CHAPTER 6
Paleoenvironment—Holocene Deposits from Shemya Island

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Introduction

Holocene climate and vegetation changes in the western Aleutians have been little studied, and few publications are devoted to the topic (Black 1976a; Heusser 1978; Thorson and Hamilton 1986). With little knowledge of variation in the Western Aleutian environment, it is difficult to define its impact on mammal and bird populations or to understand clearly the anthropogenic effects on mid- to late-Holocene ecosystems. Currently, it is unclear how climatic changes affected the history of occupation and lifeways of ancient Aleuts. Although Black (1976a) discounted the influence of climatic changes on Aleut expansion, there are insufficient radiocarbon dates for ancient settlements and Holocene climatic changes to support such a conclusion.

Materials

In 1994 Russian historical ecologists with the WAAPP (Savinetsky, Kisseleva, and Khassanov) studied Holocene deposits at two locations on Shemya Island: Alcan Creek and Shemya 9 (Figure 6-1). They briefly examined another peat deposit located at McDonald Point on the east end of Shemya in 1999.

Alcan Creek

The Alcan Creek peat bog is located in the northwestern part of Shemya, 750 m from the western seashore and about 35 m above sea level. A 2.5 m high profile (Figure 6-2) is exposed along some 60 m of the north bank of Alcan Creek, which flows west to Alcan Harbor down a gently sloping valley. The original extent of the peat bog is unknown because military construction destroyed deposits south of Alcan Creek and in the headwater area. Currently, the base of the peat bog lies 1–1.5 m above the modern stream.

Shemya 9

The basal remnants of an ancient Aleut settlement, ATU-066, are located on the top of a hill approximately 100 m inland from the south coast of Shemya Island. Military construction has removed the upper occupation levels and partially exposed the underlying stratigraphy on three sides. The top of the hill is about 18 m above sea level and is covered by dense meadow-type vegetation, predominantly Elymus arenarius, Heracleum lanatum, and Senecio pseudo-arnica.

Shemya 9, a soil profile underlying ATU-066 exposed 3.7 m of stratified deposits overlying bedrock, including 30 cm of cultural debris near the top of the column. Cultural materials
Figure 6-1: Location of soil profiles with surficial geology and archaeological sites.
included abundant sea urchin and other shell, fish and bird bones, and bone and stone artifacts. The Shemya 9 deposit is measured downward from the ground surface, and includes the cultural deposits on top of the hill (Figure 6-3).

**McDonald Point**

In 1999, researchers excavated a third profile at the eastern end of Shemya Island locally known as McDonald Point. Previous military quarrying operations exposed the sediments in profile. Deposits consist of nearly 4 m of interlayered peat and windblown sand resting on bedrock (Figure 6-4). A single radiocarbon date indicates soil deposition began more than 9,500 years ago (9547 ± 128 BP, IEMAE-1261). Because the McDonald Point profile confirms the findings from Alcan Creek and Shemya 9 it is not discussed in detail.
Figure 6-3: Profile of Shemya 9 deposit.
Methods

Soil samples 5–10 cm thick were collected from the entire profile at all three deposits. Detailed description of soil color, texture and organic inclusions allowed the definition of zones which were then analyzed for information on age, rate of soil formation, temperature and precipitation. The techniques used are briefly described here. For more information on these analyses see Dinesman et al. (1999), P’yavchenko (1963), Tyurennov (1976), and Savinetsky et al. (2004).

Organic and inorganic fractions of each sample were separated for analyses. The organic remains were used for carbon dating the deposits, and for determining relative temperature and precipitation rates. Grain size and source analysis of the mineral fractions were used to determine sedimentation rates and hydrologic conditions.

In order to date the various horizons and determine rates of soil deposition, radiocarbon samples were extracted from six layers at Alcan Creek and four layers at Shemya 9. After standard pretreatment of each sample with hot KOH, non-soluble fractions of peat were extracted, screened to remove particles coarser than 0.5 mm diameter, and submitted for radiocarbon dating (Table 6-1). The resulting dates allow us to estimate rates of soil accumulation (Figure 6-5).

