Archaeological Assessment of Geotechnical Cores and Materials, 2011 Statoil Ancillary Activities, Chukchi Sea, Alaska

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Prepared for

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EXECUTIVE SUMMARY

This report provides an archaeological assessment of seafloor coring and site survey activities conducted by Statoil USA E&P Inc. (Statoil) contractors Fugro Marine Geosciences in September, 2011, in the Chukchi Sea, Alaska, and describes archaeological analyses of recovered material. This review addresses a Condition of Approval on Statoil’s 2011 Ancillary Activities Notice. Technical assistance and quality assurance was provided by ASRC Energy Services, Anchorage, Alaska. Coring activities resulted in the recovery of wood fragments, which were subsequently dated to over 40,000 years of age. No cultural resources, of either historic or prehistoric origin, were identified in any of the materials recovered for analysis or in remote-sensing data acquired by the site survey and reviewed by the author of this report.

1. Introduction, Background, and Report Structure

This report provides an archaeological assessment of seafloor coring activities conducted by Statoil USA E&P Inc. (Statoil) contractors Fugro Marine Geosciences in September, 2011, in the Chukchi Sea, and describes archaeological analyses of recovered material. This review was conducted as a Condition of Approval on Statoil's 2011 Ancillary Activities Notice.

Geotechnical coring activities were carried out in selected blocks of the Statoil lease area, approximately 100 mi. west of Wainwright, Alaska (Figure 1). Descriptions of the study area, regional geography and climate, and their significance and impacts on human habitation are presented in Section 2. Potential for prehistoric and historic submerged cultural resources in the Chukchi is explored in Section 3. Descriptions of recovered material and subsequent analyses are described in Section 4. Acoustic imagery and seismic data are discussed in Section 5. Implications and report conclusions are presented in Section 6.

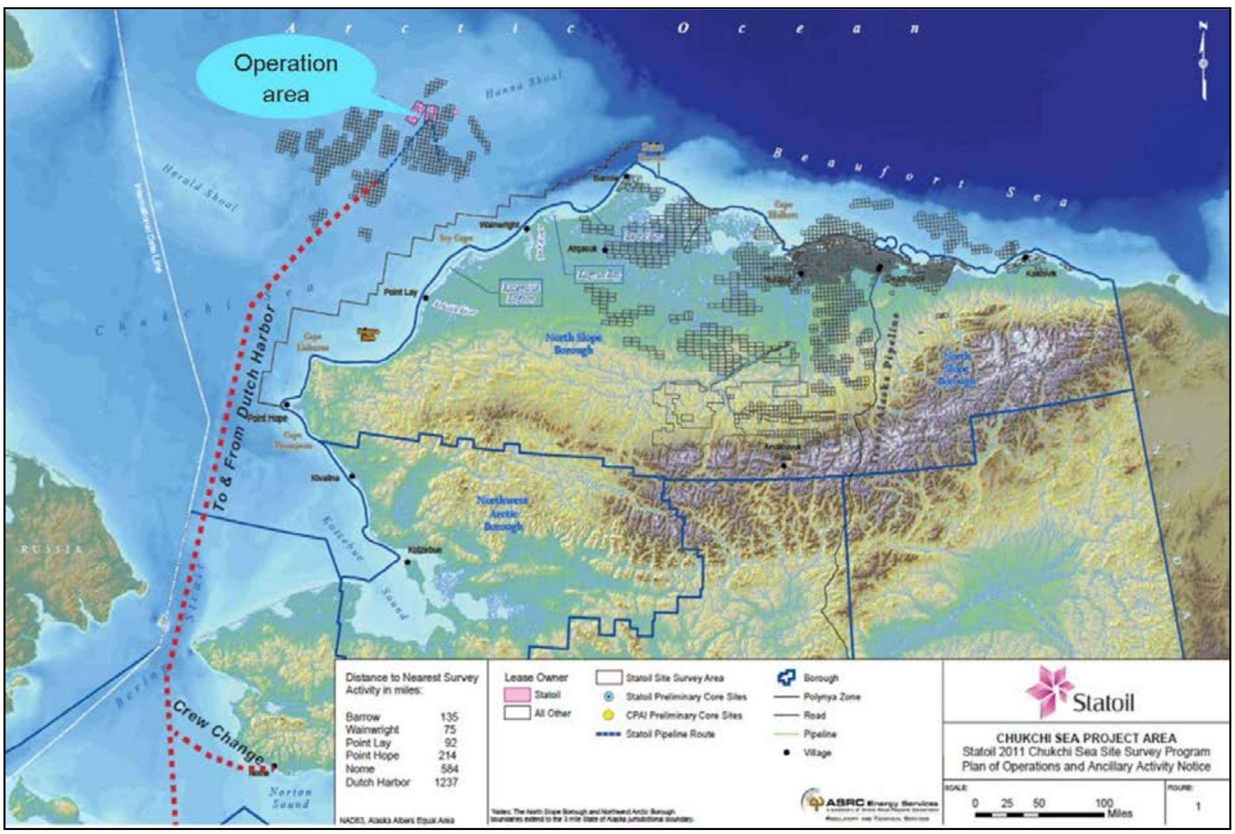

Figure 1. Project Area.

2. Geography, Climate, and Environment

Geography, climate, and environment are extremely significant factors in determining location, timing, duration, and spread of prehistoric human occupation. The Arctic is particularly interesting in this regard, as human inhabitants of the region have produced a number of highly successful subsistence and resource procurement strategies despite the cold and hostile climate. Climate changes throughout the Holocene have also had dramatic impacts on human populations as well as Arctic flora and fauna (Hoffecker 2005).

The Chukchi Sea is an approximately rectangular embayment of the Arctic Ocean, bounded on the west by the Chukotka Peninsula of Siberia, and on the east by the coast of northwest Alaska. It extends from the Bering Straits in the south to the seasonal limit of pack ice in the Arctic Ocean (Coachman et al. 1975; Aagaard 1987). The only major island in the Chukchi Sea, Wrangel Island, is located off the northern Siberian coast. The Alaskan coast from Wainwright to Point Belcher is exposed to the open ocean, allowing for both wave erosion and minor deposition. There are some sea-cliffs, but coastline topography is predominantly moderate (<2-5 m). Barrier islands from Wainwright to the Koocheak River protect the mainland from the most severe effects of waves, ice, and currents. The foothills of the Brooks Range intersect the Chukchi Sea around Cape Lisburne, where the shoreline is characterized by high sea cliffs. Northeast of Wainwright, a 20 km-long spit (Point Franklin) bounds Peard Bay, a large coastal lagoon. North of the Brooks Range, low bluffs and cliffs of the depositional coastal plain front the Chukchi Sea (Hartwell 1973).

Oceanographically, the continental shelf off the northwest coast of Alaska is relatively wide and shallow. The Chukchi Sea is located at the northeast end of the arctic continental shelf system, the world's largest, which borders the northern Eurasian land mass. The shelf system extends up to 600 km from the coast, and averages around 50 m deep. In the Chukchi Sea proper, there is a slight depth gradient from east to west, with the Alaska side averaging 30 m to 40 m in depth, and the Siberian side from 40 m to 50 m in depth (Coachman et al. 1975). The Chukchi Sea is actually rather anomalous in the arctic context, as it receives a tremendous northward discharge from the North Pacific Ocean and the Bering Sea through the Bering Strait. The influx brings nutrient-rich Pacific waters northward, and provides a migratory pathway between the Pacific Ocean and Arctic Ocean for numerous species including marine mammals (Aagaard 1987). For approximately eight months of the year the Chukchi Sea is covered by winter sea-ice and polar pack ice. However, arctic sea-ice cover has undergone significant changes in the past two decades, with four consecutive record minima attained between 2001 and 2005 (Eicken et al. 2006), a small expansion in 2006, but the lowest value ever recorded in September 2007 (Comiso et al. 2008). Although some recovery has been seen since 2007, the trend is towards shorter ice-cover seasons, and thinner ice-cover in general. These data have raised speculation that the Arctic Ocean may see entirely ice-free summers as soon as 2030 (Stroeve et al. 2007; 2012).

