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MAP OF GLACIAL LIMITS AND POSSIBLE REFUGIA IN THE SOUTHERN ALEXANDER ARCHIPELAGO, ALASKA, DURING THE LATE WISCONSIN GLACIATION

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SCALE 1:500,000

Base from Scientific Fishery Systems, Inc., Anchorage, Alaska
State Plane Coordinate System 1927 SPCS Zone 6101
North American Datum of 1927

Ongoing geologic observations by Baichtal July 1990 to present
Geology mapped in field by Ager and Baichtal in July 1998 and 1999, and by Ager, Carrara, and Baichtal in July 2000
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This map was produced on request, directly from digital files, on an electronic plotter
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ArcInfo coverages and a PDF for this map are available at http://pubs.usgs.gov

EXPLANATION

Present land area
Areas presently <125 m below sea level
Areas of the Continental Shelf presently <125 m below sea level that may have served as refugia during the late Wisconsin glaciation
Along Pacific coast part of Continental Shelf (>125 m to 200 m below present sea level)
Along Pacific coast part of Continental Shelf (>200 m to 300 m below present sea level)

Water depth greater than 300 m below present sea level
Probable late Wisconsin Cordilleran ice marginal position
Probable pre-late Wisconsin Cordilleran ice marginal position
Submarine slide scarp
Ice flow direction during late Wisconsin glaciation
Seamount—Queried where uncertain
Major concealed fault—Approximately located
Submarine fan
Bathymetric contours
Contour interval equals 25 m between 0 and –300 m
25 m
50 m
75 m
100 m
Contour interval equals 100 m between –300 and –3,000 m
Intermediate contour
Index contour

INTRODUCTION

The map area includes the southern Alexander Archipelago region of southeastern Alaska and extends about 350 km from northern Baranof Island south to Dixon Entrance. The region extends about 200 km from the Coast Mountains of the Alaska mainland west to the outer islands. The narrow strip of coastal mainland is isolated from the rest of North America by the heavily glaciated mountains. The Alexander Archipelago (fig. 1) comprises thousands of islands and intervening deep fiords. Many of the larger islands contain rugged mountain ranges exceeding 1,000 m in altitude that support small glaciers and snowfields.

The map was prepared from a digital database of water depths, based in part on National Oceanic and Atmospheric Administration (NOAA) data, and contains more than 100,000 bathymetric data points, obtained from Scientific Fishery Systems, Inc., of Anchorage, Alaska. The map was computer contoured in ArcInfo (ESRI), thus allowing topographic depiction of submarine glacial features, including probable moraines and deep glacially scoured troughs.

In addition to the glacial features, the map also depicts other features, such as seamounts, submarine slides, and fans. Several seamounts (or possible seamounts) are depicted on the map. For instance, a seamount that rises about 100 m from the ocean floor is present about 25 km west of Noyes Island. Bathymetric data indicate that an adjacent crater is more than 300 m deep. Another seamount that stands about 150 m above the ocean floor is present about 15 km south of Coronation Island. Both seamounts were probably subaerially exposed during the late Wisconsin glaciation (circa 26,000–13,000 14C yr B.P.). Other seamounts may be present to the west of Forrester Island. Although bathymetric contours depict the general trend of the ocean floor, because of the lack and spacing of data points in some areas of the map, especially west of the Continental Shelf, some features, such as these possible seamounts, may be the product of a misinterpretation of the sparse data or an anomalous data point. The same may also be true for the “hole” 40 km west-northwest of Forrester Island.

A large (about 1,500 km2) submarine slide, whose head scarp is shown on the map, is present to the west-southwest of Baker Island. Other possible submarine slides are suggested by irregular contours on the continental slope to the northwest of the mouth of the Chatham Strait trough immediately west of the Fairweather/Queen Charlotte fault. A large (about 1,800 km2) submarine fan west of Chatham Strait is depicted by the bathymetric contours.

Areas of the ocean floor along the outer coast that are less than 125 m below sea level are shaded and may have been subaerially exposed during the late Wisconsin glaciation. Because of the complex interaction of eustatic sea level fluctuations, isostatic rebound (and forebulge effects), and tectonic movements in southeastern Alaska, the exact areas of the continental shelf that were subaerially exposed by sea level lowering during the late Wisconsin cannot be identified with certainty.

