Part 3—Descriptions of Alaska's 14 Glacierized Geographic Regions

Introduction

As stated in the introduction to this volume, the primary purpose of this compilation is to provide a baseline that summarizes the areal extent and geographic distribution of Alaskan glaciers during the decade marking the advent of the Landsat series of satellites. The first satellite in the series, ERTS–1 (later renamed Landsat 1), was launched on 23 July 1972. By 2004, there had been seven satellites in the series; six successfully reached orbit and became operational for varying lengths of time. It is hoped that this baseline will be used now and by future researchers to document change in the number, length, and area of Alaska's glaciers. Because of the large geographic area involved, Alaska has been divided into 14 glacierized regions:

Coast Mountains
Alexander Archipelago
St. Elias Mountains
Chugach Mountains
Kenai Mountains
Kodiak Island
Aleutian Range
Aleutian Islands
Wrangell Mountains
Talkeetna Mountains
Alaska Range
Wood River Mountains
Kigluaik Mountains
Brooks Range

Landsat MSS imagery collected between 1972 and 1983 has been used to define 14 glacierized geographic regions in Alaska. Each geographic region is treated separately. Oblique and vertical aerial and ground photographs acquired during the period of the baseline and baseline-contemporary field observations are used to supplement the information derived from analysis of remotely sensed data. Of particular value are the high-altitude false-color infrared vertical aerial photographs of Alaska's glaciers acquired by a NASA U–2 aircraft between 1978 and 1986. Many of the AHAP photographs are used as figures throughout or cited in the text.

Pre-baseline ancillary information, such as historic ground and aerial photography and maps, and descriptive narratives of early explorers are included wherever possible to extend the baseline back to the 18th and 19th centuries or earlier if possible. These pre-baseline qualitative and quantitative data are used to characterize the activity of Alaskan glaciers before the acquisition of Landsat MSS images and to extend the documentation of long-term trends and changes.

Recent information about changes that have occurred in Alaska's glaciers after the period of the baseline is also presented if it is available. Many of these later data were acquired by increased picture element (pixel) resolution satellite sensors that did not exist at the time of the Landsat MSS image baseline—for example, Landsat Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), Advanced Spaceborne Thermal Emission and Reflection (ASTER), and satellite Synthetic Aperture Radar (SAR) imagery.

Analysis of Glacier Activity

Wherever possible, information used to produce and enhance the baseline is also used to determine the activity of individual glaciers and is included in the description of each of the 14 glacierized geographic regions and subregions. The terminus of a glacier may be advancing, retreating, or stationary. A stationary terminus generally represents a glacier that is in dynamic equilibrium, where the rate of glacier flow equals the rate of melting (that is, the glacier has a mass balance that is in equilibrium; accumulation is equal to ablation). Thus, the position of the terminus does not change. A stationary terminus may also be stagnant. In a stagnant state, glacier ice is typically detached from its source area and is no longer in motion. Frequently, stagnant ice develops a thick cover of glacial debris that insulates it from significant melting. In many such cases, the glacier-ice surface is subsequently covered by vegetation.

Evidence of Glacier Retreat Used in This Analysis

A number of glacial-geology criteria are used to determine recent glacier activity. Indicators of retreat usually involve exposure of deglacierized terrain, often with specific sedimentary and geomorphic features. Among the most common indicators are trimlines, abandoned lateral moraines, and abandoned medial moraines, although the latter are very rarely preserved. Figure 62 shows a number of retreat characteristics displayed by a valley glacier in the Chugach Mountains, informally known as *Five Stripe Glacier*. In addition to the characteristics already mentioned, vegetation-free bedrock surrounding an ice-margin is another criterion useful to document recent retreat. Figure 63 shows additional criteria such as vegetation along the break-in-slope at the lower end of the central U-shaped valley, which suggests that the glacier has not recently extended beyond that point. The absence of vegetation on the floor or walls of the hanging valley indicates that the entire surface was covered by glacier ice not too long ago and has only recently been deglacierized. A distinctive trimline on the right side of the valley and the color change near the top on the left side of the valley offer additional evidence of recent retreat.

Figure 62.*—Oblique color aerial photograph on 20 August 1977 of a valley glacier in the Chugach Mountains, informally called* Five Stripe Glacier. *The well-defined trimlines on the valley walls on both sides of the terminus, a layer of lateral moraine paralleling the left margin of the glacier and extending both above and downvalley of the terminus, and several exposed medial moraines elevated above the ice surface and extending beyond the ice margin are all evidence of recent thinning and retreat. As most of these sedimentary features are ephemeral, these changes have had to occur in a very short period of time. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

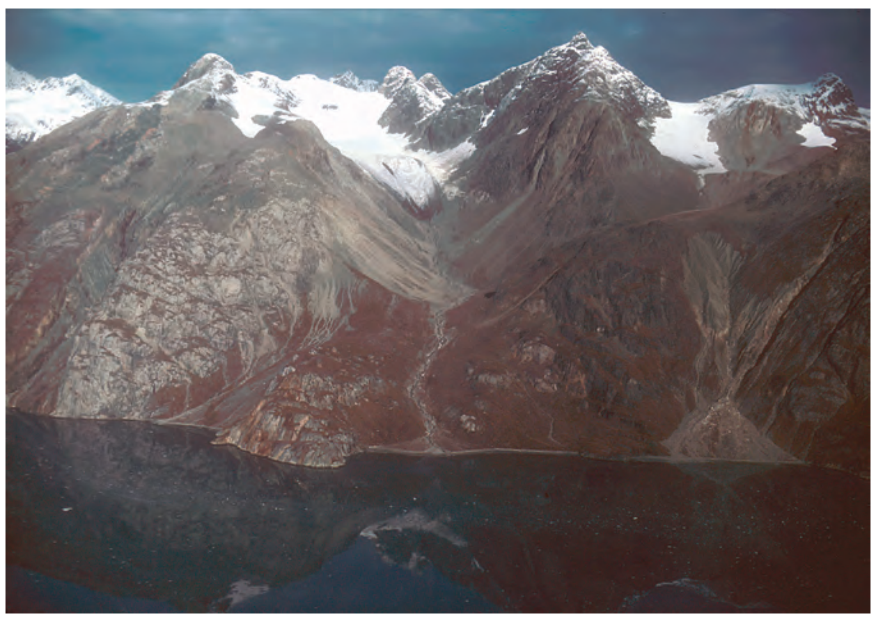


Figure 63.*—Oblique color aerial photograph on 3 October 1979 of an unnamed hanging glacier in Glacier Bay, Saint Elias Mountains, which displays additional criteria that can be used to document recent glacier recession. Vegetation along the break in slope at the lower end of the central "U"-shaped valley suggests that the glacier has not extended beyond that point recently. The absence of vegetation on the floor or walls of the hanging valley suggests that the entire surface was recently covered by glacier ice. The distinctive trimline on the right side of the valley and the color change on the left side of the valley near the top are additional evidence of recent, rapid retreat. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

Evidence of Glacier Advance Used in This Analysis

The formation of push moraines (fig. 64) and the overriding of vegetation by advancing ice (fig. 65) are two primary indicators of glacier advance. As a glacier advances, it generally displaces, flows over, or flows around anything in its path. As it advances over unconsolidated sediment, it may push both forward and upward to form a push moraine. Generally, push moraines are from 1 to 2 m high. However, they may reach a height of 5 m or more. During the 1993–95 surge of Bering Glacier, numerous push moraines developed along more than 15 km of the margin of the glacier. Many were spatulate in shape and showed evidence of an upward thrusting of the advancing terminus. If an advancing glacier encounters a forest, it sometimes uproots or shears off the trees and then overrides them (fig. 66). Glaciers that produce large quantities of fluvioglacial sediment may bury vegetation in outwash deposits to a uniform height and then override this sediment and shear trees at the top of the sediment. Subsequent erosion may expose the trunks in their *in situ* growth position (fig. 67).

Evidence of Glacier Stagnation Used in This Analysis

Sediment-covered stagnant ice may persist for decades or even several hundred years. Many of Alaska's glaciers, such as Bering, Yakataga, Fairweather, Malaspina, and Muldrow Glaciers, have vegetation, including trees more than 100 years old growing on their debris-covered stagnant ice sur-

▲ ***Figure 64.****—15 July 1978 photograph of part of the terminus of Harriman Glacier, Chugach Mountains, showing a recently formed 1-m-high push moraine. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

◄ ***Figure 65.****—14 July 1994 oblique aerial photograph of a lobe of Bering Glacier, Chugach Mountains, which was overriding an alder (*Alnus *sp.) forest as it advanced during the 1993–95 surge. The trimline above the advancing terminus and the very young vegetation suggest that a thicker ice mass recently existed in this area. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

Figure 66.*—Photograph of the results of late 19th century advance of La Perouse Glacier that sheared and overrode the trees located along its western margin. Subsequent retreat left the vegetation as an integral part of the push moraine. 18 June 1899 photograph by Grove Karl Gilbert, USGS. Photograph Gilbert 333 from the USGS Photographic Library, Denver, Colo.*

faces (fig. 68). Others, such as Herbert Glacier, have large debris-covered ice-cored moraines (fig. 69). Typically, large circular depressions known as thermokarst pits will form on these sediment-covered stagnant bodies of ice.

Figure 67.—*12 July 1991 photograph of three sheared tree trunks exposed by erosion following the recent retreat of the margin of Bering Glacier. These trunks are in growth position. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

Figure 68.—*Oblique color aerial photograph of vegetation growing on the surface of sediment-covered stagnant ice, Bering Glacier, Chugach Mountains, on 8 June 1976. The height of the ice face is about 15 m. On the Malaspina Glacier, mature spruce trees more than 100 years old, exist in a similar setting. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

Figure 69.—*8 July 1968 photograph of a debris-covered, ice-cored moraine that lies adjacent to the retreating terminus of the Herbert Glacier, Coast Mountains. This ice-cored moraine was emplaced about 40 years prior to the time of the photograph. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

As the pits expand by melting, vegetation will be displaced from the surface and fall into the thermokarst pits (fig. 70).

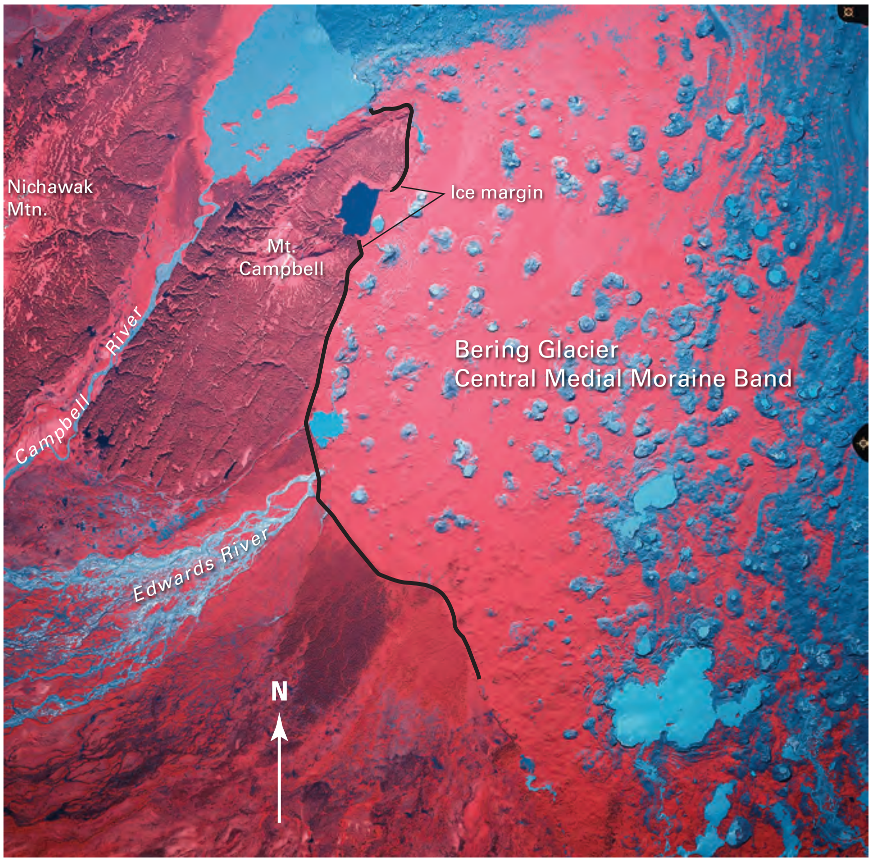


Figure 70.—*27 July 1983 AHAP false-color infrared vertical aerial photograph of large circular depressions, termed thermokarst pits, that are developing on the sediment-covered stagnant ice surface of Bering Glacier's Central Medial Moraine Band. The Central Medial Moraine Band separates the active Bering Lobe from the active Steller Lobe. Vegetation-covered ice is red in color, whereas debris-covered ice is blue gray. The largest depressions are more than 400 m in diameter. AHAP photograph no. L118F4494 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*

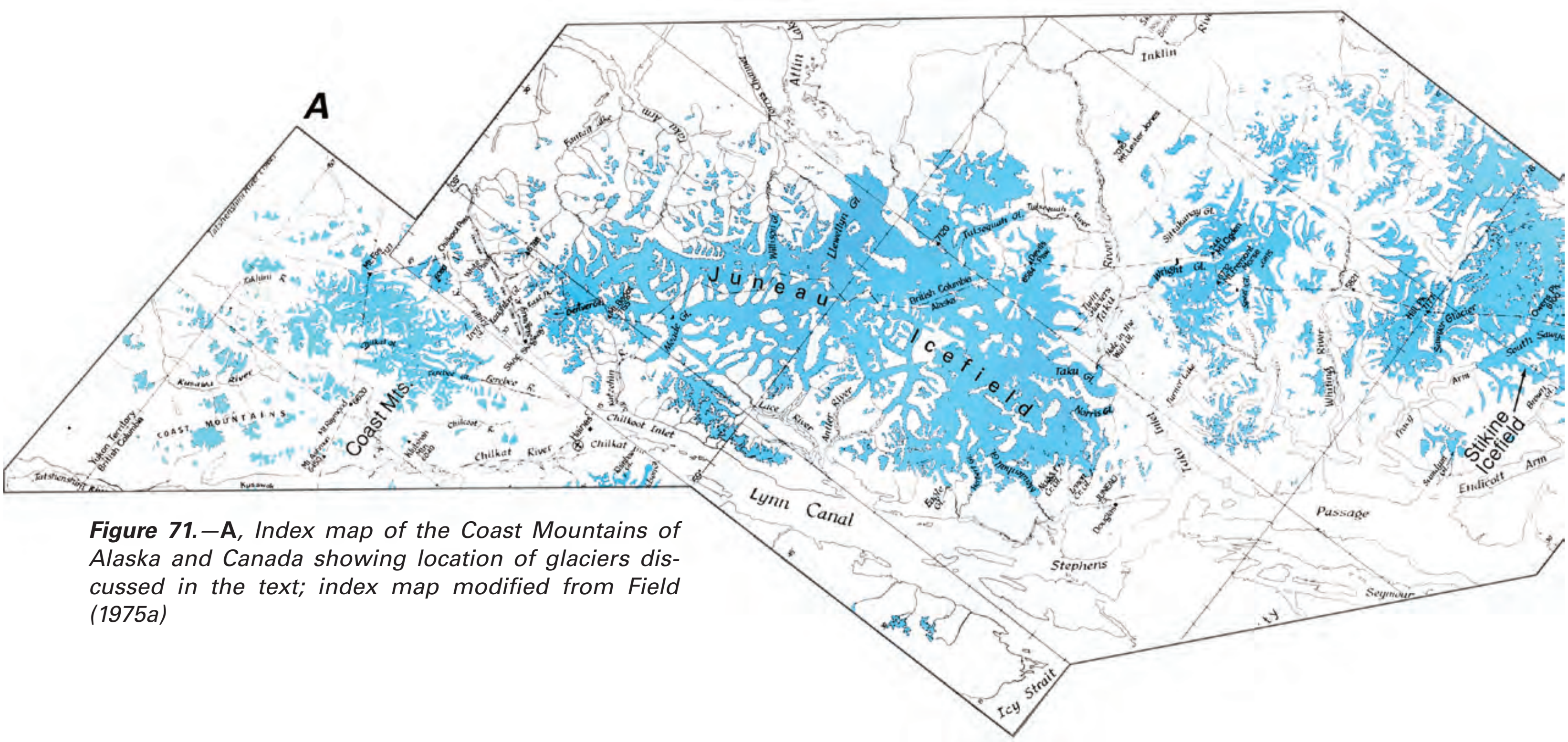


Figure 71.—**A**, *Index map of the Coast Mountains of Alaska and Canada showing location of glaciers discussed in the text; index map modified from Field (1975a)*

Coast Mountains

The Coast Mountains, which form the mainland portion of southeastern Alaska, extend for about 700 km from Portland Canal in the south to Mount Foster north-northwest of Skagway. From east to west, the glacierized area of the Coast Mountains is as much as 130 km wide (fig. 71). Included in the Coast Mountains are a number of individual ranges: Peabody Mountains, Rousseau Range, Halleck Range, Seward Mountains, Lincoln Mountains, Buddington Range, Kakuhan Range, Chilkoot Range, Sawtooth Range, and Takshanuk Mountains, all of which support glaciers. To the south, the glaciers are small and sparsely distributed. They increase in area and number to the north. The greatest concentration of Coast Mountain glaciers are in two ice fields, the *Stikine Icefield* and the Juneau Icefield. [Editors' note: Ice field is used throughout the text in its glaciological sense with reference to "an extensive mass of land ice covering a mountain region consisting of many interconnected alpine and other types of glaciers, covering all but the highest peaks and ridges" (Jackson, 1997, p. 316). The UNESCO (1970) definition is slightly different. "Ice masses of sheet or blanket type of a thickness not sufficient to obscure the subsurface topography." In this volume, icefield is standardized and used as a compound word in formal geographic place-names, that is, approved by BGN—(for example, Sargent Icefield). Most Alaskan "icefields" and associated outlet glaciers are true ice fields.] The total area of glaciers in the Coast Mountains is 10,500 km^2 (Post and Meier, 1980, p. 45). Unless otherwise noted, lengths and areas presented here are those given by Field (1975c), who used primarily