3. Potential for Submerged Cultural Resources

Potential for the existence of cultural resources in the project area is suggested from current theories of human migration and knowledge of the region's prehistoric geography. The growth of polar ice caps and continental glaciations during the Pleistocene resulted in sea levels lowered as much as 120 m below those of the modern era. During much of the late Pleistocene, the shallow continental shelf between Siberia and Alaska was thus exposed as dry land, referred to as the 'Bering Land Bridge' (Hopkins 1967). The region from eastern Siberia to eastern Alaska, encompassing the Bering Land Bridge, is often called 'Beringia' (cf. Hadley West 1996).

The Bering Land Bridge existed after about 80,000 years before the present (BP), but may have been shallowly flooded several times between 45,000 and 35,000 BP (Hopkins 1983). The landscape was arid, and glaciation was generally restricted to localized mountainous areas (mainly the Brooks Range and the Alaska Range), leaving vast extents of the region ice-free (Calkin 1988; Elias 2002). In the Chukchi Sea region, low sea levels had exposed the inner and central parts of the shelf as a broad, steppe-tundra valley. The Chukchi shelf was an important drainage pathway during periods of lowered sea level. Large drainage systems flowed down the valley, entering the Arctic Ocean through canyons near Wrangel Island and through the Barrow

Canyon (offshore from the modern coast of northwest Alaska (McManus et al. 1983:365; Hill et al. 2007; Hill and Driscoll 2008). With rising sea level, these valleys became estuaries, probably with near year-round ice cover. Due to the ameliorating oceanic influence, the now-submerged continental shelves of Beringia, including those of the Chukchi Sea, were likely the most biologically productive sector of the region from about 25,000 to 14,000 BP (Hopkins 1983:346).

The last glacial maximum (LGM) peaked at approximately 18,000 BP, and major deglaciation was underway by around 14,000 BP. The end of the Pleistocene is set by common convention at 10,000 BP. This date is somewhat arbitrary, but a number of important Pleistocene-Holocene transitional events tend to cluster around this time. In the Beringian context, one of the most important transitional events is the marine transgression leading to the final inundation of the Bering Land Bridge.

There is currently no comprehensive sea-level history for the Chukchi Sea. Data derived from radiocarbon dating of organic materials obtained from cores may be used to construct a sea-level curve, although variation may exist due to localized eustatic and isostatic conditions. Peat deposits from 50 m bsl (below current sea level) in the northern Chukchi Sea have been dated to 11,000 years BP (Elias 1996). The 50 m isobath is the lowest point of the Bering Straits, indicating that the land bridge was finally inundated by rising seas around this time. Dated peat samples from near Barrow indicate sea levels of 12 m bsl around 7000 to 6000 BP, and 1.5 m bsl at around 5000 to 4500 BP (Jordan and Mason 1999; Mason and Jordan 2002). Radiocarbon dating of peat and other organic deposits from the Beaufort Sea are generally in agreement with the above data from the Chukchi Sea. Beaufort Sea data indicate that at the beginning of the Holocene, sea level was at or below 50 m bsl. By 9000 BP, sea level had risen to about 44 m bsl, and was at 12 m bsl by about 6000 BP (Darigo et al. 2007). Within the project area, offshore waters range from ca. 37 m to 42 m in depth, meaning the seafloor in these areas was exposed until about 8,000 BP.

The existence of a land bridge between Asia and North America (and adjacent areas of exposed continental shelf) is of paramount importance for understanding theories of human colonization of the Americas (for example see Jablonski 2002; Bonnichsen et al. 2005; Morrow and Gnecco 2006). Although the possibility of an early maritime entrance is not ruled out (cf. Fladmark 1979; Dixon 1999), prevailing theories favor an overland route for the first humans in North America.

Human occupation in the New World dates from at least 15,000 cal BP (the Clovis complex in mid-latitude North America), although the oldest known archaeological sites in Alaska (the Swan Point and Broken Mammoth sites in the Shaw Creek Flats of the Tanana Valley) date to around 14,800 cal BP (Holmes 1996, 2011). Potential therefore exists for prehistoric archaeological sites along the submerged portions of the continental shelf of the Arctic and Chukchi Seas.

Theories of overland entry focus on the importance of terrestrial mammals, especially extinct Ice Age ‘megafauna’ (mammoth, steppe bison, etc.). Migrating herds of Ice Age fauna undoubtedly crossed the Bering Land Bridge, potentially drawing human predators in their wake- the first colonists of the Americas. In this view, the specialist mammoth hunters initially entered Alaska between the glaciated Brooks and Alaska Ranges, and then ventured south through an ice-free corridor between the Cordilleran and Laurentide ice sheets. Dikov (1983) has also suggested the possibility that mammoth hunters from north Yakutia crossed from Siberia to Alaska by a northern route, across what is now the Chukchi Sea. In any case, descendents of the initial colonists spread across both North and South America within 1000 years (Fiedel 2005). To achieve such rapid spread, groups would need to be highly mobile with few or no long-term habitation sites, and likely leaving traces only of hunting stations and overnight camps.

Traces of these camps in the archaeological record would consist of lithic artifacts (the remains of weapons, tools, and their manufacture), campsites (hearths, faunal remains, and tent rings), kill and butchery sites, and perhaps burials. The oldest archaeological sites in Alaska (the Denali complex sites of the Nenana and Tanana Valleys) are relatively ephemeral. Lithic artifacts are present, as is charcoal, and faunal material is sparse, except in rare deeply stratified sites such as Broken Mammoth and Swan Point (Holmes 1996, 2001, 2011).

No Holocene glaciations occurred in this rather flat and featureless zone (Calkin 1988), and no barriers to either faunal or human occupation are known. Hopkins (1983:346) suggests that human populations in Beringia prior to climatic amelioration circa 14,000 years ago would have been entirely dependent on land mammals for food as well as for other essential requirements. Because it likely had the mildest climate as well as the highest organic productivity, the now-submerged continental shelf might have been the most attractive to early human populations. The offshore areas of the project are therefore located within a region which has potential for the presence of highly significant remains of prehistoric human transit and occupation.

Recognizing the presence of prehistoric remains in the current underwater environment is difficult. Although sedimentation rates vary, virtually any deposition of sediment is likely to obscure visible traces of prehistoric human activity. Intact archaeological deposits would almost certainly be buried and thus apparent only after intrusive testing (coring or dredging). Though the likelihood may be small, the possibility of encountering prehistoric remains in the submarine environment certainly exists. Extensive paleoshoreline modeling in the Queen Charlotte Islands combined with remote sensing techniques (for example swath bathymetry) has led to the identification of high potential landforms such as paleobeaches, terraces, and fluvial confluences for archaeological sampling. Targeted "grab-bag" dredging on these high potential features has resulted in the retrieval of archaeological material from a depth of ca. 55 m in Werner Bay, western Hecate Strait (Fedje and Christensen 1999:647). This site was last sub-aerial at ca. 10,200 BP. Similar underwater investigations in shallower waters on the drowned continental shelf of Florida have resulted in the identification of a number of paleoindian sites, as well as the recovery of lithic debitage and diagnostic artifacts (Faught 2004). Underwater excavations in Europe have also resulted in retrieval of tremendously significant material, for example at the Mesolithic site of Tybrind Vig, Denmark (Anderson 1987) and along the continental shelves of France, Greece, and along the eastern Mediterranean (see Masters and Flemming 1983 for several case studies). Were Alaskan material to be added to this list, the significance would be hard to overestimate.

