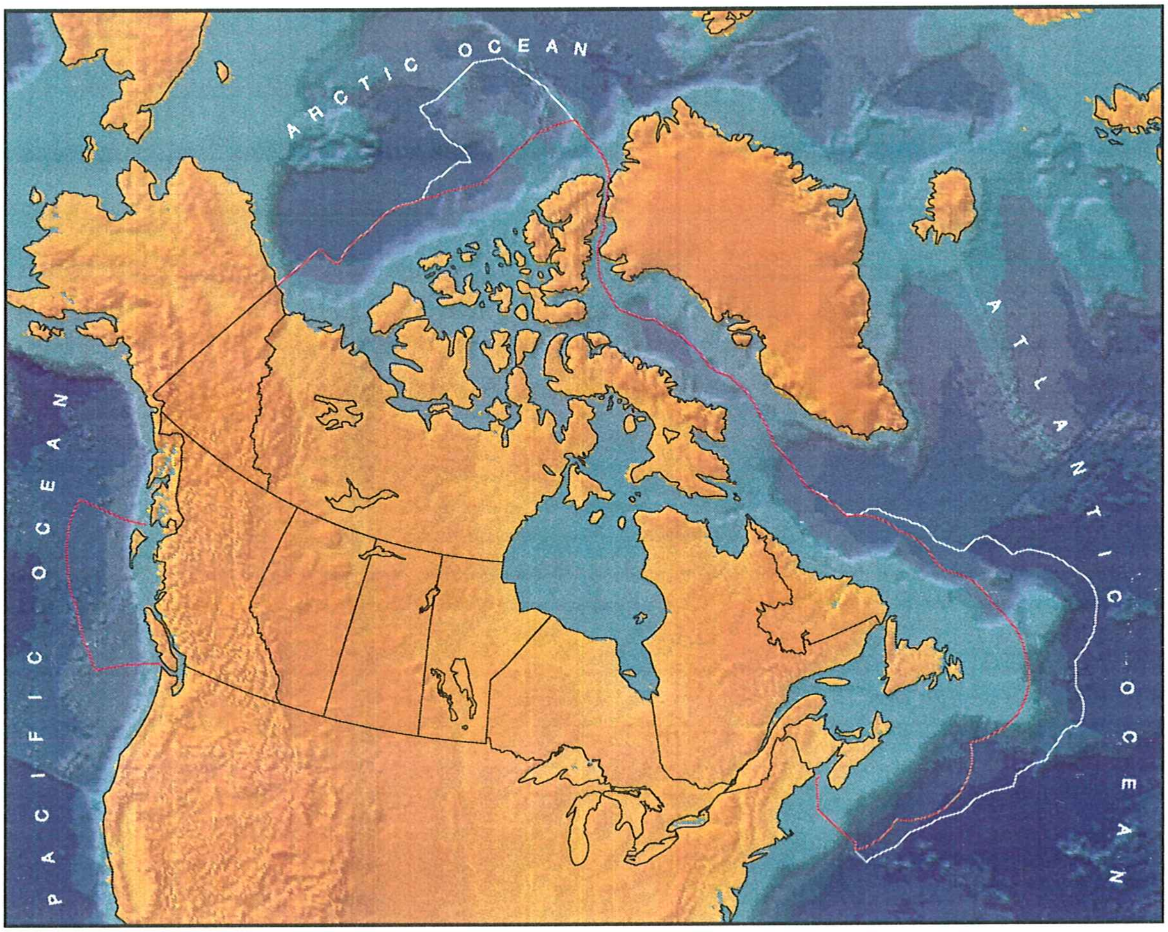
Geological Survey of Canada Open File 3209

CANADA AND ARTICLE 76 OF THE LAW OF THE SEA

DEFINING THE LIMITS OF CANADIAN RESOURCE JURISDICTION BEYOND 200 NAUTICAL MILES IN THE ATLANTIC AND ARCTIC OCEANS



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15 May 1994

EXECUTIVE SUMMARY

Article 76 of the 1982 United Nations Convention on the Law of the Sea specifies a mechanism for defining extensions to offshore areas beyond 200 nautical miles where coastal nations with wide continental margins may exercise sovereign rights over mineral and certain biological resources, and also wield a measure of jurisdiction in matters related to environment and conservation. With wide continental margins on its eastern and northern coasts, Canada has an opportunity under the terms of the Convention to support national jurisdiction and authority beyond the present 200 nautical mile limits in the Atlantic and Arctic Oceans. The total area could potentially equal that of Canada's three Prairie Provinces.

To be able to assert sovereign rights over the maximum extent of the continental shelf beyond 200 nautical miles, a wide margin state has ten years in which to assemble data describing depth of water and thickness of sediment in the areas affected, and to interpret this information in accordance with the criteria of Article 76. In the case of Canada, present data holdings appear to support the case for national jurisdiction over ~75% of the maximum claimable area in the Atlantic and 65% in the Arctic. A strategic program for acquiring and analyzing new data would strengthen this claim and likely enhance it to cover most, if not all, the claimable areas in both oceans.

Current indications are that the claimable area in the Atlantic would encompass regions with significant potential for gas, oil, and gas hydrates; less is known about the fishery potential, however the region is known to be populated by species that would be exploitable under the terms of Article 76. Information about all types of Arctic resources is inadequate for a detailed assessment of their regional potential, although the outlook for gas and oil appears generally favourable.

Cover: *Canada and adjacent oceanic regions, showing (in red) Fishing Zone limits that portray the present extent of Canadian jurisdiction over benthic and subsurface resources and (in white) a preliminary delineation of the Juridical Continental Shelf as prescribed by the 1982 United Nations Convention on the Law of the Sea. Taken together, the regions in the Atlantic and the Arctic Oceans beyond 200 nautical miles cover an area nearly equal to Canada's three Prairie Provinces.*

FOREWORD

This document summarizes the outcome of a review performed by members of an ad-hoc project team working under the direction of Richard Haworth of the Geophysics, Sedimentary and Marine Geoscience Branch of the Geological Survey of Canada (GSC), and Ross Douglas of the Canadian Hydrographic Service (CHS). A limited-edition Technical Annex contains reports from a series of focused investigations.

The review was undertaken at short notice and the document was prepared to meet an early deadline, hence it was unavoidable that some of the findings and conclusions had to be derived from preliminary and incomplete information. It is reasonably certain, however, that these findings and conclusions are conservative, and that further analysis with more complete information would only provide confirmation and amplification. It is worth mentioning also that the review drew heavily on the expertise, technical infrastructure, contacts, data bases and software developed during three decades of scientific mapping and research in the deep waters adjacent to Canada's eastern and northern coasts. Without access to these resources, there is little doubt the project would have taken much longer to complete, and with a lower level of quality.

Any opinions expressed in this document are personal and do not necessarily reflect those of the Government of Canada.

ACKNOWLEDGMENTS

The bulk of the data sets used to conduct the review were extracted from the digital archives of the Atlantic Geoscience Centre (AGC) of the Geological Survey of Canada (GSC) by Gordon Oakey, Allen Stark, and Kate Dickie. Locations of bathymetric data in the Arctic were extracted from the digital archives of the Geophysics Division of the GSC through the good offices of Walter Roest. Assessments of resource potentials were prepared by several subject matter specialists: John Wade and Alan Grant of the AGC (hydrocarbons and gas hydrates, respectively), and Terry Rowell of the Biological Studies Branch of the Department of Fisheries and Oceans (fisheries). In addition to providing useful insights into resource issues, John Wade made many useful comments relating to the overall presentation of the review's findings.

Gary Rockwell and Gerard Costello of the Canadian Hydrographic Service (CHS) provided information relating to past and projected hydrographic operations. Members of the Department of Geodesy and Geomatics Engineering of the University of New Brunswick investigated the feasibility of a numerical approach for determining the location of the foot of the continental slope. Staff of Geometrix Geodetic and Hydrographic Research Incorporated performed specialized computations required for the portrayal of various offshore parameters. Additional material was derived from several other contributors and from a variety of sources; these are acknowledged in the text.

Most figures were prepared by David Vardy and Kevin LeBlanc, using the graphics facilities of the AGC and the Atlantic Region of the CHS. Jennifer Bates and Rhonda Coulstring of the AGC Publications and Drafting Section packaged the document in its finished form.

Finally, it should be acknowledged that significant portions of the review owe their origin to an unpublished investigation performed in the early 1980s by George Somers. This work was carried out under the direction of the late Michael Keen, who at the time was Director of the AGC, and who had the foresight to anticipate the kinds of questions that would need to be addressed upon ratification of the United Nations Convention on the Law of the Sea.

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Note: The Technical Annex is a separate, limited-edition document that contains reports from a series of supporting investigations. Contact the Editor for information relating to the contents of this document.

PART I: OVERVIEW

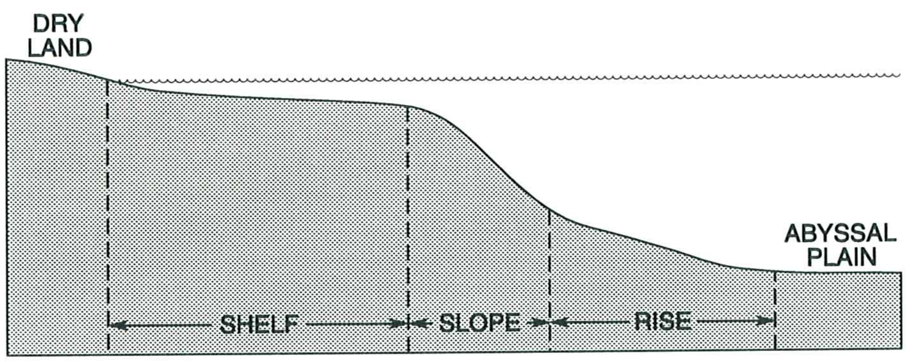
1. AN INTRODUCTION TO ARTICLE 76 OF THE LAW OF THE SEA

General principles

On 16 November 1994, the 1982 United Nations Convention on the Law of the Sea will enter into force as a component of International Law. Developed after a decade of intensive multilateral negotiations, the Convention embodies many substantial changes to the regulations governing the peaceful uses of the world's oceans and the exploitation of their resources.