During the late Wisconsin glaciation the Cordilleran glacier complex formed vast ice fields and large glaciers along the crest of the Coast Mountains. As these glaciers flowed west to the Pacific Ocean, they were joined by local glaciers originating on the higher reaches of the Alexander Archipelago (Mann and Hamilton, 1995). This extensive volume of ice was channeled into deep troughs (present-day fiords) that formed major outlet glaciers, such as the glaciers that occupied Chatham Strait and Dixon Entrance. In several places along the coast, deep glacially scoured submarine troughs indicate that glaciers reached to the edge of the continental shelf. For instance, the glacier that extended into the Dixon Entrance trough is known to have extended to the edge of the continental shelf. Its retreat began sometime after 16,000–15,000 14C yr B.P. (Barrie and Conway, 1999).

The exact extent of late Wisconsin cordilleran ice in southeastern Alaska is poorly known. Small-scale maps and reports of the region commonly show or imply ice extending west to the edge of the continental shelf (Capps, 1931; Coulter and others, 1965; Flint, 1971; Péwé, 1975; Denton and Hughes, 1981; and Prest, 1984). These maps relied heavily on earlier work, much of it of a reconnaissance nature. The map shows our interpretation of the limit of the Cordilleran ice sheet, which is more restricted than previous estimates, and possible refugia (areas that escaped the extensive glaciation of the late Wisconsin and so provided a suitable habitat for relict species) in the southern Alexander Archipelago during the late Wisconsin glaciation. In addition to the analysis of the bathymetric map, the limits of the Cordilleran ice sheet and possible refugia were also identified by analyses of aerial photographs, USGS topographic maps (1:63,360 and 1:250,000 scales), NOAA bathymetric charts (1:20,000 and 1:40,000 scales), previous literature, and reconnaissance fieldwork throughout much of the region. Ice-free areas that may have served as refugia include (1) high mountain nunataks (too small to show at map scale), (2) unglaciated ocean-facing slopes and forelands (Dahl, 1946), (3) the outer islands of the Alexander Archipelago (Worley, 1980), and (4) parts of the inner continental shelf exposed by the lowering of sea level during the late Wisconsin by an estimated 125 m (Bard and others, 1990).

The climate of the Alexander Archipelago is characterized by a wet maritime regime of mild, wet winters and cool, wet summers. Storm frequency peaks during the fall and winter. From about September to March the Aleutian Low, a semi-permanent low-pressure system in the Gulf of Alaska, directs an almost continuous series of storms across the region. These storms are blocked from intruding farther inland by the Coast Mountains, which contain many peaks more than 2,200 m in altitude, resulting in the heavy precipitation in the region. During the winter, rain may fall at sea level, but at higher altitudes snow accumulates to a considerable thickness and lasts until late summer (O'Clair and others, 1997). From April through August, the Aleutian Low is displaced by the North Pacific High, which exerts a moderating influence on the climate, as precipitation generally decreases during this period. However, mean annual precipitation exceeds 300 cm in many areas and is estimated to reach 1,000 cm in some places, such as the higher altitudes on southern Baranof Island (O'Clair and others, 1997).

Southeast Alaska, along with British Columbia, contains the most extensive temperate rainforest in the world (MacDonald and Cook, 1999). Dominant coniferous tree species include Sitka spruce (Picea sitchensis), mountain hemlock (Tsuga mertensiana), western hemlock (Tsuga heterophylla), Alaska yellow cedar (Chamaecyparis nootkatensis), red cedar (Thuja plicata), and shore pine (Pinus contorta var. contorta). The most common deciduous broadleaf tree species is black cottonwood (Populus trichocarpa). These trees are usually found on steeper, well-drained areas. Areas of poor drainage, such as flat and gentle slopes, commonly support muskeg vegetation.