Climatic changes were evaluated by examining the layer-by-layer changes in the mineral fraction and relative decomposition of peat. In cases of good drainage, these changes in peat are determined by the temporal dynamics of warming and the saturation of the deposits (Dinesman et al. 1999). To determine the degree of change in precipitation over the time of formation of the entire layer, we used the allolithic mineral content of the layer. The inorganic mineral content of pure peat cannot exceed 15% (P’yavchenko 1963), and all proportions that

<table>
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<tr>
<th>Depth of Horizon (cm)</th>
<th>Material Dated</th>
<th>Laboratory Number</th>
<th>Radiocarbon Age (years before present)</th>
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<td>Alcan Creek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–30</td>
<td>Plant remains</td>
<td>IEMAE-1199</td>
<td>562 ± 83</td>
</tr>
<tr>
<td>80–90</td>
<td>Plant remains</td>
<td>IEMAE-1201</td>
<td>3221 ± 75</td>
</tr>
<tr>
<td>130–140</td>
<td>Plant remains</td>
<td>IEMAE-1299</td>
<td>4396 ± 198</td>
</tr>
<tr>
<td>200–210</td>
<td>Plant remains</td>
<td>IEMAE-1202 &amp; 1204</td>
<td>7562 ± 104</td>
</tr>
<tr>
<td>250–260</td>
<td>Plant remains</td>
<td>IEMAE-1203</td>
<td>7924 ± 320</td>
</tr>
<tr>
<td>Shemya 9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30–35</td>
<td>Collagen from fish bones</td>
<td>IEMAE-1176</td>
<td>2244 ± 182</td>
</tr>
<tr>
<td>155–165</td>
<td>Plant remains</td>
<td>IEMAE-1198</td>
<td>2791 ± 126</td>
</tr>
<tr>
<td>185–193</td>
<td>Plant remains</td>
<td>IEMAE-1171</td>
<td>3715 ± 106</td>
</tr>
<tr>
<td>237–250</td>
<td>Plant remains</td>
<td>IEMAE-1173</td>
<td>5000 ± 230</td>
</tr>
</tbody>
</table>
Figure 6-5: Rate of soil accumulation at Alcan Creek and Shemya 9.

Exceed this value are caused by the introduction of mineral particles into the accumulating peat through the runoff of atmospheric precipitation from adjoining slopes or during flooding. Aeolian deposition is also a possible source, but its contribution to relative error in these analyses is minimized by screening which will leave only the finest grain sizes, which are most likely deposited by atmospheric or surface water (Tyuremnnov 1976). No tephra layers were found in any peat deposits here, although they often quickly weather to clay.

To estimate the change in the summer temperature regimes, we used layer-by-layer changes in the degree of peat decomposition. The degree of decomposition is determined by the percentage content of "unstructured" matrix, containing small particles of inorganic remains along with the humic matter. Aerobic microorganisms, which actively function only in the upper, peat-forming layer, play the primary role in the decomposition of organic remains. Microorganism activity in the peat layer is only possible with suitable warmth and sufficient moisture, and is suppressed by low temperatures, drying or waterlogging. If the moisture content of peat does not exceed its capacity, the deciding factor influencing decomposition is temperature (Prosohora 1988). After being covered with a developing layer of peat, the degree
of decomposition remains practically unchanged (Tyuremnov 1976). Protracted waterlogging of a well-drained bog like this site is unlikely, so that changes in the degree of peat decomposition will reflect changes in the temperature regime during the warm parts of the year (Causey et al. 2005, Savinetkii et al. 2004).

We also conducted granulometric (grain-size) analyses in order to determine the mode of transportation of the mineral fraction in the peat, and to recognize hydrological conditions governing sedimentation (Table 6-2). Minerals were identified in order to determine their source. The final analysis performed on the soil samples was a standard macrofossil analysis (Grosse-Brauckmann 1986) to characterize ancient floral communities.