Article 76 of the Convention (reproduced in Appendix A) will have significant potential impact on Canada and other coastal nations with wide continental margins. By ratifying the Convention, nations will have a means of ensuring international recognition of their respective national sovereign rights and jurisdictions in new marine areas beyond the limits of their present exclusive economic zones. With certain qualifications, these extended jurisdictions will apply to the non-living resources of the seabed and its subsoil, and to sedentary living resources that dwell on the seafloor.

PHYSIOGRAPHIC COMPONENTS OF THE CONTINENTAL MARGIN



*There is more to a continent than the part that sticks out of the ocean: there is also a fringe that extends below sea level, creating a transitional zone between dry land and the deep ocean. This zone is known as the **continental margin**, and its width varies substantially in different parts of the world. For instance, it extends more than 500 kilometres across some parts of the Grand Banks of Newfoundland, while off Vancouver Island it measures only about 30 kilometres. The margin generally consists of three parts: the shelf, the slope, and the rise.*

*The **continental shelf** is a shallow, gently sloping zone that extends from the shore to a point where the bottom abruptly begins to steepen. Worldwide, there is considerable variability, but the average depth of the shelf is usually about 200 metres, with a gradient of 1 in 1000. Note that this **physiographic** continental shelf is not the same thing as the **juridical** continental shelf (see Sidebar on the Juridical Continental Shelf).*

*The **continental slope** begins where the shelf ends, with a strong increase in bottom gradient - usually more than 1 in 40. It is bounded at its outer limit by an abrupt decrease in gradient.*

*The **continental rise** is the seafloor beyond the base of the continental slope, generally with a gradient between 1 in 40 and 1 in 1000, and leading down to the abyssal plain.*

For Canada and other nations so affected, this provision could significantly increase the international recognition of claims to potential assets in offshore oil and gas, seabed minerals and some fisheries. It would also confer on such nations new responsibilities for resource management and environmental protection in areas of extended jurisdiction.

The outer limits of the continental shelf over which the marginal state can claim jurisdiction are established on the basis of information submitted by the marginal state concerning the nature of the "submerged prolongation" of its land mass beyond 200 nautical miles. The nature of this information, detailed in Article 76, involves a series of criteria based on bathymetric and geologic factors. A claim shall be submitted to the UN Commission on the Limits of the Continental Shelf; this body will make a recommendation on the basis of which the coastal state establishes "final and binding" limits of its continental shelf. The Commission will be established within 18 months of the Convention's entry into force with members elected from nationals of the states that have ratified the Convention.

The Convention will come into effect on 16 November 1994 for those nations that ratified it up to 15 October 1994 (see Appendix B for list of first sixty ratifying nations). The wide-margin coastal states among them will have until 14 November 2004 to define the outer limits of the affected areas and to present their claims for extended jurisdiction. Wide-margin coastal states that ratify the Convention after 14 November 1994 will have ten years from the date of their respective ratifications to define their outer limits and to present their claims.

THE JURIDICAL CONTINENTAL SHELF

With the appearance of Article 76 in the 1982 UN Convention on the Law of the Sea, a new definition of 'continental shelf' entered the lexicon: the term now applies to the 'natural prolongation' of a coastal state's land territory. In this sense, it does not refer explicitly to the physiographic continental shelf: in fact, it encompasses all three physiographic components of the continental margin - shelf, slope, and rise (see Sidebar on the Physiographic Components of the Continental Margin).

*Where the outer edge of this legal or **juridical** continental shelf is located depends on the width of the continental margin. If the margin is narrow, (as off western Canada), the juridical shelf has a width of 200 nautical miles (about 365 km): in the Canadian context, this matches the outer limit of the Fishing Zone where Canada exercises full jurisdiction over the fisheries. If the margin is wide (as off eastern and northern Canada), the width of the juridical shelf depends on the topography of the seafloor and sub-bottom, and may be up to 350 nautical miles (about 640 km), or 100 nautical miles past the 2500 metre isobath. In this case, the coastal state exercises partial jurisdiction over living and non-living resources beyond 200 nautical miles.*

The case for Canada

As shown in the front cover illustration, the Convention provides Canada with grounds for claiming significant territory beyond the edge of the physiographic continental shelf on the Atlantic and Arctic margins (the provisions of Article 76 for extension of jurisdiction beyond the physiographic continental shelf do not apply on the Pacific margin, where the continental margin is narrow). The Atlantic margin (Figure 1.1) encompasses not only broad shelves such as the Scotian Margin and the Grand Banks of Newfoundland, but also natural components of the continental margin such as Flemish Cap and Orphan Knoll. The Arctic margin (Figure 1.2) includes the

Alpha Ridge and part of the Lomonosov Ridge, two major structures that extend well offshore from the Canadian landmass.

On both margins, the size and character of these features justify national resource jurisdiction well beyond the 200 nautical mile limit. From available information, it has been estimated that the total area of jurisdiction beyond 200 nautical miles could amount to about 1.76 million square kilometres, which is nearly equal to the combined areas of Manitoba, Saskatchewan, and Alberta. These and other comparisons are illustrated in Appendix C. This is only a preliminary assessment based on an analysis of incomplete and in some cases unqualified data: more information and more work are needed to confirm these initial calculations.

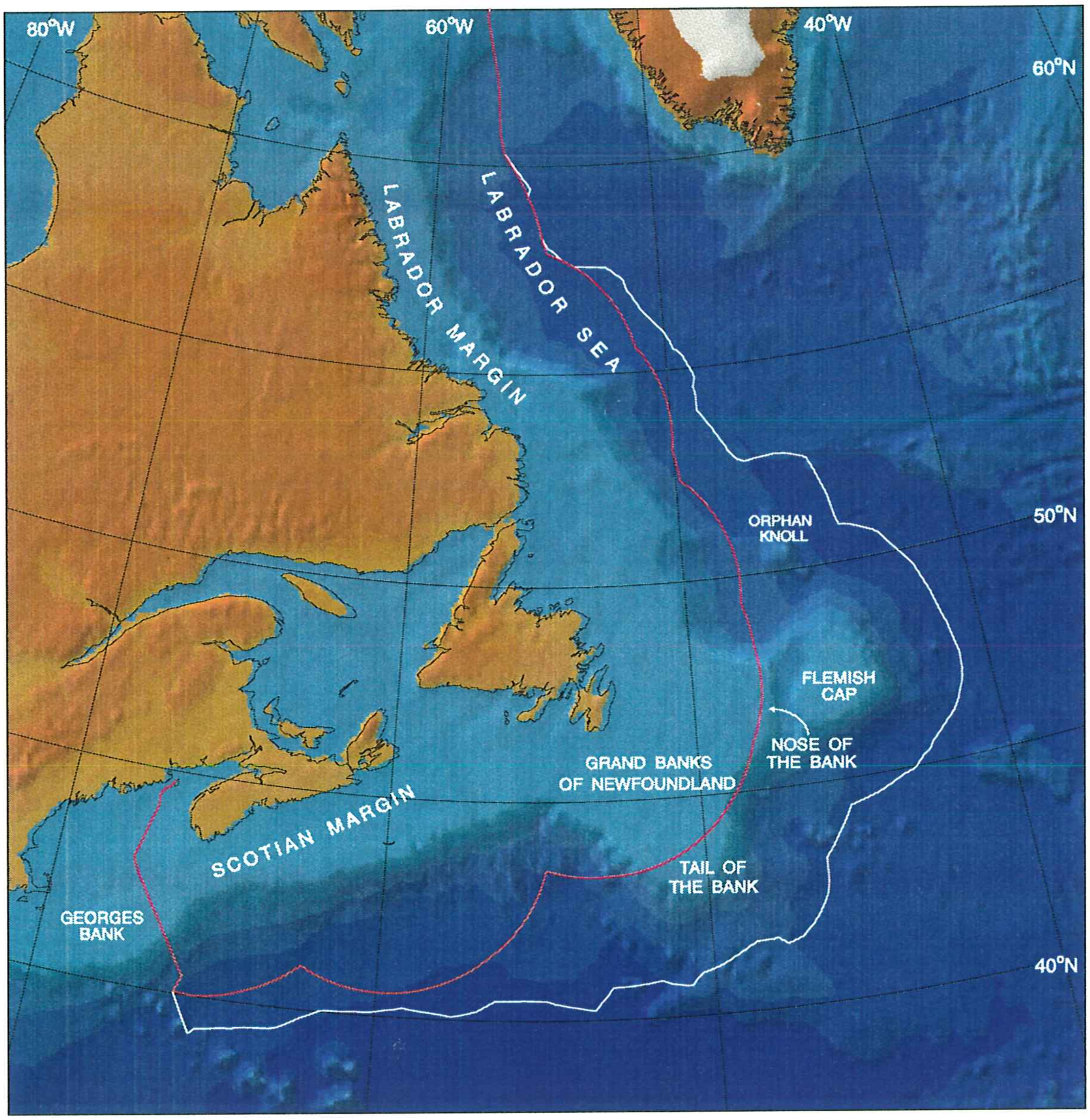


Figure 1.1 *Canada's Atlantic margin, portraying (in red) the Fishing Zone limits that circumscribe the nation's present jurisdiction over benthic and subsurface resources, and (in white) a preliminary delineation of the juridical continental shelf.*