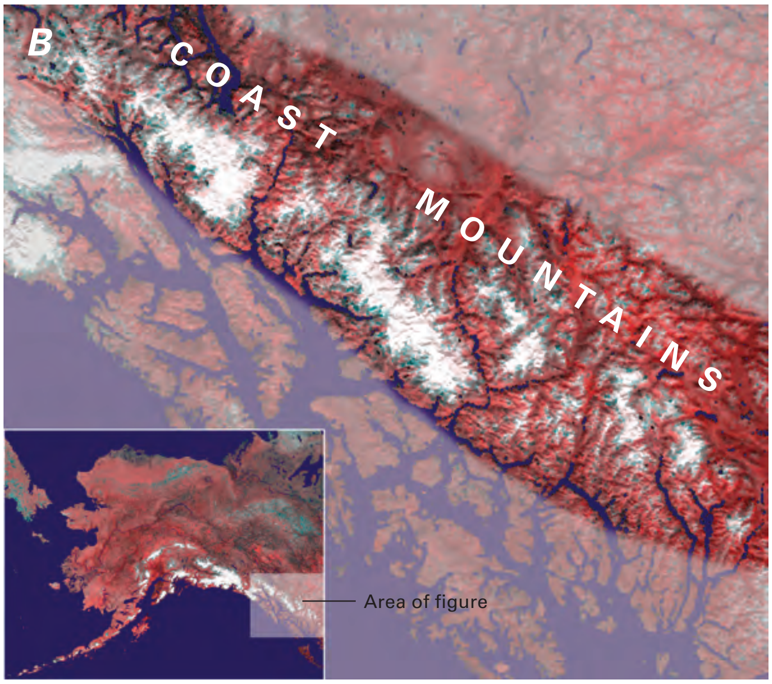
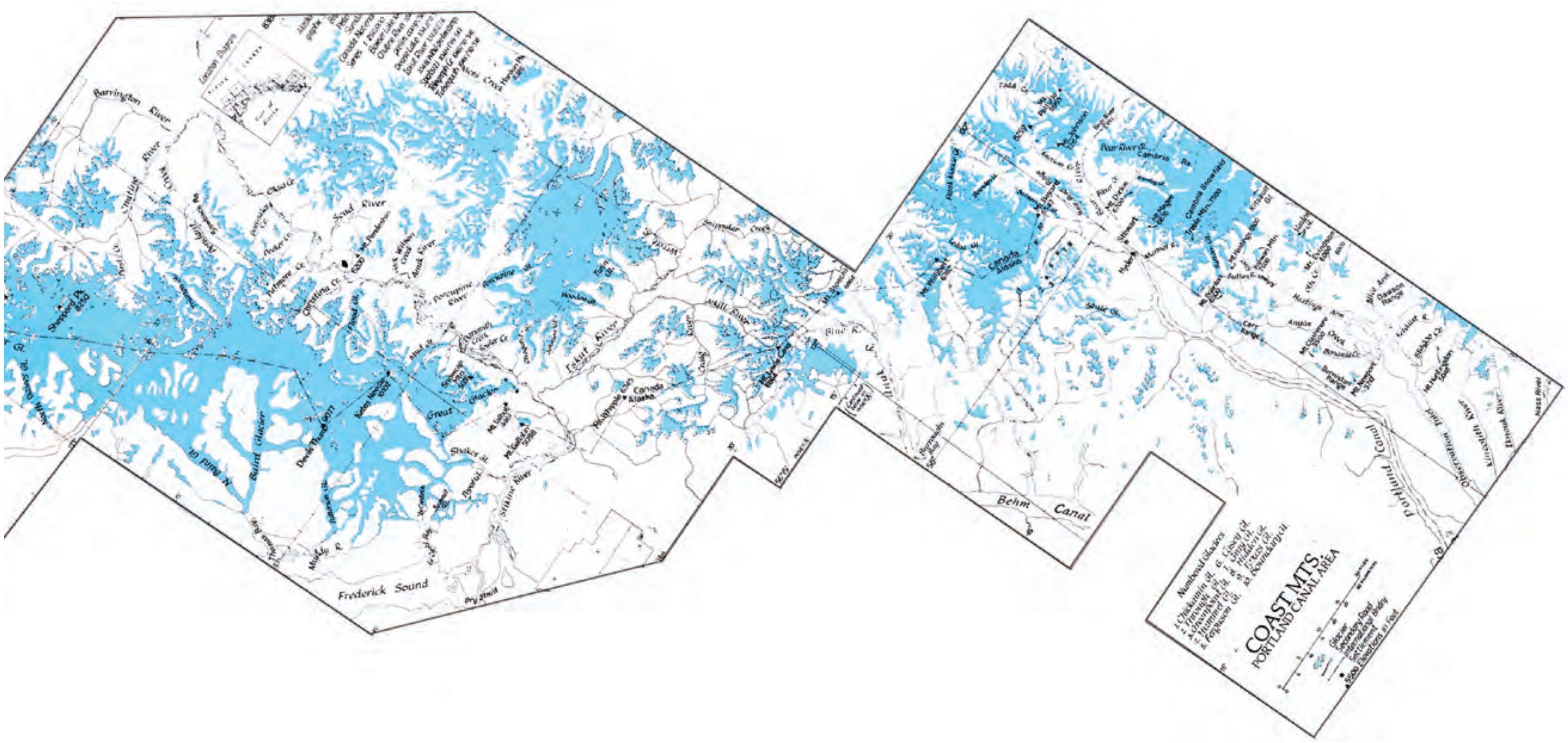


Figure 71.—**B**, *Enlargement of NOAA Advanced Very High Resolution Radiometer (AVHRR) image mosaic of the Coast Mountains in summer 1995. National Oceanic and Atmospheric Administration image mosaic from Mike Fleming, USGS, EROS Data Center, Alaska Science Center, Anchorage, Alaska.*



USGS 1:250,000-scale topographic maps (appendix A) for his quantitative measurements. These maps were generally compiled from aerial photography acquired and ground surveys performed between 1948 and 1964 and vary in the accuracy of the cartographic representation of the glaciers.

Much diverse information is available to monitor changes in the glaciers of this area. Baird Glacier (in the central Coast Mountains at lat 57°13'N., long 132°26'W.) is typical of the area. It was covered by early (1977, 1979, 1980) and later (post-1980) Landsat imagery and aerial photography (1929, 1948, 1967, 1979) and has also been surveyed and mapped many times. It was first surveyed by the United States Coast and Geodetic Survey in 1887 (USC&GS, 1891). It was then mapped by the IBC in 1894, during which time O.J. Klotz (1895, 1899) performed "a photo-topographic survey of the front of the glacier for the study of its motion," (Klotz, 1899, p. 523). It was visited by USGS field parties in 1904, 1922, 1923, and 1924, mapped again by the USC&GS in 1924, visited by an AGS field party in 1941 (Field, 1942), and then topographically mapped by the USGS between 1948 and 1961.

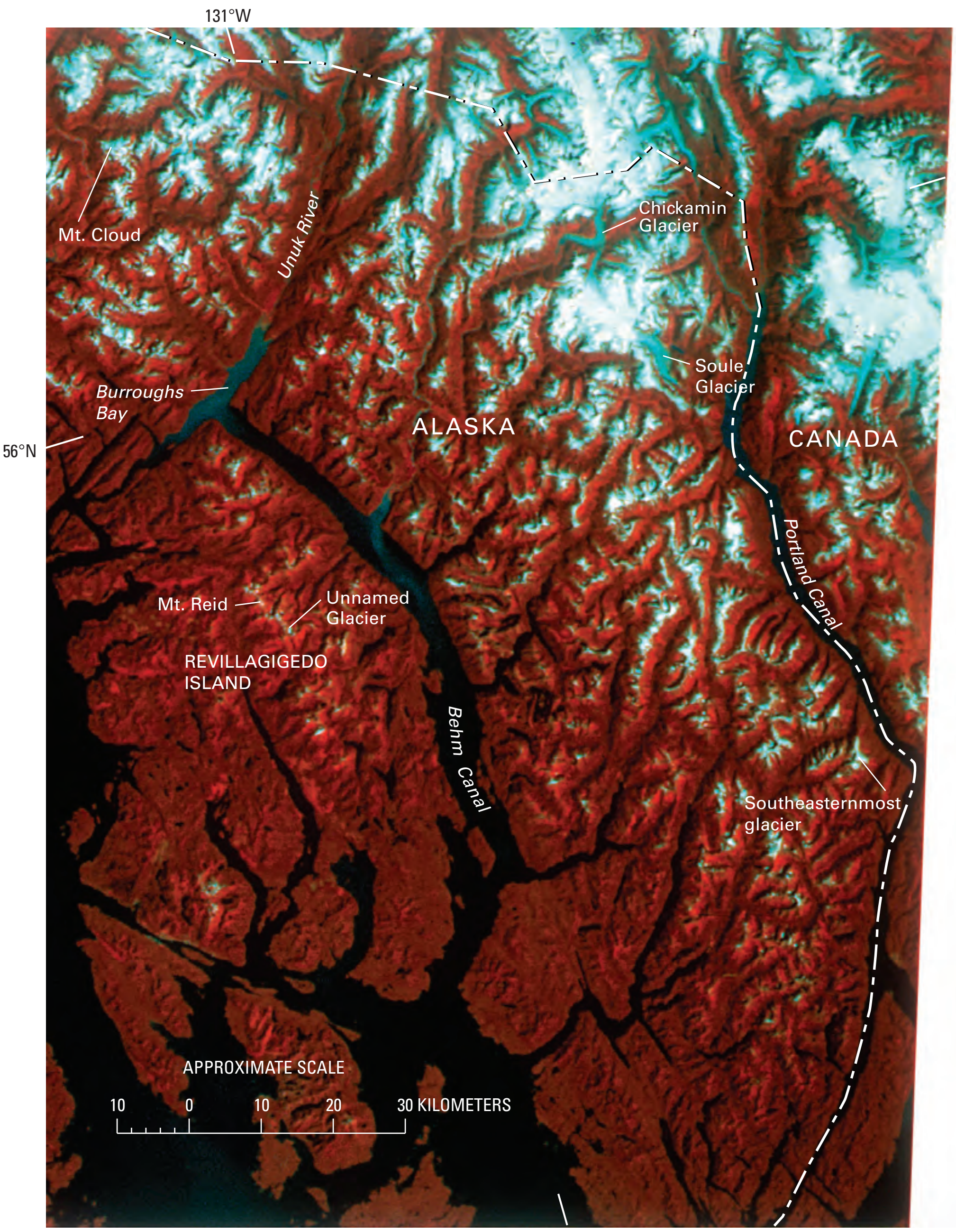


***Figure 72.**—Part of an annotated Landsat 2 MSS false-color composite image showing the Portland Canal to Burroughs Bay and Unuk River segment of the Coast Mountains and Revillagigedo Island. The locations of numerous Coast Mountain glaciers, up to 22 km in length, and the only glacier on Revillagigedo Island are shown. Landsat image (22027–19085; 10 Aug 1980; Path 59, Row 21) is from the USGS, EROS Data Center, Sioux Falls, S. Dak.*

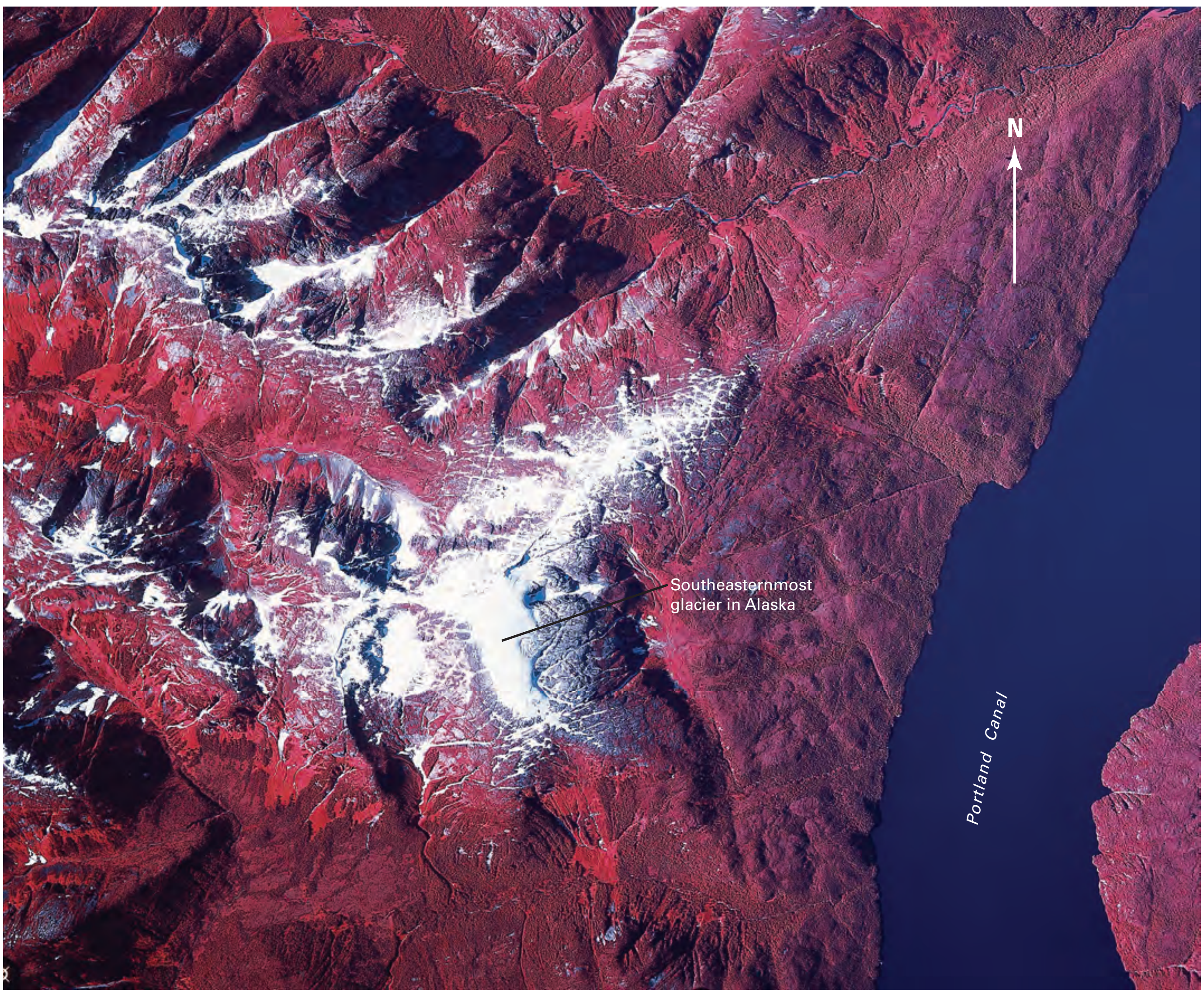
Additional studies, such as tree-ring investigations, were carried out by Donald Lawrence (Lawrence, 1950).

Portland Canal to Burroughs Bay and the Unuk River

Landsat MSS images that cover the Coast Mountains from Portland Canal to Burroughs Bay and the Unuk River have the following Path/Row coordinates: 58/21 and 59/21 (fig. 3*A*, table 1). This region contains several hundred glaciers, including the southeasternmost glaciers in Alaska (figs. 72, 73). Only about a dozen glaciers are named. Most glaciers are small (generally less than 2 km long) and show evidence of recent retreat (fig. 73). Soule Glacier, one of the larger glaciers in the region, has an area of about 66 km^2 (Field, 1975c, p. 99). Its terminus retreated about a kilometer in the 31 years between 1948, when aerial photography was acquired for mapping, and 14 August 1979, when it was photographed by the AHAP program (figs. 74*A*, *B*). It was still retreating when it was photographed from the space shuttle in August 1989 (see NASA Space Shuttle photograph no. STS028–073–039 acquired in August 1989).

Similarly, 26-km-long Chickamin Glacier, the largest glacier in the region, has an area of about 140 km^2 (Field, 1975c, p. 99). It retreated about 1 km and formed an ice-marginal lake in the 24 years between 1955, when it was mapped (USGS Bradfield Canal 1:250,000-scale map, appendix A), and 14 August 1979, when an AHAP false-color infrared vertical aerial photograph

Figure 73.—*Part of a 12 August 1979 AHAP false-color vertical aerial photograph of the unnamed southeasternmost glacier in Alaska. This 1.5-km-long glacier shows evidence of recent retreat and is fringed by vegetation-free exposed bedrock that appears grey. AHAP photograph no. L185F4825 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*



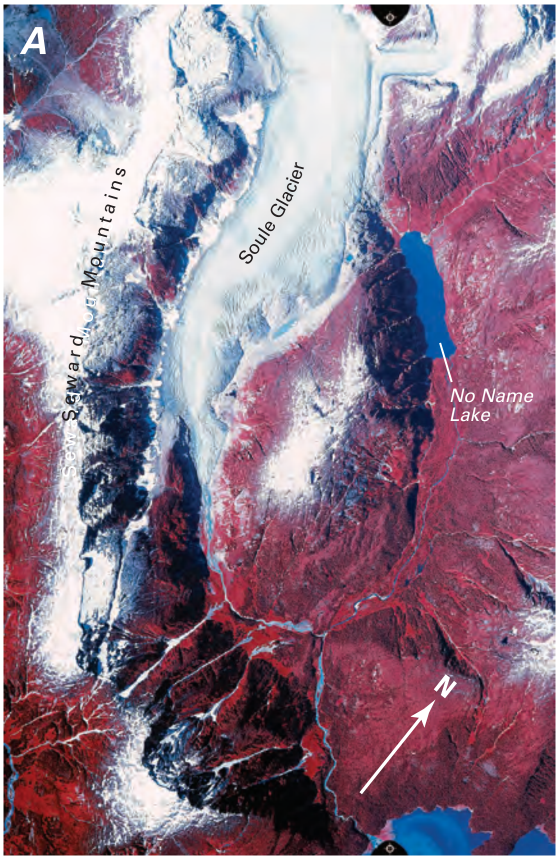


Figure 74.—**A**, *Part of a 14 August 1979 AHAP false-color vertical aerial photograph of the lower 7 km of the retreating Soule Glacier, located between the Lincoln Mountains to the northeast and the Seward Mountains to the west. Trimline development and the formation of two small ice-marginal lakes indicate recent downwasting. Tributary hanging glaciers that previously descended from the Seward Mountains have also recently retreated. AHAP photograph no. L183F5093 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.* **B**, *Part of USGS Ketchikan map (1955) showing the Soule Glacier and environs. On the 1948 aerial photographs used for the map, Soule Glacier was nearly a kilometer longer than shown on the 1979 AHAP photograph. USGS Alaska Topographic Series, 1:250,000-scale, Ketchikan, Alaska-Canada (appendix A).*

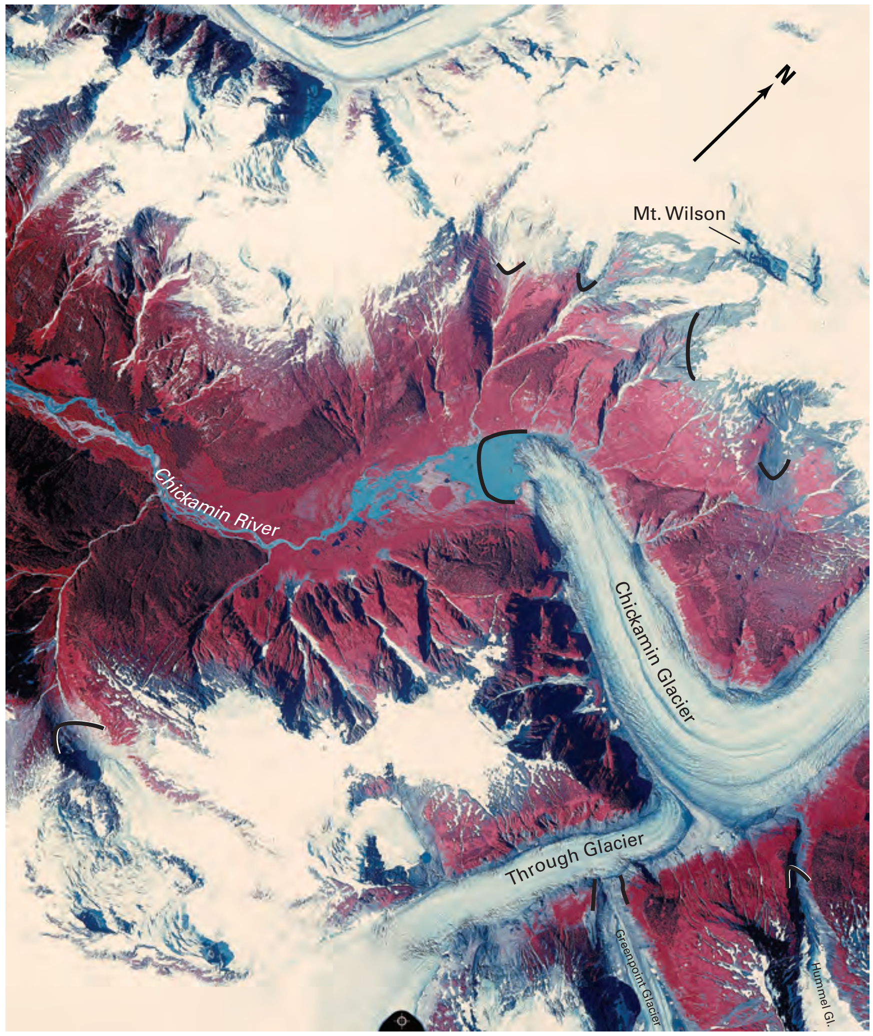
was acquired (fig. 75). Field (1975a) reported that, during the first two-thirds of the 20th century (1902–1964), Chickamin Glacier retreated more than 2.7 km, an annual rate of approximately 44 m a^{-1}. Elsewhere in this region, Through Glacier (approximately 8 km) and Gracey Creek Glacier (approximately 5.25 km) exceed 5 km in length. All of the larger glaciers are located in the northern part of this region in the higher elevations, and all show evidence of recent retreat. Texas Glacier (8 km long in Alaska, with an area of about 12 km^2) (Field, 1975c, p. 99) and Hummel, Ferguson, Casey, and Hidden Glaciers, all located east and southeast of Chickamin Glacier, are mapped with vegetation-free zones around their perimeters.