Results

Alcan Creek

Alcan Creek radiocarbon dates show that deposition began nearly 8,000 years ago. During the first 400–500 years, the rate of deposition was rapid, with soils accumulating at 1.8 mm/year (Table 6-2). Thereafter, and through the middle of the 15th century AD, sediment accumulated in the peat bog at much slower rates of 0.22–0.42 mm/year.

The Alcan Creek profile can be divided into three zones:

- The lowest, Zone 1, 250–264 cm, represents a paleosol formed on bedrock beginning about 8000 years BP. The fine sorting of the mineral fraction in the buried silt, its lamellar structure, and the presence of plant remains indicate that this early soil developed during periodic flooding, or within standing or slow-moving water. The water carried fine silt that periodically covered the plant cover, enriching the soil and allowing the development of plant growth.

- After 8,000 years ago (7924 ± 320, Table 6-1), soil-formation processes abruptly changed. Clayey sediments permeated with plant remains, and interspersed with sandy layers gradually covered the lowest paleosol over a period of 4,700 years (7990–3220 BP). Zone 2 is a 150 cm soil deposit between profile interval 260–90 cm which accumulated in a marsh or wet floodplain. The graph of the deposit (Figure 6-6) suggests the deposition rate was variable. During the first stage, 7900–7650 BP (260–200 cm), the accumulation was relatively rapid: 1.8 mm/year. Between 7650 and 4400 BP (200–130 cm), it diminished to 0.21 mm/year. From 4400 to 3220 BP (130–90 cm), it increased to 0.42 mm/year.

- The upper portion of the deposit, Zone 3, 90–20 cm is composed of pure peat formed during a 2,600-year period (3220–560 BP) at a rate of 0.22 mm/year. Absence of an elevated mineral fraction in this layer confirms that good drainage existed during this period and that sediment introduction from surface erosion and stream overflow were negligible. At the same time, the area remained sufficiently wet for peat formation to occur. The upper peaty-sod horizon was formed during the last 560 years.

Morphological analyses of sediments, in both the field and laboratory, revealed that the Alcan Creek deposit formed under different conditions of moisture availability over time. Zone 2, the mineralized part of the deposit between 260–90 cm in depth, is uniform fine sand, without a single pebble, and no obvious sedimentary structure (Table 6-2). It represents diluvial deposition from flooding in the immediate area. A mineral content of 62–77% confirms this, and indicates that for 3,400 years stable atmospheric precipitation was higher than it is now.

Zone 3, 90–0 cm deep, is a true peat bog. The highest moisture occurred during the first half of peat formation, i.e., 7,990–4,560 years ago. Around 4,500 years ago the introduction of mineral grains into the sediments stopped and the rate of peat formation did not change.
Table 6-2: Granulometric composition of the mineral fraction of the Alcan Creek deposit.