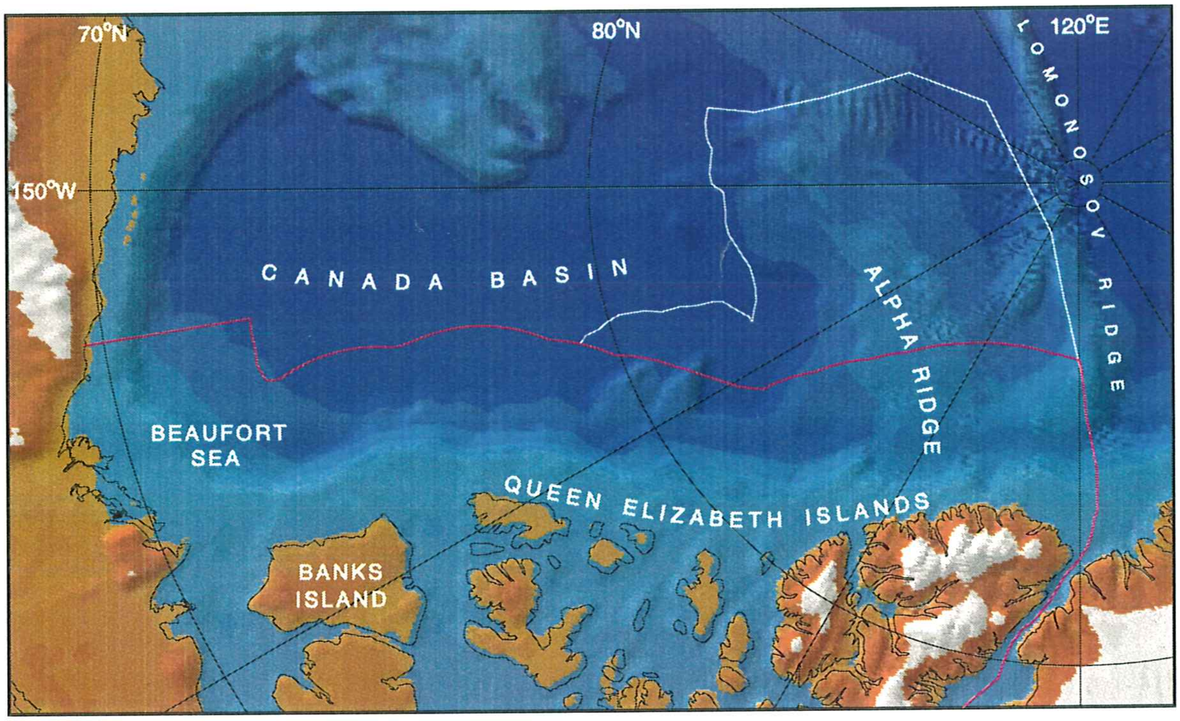


Figure 1.2 *Canada's Arctic margin, portraying (in red) the Fishing Zone limits that circumscribe the nation's present jurisdiction over benthic and subsurface resources, and (in white) a preliminary delineation of the juridical continental shelf.*

2. GENERAL IMPLEMENTATION OF ARTICLE 76

Justification for extending jurisdiction beyond the 200 nautical mile limit

Before proceeding to implement Article 76, a wide margin state must identify the seabed features that it proposes to enclose within the new continental shelf, and to determine whether it has a case for claiming them as components of the 'natural prolongation of its land territory'. Physiographic considerations are likely to be the determining factors in most cases, but geological arguments could be developed in particular situations where submarine elevations retain continental affinities even when not contiguous to parent physiographic continental shelves.

After identifying the potential extent of its juridical continental shelf, a wide margin state must follow three basic steps in defining the outer limit; these are shown in Figure 2.1.

The foot of the slope

The first step in the process requires the location of the 'foot of the continental slope', which is the line along the base of the slope where the gradient of the seafloor undergoes its maximum change. This is a key feature that provides a baseline for the procedures described in the next two paragraphs: judicious determination can add considerably to the area enclosed by the final outer limit.

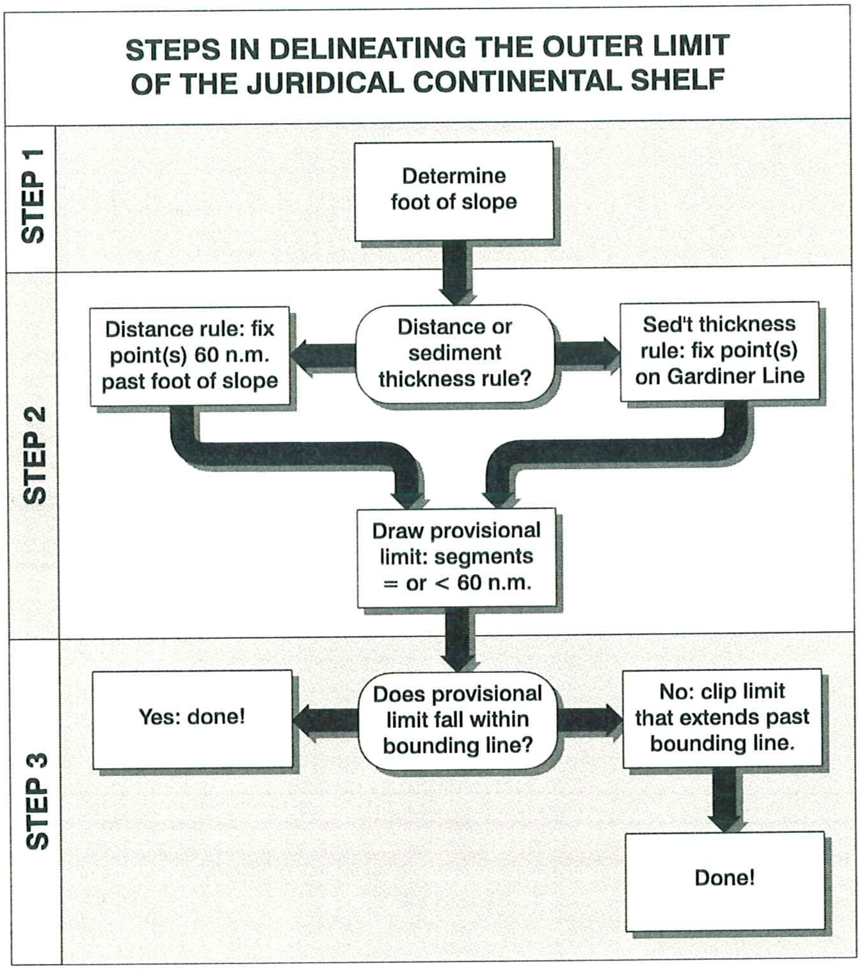


Figure 2.1 *A simplified representation of the procedures specified in Article 76, for defining the outer limits of partial resource jurisdiction beyond the current 200 nautical mile limit.*

Distance and sediment thickness formulae

The second step involves the definition of a provisional outer limit by a series of straight lines that join fixed points no more than 60 nautical miles apart. The locations of these fixed lines are determined with respect to their distance from the foot of the continental slope. As shown in Figure 2.2, there are two methods for determining distances to fixed points: the *distance formula*, and the *sediment thickness formula*. For any particular point, it is the state's prerogative to select the formula it prefers.

The distance formula involves a simple measurement of distance: 60 nautical miles to seaward from the foot of the slope. The sediment thickness formula is more complicated, and requires the measurement of the thickness of sediment beneath the ocean floor: the fixed point is where sediment thickness equals one percent of the distance back to the foot of the slope. The limit defined by a succession of such points is known colloquially as the *Gardiner Line*, after one of its principal architects (Gardiner, 1978).

The concept of the bounding line

Regardless of the method chosen for its delineation, the outer limit cannot extend beyond a

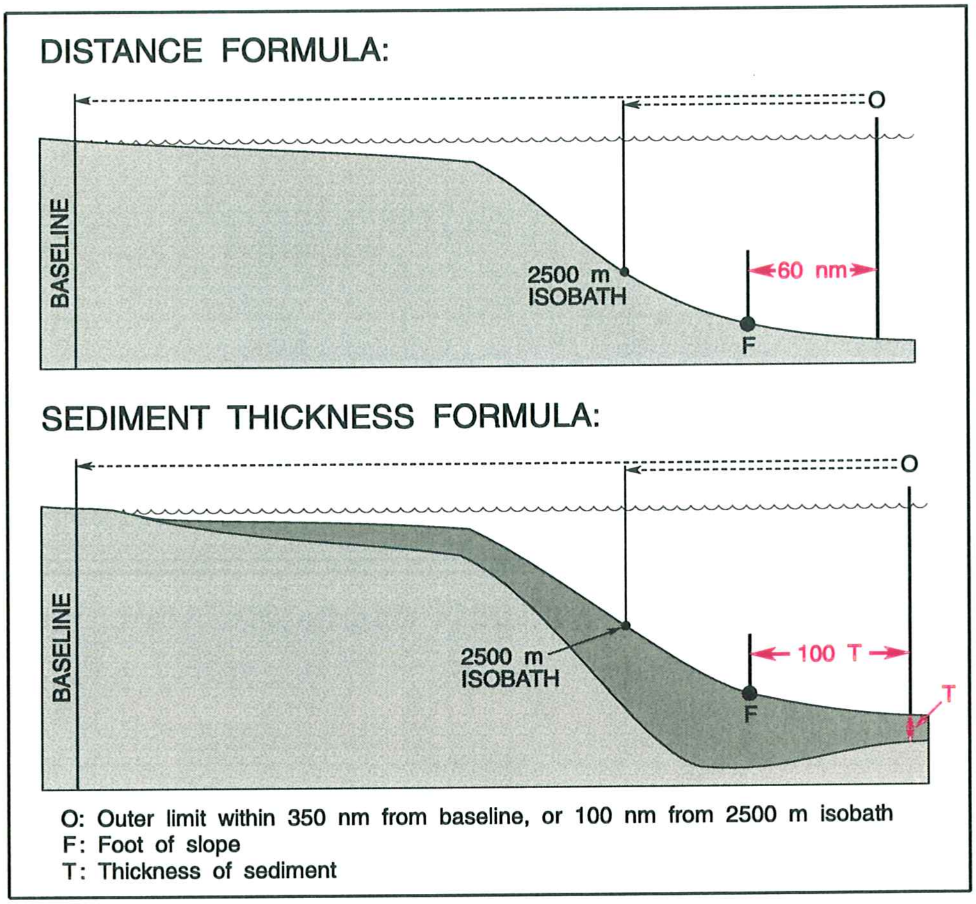


Figure 2.2 *The distance and sediment thickness formulae specified by Article 76 for delineating the outer limit of the juridical continental shelf. It is left to the discretion of the coastal state to decide whether the formulae should be applied singly or in combination.*

maximum of 350 nautical miles from the state's territorial sea baselines, or 100 nautical miles beyond the 2500 metre isobath, unless the features being claimed as part of the continental shelf are 'submarine elevations that are natural components of the continental margin, such as plateaux, rises, caps, banks, and spurs'. Where states with opposite or adjacent coasts are involved, the Article declares only that its provisions are 'without prejudice to the question of delimitation of the continental shelf' between such states; for the purposes of this discussion, it will be assumed that the outer limit does not extend beyond any maritime boundaries previously established with neighbouring states. For convenience, these three limiting features can be amalgamated into a single *bounding line* beyond which the outer limit may not extend. Figure 2.3 illustrates how two of these three criteria may be compounded in the delineation of the outer limit, and also how the bounding line is constructed.

