COOPERATIVE PREPARATIONS FOR DETERMINING THE OUTER LIMIT OF THE JURIDICAL CONTINENTAL SHELF IN THE ARCTIC OCEAN: A Model for Regional Collaboration in Other Parts of the World?

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INTRODUCTION

With a semi-enclosed configuration that is bounded by several coastal States, the Arctic Ocean represents an amalgam of the circumstances and issues that pertain to the definition of the outer limit of the continental shelf in other parts of the world ocean. This article reviews the Arctic situation in that context, and describes how the affected coastal States are taking collective action to deal with the challenges and opportunities that are presented to them by Article 76 of the UN Convention on the Law of the Sea (UNCLOS).

THE CONTINENTAL SHELF SCENARIO IN THE ARCTIC OCEAN

The Arctic Ocean represents an amalgam of the circumstances and issues that pertain to the definition of the outer limit of the continental shelf in other parts of the world ocean.

The Arctic Ocean is completely encircled by the combined exclusive economic zones (EEZs) of five coastal states: Canada, Denmark (Greenland), Norway, Russia, and the USA (Figure 1). The margin of each State features one or more natural prolongations of its land territory, with continental affinities that provide grounds for establishing jurisdiction over resources of the seabed beyond 200 nautical miles (nm), according to the provisions of Article 76. In clockwise order around the Arctic Ocean, these prolongations are: the Chukchi Borderlands, the Mendeleev Ridge, the Siberian extremity of the Lomonosov Ridge, the Yermak Plateau, the Morris Jesup Plateau, the North American extremity of the Lomonosov Ridge, and the Alpha Ridge (Figure 1).

The Lomonosov Ridge is considered to be a sliver of continental material that was once attached to the continental margin of Scandinavia and northwestern Russia, and which became separated from it through sea floor spreading. This Ridge now divides the Arctic Ocean into two major basins – the Eurasian Basin in the east, and the Amerasian Basin in the West. The latter Basin is further bifurcated by the Mendeleev and Alpha Ridges, which are actually the extremities of a broad, continuous elevation that links the continental margins of Siberia and North America respectively. Not included in the above inventory of prolongations is the Gakkel or Arctic Mid-Ocean Ridge, which extends from the margin of Greenland to Siberia, but which has an oceanic structure by virtue of its mechanism of formation, i.e. sea floor spreading.

ISSUES THAT COULD AFFECT THE DETERMINATION OF OUTER LIMITS IN THE ARCTIC OCEAN

Several regional issues could affect the timing and the process for determining the outer limits of the continental shelves of the Arctic coastal States. A significant factor is the prospect for contention caused by overlapping continental shelf claims beyond 200nm, between adjacent and/or opposite States. Given that the resolution of bilateral boundary disputes is not within the purview of the UN Commission on the Limits of the Continental Shelf (CLCS), this suggests that coastal States may find it beneficial to develop an understanding among themselves concerning bilateral delimitations, prior to depositing their submissions with the Commission.

From a procedural perspective, another important factor is the non-uniform status of the Arctic coastal States with respect to UNCLOS: only Norway and Russia have ratified the Convention, and in fact they appear to have made significant progress in the tasks associated with the delimitation of their continental shelves. Having yet to ratify UNCLOS, the three remaining States – Canada, Denmark and the USA – are at

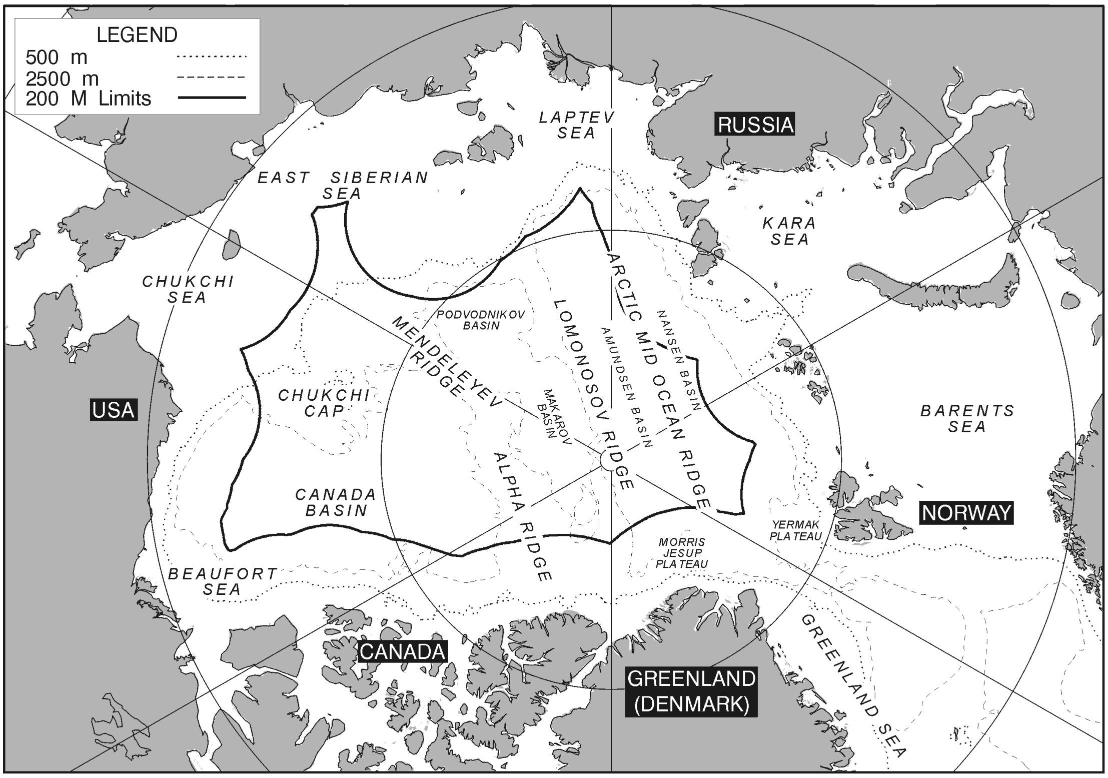

Figure1. Coastal States that surround the Arctic Ocean, their joint EEZs, and the natural prolongations of their land territories: Chukchi Cap, Mendeleev-Alpha Ridges, Lomonosov Ridge, Morris Jesup Plateau, and Yermak Plateau (adapted from Macnab *et al*, 1996).