<table>
<thead>
<tr>
<th>Elevation above Stream Bed</th>
<th>Depth (cm)</th>
<th>Age (RCYBP)</th>
<th>Mineral Content (%)</th>
<th>Coarse Sand 1-0.5 mm</th>
<th>Medium Sand 0.5-0.25 mm</th>
<th>Fine Sand 0.25-0.1 mm</th>
<th>Very Fine Sand 0.1-0.05 mm</th>
<th>Silt 0.05-0.01 mm</th>
<th>Clay 0.01 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>10-20</td>
<td>562 ± 83</td>
<td>11.0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<td>100</td>
</tr>
<tr>
<td>3 m</td>
<td>80-90</td>
<td>3221 ± 75</td>
<td>9.5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>100</td>
</tr>
<tr>
<td>2 m</td>
<td>130-140</td>
<td>4396 ± 198</td>
<td>20.0</td>
<td>—</td>
<td>6.8</td>
<td>25.0</td>
<td>43.2</td>
<td>—</td>
<td>100</td>
</tr>
<tr>
<td>1 m</td>
<td>160-170</td>
<td>61.9</td>
<td>—</td>
<td>6.8</td>
<td>41.9</td>
<td>44.6</td>
<td>7.5</td>
<td>23.6</td>
<td>100</td>
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<tr>
<td>1 m</td>
<td>200-210</td>
<td>7532 ± 168; 7727 ± 133</td>
<td>61.0</td>
<td>—</td>
<td>—</td>
<td>34.5</td>
<td>44.6</td>
<td>7.5</td>
<td>28.4</td>
</tr>
<tr>
<td>1 m</td>
<td>250-264</td>
<td>7924 ± 320</td>
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<td>—</td>
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</tr>
<tr>
<td>&gt; 264</td>
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<td>14</td>
<td>23.5</td>
<td>—</td>
<td>37.0</td>
<td>6.4</td>
<td>—</td>
<td>5.3</td>
<td>13.2</td>
</tr>
</tbody>
</table>
This suggests atmospheric precipitation dropped and then stabilized. The bog received moisture from subsoil waters, spring melt, and summer surface waters. This corresponds also with the gradual rise of sea level to the modern mark about 5,000–4,000 years ago (Black 1976b; Kaplin 1982; Kaplin et al. 1991).

The rate of peat decomposition varied over the 8,000 years of deposition but averaged 36.1%. With increased decomposition during warmer periods and decreased decomposition during cooler periods, we have inferred several long-term variations in temperature (Figure 6–4). Comparatively warm periods are recognized at 8000–7700 BP, 6750–6250 BP, 5750–4750 BP, 4100–3850 BP, and 3600–3350 BP, and from 1750 BP to present, with the maximum temperature occurring at 6,750–6,250 years ago.

Comparatively colder periods are noted between 7700–6750 BP, 6250–5750 BP, 4750–4100 BP, 3850–3600 BP, and 3350–1750 BP, with the minimum temperature occurring between 2,600 and 2,150 years ago. The general duration of both warm (3,500 years) and cool (3,900 years) periods was approximately equal.
Macrofossil analysis agrees with the division of the deposit into the upper Zone 3, and lower Zone 2 levels described above. In general, Zone 2 is a fibrous peat consisting primarily of the roots and other underground organs of sedges (Carex spp.). A small amount of fragmentary Equisetum sp. epidermal tissue, seeds of rushes (Juncus sp.), fruits of sedges (Carex sp.), and leaves of mosses, including Sphagnum, were found as well. Roots and leaves of grasses (Gramineae) were also identified in small quantities.

In contrast, roots and other underground parts of grasses (Gramineae) were abundant in Zone 3. Roots and bark of shrubs (Empetrum nigrum and Vaccinium sp.) were also common. Thus, the upper peat of this deposit differs markedly from the lower by the presence of shrubby vegetation and grasses, and by the absence of Sphagnum.

Heussler (1990) detected similar changes in the botanical composition of peat during palynological analysis of a peat deposit on Attu Island. The lower part of the Attu section was formed from 6700 to 5200 years BP. The pollen spectrum of that section was dominated by sedges (Cyperaceae) along with small amounts of pollen of other taxa such as grasses (Gramineae), Umbelliferae, ferns, and Sphagnum. In contrast, the spectrum of the upper part was dominated by pollen of grasses and Empetrum nigrum.

These changes in the botanical composition of peat on Shemya and Attu islands represents the change from sedge and sedge-grass meadow communities—with Sphagnum and forbs typical of wetter localities—to heath with a predominance of dwarf shrubs (Empetrum nigrum, Vaccinium sp.) and grasses. Currently, these heaths can be found in different places, from hilltops to depressions, but always on well-developed organic soils. This replacement of a sedge-meadow-type community by heath with dwarf shrubs and grasses mirrors the changes in precipitation.

