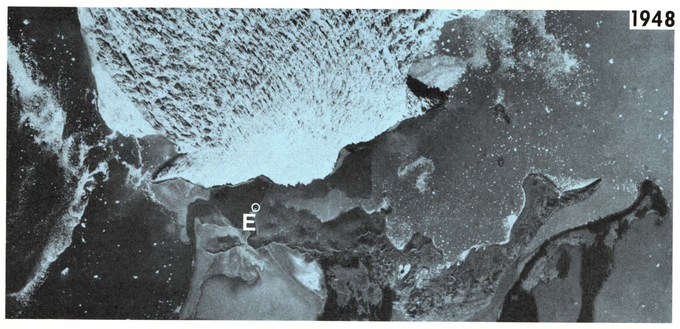
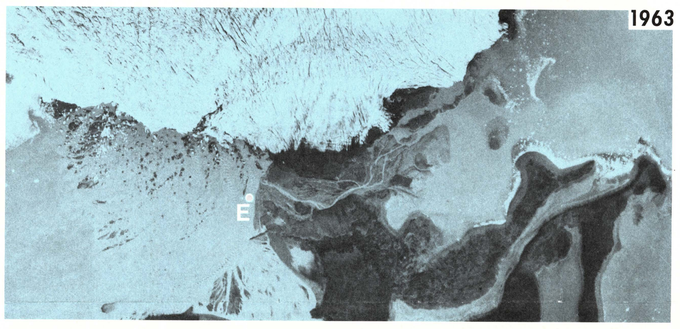
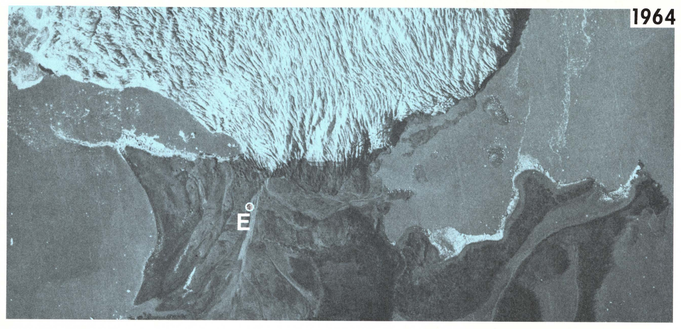
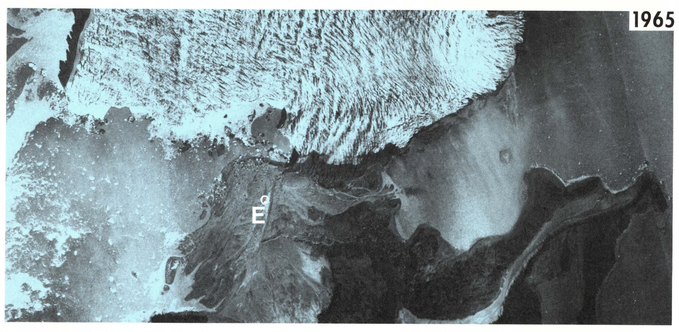
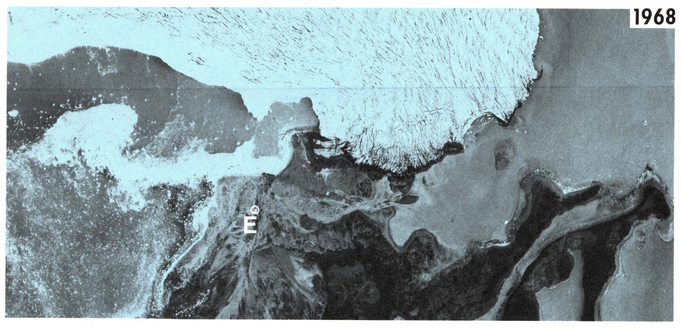
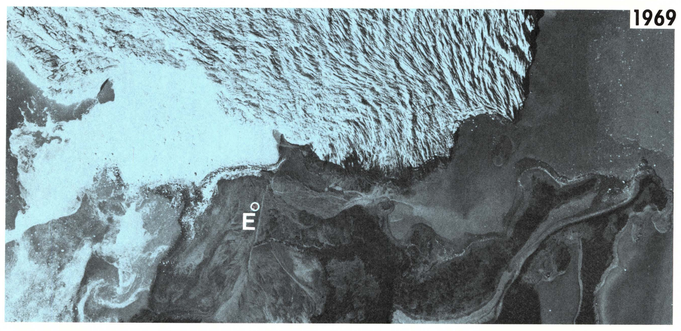