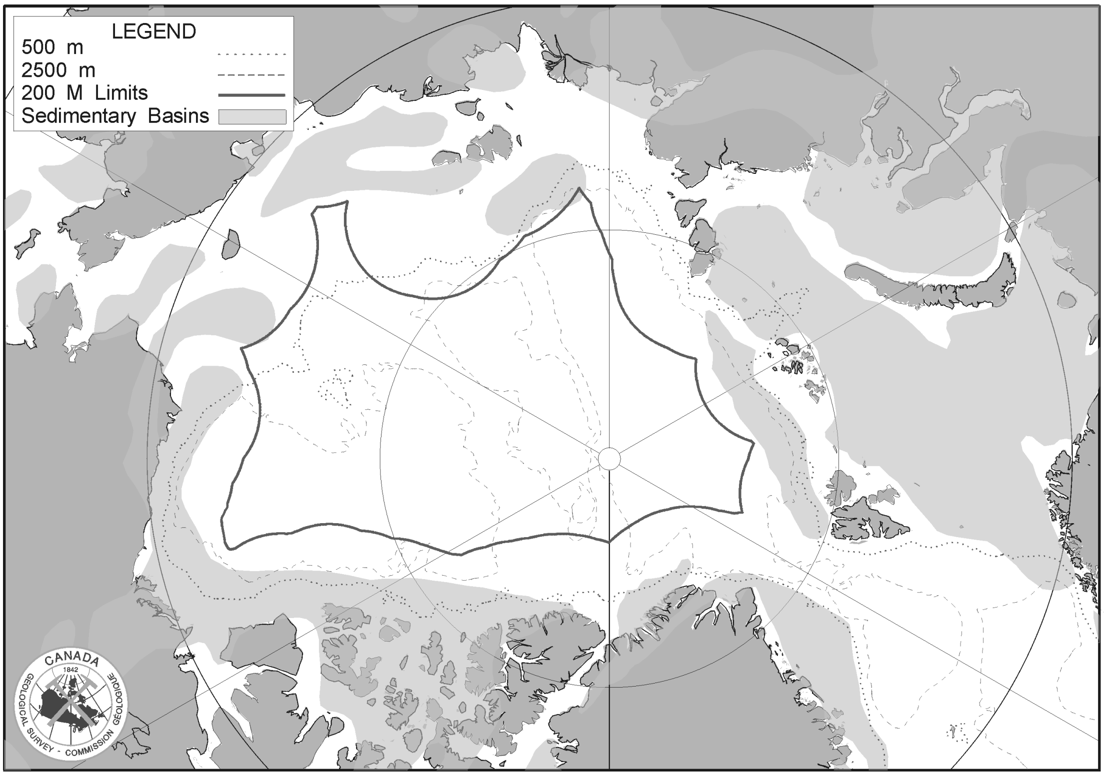

Figure 2. Sedimentary basins of the Arctic Ocean, suggesting that gas and oil reservoirs may be located for the most part within the combined EEZs of the Arctic Coastal States (adapted from Greene and Kaplan, 1987).

different levels of readiness. Hence the preparatory efforts for individual continental shelf submissions seem destined to follow different timetables.

Alternative approaches for describing bathymetry and sediment thickness in this region may be necessary.

Significant portions of the Arctic Ocean are inadequately mapped, particularly those that lie beneath the year-round polar ice pack. Some States dispose of more Arctic data than others; however not all the information that exists is available in the public domain, and of the data sets that are in open circulation, many are only marginally suitable for Article 76 purposes. Acquiring new data in the Arctic can be a difficult and expensive undertaking, under operating conditions that preclude techniques and instrumentation that are used routinely in other parts of the world ocean. Alternative approaches for describing bathymetry and sediment thickness in this region may therefore be necessary.

Interpretive styles and criteria may vary among States and investigators, resulting in incompatible procedures and findings, particularly in areas where subjective judgements might be called into play, e.g. locating the foot of the slope, or determining the points that define the Gardiner line, where the thickness of sedimentary material is equal to 1% of the distance back to the foot of the slope.

Prospects for resources on and beneath the deep Arctic seabed are not well known.

Prospects for resources on and beneath the deep Arctic seabed are not well known. Published studies have analysed the distribution of sedimentary basins that might bear hydrocarbons, but in the current state of knowledge, these appear to be totally restricted to the EEZs of the coastal States (Figure 2), and hence not subject to the extended jurisdiction conferred by Article 76. On the other hand, an extrapolation of conditions in other regions (Max and Lowrie, 1993) suggests that significant portions of the deep Arctic basin might harbour gas hydrates or frozen methane (Figure 3). If and when suitable technology is developed for their extraction, these may contribute significantly to the coastal States' energy budgets.

Living resources of the deep Arctic seabed – referred to in UNCLOS as sedentary species – have not been catalogued exhaustively. With deep areas lying generally beyond the limits of conventional fisheries operations and research, the varieties and quantities of food stocks have not been properly assessed – this situation prevails in other oceanic regions as well. Non-food resources such as pharmaceuticals and DNA material might also be extracted from certain life forms that develop and flourish under the Arctic's unique environmental conditions (low temperatures, alternating seasons of light and darkness, and diminished ocean-atmosphere exchanges on account of permanent ice cover).

Some of the issues outlined above could apply equally well to other regions where extended continental shelves may need to be partitioned among two or more coastal States. These regions include the Bering Sea and the West Pacific Ocean margin, Southeast Asia and Oceania, the Bay of Bengal, the Arabian Sea and the East African margin, the Atlantic Ocean margins and the Gulf of Mexico, and the West Central American margin.