The potential preservation of prehistoric cultural remains in the project area is further complicated, however, by the dynamic environmental characteristics of the Chukchi Sea, especially the seasonal growth and movement of sea ice. Sea ice can be broadly classified in three forms: landfast (or shorefast) ice, stamukhi (or shear) ice, and pack (or polar) ice (Wadhams 2000; Leppäranta 2005). Landfast ice is attached to the shore, is generally immobile, and extends offshore to about the 20 m isobath. Landfast ice along the Chukchi coast of Alaska can also be frozen in contact with the seafloor, leading to the term ‘bottomfast’ ice (cf. Wadhams 2000). ‘Stamukhi’ ice is formed in the zone of dynamic interaction between landfast ice and pack ice. Intense shear and pressure ridging occurs in this zone, particularly in water depths between 15 and 45 m. Grounded stamukhi ridges form a stabilizing buffer zone at the seaward edge of the landfast ice zone, where incursions of polar pack ice impact the relatively immobile shorefast ice. Pack ice includes both first-year and multi-year ice and is mobile and dynamic, moving under the influence of winds and water currents. Ice formation and extent in the Chukchi Sea is seasonally variable. Ice formation generally begins in October, and reaches an annual maximum in February or March; melting begins in May or June and pack ice retreats during July and August. The Chukchi shelf is therefore under ice cover for 7 to 10 months each year (Belchansky et al. 2004).

Pack ice is subject to immense wind fields generated over a large area. Wadhams (2000:65) estimates that concentrated pack ice responds to wind fields integrated over a distance of up to 400 km upwind. The convergence of fields of moving pack ice (or pack ice impacting with shorefast ice) results in linear deformation features called pressure ridges. The intense pressures eventually build up ice masses both above the water’s surface (ice sails) and below (ice keels). Ice keels are far more extensive than sails (the average sail-height-to-keel-depth ratio is 1:4.5, although it may be as high as 1:9) (Kovacs and Mellor 1974:136). Ridge keels are also generally 2 to 3 times wider than sails (Wadhams 2000:65). Ice gouging occurs where ice keels are driven into the seabed, and are moved by the accumulated energies of the encompassing pack ice structure. The resulting furrows or tracks in the seafloor are described as ice gouges (Barnes et al. 1984), or ice scour (Wadhams 2000). Ice grounding and gouging are common in all arctic coastal waters, from the sea's edge to considerable depths (Kovacs and Mellor 1974). Seasonal patterns of ice formation and movement determine the locations and intensity of ice gouging. Although the most intense areas of ice gouging occur in the stamukhi zone, gouges have been observed in water depths from 0 to 125 m (Barnes et al. 1984:193). Limited or no gouging occurs in the landfast zone during periods of maximum ice extent, however gouging likely occurs in this zone during spring break-up. Barnes et al. (1984) also noted gouge widths up to ca. 70 m, and to depths of up to 5.5 m below the seafloor. Deep gouges tend to produce high flanking ridges to either side, creating combined vertical relief of up to 8 m. The highest gouge densities are in water between 20 and 40 m deep, as are maximum gouge depths. Gouges in water deeper than ca. 55 m are assumed by some researchers to be relict from periods of lower sea-level, as modern ice features do not generally have keels extending beyond ca. 60 m deep (Kovacs and Mellor 1974:146). Others, however, suggest that keels of great depth may occasionally form in shear zones along the shelf, and that deepwater gouges may thus be modern in origin (for example Reimnitz and Barnes 1974:344; also Barnes et al. 1984:190). Wadhams (2000:72) also ascribes deepwater gouges to rare pressure ridges of extreme depth, embedded in the polar pack, which scour the seabed without halting the pack as a whole.

No comprehensive study has been undertaken regarding the potential effects of ice gouging on submerged archaeological sites, and the consequent ramifications for site formation processes. Sediment cores collected from the stamukhi zone are turbated and lack horizontal stratigraphy. Both seaward and landward of the stamukhi zone, horizontal laminations produced by water currents are found, which suggests frequent reworking of bottom sediments by ice in the stamukhi zone (Barnes et al. 1984:206). A recent study of potential relict terrestrial landforms in the Beaufort Sea was restricted to the seafloor shoreward of the 20 m isobath, based on the assumption that shorefast ice would protect the bottom from winter gouging (Darigo et al. 2007). In the Chukchi Sea, the Minerals Management Service has concluded that "shipwrecks are likely to have survived in the [193] area, especially those that may be at a depth beyond intensive ice gouging" (MMS 2007:III-123).

3.1 Shipwreck Archaeology in the Chukchi Sea

There are 81 historic-period wrecks in the Chukchi Sea project area listed in the Alaska Shipwreck Database (MMS 2009). The earliest documented wreck in this region is the French whaling vessel *Caulaincourt*, which was caught in the ice off Point Belcher in September of 1861. The stretch of coast between Icy Cape and Point Belcher would prove to be one of the most dangerous areas of the Chukchi Sea, claiming at least 36 vessels over the next 50 years. A single calamity off Point Belcher, the 1871 whaling fleet disaster, was responsible for 31 shipwrecks in a single season. Another dangerous area was the region around Point Barrow, claiming at least 22 shipwrecks. Patterns of wreck event frequency and distribution are evident: most shipwrecks occurred near the shore, especially in the two areas mentioned above. Only six vessels are listed as being lost more than 25 km from land.

Two previous archaeological investigations have been undertaken in the Chukchi Sea region seeking to identify potential wreckage from the 1871 whaling fleet disaster. The first, dubbed the "Jeremy Project" after the main investigator, was undertaken in 1998 as a student project with collaboration from the US Coast Guard, NOAA, the MMS, and the US Navy (Ota et al. 1999). Using a remotely-operated vehicle (ROV) deployed from the USCG icebreaker *Polar Sea*, the team located the apparent remains of a wooden ship. Coast Guard and Navy divers subsequently dove on the target, confirming wooden remains at the site, and reporting a second possible wreck as well. No site map was ever prepared, and no archaeological report was issued.

The second project focusing on the wrecks of the 1871 whaling fleet was a four-year investigation headed by Minnesota shipwreck diver Randolph Beebe, with financial support from the National Science Foundation and National Geographic Society, and logistical assistance from the Barrow Arctic Science Consortium. In 2005, Beebe's team used specially-designed compact side-scan sonar and an inflatable boat to search for targets along the coastline (Beebe and Jensen 2006). The team returned for further field seasons in 2007 and 2008, when they focused on documenting the extensive wreckage and artifacts washed up along the shore between Wainwright and Point Franklin (Beebe 2008).

The survey of thirty-two miles of coastline between Point Belcher and Point Franklin located 219 artifacts or ship hull fragments. Ship remains varied in size and material from a 22 m hull fragment located on the westernmost point of Peard Bay to small iron fittings and fragments of ship sheathing. All hull fragments were surrounded by smaller pieces of wreckage. Their location in relationship with each other and differing details of ship construction indicate that they came from at least six discrete vessels. Other types of artifacts include a ship's rudder, compressed gunpowder, a chainplate, a mast parrel, and fragments of frames and planks. All artifacts were more or less evenly distributed along the whole stretch of coast from Point Belcher to Point Franklin, and most were located within 100 m of the surf zone.

Since these artifacts are distributed more or less equally along the entire search area, not just around the hull fragments, it is likely that the smaller wreckage comes not only from the further disintegration of shore artifacts, but also washes ashore from currently submerged sites. This hypothesis is supported by the fact that local beachcombers continue finding whaling irons and other artifacts after storms. The lack of large metal artifacts, such as ships' anchors, indicates that they remain on the sea bottom, possibly still in association with ship remains. The potential for archaeological resources therefore exists in the Chukchi Sea, although the effects of the ocean's dynamic and complex environmental processes must be taken into account.

4. Materials and Analyses

Materials recovered during the 2011 project and utilized for the archaeological assessment consist of the following:

1. Wood fragments, recovered from four separate boreholes.
2. Dedicated archaeology core sample (a single 1m core).
3. Geotechnical cores.

Materials, analytical methods, and results are described below.

4.1 Wood Fragments

Wood fragments were recovered from cores taken from four separate boreholes. Water depths ranged from 39.7 m to 40.3 m, and fragments were found at core depths ranging from 11.3 m to 26 m. Three of the cores (CHUK1200, 1201, and 1202) were taken from locations within 100 m of each other. The last (CHUK1000) was taken from a location over 3.5 km distant from the other three (Figure 2). These are among the first wood fragments ever recovered from the Chukchi Sea shelf, and potentially the farthest north ever found in Beringia (Figures 3-6). A summary of information relating to the wood fragments is provided in Table 1.