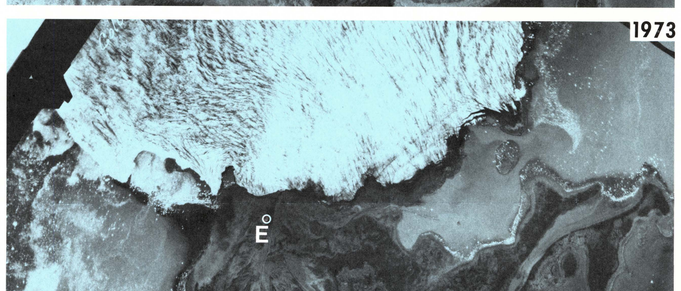


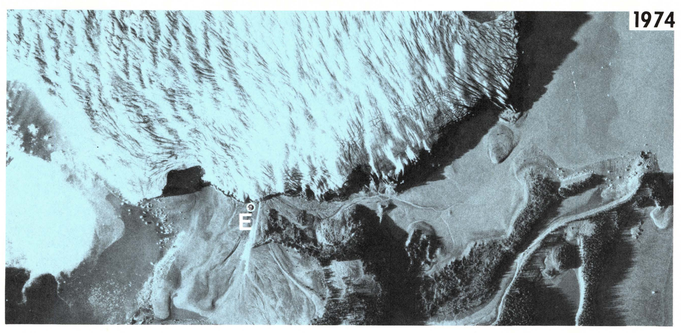


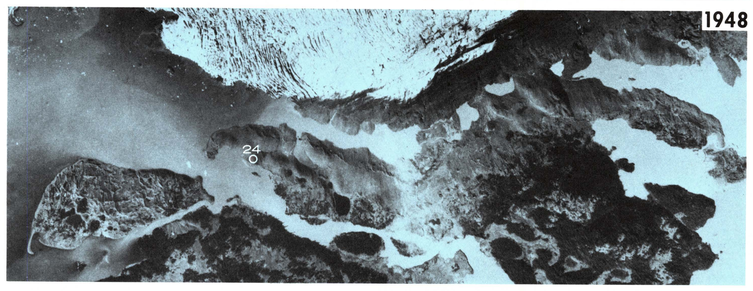


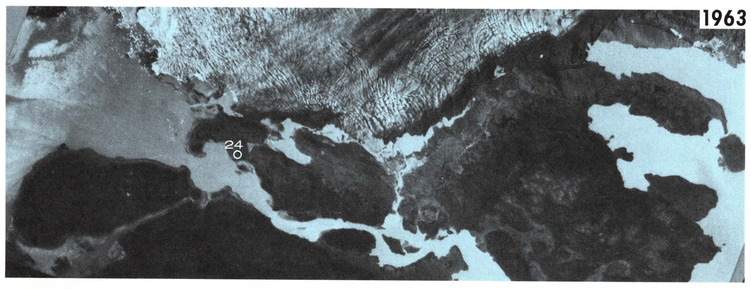


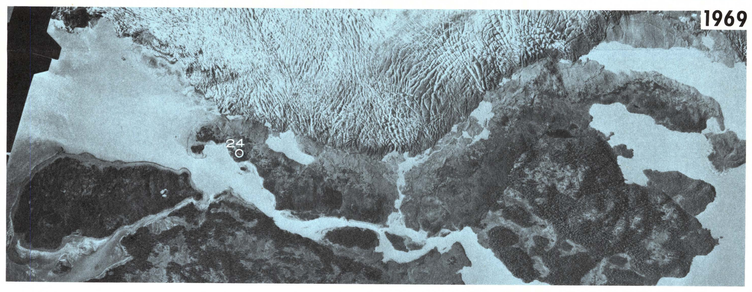












DETERMINING THE RATE OF GLACIER FLOW FROM MOVEMENT OF SURFACE DEBRIS 1961–74

(Oblique photographs, right)

On the glacier's surface near the center of the 1961 photograph can be seen a black streamer of rock debris followed by several smaller piles of fragments. The source of this material is from rock avalanches which take place on one of the glacier's tributaries. The flow rate in the central part of the glacier can be determined by plotting the changing positions of such debris with time; between 1963 and 1968 the ice moved over 3,400 m with an average speed of 680 m per year or 1.9 m per day. The photographs show the debris moving down the glacier; by 1965 the largest and most conspicuous avalanche deposit was calving from the glacier's terminus. Practically all of the avalanche deposits had been calved into Columbia Bay by 1974, and this part of the glacier was debris free, in marked contrast to the earlier views.