RESPONSES OF THE ARCTIC COASTAL STATES, AT THE TECHNICAL LEVEL

In the interest of achieving a harmonious and consistent determination of outer continental shelf limits in the Arctic Ocean, investigators from the five coastal States have adopted an informal strategy for dealing with those issues above that fall within the realm of their technical competence. Inherent in this strategy is the understanding that any collaboration will concentrate exclusively on the technical aspects of determining outer limits only, with no consideration being given to the construction of bilateral limits; the latter issue is best handled at the political and diplomatic level.

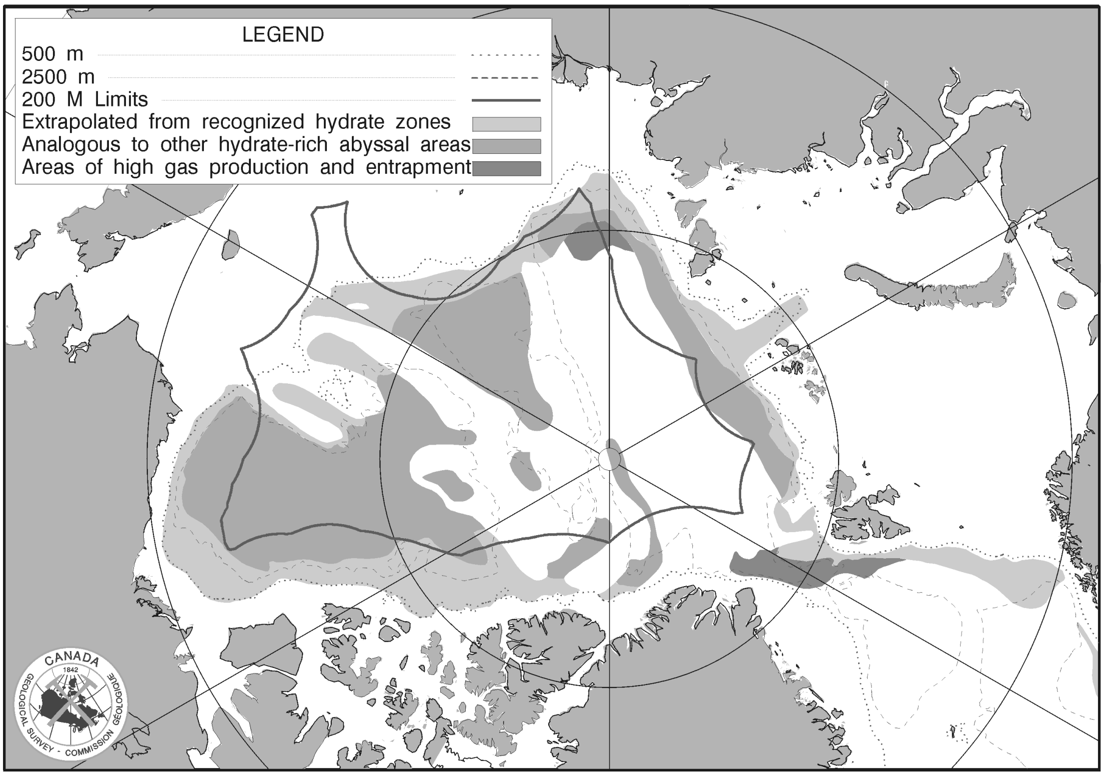

Figure 3. Projected concentrations of gas hydrates in the Arctic Ocean basin, showing them for the most part to be outside of the combined EEZs of the Arctic Coastal States (adapted from Max and Lowrie, 1990).