EVIDENCE FOR REFUGIA IN THE ALEXANDER ARCHIPELAGO

The presence of refugia during the late Wisconsin glaciation along the Pacific coast of Alaska and British Columbia based on the distribution of plants and animals has been suggested by a number of authors (Cowan, 1935; Hultén, 1937; McCabe and Cowan, 1945; Heusser, 1960, 1989; Banfield, 1962; Randhawa and Beamish, 1972; Worley and Jaques, 1973; Jaques, 1973; Worley, 1980) and seems to be well documented for the Queen Charlotte Islands (south of the map area) (Foster, 1965; Warner and others, 1982; Heusser, 1989). Clague and others (1982) concluded that possible refugia in the Queen Charlotte Islands included (1) a shallow offshore platform bordering eastern Graham Island that was probably exposed during the late Wisconsin glaciation, (2) nunataks in the mountains of Graham and Moresby Islands, and (3) headlands, islands, and interfiord ridges along the west coast of the Queen Charlotte Islands.

The limited extent of late Wisconsin glaciation and possible refugia in the Queen Charlotte Islands suggests that the Alexander Archipelago, with a similar topography and climate, may also have had an incomplete ice cover. Indeed, several investigators have concluded that the distribution of flora and fauna in the Alexander Archipelago suggests that there may have been unglaciated areas that served as refugia during the late Wisconsin and as centers for biotic dispersal upon deglaciation (Hultén, 1937; Heusser, 1960, 1989; Harris, 1965; Klein, 1965; Worley and Jaques, 1973; Jaques, 1973; Worley, 1980; Heaton and others, 1996). Furthermore, these refugia may have served as "stepping stones" for human migration along the coast of North America during the late Pleistocene (Heusser, 1960, 1989; Dixon and others, 1997; Dixon, 1999, 2001).

Of the 107 mammal species or subspecies in southeast Alaska, 27 mammal taxa are endemic to southeastern Alaska and an additional 11 taxa have ranges that are largely confined to the region (MacDonald and Cook, 1999; Cook and others, 2001). The endemic forms of mammals occur most frequently on the outer islands, including Baranof, Chichagof (north of the map area, see fig. 1), Coronation, Forrester, and Warren, whereas the islands lying closer to the mainland are often occupied by mainland forms (Klein, 1965). The endemism is attributed to the glacial history and the complex geography of the region that isolated the fauna. The high degree of endemism and its increase toward the outer islands have been interpreted as suggesting that refugia existed in some areas of the exposed continental shelf and the outer islands of the Alexander Archipelago (see discussion in Heusser, 1989).

Brown bears (Ursus arctos) provide an example of a mammal that may have survived the late Wisconsin glaciation in refugia in the Alexander Archipelago. Differences in mitochondrial DNA (mtDNA) sequences suggest that brown bears in the Alexander Archipelago constitute a distinct clade and are more closely related to present-day polar bears (Ursus maritimus) than brown bears on the mainland (Heaton and others, 1996). Based on this and other evidence, these authors concluded that brown bears and possibly other large mammals have continuously inhabited the archipelago for at least 40,000 years and that habitable refugia were therefore available throughout the late Wisconsin glaciation (Heaton and others, 1996).

Ermine (Mustela erminea) also provide an example of a mammal that may have survived the late Wisconsin glaciation in refugia in the Alexander Archipelago. Differences in mtDNA sequences suggest three distinct clades of ermine in southeast Alaska (Fleming and Cook, 2002). Two of these clades have a wide distribution; however, the “island” clade is found only on Prince of Wales, Suemez, Heceta, and Graham Islands. Because of the island clade’s restricted distribution and its degree of divergence from the other two clades, Fleming and Cook (2002) concluded it has been isolated for a prolonged period of time and probably survived the late Wisconsin glaciation in coastal refugia.

Chum salmon (Oncorhynchus keta) provide further evidence suggesting that refugia may have existed in the Alexander Archipelago during the late Wisconsin glaciation (Kondzela and others, 1994). The genetic variation of this species is clustered regionally, such that populations from Prince of Wales Island are more like each other than elsewhere in southeast Alaska or British Columbia. This information was interpreted to suggest that the present-day populations of chum salmon are likely to have been derived from late Wisconsin-age populations that existed along the outer shores of the present-day continental shelf and used stream channels in refugia that are now underwater (Kondzela and others, 1994).

