over-simplify the problem. Both types occur and need descriptive terms, but we think great confusion will arise if the term "ice island" is adopted for yet another kind of feature. "Ice island" was used widely for icebergs by visitors to the Southern Ocean during the late eighteenth and early nineteenth centuries. This usage had been dropped by about 1840, but the term was re-introduced in 1946 for the large low floating tabular bergs which have been found in the Arctic Ocean.

It seems to us that, despite its unsuitability, the latter use is now firmly established, especially in Canada and the United States. The literature on Arctic ice islands is extensive. Experience has already shown that attempts to alter this term, as suggested by Mr. Law, are unlikely to gain general agreement. It also seems essential to avoid quite different meanings in the Arctic and Antarctic.

Mr. Law considers the terms "ice rise" unsuitable for the Antarctic features which he describes (and we agree with him) but he appears to have overlooked the fact that "ice rises" are quite different from any of the features he describes. The suggested definition of "ice rise" (Armstrong and Roberts, 1956, p. 7) is: "A mass of ice resting on rock and surrounded either by an ice shelf, or partly by an ice shelf and partly by sea and/or ice-free land. No rock is exposed and there may be none above sea-level. Ice rises often have a dome-shaped surface. The largest known is about 100 km. across." Roosevelt Island, mentioned in Mr. Crary's letter, is a typical example. Similar features, well in from the ice front, are very common in the area south and west of Alexander Island and in the ice shelf south and east of Thurston Peninsula on the Eights Coast. It seems, in fact, that these features are likely to be discovered and mapped in increasing numbers. The larger ones will certainly have to be given individual place-names. The problem is not confined to the Antarctic, as is shown by Hattersley-Smith (1956). A more recent paper by the same author dealing with the Ward Hunt Ice Shelf in northern Ellesmere Island exemplifies the ambiguity in one sentence: "The ice island formed by the breaking away of the ice shelf in this area . . ." He is referring to the floating feature, *not* to the residual ice-covered island. An "ice rise" can, of course, become an "ice island" (in the sense proposed by Mr. Law) if the ice front breaks back far enough to leave it entirely surrounded by water. Mr. Crary also recognizes this possibility, but does not discuss the term "ice rise."

For these reasons, we suggest that while the simple generic terms "island" and "ice rise" are sufficient for use in place-names, there is need for further terms (not to be compounded in place-names) to distinguish Mr. Law's types of ice-covered island. There is, incidentally, at least one more distinct stage of Mr. Law's types (3) and (4), illustrated by Wright and Priestley (1922), in which the ice dome is continued out to sea by a flattened selvage of floating ice. All these are subject to temporal change, in addition to the difficulties of precise visual recognition. How, for instance, is one to distinguish between Mr. Law's type (3) and a grounded berg of similar aspect? It is perhaps indicative that the Russians—normally addicted to fine distinctions—use only one term, *ledyanaya kupola*, for both "ice rise" and Mr. Law's islands of types (3) and (4) (Dolgushin, 1958). We hesitate to suggest terms, as distinct from descriptions, at this early stage of investigation. It is first desirable that others should comment on Mr. Crary's willingness to alter the term "ice island." If this could find general support, we think it provides the best solution.

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SIR, *Ice thickness variations at an advancing front, Coleman Glacier, Mt. Baker, Washington*

For a decade prior to a hot, dry Summer in 1958, most glaciers in the north-western United States increased in volume.[1, 2, 3] Measurements were made during this period at the Coleman Glacier on Mt. Baker, Washington, and the resulting data indicate interesting relationships between ice flow and ice thickness. The ice flow is apparently not proportional to the thickness or gradient but may depend on a

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longitudinal compressive force transmitted from more active ice upstream. The data [3] show that the advance of the Coleman Glacier ended abruptly after a net average loss in thickness of 7 m. over the entire glacier in 1958. The ice thickness at the terminal tongue decreased 15 m. between June and September of that year. However, the thickness of the tongue was still greater than in previous years when the ice was advancing rapidly.

Data on the annual advance (possible error ± 2 m.) at the Coleman Glacier front since 1954 are:

1954–55	99 m.
1955–56	76 m.
1956–57	58 m.
1957–58	49 m.
1958–59	0 m.
1959–60	2 m.