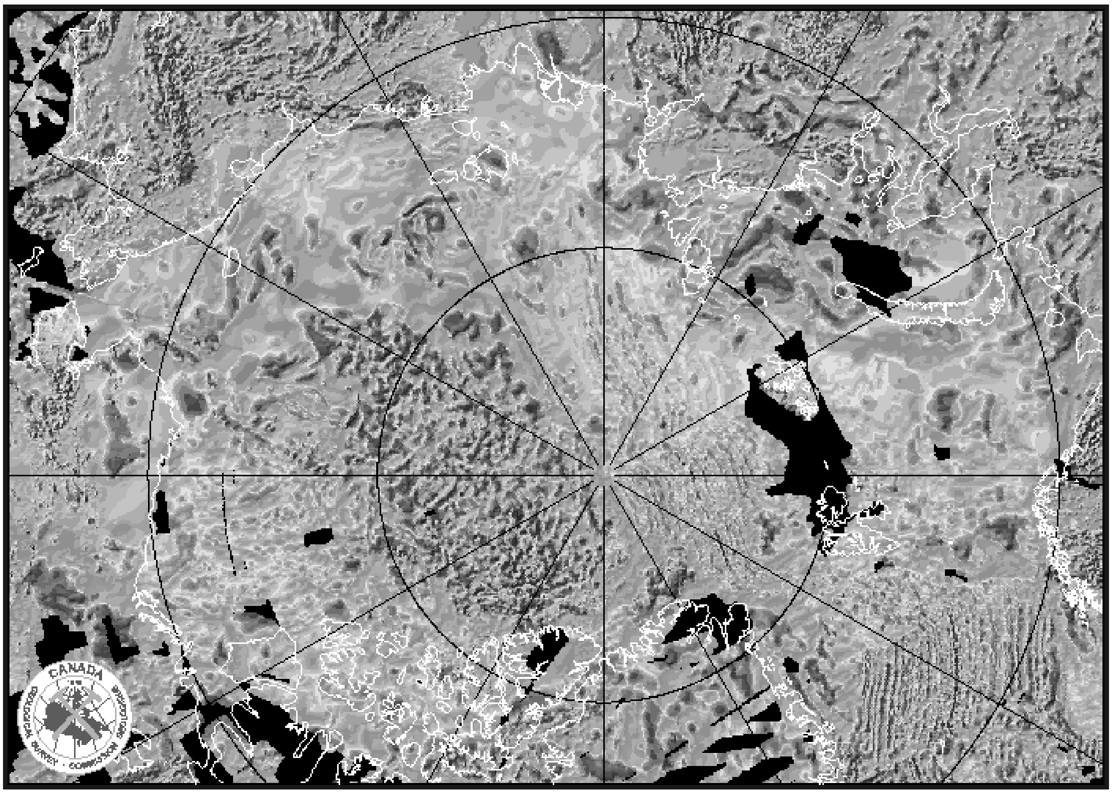

Figure 4. The magnetic field of the North Polar Region, constructed by Verhoef *et al* (1996) from a compilation of (mostly) airborne observations. In conjunction with other geophysical parameters, this information may provide "*evidence to the contrary*" for determining the location of the foot of the slope.

***…collaboration has resulted in the development of a new regional bathymetric data model…which provides a much improved description of the depth and morphology of the seabed north of 64ºN*.**

Accordingly, investigators from the five coastal States have met regularly since 1996 to discuss the coordination of scientific and technical procedures involved in the implementation of Article 76, and to develop a common understanding of the factors peculiar to the Arctic Ocean that impact upon those procedures, e.g. the identification and classification of natural prolongations, the criteria for locating the foot of the slope and the Gardiner line, etc. To the limit of practicability, the investigators have also agreed to construct common models of bathymetry and sediment thickness, so that inconsistencies between their respective results are caused by varying methods of interpretation, and not by incompatibilities between data holdings.

To date, this collaboration has resulted in the development of a new regional bathymetric data model that replaces a widely-used, but obsolete, chart, and which provides a much improved description of the depth and morphology of the seabed north of 64ºN. Bearing the rubric International Bathymetric Chart of the Arctic Ocean (IBCAO), the model consists essentially of a 2.5km by 2.5km grid, constructed by an international team from data sets that were provided by 14 agencies in 10 countries (Jakobsson *et al*., 2000). This activity lasted from 1997 to 2000, and was endorsed by the International Arctic Science Committee (IASC), the Intergovernmental Oceanographic Commission (IOC), and the International Hydrographic Office (IHO). Final products have been released in print and digital form, the latter being freely available for downloading from the project's public website(www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html).

A second international initiative is proposed to begin in 2001, for the purpose of constructing a new database and Map of Arctic Sediment Thickness (MAST). This activity has been sanctioned by IASC, and endorsement will be sought from other international organisations. In the meantime, an international team operating under Russian leadership is engaged in project planning, concentrating initially on the identification of suitable data sets. It has been determined that Russian data holdings will likely comprise the major component of the new map and data base, reflecting that State's extensive mapping activities in the Arctic between the 1960s and the 1990s. In an arrangement similar to that for IBCAO, it is envisaged that final products will be issued in printed and digital form.

An informal objective of the collaborative activities outlined above is to foster among the five coastal States a common perspective of their combined outer continental shelf limits.

Other international initiatives have resulted, or will result, in the development of related geophysical data bases and maps that could provide *"evidence to the contrary"* when locating the foot of the slope. In 1996, the Geological Survey of Canada released a map and a digital grid (Figure 4) that incorporated data provided by over 40 organisations in 15 countries to describe the magnetic field of the region north of 64ºN (Verhoef *et al*., 1996). Currently, a cooperative effort between Russian and US investigators is incorporating new aeromagnetic data with a view to upgrading this description. In the meantime, an analogous operation is underway (Kenyon and Forsberg, 2000) to develop a map and a digital grid that will describe the gravity field over the same region (Figure 5). This initiative is being handled by an international team operating under the auspices of the International Association for Geodesy (IAG); circumstances permitting, a target date of 2001 has been proposed for the release of the map and grid.

An informal objective of the collaborative activities outlined above is to foster among the five coastal States a common perspective of their combined outer continental shelf limits. Working independently or in collaboration with its neighbours, each State would develop an outer limit that fronted upon its own coast, endeavouring in the process to create a seamless blend with the limits constructed by adjacent States.