Shore pine (Pinus contorta var. contorta) presently occupies a wide range of soil conditions along the Pacific Coast from northern California to the Alaskan panhandle. This subspecies played a significant role in the early postglacial forest succession of the Pacific Northwest as its pollen is abundant in many early postglacial pollen diagrams (Heusser, 1960). In the Alexander Archipelago, shore pine was the dominant early postglacial tree species. The early arrival of shore pine and mountain hemlock at a site on Pleasant Island in the Glacier Bay region (north of the map area) of southeastern Alaska has been interpreted as suggesting an expansion from refugia in the Alexander Archipelago (Hansen and Engstrom, 1996). In addition, five alleles, found nearly exclusively in Pinus

contorta var. contorta, suggest that it has been a separate entity for a considerable period of time (Wheeler and Guries, 1982) and is best explained by a "multiple north-coast refugia" model that includes parts of the Alexander Archipelago.
Subalpine fir (Abies lasiocarpa) exists as isolated (disjunct) stands on Dall (Harris, 1965), Prince of Wales (Worley and Jacques, 1973), Heceta, and Kosciusko Islands. This species inhabits the interior of British Columbia but only extends westward through the Coast Mountains in several places (Heusser, 1989). The isolated stands are about 150–250 km west of the main range of this species and may have survived during the late Wisconsin glaciation in refugia within the Alexander Archipelago.

POSSIBLE REFUGIA IN THE SOUTHERN ALEXANDER ARCHIPELAGO

Many of the high mountains of Admiralty, Baranof, Chichagof, and Prince of Wales Islands appear to have stood above the level of Cordilleran ice during the late Wisconsin glaciation. However it is doubtful that low-altitude forms of plants and small mammals survived on these nunataks (Klein, 1965). More than likely, refugia in the Alexander Archipelago were confined to the unglaciated ocean-facing slopes and forelands, the outer islands, and parts of the exposed inner continental shelf. Possible refugia may have existed in and near the following areas: Baranof Island, Coronation Island, Warren Island, a large area stretching from west of Heceta Island in the north to Forrester Island in the south, Dall Island, and Prince of Wales Island. A discussion of each of these areas follows.

BARANOF ISLAND

Baranof Island is one of the largest (4,065 km2) islands in the Alexander Archipelago. It contains a high mountainous divide whose altitudes generally range from about 600 m to as much as 1,625 m. The higher peaks on the island support small glaciers and ice fields today. USGS 1:63,360-scale topographic maps (Port Alexander A2, A3, B2, B3&B4, C2, C3, C4) of Baranof Island indicate that the mountainous divide was high enough in most places to contain the ice of the large outlet glacier in Chatham Strait. Ice from Chatham Strait did flow west through the low pass in the divide at Gut Bay to contribute ice to the glacier in Whale Bay. A NOAA bathymetric chart (17328) shows a deep glacial trough extending about 8 km southwest from the mouth of Whale Bay onto the continental shelf. The divide was not breached again for another 45 km to the south where ice from Chatham Strait overflowed into Puffin Bay Fiord. Hence the outlet glacier in Chatham Strait was largely confined to the strait where it flowed due south to the southern tip of Baranof Island. At this point the glacier turned sharply to the west to the outer edge of the continental shelf. Therefore, from Whale Bay south to near the southern end of the island, the western side of Baranof Island was subjected to only local mountain glaciers. These glaciers headed in cirques on the island's divide and flowed to the southwest. South of Whale Bay the terrain along the western coast has a strong structural trend to the northwest. Here, streams, lakes, ridges, and valleys are aligned to the northwest. Many of the valleys have V-shaped profiles. Local mountain glaciers flowing southwest from the divide were blocked and diverted northwest by ridges 300–580 m in height, protecting this area from glaciers. Marine terraces along the western coast of Baranof Island are low (5–10 m), suggesting a reduced ice thickness (assuming that the terraces are the result of isostatic rebound and have not been effected by tectonic uplift).

During field work in the summer of 2000 in the area south of Whale Bay (Sandy Bay and Still Harbor), we failed to find any glacial deposits such as till, outwash, or large granitic erratics from the Coastal Mountain batholith that should have been present had the area been overridden by the western margin of the Cordilleran ice sheet. Glacial landforms such as polished rock surfaces are absent in these areas. We also examined aerial photographs of the area and saw no evidence of glacial landforms. These data suggest that the western part of Baranof Island in the vicinity of Whale Bay and the adjacent continental shelf, which was exposed by a lowering of sea level during the late Wisconsin glaciation, an area of about 900 km2 (Carrara and others, 2002), may have served as a refugium.

