# ICEBERG SCOUR DATA MAPS FOR THE GRAND BANKS OF NEWFOUNDLAND BETWEEN 46°N and 48°N

S.J. d'Apollonia* and C.F.M. Lewis

Atlantic Geoscience Centre
Geological Survey of Canada
Bedford Institute of Oceanography
Dartmouth, N.S.

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## INTRODUCTION

Iceberg scourings on the eastern Canadian continental shelves cause deformation of sediments and produces a wide range of geomorphic features that range from barely detectable 'brushings' of the seafloor to discontinuous craters or pit-like depressions and continuous furrows, in places over 10 km in length, up to 200 m in width and in some instances over 10 m in depth. These iceberg scours appear to have accumulated on the seabed over a considerable period of late glacial and post-glacial time. Present research efforts are being directed at methods of characterizing the ice scour features, understanding the ice scouring process and of estimating scour ages to assess the present rate of ice groundings in specific areas. This information is essential for meaningful risk analysis of the iceberg scouring hazard in connection with the design, construction and regulation of offshore seabed oil and gas production and transportation facilities.

As part of the research into the nature and effects of iceberg groundings, a computerized data base has been developed under contract at the Atlantic Geoscience Centre, Geological Survey of Canada, to facilitate the organization and analysis of measured iceberg scour parameters. Because of the high level of interest in the ice scouring problem regarding planning and development of the Hibernia oil discovery on the northeast Grand Bank of Newfoundland, these measurements are being released now in advance. The maps in this open file show posted values from the ice scour data base for the northern Grand Banks region between 46°N and 48°N, and 46°W to 54°W at a scale of 1:250,000.

Four maps of the northeast Grand Banks (Fig. 1) between 46°N and 48°N and 46°W and 50°W are compiled showing values of maximum scour depth, maximum scour width, per cent seabed disturbance and scour occurrences $Km^{-2}$

respectively. The same parameters are shown in a similar set of four maps for the northwest Grand Banks (Fig. 1) between 46°N and 48°N and 50°W and 54°W. It is expected that future editions of these maps will incorporate additional data currently under analysis.

## Survey Techniques and Methods of Analysis

The data is based on 1760 km of concurrent high resolution seismic reflection profiles and sidescan sonograms collected during research cruises in the area between 1977 and 1980. The survey dates and ships' speeds together with the distribution of areas analyzed for each cruise are given in Table 1. The iceberg scour parameters were analyzed for each ten minutes of trackline (approximately 2 Km). The sample areas vary slightly due to minor fluctuations in ship speed. For example, the mean and standard deviiation for all sample lengths are 1863 $\pm$ 354 m.

The Huntec Deep Towed high resolution Seismic System (Huntec DTS) (McKeown, 1975 and Hutchins et al. 1976) which utilizes a wide frequency bandwith (0.5 to 10 kHz), submerged boomer source and quantitative signal processing, provided precise heave-compensated profiles of seabed relief. For the C.S.S. Hudson cruises (Table 1) the BIO dual channel sidescan sonarsystem was used (Jollymore, 1974). This system was operated with a 70 KHz pulse firing once per second for a slant range of 750 m. Data from the Mobil/C-CORE Cruise is based on an O.R.E. dual channel sidescan sonar system operated with 97 kHz pulses firing each ½ sec. for a slant range of 375 m. The ice scour measurements were digitized, corrected for scale distortion and normalized where applicable. The values were then posted and plotted by computer on an Xynetics flatbed plotter at the same scale as the

bathymetric maps of the published Natural Resources map series. The bathymetric maps were superimposed on the corresponding iceberg scour data maps and the combination photomechanically reproduced as single composite sheets.

## ICE SCOUR PARAMETERS

The ice scour parameters were selected to document regional variability and extreme characteristics of seabed ice scours. These parameters are described and defined below.