Burroughs Bay and the Unuk River to the Stikine River

Landsat MSS images that cover the Coast Mountains from Burroughs Bay and the Unuk River to the Stikine River have the following Path/Row coordinates: 58/21, 59/21, and 60/20 (fig. 3*A*, table 1). This region contains several hundred glaciers, only one of which (Nelson Glacier) is named (figs. 76, 77). Most are small (generally less than 2 km long) and show evidence of recent retreat. Several areas between Bradfield River and Cone Mountain, generally above 1,500 m in elevation, host significant accumulations of glacier ice. The largest of these accumulations is a small ice field centered about 11 km southeast of Cone Mountain. About a dozen individual distributary glaciers descend from the ice field, some to elevations as low as approximately 500 m. A similar accumulation of ice occurs east of Mount Cloud.

Five-kilometer-long Nelson Glacier, located about 25 km east of Wrangell, heads between Marsha Peak (1,380 m) and Mount Waters (1,330 m). It and the many smaller unnamed glaciers adjacent to it show significant evidence of recent retreat. Nelson Glacier retreated about 1 km and formed an ice-marginal lake in the 31 years between 1948 and 14 August 1979, the dates that aerial photography was acquired (fig. 77).

► ***Figure 75.***—*14 August 1979 AHAP false-color vertical aerial photograph of the lower 8 km of the Chickamin Glacier and adjacent Through, Greenpoint, and Hummel Glaciers. Many other small unnamed glaciers occur on the flanks of Mount Wilson. Exposed bedrock around many of the smaller glaciers documents recent retreat. All of the named glaciers and most of the unnamed glaciers are retreating. When photographed in 1948, Greenpoint Glacier made contact with Through Glacier and Through Glacier made contact with Chickamin Glacier. The heavy black lines show the approximate extent of glacier termini in 1948. AHAP photograph no. L183F5097 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*



▼ ***Figure 76.***—*Annotated Landsat 2 MSS false-color composite image mosaic showing the Coast Mountains from Burroughs Bay and Unuk River to the Stikine River. The image mosaic depicts Nelson Glacier, a small icefield southeast of Cone Mountain, and another concentration of ice east of Mount Cloud. Landsat images 22028–19141; 11 August 1980; Path 60, Row 20 (north) and 22027–19085; 10 August 1980; Path 59, Row 21 (south) are from the USGS, EROS Data Center, Sioux Falls, S. Dak.*

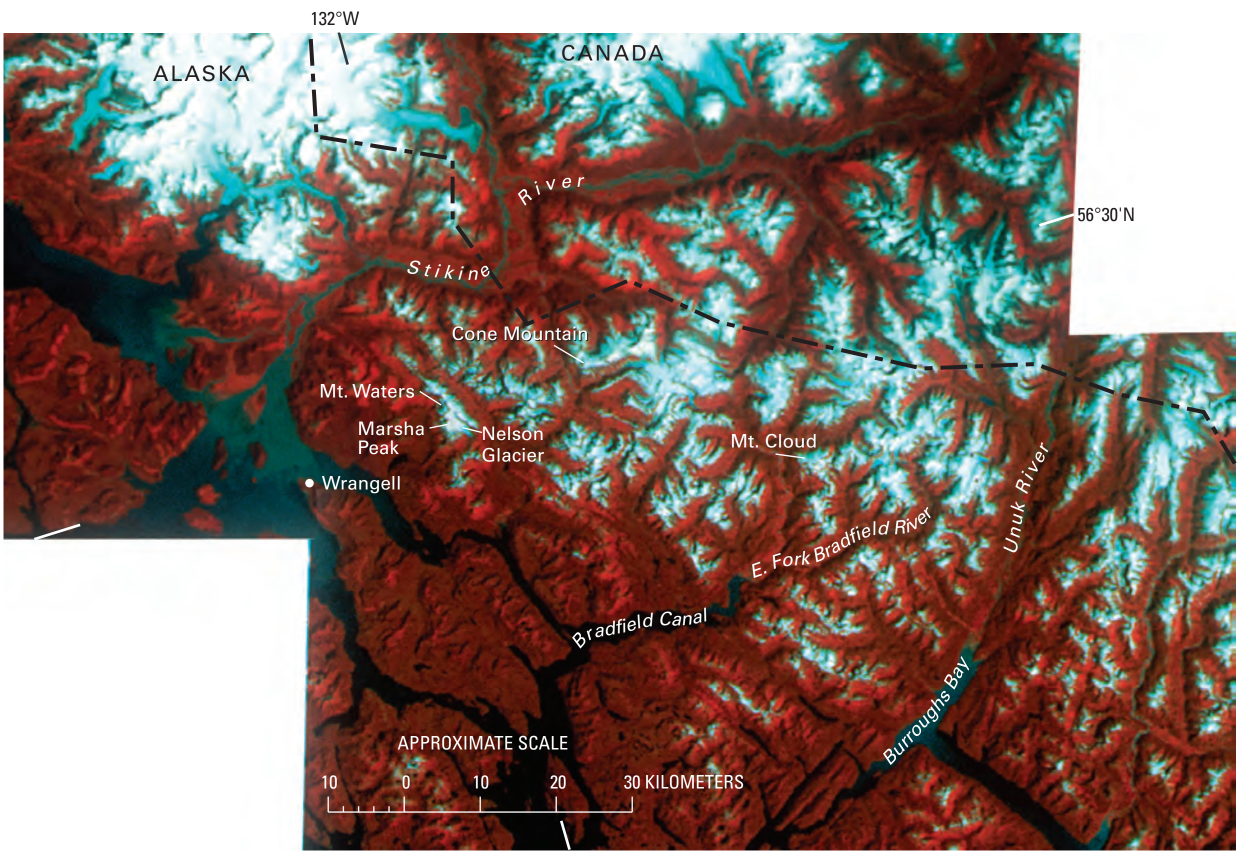


Figure 77.—*Part of an 11 August 1979 AHAP false-color vertical aerial photograph of 5-km-long Nelson Glacier and adjacent smaller, unnamed glaciers, many snow covered. Vegetation-free, recently exposed bedrock around Nelson Glacier and many of the smaller glaciers documents recent retreat. AHAP photograph no. L189F4363 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*

Stikine River to Taku River

Landsat MSS images that cover the Coast Mountains from the Stikine River to the Taku River have the following Path/Row coordinates: 59/20, 60/20, 61/19, 61/20, and 62/19 (fig. 3*A*, table 1). Between the Stikine River and the Whiting River, the glaciers increase in number, size, and organization (fig. 78*A*). The southernmost tidewater glaciers in Alaska are found here (fig. 41). Most glaciers in this region are distributaries of the *Stikine Icefield*, which extends from north of the Stikine River to south of the Taku River. The *Stikine Icefield* straddles the crest of the Coast Mountains along the U.S.-Canadian Border and has a length of approximately 190 km. This region contains several hundred glaciers, about a dozen of which are named. More than a dozen glaciers are 15 km in length or longer. Several of the larger glaciers originate in Canada at elevations above 2,000 m and flow westward to sea level. The word "Stikine" is the Tlingit name for Great River. Much of the southern *Stikine Icefield* is shown in an August 1997 photograph taken from the space shuttle (fig. 78*B*).

The southernmost glaciers in this region—Popof, Summit, and Shakes Glaciers—occur just north of the Stikine River. Nine-kilometer-long Popof Glacier, which has an area of about 18 km^2 (Field, 1975c, p. 108) and is located near the mouth of the Stikine River, was one of the first named glaciers

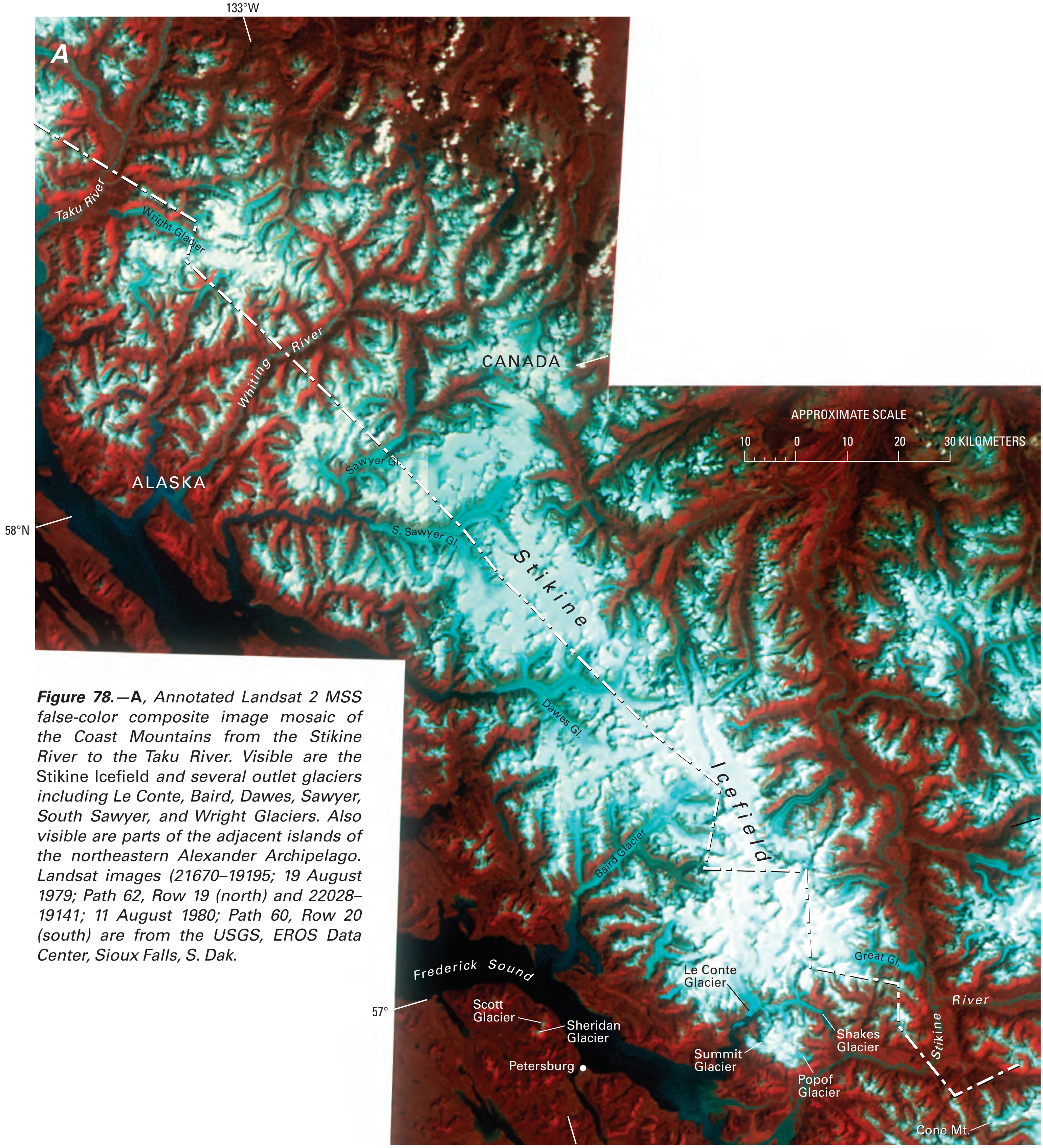


Figure 78.—**A**, *Annotated Landsat 2 MSS false-color composite image mosaic of the Coast Mountains from the Stikine River to the Taku River. Visible are the* Stikine Icefield *and several outlet glaciers including Le Conte, Baird, Dawes, Sawyer, South Sawyer, and Wright Glaciers. Also visible are parts of the adjacent islands of the northeastern Alexander Archipelago. Landsat images (21670–19195; 19 August 1979; Path 62, Row 19 (north) and 22028–19141; 11 August 1980; Path 60, Row 20 (south) are from the USGS, EROS Data Center, Sioux Falls, S. Dak.*