CORONATION ISLAND

Coronation Island, about 70 km2 in area, is one of the outermost islands in the Alexander Archipelago and lies about 40 km southeast of the southern end of Baranof Island across Chatham Strait. The highest point on the island is Needle Peak at an altitude of about 600 m.

The presence of the endemic Coronation Island vole (Microtus longicaudus coronarius) on Coronation and Warren Islands, a subspecies(?) of the long-tailed vole (Microtus longicaudus), may indicate a long period of separation for the two subspecies of voles. This suggests that refugia may have existed on or near Coronation and Warren Islands, although this argument is doubted by McDonald and Cook (1999), who thought the difference between the two subspecies is insignificant.

A brown bear skeleton, which yielded a radiocarbon age of 11,630 14C yr B.P., was found in a cave on Coronation Island (Heaton, 2002). Brown bears are not found on the island today (MacDonald and Cook, 1999), and the presence of brown bears soon after deglaciation may indicate the presence of nearby refugia that brown bears could have migrated from.

Although the large outlet glacier in Chatham Strait was only about 10–15 km to the northwest of Coronation Island, aerial photographs and the USGS topographic map (Craig D7&D8) of the island do not display features that indicate the island was overrun by late Wisconsin Cordilleran ice. Several drowned amphitheathers indicate that the island supported local glaciers sometime in the past (pre-late Wisconsin?). With only one exception, the NOAA bathymetric chart (17402) does not show any troughs extending from the amphitheaters out onto the ocean floor. Bathymetric data indicate a trough (>55 m depth) in Windy Bay, however the trough shoals several kilometers to the west, indicating that the glacier was not extensive. The map and the NOAA bathymetric chart indicate a relatively smooth, featureless ocean floor south and west of the island. Hence, the unglaciated ocean-facing slopes and forelands on Coronation Island and the adjacent continental shelf to the south and west, an area of about 750 km2, (Carrara and others, 2002) may have been a refugium during the late Wisconsin glaciation.

WARREN ISLAND

Warren Island, about 50 km2 in area, is about 15 km east of Coronation Island and separated from that island by Sumner Strait. The highest point on Warren Island is Bald Peak at an altitude of about 675 m.

The map and NOAA bathymetric chart (17402) indicate deep glacially scoured troughs along the west and east sides of Warren Island. During the late Wisconsin, a lobe of ice flowed into the deep (>275 m) Sumner Strait trough. To the east of Warren Island, a lobe of ice flowed into the deep (>180 m in places) Warren Channel. However, south of Warren Island a broad, shallow (<90 m) shelf extends for about 10 km. The USGS topographic map (Craig D6) of the island shows several drowned valleys on the east side of the island that head in large amphitheaters and suggests that the island supported only local glaciers during the late Wisconsin. Therefore, ocean-facing slopes and forelands on Warren Island and the adjacent continental shelf to the south may have served as a small (65 km2) refugium during the late Wisconsin.

AREA FROM WEST OF HECETA ISLAND IN THE NORTH TO FORRESTER ISLAND IN THE SOUTH

A large area of the continental shelf (2,500 km2) stretching for more than 100 km from west of Heceta Island in the north to Forrester Island in the south, and averaging about 25 km west to east, may have served as a refugium during the late Wisconsin glaciation. Although much of Heceta Island appears to have been covered by Cordilleran ice, ocean-facing slopes and forelands on the western side of Noyes, Baker, and Suemez Islands and the adjacent continental shelf may have served as a refugium.