The outer limit of the continental shelf

The third step in the process is to determine whether any portions of the provisional outer limit extend beyond the bounding line, and to eliminate those that do. The resulting line will then be a composite of the provisional outer limit and the bounding line: this is the new outer limit of the juridical continental shelf.

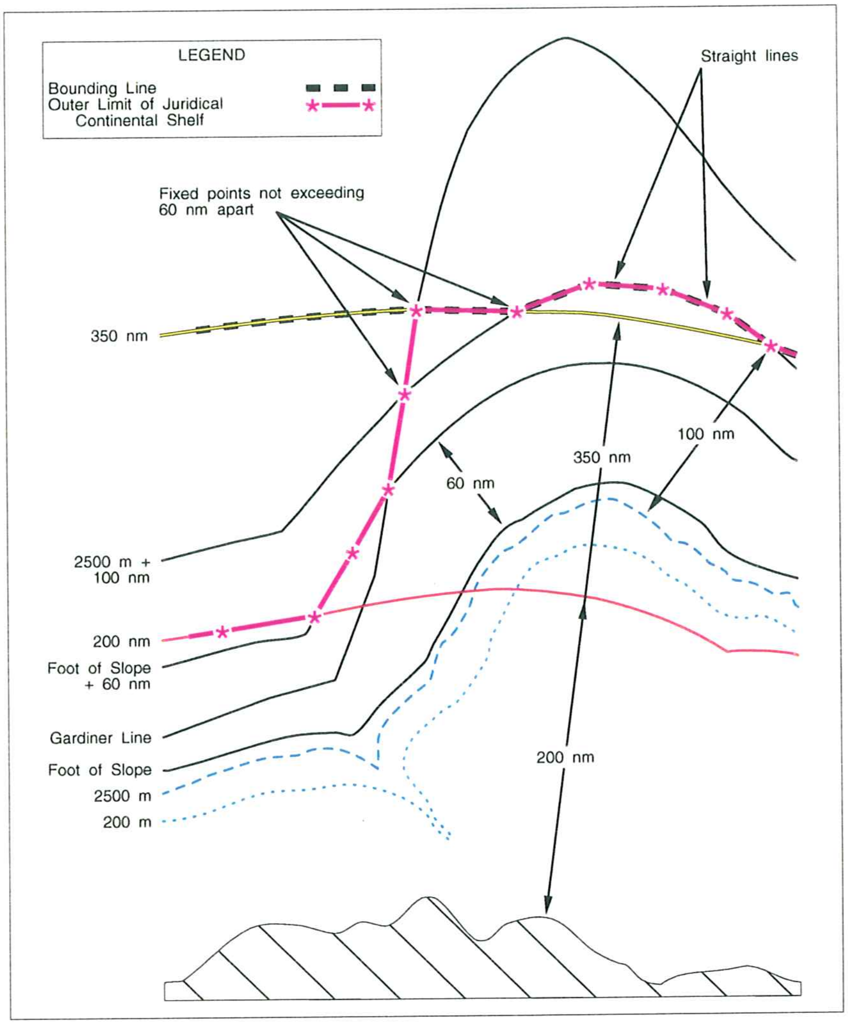


Figure 2.3 *Application of Article 76 criteria and the bounding line to delineate the outer limit of the continental shelf (adapted from "A Guide to the Provisions of the 1982 United Nations Convention on the Law of the Sea Relating to Marine Scientific Research", Royal Society); drawing is not to scale.*

Information requirements

As outlined in the preceding sections, a coastal state needs to know the accurate locations of five features in order to apply fully the provisions of Article 76: (1) the 200 nautical mile limit measured from the state's territorial seas baseline; (2) the 350 nautical mile limit measured from the same baseline; (3) the foot of the continental slope; (4) the 2500-metre isobath; and (5) the Gardiner Line.

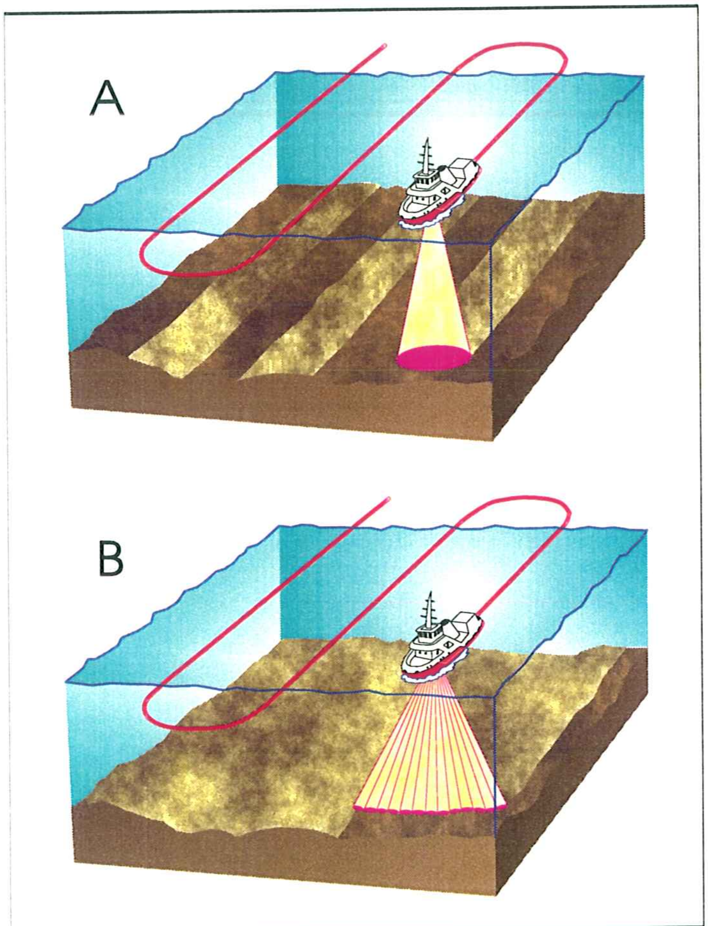
The locations of the first and second features - the 200 and 350 nautical mile limits - are relatively straightforward to determine either graphically from charts, or numerically by geodetic computation, as outlined in Appendix D.

Determining the location of the third feature - the foot of the slope - requires the knowledge of water depths along a series of profiles perpendicular to the edge of the continental shelf, with subsequent analysis to identify the line of maximum change of seabed gradient along the base of the continental slope. For this procedure, it is not essential to have absolute accuracy in the representation of depth, but the geographic co-ordinates of the depth values along each profile must be accurately known. The outcome of this analysis depends heavily on the quantity and distribution of profiles, and on the criteria applied in their interpretation; these factors are discussed briefly in Appendix E. Errors at this stage will propagate into subsequent applications of the distance and sediment thickness formulae.

The location of the fourth feature - the 2500 metre isobath - is required as a baseline for constructing a limiting line 100 nautical miles to seaward, which defines one component of the bounding line. This necessitates the measurement of absolute water depths with the utmost accuracy, which in the present state of the art is considered to be plus or minus one percent of the water depth. At a depth of 2500 metres over seafloor with a two degree slope, even this error can lead to a potential uncertainty of plus or minus 715 metres in the inferred location of the 2500 metre isobath, and in the corresponding segment of the bounding line (specifically: if

MEASURING THE DEPTH OF WATER

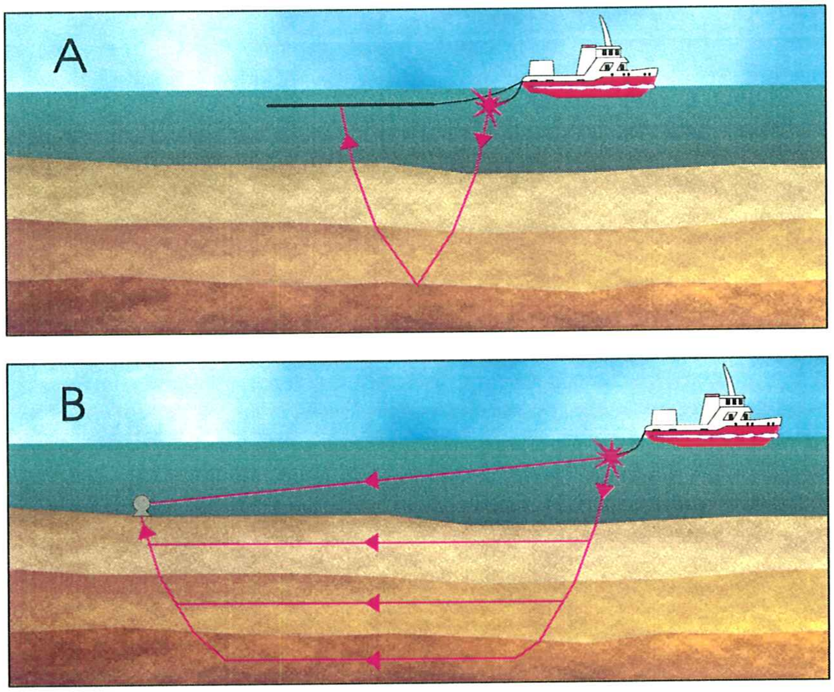
*Water depth is measured by the technique of **echo-sounding,** in which a transducer mounted on a ship's hull emits an acoustic pulse, and then measures the time taken by the pulse to complete a round trip back to the ship after reflection from the seafloor. The elapsed time is converted to depth, using a reasonable assumption about the average velocity of sound through the water column. This process is repeated at regular intervals as the ship advances along its track, yielding a succession of depth values.*



Inaccuracies in bathymetric mapping can arise from: (1) imperfect knowledge of the sound velocity in sea water; (2) use of a wide angle echo sounder that ensonifies large 'footprints' and yields average depth values over rugged bottoms (A); (3) errors in determining the position of the sounding vessel at the time of observation.

