally not identifiable unless particular specimens exhibit characteristic features. In future, having a palaeoethnobotanist or knowledgeable crew and/or community member on site that could conduct a botanical inventory, create a reference collection, and make observations on site formation processes affecting plant deposition would greatly aid the analytic process.

Macroremains were recorded by count or presence (Table 1, Appendix 1). Seeds are tallied by count. Whole seeds were counted as 'one', while half or partial seeds were counted as 'one half'. All other macroremains are marked as present since counts will not yield MNI information and most weights are negligible. Analysis includes a limited quantitative examination of archaeobotanical data, including explorations of ubiquity, taphonomy, seasonality, and ancient plant use.

Results: Plant Inventory

This plant inventory describes each plant taxon identified in the Togiak village archaeobotanical assemblage. The inventory is organized by botanical order, family, and genus and species within these. Yup'ik names are provided where known. Each entry describes the presence and context of the specific taxon, its ecology and associated ethnobotanical knowledge. Pictures of individual taxa show their colour and condition after considerable time underground and don't generally reflect their looks when 'fresh'. Ecological information is primarily derived from Hulten (1968) and the Togiak National Wildlife Refuge Plant List (US Fish and Wildlife Service 1997). Ethnobotanical knowledge is derived from published and unpublished resources, particularly the Yukon-Kuskokwim Ethnobotany (Jernigan n.d.), Aleut-Unangax Ethnobotany: An Annotated Bibliography (CAFF 2006), The Nelson Island Eskimo (Fienup-Riordan 1983), and local knowledge about specific plant taxa from Kristen Barnett and Annie Blue (2007).

In Table 1, I present an overview of plant macroremains identified in the Togiak archaeobotanical assemblage. Appendix 1 provides the complete data. Overall, 67 samples are represented since one sample was void and another empty of the original 69 spot samples (the empty sample was the sole sample from core 6.1, so it is removed from Table 1). A conservative count of nine plant taxa from eight families is represented in the Togiak archaeobotanical assemblage. However, the number is likely greater since several families each of algae, grasses, sedges, and mosses are present.

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Table 1. Overview of Plant Macroremains in Togiak Archaeobotanical Assemblage

Common name[1]	**Frequency (n)**									**Total (n)**
Core	**1**	**3**	**4**	**7**	**9**	**10**	**28**	**29**	**30**	
No. Samples	4	2	3	2	4	3	15	27	7	**67**
Seeds										

Cloudberry							6.5	19		**25.5**
Crowberry						2	9.5	125		**136.5**
cf. Red raspberry							0.5	1		**1.5**
Sedge							1	2		**3**
Wormwood								1		**1**
Unidentified							3.5	14.5		**18**
Totals	**0**	**0**	**0**	**0**	**0**	**2**	**21**	**162.5**	**0**	**185.5**
Other Plant Parts										
Sedge stem									1	
Grass stem	x						x	x		
Wood fibre	x	x	x	x	X	x	x	x	x	
Charcoal flecking						x	x	x		
Deciduous bark					X	x	x	x	x	
Rootlets		x	x			x	x	x	x	
Twigs	x				x	x	x	x	x	
Moss							x	x		
Flower petal	1									
Thorn									1	
Kelp			x		x	x	x	x	x	
Kelp bladder					x		x	x	x	
?Reindeer lichen							x	x		

1. Yup'ik terms and Latin names are found in the inventory below.

ANGIOSPERMS: MONOCOTS

Cyperaceae (Sedge family)

Carex spp. / *Utngungssarat, utngungssaq, kelugkaq*

One stem and three achenes (seeds) from three different contexts were identified as sedges in the Togiak assemblage. The stem is triangular in shape, identifying it as a sedge. Sedges are robust plants that serve as soil stabilizers in both streamside and wetland systems throughout the world (Wilson et al.

