Extreme ice-scouring processes on the Canadian Beaufort Shelf caused by sea-ice pressure ridge keels

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Knowledge of the processes of seabed scouring by pressure ridge keels and the spatial and temporal distribution of extreme scour events is required to protect Arctic subsea pipelines and well heads from damage by ice keels. The seabed is saturated with ice scours that range in age from new to several hundred years old. Annual repetitive mapping of the same sectors of the Beaufort seabed with traditional digital sidescan sonar, echo sounder and subbottom profiler allows for the identification of new ice scouring events against a seabed populated by relict scours. Such surveys during the 70s and 80s resulted in the generation of a digital database of new scour events and the identification of extreme scours as those events equal to or greater than 2 metres in depth below the seabed. Insufficient numbers of extreme events were mapped to generate a database statistically adequate for regulatory guidelines or engineering design requirements. After an 11 year hiatus, repetitive mapping was resumed in 2001 using both the traditional survey equipment and new multibeam technology.

From a database of 8560 new events generated between 1979 and 2004, only 188 new extreme events have been mapped. Depths range from 2 to 5 metres, widths vary from only a few meters to 444 metres for multikeeled scours and the orientation of these scours is dominantly NW-SE. These extreme events occur in water depths ranging from 13 to 39 metres across the Beaufort Shelf. In addition, extreme ice keels have also been identified generating ice scours in water depths of 25 to 55 metres – the limiting water depth for ice scouring by the present day sea-ice regime. The spatial distribution of extreme events across the shelf is primarily controled by water depth, geographic location and sediment strength properties. The ice scouring process is complex. Along track, ice scours are observed to increase in depth, rise-up, drop-down and run at constant depth.

Due to limited numbers, the impact rates of extreme events across the shelf are poorly known and the return periods of extreme events over a 100 year time frame have yet to be determined. The impact of ameliorating climate conditions on the recurrence rate of extreme events over the next few decades is also poorly constrained because of the wide range of predictions for sea-ice distribution.