### 1. Maximum Scour Depth

The maximum scour depth is measured vertically below the projected (from undisturbed adjacent seabed) original seabed to the deepest point in the deepest depression (Fig. 2) of all scours crossing the ship's track in each sample area. This measurement is taken from the Huntec DTS data and because of this system's capability of removing the effects of wave-and ship-induced motion it is possible to resolve differences in depth to 0.5 m routinely and to 0.2 m occasionally for areas with a smooth seabed. The effects of acoustic side echoes on the scour depths were taken into account. The measurements assume a sound velocity in sea water of 1500 m/sec. The maximum depth values are posted in metres. Zero values (0.0) indicate areas that show either the presence of scours without measureable depressions or the complete absence of scours. The maximum depth values for northeast Grand Bank is 2.5 m and 9.0 m for northwest Grand Bank.

## 2. Maximum Scour Width

The maximum scour width is measured between embankments (crest to crest) of the widest visible scour in each sample area (Fig. 2). This measurement, in metres, is taken from the sidescan records and is corrected for image distortion arising from differences in the cross-track and along-track scales. Although a given interval on the sidescan record can be read accurately to within 2 to 5 m for the cross-track and along-track directions the uncertainty in estimating true scour width may be several metres more due to difficulties in discerning the actual boundaries (which can be gradational) between scour trench and embankment. As is the case for scour depth, the width measurements are based on an assumed sound velocity of 1500 m/sec in sea water. Generally the width values are all finite. Posted zero (0.0) values indicate sample areas showing no evidence of ice scours. Maximum scour widths range up to 124 m for northeast Grand Bank and to 188 m for northwest Grand Bank.

## 3. Per Cent Seabed Disturbance

This parameter is a visual estimate of the percentage of each sample area that appears to have been disturbed by iceberg impacts. The disturbed area includes all discernible scours with their embankments, and all discernible crater or pit depressions attributed to iceberg groundings. These estimates are made from sidescan records by comparison with diagrams of known percentage disturbance. The estimated accuracy is listed below:

| Per Cent Seabed Disturbance | Estimated Accuracy |
|---|---|
| 0-10, 90 - 100 | ± 2% |
| 10-20, 80 - 90 | ± 5% |
| 20-30, 70 - 80 | ± 10% |
| 30 - 70 | ± 20% |

The per cent seabed disturbance values range to 17% in northeast Grand Bank and to 95% in northwest Grand Bank.

## 4. Scour Occurrences per Square Kilometre

This parameter represents the number of independent ice scour events counted on the sidescan record for each sample area. The count is normalized to one square kilometre by dividing the number of scour occurrences by the area of each sample. This parameter, as for per cent seabed disturbance, is sensitive to the resolution threshold of the survey sidescan sonar and may be somewhat underestimated by undetected small-scale features. Nonetheless the parameter mapped is considered a worthwhile indicator of minimum concentration and relative variability of seabed ice scours. The number of occurrences ranges up to 8 $km^{-2}$ for the shallower portions of Grand Bank above the 100 m isobath. In deeper water the scour occurrences per square kilometre are generally higher ranging up to 55 $km^{-2}$.

## Qualifying Remarks

No attempt is made to interpret the values presented. Users of the data would be wise to keep several points in mind if they wish to

generalize or draw conlusions form the information.

1. No distinction is made regarding the age of ice scours as definitive dating criteria are not yet available. Thus the posted values refer to the complete seabed record of ice scouring as it is presently known without regard to time. According to Fader and King (1981) and to Lewis and Barrie (1981) it is possible that the total scour population is composed of a deep water, older, late glacial set and a shallower water, younger, post glacial set.

2. The transport potential for sediments under the influence of waves, currents and bioturbation is yet to be evaluated. However, some bedforms indicating transport are known to exist (Fader and King 1981, Amos and Barrie 1980, Lewis and Barrie 1981) and therefore some modification of ice scours, even obliteration, by erosional and depositional processes may have occurred in areas susceptible to resuspension and transport.

