ALASKAN LANDFAST SEA ICE VARIABILITY AND EPISODIC EVENTS

A. Mahoney, H. Eicken and L. Shapiro

Geophysical Institute, University of Alaska Fairbanks, PO Box 757320, Fairbanks, Alaska, 99775 USA

Interest in the fast-ice regime of the Alaskan coast was prompted by the needs of coastal oil development, coincident with an increasing interest in the ice cover of the Polar Regions as a component of the climate system. In recent years, offshore development has forged ahead with an increased economic commitment, while concerns are rising both locally and globally about the response of the coastal ice to recent climate trends.

Of particular interest from the perspective of coastal processes are the duration of the landfast sea ice season and the occurrences of episodic events such as ice-shoves (referred to as an "ivu" by the local Iñupiat Eskimo) and break-out events, where the landfast ice becomes detached (See Figs. 1 and 2). Ice shoves are capable of considerable damage to property and infrastructure and are also able to rework beach material and deposit it beyond the reach of waves. This is thought to be the dominant depositional mechanism on some barrier islands (Reimnitz et al. 1990). The presence of open water and drifting floes in the nearshore zone, following an ice breakout event, presents an opportunity for considerable sediment working at a time of year when such processes are normally considered inactive.

Typically, the start of the landfast ice year is marked by in-situ formation of ice in sheltered regions of the coast. Ice typically forms later on exposed coastlines through the advection of ice from offshore. The landfast ice may go through several periods of detachment and reformation before it stabilizes around the middle of winter. The onset of spring sees melt ponds forming on the ice cover and flooding by rivers, where present. As melt progress the ice cover becomes weaker and floating in places where it may previously have been

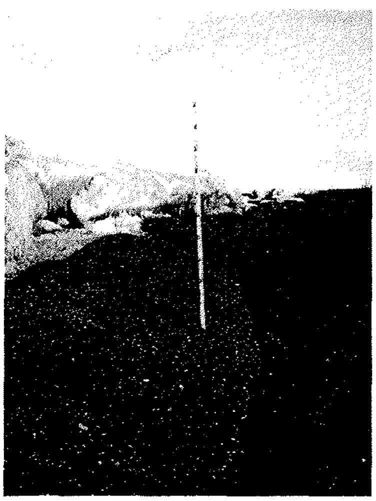

Figure 1. Berm of beach material pushed up in front of advancing ice during an ice shove on June 18 2001 at Barrow, Alaska.

Figure 2. Radarsat scene showing an ~20 km section of landfast ice broken away from the coast near Barrow, Alaska in mid-December 2001.

grounded. On exposed coasts the ice is then removed by offshore wind and current forces, while in sheltered regions, the ice may melt in-situ. Periodic events may affect the landfast ice during this development, sometimes with lasting consequences for the ice cover such as is discussed later.

In this study we examine over 305 AVHRR scenes and field data from 1998 to 2001 describing the development of the landfast ice in the Alaskan Arctic from formation in the fall through to melting and break-up in the spring. Key events were identified and compared with the previous studies made in the 1970's (Barry et al. 1979; Shapiro and Metzner 1989). The methods used to identify events in the earlier studies are not the same as those used here and so the nomenclature for the events is not identical.

Recent reports suggest the ice-year in the Arctic is shortening, but the three years forming this study suggest that this is not necessarily the case. Rather, the timing of events within the ice-year have changed and the landfast ice experiences a shorter stable period, while the overall length of time landfast ice is present remains much the same (see Fig. 3).

The most marked difference is in the stabilization of the ice cover. The mean date of stabilization of the landfast ice in winter, after which little or no further deformation takes until spring, was approximately two weeks earlier in Barrow and one week earlier along the central Alaskan Chukchi coast. The fast ice of the Beaufort Sea apparently stabilizes earlier, but it is felt this may be due to misidentification of landfast ice in AVHRR imagery and further field data is required in this region. The dates of "freeze-up" and the events in the latter part of the landfast ice year appears notably unchanged

Examination of the interannual variability of events in the 1998-2001 period suggests that dynamic (rather than thermodynamic) processes may be responsible for the observed changes. Fig. 4 shows the range of dates of occurrence of each event relative to its mean. It is clear that the events with the greatest date range are those that are governed by predominantly dynamic processes such as stabilization and river break-up. The least variability is observed in those events dominated by thermodynamic processes such as ice formation in sheltered regions and the appearance of melt ponds.