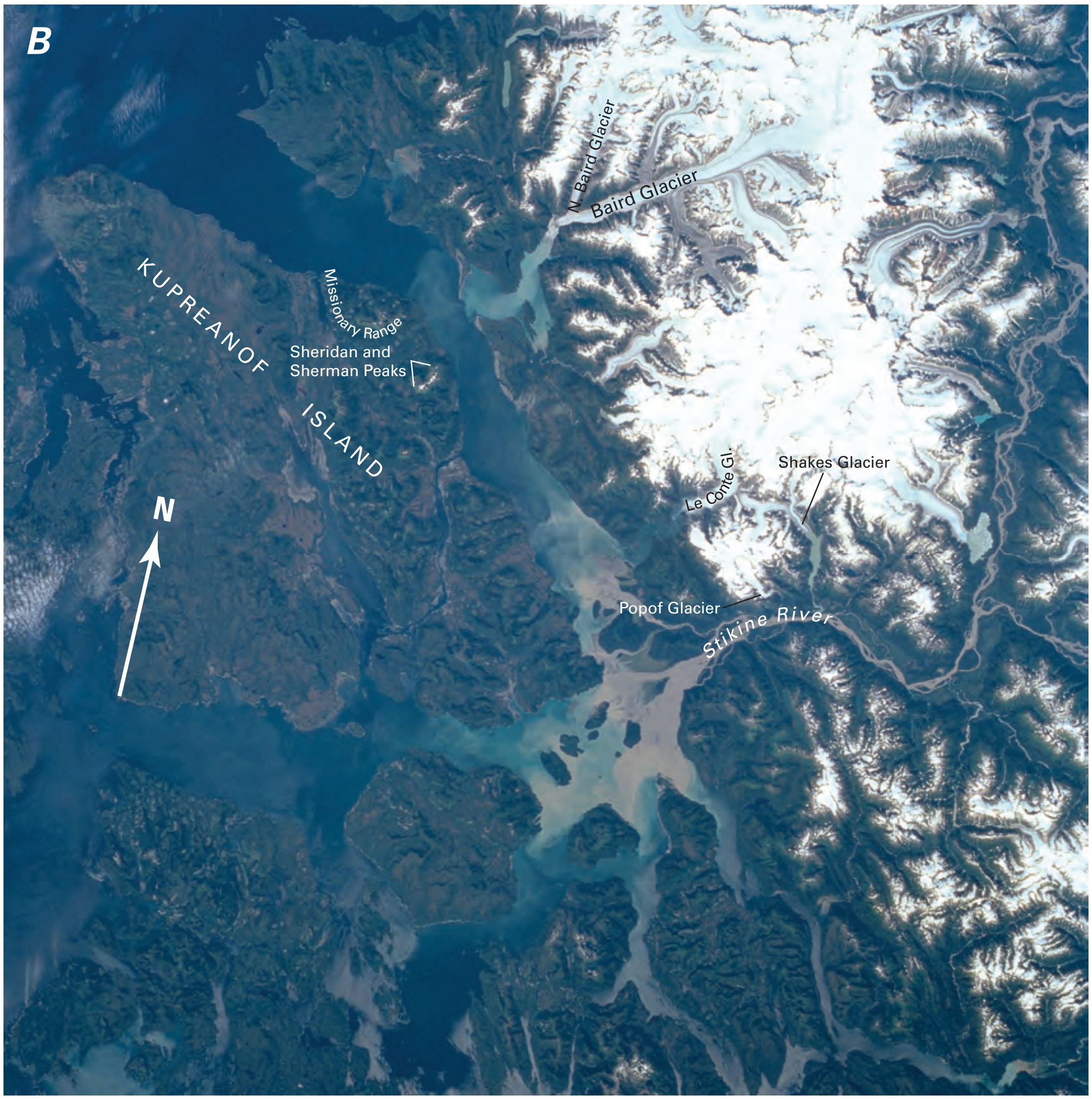


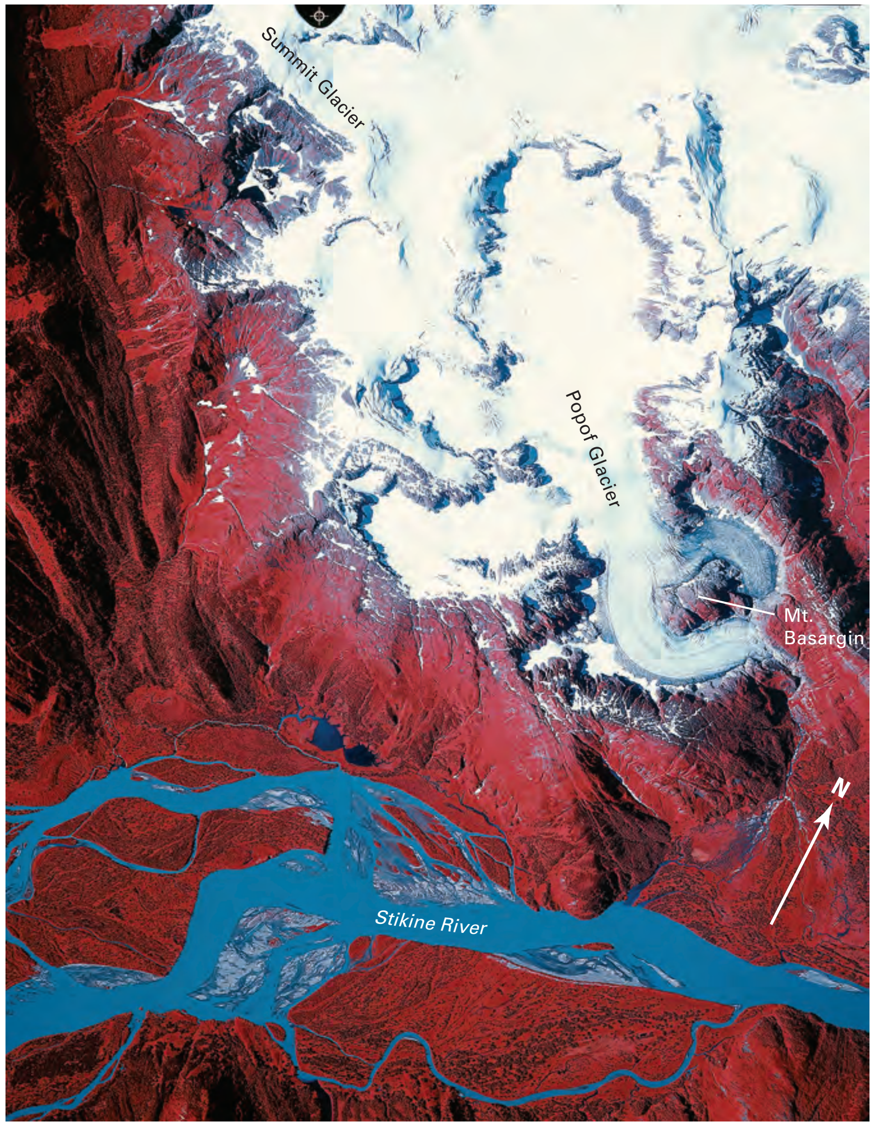
Figure 78.—**B**, *August 1997 Space Shuttle photograph of the southern part of the* Stikine Icefield, *including Popof, Shakes, LeConte, Baird, and North Baird Glaciers, some of the largest in the southern Coast Mountains. Also shown is the south-central part of Alexander Archipelago including Missionary Range and Sherman and Sheridan Peaks, the sites of the only reported glaciers on Kupreanof Island. Space shuttle photograph No. STS085–709–028 is from the National Aeronautics and Space Administration.*

in Alaska. The name first appeared on the Russian Rynda Survey in 1863, although, at that time, it was spelled with two "f"s (fig. 11). Thirteen years later, Canadian surveyor Joseph Hunter called it *First Glacier*. Since it was first surveyed more than 125 years ago, its terminus has retreated about 3 km. In the 31 years between 1948 and 11 August 1979, the dates when aerial photography was acquired (fig. 79), the two lobes of ice that joined to form the glacier's 1948 terminus separated and the northern lobe retreated approximately 0.5 km.

Eighteen-kilometer-long Shakes Glacier, with an area of about 56 km^2 (Field, 1975c, p. 109), is another glacier that shows significant change in the 31 years between aerial photographic flights. When it was photographed in 1948, its terminus dammed the northern end of Shakes Lake and created a small impoundment. When it was photographed on 11 August 1979 by the AHAP Program (fig. 80*A*), the terminus was calving large icebergs and had retreated about 0.7 km. In the 11 years that followed, the glacier retreated another 0.7 km, according to a 23 August 1990 oblique aerial photograph (fig. 80*B*).

Le Conte Glacier, "long known to the Indians as Hutli or the Thunderer, because of the noise produced by ice falling from its face" (Russell, 1897, p.78), has a length of 36 km, an area of 472 km^2 (Viens, 1995; tables 2, 3), ice speeds near the terminus of up to 23 m d^{-1}, and an AAR of 0.93. Le Conte Glacier was photographed on 11 August 1979 by the AHAP Program (L189F4355). It is the southernmost tidewater glacier in North America and probably in the

Figure 79.—Part of an 11 August 1979 AHAP false-color vertical aerial photograph of 8-km-long Popof Glacier, the upper reaches of Summit Glacier, and about a half-dozen smaller unnamed glaciers, many snow covered. Popof Glacier and almost all of the unnamed glaciers show evidence of recent retreat documented by trimline and vegetation-free, recently exposed bedrock. When photographed in 1948, the two lobes of Popof Glacier, which flow around Mount Basargin, were joined. AHAP photograph no. L189F4358 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.



entire Northern Hemisphere. Its 1.5-km-wide terminus sits at the head of Le Conte Bay in water depths of about 260 m. At the end of the 20th century, Le Conte Glacier had an extremely active calving terminus, producing large quantities of icebergs from a 50-m-high face. Between 1887, when it was first charted, and 1963, Le Conte Glacier retreated 3.7 km (Post and Motyka, 1995). This retreat was followed by a period of terminus stability from 1963 to 1994 (fig. 81). In the later years of the 20th century, the terminus began to actively retreat. Between 1994 and 1998, the glacier retreated 2 km, much of it by submarine calving (Echelmeyer and Motyka, 1997; Hunter and others, 2001; Connor and others, 1999; White and others, 1999).

Hunter and others (2001) reported that, since 1998, the glacier has entered a phase of temporary stability at a constriction in the fjord. They concluded that surface-ice speeds indicate that sliding dominates ice flow in the glacier's lower reaches. Between 1998 and 2000, they performed oceanographic monitoring in the ice-proximal basin at the glacier's stable face, including repeat bathymetric surveys, conductivity, temperature, and depth (CTD) casts, and near-surface velocity measurements. They measured suspended sediment concentrations near the ice margin of up to 55 mg l^{-1}. At a distance of 10.5 km from the terminus, these concentrations decline to 20 mg l^{-1}. Near-surface water-column velocity measurements range from 12 to 52 cm s^{-1} within 0.25 to 0.5 km of the ice margin, where flow was generally away from the ice margin in a radial pattern. They estimated discharge to

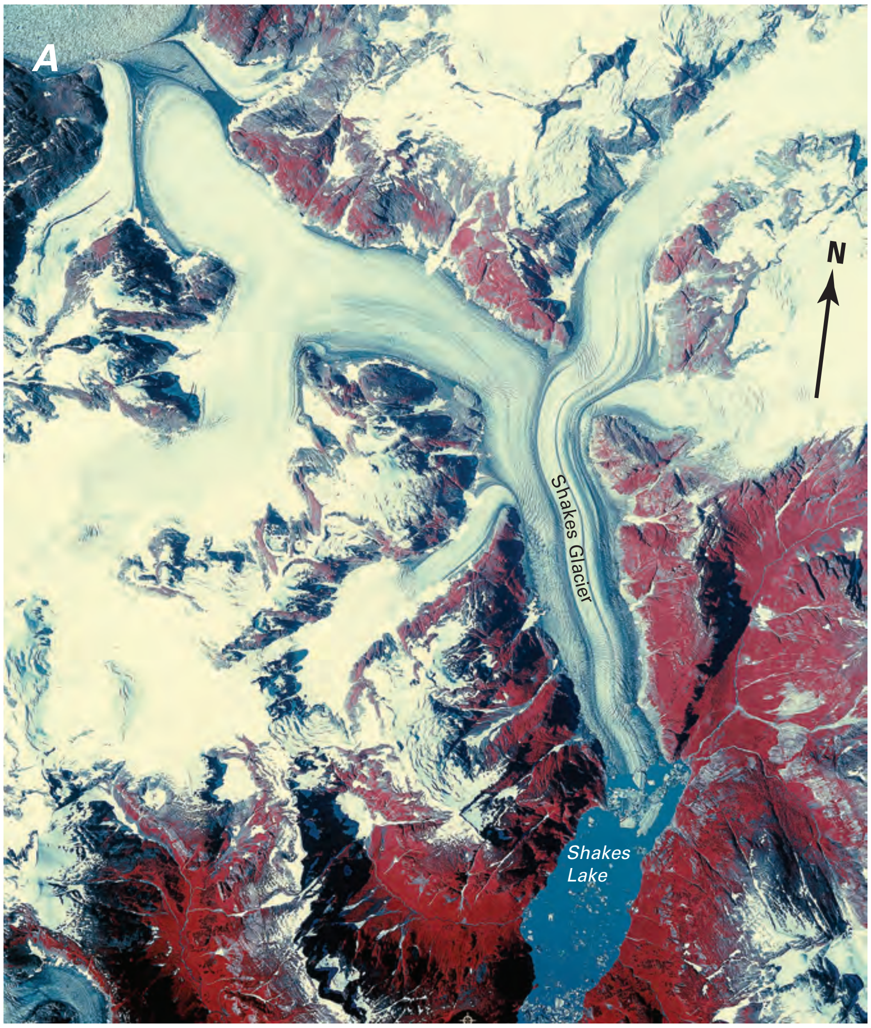


Figure 80.—**A**, *An 11 August 1979 AHAP false-color vertical aerial photograph of 11-km-long Shakes Glacier and about a dozen smaller unnamed glaciers, many snow covered. Shakes Glacier and all of the unnamed glaciers are retreating. Icebergs as large as 0.7 km across have recently calved. The trimline on the east side of Shakes Glacier and the empty hanging valleys on the west side of the lower part of the glacier document recent retreat and thinning. AHAP photograph no. L188F4225 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.* **B**, *23 August 1990 annotated USGS oblique aerial photograph of the terminus of Shakes Glacier. The right side of the glacier has a conspicuous trimline, indicative of recent rapid thinning. Many of the tributary glacier termini also show evidence of recent retreat. The heavy black lines show the approximate locations of the terminus in 1948 and 1979. There was about 0.7 km of retreat during each time interval. Photograph no. 90–R1–8 by Robert M. Krimmel, U.S. Geological Survey.*

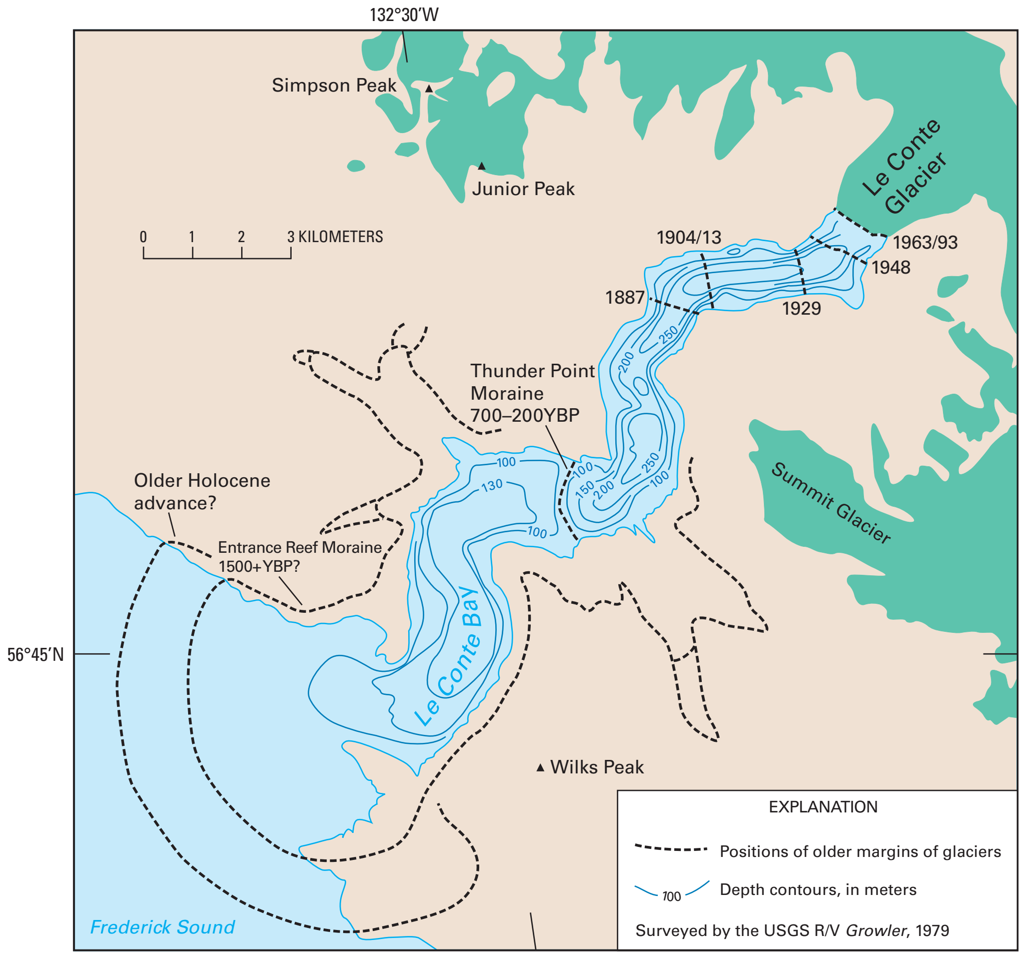


Figure 81.*—Map of Frederick Sound and Le Conte Bay showing bathymetry and terminus positions of Le Conte Glacier for the past several thousand years. Water depths shown for Le Conte Bay are as of 1979. By the end of the 20th century, the glacier retreated nearly an additional 2 km. Map is adapted from Post and Motyka (1995).*

be 6,088 $m^3\ s^{-1}$. Depths in the LeConte Bay exceed 260 m along the 1.4-km-wide terminus. Sediment accumulation is restricted to a small basin near the ice margin where approximately $7\times10^6\ m^3$ of sediment has accumulated between the end of 1998 and 2000. Extrapolated across the entire glacier, this amount equates to approximately 5 mm a^{-1} of denudation.

Patterson Glacier, with an area of about 104 km^2 (Field, 1975c, p. 109), has been observed since 1879, the year that William Dall named this 23-km-long glacier (Field, 1975c, p. 109) for the then Superintendent of the Coast Survey. Patterson Glacier was photographed on 11 August 1979 by the AHAP Program (L189F4353). Near the end of the 19th century, the terminus bifurcated, flowing to both the east and the west, and was slowly advancing and knocking down trees (USC&GS, 1891). Klotz (1899) visited it in 1894 and documented that the slope of the first 16 km of the glacier was 4°25'. When Field next reported on the glacier, nearly 50 years later in 1941 (Field, 1942), it had retreated about 600 m. In the 7 years that followed, it retreated another 600 m (Field, 1975a); another 700 m of retreat occurred between 1948 and 1964 and another 200 m through 1968. In the 31 years between 1948 and 1979, the dates when aerial photography was acquired, the glacier retreated about 1 km. The photography displays several indicators of recent thinning such as trimlines, ice-marginal lakes, and vegetation-free bedrock near the terminus. In all, Patterson Glacier retreated more than 3 km during the 20th century, forming an ice-dammed lake to the east. Continued retreat has resulted in the draining of the basin.

Baird Glacier is unique in the Coast Mountains because it had been advancing at least since the late 19th century. The 50-km-long glacier (fig. 82) has an area of about 784 km^2 (Viens, 1995) (tables 2, 3) and terminates at an outwash plain-delta that it built into the head of Thomas Bay. Since it was

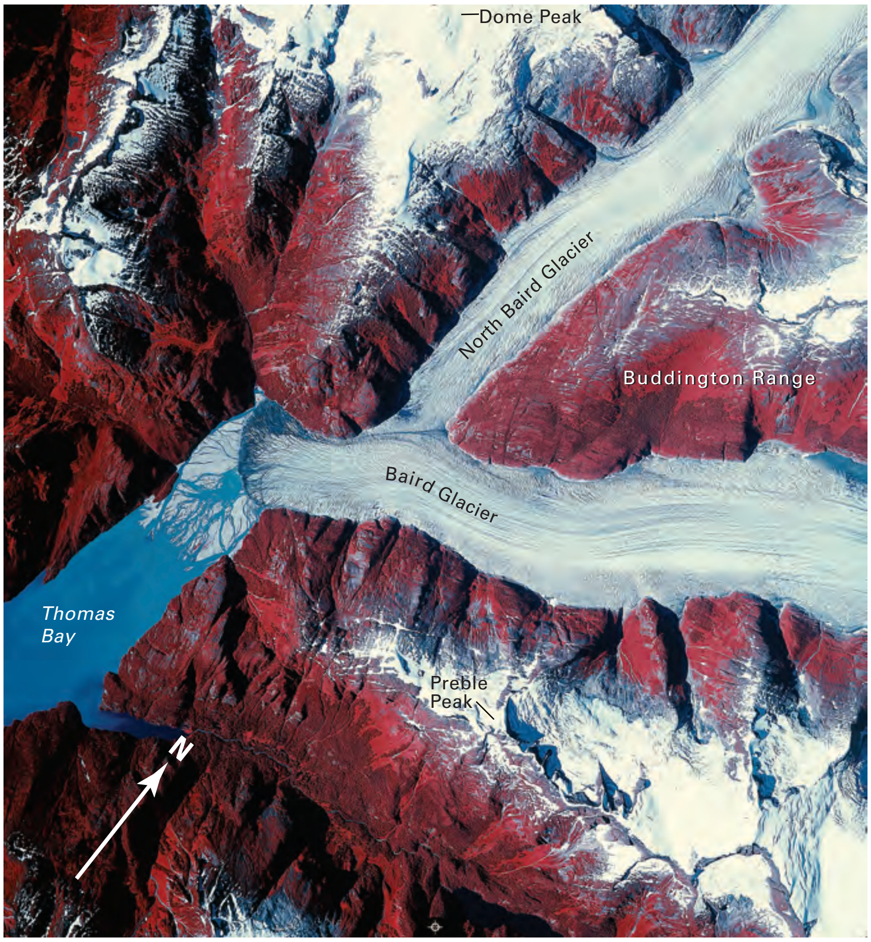


Figure 82.—*11 August 1979 AHAP false-color vertical aerial photograph of the terminus of 35-km-long Baird Glacier, its primary tributary North Baird Glacier, and a number of smaller unnamed glaciers, many snow covered. Although Baird Glacier displays several indicators of recent thinning, especially the beginning of trimline development, the terminus was slowly advancing. Many of the small tributary glaciers, adjacent to both Baird and North Baird Glacier, are characterized by the appearance of vegetation-free bedrock. AHAP photograph no. L189F4349 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*

first mapped in 1887, the glacier had been slowly advancing, but it is now slowly retreating. From 1887 to 1941, the advance totaled about 1 km (Field, 1942). From 1941 through the end of the 20th century, the glacier also advanced about 1 km. The recent advance was accompanied by a gradual thinning. Between 1887 and 1948, the outwash plain-delta at the head of Thomas Bay has lengthened by more than 2 km. As late as the 18th century and early 19th century, descriptions of Baird Glacier mention icebergs in Thomas Bay (Field, 1975a). It is likely that Baird Glacier had a tidewater terminus before 1887. Rapid accumulation of sediment built a sedimentary apron in front of the glacier margin, infilling the head of the bay. Lengthening of the sedimentary apron into Thomas Bay at a rate that exceeded the rate of advance of the glacier margin would explain the transition from a tidewater calving margin to a terrestrial terminus.