Noyes (85 km2), Baker (105 km2), and Suemez (135 km2) Islands are three outer islands to the west of Prince of Wales Island. USGS topographic maps (Craig B5, B6, C5, C6) of Noyes Island indicate that Cordilleran ice was banked up against the northeast and east sides of the island as it flowed through the St. Nicholas Channel. Two valleys on the southern part of the island were invaded by overflowing ice from the St. Nicholas Channel and these glaciers flowed to the west side of the island. However, the rest of the island does not appear to have been crossed by late Wisconsin Cordilleran ice, although several U-shaped valleys indicate that the island may have supported local glaciers. The NOAA bathymetric chart (17406) indicates that the St. Nicholas Channel reaches a depth of 115 m. However this channel and the two glaciated valleys on the southern part of the island do not extend onto the ocean floor south of Noyes Island. The bathymetric chart shows a relatively smooth, featureless ocean floor extending west for about 50 km to the edge of the continental shelf, for about 25 km of this distance the depth is less than 125 m and may have been exposed by sea level lowering during the late Wisconsin.

On Baker Island analysis of aerial photographs and USGS topographic maps (Craig B5, B6) suggests that continental ice from the lobe in Bucareli Bay, immediately east of Baker Island, flowed through only one low valley to the west side of the island. The highest point on the floor of this valley is about 30 m. The rest of the island's divide does not appear to have been breached by ice from the east. Several drowned valleys on the island indicate the presence of local glaciers. The map and a NOAA bathymetric chart (17406) indicate a deep (>275 m in places) glacial trough In Bucareli Bay. To the west the map and bathymetric charts indicate a smooth, featureless ocean floor extending about 30 km to the edge of the continental shelf. For much of this distance the depth is less than 125 m and may have been exposed by sea level lowering during the late Wisconsin.

Analysis of aerial photographs and USGS topographic maps (Craig A4, A5, B4, B5) of Suemez Island suggests that much of the island was inundated by continental ice, both from the lobe in Bucareli Bay along the west side of the island and a small lobe along the east side of the island. Ice from these lobes appears to have flowed into the interior of the island, such that only the higher parts may have been above the ice level. High steep slopes rising 600 m above sea level that seem to have been unglaciated flank the southern part of the island. However it is doubtful that any significant refugium existed on the island.

Forrester Island lies in the far southwestern part of the Alexander Archipelago about 30 km west of Dall Island. The island is only about 8 km long (north to south) and about 2 km at its widest point (USGS topographic map Dixon Entrance D5). The central ridge, which trends north to south, culminates at an altitude of 410 m. The island shows no signs of prior glaciation (Worley, 1980). A thorough search of the island for the deepest and oldest peat section yielded a radiocarbon age of only 6,470±160 14C yr B.P. from the basal peat of a section about 2.75 m deep (Worley, 1980). The young radiocarbon age and the low floral diversity led Worley (1980) to suggest that Forrester Island may have been uplifted above sea level in postglacial times and hence to discount the probability of the island having been an important refugium during the late Wisconsin. However, the amount of uplift required to raise the island so high above present sea level during postglacial time seems unlikely.

DALL ISLAND

Dall Island (655 km2) is about 90 km long (northwest to southeast) and about 15 km across at its widest point. The drainage divide culminates at an altitude of about 760 m, although the highest point is Thunder Mountain along the west side of the island at an altitude of about 950 m. Aerial photographs and USGS topographic maps (Craig A3, A4; Dixon Entrance C3, D3, D4) of the island indicate that it has been substantially glaciated, both by local glaciers and possibly by Cordilleran ice or ice from Prince of Wales Island from the east in the northern one-third of the island. The southern part of the island supported local glaciers but Cordilleran ice appears to have been confined to the island's east side. The map and the larger scale NOAA bathymetric charts (17408, 17409) indicate a steep ocean floor off the west coast of the island; for most of the length of the island the 90-m (50-fathom) contour is less than several kilometers offshore. Deep major channels are absent along the west coast, indicating that major outlet glaciers did not cross the island.

Several lines of biological evidence suggest that refugia may have been present on or near Dall Island. As discussed earlier, isolated stands of subalpine fir on the island (Harris, 1965) could have been derived from refugia within the region. A brown bear skeleton, which yielded a radiocarbon age of 11,715 14C yr B.P., was found in a cave on Dall Island (Heaton, 2002). Brown bears are not found on the island today (MacDonald and Cook, 1999), and the presence of brown bears soon after deglaciation may indicate the presence of nearby refugia that the bears migrated from.