Although only three years of data are presented here, the events of the 2001-2002 ice year support these observations. These data have not been included, partly because they are not completely analyzed yet, but also because of the difficulty of fitting them into the scheme of the current data. In Barrow, the landfast ice saw no stable period with two wintertime breakouts in December (Fig. 2) and March. Whether these changes in the landfast ice evolution are an ongoing trend or part of a natural oscillation within the Arctic is unclear, but nevertheless there are immediate implications. The time during which the sea ice is suitable for traveling on is shortened, yet the hindrance to shipping is not lessened.

Furthermore, the susceptibility of the landfast ice to episodic events is likely to be higher. The current and previous two ice years have seen an apparently unprecedented number of ice breakout events. In June 2001, the ice was pushed on-shore over a length of at least 20 km during an ivu event. Based on aerial photography, remote sensing and ground observations we examine the extent and variability of the shove as well as large scaling forcing. It comes to light that the thermal regime of the ice was fundamental in governing its response to onshore stress and such events may become more common if unstable ice conditions become more prolonged.

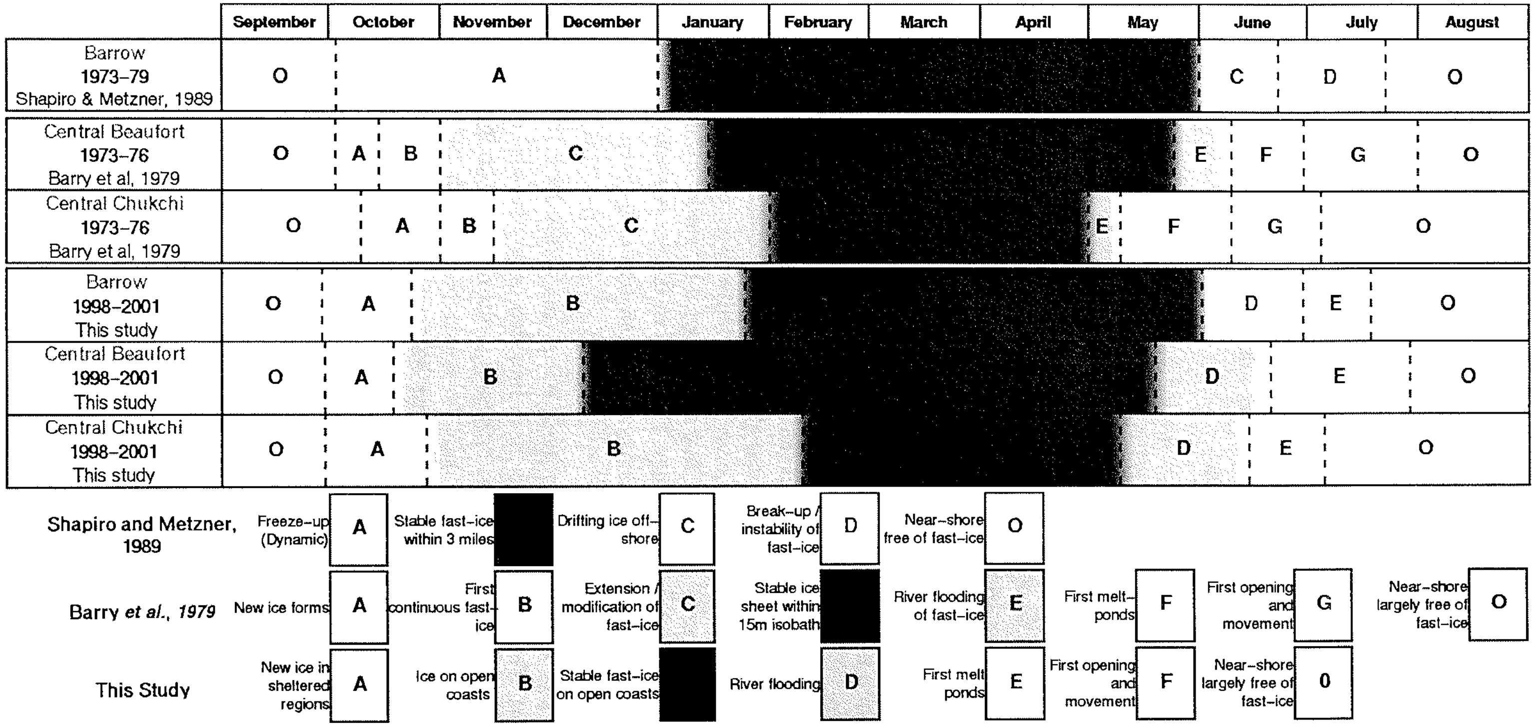

Figure 3. Comparison of recent observations of the timing of events within the landfast ice year along the Alaskan Arctic coast with those of approximately 25 years ago. The beginning and end of the ice year on all parts of the coast are show remarkably little difference. However, the duration of the stable period shows a significant reduction at Barrow and on the central Chukchi coast. The difference on the central Beaufort coast is thought to stem from difficulty identifying landfast ice from satellite imagery.

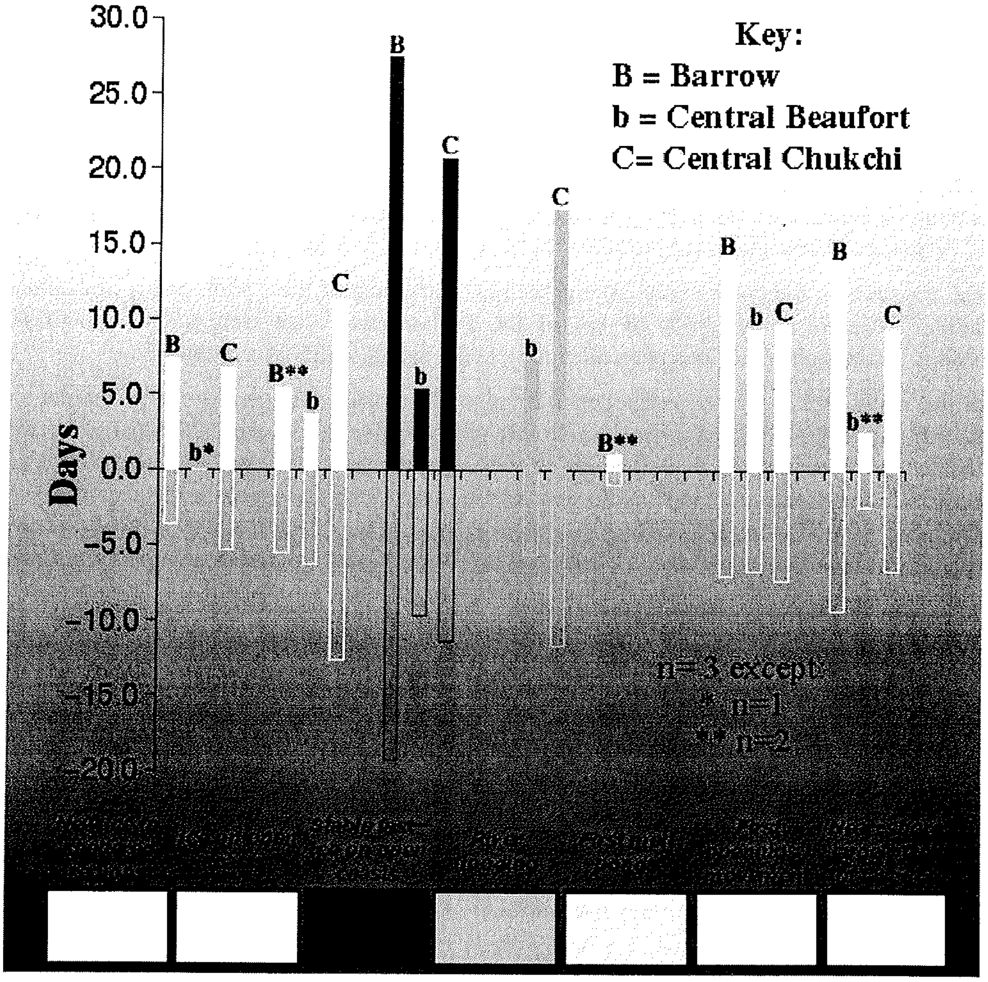

Figure 4. Earliest and latest occurrences of events within the landfast ice year relative to the mean date of their occurrence.