3. Fader and King (1981) have described areas on the northwestern Grand Banks which appear on sidescan sonograms as sublinear patterns resembling discontinuous iceberg scour berms. These features have been interpreted as partially buried iceberg furrows, and cover extensive areas of the northwestern Grand Banks in water depths greater than 125 metres. Because individual iceberg scours are not clearly defined or delineated within these patterns, they are not included in the present compilation. However, clearly-defined scours which are superimposed on the partially buried furrows are included in the present compilation.

4. The posted values are part of a broad regional overview and do not include ice scours discovered in detailed surveys within the Hibernia area,

for example. See Lewis and Barrie, 1981, for discussion of these data.

5. The interpretation of sidescan imagery and the recognition of samll ice-formed features is somewhat subjective being dependent on the vagaries of acoustic backscatter from sediment textural changes and seabed relief. For this reason only clearly-defined ice scours have been evaluated and poorly-defined features may have gone undetected leading to the possibility that the 'seabed disturbance' and 'scour ocurrences' parameters may be somewhat underestimated. On the other hand the maximum scour width and depth parameters are probably well-resolved.

## COMPILATION RESPONSIBILITIES AND ACKNOWLEDGEMENTS

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Research Cruises and Distribution of Ice Scour Parameters

Table 1

| Cruise | Ship | Dates | Average (Kts) Survey Speed | NUMBER OF AREAS ANALYZED FOR: Maximum Scour Depth | Maximum Scour Width | Per Cent Seabed Disturbance | No. Scour Occurrences $Km^{-2}$ |
|---|---|---|---|---|---|---|---|
| BIO 77-011 | C.S.S. Hudson | May/77 | 5.8 ± 0.7 | 81 | 83 | 85 | 85 |
| BIO 78-023 | C.S.S. Hudson | July/78 | 6.0 ± 0.5 | 20 | 20 | 20 | 20 |
| BIO 80-010 | C.S.S. Hudson | May/80 | 5.8 ± 1.0 | 577 | 656 | 693 | 693 |
| Mobil-C-CORE | Polaris V | Oct/80 | -- | 0 | 124 | 136 | 136 |

