

8.7 The West Greenland Iceberg Environment

To shipping the most dangerous aspect of ice in the sea is the occurrence of icebergs. They differ from sea ice in many ways:

- they originate from land,
- they produce fresh water on melting,
- they are deep-drafted with appreciable heights above sea level,
- they are always considered as an intense local hazard to navigation and offshore activity.

The process of calving from the front of a glacier produces an infinite variety of icebergs, bergy bits and growlers with calving occurring throughout the year. Icebergs are described by their size according to the following classification:

<u>Type</u>	<u>Height (above sea level)</u>	<u>Length</u>
growler	less than 1 m	up to 5 m
bergy bit	1 to 5 m	5 to 15 m
small iceberg	5 to 15 m	15 to 60 m
medium iceberg	16 to 45 m	61 to 120 m
large iceberg	46 to 75 m	121 to 200 m
very large iceberg	over 75 m	over 200 m

The production of icebergs on a volumetric basis varies only slightly from year to year. Once calving is accomplished, meteorological and oceanographic factors begin to affect the icebergs. Icebergs are carried by sea currents directed by the integrated average of the water motion over the whole draft of the iceberg. However, wind also plays an important role, either directly or indirectly.

8.7.1 Iceberg sources

Glaciers are numerous in West Greenland, however, the productive glaciers are concentrated between Nares Strait and Disko Bay. Although icebergs occur throughout the West Greenland waters between 60° N and 72° N, they are rare in some areas, e.g. off Sisimiut. In other areas, e.g. in Disko Bay, hundreds of icebergs are always present (Figure 8.17 and 8.18).

Eastern Baffin Bay north of Upernavik is a major source of icebergs. Over 10,000 icebergs are

calved from 19 major glaciers every year (Figure 8.19). Some of these are capable of producing icebergs of about 1 kilometer in diameter. Several active glaciers in Uummannaq Fjord and Disko Bay produce 10-15,000 icebergs per year, and they are very important for the iceberg input to the northern Davis Strait and Baffin Bay. The most active glacier is located near Ilulissat moving at the rate of 20 m/day. This glacier produces over 20 km³ of ice per year. The total annual production of icebergs calved in the Baffin Bay and the northern Davis Strait is estimated to be about 25-30,000, estimates however vary up to as high as 40,000. Surveys conducted by USCG International Ice Patrol decades ago indicate that the total number of icebergs in Baffin Bay and the northern Davis Strait are of the same order of magnitude. Almost no icebergs are produced south of Disko Bay. Here the fjords are longer, narrower, and shallower than in the northern areas of the Greenland west coast, and the calving is in the form of growlers and bergy bits rather than icebergs. Growlers and bergy bits nearly always melt before reaching the open sea. However, from time to time the glacier in Narsalik Fjord produces ice which affects offshore areas for a couple of days.

[satellite image]