Modern technology has considerably reduced these errors: sound velocity can be measured with sensors launched from the ship at regular intervals; narrow beam echo sounders not only ensonify small areas on the seafloor, but can be ganged together to yield multiple - and simultaneous - depths in a lateral swath perpendicular to the direction of the ship's advance (B); modern navigation systems such as GPS (Global Positioning System) provide reliable positioning around the clock and in all areas.

MEASURING THE THICKNESS OF SEDIMENTS



Sediment thickness is measured by the technique of ***seismic reflection*** *(A), in which a powerful source of acoustic energy produces pulses that penetrate the seafloor and reflect off the boundaries that separate the sedimentary layers beneath the seafloor. Converting round-trip travel times to produce a picture of sediment thickness requires a knowledge of the velocity of sound through sedimentary layers; this is less straightforward than the derivation of simple water depth, because sound velocity varies with sediment type and is not always available.*

Seismic reflection techniques can be classified as ***single-channel*** *or* ***multi-channel,*** *according to the methods used for detecting, recording, and processing the reflected signals. The single-channel technique records and processes each returning pulse as a single observation. The multi-channel technique detects each returning pulse many times along an array of hydrophones deployed in a towed streamer that may be hundreds, or even thousands of metres long; these pulses are recorded separately, and subjected to special processing that exploits their redundancy in order to strengthen the signal-to-noise ratio, and to apply a variety of corrections.*

Sediment sound velocities can sometimes be acquired directly from borehole measurements in the local sedimentary structures. Alternatively, if the hydrophone array is sufficiently long, special processing techniques can be applied to extract velocity information from multi-channel reflection data. These approaches are not always practicable, so the technique of ***seismic refraction*** *(B) is often applied: this entails large acoustic pulses similar to the reflection method, the main difference being that their travel times are measured after they have propagated horizontally over known distances through layers of sediment. Major inaccuracies with this procedure arise from two sources: (1) the presumption of a homogeneous and geometrically well-defined medium through which the sound propagates; (2) errors in determining the position of the observing vessel and/or the remote instrumentation at the moment of measurement.*

the observed depth is too low or too high by one percent, the 2500 metre contour and the bounding line could appear to be located 715 metres downslope or upslope, respectively, of their proper positions). This translates into uncertainty over the size of the area encompassed by the new outer limit, and over the quantity of resources within that area.

The location of the fifth feature - the Gardiner Line - requires the measurement of sediment thickness by the seismic technique; this is similar to echo sounding, but uses stronger acoustic pulses that penetrate the seafloor and reflect from the boundaries that separate the sedimentary layers beneath the seafloor. Because of uncertainties involved in the procedure, inaccuracies in the calculated sediment thickness could typically be 10%. This will have a significant impact on the location of the Gardiner Line. If one kilometre of sediment thickness is measured at a distance of 100 km from the foot of the slope, that 10% error in thickness translates into a distance uncertainty of 10 km. In addition to this problem, there are ambiguities inherent in the interpretation of the seismic profile, as outlined in Appendix F.

3. INTERNATIONAL PROSPECTS

Thirty-two countries have been identified as prospective wide margin states (Appendix G). Taken together, these nations are likely to share many interests in the development and application of standard methodologies for delimiting juridical shelf limits. The development of common approaches for interpreting Article 76 could do much to reduce the potential for confusion and ambiguity, and to simplify the justification process before the UN Commission on the Limits of the Continental Shelf.

Within 18 months of the Convention coming into force, the Commission will be established with membership from those countries that have ratified the convention. Nations that move quickly to ratify the Convention and delineate their juridical shelf limits will be well placed: (a) to develop significant leads in methodology development; (b) to demonstrate their competence in the field and to assume early positions of leadership in the theoretical and practical aspects of this work; and (c) to establish important precedents in the recommendations made by the Commission. They can also expect to position themselves as providers of expertise and services in tasks related to Article 76, and to capitalize on export opportunities as other nations take steps to delineate their own juridical shelf limits.

Membership of the Commission is for a period of 5 years, with the potential for renewal. There is therefore considerable benefit to be gained by ratifying the Convention before membership of the Commission is fixed, in order to be eligible for membership on the Commission, and to gain the advantages identified above.

PART II: THE CANADIAN PERSPECTIVE

4. RATIONALE AND BASIS OF THE CANADIAN CLAIM

Atlantic Margin

Canada's Atlantic margin is characterized by a wide, shallow continental shelf (Figure 1.1). Physiographic and geologic considerations provide strong grounds for asserting that the Grand Banks and Flemish Cap are 'submerged prolongations' of the country's land mass. The case for Orphan Basin and Orphan Knoll is less clearcut, however current geological thinking is that both features are underlain by continental crust. In any case, the area to be claimed cannot be larger than the zone illlustrated in Figure 4.1.

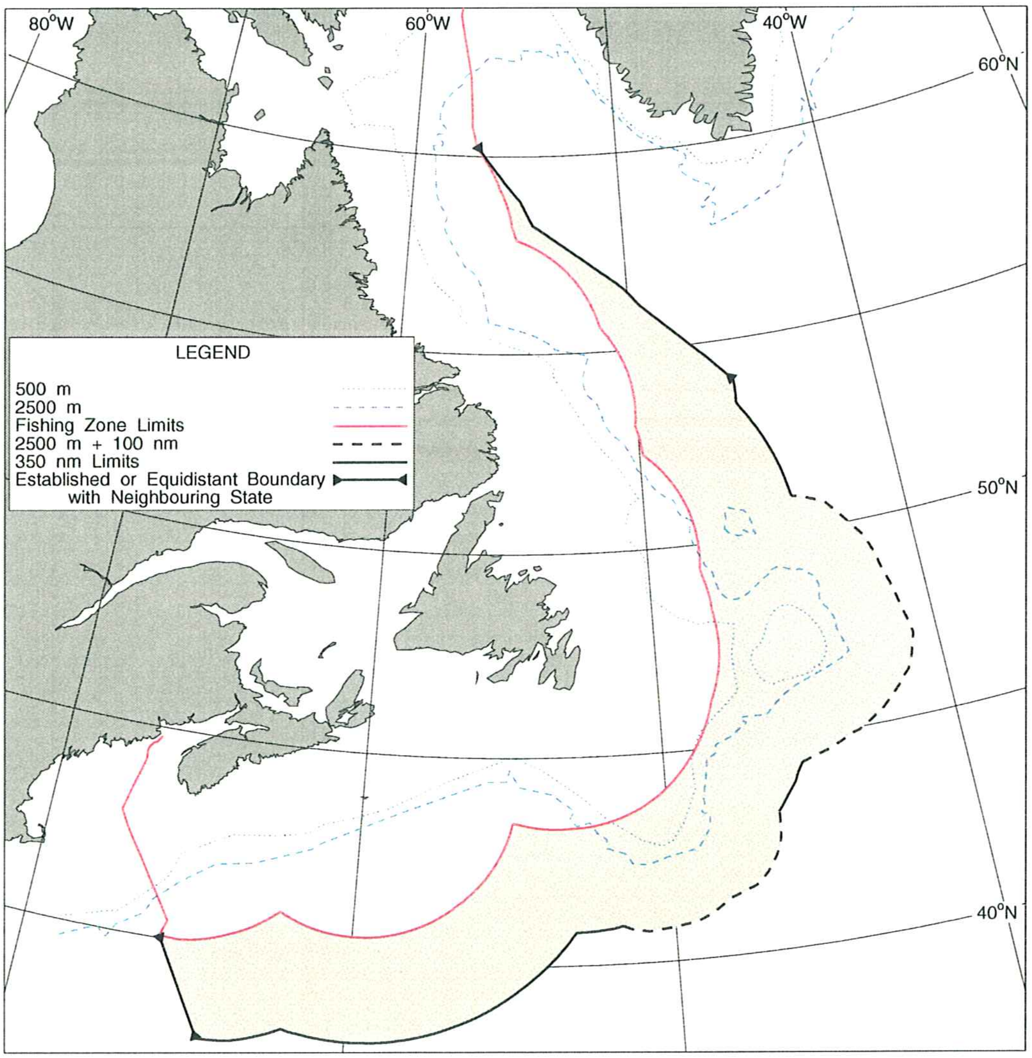
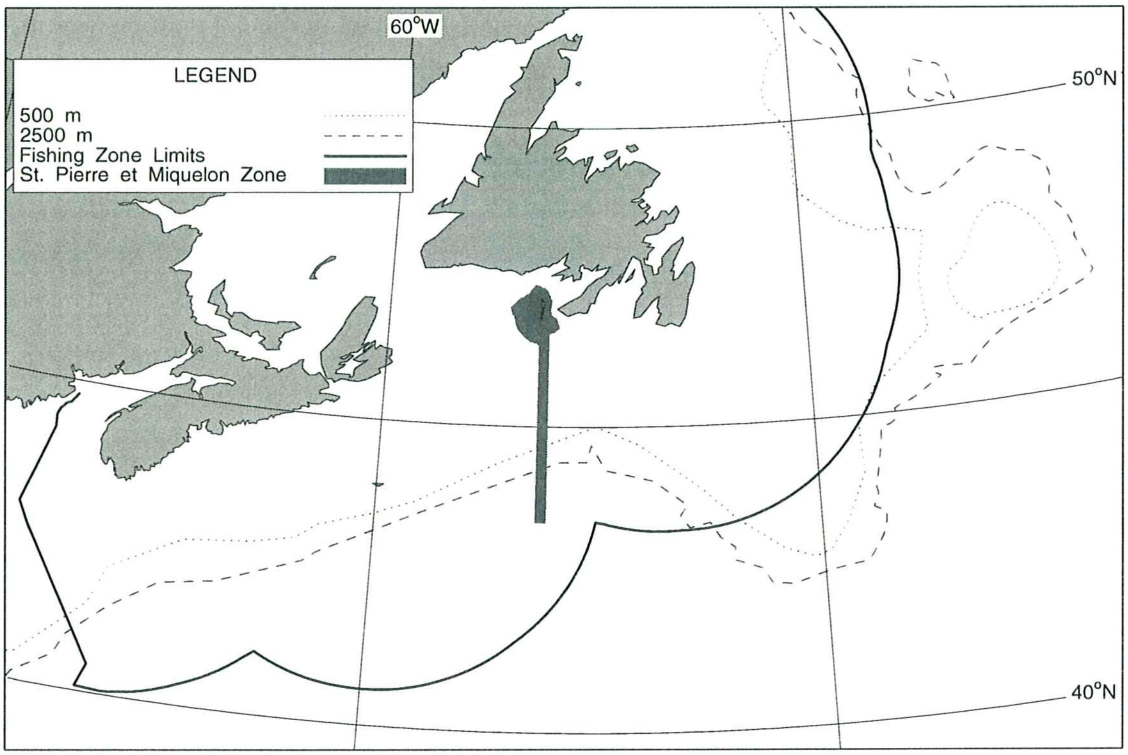