**Shemya 9**

Four radiocarbon dates (Table 6-1) from Shemya 9 indicate that this deposit began forming before 5000 BP and continued for at least 3,234 years. This latest date of 2244 BP on fish bone is subject to a carbon reservoir correction of 434 years giving an effective date of 1810 BP. According to the graph of deposition rates (Figure 6-3), the interval between 237–155 cm was formed over a period of 2,200 years, between 5000–2790 BP, at a rate of 0.34 mm/year. The rate of accumulation subsequently increased to 2.1 mm/year for between 2790–2240 BP.

Based on morphological features, the Shemya 9 profile can be divided into five zones:

- **Zone 1** (370–237 cm), formed before 5,000 years ago, and is represented by a meter of light-yellow clay with inclusions of pebbles and blue clay. This is covered by 20 cm of brown loam and capped by a dense, black, humic paleosol at 250–237 cm.

- **Zone 2**, between 237 and 155 cm, is a complex of clearly delineated sandy-clayey sediments deposited between 5000–2790 BP, at an average rate of 0.34 mm/year. Dark brown sandy layers with rusty stains, are interleaved with dark, plant-rich layers that appear to be buried humic paleosols. The most obvious of these are located at depths 210–185 cm and 176–155 cm. These two layers appear to be buried soil horizons.

- **Zone 3**, at 155–102 cm, consists of sandy lenses complexly interleaved with clayey layers. This interval resembles the layer previously described, but was deposited more rapidly at a rate of 2.0 mm/year for approximately 250 years (2790–2550 BP).

- **Zone 4**, 102–60 cm, is a homogeneous sandy soil with a buried humic horizon. Numerous modern plant roots penetrated this layer, making direct radiocarbon dating impossible for this interval.

- **The uppermost stratum**, Zone 5, 60–10 cm, is composed of sandy sediments. Aleut cultural remains dominate the lower 30 cm of the profile. This layer formed over
a very short time, between 2350 and 2240 BP, at about 2.7 mm/year. Military construction removed the upper part of this cultural layer. The topmost modern rootzone has been deposited over the last 60 years.

Basement rocks of the Lower Series underlie the Shemya 9 deposit (Coats 1956; Gates et al. 1956). Based on radiocarbon dates, Zone 2 sediments, above 237 cm, were formed after 5000 years BP. There are no rounded pebbles or remains of sea or freshwater organisms. This suggests it was not formed by marine processes. It is not of diluvial-proluvial genesis because of its well-defined stratification and sorting. Similar deposits are known for many of the Aleutian Islands (Black 1980; Coats 1956; Gates et al. 1956).

The granulometric and mineralogical analyses of the sediments (Table 6-3) confirm the deposit is aeolian, laid down by winds winnowing away the finer-grained fractions of beach deposits. This process is still operating and is readily observed. The entire deposit consists primarily of coarse- and fine-grained sand. The mineral composition of the sand resembles that of the parent material of the island; angular grains of quartz (10 to 18%); feldspar (10 to 25%); amphiboles (5 to 12%); and pyroxene (5 to 25%). Angular grains indicate a short distance between the source area and deposition.

Conclusions

Analysis of the three soil profiles show that favorable conditions for soil formation and accumulation have existed on Shemya Island for 9,500 years, since the early Holocene. The following preliminary conclusions can be made:

- The period 7900–4500 BP was characterized by atmospheric precipitation which greatly exceeded that of modern times. Between 4500 and 3200 years BP, there was a period of general reduction of atmospheric precipitation. During the last 2,500 years (3200–560 BP), atmospheric precipitation stabilized at lower modern levels.
- Cycles of temperature change were observed, but the change did not result in any disastrous effects on the Aleutian ecosystem. Comparatively warm periods are noted between 8000–7700 BP, 6750–6250 BP, 5750–4750 BP, 4100–3850 BP, 3600–3350 BP, and from 1750 BP to present, with the maximum warming period

<table>
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<tr>
<th>Depth (cm)</th>
<th>Age (RCYBP)</th>
<th>Coarse Sand 1-0.5 mm</th>
<th>Medium Sand 0.5-0.25 mm</th>
<th>Fine Sand 0.25-0.1 mm</th>
<th>Very Fine Sand 0.1-0.05</th>
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<td>2244 ± 182</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>47.5</td>
<td>12.5</td>
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<td>2</td>
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occurring between 6750 and 6250 BP. The longest warming trends occurred between 5750 and 4850 BP and from 1750 BP to the present.