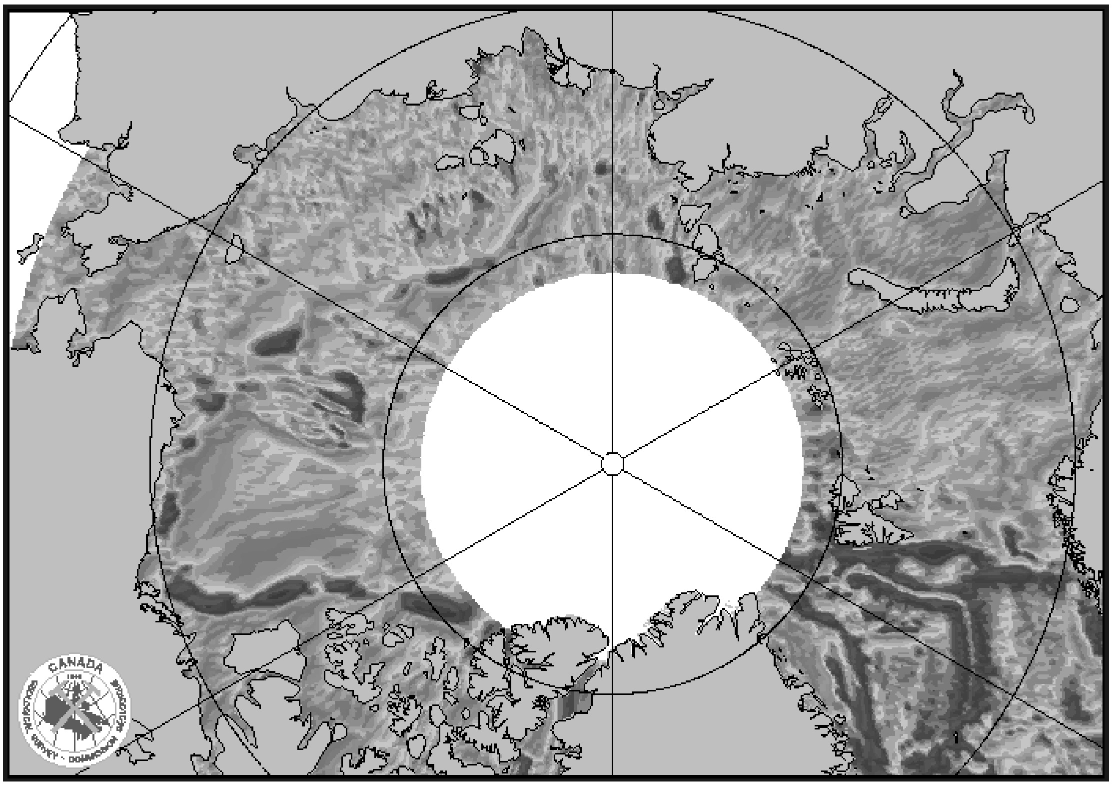

Figure 5. The gravity field of the North Polar Region, derived by Laxon and McAdoo (1994) from measurements of oceanic altimetry from the ERS-1 satellite. The data gap in the centre is caused by the inclined orbital plane of the satellite, which never passes over the North Pole. In conjunction with other geophysical parameters, this information may provide "*evidence to the contrary*" for determining the location of the foot of the slope.

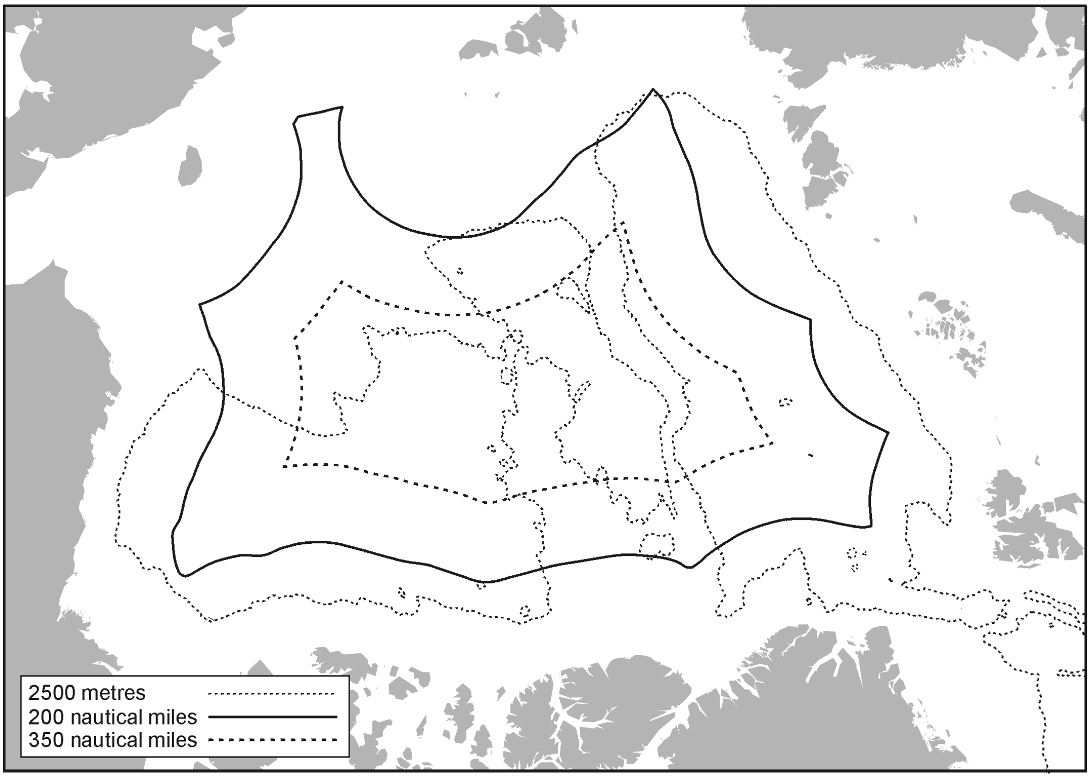

Figure 6. 200 and 350 mile limits in the Arctic Ocean. The former delineates the outer limit of the combined EEZs of the Arctic Coastal States, while the latter is a *cutoff limit* prescribed by Article 76.

CONSTRUCTION OF HYPOTHETICAL OUTER LIMITS OVER THE ENTIRE ARCTIC OCEAN

Using publicly-available information, a study was undertaken to develop a preliminary appraisal of the regional situation with respect to delimitation of the continental shelf. The results of this work do not represent the official view of any coastal State, or even necessarily the final views of its authors. The investigation was performed for academic interest and illustrative purposes only, in the expectation that its outcome would provoke discussion among implementors of Article 76, which in turn might help resolve some of the misconceptions and ambiguities that can occur when applying the provisions of the Article.

Public information that was used in this investigation included the World Vector Shoreline (WVS), the IBCAO bathymetric grid (described above), and a 5' by 5' grid of sediment thickness that was derived from a 1º by 1º world grid constructed by Laske and Masters (1997), using information extracted from the Arctic sediment map of Jackson and Oakey (1986). Basepoints needed for the construction of 200 and 350nm limits were taken from a study by Macnab and Carrera (1996). All of this information was imported into the CARIS LOTS software package for continental shelf delimitation (van de Poll *et al*., 2000), which was used to perform all the operations described in the following paragraphs.

The first operation entailed the construction of the 200 and 350nm limits, which consisted of two sets of circular arcs centred upon the basepoints of Macnab and Carrera (1996) (Figure 6). The 200nm limit illustrates the extent of the combined EEZs of the five Coastal States, while the 350nm limit is a *cutoff limit* specified in Article 76. This procedure was followed by the extraction of the 2,500m isobath, and its projection seaward by 100nm (Figure 7). The line so projected is another *cutoff limit* specified in Article 76.