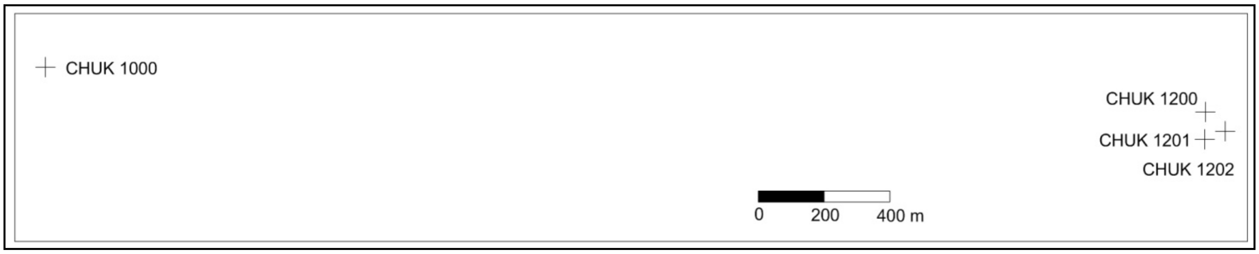

Figure 2. Map of core locations.

Figure 3. Wood fragments and gravel from borehole CHUK-1000.

Figure 4. Wood fragments from borehole CHUK-1200.

Figure 5. Wood fragments from borehole CHUK-1201.

Figure 6. Wood fragments from borehole CHUK-1202.

4.11 Dating and Speciation

Samples from each batch of wood fragments were submitted for Accelerator Mass Spectrometry (AMS) radiocarbon dating both at Beta Analytic laboratories and the University of Arizona/National Science Foundation AMS radiocarbon facility. Beta Analytic was able to date only one sample (CHUK1202), as all submitted samples proved to be near or beyond the range of radiocarbon dating techniques[1]. Likewise only a single sample was dated at the University of Arizona/National Science Foundation AMS facility. Dating results are also shown in Table 1, and laboratory reports are provided in Appendix A.

[1] Due to the half-life of the ^{14}C isotope, radiocarbon dating techniques have a limiting maximum of approximately 40,000 to 45,000 years, at which point the amount of ^{14}C left in a sample is too small to be detected against the normal ambient background signal. As a statistical determination, the age of samples beyond 43,500 years is reported by the laboratory as "infinite".

Borehole	CHUK1000	CHUK1200	CHUK1201	CHUK1202
Date recovered	9/6/2011	9/15/2011	9/15/2011	9/16/2011
Water depth (m)	39.7	40.3	40.3	40.3
Core depth (m)	17	16.3	11.3	26
Sediment	Sand, pebbles	Clay	Clay	Clay
Weight (g) (incl. matrix)	8.9	33.5	289.5	115.7
Radiocarbon Age (Beta)	>43,500 BP	>43,500 BP	>43,500 BP	42,920±710 BP
Calibrated Age (BP)	-	-	-	44,847-47,648
Lab No. (Beta)	Beta-307535	Beta-307536	Beta-307537	Beta-307538
Radiocarbon Age (Arizona)	49,500±4,000 BP	>49,900 BP	no result	no result
Lab No. (Arizona)	AA-97944	AA-97945	-	-
Calibrated Age (BP)	beyond curve	-	-	-
Speciation	?	spruce, pine, or larch	?	likely a conifer

Table 1. Summary of data relating to wood fragments.

The single radiocarbon determination obtained from the Beta Analytic Lab (CHUK-1202, Beta-307538) is 42,920±710 BP. When calibrated to calendar years using the Calib 6.0 calibration program and the Intcal09 curve (Riemer et al. 2009), this determination is 44,847 – 47,648 cal BP with a standard deviation of 2 sigma (Figure 7).

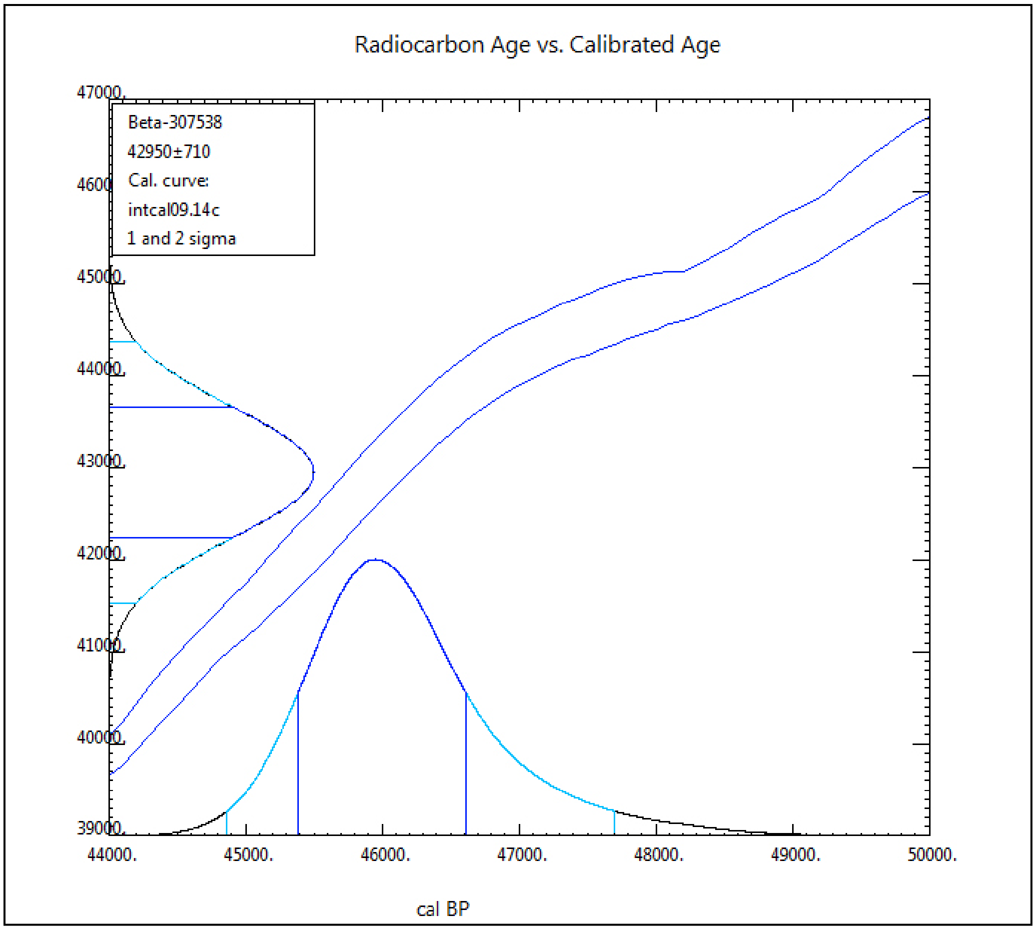

Figure 7. Radiocarbon date calibration (vertical axis is radiocarbon age, horizontal axis is calibrated age) for CHUK-1202 sample.

Wood samples were also submitted to the University of Arizona Geosciences Palynological Laboratory for speciation analysis. Speciation analysis results are provided below, and also summarized in Table 1. The following are observations made by Dr. Owen Davis of the University of Arizona Palynological Laboratory (Davis pers. comm. 2011):

> The organic material is homogenized and smears when cut with a razor. Cells or other structures needed for rudimentary identification are not visible. Internally, much of each sample is full of silt-sized mineral grains, probably iron sulfides. Cellulose has migrated so that in most places the cell structure no longer exists.
> Observations on individual samples:
> CHUK1000 – rays evident on one side of specimen.
> CHUK1200 – cross-section shows a ring of early-wood resin canals, likely spruce, pine, or larch.

CHUK1201 – cross-section shows round areas filled with mineral grains – likely a broad-leaved plant.
CHUK1202 – uniseriate rays evident on one side of specimen – likely a conifer.