- Comparatively colder periods are noted between 7700–6750 BP, 6250–5750 BP, 4750–4100 BP, 3850–3600 BP and 3350–1750 BP, with the minimum temperature occurring 2600–2150 BP. The longest summer cooling trends occurred between 7700 and 6750 BP and between 3350 and 1750 BP.

- During the second half of the middle Holocene (5000–1800 BP) winds deposited fine-grained material from beaches on island slopes near the sea.

Eustatic sea level rise began at the end of the Pleistocene and reached its modern level in tectonically stable areas about 4,000 years ago (Black 1980; Kaplin 1982; Kaplin et al. 1991). However, the Aleutian Ridge is a very active seismic area. According to Black (1980), the relative changes of sea level during the Holocene in the Aleutian Islands were not simultaneous because of the different direction of tectonic movements of the North American and North-Pacific plates. According to R. Black (Thorson and Hamilton 1986), sea level stabilized at modern levels in the eastern Aleutians 11,000 years ago and in the west about 5000 BP. Therefore, the beginning of the aeolian deposition coincides with time of stabilization of sea level in the Near Islands.

It remains difficult to determine how climatic and geomorphological factors influenced ancient Aleut culture. No radiocarbon-dated and identified osteological materials have been available for such interpretations. However, for the first time, it is possible to use results from C-14 dating of basal horizons from different human settlements in the Near Islands. Out of eight known dates (Table 6–4), seven fall during or near the end of the longest-lasting cool interval 3350–1750 years BP, and all dates fall within comparatively dry periods.

If these dated sites represent the earliest movements of ancient Aleuts into the Near Islands, it appears the migrations occurred during a relatively dry and cool period of the Late Holocene. According to Sorkina (1963), climatic cooling the North Pacific may have occurred during periods of weakening cyclonic activity—characterized by weakening of the wind. Wind velocity was probably critical to Aleuts when they crossed the widest interisland oceanic passages in the western Aleutians. Future data on the long-term ecological shifts of this region should provide answers to other questions about prehistoric Aleut migrations and adaptations.

<table>
<thead>
<tr>
<th>Site</th>
<th>Conventional Date BP</th>
<th>Material</th>
<th>Reservoir Corrected Age BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agattu (ATU-001) (M-12a)</td>
<td>2500 ± 300</td>
<td>Wood</td>
<td>2500 ± 300</td>
</tr>
<tr>
<td>Agattu (ATU-001) (M-12b)</td>
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<td>Wood</td>
<td>2630 ± 300</td>
</tr>
<tr>
<td>Shemya (ATU-003) (Beta-40421)</td>
<td>2030 ± 70</td>
<td>Charcoal</td>
<td>2030 ± 70</td>
</tr>
<tr>
<td>Shemya (ATU-061) (Beta-39104)</td>
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<td>Bone</td>
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</tr>
<tr>
<td>Shemya (ATU-061) (IEMAE 1175)</td>
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<td>Fish bone</td>
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</tr>
<tr>
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<td>1845 ± 90</td>
<td>Bone</td>
<td>990 ± 100</td>
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<tr>
<td>Anchitka 31 (RAT-031) (I-4735)</td>
<td>2550 ± 95</td>
<td>Bone</td>
<td>1695 ± 105</td>
</tr>
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<td>2254 ± 95</td>
<td>Charcoal</td>
<td>2245 ± 95</td>
</tr>
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</table>

1. Appendix G, assumed marine reservoir correction 855 ± 40 radiocarbon years (see Chapter 15).
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