CHANGES IN TIDAL EMBAYMENTS 1938–74

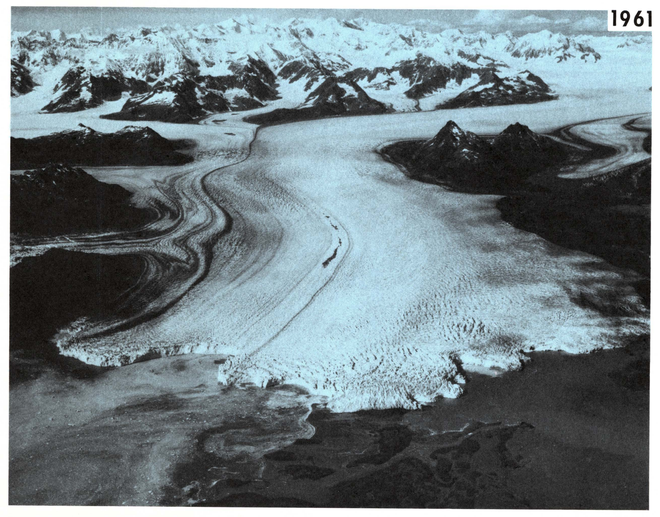
(Oblique photographs, right, and below)

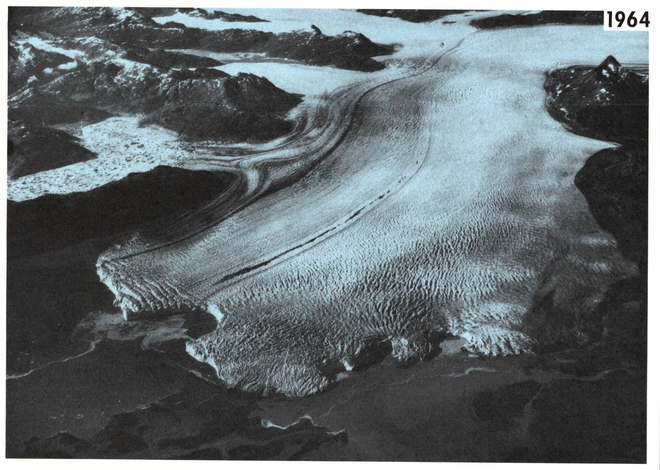
The fluctuating position of the tidal terminus is displayed by the series of oblique aerial views on the right. The eastern margin ends on land or in lakes (right side of photographs). The Heather Bay part of the glacier (lower right) ends on moraines exposed at low water; various sizes and shapes of embayments form between these shoals annually and discharge small icebergs. The glacier's center overrides the northern end of Heather Island (lower center of most views). The main calving terminus is situated between Heather Island and the western shore of Columbia Bay. Here the ice terminates in a spectacular 50- to 80-m-high cliff (lower left to center) from which innumerable icebergs, some occasionally up to 100 m or more in length, are discharged almost continuously.