4.12 Geologic Context

Analysis of seismic profiler data allows characterization of the geologic contexts where seafloor coring was undertaken. The sedimentary sequence was divided into units on the basis of geology. Wood fragments were recovered from depths ranging from 11.3 to 26 m below the seabed. At all borehole locations, theses positions correspond to a geologic unit comprised of channelized and mass-transport deposits of clays and silts with occasional minor sands. The lithology and boundaries within this unit vary vertically and horizontally, but show consistency across a wide area. This context is likely associated with a network of paleochannels that were downcut and incised during periods of lower sea level associated with glacial intervals. Previous investigations of the Chukchi shelf have determined that this paleodrainage network likely originated with ancient routes of the Kokolik, Kukpowruk, and Utukok rivers of northwest Alaska (Hill et al. 2007, Hill and Driscoll 2008).

4.13 Significance

The age of the wood fragments is considerably older than the Final Wisconsinan glaciations (LGM ca. 18,000 yrs BP), and hence far earlier than any human presence in Beringia. Archaeological import is therefore limited; the dating results are significant, however, for their implications regarding regional Late Pleistocene environment and climate. As noted by numerous researchers (Brigham-Grette et al. 2004; Sher et al. 2005; Lozhkin et al. 2011), the past climate of the Beringia remains enigmatic. The environmental history of the Bering Land Bridge in particular has been difficult to elucidate, with little clear knowledge about the dynamics of environment on shelf land during climatic variations.

Dating analysis of the wood fragments indicates an age of roughly 43,000 to 50,000 ^{14}C yrs BP; this dates the material to the period often referred to as the Karginsky or Middle Wisconsinan interstade (equivalent to Marine Isotope Stage 3 [MIS-3]) (Hopkins 1982; Anderson and Lozhkin

2001; Lozhkin and Anderson 2011). The Karginsky, a period of reduced ice sheets occurring between major Wisconsinan glaciations, is considered to date to approximately 60 – 28 ka cal yr BP (57 – 25 ka ^{14}C yr BP) (Brigham-Grette 2004)[2]. Some researchers have argued for a period of milder climate with richer vegetation during MIS-3 in Siberia (Western Beringia, WB) (Kind 1974; Schweger 1982; Andreev et al. 2002), while others have posited colder, steppe-tundra conditions (Sher et al. 2005). Sher in particular, on the basis of the late Pleistocene sequence exposed at the Mamontovy Khayata site in the Lena River delta, has argued for a MIS-3 biome assemblage in Siberia similar to those of modern tundra. This contrasts with Andreev et al. (2002), who suggest generally more favorable climatic conditions (the "Malokhetsky optimum") around 42.5 – 33 ka ^{14}C yr BP. Lozhkin and Anderson (2011), using data from 10 different sites in eastern Siberia (including lake cores), found evidence to suggest that both schemes may be valid. Northern areas likely experienced little climatic amelioration, but a climatic optimum is evident during mid-MIS-3 in southern and eastern parts of Siberia. Recent paleoecological data from Duvanny Yar, Siberia, also indicate a warmer and moister regime during MIS-3 than during MIS-2 (26 – 11 ka ^{14}C yr BP) (Zanina et al. 2011). This corresponds to some evidence from Eastern Beringia (Alaska and the Yukon), where fossil insect assemblages show a warming trend during early phases of the interstadial (Elias 2001). Analysis of data from coastal northwest Alaska suggests shrub-tundra vegetation with other microhabitats in protected areas (Schweger 1982, also see Blinnikov et al. 2011 for large-scale analysis over most of the Late Pleistocene). Forests were present although likely limited to interior lowlands (Anderson and Lozhkin 2001).

The presence of coniferous trees along the northern margin of Beringia may modify this picture, but is not totally unexpected. While the full extent of forestation in Late Pleistocene Beringia is not entirely clear, regional and episodic growth is evident. Larch (*Larix*) was present in Siberia in well-protected sites in the north, and as forest or forest-tundra in the southest during the MIS-3 optimum (Lozhkin and Anderson 2011). Zazula et al. (2006) report black spruce (*Picea mariana*) and white spruce (*Picea glauca*) within the Yukon Territory at the onset of glacial conditions during the MIS-3/2 transition (ca. 26 – 24.5 ka ^{14}C yr BP) (also noted by Schweger et

[2] In accordance with the 1983 North American Stratigraphic Code, all Marine Isotope Stage equivalent dates, both radiocarbon and calendar, are expressed as "ka yr BP" (for "thousands of years before the present").

al. 2011). Elias (2010) provides evidence for the establishment of boreal forests in the Alaskan and Yukon interior during MIS-3, but notes both dramatic temperature oscillations and a variety of localized habitats during this interval. The picture that emerges is one of mosaic communities with potential for considerable regional variability, and frequent fluctuations between relatively warm and cool conditions throughout the interstade (cf. Brigham-Grette et al. 2004).

Sea Level:

Global ESL curves indicate sea levels for the Chukchi shelf were higher than during LGM (ca. 120 m bsl), at approximately 60 m bsl during early MIS-3 and as low as 80 m bsl for the mid- to late- interstade (Lambeck et al. 2002; Brigham-Grette et al. 2004; Lozhkin and Anderson 2011). The position of the wood fragments at ca. 50-60 m bsl indicates a near-coastal location, likely not inundated until after the last glaciation (Figure 8). The fairly wide distribution of core locations where wood fragments were encountered suggests (although not conclusively) that they were found in growth position, rather than as products of secondary deposition.

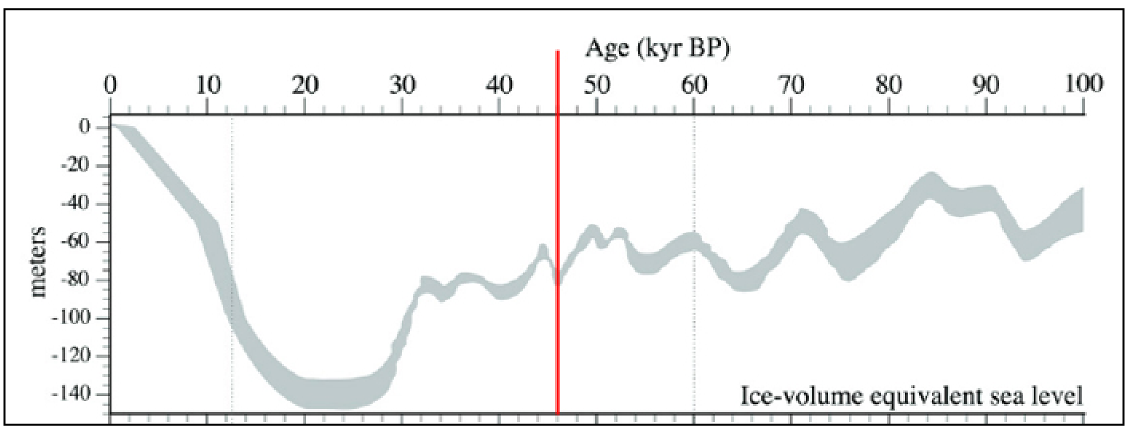

Figure 8. Ice-volume equivalent sea level curve for Beringia, adapted from Brigham-Grette et al. 2004. Red line shows approximate age of wood fragments.

4.2 Dedicated Archaeology Core Sample

A single 1-m core sample was taken as a dedicated archaeological core. The sample was taken with a piston-driven push, extending from the seafloor “mudline” down to one meter below the seafloor. The sample was received sealed in the steel core jacket, which was cut open using a metal saw. Half of the core was used for analysis; the other half is archived for potential future research (Figures 9 and 10).