While the terminus of Baird was advancing, several of its tributaries were significantly downwasting. Two glaciers, Oasis Glacier and Witches Cauldron, have retreated and thinned to the point that ice from the trunk of Baird Glacier flows into both valleys; the ice extends about 8 km into the Witches Cauldron valley. Oasis Glacier and Witches Cauldron were photographed on 11 August 1979 by the AHAP Program (L188F4232). Most of the unnamed valley glaciers located north and west of Baird Glacier are also retreating and thinning. These glaciers were also photographed on 11 August 1979 by the AHAP Program (L188F4237).

Endicott Arm is a 48-km-long southeast-trending fjord that penetrates the Coast Mountains from Stephens Passage. Dawes and North Dawes Glaciers are located in two arms at its head. The glaciers were photographed on 11 August 1979 by the AHAP Program (L188F4240). Dawes Glacier was originally named *Young Glacier* by John Muir, who visited it in 1880 (Muir, 1915). It has an area of about 653 km^2, is 37 km long, and has a rapidly retreating tidewater calving terminus (Viens, 1995) (tables, 2, 3). In the 78 years between 1889, when it was mapped by the USC&GS (1891), and 1967, when it was photographed by the USGS, the terminus retreated about 6.8 km, an average of almost 90 m a^{-1}.

North Dawes Glacier, with a length of about 16 km and an area of about 50 km^2 (Field, 1975c, p. 111), was a tidewater calving glacier when Muir observed it in 1890. By 1923, its terminus had retreated about 525 m and was located on land (Buddington and Chapin, 1929). Between 1929 and 1961, another 1.8 km of terminus retreat occurred. D.B. Lawrence (reported by Field, 1975a) suggested that, before about 1790, the termini of Dawes and North Dawes Glaciers combined to form a single large glacier at the head of Endicott Arm, at least 10 km more advanced than their 1979 positions as shown on a 11 August 1979 AHAP photograph (L188F4240).

Fords Terror, a T-shaped 12-km-long tributary fjord of Endicott Arm, was so named by an 1889 USN surveying party because it was "very narrow at one point. Floating ice from glaciers, with falling tide, jamming in this contracted throat makes it a dangerous place" (reported by Orth, 1967). Several kilometers up valley from the head of the eastern end of the T are two glaciers—Brown and South Brown Glaciers—that have a history of very rapid retreat in the late 19th and 20th centuries. When Muir visited them in 1880, the two glaciers were joined and their combined terminus, called Brown Glacier, was a tidewater calving glacier. Thirteen years later, in 1893, the terminus was first mapped by the Boundary Survey. By 1909, when the Boundary Survey resurveyed the terminus, the terminus had moved onto land and had retreated about 2.5 km from its 1893 position. In 1923, when USGS geologist A.F. Buddington examined Brown Glacier, he called its retreat "the most conspicuous case of glacial retreat seen by the writer on the mainland" (Buddington and Chapin, 1929, p. 31–32).

In 1935, Field (1937) photographed the glacier and documented that the terminus was about 3 km from the shoreline and about 5.5 km from its 1890s position. In the 75 years between 1893 and 1968, the date of the latest position determined by Field (1975a), the glacier had retreated nearly 10 km, an average retreat rate of 125 m a^{-1}. In 1948, it had a length of about 9 km and an area of about 18 km^2 (Field, 1975c, p. 111). Today, only debris-covered remnants remain. South Brown Glacier separated from Brown Glacier between 1923 and 1929. It, too, retreated rapidly, losing about 2 km of length between 1929 and 1948. By 2000, only a small debris-covered mass remained. Retreat since 1948 approached 10 km.

Four-kilometer-long Sumdum Glacier is the largest and only named glacier between Endicott Arm and Tracy Arm. When it was first photographed by the Boundary Commission in 1893, it was a land-terminating glacier located at the forest edge but near sea level. It was little changed when Buddington observed it in 1923. However, by 1948, it had retreated nearly a kilometer and had a terminus elevation of about 335 m (Field, 1975a). The name "Sumdum" which is derived from the Tlingit word for the booming sound made when icebergs calve from the glacier, suggests that, at some time before 1893, Sumdum Glacier was an active tidewater calving glacier.

Named for former Secretary of the Navy Benjamin Tracy (1889–93), 45-km-long Tracy Arm has two tidewater glaciers at its head. The two—South Sawyer Glacier (fig. 83) and Sawyer Glacier (fig. 84), both of which arise in Canada—may have been joined as recently as about 1880. At the end of the 20th century, their termini were about 7.5 km apart. Sawyer Glacier has a length of 37 km and an area of 399 km^2 (Viens, 1995) (tables 2, 3). South Sawyer Glacier has a length of 50 km and an area of 683 km^2 (Viens, 1995) (tables 2, 3). In the 68 years between 1899 and 1967, South Sawyer Glacier retreated about 3.5 km, and Sawyer Glacier lost nearly 1 km. This retreat was interrupted by long periods of stability. In 2001, the terminus positions of both Sawyer Glacier and South Sawyer Glacier showed evidence of thinning and retreat. All of the other cirque and former valley glaciers in Tracy Arm showed significant evidence of retreat.

North of Tracy Arm and south of Whiting River are a number of unnamed glaciers, most of which are generally less than 5 km in length and drain into the Whiting River. No information is available about the recent status of these glaciers.

Between the Whiting and Taku Rivers, Speel Glacier, with a length of 15 km and an area of 42 km^2 (Field, 1975c, p. 113), and Wright Glacier are the only two named glaciers. Field (1975a) stated that Speel Glacier retreated about 3 km from its recent "Little Ice Age" maximum position and that a little more than 1 km of retreat occurred in the 20 years between 1948 and 1968. Wright Glacier has a length of 33 km and an area of 148 km^2 (Field, 1975c, p. 113). Between 1891 and the early 1960s, it retreated more than 4 km, forming an ice-marginal lake. A comparison of the positions of both glaciers on the Taku River map (USGS, 1960; appendix A) and a 9 September 1984 Landsat TM image of the northern part of the Stikine River to the Taku River region (fig. 84) shows that both glaciers have undergone significant retreat during the baseline period.

Figure 83.—*26 August 1960 oblique aerial photograph of the terminus of South Sawyer Glacier, showing evidence of recent calving and the development of a calving embayment on the right (east) side of the terminus. The left (west) side of the glacier has a conspicuous trimline, indicative of recent rapid thinning. Many of the tributary glacier termini also show evidence of recent retreat. Photograph no. R18 by Austin Post, U.S. Geological Survey.*

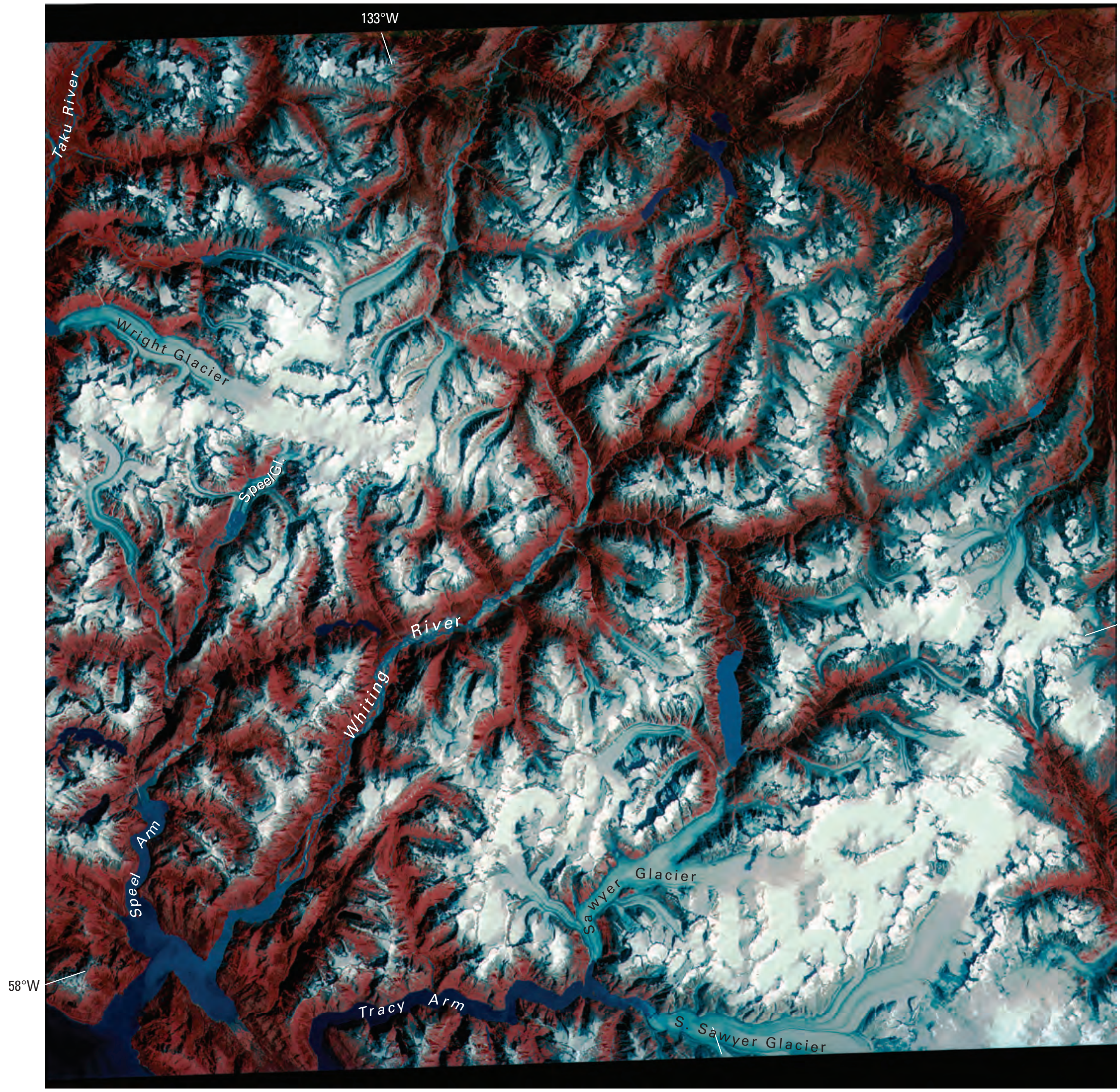


Figure 84.—*Annotated Landsat 5 TM quarter-scene, false-color composite image acquired on 9 September 1984 of the Coast Mountains from just south of Tracy Arm to the Taku River, including the Sawyer, South Sawyer, Speel, and Wright Glaciers. Approximate scale 1:500,000. Non-standard Landsat image by the USGS, EROS Data Center, Sioux Falls, S. Dak.*

Taku River to the Canadian Border East of Gilkey Glacier

Landsat MSS images that cover the Coast Mountains region from the Taku River to the Canadian border have the following Path/Row coordinates: 61/19, 62/19, 63/18, 63/19, 64/18, 64/19, 65/18, and 65/19 (fig. 3*A*, table 1). A mosaic of three of these scenes covers the entire area (fig. 85). For comparison, a 9 September 1984 Landsat TM image of the southern part of the Taku River to the Canadian border region (fig. 86) is also presented. The dominant glacier feature in this region is the Juneau Icefield, one of the largest ice fields

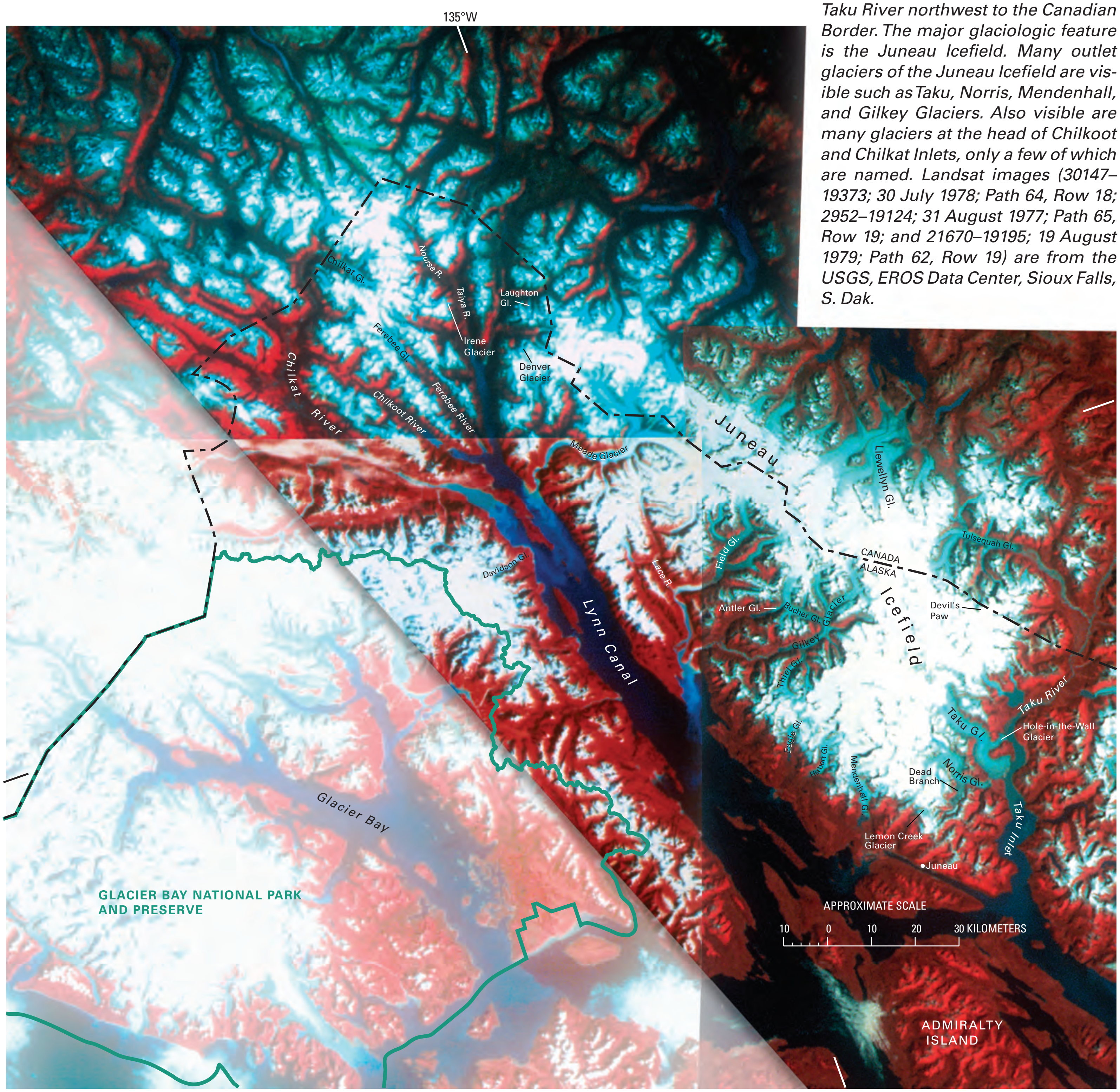


***Figure 85.**—Annotated Landsat 2 and 3 MSS false-color composite image mosaic of the Coast Mountains from the Taku River northwest to the Canadian Border. The major glaciologic feature is the Juneau Icefield. Many outlet glaciers of the Juneau Icefield are visible such as Taku, Norris, Mendenhall, and Gilkey Glaciers. Also visible are many glaciers at the head of Chilkoot and Chilkat Inlets, only a few of which are named. Landsat images (30147–19373; 30 July 1978; Path 64, Row 18; 2952–19124; 31 August 1977; Path 65, Row 19; and 21670–19195; 19 August 1979; Path 62, Row 19) are from the USGS, EROS Data Center, Sioux Falls, S. Dak.*