2008:14-16). *Carex*, the most abundant genus of the sedges, grows in moist to fully inundated conditions, in fresh and saline water. Sedges are used in (at least) two ways by Yup'ik peoples. The fleshy base of the stems are part of a group of foods known as 'mouse foods', which are cached by voles in fall, and in turn collected by people. Mouse food, known as *utngungssarat* and *utngungssaq,* is eaten with seal meat or seal blood soup (Jernigan n.d.:57). Lyngby's sedge, in particular, grows in monocultural stands and is harvested en masse for household uses by Yup'ik communities. Known as *kelugkaq*, the seeds can be cooked and eaten like rice, while the stems are dried and braided for mats, baskets, boot liners, and other uses (Blue 2007; Jernigan n.d.:124).

Figure 1. Sedge achene (seed)

Poaceae (Grass family) / *Taperrnaq*

Compressed grass stems are present in eleven spot samples at Togiak. Unfortunately, there are neither seeds nor inflorescences present to speciate these grasses. A variety of beach grasses, described earlier, are used by Yup'ik communities for household technologies. One of the most common beach grasses is rye grass (*Elymus arenarius*), which is ubiquitous on sandy beaches across the circumpolar north (Hulten 1968:193). Elders say the salt water makes it extremely tough and good for fish baskets, jump ropes, and other uses (Jernigan n.d.:127).

Figure 2. Compressed grass stem

ANGIOSPERMS: DICOTS

Compositae (Aster family)

Artemisia tilesii (wormwood, stinkwood) / *Caiggluk*

A single *Artemisia* seed was recovered in the Togiak assemblage. This is a cosmopolitan herbaceous perennial with a wide northern distribution that thrives in disturbed contexts, such as human habitations (Burt 2002:188). Yup'ik peoples, as well as Unangan, used the petals, stems, and plant as a whole for many medicinal purposes, including respiratory and skin conditions, pain and arthritis, sore throats and colds, and as a general tonic taken as tea or poultice (Jernigan n.d.:102; CAFF 2006:4; Overfield et al 1980). The strong pungent smell of the plant can remove unpleasant odours, and can be burned as an insect repellant (Jernigan n.d.:103; Overfield et al 1980).

Figure 3. Wormwood seed

Ericaceae (Heather family)

Empetrum nigrum (crowberry) / *Tan'gerpiit*

Crowberries are the most abundant seeds recovered at Togiak, with 136.5 identified in nine contexts. Over three quarters of them (n=104) were recovered from spot sample C160, explored further in the discussion. Crowberries are a trailing woody perennial that form dense groundcover and are common across the circumpolar north (Hulten 1968:716). Crowberries were used as both food and technology by Yup'ik and many other northern peoples (cf. CAFF 2006:5). The berries were gathered both at the beginning of spring as the snow melted and again in the late summer (Fienup-Riordan 1983:124). They were often prepared into *akutaq,* "Eskimo ice cream", and could be used to relieve thirst (Jernigan n.d.:40-1). Juice could be made to relieve sore eyes; dye was made from the dark purple to blueish berries; and the branches were sometimes used for fuel and bedding (CAFF 2006:5; Jernigan n.d.:40-1).

Figure 4. Crowberry seeds

Rosaceae (Rose Family)

Rubus chamaemorus (cloudberry, salmonberry, baked-apple) / *Naunrat*

Cloudberries are the second most abundant seeds in the Togiak assemblage, with 25.5 seeds distributed across eleven contexts. Cloudberries are one of the most common edible species in the north. The plant is a low herbaceous perennial that prefers peaty substrates (MacKinnon et al 2009:95). The berries were harvested in mid-summer and could traditionally be stored in a gunny sack in the water until freeze-up and then in a seal gut bag through the winter. They were eaten fresh and in the cold seasons as *akutaq* (Jernigan n.d.:47-8).