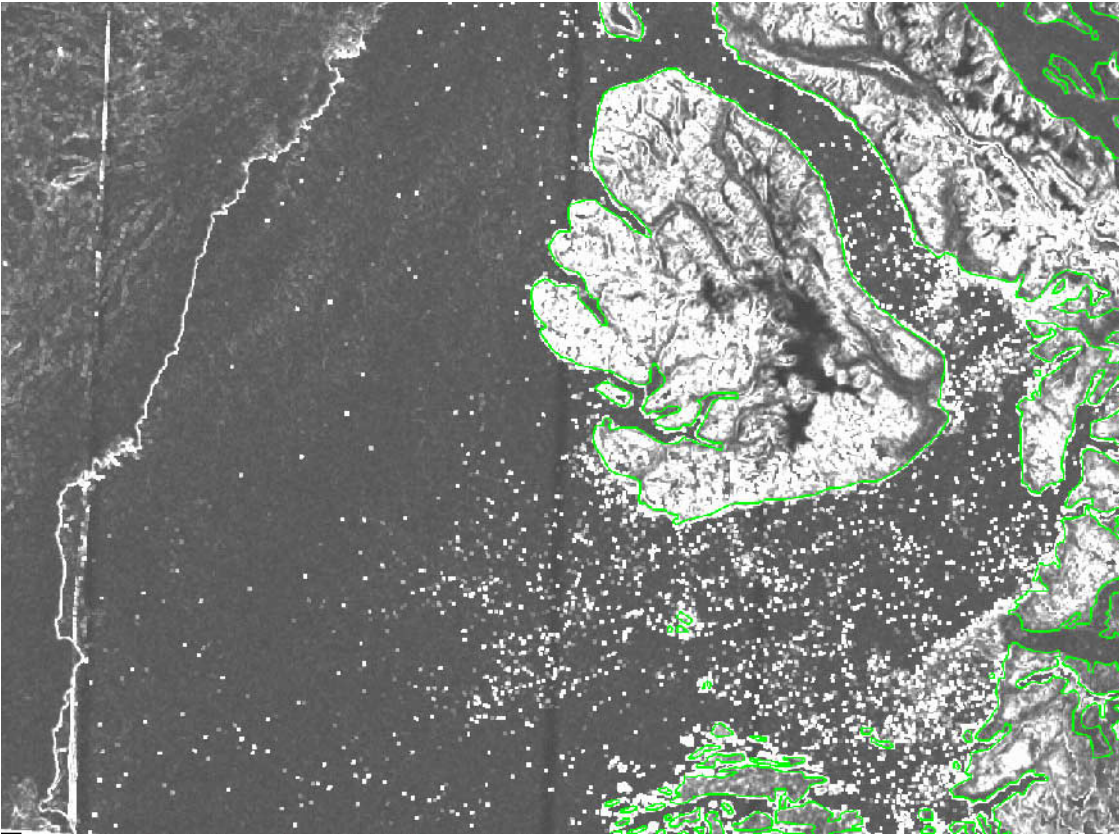


Figure 8.17. Radarsat PMR-filter image from June 14th 1999 20 UTC of the Disko Bay area showing the distribution of targets (icebergs). The 'West Ice' - edge is found in the western part of the image. (source: Radarsat).



Figure 8.18. June 12th 1997. Glacial Ice, primarily small icebergs and bergy bits from one of the major sources in Northeastern Disko Bay, Torssukatak, which produces about 16 km³ ice/year. (Photo: Keld Q. Hansen).