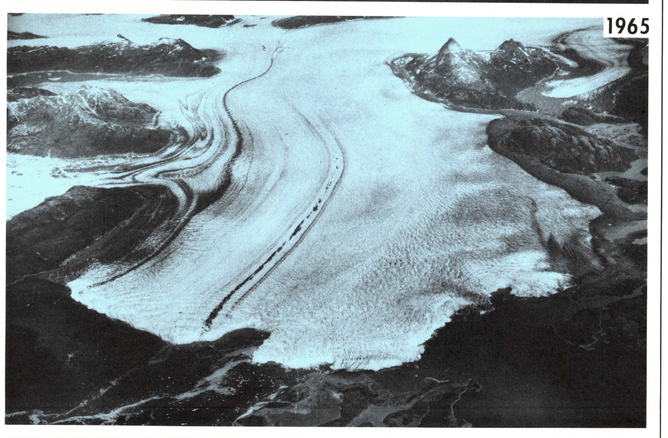
During most years large, U-shaped embayments are formed in the glacier's terminus where large subglacial rivers discharge. Columbia Glacier is unique among Alaskan tidal glaciers for the size and shifting positions of these features. Shown below are especially large embayments. These formed on both sides of Heather Island in 1938. In 1971 the subglacial river had shifted to the western margin where a very large embayment formed. In 1972 the depth of the embayment had been reduced but the opening had greatly enlarged laterally. In the 1972 photograph the position of the submerged terminal moraine can be traced by a line of stranded icebergs extending from the low point in the lower left.

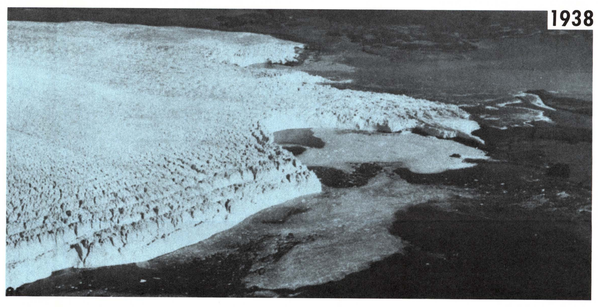
Embayments occasionally enlarge into the glacier until the top of the ice cliff may become as high as 100 m above sea level, as shown in photographs taken in 1938, 1961, 1968 and 1971. The center of the embayment then extends into the glacier to the limit of extensive slumping, marked by a series of enormous crevasses which form as the ice approaches the terminus. This is judged to mark the inner side of the submarine shoal. It is when embayments reach this point that the glacier's stability becomes critical.

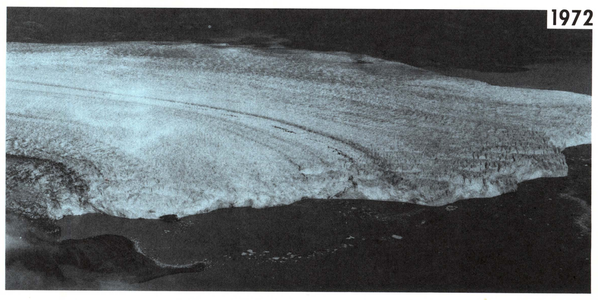
The 1938 photograph was taken by Bradford Washburn.

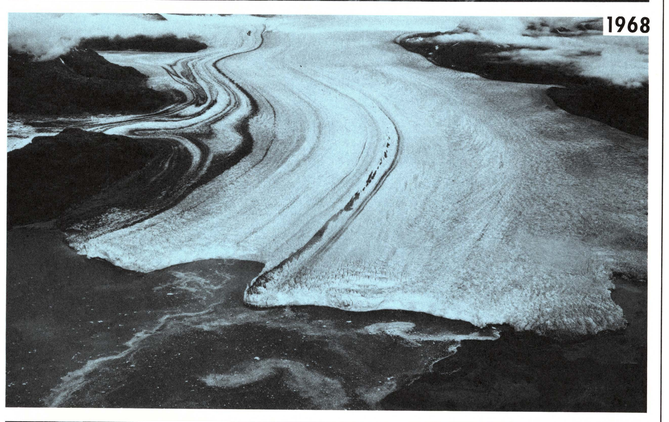


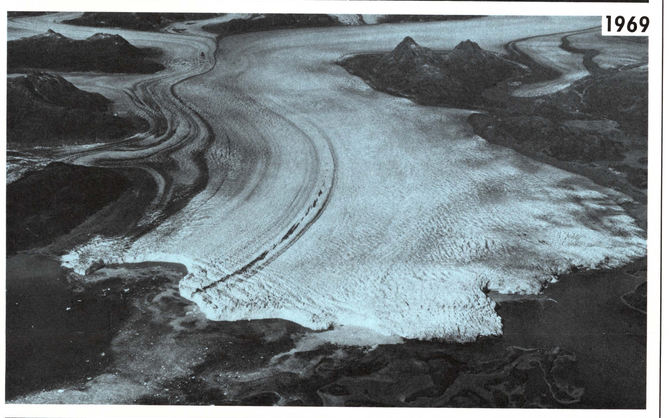












CHANGES OF THE TERMINUS ALONG THE EASTERN MARGIN, 1948–74

SCALE 1:10,000

(Vertical photographs, above)