Figure 5. Cloudberry seeds

Rubus cf. *ideaus* (red raspberry)

Two seed fragments from different contexts look like red raspberry based on their shape, size, and surface reticulation. Red raspberry is an upright shrub that grows in thickets across Alaska and the Canadian North and will often hybridize with other raspberries, such as *Rubus spectabilis* (Hulten 1968:604). Like other raspberry species, the berries and early spring shoots of red raspberry were commonly used as foods, and the leaves as medicine, particularly for women's reproductive health (Hrdlicka 1945; MacKinnon et al 2009:94-5). This species is mentioned in regional but not local plant lists and guides; it may either go by another common name or it could have grown here in the past but not the present.

Figure 6. Possible red raspberry seed

Unidentified seeds

Eighteen unidentified seeds and fragments and sixteen unidentified seed coats were recovered from the Togiak assemblage. These seeds cannot be further speciated without the aid of a local reference collection.

Deciduous bark

Deciduous bark was found in nine spot samples in the Togiak assemblage. The bark is smooth and generally greyish brown and may be alder (*Alnus* spp*.).* Several sub-species of scrub alder grow in vicinity of the Old Togiak village. Alders are used medicinally for pain and widely used for smoking fish, as a general fuel and a yellow dye, and for making ash to combine with tobacco (as a second choice to willow; Jernigan n.d.:13-14).

Figure 7. Deciduous bark

Woody parts

A wide variety of woody parts were found in the Togiak archaeobotanical samples. These include wood fibre (n=36 samples), rootlets (n=11), twigs (n=12), and charcoal flecks (n=7). The majority of these woody parts are too fragmentary and/or friable to identify. Larger wood and charcoal specimens are being identified in a separate analysis.

Thorn

A single woody thorn was recovered from spot sample C274. Based on the general lack of prickly plants in the area, this may be derived from red raspberry, but more likely, based on the thickness of the thorn, it is from a thistle (*Cirsium* spp.).

Flower petal

A single tiny blue flower petal was recovered from spot sample C009. There are at least 20 wildflowers with blue to purple petals in the Arctic (Burt 2000:6-7), all of which are quite tiny, which precludes identification of this specimen.

MOSSES / *URUQ*:

Moss was present in eight of the Togiak samples, clustering in cores 28 and 29. In Yup'ik, moss is *uruq*, a general term that includes step, peat, and Sphagnum mosses (Jernigan n.d.:134). The moss in the Togiak samples is fragmentary but appears to be low-growing. Yup'ik peoples traditionally used mosses for cleaning, packing, and fermenting fish, as well as for sanitary and wicking purposes (Jernigan n.d.:134-6).

Figure 8. Moss specimens

LICHEN:

? Cladonia rangiferina (reindeer lichen, reindeer moss)

Lichen was present in four of the Togiak archaeobotanical samples. A variety of lichens grow in Arctic environments. One of the most common and widely used is *tuntut neqait,* reindeer lichen (Jernigan n.d.:146). It is widespread on the tundra of the Kuskokwim region, and was used by Yup'ik as an abrasive for cleaning and as a travel and famine food (Jernigan n.d.:146; also CAFF 2006:6).

Figure 9. Possible reindeer lichen

ALGAE:

Algae is the most ubiquitous plant remain in the Togiak assemblage, found in 41 samples. Some specimens are shiny on one side and dull on the other; others are smooth or striated. Some have small bladders. These appear to be kelp, of which there are several families in the region, including ribbon kelp (*Alaria marginata),* bladderwrack (*Fucus gardneri),* and bull kelp (*Nereocystis* spp.). Based on the presence of bladders in nine samples, bladderwrack, known in Yup'ik as *elquat epuit* (Jernigan n.d.:144)*,* is definitely present.