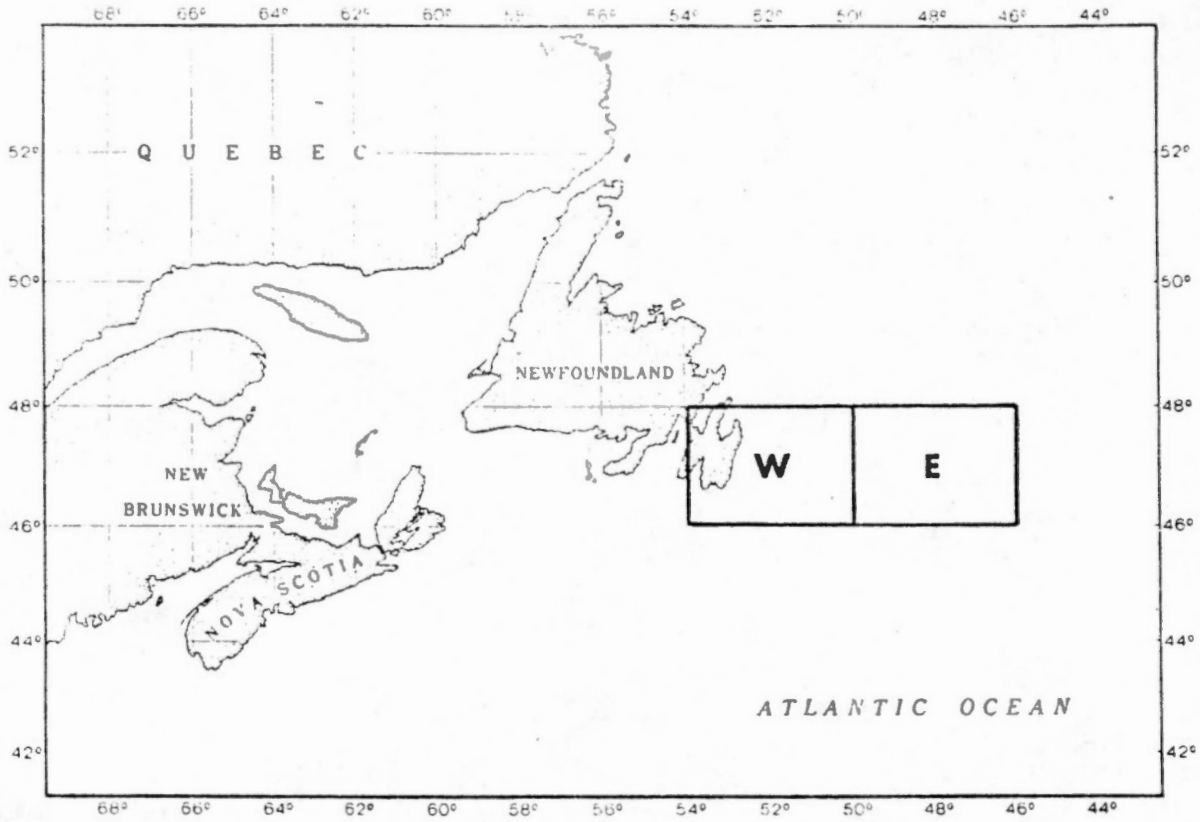


Fig. 1 Index map showing area covered by iceberg scour data maps for the northwestern Grand Bank (W) and the northeastern Grand Bank (E).

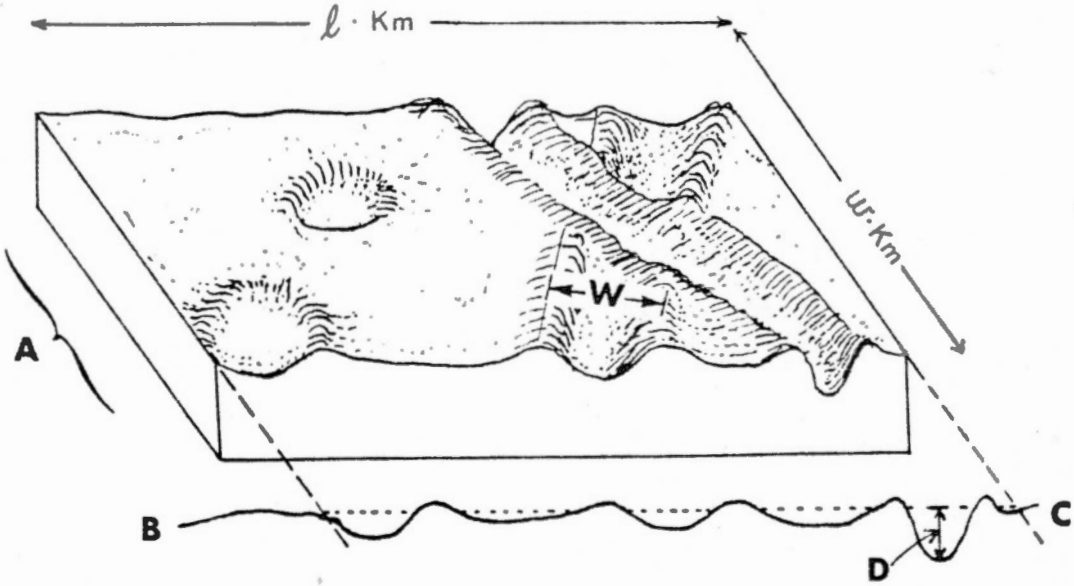


Fig. 2. Diagramatic definition for sidescan sample area A and concurrent seabed profile on trackline B-C. Two iceberg furrows and two iceberg craters (pits) are illustrated. D is the maximum depth and W the maximum width for all scours in the sample area. The width W is measured normal to the trend of the widest scour. The estimated areal seabed disturbance is 40% + 10% and the number of scour occurrences is 4 in this example. The normalized occurrence parameter would be $4/\ell.\omega$.