Next, the location of the foot of the slope was determined throughout the study area by picking a series of profiles in the Eurasian and Amerasian Basins, and by identifying on each profile the point(s) of maximum change in the gradient of the seabed. The lines defined by these points were then projected seaward by 60nm (Figure 8), to realise the *distance formula* specified in Article 76.

…the combined continental shelves of the five coastal States occupy most of the Arctic Ocean, except for two distinct 'donut holes.'

An analogous procedure was used to select a series of profiles in the same three basins with a view to applying the *sediment thickness formula*, but in this situation only the Eurasian profiles described sedimentary wedges that thinned to 1% of the distance back to the foot of the slope, thereby defining a Gardiner line that enclosed the Gakkel Ridge. In contrast, none of the sedimentary wedges portrayed in the Amerasian profiles thinned to 1% beneath the deep parts of the Basin, i.e. for each profile, the substantial thickness of sediment forced the Gardiner line to a location in shallower water, on the opposite side of the Basin (Figure 9).

A straightforward combination of the above-derived formula lines and cutoff limits according to the prescriptions of Article 76 demonstrates that the combined continental shelves of the five coastal States occupy most of the Arctic Ocean, except for two distinct 'donut holes' (Figure 10). The first is a small, trapezoidal zone in the Mendeleev Abyssal Plain that is circumscribed by segments of the two cutoff limits, i.e. the 350nm limit and the 2,500m isobath projected seaward by 100nm; the perimeter of this donut hole represents the combined outer limits of Canada, Russia, and the USA.

The second donut hole is a larger, elongated region that encompasses the Gakkel Ridge, and which is circumscribed by segments of several limits and lines: the 200nm limit, the two cutoff limits (350nm and the 2,500m plus 100nm), and the two formula lines (distance and sediment thickness); the perimeter of this donut hole represents the combined outer limits of Denmark, Norway, and Russia.

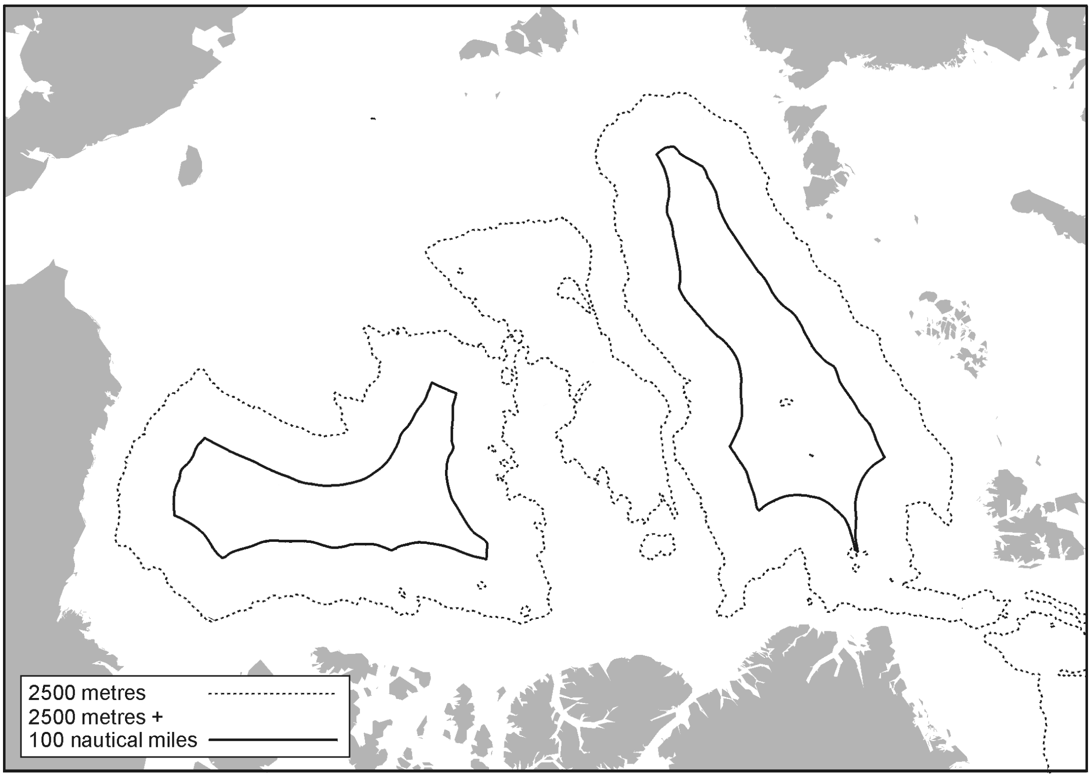

Figure 7. The 2,500 metre isobath projected seaward by 100 nautical miles. The projected line is another *cutoff limit* prescribed by Article 76.