Figure 10a. Algae (kelp)

Figure 10b. Partial kelp bladder

Kelps are commonly used for both food and technology by coastal Alaskans. Barnett (pers. comm.) notes that both bull and ribbon kelp are present around Togiak today, and sea lettuce (*Ulva* spp.) can be gathered further afield. Herring often spawn on "kelp". Bull kelp is harvested today from a boat, from which it can easily be cut. Both bull and ribbon kelp range from a golden color to brown. Amongst other coastal Alaskan, larger, thicker kelps were sliced to make rope, fishing lines, and once gardening was taken up, fertilizer (Bank 1956; CAFF 2006:5). One report based on Unangan knowledge from the Aleutians is of a short brown edible kelp that grows on rocks, likely bladderwrack, which is also known as rock weed (Kudrin 1980 cited in CAFF 2006:49). Another kelp used by Unangan peoples was peeled to reveal the "crisp and fresh, slightly salty" center (Ransom 1946 cited in CAFF 2006:64).

Results: Archaeobotanical Analysis

This section presents an archaeobotanical analysis of the plant macroremains recovered in the Togiak mounds. I begin by looking at the ubiquity and abundance of the most common taxa in the archaeobotanical assemblage, and then turn to discussions of site-level taphonomy, ancient site use, and seasonality.

Ubiquity & Abundance

Ubiquity is percent presence, referring to what percentage of samples a specific plant part is found in. In Figure 11, I present the most ubiquitous plant taxa in the Togiak assemblage. In the chart, the ‘n’ on top of each bar refers to the frequency of contexts each taxon is found in. For example, kelp is the most ubiquitous macroremain, found in 61.2% or 41 of 67 samples. Kelp is followed in ubiquity by wood fibre, cloudberry and grass stems, crowberry and moss. Many samples contain a combination of wood fibre, other woody parts, and sometimes kelp and a few seeds; many other samples are kelp alone.

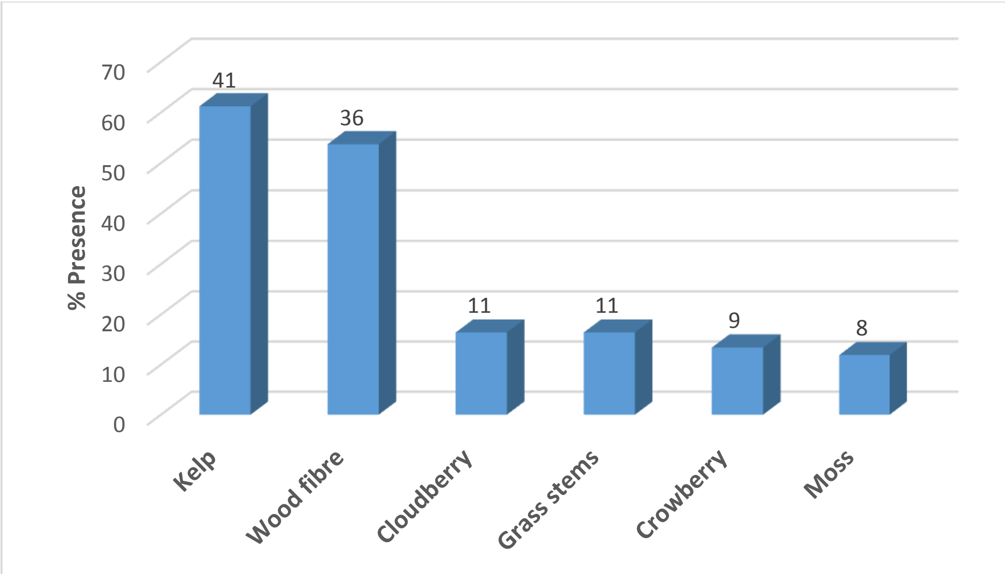

Figure 11. Most ubiquitous plant taxa in the Togiak assemblage

While the overall diversity and abundance of macroremains is moderate, there is some patterning within the Togiak assemblage. Overall, a greater density of organic plant materials is found in the deeper mound sequences, a simple fact of preservation. The majority of woody parts, kelp, lichen, moss and seeds are found in core 10, and to a greater extent core 28 and 29. There are 185.5 seeds total in the seed assemblage, with a notable clustering within cores 28 and 29. The largest proportion of seeds is found in sample C160, deep within core 29. It is quite possible that the crowberry (n=104) and cloudberry (n=10.5) seeds found here may have been situated within a storage context, such as a basket that has since decayed.