The 1910 and 1917–22 advances (sheet 2) covered nearly all of the barren areas visible in the 1948 scene including the island on the left (note complex series of moraines). Station 24, shown on sheets 1 and 2, is identified. The glacier pushed into the river channel (lower center), abutted against the forested hills (right center), and covered most of the peninsula extending into the lake at the right. A lesser advance occurred in 1935, roughly outlined by the extent of vegetation in the 1963 view. The greatest known retreat of the glacier in this sector is shown in the 1948 photograph. A strong advance then took place which culminated in 1950, forming small moraines from which the glacier had again receded by 1963. Another advance in progress culminated in 1972; the glacier then retreated slightly from this position as shown in the 1974 photograph. Note the progressive change in vegetation as brush and first generation forest reoccupies areas exposed by glacier retreat.

The 1948 photograph was taken by the U.S. Coast and Geodetic Survey.

CHANGES OF THE TERMINUS ON HEATHER ISLAND, 1948–74

SCALE 1:10,000

(Vertical photographs, left)

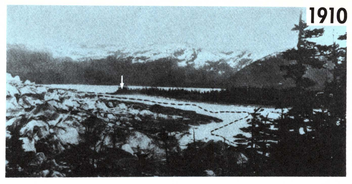
These vertical views, taken between 1948 and 1974, show several advances and retreats of the glacier and changes in topography and vegetation. Photo station "E," shown on sheets 1 and 2, is identified. In the 1948 view the glacier is nearly cut off from the island by a shallow lagoon; the severely crevassed and brilliant white ice indicates that the glacier was advancing when the photograph was taken. Note the barren, unvegetated state of the 1917–22 moraines in the lower left center of the view and the wormlike terminal moraine marking the limit of the 1935 advance.

In July 1963 a large river was emerging from under the ice destroying much of the 1935 moraine, and outwash deposits were rapidly filling the shallow lagoons. The smooth black ice where the glacier terminates on the island and open water between the glacier and outwash demonstrates that this portion of the glacier was retreating, but on the right side a slight advance was in progress.

The 1964 photograph shows no large-scale changes despite the severe shaking of the Alaska earthquake, whose epicenter was located near the glacier.

The 1965 view shows the glacier slightly in advance of 1964, and by 1968 the eastern portion of the front had advanced as much as 150 m. Meanwhile the western portion had retreated from the outwash even further than in 1964. A new advance of the central part of the ice cliff was taking place in 1969 but was waning in 1973, as the land-fixed ice was again smooth, indicating retreat. The 1974 photograph shows the glacier advancing strongly; points exposed as early as 1935 were being covered. This advance averaged slightly less than 1 m per day in July 1974.

The 1948 photograph was taken by the U.S. Coast and Geodetic Survey.



CHANGES IN THE GLACIER MARGIN AND VEGETATION ON HEATHER ISLAND, 1910–74

The June 24, 1910, view, taken near station 3 (sheet 1), shows the glacier advancing into the lagoon situated on the northern side of Heather Island. The picture displays in the foreground a mature forest, with trees at least 500 years old (Cooper, 1942). The dashed line indicates the position the glacier reached in September 5 of the same year.

Data and 1910 photo are from Tarr and Martin (1914).

The 1974 panorama, made to the same scale, was taken from near the same point as the earlier photograph. The 1917–22 advance of the glacier overwhelmed the old photograph point and destroyed the forest for some distance to the south; the nearest remaining mature forest is in the far right of the view. Much of the lagoon was filled with moraine upon which a first generation forest is becoming established. The glacier meanwhile has retreated markedly to the far left of the panorama.

Arrow indicates position of photographic station 8 (Plate 1).

PHOTOGRAPHS ILLUSTRATING CHANGES WITH TIME IN COLUMBIA GLACIER

Interior—Geological Survey, Reston, Va.—1975—W76064

PRELIMINARY HYDROGRAPHY AND HISTORIC TERMINAL CHANGES OF COLUMBIA GLACIER, ALASKA

By
Austin Post

1975