The sediment core measured 95 cm in length when removed from the metal core jacket. Sedimentary and stratigraphic descriptions were taken (see Figure 11). The uppermost 20 cm (around the "mudline") were nearly liquid with a slurry-like consistency, while the lower 75 cm were well-consolidated. Consolidated sediments were homogenous dark-grey silts and silty clays. Mollusk shell (unidentified bivalve) fragments were recovered from a core depth of 55-60 cm when samples were wet-sieved in the laboratory. Samples were taken every 5 cm for Loss on Ignition (LOI) analysis, and every 10 cm for further sedimentary and soil chemistry analyses (particle size analysis [PSA], Chittick analysis, Walkley-Black analysis, and magnetic susceptibility) (Figure 11). Grain-size changes generally reflect changes in provenance of sediment sources, the proximity of the sediment source to the core site, or the dynamics of the depositional environment. LOI, Walkley-Black, and Chittick analyses were undertaken to determine inorganic carbon, carbonate, and organic matter content of samples (see Appendix B for descriptions of analytical methods and techniques). Changes in inorganic carbon reflect changes in sediment sources, and organic matter content is a reflection of numerous factors, including aquatic productivity, and the flux of mineral content in regional seawater.

Mollusk shell fragments from the dedicated core were radiocarbon dated to 3820±30 BP. A marine reservoir correction of 465±95 was applied to this determination, resulting in a final age of 3360±100. When calibrated to calendar years using the Calib 6.0 calibration program and the Marine09 curve (Riemer et al. 2009), this determination is 2930 – 3440 cal BP with a standard deviation of 2 sigma. This date suggests sedimentation rates at the core retrieval site slightly higher than those suggested by Hill and Driscoll (2008), who on the basis of core samples recovered from numerous locations on the Chukchi shelf extrapolated sedimentation rates of ~1.45 m/kyr from 8,000 to 10,700 yr BP, decreasing to ~0.05 m/kyr in the last 8000 yr.

Figure 9. Dedicated core before opening steel core barrel. Core length is 1 m.

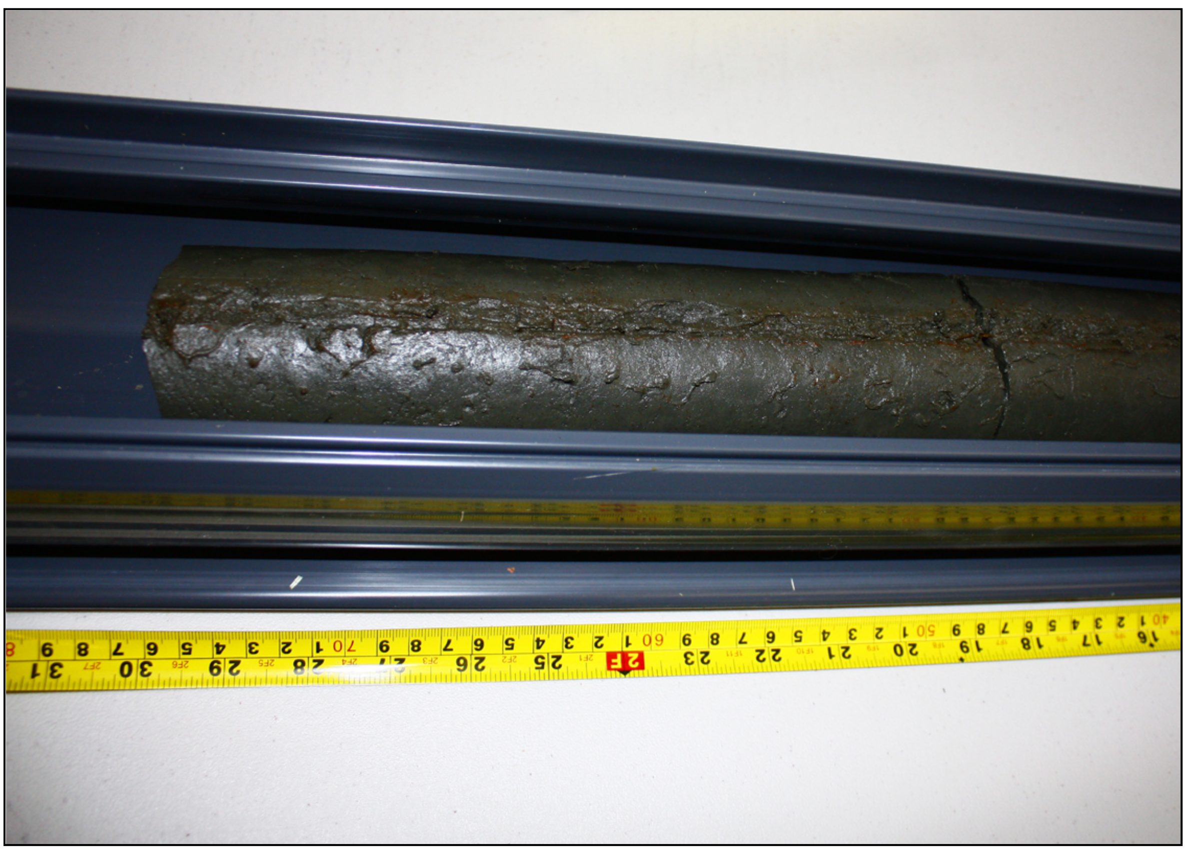

Figure 10. Dedicated core sample sediments after removal from steel core jacket.

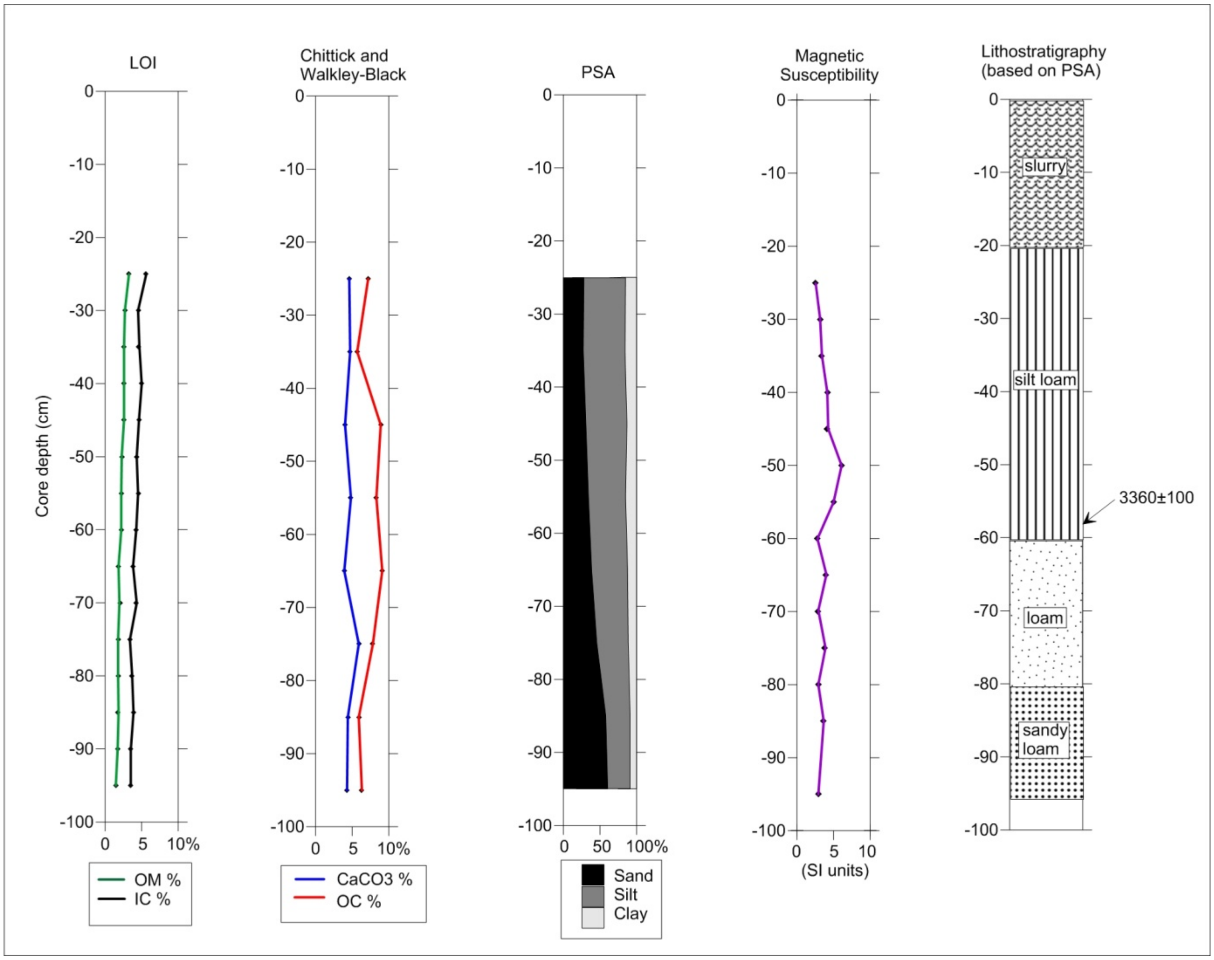

Figure 11. Results of soil chemistry, magnetic susceptibility, and particle size analysis for the dedicated archaeology core. Left axis on all diagrams is core depth in cm.