Taphonomy & Ancient Plant Use

The Togiak mounds are as much as 4 metres thick in places and contain dense layers of organic material. Here I ask what site formation processes deposited the plant macroremains identified and what traces of ancient plant use activities can be discerned from the archaeobotanical assemblage. All plant macroremains in the assemblage are uncharred except for occasional charcoal flecking. The plant taxa identified are local to the site area—derived from foreshore, beach, open, disturbed, and tundra locales—and all represent angiosperms or flowering plants rather than conifers (nb. no spruce parts were identified). These plant parts could either have been deposited on site naturally or culturally. Natural vectors of deposition could include insects, rodents, wind, and wave action. Seeds in particular move around easily and could be deposited as seed rain. All plant taxa in the assemblage have known ethnobotanical uses amongst the Yup'ik and were likely *also* harvested and deposited via cultural uses as foods, medicines, technologies, and other purposes.

Several plants in the Togiak assemblage are food plants. 'Mouse food' is represented by sedge seeds; fruits by crowberry, cloudberry, and red raspberry; and, both lichen and algae (kelp) are occasional food sources. Crowberry and cloudberry, as the most abundant of the berries, may have been deposited on site in the course of cultural processes such as preparation, consumption, and storage. While several cores yielded fauna and charcoal, no charred plant remains were recovered and there is therefore no trace of cooked plant foods.

There are a number of technological plants in the assemblage. These include sedge and grass stems, moss, lichen, kelp, bark, and many woody parts. Sedges and grasses were used for baskets, mats, bedding, and lining, while grasses and kelp were braided into rope, fish line, and the like. Lichens are an abrasive, moss an absorbent, and wood and bark were used for fuel, building, and weaving. Apart from kelp, the most abundant macroremain is uncharred wood that is present is fibrous fragments pressed together often at cross-angles. It looks as though this material could well have been used for roofing insulation, in addition to the winter snow layer.

Several medicinal plants are also present in the Togiak assemblage. Wormwood is a wide spectrum plant medicine all of whose parts can be used for specific maladies and as a general tonic. All members of the raspberry family are known to have medicinal properties; raspberry leaf tea continues to be widely used today to encourage healthy reproduction, pregnancy, and birthing.

Seasonality

The growing season is short and often spectacular in the Arctic, making seasonal assessments based on the ripening of local plants limited to about half the year. Spring comes in late April to May, summer is July and August, and first frost may be in late August or September. The Togiak assemblage potentially contains plants from throughout the growing season. The best seasonal indicators are seeds not stored for winter use, but all components of the Togiak plant assemblage were potentially harvested for year-round use. Red raspberries ripen in early to mid-summer, cloudberries in mid-summer, and crowberries later in the summer. Wormwood flowers in summer but would have been collected in late August or September when the plant medicine was strongest. Different sedges flower throughout the summer months. While highly generalized, this limited pattern indicates that Togiak villagers were present on site through at least parts of the growing season, enough to harvest key plant resources, potentially reflecting the annual cycle suggested by the Nelson Islanders (Fienup-Riordan 1983).

Discussion & Prospects

The Togiak archaeobotanical assemblage is limited but shows great promise and prospects. Nine plant taxa from eight families include plants used as foods, technologies, and medicinals by Yup'ik peoples of the past and present. All plant macroremains recovered on site are uncharred, with the exception of charcoal flecks, suggesting a combination of natural and cultural depositional processes. The small seed assemblage has greatest density within the deeper mounds, where there is less disturbance and greater preservation potential from the permafrost. A sequence of radiocarbon dates from the Togiak mounds place its occupation ca. 150 to 725 years ago (Barnett pers. comm.). These dates are comparable with Kowta's (1963) estimates based on artifact sequences.