Figure 4.1 *The maximum claimable region beyond 200 nautical miles in the Atlantic under Article 76, according to present information. The outermost bounding line is a composite of three features: line segments located 100 nautical miles seaward of the 2500 metre isobath; arcs defined by the 350 nautical mile limit; and established or equidistant boundaries with neighbouring states.*

Article 76 concerns in the Atlantic region are primarily resource-driven. For the most part, shelf areas on this margin are within relatively easy commercial access: historically, the region has been a prolific provider of seafood, and it now offers the promise of substantial hydrocarbon resources. Within the current state of knowledge, the region beyond 200 nautical miles is therefore considered resource-rich. In the past, Canada has exercised its sovereign rights over these resources through the issuance of exploration permits. Article 76 offers a procedure for determining the limit of the exercise of Canadian sovereign rights through an international instrument.

THE FRENCH MARITIME AREA OFF NEWFOUNDLAND



In an arbitration decision handed down on 10 June 1992, France was awarded exclusive jurisdiction over resources in an area encircling St. Pierre and Miquelon Islands, with a narrow elongation extending 200 nautical miles due south. As shown in the accompanying figure, this extension is contained entirely within Canada's Fishing Zone, and does not pass through any portion of the 200 nautical mile limit that circumscribes the Zone.

Arctic Margin

In contrast, Canada's Arctic margin has a fairly narrow continental shelf, but it features two relatively deep ridge structures oriented perpendicular to the coast and extending well into the Arctic Ocean (Figure 1.2). Current geological evidence supports the case for considering the Alpha Ridge and part of the Lomonosov Ridge as 'submerged prolongations' of the Canadian landmass: the former shows geological affinity with Canada's northernmost island, while the latter appears to be continental in nature. The area to be claimed cannot be larger than the zone illustrated in Figure 4.2.

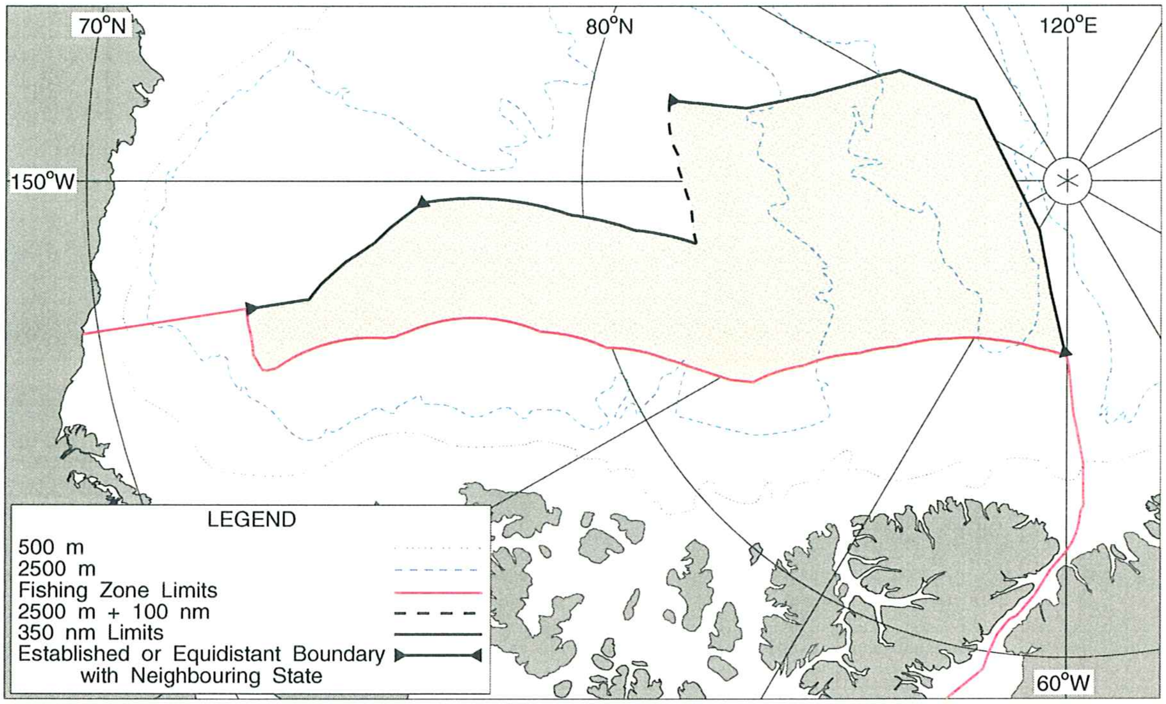


Figure 4.2 *The maximum claimable region beyond 200 nautical miles in the Arctic, according to present information. The outermost bounding line is a composite of three features: line segments located 100 nautical miles seaward of the 2500 metre isobath; arcs defined by the 350 nautical mile limit; and established or equidistant boundaries with neighbouring states.*

Resource access is severely hampered on this margin by the relative depth of the seafloor, by permanent ice cover, and by unfavourable climatic and operating conditions. The region features major offshore sediment basins with good long-term hydrocarbon potential, but it seems clear that their commercial development will have to wait for advances in exploitation technology, and for significant improvements in the global economy. In the short and medium terms therefore, Article 76 interests in this region are not primarily resource-driven.

Article 76 interests in the Arctic, however, may be driven by pressing environmental concerns: with only one deep-water channel linking it to the world ocean, the Arctic Ocean is essentially an enclosed sea that has become a repository of long-lasting toxic wastes, many resulting from disposal practices in nations that border the Arctic and North Atlantic Oceans. The effects of these materials are no respectors of national boundaries: their monitoring and mitigation will require effective international action. To prevent further damage and to initiate remedial measures, Arctic coastal nations may in due course have to establish a regime for protecting and managing their common offshore - a regime that will require clear definitions of each country's zone of interest and responsibility.

5. KNOWN AND POTENTIAL RESOURCES IN THE AREAS AFFECTED

Hydrocarbons of the Atlantic Margin

Oil and natural gas occur in sedimentary basins, and studies confirm the existence of vast basins throughout the entire Atlantic margin from Georges Bank to the northern Labrador Sea (see Wade, in Technical Annex). In many cases there are seaward extensions of basins that occur beneath the physiographic shelves, and which contain proven hydrocarbon resources. Hence their inclusion within Canadian jurisdiction could be of considerable importance.

Several criteria are key to the formation and preservation of hydrocarbons. Thick sedimentary formations with organic-rich beds must be in place to provide a source for the hydrocarbons; over geologic time, these source rocks must have been subjected to sufficient heating to convert their organic matter to petroleum. Porous beds with impermeable top seals are then needed to trap and to retain the hydrocarbons.

Petroleum geological studies of the Atlantic margin reveal that these criteria can exist in four evaluation areas within the maximum claimable area (i.e. between the 200 nautical mile limit, and the bounding line beyond which the juridical continental shelf may not extend, according to present information). The areas are illustrated in Figure 5.1, along with locations of significant hydrocarbon discoveries. Ranking them in descending order according to their relative hydrocarbon potentials, they are: Northeast Newfoundland, Scotian Basin, South Grand Banks, and Labrador Sea.

Northeast Newfoundland

The sedimentary formations in this area are in part contiguous with those of the Jeanne d'Arc Basin, which is located further inshore and is both source and reservoir of about 5 billion barrels of oil and 23 trillion cubic feet of gas. Proximity to these assessed resources greatly improves the probability of hydrocarbon occurrence in the Northeast Newfoundland region.

Scotian Basin

This very large sedimentary basin extends well onto the shallow physiographic continental shelf, where 22 significant oil and gas discoveries have been made to date. Within the prospective zone of jurisdiction, the Basin's large volume of mature sediments offers all the prerequisites for hydrocarbon occurrence and therefore for significant oil and gas reserves.