Results from soil Chemistry and particle size analysis of the dedicated archaeological core indicate several trends (Figure 11). The sand fraction increases towards the bottom of the core, likely a reflection of increased marine deposition since LGM, with the silt fraction increasing later in time. Soil chemistry shows variation in organic matter and inorganic carbon content, likely reflecting changes in the benthic habitat as sea levels increased through the Holocene.

4.3 Geotechnical Cores

Geotechnical cores were processed at the Fugro Marine Geosciences facility in Houston, Texas. The geotechnical cores total approximately 456 m in length. These sediment cores were never fully opened or extruded from the metal core jackets, rather they were cut at select specific locations; this results in higher-quality sample material for geotechnical stress and compression tests. Each cut is generally only several inches in length. The cores were initially x-rayed to determine which specific locations will be cut and analyzed; each subsequent cut and analysis was based on the cumulative previous results. The unopened core remainders were archived for future needs.

Fugro made the following materials available for archaeological analysis: all core x-rays, core drill logs, sedimentary descriptions, and photographs and descriptions of samples from opened segments. No organic materials or artifacts were encountered in any of the geotechnical cores during analysis. Examples of radiographs and sample photographs from Fugro are presented in Appendix C.

5. Acoustic and Seismic Data

Bathymetry (seabed depth and topography) in the vicinity of all borehole locations was determined by multibeam echo sounder. Seabed depths in the project area range from 37.5 m bsl to 42 m bsl. The seabed topography is controlled by sediment accumulation, redistribution, and scour generated by the winter ice pack (see Section 3). Seabed gradient is low and there is minimal relief. Seabed morphology is dominated by ice scour and striations, which vary in depth, age, and orientation. Scour width varies considerably, with the largest up to 40 m wide, and with lengths up to around 15 km. Numerous minor scours less than 10 m in width were also observed. Subsurface analysis was derived from seismic profiling data. The lithology consists essentially of clays and silts with numerous sandy interbeds and lenses. No evidence of cultural resources was observed in any of the acoustic and seismic data analyzed in this review.

6. Conclusions and Recommendations

No cultural resources, of either historic or prehistoric origin, were identified in any of the materials recovered for analysis or in remote-sensing data acquired by Statoil’s 2011 Site Survey and reviewed by the author of this report. This assessment has shown the value and research potential of materials obtained from coring and remote-sensing data acquired in the Chukchi shelf region. It is recommended that future projects in the region conduct similar review and analyses.

The location of the Chukchi continental shelf between Eurasia and North America makes it an extremely significant region for current theories of human migration and colonization of the Americas. As part of the ‘Bering Land Bridge’, the submerged portions of the Chukchi Sea between Siberia and Alaska may hold evidence regarding the earliest human occupations of the New World (Section 2 of this report). The Chukchi shelf can also provide evidence relating to paleoclimates and environmental conditions before, during, and after the last glaciation.

Wood fragments from the CHUK1000, 1200, 1201, and 1202 cores date to the Karginsky Interstadial (MIS-3), a period of ameliorated climate and reduced ice sheets occurring between major Wisconsinan glaciations. Paleoclimate and environmental data from this period are patchy, and have been greatly reconstructed from lake cores or stratigraphic sections from either Siberia (western Beringia) or Alaska and the Yukon (eastern Beringia). Paleoenvironmental data from currently submerged areas of Beringia are greatly lacking. Data summarized in the most recent literature indicate that vegetation differed, with western Beringia more extensively forested than eastern, and sea levels lower than present, ca. 80 m bsl. Regional climate variations during this period are hard to accurately date, as the period in question is near the limit of reliable radiocarbon dating. The Chukchi wood fragments add valuable information to the body of evidence used to reconstruct paleoclimates from this region, which in turn inform models used to understand current climate change in the Arctic.

Acknowledgements:

The Statoil Alaska technical team (Karin Berentsen, Roy Wollvik, Dr. Tom Guttormsen, and Eelco van Raaij) gave their full support and encouragement to the investigations detailed in this report. Dr. Jenna Hill at the Scripps Institution of Oceanography, and Dr. Julie Brigham-Grette at the University of Massachusetts assisted me with background research and materials analysis.

Joshua Reuther at the University of Arizona provided Loss on Ignition and Magnetic Susceptibility analyses on sediments from the dedicated core, and Jennifer Kielhofer at the University of Arizona Geosciences Laboratory performed soil chemistry and particle-size analysis. Dr. Owen Davis of the University of Arizona Palynology Laboratory undertook speciation analysis of the wood fragments. The Department of Archaeology at the University of Exeter provided research library access, and Anchorage Sheet Metal opened the dedicated archaeological core at no cost.

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Appendix A

Laboratory Reports

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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jason Rogers

Report Date: 10/26/2011

Material Received: 10/14/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 307535	NA	-26.0 o/oo	> 43500 BP

SAMPLE : SCC-1000-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
COMMENTS:

(1) The 14C activity was extremely low and almost identical to the background signal. In such cases, indeterminant errors associated with the background add non-measurable uncertainty to the result. Always, the result should be considered along with other lines of evidence. The most conservative interpretation of age is infinite (i.e. greater than).
(2) A Measured Radiocarbon Age is not reported for infinite dates since corrections may imply a greater level of confidence than is appropriate.

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 307536	NA	-24.4 o/oo	> 43500 BP

SAMPLE : SCC-1200-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
COMMENTS:

(1) The 14C activity was extremely low and almost identical to the background signal. In such cases, indeterminant errors associated with the background add non-measurable uncertainty to the result. Always, the result should be considered along with other lines of evidence. The most conservative interpretation of age is infinite (i.e. greater than).
(2) A Measured Radiocarbon Age is not reported for infinite dates since corrections may imply a greater level of confidence than is appropriate.

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 307537	NA	-24.1 o/oo	> 43500 BP

SAMPLE : SCC-1201-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
COMMENTS:

(1) The 14C activity was extremely low and almost identical to the background signal. In such cases, indeterminant errors associated with the background add non-measurable uncertainty to the result. Always, the result should be considered along with other lines of evidence. The most conservative interpretation of age is infinite (i.e. greater than).
(2) A Measured Radiocarbon Age is not reported for infinite dates since corrections may imply a greater level of confidence than is appropriate.

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jason Rogers

Report Date: 10/28/2011

Material Received: 10/14/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 307538	42920 +/- 710 BP	-22.9 o/oo	42950 +/- 710 BP

SAMPLE : SCC-1202-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
COMMENT: The result is outside of calibration range.

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

Contact: Rogers, J.