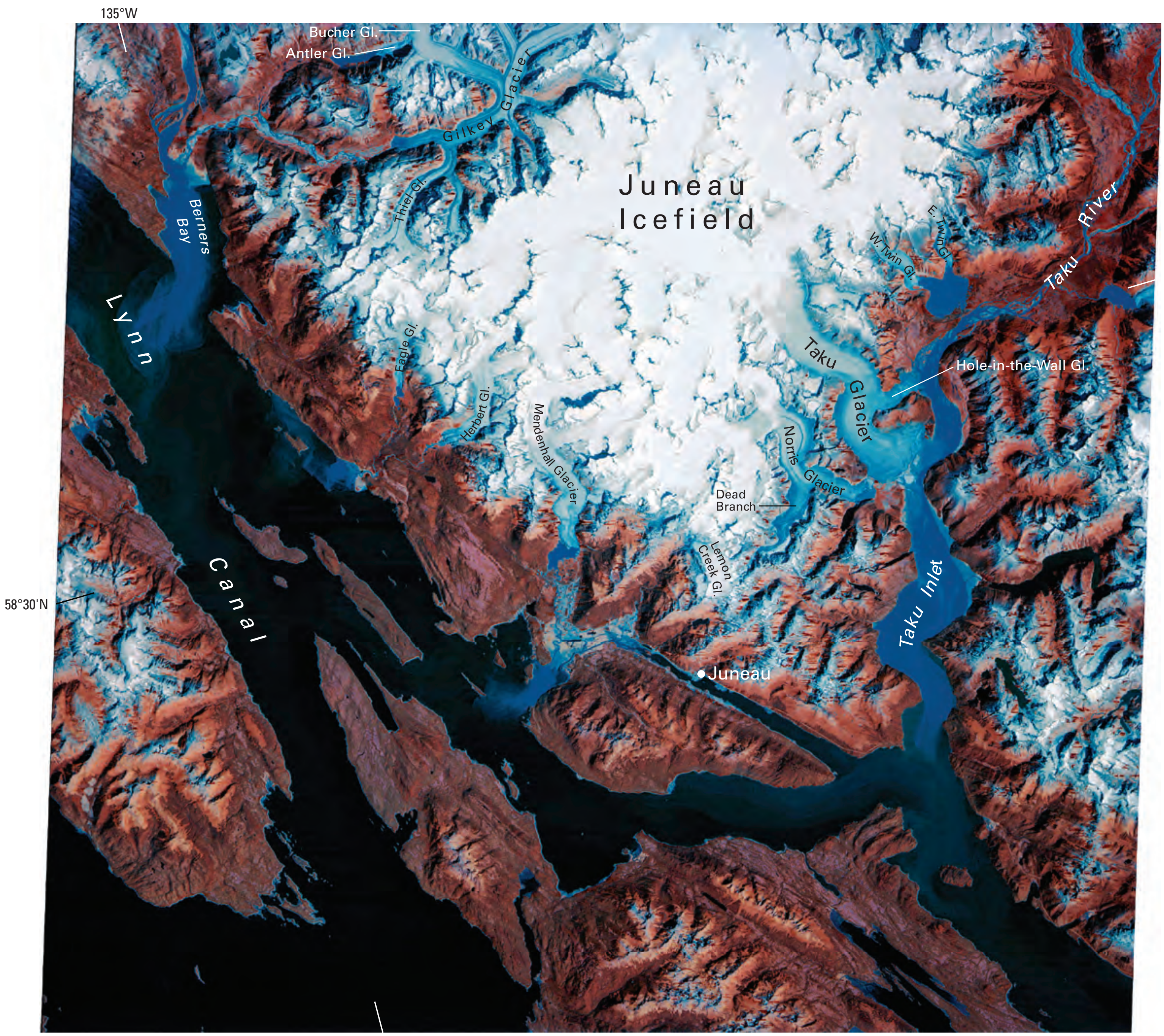


Figure 86.—*Annotated Landsat 5 TM quarter-scene, false-color composite image acquired on 9 September 1984 of the Coast Mountains from east of the Taku River to west of Berners Bay. Outlet glaciers from the Juneau Icefield include the Twin, Hole-in-the-Wall, Taku, Norris, Lemon Creek, Mendenhall, Herbert, Eagle, Gilkey, and Bucher Glaciers. According to Robert M. Krimmel (written commun.) "All of the various tidewater and non-tidewater glaciers that flow from the ice field, except the Taku Glacier, have been in a general recession since before 1900." Miller (1963) attributes this difference in activity to the relative greater area of the Taku Glacier that is above the snowline (larger accumulation area); thus, it has maintained a positive mass balance and advanced. The other glaciers in the area, at lower altitudes and with smaller accumulation areas, have negative mass balances. Approximate scale 1:500,000. Landsat image L5057019008425350 is courtesy of Robert M. Krimmel, U.S. Geological Survey, and is from the USGS, EROS Data Center, Sioux Falls, S. Dak.*

in Alaska. It is located along the crest of the Coast Mountains between the Taku River and Devil's Paw to the south, Lynn Canal to the west, and the Antler-Gilkey River drainages to the north. Like the *Stikine Icefield*, a portion of the Juneau Icefield is located in British Columbia, but most of the 1,215- mi^2 (1,955 km^2) ice field is located in Alaska (Molnia, 2001, p. 62). Large glaciers that drain the Juneau Icefield are the Taku, Norris, Hole-in-the-Wall, Mendenhall, Herbert, Eagle, Gilkey, and Antler Glaciers on the Alaskan side of the ice field and the Llewellyn and Tulsequah Glaciers on the Canadian side. The ice field, which was known as the "home of the spirits" to the Tlingits, has about 40 major and 100 minor glaciers (Miller and others, 1987).

East of Lynn Canal and north of the Gilkey River, a significant number of large glaciers—including the Field, Meade, Laughton, and Denver Glaciers—drain the central névé or interconnected outlying névés on the crest of the Coast Mountains. Field (1975a, p. 85), however, classified these areas as being separate from the limits of the Juneau Icefield. Coast Mountains glaciers also exist west of Lynn Canal in the mountains that are drained by the Taiya, Ferebee, and Chilkat Rivers. Ferebee, Chilkat, and Irene Glaciers are the only named glaciers, but several large unnamed glaciers exist along the Nourse River and in the Chilkat and Chilkoot River drainages.

Most of the glaciers on the Alaskan side of the Juneau Icefield are retreating. One major exception is 60-km-long Taku Glacier, which has an area of about 831 km^2 (Viens, 1995) (tables 2, 3) (figs. 87, 88). It was advancing during the Landsat baseline period, was stable for about a decade, and, at the beginning of the 21st century, began to readvance. Taku Glacier is the primary outlet glacier from the Juneau Icefield. Taku Glacier was known by the Tlingits as "Klumma Klutt or Klumu Gutta," a Tlingit name meaning "Spirits House." It was also previously named *Schulze Glacier* and *Foster Glacier*. Muir (1893) said of Taku Glacier: "To see this one glacier is well worth a trip to Alaska." During much of the 20th century, Taku Glacier was advancing across Taku Inlet at a rate of nearly 100 m a^{-1} and knocking down trees in forests along both of its margins (fig. 88). It also was overriding moraines

***Figure 87.**—11 August 1979 AHAP false color vertical aerial photograph of Taku Inlet and the lower portions of Taku and Norris Glaciers. Also shown is Hole-in-the-Wall Glacier. As recently as about 1750, Taku Glacier was more than 3.5 km beyond its late 20th century position. At that time, it dammed Taku River at Taku Point. A large ice-dammed lake extended northeast into Canada. Many ice-free cirques and areas of vegetation-free bedrock southeast of the Taku Inlet show that many small glaciers in this area are actively thinning and retreating. AHAP photograph no. L188F4260 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*

Figure 88.—14 September 1968 oblique aerial photograph of the northeastern terminus of the then-rapidly advancing Taku Glacier as it advanced into the adjacent spruce forest and bulldozed trees. Photograph by Austin Post, U.S. Geological Survey.

and outwash of Norris Glacier located to its southwest. At the end of the 19th century, when the recent advance of Taku Glacier began, it was a tidewater calving glacier with depths in its fjord exceeding 100 m. When the terminus was photographed by the Alaska Aerial Survey Expedition in the late 1920s, it was still tidewater. Sediment produced by the advancing glacier began filling upper Taku Inlet, so that, by the mid-1930s, ships that previously had had access to the terminus of the glacier could not enter the inlet. About 1937, Taku Glacier's advancing terminus began forming a push moraine that protected the terminus and restricted calving. Advance continued until about 1988. During the last few years of the 20th century, the terminus position appeared to be stable. A map prepared by Post and Motyka (1995) showing the location of the terminus of Taku Glacier for the previous 250 years is presented as figure 89.

Nolan and others (1995) used radio-echosounding and seismic-reflection techniques to measure Taku Glacier's ice thickness and bed morphology. Maximum ice thickness was about 1,477 m, and minimum bed elevation was about 600 m below sea level. They determined that the sub-sea-level basin that underlies the glacier extends about 50 km up-glacier. Future retreat of the glacier would expose a deep fjord basin extending well into the Coast Mountains. Along one transect near the Brassiere Hills, 5.5 km up-glacier from the terminus, the maximum ice thickness was 558 m, and the maximum depth of the bed was 212 m below sea level. Even more importantly, Nolan and others (1995) compared the surface elevation in 1989, the date of the survey, with the 1948 surface elevation determined from photogrammetry. They stated that the glacier had thickened by "10–25 m over the past 40 years," but measurement of the differences between the 1948 and1989 surface elevations (Nolan and others, 1995, fig. 4) showed thickening of more than 100 m on the northeastern side of the transect. Regardless of the actual amount of thickening, a positive mass balance so close to the glacier's terminus is significant. Geodetic airborne laser altimetry studies performed by K.A. Echelmeyer in 1999 indicated that Taku Glacier was thickening (Shad

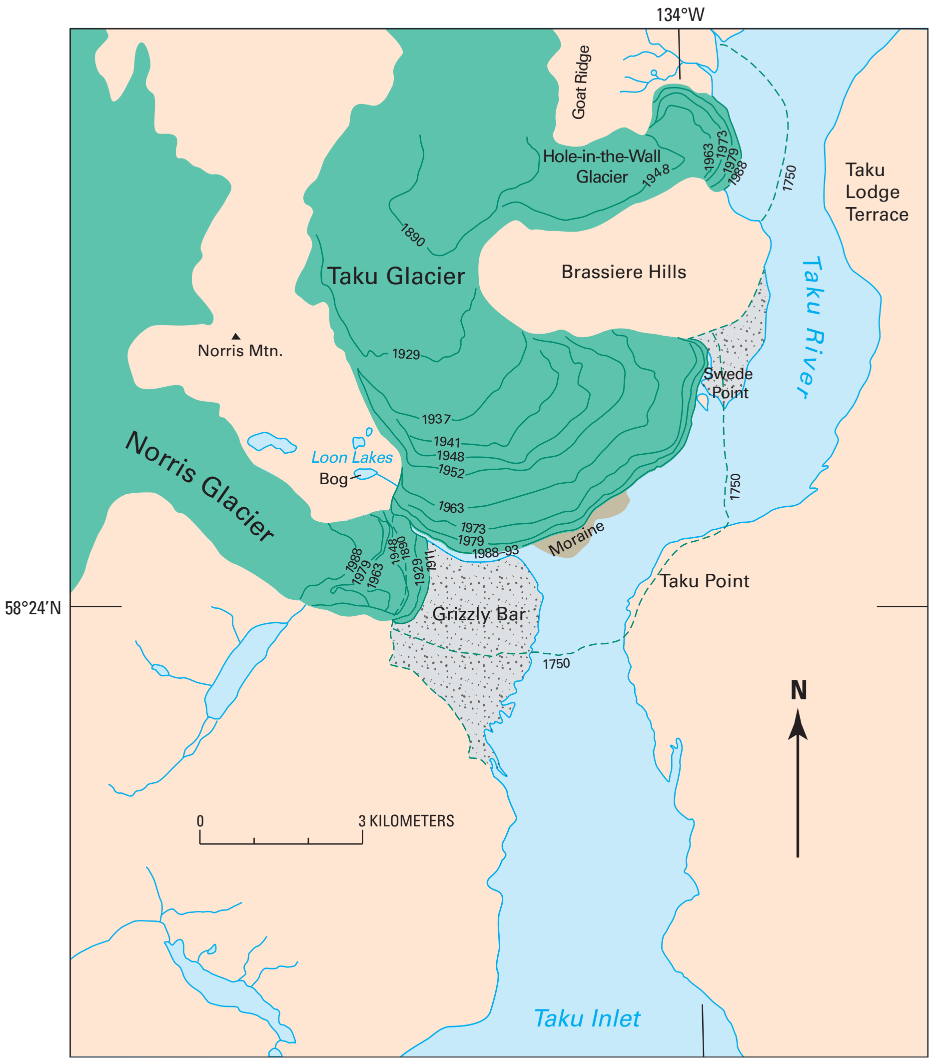


Figure 89.*—Map of the Taku Inlet and River area showing terminus positions of Taku, Norris, and Hole-in-the-Wall Glaciers for 1750 and the past hundred years or so. Map is adapted from Post and Motyka (1995).*

O'Neel, Geophysical Institute, University of Alaska Fairbanks, personal commun., 7 January 2000).

Motyka and others (2001) reported that, between late 2000 and the summer of 2001, Taku Glacier has begun to readvance at a rate of 30 cm d^{-1}. The advance has caused striking deformation of adjacent proglacial sediments. Compression by the advancing ice has caused the outward propagation of at least two prominent bulges: the more distal (width 35 m, height 3 m) at a rate of about 10 cm d^{-1} and the more proximal (width 80 m, height 4.5 m) at a rate of 15 cm d^{-1}. There are no visible thrust faults in the sediments, but shear must be occurring as part of bulge propagation. Although the glacier's terminus region remained stationary during the 1990s, it continued to thicken, with surface elevation rising at an average rate of 1.4 m a^{-1}. Previous work showed that Taku Glacier is actively excavating soft sediments and entrenching itself into these sediments as its terminus continues to grow and advance.

Twenty-seven-kilometer-long Norris Glacier, with an area of about 183 km^2 (Field, 1975c, p. 116) (fig. 89), located in a parallel drainage immediately west of the Taku Glacier, is proof that adjacent glaciers do not always act in a similar fashion. While Taku Glacier had retreated up its valley during the second half of the 19th century, Norris Glacier was actively advancing and reached its most recent maximum position between 1911 and 1917. Through the remainder of the 20th century, when Taku Glacier was advancing as much as 100 m a^{-1}, Norris Glacier retreated about 2 km and thinned by many tens of meters. At the start of the 20th century, the southwestern limb of the Norris

Glacier, known as the "Dead Branch," was an active ice-supplying tributary with a gradient sloping to the northwest. The glacier was photographed on 11 August 1979 by the AHAP Program (L189F4321). During the early 20th century, its upper reaches thinned so significantly that a reversal of drainage occurred. At the end of the 20th century, most of the "Dead Branch" was stagnant, wasting away in place, with only minimal ice flow from the main trunk of Norris Glacier into the thinning distributary arm. Several ice-free cirques and areas of vegetation-free bedrock around the "Dead Branch" and on the western side of Norris Glacier indicate that many small glaciers in this area are actively retreating and thinning.

Hole-in-the-Wall Glacier, a distributary lobe of Taku Glacier (figs. 89, 90), has also experienced a major retreat and readvance since the "Little Ice Age." In about 1750, the glacier extended to its "Little Ice Age" maximum position, nearly 1 km beyond its 20th century maximum position. By 1890, Hole-in-the-Wall Glacier had retreated nearly 4.5 km. The current glacier formed when an arm of Taku Glacier thickened during the first half of the 20th century and overtopped the divide between Goat Ridge and the Brassiere Hills in about l940 (fig. 89). During much of the second half of the 20th century, its continued advance formed a bulbous terminus that extended to near the Taku River (fig. 90). At the end of the 20th century, the terminus of Hole-in-the-Wall Glacier was stable.

East and West Twin Glaciers, formerly Twin Glacier (fig. 91), are also distributaries of Taku Glacier and drain Hades Highway, the eastern branch of Taku Glacier. Before the late 1920s, the two glaciers were joined and filled much of the present Twin Glacier Lake basin, separating just before 1929 (fig. 92). Lawrence (1950) determined that the combined glacier began to retreat from its "Little Ice Age" maximum terminal moraine position between 1775 and 1777. He also determined from other dated moraines that the retreating glacier did not expose any of the ice-marginal lake basin until about 1880. Through 1948, D.B. Lawrence (1950) determined that the West Twin Glacier (1948 length of about 7 km) had retreated 5.2 km; the East Twin Glacier (1948 length of about 10 km) retreated 4 km. The retreat of both glaciers has continued for the remainder of the 20th century; each glacier has lost more than 1 km.

Field (1975a) described 6-km-long Lemon Creek Glacier (fig. 86) (see AHAP false-color infrared vertical aerial photograph no. L190F0390 acquired on 11 August 1979) as being an extension of the Juneau Icefield rather than an ice-field-outlet glacier. Lemon Creek Glacier has been the site of many detailed studies since the early 1950s and, beginning in 1957, was one of the

Figure 90.*—28 July 1968 oblique aerial photograph of the bulbous terminus of the then-advancing Hole-in-the-Wall Glacier, Coast Mountains. Photograph by Bruce F. Molnia, U.S. Geological Survey.*

__Figure 91.__—11 August 1979 AHAP false-color vertical aerial photograph of the termini of East and West Twin Glaciers, Coast Mountains. The arcuate latest "Little Ice Age" terminal moraine complex south of Twin Glacier Lake is clearly seen. AHAP photograph no. L189F4406 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.

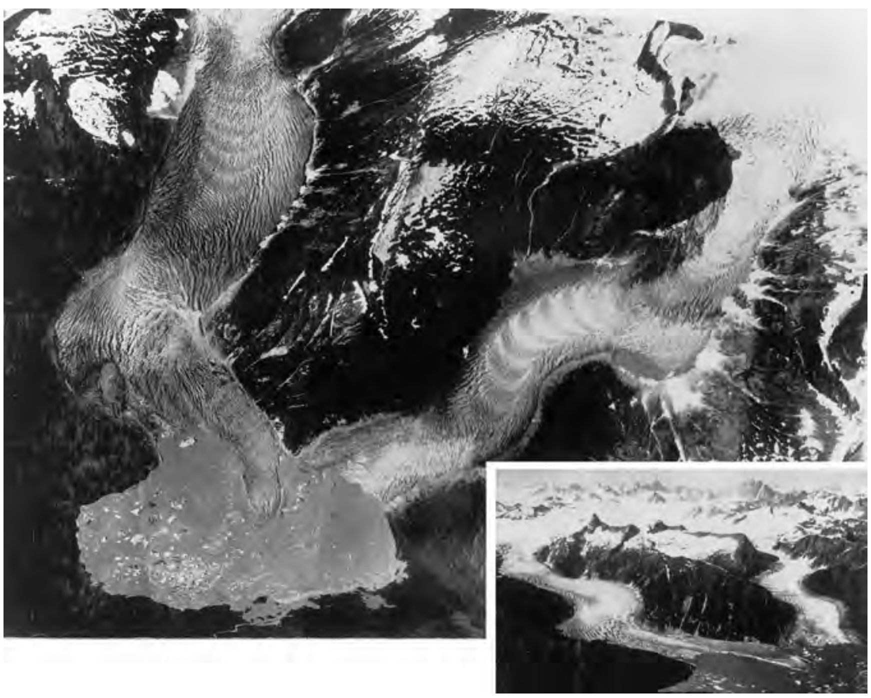


__Figure 92.__—Bagley camera vertical and high-angle oblique (inset) 1929 aerial photographs of East and West Twin Glaciers, Coast Mountains. Photograph Alaska 185 from the USGS Photographic Library, Denver, Colo. (See also fig. 30.)

glaciers mapped by the AGS, as part of its IGY mapping project (American Geographical Society, 1960). It was remapped by Marcus and others (1995) and surveyed by using geodetic airborne laser altimeter (surface-elevation) profiling by Sapiano and others (1998). Its post-"Little Ice Age" history has been documented by Heusser and Marcus (1964). About 1759, Lemon Creek Glacier began to retreat from its "Little Ice Age" maximum moraine. By 1958, retreat totaled 2.5 km. Maximum retreat rates were 37.5 m a^{-1} during the period 1948 to 1958. Sapiano and others (1998) updated these observations through 1995. They found that, between 1957 and 1989, the glacier retreated another 700 m and an additional 100 m between 1989 and 1995. Through 1995, Lemon Creek Glacier had retreated about 3.3 km, an average retreat rate of about 14 m a^{-1}.