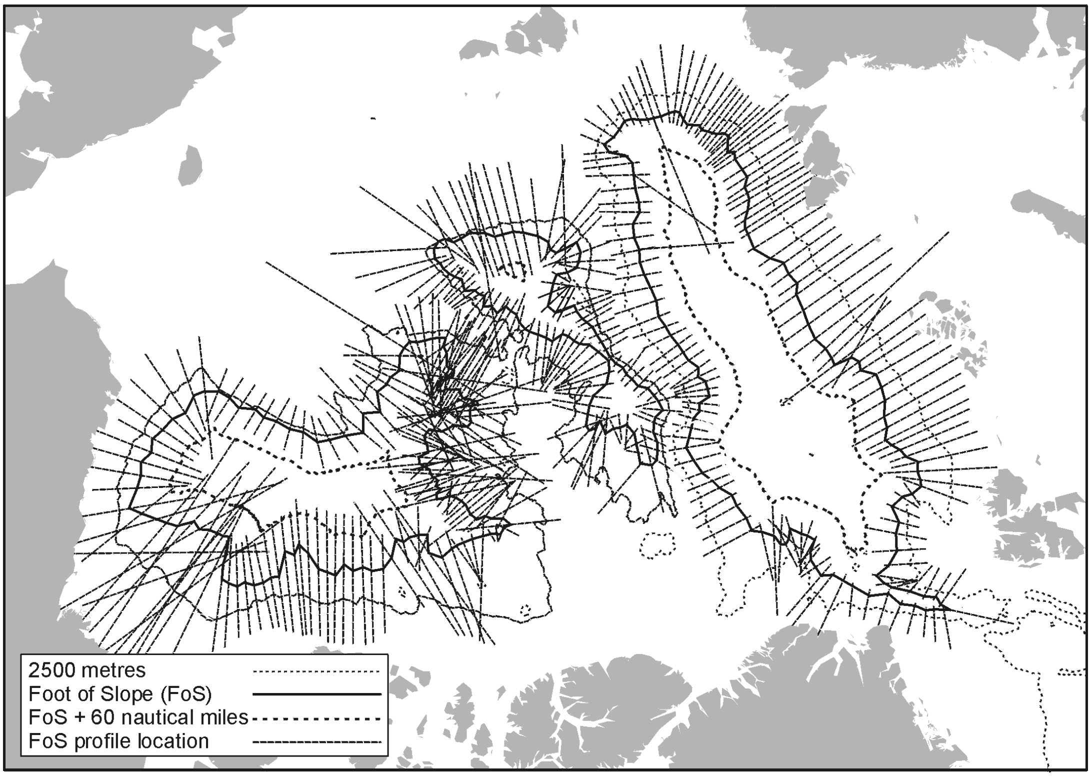

Figure 8. The location of the Foot of Slope (FoS) was determined from an examination of the bathymetric profiles in the locations shown above. The FoS line encloses three distinct regions in the Eurasian Basin, in the Podvodnikov-Makarov Basins, and in the Canada Basin. Within each region, the FoS line has been projected by 60 nautical miles in a realisation of the *distance formula*.

CONCLUSIONS, OBSERVATIONS AND QUESTIONS

This analysis, which remains partially conjectural pending verification of the sediment model that was employed, has demonstrated that Article 76 will entitle five coastal States to claim sovereign rights over resources of the seabed and subsoil throughout most of the Arctic Ocean. Only two regions appear to be exempt from this projected jurisdiction: a small area in the Mendeleev Abyssal Plain, and a larger one that encompasses the Gakkel Ridge, an oceanic spreading centre. These will remain a part of the Area, with resources that fall within the jurisdiction of the International Seabed Authority.

Article 76 will entitle five coastal States to claim sovereign rights over resources of the seabed and subsoil throughout most of the Arctic Ocean.

In many parts of the study area, the determination of the foot of slope was problematic on account of poor or non-existent differentiation between the continental slope and rise, or of structures that masked the regional morphology and posed a challenge in the selection of the point of maximum change in the gradient of the seabed. Dealing with these circumstances was facilitated considerably through the use of a software package that supported data analysis in an interactive mode, and which permitted high levels of iteration for developing solutions that were self-consistent. Analysis and interpretation were similarly facilitated by the availability of coherent and isotropic data sets that had been carefully pre-screened for errors and inconsistencies.

The investigation served time and time again as an effective catalyst for reflection and discussion that focused on the meaning and interpretation of various clauses in Article 76. Given the informal, non-committal nature of the task, it was straightforward to experiment with different analytical approaches for the purpose of confirming or disproving the validity of one viewpoint over another. Many of these discussions and trials transcended Article 76, having a direct and significant bearing upon the resolution of important scientific issues, such as the tectonic framework and history of the Arctic Ocean basin.

This investigation was almost totally based upon gridded data sets that represented the only comprehensive descriptions of the depth and sediment thickness of the Arctic Ocean basin. While the results were deemed acceptable for a provisional study, it should be pointed out that over the short to medium term, the IBCAO bathymetric description is not likely to be substantially improved in deep water regions, barring the institution of a significant – and costly – mapping program. The description of sediment thickness, on the other hand, is likely to improve if and when the proposed MAST project achieves its objectives – but even this product may have to depend on intelligent speculation in some areas that suffer from a paucity of real observations, for example through the use of gravity and magnetic data to control interpolations between widely-spaced seismic profiles.

There is no question that gridded forms of bathymetric and sediment thickness information may not be as satisfactory as complete suites of original observations, but given the difficulties of collecting data in the Arctic region, this state of affairs is not likely to improve for some time. Under the circumstances, coastal States that intend to use the existing IBCAO bathymetric grid for locating the foot of slope and the 2,500m isobath, and the anticipated MAST grid for constructing the Gardiner line, may wish to seek prior confirmation from the CLCS concerning the acceptability of these grids for Article 76 purposes. The alternative is to embark upon expensive and time-consuming data-gathering operations that may well result in only minor changes to the provisional results outlined above.

A final point concerns the response of the CLCS to expected submissions from the Arctic coastal States. As described above, an informal consultative process has been established among these States to develop a common understanding of the technical problems that are peculiar to the study area, and to promote a coordinated approach Arctic coastal States. As described above, an informal consultative process has been