These data suggest that the unglaciated ocean-facing slopes and forelands along the west side of Dall Island and narrow strips of adjacent continental shelf exposed by a lowering of sea level may have formed a series of refugia in the region.

PRINCE OF WALES ISLAND

Prince of Wales island is the largest island (6,675 km2) in the Alexander Archipelago. Although not an outer island, Prince of Wales Island contains several fossil localities that provide important information regarding the extent and duration of the late Wisconsin glaciation. Radiocarbon ages have been obtained from bones of Pleistocene and Holocene animals recovered from caves in the northwestern part of the island (Heaton and others, 1996; Baichtal and others, 1997; Dixon and others, 1997). The radiocarbon ages have been processed by several different laboratories and are uncorrected for those animals with a marine diet (correction of about 600 years) so that there may be some discrepancy in the ages. Nonetheless the 42 radiocarbon ages form an almost complete sequence from about 40,000–10,000 14C yr B.P. (Heaton, 2002). Although till of apparent late Wisconsin age is present at the mouth of On Your Knees cave, near Protection Head, the radiocarbon ages are important in that they indicate that this part of northern Prince of Wales Island could not have been covered by glacial ice during much of the late Wisconsin. A gap in the radiocarbon ages occurs between about 17,100 and 14,500 14C yr B.P. It may simply be a random gap due to the limited number of radiocarbon ages or it may indicate the time when the cave entrance was covered by glacial ice. As the source of Cordilleran ice on Prince of Wales Island was from the north and northeast and apparently of limited duration, some areas in the southern part of the island may have been free of Cordilleran ice and supported only local glaciers during the late Wisconsin (S.M. Karl and T.D. Hamilton, U.S. Geological Survey, oral commun., 2001). Hence, some lowland areas on the southern part of Prince of Wales Island may have served as a refugium.

Fossil remains of brown bear, a species not present on Prince of Wales Island today, have been found in several caves on the island. At On Your Knees cave a radiocarbon age of 35,365±800 14C yr B.P. was obtained on the remains of a brown bear, clearly indicating the presence of this species on the island prior to the late Wisconsin glaciation (Heaton and others, 1996). Radiocarbon ages on the remains of brown bears found in other caves on the island range from 12,295±120 to 7,205±65 14C yr B.P. (Heaton and others, 1996; Heaton, 2002). The presence of brown bears on the island soon after regional deglaciation may indicate the presence of nearby refugia that the brown bears migrated from.

The dispersal of mammals from refugia to recently deglaciated terrain may have been facilitated by the presence of sea ice. Ringed seals (Phoca hispida) are an indicator of sea ice, and their remains, which appear to have been scavenged, are quite abundant in On Your Knees cave (Heaton, 2002). Radiocarbon ages of ringed seal bones range from about 24,000 to 14,000 14C yr B.P. (with some gaps) (Heaton, 2002) but suggest that the area around northwestern Prince of Wales Island supported sea ice and therefore may have facilitated the movement of large mammals during this time.

REFUGIA AND EARLY MAN

Radiocarbon ages (uncorrected) indicate the presence of early man in the Alexander Archipelago (Prince of Wales Island) by 9,700 14C yr B.P. (Heaton and others, 1996) and the Queen Charlotte Islands by 9,300 14C yr B.P. (Josenhans and others, 1997). In addition, archeological evidence is thought to demonstrate an established marine adaptation by people living in the Alexander Archipelago by 10,000 14C yr B.P. (Dixon and others, 1997). Prehistoric inhabitants of the archipelago would more than likely have been confined to the coastal regions, which contained abundant sea life, and to the mouths of major rivers, which supported large salmon migrations. Although several archeological sites dating from the early Holocene are present on the outer islands of the archipelago (see discussion in Dixon, 1999), because of the rapidly rising sea level at the end of the Pleistocene and subsidence in some areas due to tectonic activity, much of the possible earlier evidence of human occupation along the outer coast is likely now below sea level. Evidence of early postglacial human occupation may exist farther to the east near the Alaska mainland where the continental ice was much thicker and isostatic rebound greater. There, late Pleistocene and early Holocene marine deposits are found above present-day sea level (Mobley, 1988).

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Figure 1. Index map of the Alexander Archipelago of southeastern Alaska, showing map area.