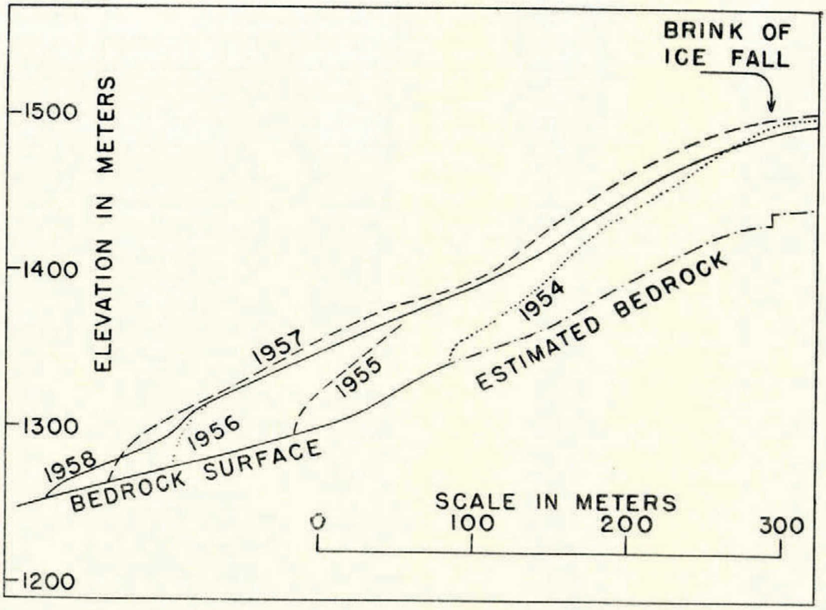

Fig. 1. Profile of Coleman Glacier tongue at end of ablation season

Although the advance was greatest between 1954 and 1955, the volume increase at the tongue was greatest during the 1955–56 season. The flow into the tongue below an elevation of 1,500 m. was reduced after a warm Summer in 1956, probably as a result of a decrease in ice thickness in the region between 1,500 and 1,800 m.

Supplementary data on the ice thickness at the tongue are illustrated by the profiles plotted in Figure 1. The gradient is shown without exaggeration; it decreases abruptly at approximately 1,500 m. The change, which is marked by a series of crevasses, defines the brink of the ice fall shown in the profiles. Above this elevation is a large, relatively flat region which feeds the terminal tongue which is not shown in Figure 1. The thickness at the brink of the ice fall could be estimated because a rock cliff was exposed near this point until 1956. The advances shown in the illustration are generally indicative of the response at the front but do not check with the tabulated data because the direction of advance did not follow the line of this profile. The 1959 and 1960 profiles are nearly identical with the 1958 profile and are not plotted.

Although the tongue thickness was greater in 1958 than in 1954, except at the brink of the ice fall, the flow of ice was drastically reduced after a single Summer of unusual melting. The convex, bulging front which is characteristic of active ice flow was replaced by a tapered front which appeared to be sliding or moving along shear planes. Meager flow in 1958–59 was offset by melting, but the front plowed ahead 24 m. during the Winter of 1959–60, pushing up a small moraine. This advance was nearly destroyed by increased melting during the Summer.

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SIR,

Growth rate of sea ice

During the course of field work at Thule, Greenland, in conjunction with an Air Force Cambridge Research Center sea ice project, ice thicknesses were measured in a protected part of North Star Bay, an arm of Baffin Bay, over the greater part of two ice growth seasons. Measurements were made at several locations both on the sea ice and on pools that were artificially opened up in it daily for the first month after freeze-up of the 1956–57 season. Snow cover was slight (several centimeters or less) throughout the period of most intensive measurement and averaged less than 30 cm. in March for both years of record. All air temperatures were measured at least 6 m. above the ice surface. Ice thicknesses were measured in a small area on a single uniform sheet. There existed no complications such as rafting, above freezing temperatures, runoff, or large and variable amounts of snow. The resulting curve is particularly well documented in the initial parts where data have previously been sparse. Two important conclusions may immediately be drawn from the data:

1. The growth curve cannot be fitted by a single, simple power law such as results from the pure ice growth theories of Stefan [1] or Tamura,[2] which have been extensively applied to sea ice.

2. The relatively small scatter indicates that for a first approximation time and temperature may be compounded into a single parameter, namely, the exposure (degree-days or degree-hours of frost), and this is the most important parameter controlling the thickness of ice forming under a wide variety of conditions even on such a temperature-sensitive material as sea ice. This commonly accepted procedure needs statistical justification since a proper theory of sea ice growth requires knowledge of the actual thermal history, as well as such meteorological variables as humidity, wind velocity and radiation.

Although the principal purpose of this note is to make available the thickness data it might be useful to develop briefly the pertinent theory. The growth equation may be derived by equating the latent heat of ice formation to the heat removed from the ice to the air:

$$\int L\rho de = \int \frac{k\ (\theta_s - \theta_f)}{e}\, dt = \int \frac{h(\theta_a - \theta_s)}{e'}\, dt, \tag{1}$$

where L = latent heat,
ρ = ice density,
e = ice thickness,
k = ice thermal conductivity,
t = time,
θ_a = air temperature,
θ_s = ice surface temperature,
θ_f = freezing point,
e' = effective boundary layer thickness,
h = transfer coefficient of boundary layer.

The effective transfer coefficient, K, of the ice and boundary layer system may be written:

$$K = \frac{e+e'}{ke'+he}\,(hk),$$