South Grand Banks

Several small sedimentary basins occur in this area, which has good potential for new hydrocarbon resources. Encompassing the Nose and Tail of the Banks, the region includes at least one significant natural gas discovery. It is, in part, contiguous with the Jeanne d'Arc Basin which sourced and contains about 5 billion barrels of oil and 23 trillion cubic feet of gas.

Labrador Sea

Adjacent to areas with established natural gas resources, this area possesses all the prerequisites, but the probability of hydrocarbon occurrence is less here than in the other areas. This is due primarily to the young age of the sediments, and to the presence of extensive volcanic facies.

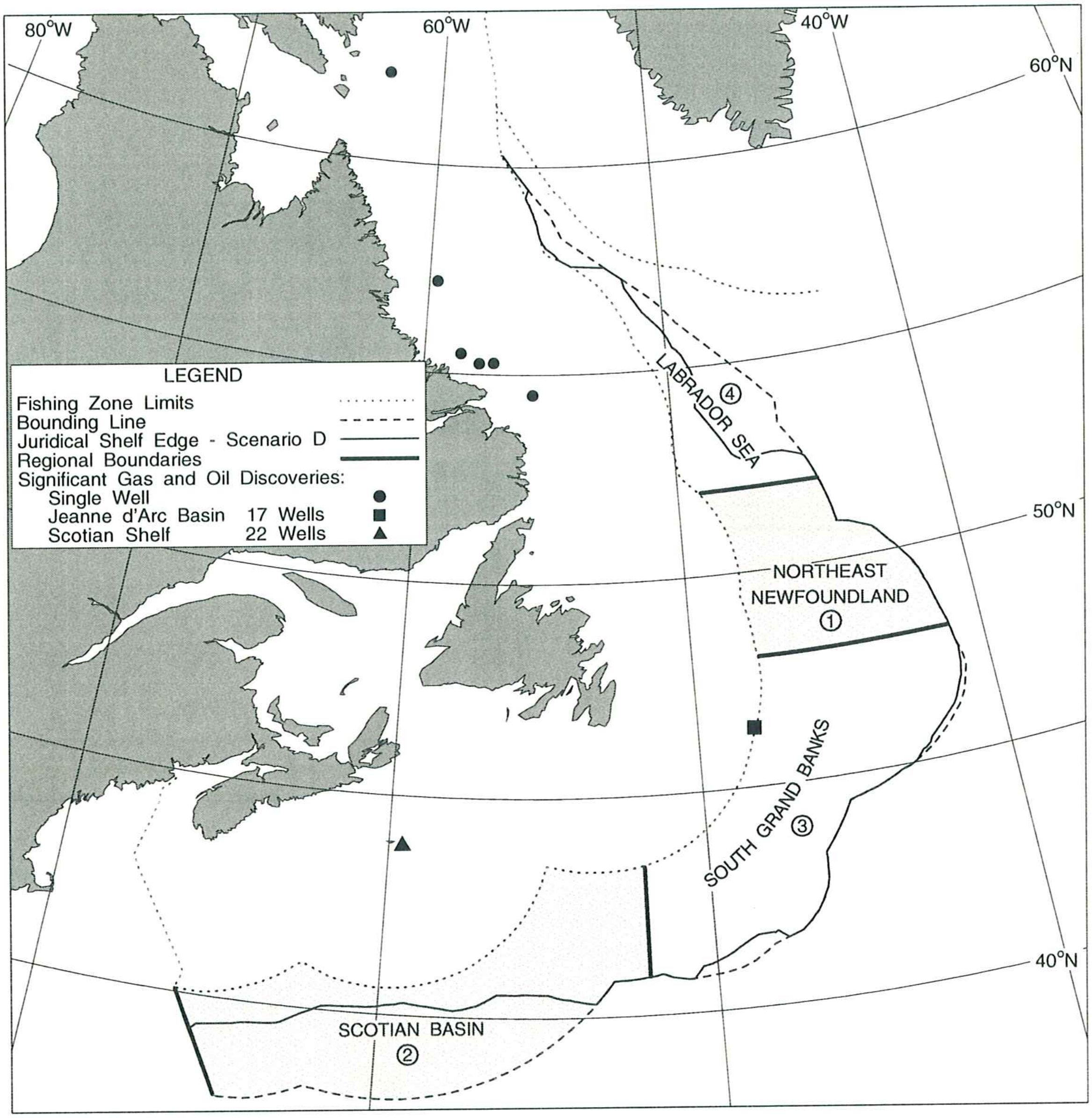


Figure 5.1 *Hydrocarbon evaluation areas and locations of significant gas and oil discoveries. Circled numbers indicate the rankings of the areas in terms of their relative hydro-carbon potential.*

In the Atlantic margin, known and potential hydrocarbon resources offer the primary economic justification for seeking international recognition of Canadian jurisdiction beyond 200 nautical miles.

Gas hydrates of the Atlantic and Arctic Margins

Gas hydrates are a particular form of hydrocarbons that occur globally beneath the world's oceans, and like oil and natural gas may be of considerable economic significance in the extended jurisdiction zone (see Grant, in Technical Annex). Their widespread occurrence has only been appreciated since the late 1970s, with evidence coming principally from seismic data and from sampling by the Ocean Drilling Program.

Gas hydrates are ice-like crystalline solids formed by entrapment of gas molecules in a hydrogen-bonded cage of water molecules. The guest gas molecule in most naturally occurring hydrates is methane. A remarkable property of gas hydrates is that at elevated pressures, they can form at temperatures above the freezing point of water. These conditions prevail off Canada's Arctic and Atlantic margins, where bottom water temperatures are low enough to support the existence of gas hydrates beneath the continental slope and rise, and also beneath the abyssal plain.

Studies on the Atlantic margin of the United States indicate that the methane in gas hydrates is a possible major energy resource. Comparable studies have not been carried out on the Canadian margins, but current knowledge plus an extrapolation of the US studies suggest that the Atlantic seabed in Canada's prospective zone of extended jurisdiction could contain nearly 200,000 trillion cubic feet of gas. Similarly, the seabed in the Arctic could contain up to 150,000 trillion cubic feet. Taken together, these reserves represent sufficient energy to heat one million Canadian homes for about one million years.

Minerals

Worldwide, nine commodities have been, or are being, commercially mined in the offshore. For example, in the UK, marine aggregates account for 15% of the national production. As well, tin from offshore Southeast Asia has historically accounted for 7% of world production.

Some deposits of clay, sand and gravel that occur on the seafloor in shallow waters within tens of kilometres of Canada's coastline are commercially valuable because of their quality or the other minerals that they contain. Several tens of proposals have been made to develop gold, sand, gravel, and heavy mineral deposits offshore of Nova Scotia, Prince Edward Island, Newfoundland, Quebec and British Columbia, but agreement over a joint management approach is needed before these can be implemented. A cursory estimate is that two to ten mines could be developed over the next five to ten years, mostly in Atlantic Canada, with gross revenues of $30 to $450M, employing 150 to 300 persons.

In all the cases cited, the mineral resources that have been identified are confined to the continental shelf, relatively close to shore and would not be affected by Canada's ratification or otherwise of the Law of the Sea Convention.

Beyond the edge of the continental shelf the principal mineral resources of value that could fall within national jurisdiction are "manganese nodules". It is unlikely that there would be a significant quantity of this resource within the zone of potentially uncertain jurisdiction close to the seaward limit claimable under Article 76. The greatest benefit would probably be gained through exploitation by Canadian industry of the seabed minerals in the international "area" beyond the zones of national jurisdiction.

Fisheries of the Atlantic Margin

Article 77 of the Convention defines the living resources that can be exploited by the coastal state beyond 200 nautical miles as "living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or subsoil". In addition, Articles 118, 145, and 192 of the Convention describe the responsibilities of coastal states with respect to fisheries and environmental management in the areas beyond 200 nautical miles.

Only limited information is available on the living and ecological resources of the slope, rise, and deeper areas of the continental margin; a comprehensive research program has been proposed to assess the region's potential (see Rowell, in Technical Annex). The following summary of existing resources is not comprehensive, and is only intended to provide a general overview of the apparent level of available information. In view of the responsibilities that would devolve upon Canada for fisheries and environmental management, species are included which may have commercial potential, and that are essentially bottom-dwelling although not in constant contact with the seabed. Also important to consider are a wide variety of species lacking direct commercial potential but of great significance both as food web resources and to the environment and seabed habitats: polychaete worms, echinoids, molluscs, etc. No information on these were readily available for inclusion in this document.

Georges Bank and Scotian Margin Region

In this region, the 200 mile limit is well seaward of the shelf edge, and any extension would be in waters of the slope and rise. Most fisheries for benthic invertebrate species are conducted in coastal waters or on the shelf in depths of less than 200 m. Only two species have been commercially fished on the upper slope: the American lobster *(Homarus americanu)* and the deepsea red crab *(Chaceon (Geryon) quinquedens).* These are further described in the Technical Annex.

There are presently no fisheries for benthic invertebrate species on the deep slope regions. The fisheries potential for deepwater species of both fish and invertebrates are reviewed in the Technical Annex (Rowell). In all cases, detailed information on distribution and abundance are lacking, making it difficult to assess their commercial potential. Entirely bottom-dwelling species with greatest fishery potential include: the crabs *Lithodes maja* (northern stone crab), *Neolithodes grimaldii* (porcupine stone crab), and *Chionecetes opilio* (snow crab); and the lobsters *Munis valida, Polycheles granulatus* and *Stereomastis sculpta.* See also the Technical Annex.

Grand Banks and Labrador Shelf Region

Information is not available on exploitable species in this region.

6. EXISTING DATA BASES FOR JURIDICAL SHELF DELINEATION

Atlantic Margin

Bathymetry

A considerable body of information exists on the Atlantic margin (Figure 6.1), acquired mostly during systematic survey operations mounted by agencies of the Canadian Government beginning in the early 1960s. Supplementary data sets have been collected by commercial and academic organizations from Canada and other nations. The quality and distribution of these observations are very uneven: many were collected in the time prior to the UN Convention, with no particular attention being paid to seabed features relevant to Article 76.