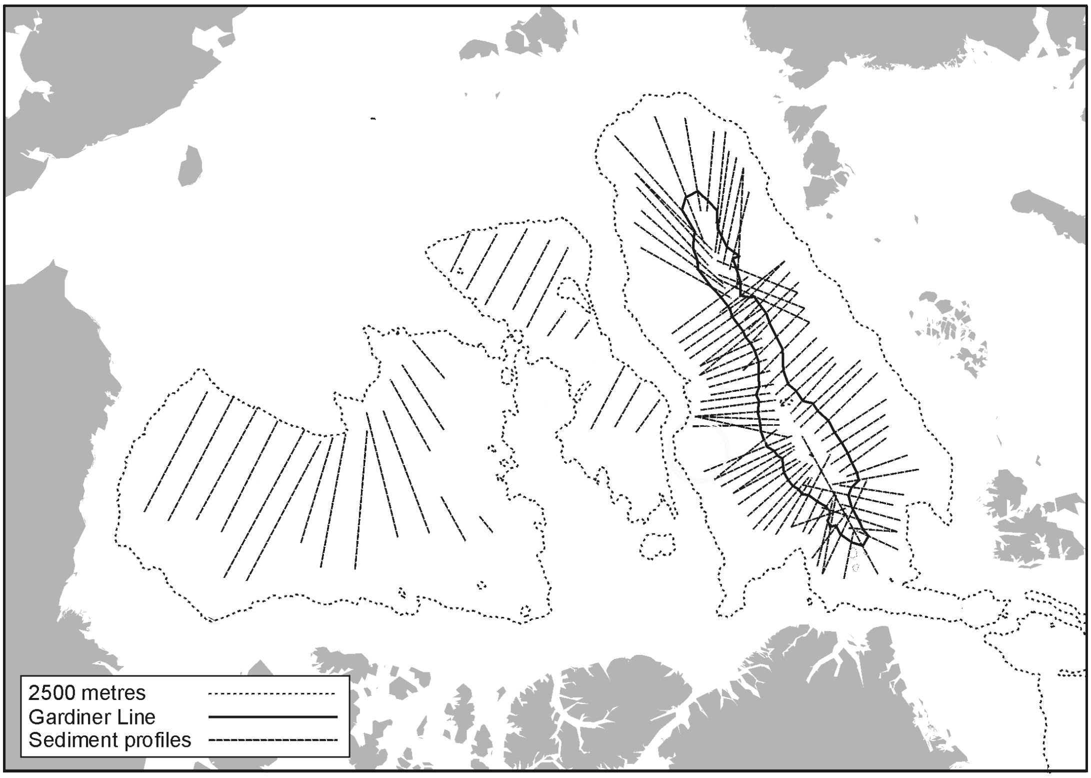

Figure 9. The location of the Gardiner line was determined from an examination of the sediment profiles in the locations shown above. The *sediment thickness formula* can be realised only in the Eurasian Basin.

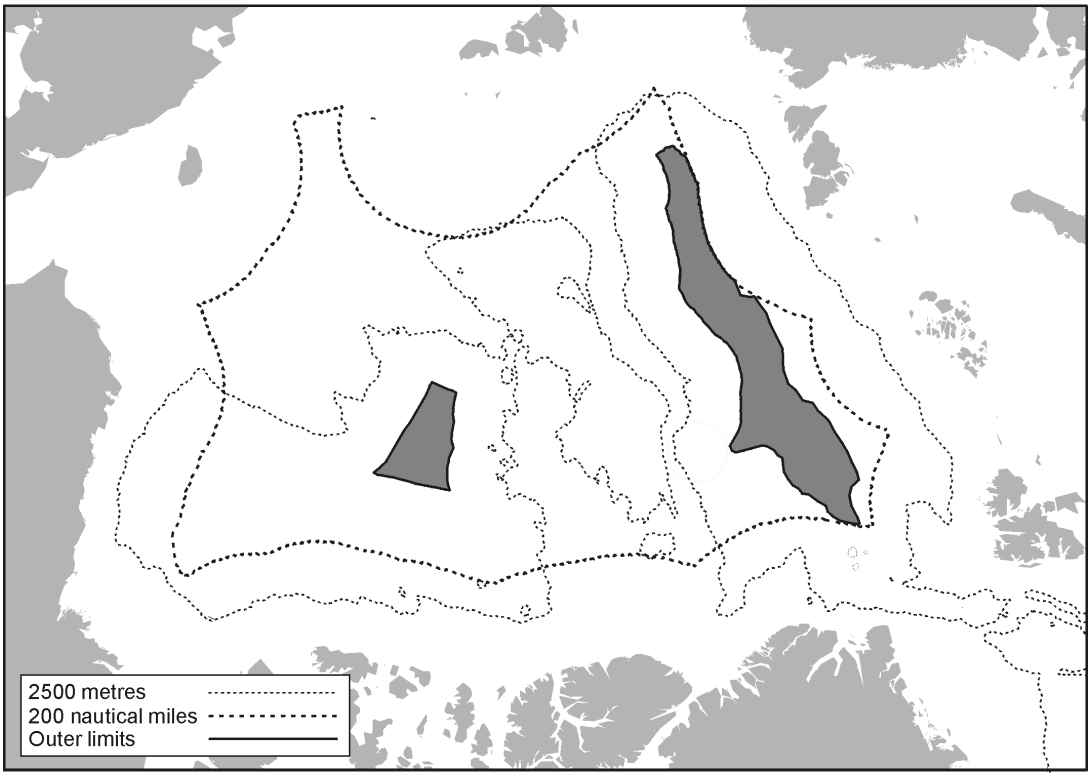

Figure 10. The combined continental shelves of five Coastal States occupy most of the Arctic Ocean, except for two 'donut holes'. The smaller opening is bounded by segments of the 350nm limit and the 2,500m isobath plus 100nm; these are the outer limits of Canada, Russia, and the USA. The larger opening is bounded by segments of the 200 and 350nm limits, the 2,500m isobath plus 100nm, and the lines constructed in accordance with the distance and sediment thickness formulae; these are the outer limits of Denmark, Norway, and Russia.

established among these States to develop a common understanding of the technical problems that are peculiar to the study area, and to promote a coordinated approach to their resolution. It follows that their respective submissions, whether prepared independently or in close collaboration, will likely feature general consistencies that reflect common viewpoints and approaches which have emerged from ongoing technical discussions. In consideration of the fact that Arctic submissions are likely to be lodged with the CLCS over a period of several years, and that they are likely to be handled separately by transient sub-commissions with varying compositions, coastal States may wish to seek reassurances from the CLCS that its recommendations concerning their respective submissions will match them in consistency.

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