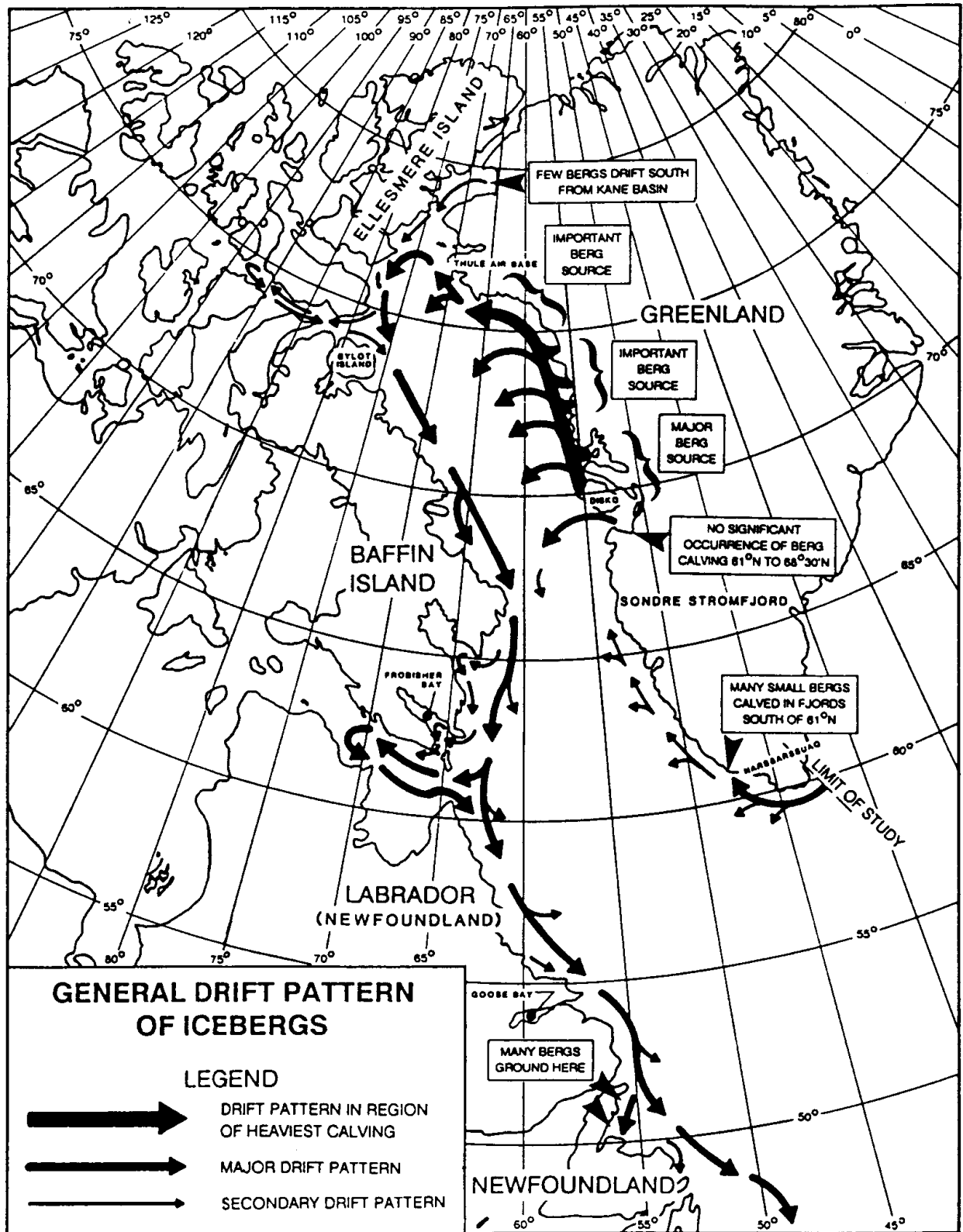


Figure 8.19. Major iceberg sources and general drift pattern in the West Greenland Waters. (US National Ice Center, Washington DC).

8.7.2 Iceberg drift and distribution

On a large scale the basic water currents and drift of icebergs in Baffin Bay and northern Davis Strait are fairly simple. There is a north-flowing current along the Greenland coast and a south-flowing current along Baffin Island and the Labrador coast, giving an anti-clockwise drift pattern. However, branching of the general currents cause variations, and these can have a significant impact on the iceberg population and their residence time. Although the majority of icebergs from Disko Bay are carried northward to northeastern Baffin Bay and Cape York before heading southward, icebergs have also been observed to be diverted into one of the west-branching eddies without passing north of 70° N. Most of the icebergs from Baffin Bay drift southward in western Davis Strait, joining the Labrador Current further south, although some may enter the eastern Davis Strait area west of Disko Island instead. Icebergs produced in Disko Bay or Baffin Bay generally will never reach the Greenland shores south of 68° N. Many icebergs produced in the Disko Bay enter Davis Strait, partly through Vaigat and partly along the southern coast of Disko Island. Some icebergs manage to drift towards or into southern Disko Bay from the Davis Strait due to onshore component of the currents west of Aasiaat. Icebergs south of Sisimiut are of East Greenland origin. Occasionally many small icebergs and bergy bits calved in Southwest Greenland fjords are observed close to the coast in this area, however, these ice masses normally melt quickly and only rarely affect ocean areas farther offshore.

In a study in the late 1970s, DHI/GTO found the lowest iceberg densities in West Greenland at the northern part of Lille Hellefiskebanke and at the southern part of Store Hellefiskebanke between 65° N and 66° N. Iceberg densities increased both towards north and south. The density of icebergs in Disko Bay was significantly higher than outside the bay, with maximum concentrations of icebergs occurring in the northeastern part of Disko Bay. The iceberg density generally was highest in early summer, except in the area near Disko Bay where the highest density was seen in late summer, probably due to higher calving activity of the glaciers during the summer months. A similar distribution can be derived from data from USCG International Ice Patrol and the Canadian Ice Service and can also be observed by shipping companies operating in the area.

Icebergs only occasionally are seen in eastern Davis Strait between Nuuk and 67° N as a result of the pattern of dominant currents, the bathymetry, and the distance to calving glaciers. Growlers, bergy bits and a few icebergs usually do not drift out of Godthåb Fjord and could hardly ever affect the Fyllas Banke. The seasonal maximum density of icebergs in this area is normally closely related to the actual distribution of 'Storis'. Thus, under normal conditions, the seasonal maximum occurs from late April until late July. Off the ice edge of the 'Storis', the deterioration of icebergs increases significantly and therefore the seasonal minimum of glacial ice in the Fyllas Banke area normally occurs during the fall months of September to November. Due to the observed westward branching of the West Greenland Current and the bathymetry south of Fyllas Banke, the largest icebergs will probably be observed on the western side of the Fyllas Banke area, but some of these may manage to drift northeast into the deeper waters between Fyllas Banke and Toqqussaq Banke. **[satellite images]**