AA #	Sample ID	Suite	Material	d13C	F	14C age BP
AA97944	SCC-1000-02	1 of 4	wood	-27.6	0.0021+-0.0010	49,500+-4,000
AA97945	SCC-1200-02	2 of 4	wood	-24.3	<0.0020+-	>49,900+-
AA97946	SCC-1201-02	3 of 4	wood	-35.5	x	+- x x
AA97947	SCC-1202-02	4 of 4	wood	-30.0	x	+- x x

Appendix B

Analytical Methods and Techniques

(Particle Size and Soil Chemistry Analyses)

Loss on Ignition Methods

The loss-on-ignition (LOI) method was used to calculate the approximate amount of organic and inorganic carbon based on the loss of sample weight (percent weight [%wt]) after being combusted at different temperatures in an oven and muffled furnace. Organic carbon in samples tends to combust at temperatures between 200°C and 550°C without significant loss of the inorganic carbon component, which combusts into CO_2 at temperatures between 800°C and 1000°C. The combustion of CO_2 at 800°C and 1000°C is assumed to originate from $CaCO_3$, or calcium carbonate.

Chittick Methods

To determine calcium carbonate percentage, a Chittick apparatus is to take readings of evolved CO2. 6N HCl are added to roughly 10 grams of sample. The sample is then allowed to react for roughly 2 minutes while taking the volumetric reading with the Chittick apparatus.

Walkley-Black Methods

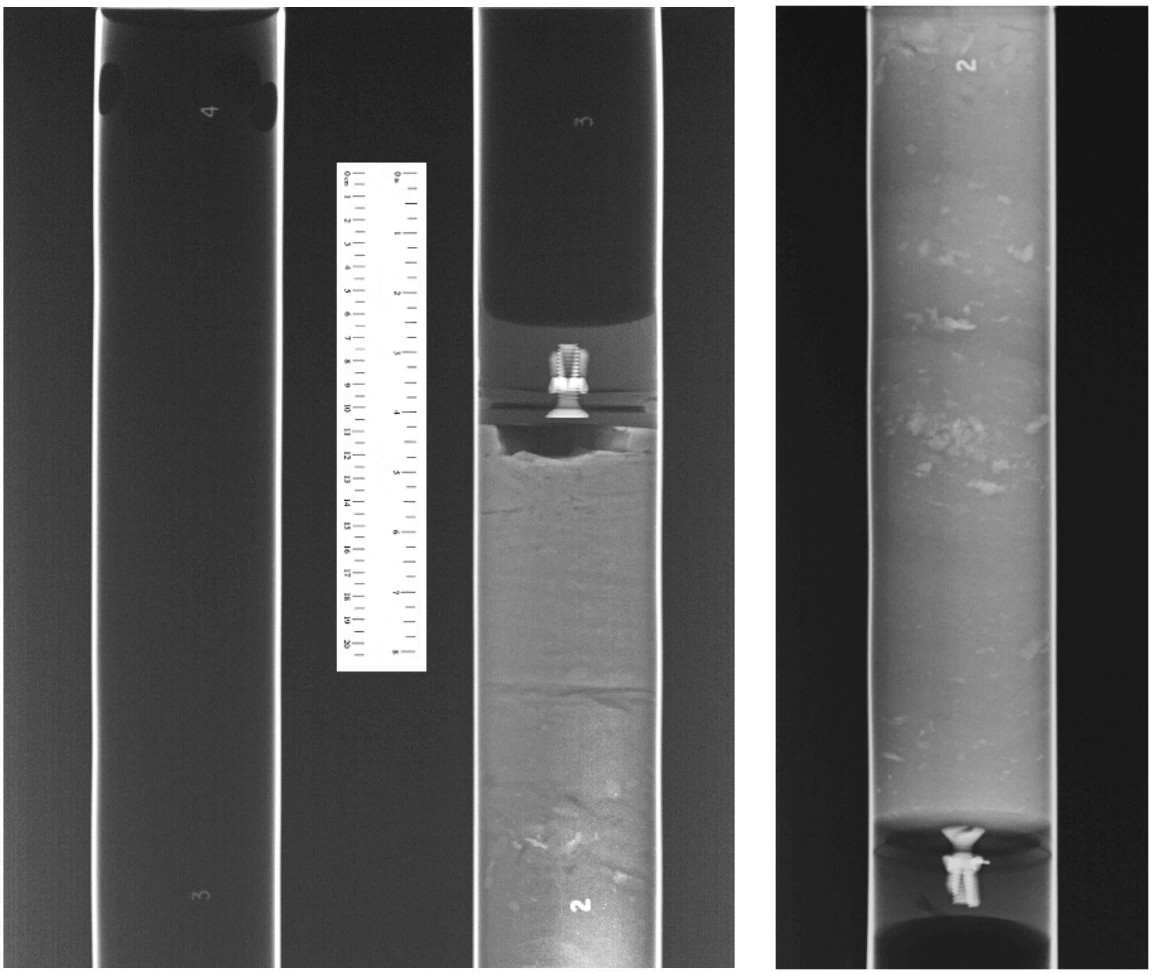
The Walkley-Black method was used to determine organic matter percentage. Normality of ferrous sulfate is first calculated using 3 blanks. The same reaction test is then run on each individual sediment sample.

Particle Size Analysis Methods

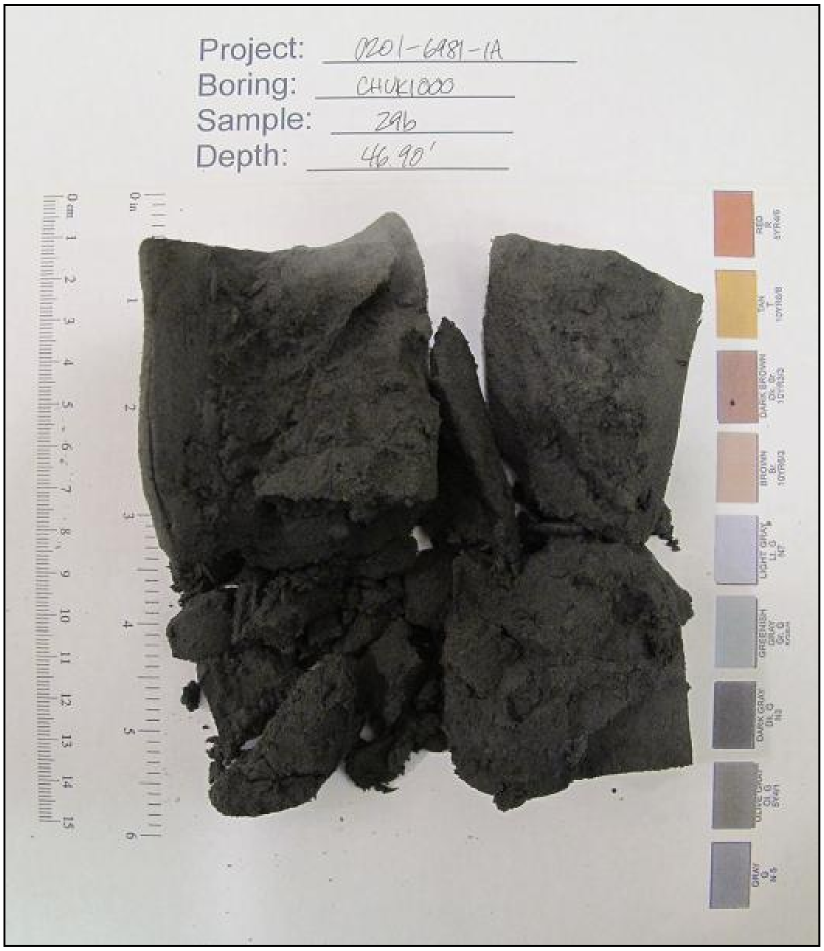
The pipette method was utilized to determine particle size distribution. Pretreatment involved adding .5N HCl to each 25 gram sample to remove carbonates, then adding a 10 ml aliquot of 30% hydrogen peroxide to each sample to oxidize organic matter, and finally adding a 25 ml aliquot of sodium pyrophosphate to each sample to disperse the clays. The samples were then centrifuged and placed on a shaker overnight before wet sieving. For the pipette portion of the analysis, 25 ml draws were taken at 20 cm to collect the silts, and after the appropriate settling time had passed, 25 ml draws were taken at 5 cm to collect the <4 micrometer fraction.

Appendix C

Sample Radiographs and Photographs from Geotechnical Testing



Sample core x-ray radiographs from geotechnical analysis.



Sample photograph of split core sample from geotechnical testing.