Mendenhall Glacier was visited by John Muir in 1879. Muir (1915, p. 219) described it as "one of the most beautiful of all the coast glaciers that are in the first stage of decadence." Originally known as *Auk Glacier* after the Auks, a Tlingit tribe, Mendenhall Glacier is 21 km long and 100 km^2 in area (Field, 1975c, p. 116) (figs. 85, 86). Its "decadence" has amounted to more than 5 km of retreat from its "Little Ice Age" maximum position. Lawrence (1950) determined that retreat began between 1767 and 1769; by 1910, the terminus had retreated about 1.5 km, an average retreat rate of about 10 m a^{-1}. This period of retreat included a readvance that tilted trees in the mid-1800s. Between 1910 and 1949, the last year of Lawrence's field investigation, the glacier had retreated another 1.5 km, an average rate of nearly 40 m a^{-1}. Near the beginning of the 20th century, the continuing retreat began to expose a bedrock basin that became the location of an ice-marginal lake that fronted the central portion of the glacier's terminus. Through the early 20th century, ongoing retreat exposed more of the basin and enlarged the lake. One reason for the significant difference in pre-1910 versus post-1910 retreat rates is the addition of calving as a means of ice loss. Previously, when the terminus was land based and sublimation was not included, only melting was responsible for ice loss. With the development of the ice-marginal lake, a single calving event could remove a volume of ice from the glacier's terminus equal to what otherwise would take weeks or months to lose by melting. However, the shrinking of Mendenhall Glacier is caused primarily by surface melting throughout the entire length of the glacier and secondarily by calving of its terminus into a proglacial lake (Motyka and others, 2003). The glacier continued to retreat through the start of the 21st century.

During much of the 1990s, the southeastern margin of the glacier retreated more rapidly than it had during the previous four decades. This rapid retreat and other recent changes at the margin were not entirely related to changing climate, but were instead the result of an unusual sequence of events triggered by a small advance of the glacier during the winter of 1984–85 (Molnia, 1989a, 1991). Like the mid-19th century readvance described by D.B. Lawrence, minor short-lived readvances are not uncommon. The author observed evidence of such advances in 1974 and 1977.

Before the winter 1984–85 advance, the eastern edge of Mendenhall Glacier's margin was separated from its valley wall by the channel and outwash plain of Nugget Creek, a stream that flowed into the Mendenhall Valley along the eastern valley wall adjacent to the glacier terminus. The 1984–85 advance, which occurred while Nugget Creek's discharge was near zero, pushed a mass of basal ice and moraine across the valley, covering the outwash plain and blocking the course of Nugget Creek (figs. 93*A, B*). In the spring of 1985, as Nugget Creek's flow increased, water pooled on the glacier's surface and eventually overtopped the low point of the push moraine dam. The result was a flood, which perpetuated itself by partially melting and eroding the dam. In time, Nugget Creek's water melted a lake-basin depression into the glacier. By the summer of 1985, the expanding ice-surface lake continued to melt downward, finally reaching the level of adjacent Mendenhall Lake. Water entering the new lake from Nugget Creek drained subglacially into Mendenhall Lake and resulted in Nugget Creek's abandonment of its outwash plain. Between 1986 and 1988, the ice-bound lake, located within the glacier a few hundred meters behind the terminus, continued to expand, essentially consuming the glacier from within. Iceberg production from the walls of the ice-bound lake further accelerated its growth. During the period of expansion, iceberg calving was more of a growth factor than melting (fig. 93*B*). During the summer of 1988, the expanding lake grew in size to the point where it breached the remaining glacier ice at the terminus of Mendenhall Glacier, merging with Mendenhall Lake (fig. 93*C*). The entire southeastern terminus of the glacier thus was fronted by the deep waters of Mendenhall Lake, as shown in a 2 July 1989 photograph (fig. 93*D*). During the 4-year duration of this event, the eastern margin of the glacier retreated nearly 0.5 km. Loss of ice through iceberg production is responsible for this exceptionally rapid retreat. Its continuation will ultimately result in Mendenhall Glacier's retreat out of its lake basin. When the glacier was observed in 2004, it had retreated more than 600 m from Nugget Creek and thinned significantly.

In 1998, Shad O'Neel of the Geophysical Institute, University of Alaska Fairbanks, performed mass-balance studies on Mendenhall Glacier. He measured 12.75 m of ablation at the Mendenhall Glacier terminus (O'Neel, written commun., 7 January 2000).

Figure 93.—**A***, 5 July 1985 photograph of the eastern terminus of the Mendenhall Glacier, Coast Mountains, taken from the location of the glacier's terminus at the end of the 1930s. The ridge of sediment in contact with the glacier at the right center of the photograph is part of the push moraine formed by the 1984-85 advance of the glacier.*

Figure 93.—**B**, *29 May 1986 north-looking, ground-based photograph of the easternmost part of the terminus of Mendenhall Glacier in Mendenhall Lake. The icebergs adjacent to the glacier margin have recently separated from the terminus, partly because of subglacial erosion by water seeping from the ice-bound lake. The terminus and the push moraine in the center of the photograph form the dam. Nugget Creek, descending from the valley wall to the right, is the source of most of the water in the ice-bound lake. Note the person for scale.* **C**, *27 June 1988 photograph of the location of Mendenhall Glacier's former ice-bound lake. Breaching of the ice-marginal dam resulted in the joining of the lake with Mendenhall Lake.* **D**, *2 July 1989 photograph of the eastern terminus of the Mendenhall Glacier, Coast Mountains, taken from near the same location as figure 93*A. *The push moraine is essentially gone, and the glacier has lost nearly 500 m of its terminus in 4 years. Photographs by Bruce F. Molnia, U.S. Geological Survey.*

Herbert Glacier, northwest of Mendenhall Glacier, has a length of 17 km and an area of 68 km^2 (Field, 1975c, p. 116) (figs. 69, 86, 94). It was examined by Knopf (1912) in 1909 and 1910 and by Wentworth and Ray (1936) in 1931. However, work by Lawrence (1950) was instrumental in documenting changes in its position since the "Little Ice Age." Herbert Glacier reached its maximum about 1700 and remained at or near this position for about the next 65 years. Retreat began about 1766 and was continuing when Lawrence performed his fieldwork in 1949. During this 183-year period, retreat totaled 3.29 km, yielding an average retreat rate of 18 m a^{-1}. Field (1975a), on the basis of aerial photographs taken by Post through 1969, reported that, between 1949 and 1969, the glacier retreated about another 0.55 km, yielding an average retreat rate of 27.5 m a^{-1}. Retreat continues through the early 21st century.

Eagle Glacier, having a length of 13 km and an area of 50 km^2 (Field, 1975c, p. 116), is less well known than adjacent Herbert Glacier. Work by Lawrence (1950) documented that "one of the oldest of the recessional moraines has been ice free since about 1785–1787." Through 1949, retreat was about 2 km, about half occurring during the period 1900–49. Field (1975a) reported that, during the 1950s, the terminus became stagnant and "virtually detached" from the retreating glacier. Between 1958 and 1967, the glacier retreated about 700 m, an average annual retreat rate of 37 m a^{-1}.

Gilkey Glacier, in a remote location more than 15 km east of Lynn Canal, is the northwesternmost outlet glacier of the Juneau Icefield. It is 32 km long and has an area of about 245 km^2 (Field 1975c, p. 116) (figs. 86, 95). It was virtually unknown until it was observed from the air in 1942 by the U.S. Army Air Corps. During the more than 60 years since it was first photographed, it has been retreating. Field (1975a) reported that, between 1948 and 1967, the terminus retreated about 600 m, a retreat rate of about 31 m a^{-1}. By 1961, an ice-marginal lake had begun to develop. As was the case with Twin and

Figure 94.—*Oblique aerial photograph of the lower reaches of the retreating Herbert Glacier and its valley, Coast Mountains, on 24 August 1963. The arcuate recessional moraines in the foreground date from the late 18th and 19th centuries. Photograph by Austin Post, U.S. Geological Survey.*

Figure 95.—11 August 1979 AHAP false-color vertical aerial photographic mosaic of Gilkey Glacier and a number of its named and unnamed principal tributaries. Named tributaries include Thiel, Battle, Bucher, and Echo Glaciers. All show evidence of recent retreat and thinning. Retreat and thinning of the terminus of the Gilkey Glacier have resulted in the formation of an ice-marginal lake at the terminus and the development of a well-defined trimline along its north side. Thiel and Battle Glaciers no longer flow into the Gilkey Glacier, nor do they join each other. A small lake is developing along the east side of the Thiel/Battle Glaciers margin. A distinct trimline has formed along the north margin of the Bucher Glacier and along both margins of the unnamed tributary glacier (labeled "A") that joins the Gilkey Glacier from the north. Echo Glacier barely reaches the floor of Avalanche Canyon. The tongue of Gilkey Glacier ice that Echo Glacier previously joined on the floor of Avalanche Canyon has retreated, resulting in the formation of an ice-marginal lake. A similar but significantly larger lake has formed in the valley to the west. Most of the small unnamed glaciers in the photograph also show evidence of active thinning and retreating. AHAP photograph nos. L188F4268 and L189F4314 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.

Mendenhall Glaciers, iceberg calving further enhanced the rate of retreat. In each illustration of the ice-marginal lake (figs. 86, 95), recently calved large icebergs can be seen near the head of the lake. By 1984, the lake was about 1.5 km long. The principal named tributaries to the Gilkey Glacier—Thiel, Battle, Bucher, and Echo Glaciers—all show evidence of recent retreat and thinning. By 11 August 1979 (fig. 95), former tributary glaciers that flowed from Avalanche Canyon and the unnamed valley to its west had retreated so far that Gilkey Glacier was entering both valleys and forming ice-marginal lakes. In the late 1960s, up-glacier at elevations above 1,000 m, many tributary glaciers to the Gilkey were also showing evidence of thinning and retreat.

Glaciers North of the Juneau Icefield

On the eastern side of Lynn Canal from north of Juneau Icefield to the head of Taiya Inlet, the principal named glaciers include Antler, Field, Mead, Schubee, Laughton, and Denver Glaciers. A significant accumulation of glacier ice, spanning more than 35 km, also occurs in the Kakuhan Range parallel to Lynn Canal and northwest of Berners Bay, continuing along the ridge capped by Sinclair Mountain to the southern edge of Mead Glacier.

In the mid-18th century, Antler Glacier had a length exceeding 9 km (Miller, 1964). Antler Glacier retreated through the beginning of the 20th century and then, like Taku Glacier, began to readvance. By 1925, the end of this period of advance, its terminus had moved down valley nearly 1.5 km, and the glacier reoccupied much of the area exposed during the 19th century. By 1948, the position of the retreating terminus was about 2.4 km from the mid-18th century maximum and a 1700-m-long ice-marginal lake fronted the terminus. By 1984, Antler Glacier (fig. 86) had a length of less than 3 km, and the enlarging lake was nearly 5 km long. Retreat continues through the early 21st century.

By 1979, 30-km-long Field Glacier had retreated less than 1 km from its "Little Ice Age" maximum position. The glacier was photographed on 11 August 1979 by the AHAP Program (L188F4272). Since then it has retreated about 2.3 km and an ice-marginal lake is located at the terminus. Large

trimlines along both sides of its margin document that a significant thinning has occurred. Similar thinning is exhibited by its two principal tributaries. The surface elevation of the tributaries appears to be lower than that of the main glacier, and no flow into the main glacier can be seen. Named Field Glacier in 1995 by Austin Post in honor of the late William O. Field, the glacier had an area of more than 250 km^2 and is located at the head of the eastern branch of the Lace River.

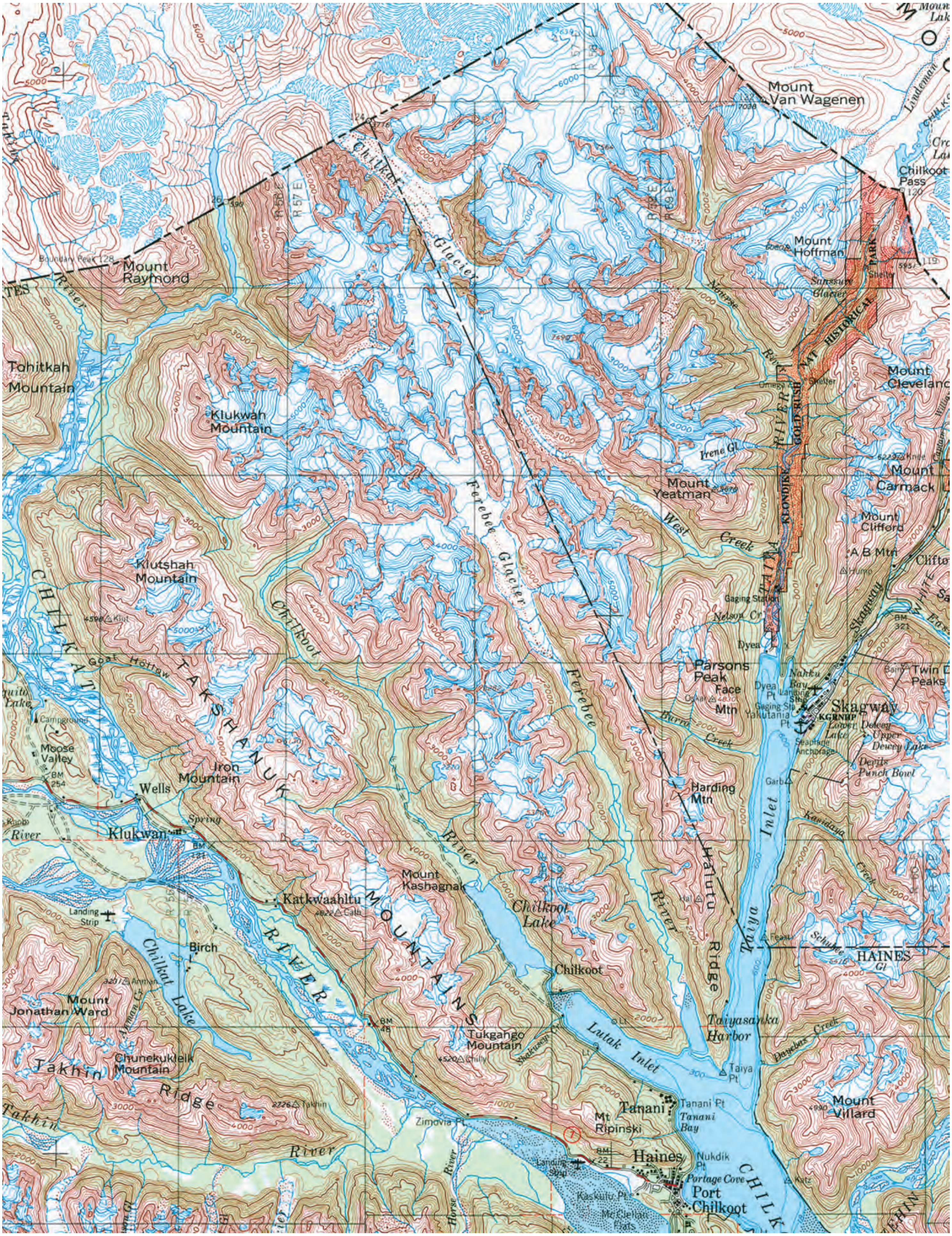
Meade Glacier has a length of 37 km and an area of about 400 km^2 (Field, 1975c, p. 118). The glacier was photographed on 11 August 1979 by the AHAP Program (L188F4277). It is located about 25 km southeast of Skagway and is another glacier with little history of scientific investigation. Field (1975a, p. 87) stated that it had "receded very little since its last maximum," which he described as being 400 to 800 m down valley from its 1948 terminus position. Field also stated that, in the 21 years between 1948 and 1969, the terminus retreated an additional 400 m and an ice-marginal lake that existed in 1948 was filled with sediment (Field, 1975a). This information indicates that Meade Glacier retreated at a rate of about 20 m a^{-1} between 1948 and 1969. The terminus position measured by the author from 1979 AHAP photography is only about 300 m upstream of the position mapped from 1948 aerial photography. If Field's statement about the glacier retreating in 1969 is correct, then the terminus would have had to advance about 100 m in the decade between 1969 and 1979. The 11 August 1979 AHAP photograph (L188F4277) shows that two unnamed tributaries have well-developed trimlines along their margins. One tributary does not appear to flow into the main trunk; the other clearly does. Down-valley vegetation indicates that most of the small unnamed glaciers in the photograph, have been separated from the main trunk for many years. All of the small glaciers show evidence of active thinning and retreat. Since 1979, Meade Glacier has retreated and thinned by more than 1 km and thinned by more than 100 m.

At the beginning of the 20th century, Denver Glacier, located about 7 km east of Skagway, was a popular destination and one of the most visited glaciers in Alaska. Field (1975a) stated that its terminus was photographed by C.L. Andrews in at least three different years: 1903, about 1912, and 1938. During the summer of 1903, Andrews observed that the glacier had retreated 12 m in just two months along an extensive barren zone fronting the terminus (Reid, 1904). Andrews' 1912 photographs show that the glacier had advanced across the barren zone and had reached a vegetated area (Field, 1975a). The 1938 photographs show that the glacier was once again retreating. Trimetrogon aerial photographs taken in 1941 and 1942 depict an older terminal moraine down valley from the 1903 location. As mapped in 1948, the glacier terminus was about 1.5 km up valley from this moraine. By 1958, the glacier had retreated another 900 m. Field (1975a) reported that, by 1964, "the terminus had receded considerably since 1958." When observed by the author in 2004, it had retreated about an additional 2 km.

In the Coast Mountains north of Lynn Canal and east of Chilkat River, a number of small and medium-sized glaciers exist (fig. 96). Only three—Ferebee, Irene, and Chilkat Glaciers—are named. No information about scientific investigations on any of these three glaciers or any others in this area could be found. Chilkat Glacier, formerly named *Leslie Glacier* in the 1890s, is the largest, with a length of about 23 km and an area of about 107 km^2 (Field, 1975a, p. 121). An unnamed glacier located immediately to its west (fig. 97) typifies the response of glaciers in this region. Since this north-flowing glacier was photographed in 1948, its terminus has thinned and retreated until it barely extends across the border into Canada.