8.7.3 Icebergs from East Greenland glaciers

Thousands of large icebergs are calved every year from several glacier outlets on the east coast of Greenland. When the icebergs reach open sea they drift southwards in the East Greenland Current, which also contains large amounts of sea ice from the Arctic Ocean most of the year. Even in winter, most of the sea ice from high latitudes melts when it drifts southward off the southeast coast of Greenland. Many icebergs drift off the sea ice edge and melt quickly due to a higher water temperature here and to the wave/swell action. Within the sea ice edge in the cold East Greenland Current, the deterioration of the icebergs is limited. The actual positions of icebergs off Southwest Greenland is to a certain extent controlled by the occurrence and the distribution of multi-year ice 1-2 months earlier. Under normal conditions, sea ice occurs in the Cape Farewell area from early winter until late summer. During spring and early summer, the sea ice sometimes drifts into the

Fyllas Banke area. Therefore, the maximum iceberg density off Southwest Greenland is expected to occur in early and mid-summer. This pattern was indirectly observed in the DHI/GTO study in the late 1970ies (Mangor and Zorn 1983). 'Storis' was observed off the southwest coast of Greenland for several weeks during each of both years' study, however, the sea ice distribution and length of the sea ice season were close to normal conditions.

Large variations in the number and size of icebergs rounding Cape Farewell are to be expected because of the variability of the currents, the amounts of sea ice, and weather conditions. An important factor controlling the iceberg environment off Southwest Greenland is the input of icebergs to the East Greenland Current at high latitudes during summer. It is well known that sea ice is present off the east coast most of the year, although there are large seasonal and inter annual variations, especially during summer. In many cases the occurrence and drift of sea ice controls the movements of icebergs. If the fast ice in fjords with major iceberg sources, e.g. Scoresbysund or Kong Oscar Fjord, does not melt during summer, or if the East Greenland sea ice does not drift off the coast, this will probably reduce the input of icebergs to the East Greenland Current and cause a decrease in the number of icebergs at lower latitudes. However, this phenomenon has not been systematically investigated.

8.7.4 Iceberg dimensions

The characteristics of iceberg masses and dimensions off the Southwest coast of Greenland are poorly investigated, and the following is mainly based on the DHI/GTO study in the late 1970s.

In Eastern Davis Strait the largest icebergs were most frequently found south of 64° N and north of 66° N. South of 64° N, the average mass of an iceberg near the 200 m depth contour varied between 1.4 and 4.1 million tons, with a maximum mass of 8.0 million tons. Average draft was 60-80 m and maximum draft was 138 m. Between 64° N and 66° N, average masses were between 0.3 and 0.7 million tons. The maximum mass was 2.8 million tons. Average draft was 50-70 m and maximum draft is estimated to be 125 m.

The largest icebergs north of 66° N were found north and west of Store Hellefiskebanke. The average iceberg mass was about 2 million tons with a maximum mass of 15 million tons. In Disko Bay, the average masses of icebergs were in the range 5-11 million tons with a maximum recorded mass of 32 million tons. Average draft was 80-125 m and maximum draft was 187 m. It is worth noting that many icebergs are deeply drafted and due to the bathymetry large icebergs will not drift into shallow water regions, e.g. at Fyllas Banke where the water depth in large areas is only about 100 meters. Thus, large icebergs will ground before they drift into many offshore areas in Greenland.

Maximum draft can be evaluated by studying factors which limit the dimension: glacier thickness, topographic factors which cause icebergs to be calved in small pieces, and thresholds in the mouths of the fjords with glaciers. The measurements of iceberg drafts north of 62° N indicate that an upper limit for a draft of 230 m will only be exceeded very rarely, however, no systematic maximum draft measurements exist and the extremes remain unknown. Several submarine cable crushes or breaks have occurred at water depths of about 150-200 meters; the maximum depth recorded was 208 meters, southwest of Cape Farewell. These observations agree with the DHI/GTO conclusions, however, larger drafts of icebergs of East Greenland origin cannot be excluded because observations are sparse. The large icebergs originating in Baffin Bay are expected to have a maximum draft of about 250-300 meters.

A field program, Berg Watch 97, carried out by the Danish Meteorological Institute, Danish Hydraulic Institute and ASIAQ/Greenland Field Investigations documented the presence of very large icebergs in eastern Baffin Bay characterized by a draft of more than 260 meters, or a mass of

up to 90,000,000 tons, or a diameter of more than 1400 meters. Due to the predominant currents in Baffin Bay and Davis Strait, these icebergs will not reach the West Greenland shores south of 68° N. Surveys conducted by the USCG International Ice Patrol and other field studies of icebergs in the East Canadian Waters have improved the knowledge on the iceberg environment in the western Davis Strait and the Labrador Sea. However, the amount of iceberg data relevant for the Eastern Davis Strait are very sparse.