The range of plant taxa present in the archaeobotanical assemblage has close parallels with pollen diagrams at Togiak. Pollen microremains and plant macroremains are complementary as data sources because pollen deposition is clearly natural while the deposition of macroremains is a combination of natural and cultural processes (cf. Pearsall 2000). The three most common taxa in the pollen diagrams are grasses, sedges, and alder, the first two present and the third likely present in the macroremain data (Zutter 2015, and following). *Artemisia* is also present in both data sets and potentially thistle as well. Many taxa with known ethnobotanical uses are present in the pollen data that would likely show up with further on-site sampling of macroremains, such as currants (*Ribes* spp.), willow (*Salix* spp.), spruce (*Picea* spp.), and additional members of the heather family (beyond crowberry), such as bearberry (*Arctostaphylos alpina*) and bog cranberry (*Vaccinium oxycoccus*). Alternatively, two taxa that appear in the macroremains but not the pollen are the raspberry species, cloudberry and red raspberry. Their presence on site is in large part a reflection of cultural use and deposition.

Though limited in overall diversity, the Togiak data adds a great deal of knowledge to Alaskan palaeoethnobotany. Many of the plant taxa identified have never been documented within Alaskan sites, including all of the berries, wormwood, mosses, lichens and algae. The most abundant edible taxa—cloudberry and crowberry—are especially notable, since they are ubiquitous in Arctic landscapes and used widely by Yup'ik and other northern peoples. The Togiak assemblage also shows an ecological gradient with sites to the north and south. Our work at Cape Addington Rockshelter in the Alaskan panhandle produced several species of conifers, including Douglas-fir deposited as driftwood, red elderberry, and salmonberry (Lepofsky et al 2001), that are beyond their range in Bristol Bay (though climate change is rapidly shifting these distributions). Conversely, based on the combined arboreal data from pollen and macroremains, diversity is greater at Togiak than further north, well beyond the treeline where there is an even greater reliance on driftwood (cf. Alix 2009, 2016).

This study is intended as a preliminary exploration of ancient plant use at the Old Togiak village, Temyiq Tuyuryaq. The assemblage presented here makes a great beginning from which to build. As suggested, several classes of plants that do not generally survive further south are present in the Togiak samples, including many uncharred components and particularly the soft parts such as stems, petals, lichens, mosses, and algae. These data sources show exciting promise for future study. There are currently a number of data and identification gaps that can be filled with greater familiarity with Alaskan plant species, assembling more ethnobotanical studies and knowledge, conducting a plant inventory in vicinity of the site, and building a local reference collection. In time, a more refined data set could allow us to look at variability of plant macroremains across space and time on site and to address questions about the persistence and change of Yup'ik foodways, medicinal and technological traditions.

Acknowledgements. Many thanks to John Blong, Doug Veltre, and Chuck Arnold for suggesting plant resources. Special thanks to Kristen Barnett for help with local plant and cultural knowledge and to Kristen and Anna Prentiss for their site knowledge.

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Appendix 1. Inventory of Plant Macroremains from Togiak Mound Cores

Provenience				Seeds							Other Macroremains													
Core no.	Sample no.	Radiocarbon dates (cal BP)	Approximate depth	Cloudberry (*Rubus chamaemorus*)	Crowberry (*Empetrum nigrum*)	Red Raspberry (*Rubus* cf. *ideaus*)	Sedge (*Carex* spp.)	Wormwood (*Artemisia tilesii*)	Unidentified Seeds	Total	Sedge stem (Cyperaceae)	Grass stem (Poaceae)	Wood fibre	Charcoal flecking	Deciduous bark	Rootlets	Twigs	Moss	Flower petal	Thorn	Unidentified seed coats	Algae / Kelp	Kelp bladder (cf. *Alaria marginata*)	?Reindeer lichen (*Cladonia rangiferina*)
1.2	C009	301-357																	1					
1.2	C006	388-344															x							
1.2	C007	388-424										x	x											
1.2	C010	493-531										x												
3.1	C019	141-152											x											
3.1	C021	141-152														x								
4.1	C016	345-441											x											
4.1.1	C067	571-671											x									x		
4.1.1	C069	571-671											x			x								
7.1	C030	672-706											x											
7.1	C035	672-706											x											
9.1	C102	569-643																				x		
9.1	C101	571-617															x					x		
9.1	C199	571-617											x											
9.1	C276	571-671																				x	x	