Ferebee Glacier has a length of 20 km and an area of 55 km^2 (Field, 1975c, p. 121). The glacier was photographed on 11 August 1979 by the AHAP Program (L189F4298). An examination of the 1979 AHAP aerial photography of Ferebee Glacier and adjacent glaciers showed, in each

► ***Figure 96.***—*Part of the USGS (1961) 1:250,000-scale map of Skagway, Alaska-Canada, showing the occurrence of glaciers north of the Lynn Canal, west of Taiya Inlet, and east of the Chilkat River. Only three glaciers are named—the Chilkat, the Ferebee, and the Irene Glaciers. All glaciers in the area show evidence of retreat.*


Mount Van Wagenen
Chilkoot Pass
Mount Hoffman
Saussure Glacier
KLONDIKE GOLD RUSH NAT HISTORICAL PARK
Mount Raymond
Boundary Peak 128
Chilkat Glacier
Tohitkah Mountain
Klukwah Mountain
Mount Cleveland
Irene Gl
Mount Yeatman
Mount Carmack
Mount Clifford
A B Mtn
West Creek
Ferebee Glacier
Klutshah Mountain
Chilkoot
Gaging Station
Nelson Cr
Dyea
Skagway
CHILKAT
TAKSHANUK
Parsons Peak
Face Mtn
Twin Dewey Peaks
Nahku Bay
Dyea Pt
Yakutania Pt
Lower Dewey Lake
Upper Dewey Lake
Devils Punch Bowl
Burro Creek
Ferebee
Moose Valley
Campground
Iron Mountain
Wells
Harding Mtn
Klukwan
Spring
River
Inlet
Katkwaahltu
MOUNTAINS
Mount Kashagnak
Chilkoot Lake
Haines Highway
Halutu Ridge
River
Taiya
Landing Strip
Birch L
Chilkat Lake
RIVER
Chilkoot
HAINES
Mount Jonathan Ward
Taiyasanka Harbor
Lutak Inlet
Tukgahgo Mountain
Chunekukleik Mountain
Takhin Ridge
Taiya Pt
Tanani
Tanani Pt
Tanani Bay
Mount Villard
Mt Ripinski
Zimovia Pt
River
Haines
Nukdik Pt
Portage Cove
Port Chilkoot
Kaskulu Pt
McClellan Flats
CHILK

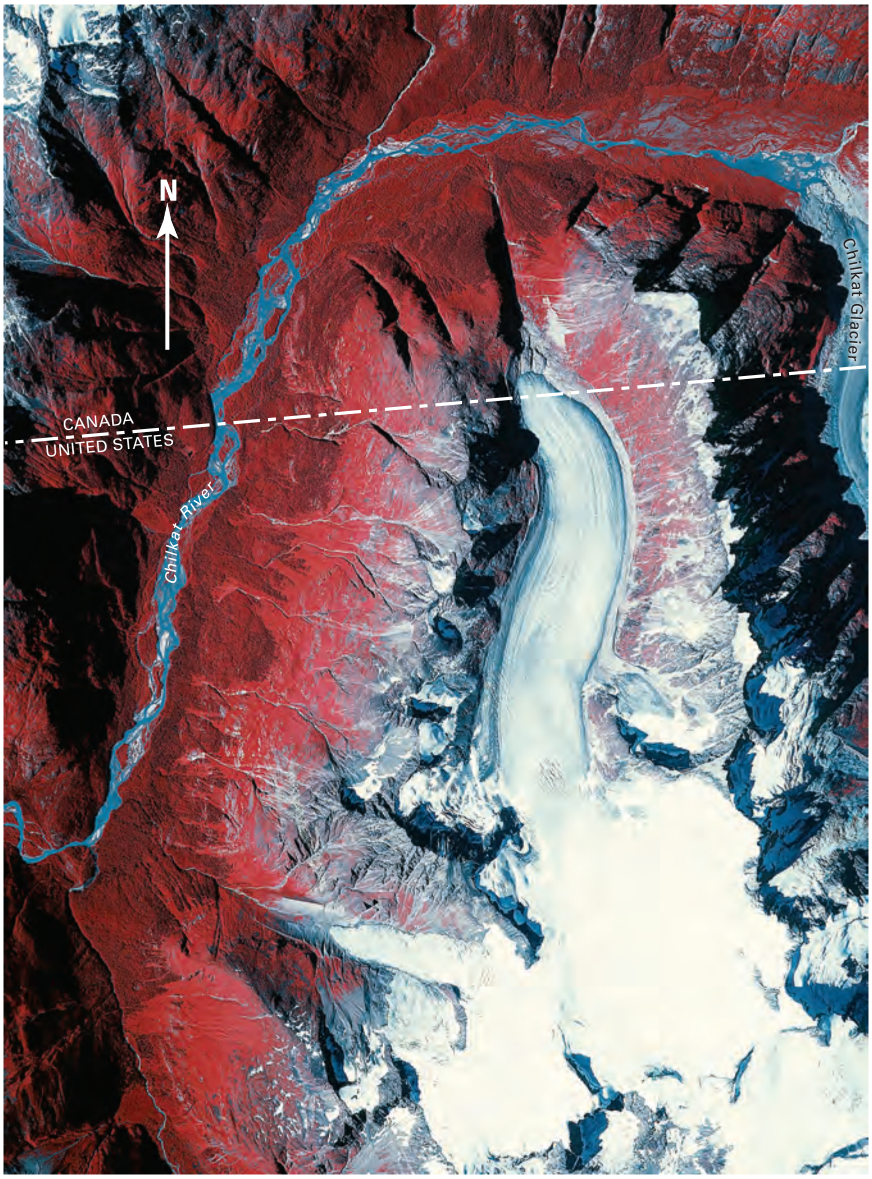


Figure 97.—*11 August 1979 AHAP false-color vertical aerial photograph of an unnamed 4-km-long glacier to the west of Chilkat Glacier. The unnamed glacier retreated south across the border into the United States in the 1980s. The terminus of Chilkat Glacier can be seen in the upper right of the photograph. AHAP photograph no. L189F4294 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.*

instance, conspicuous evidence of recent retreat. The retreat of the tributaries and the thinning of Ferebee Glacier have caused every one of the former tributaries to lose contact with the glacier. In the eastern part of this area adjacent to Irene Glacier, examination of a 11 August 1979 aerial photograph taken by the AHAP Program (L188F4285) failed to identify any glaciers that were advancing, and few that appeared to be stable. All the glaciers show either vegetation-free bedrock or outwash deposits, exposed lateral moraines, well-developed trimlines, ice-marginal lakes, or other evidence of active thinning and retreat. All of the glaciers in the Takshanuk Mountains east of the Chilkat River (fig. 96) showed evidence of recent retreat.

Summary

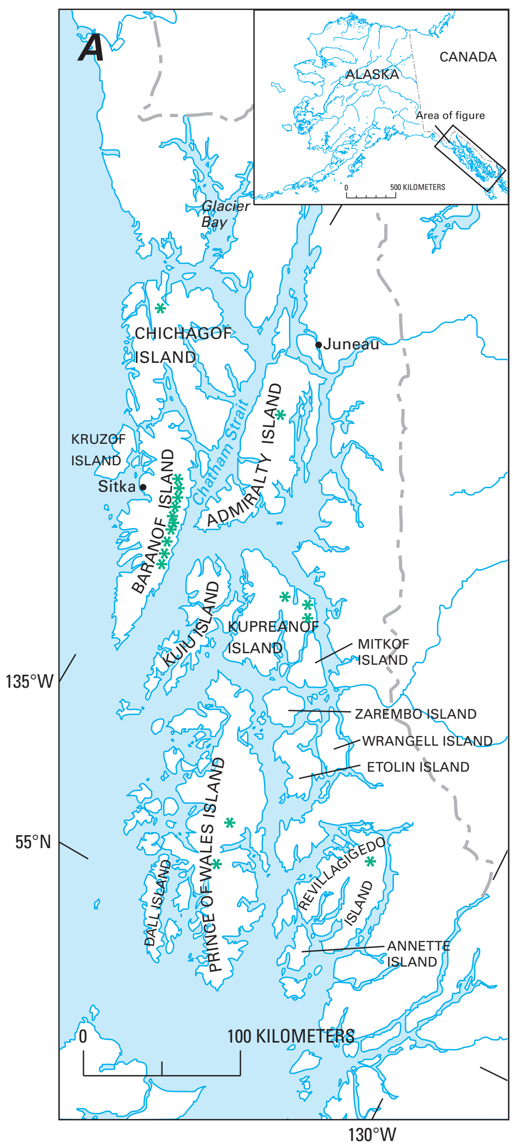
During the period of the Landsat baseline (1972–81), Baird, Taku, Hole-in-the-Wall, and Mead Glaciers were advancing. Available evidence suggests that all other valley and outlet glaciers in the Coast Mountains were thinning and retreating. At the end of the 20th century, Baird and Taku Glaciers were advancing, and Hole-in-the-Wall Glacier was stable. No new information was available about Mead Glacier. All other observed valley and outlet glaciers in the Coast Mountains continued to thin and retreat.

Alexander Archipelago

The Alexander Archipelago is a group of about 1,100 islands in southeastern Alaska that extends 450 km from south to north, from the Canadian border at Dixon Entrance to Cross Sound and Icy Strait (fig. 98). Examination of topographic maps and aerial photography indicated that, in the middle of the 20th century, glaciers existed on these islands. Most, if not all, of these glaciers were retreating at the time of observation. Glaciers may presently exist in mountainous areas on the six main islands of the archipelago: Revillagigedo, Prince of Wales, Kupreanof, Baranof, Chichagof, and Admiralty. None of the glaciers on any of these islands has been studied in detail. The total area of glaciers in the Alexander Archipelago is estimated by the author at less than 150 km^2.

Revillagigedo Island

Located between the Alaska mainland and Prince of Wales Island, 90×55-km Revillagigedo Island has elevations that reach 1,400 m. A single 0.8×0.4-km unnamed glacier is located about 3.5 km south of 1,225-m-high Mount Reid, the highest point on the island (fig. 72) (see NASA space shuttle photograph no. STS028–073–039 acquired in August 1989). This glacier is also shown on the USGS (1955) Ketchikan C-4, Alaska, 1:63,360-scale topographic map (appendix B), which is based on 1948 aerial photography. It heads at an elevation of about 915 m. The 1995 revision of the map indicates no change in the glacier, although it does show a new snowfield on the eastern flank of Mount Reid. The snowfield was probably present earlier but not mapped. Landsat MSS images that cover the location of the glacier on Revillagigedo Island have the following Path/Row coordinates: 58/21 and 59/21 (fig. 3*A*, table 1). No other information about this glacier could be located.



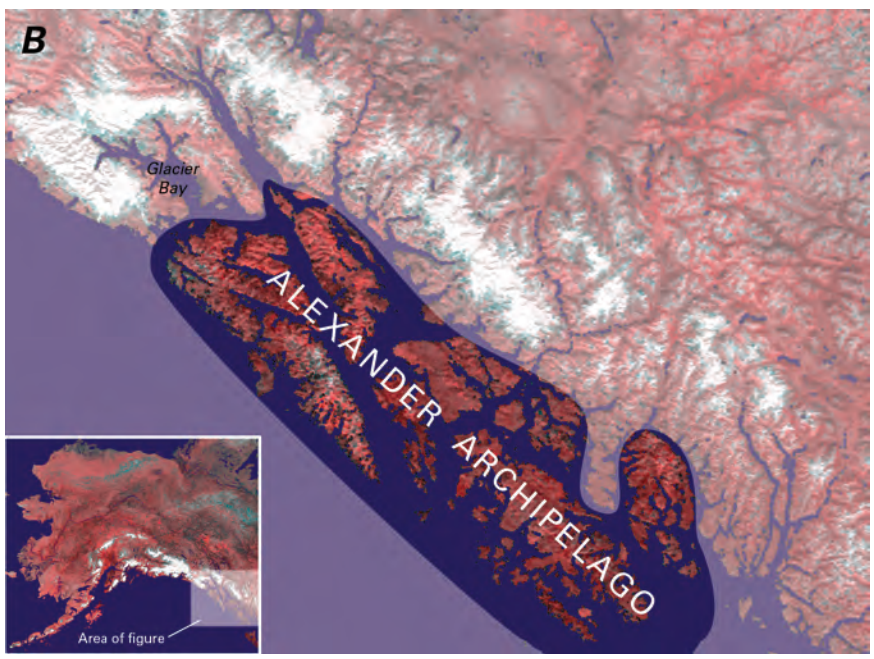


Figure 98.—**A**, *Index map of the Alexander Archipelago showing the six main islands where glaciers are located. The green asterisks indicate the approximate location of mapped glaciers.* **B**, *Enlargement of NOAA Advanced Very High Resolution Radiometer (AVHRR) image mosaic of the Alexander Archipelago in summer 1995. National Oceanic and Atmospheric Administration image mosaic from Michael Fleming, Alaska Science Center, U.S. Geological Survey, Anchorage, Alaska.*

Prince of Wales Island

At 212×72 km, Prince of Wales Island is the largest of the islands of the Alexander Archipelago. The USGS (1975) Craig, Alaska, 1:250,000-scale topographic map, which is based on 1950–56 aerial photography, shows one small unnamed southeast-facing glacier on the southern face of 1,160-m Pin Peak, south of Black Bear Lake. Its length is less than 1.0 km. Its runoff drains into the Harris River and finally enters Twelvemile Arm. The Landsat 1–3 MSS image that covers this area has the following Path/Row coordinates: 60/21 (fig. 3*A*, table 1). The most recent 1:63,360-scale maps of the area do not show any glaciers (Craig, B2, 1997; C3, 1994; appendix B). No other information about this glacier could be located.

Kupreanof Island

Separated from the Alaska mainland by Frederick Sound, 90×45-km Kupreanof Island has elevations that approach 1,200 m. Field (1975a) reported that several small unnamed glaciers are located on the eastern side of the island. All are 10 to15 km north of Petersburg and less than a kilometer in length. They exist on peaks near Frederick Sound: one on 1,190-m-high Sherman Peak, one on 1,100-m-high Sheridan Peak, and one in the Missionary Range. Their location is shown on figure 78*A*, the Landsat MSS image that covers the eastern part of Kupreanof Island, and on an August 1997 space shuttle photograph (fig. 78*B*). The Landsat 1–3 images that cover the area have the following Path/Row coordinates: 60/20 and 61/20 (fig. 3*A*, table 1).

Baranof Island

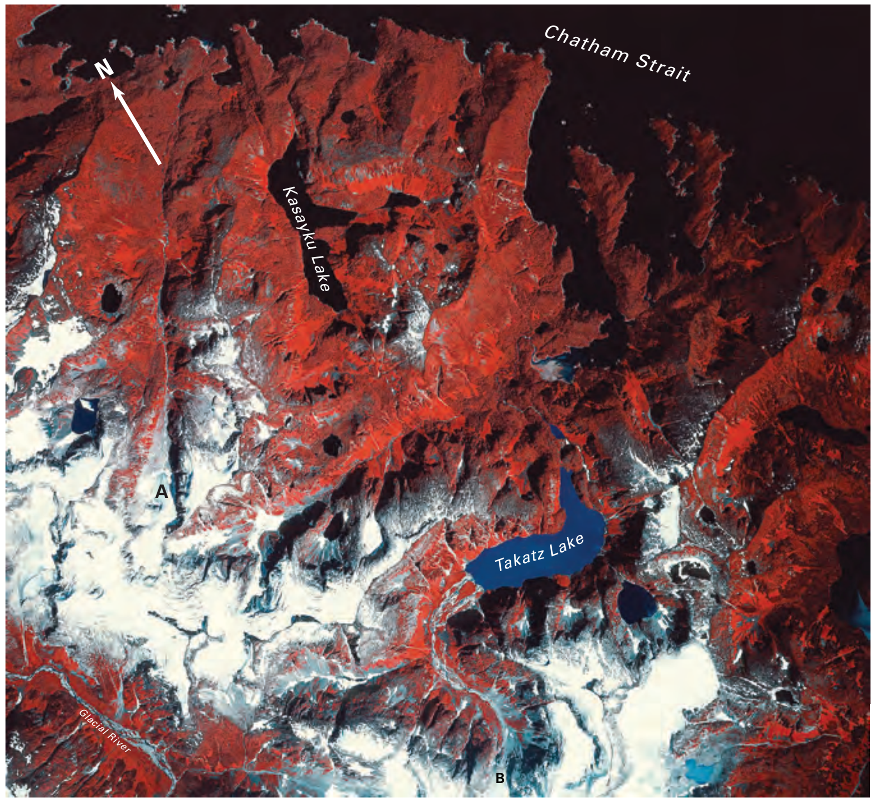
Along the crest of 170-km-long Baranof Island, more than 50 unnamed glaciers extend for approximately 90 km from west of Patterson Bay to the northern side of an unnamed 1,430-m peak 4.6 km north of Annahootz Mountain. These glaciers were photographed in 1926 by the USGS-USN Aerial Photographic Expedition. Their location is shown on a Landsat 2 MSS image and on a space shuttle photograph (see NASA space shuttle photograph no. STS028–083–057 acquired in August 1989) that cover the eastern part of Baranof Island. The Landsat images that cover the area have the following Path/Row coordinates: 61/20, 62/20, and 63/20 (fig. 3*A*, table 1). An examination of the photographs and images showed much evidence of thinning and retreat.

The largest of these glaciers extends for about 5 km on a ridge between 1,100-m-high Mount Furuhelm and an unnamed 1,624-m peak. Numerous parallel and subparallel fjords, some as long as 65 km, cut through Baranof Island. The fjords are evidence of the area's extensive past history of glaciation. Snow-covered glaciers both north and south of Mount Furuhelm show vegetation-free exposed bedrock, evidence of recent retreat on a photograph taken 11 August 1979 (fig. 99) (see also AHAP false-color infrared vertical aerial photograph no. L200F4540 acquired on 12 August 1979). Many of the glaciers in the vicinity of Mount Furuhelm were photographed in 1926 with a three-lens Bagley aerial camera (figs. 26, 29).

Chichagof Island

The northwesternmost island of the Alexander Archipelago, 116-km-long Chichagof Island, has more than a dozen small unnamed glaciers near its northern end. Each is less than one kilometer in length. Their location is imaged by Landsat 1–3 MSS scenes with the following Path/Row coordinates: 63/19, 64/19 and 65/19 (fig. 3*A*, table 1). One glacier flows northwest from the summit of Pegmatite Mountain down to an elevation of about 350 m (see AHAP false-color infrared vertical aerial photograph no. L199F190 acquired on 12 August 1979). Vegetation-free bedrock around the margins of many of the glaciers in this area indicate recent retreat.

Figure 99.—11 August 1979 AHAP false-color vertical aerial photograph of Baranof Island showing the area north of Mount Furuhelm and east of Sitka. Here many of the glaciers east of Glacial River are fringed by vegetation-free bedrock. Two in particular, unnamed glaciers labeled A and B, each show about 0.5 km of recent retreat. AHAP photograph no. L199F211 from the GeoData Center, Geophysical Institute, University of Alaska, Fairbanks, Alaska.



Admiralty Island

On central Admiralty Island, two glaciers are shown on the USGS (1951) Sitka, Alaska, 1:250,000-scale topographic map (appendix A), which is based on 1949 and 1951 aerial photography. They are located on an unnamed 1,000 to 1,200-m-high mountain ridge between Hasselborg Lake and Lake Florence. The larger is about 2 km in length; the smaller is only about 0.8 km in length. Their location is shown on Landsat MSS images with the following Path/Row coordinates: 61/20 and 62/19 (fig. 3*A*, table 1). No other information about these glaciers could be located.

Summary

During the period of the Landsat baseline (1972–81), all available evidence suggests that the glaciers in the Alexander Archipelago were thinning and retreating. No information is available about the status of these glaciers through the early 21st century. However, their small size, low elevation, and southerly location in an area with significant late 20th century temperature increases suggests that they have probably continued to thin and retreat.