10.1	C043	388-424											x	x		x	x					x		
10.1	C044	388-424			2					2			x			x								
10.1	C050	388-424											x		x		x							
28.1	C224		27-43cm														x							
28.1	C238		53-74cm													x						x		
28.2	C246	543-623	3.5-12.5cm										x									x		
28.2	C251	543-623	3.5-12.5cm	1	2	1				4			x	x							1	x		
28.2	C232		12.5-26cm	1						1		x	x					x				x		
28.2	C219		27.5-34cm	2.5		0.5			1	4								x				x		
28.2	C264		31-34cm									x			x									
28.2	C260		36-45cm						0.5	0.5			x									x	x	
28.3	C254		6-14cm	0.5	6.5				1	8		x						x				x		
28.3	C267		6-14cm										x											
28.3	C182		17-24cm		1		1			2			x									x		
28.3	C205		28.5-53cm	1.5					1	2			x					x			1	x	x	
28.3	C206		28.5-53cm										x											
28.3	C237	296-318	53-74cm										x									x		x
28.4-28.3	C192	689-723	21.5-34/0-6cm									x	x			x		x				x		
29.1	C175		8.5-10cm									x				x						x		
29.1	C173		10-12.5cm						0.5	0.5												x		
29.1	C181		10-12.5cm				1			1						x						x		
29.1	C147		12.5-19.5cm																			x		
29.1	C142		12.5-19.5												x		x					x		
29.1	C144												x											
29.1	C190		25.5-29cm									x										x		
29.1	C174		30-34cm													x							x	
29.1	C141		36-42									x										x		
29.1	C145	337-441	45-53cm										x	x		x								
29.1	C148		45-53cm						1	1			x											
29.1	C149		45-53cm																			x		

29.1	C136		53-70.5						0.5	0.5			x	x		x						x		
29.2-29.1	C151		48-87/0-4cm		1					1			x	x								x	x	x
29.2-29.1	C156		48-87/0-4cm	1.5	15				1	17.5		x	x	x			x					x		
29.2-29.1	C244		48-87/0-4cm									x												
29.2-29.1	C250		48-87/0-4cm																			x		
29.2	C249		0-4cm																			x		
29.2	C130		0-21.5cm	3	1				1	5			x	x	x			x						
29.2	C131		0-21.5cm																			x		
29.2	C139		0-21.5cm	0.5						0.5														
29.2	C273		0-21.5cm																			x		
29.2	C266		26-45cm										x									x		
29.2	C160		26-48cm	10.5	104		1			115.5								x			3	x		
29.2	C164		26-48cm	1	4					5			x					x				x		x
29.2	C170		26-48cm	2.5				1	10.5	14											11			
29.2	C145		45-53cm																			x		
30.1	C088	521-540	2-12cm								1						x					x	x	
30.1	C257	521-540	2-12cm												x									
30.1	C103		14-30cm												x		x					x		
30.1	C272		14-30cm														x							
30.2	C127	576-659	0-24cm										x		x							x	x	
30.2	C274	579-569	0-24cm										x				x			1				
30.2	C129	664-679	27-36cm										x										x	
Totals				**25.5**	**136.5**	**1.5**	**3**	**1**	**18**	**185.5**											**16**			