The data base is probably adequate for foot of slope determination in some areas. Determining the 2500 metre isobath may be problematic in all areas, because measurements were made with old technology featuring poor to non-existent velocity control, with wide beam echo sounders that ensonified wide swaths on the seafloor and which were therefore constrained to derive average depths within their large 'footprints'. This data base needs to be upgraded in selected areas through the collection of new data by means of modern multibeam technology.

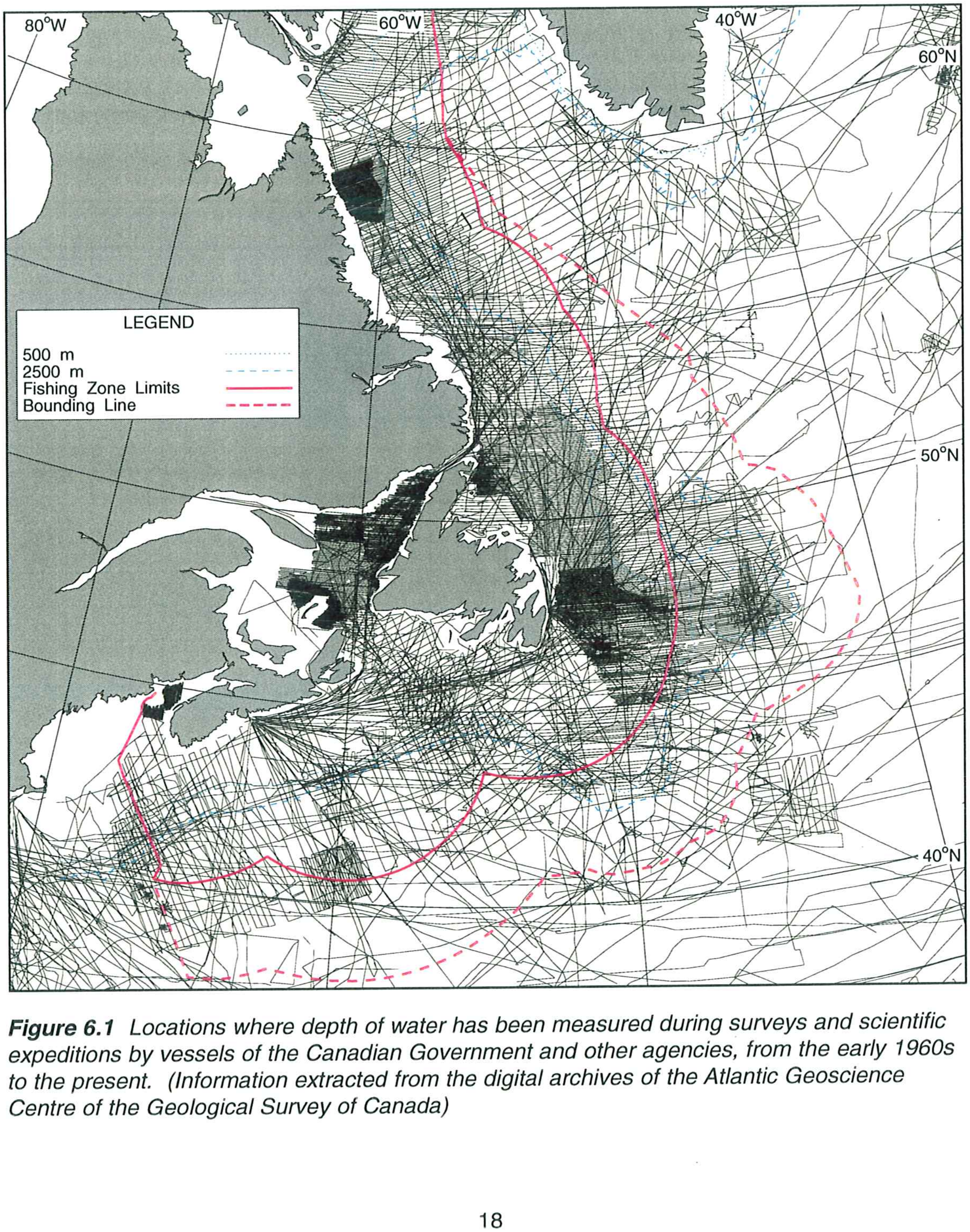


Figure 6.1 *Locations where depth of water has been measured during surveys and scientific expeditions by vessels of the Canadian Government and other agencies, from the early 1960s to the present. (Information extracted from the digital archives of the Atlantic Geoscience Centre of the Geological Survey of Canada)*

Sediment thickness

Compared to the body of assembled observations over the shallower parts of the margin, seismic measurements are not plentiful in the deeper waters of the outer margin (Figure 6.2). The data have been acquired by a variety of academic, government, and commercial organizations, from Canada and elsewhere. Measurements represent a mix of single- and multi-channel reflection seismic observations, with refraction profiles executed in certain key areas.

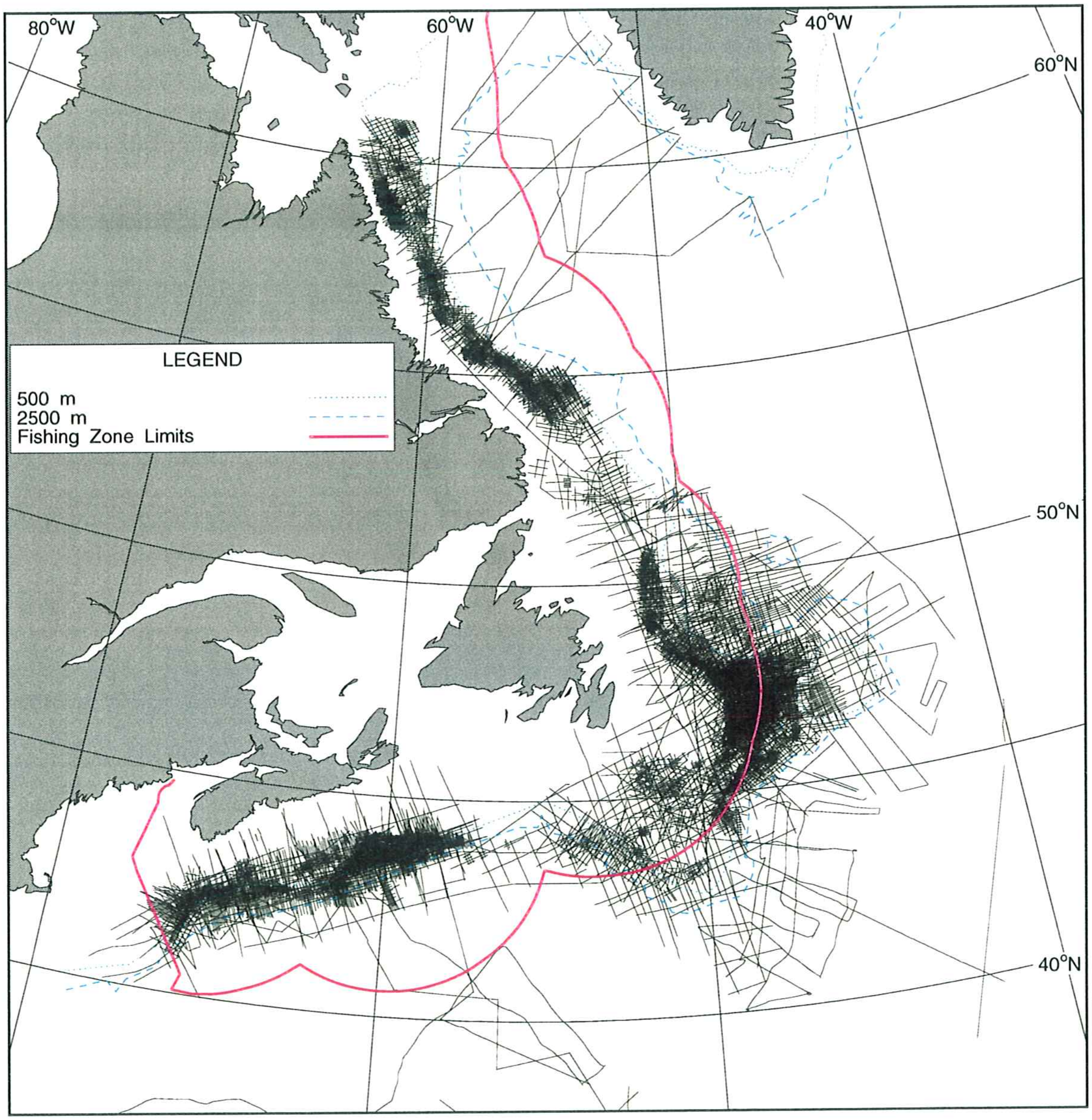


Figure 6.2 *Locations where seismic reflection data have been collected during multichannel surveys by vessels operating for the most part on behalf of the gas and oil industry; most data were collected during the 1970s and early 1980s. (Information extracted from the digital archives of the Atlantic Geoscience Centre of the Geological Survey of Canada)*

Most of the single-channel profiles fail to show acoustic basement, and cannot be used for Article 76 purposes. Quality and distribution of the remaining data are very uneven. This data base needs upgrading in most areas beyond 200 nautical miles through the systematic acquisition of new multichannel information.

Figure 6.3 illustrates a provisional data base that describes the thickness of sediment off the Atlantic margin (see Oakey and Stark, in Technical Annex). In deeper waters, this data base has only limited suitability for Article 76 purposes because it was not derived from a well-controlled set of seismic profiles (compare with Figure 6.2), but from a compilation that assembled material from many different sources that were non-uniform in terms of quality, distribution, and accuracy. Much of this material consisted of published and unpublished maps that portrayed sparse data and/or speculative interpretations; measurements of sedimentary sound velocities are non-existent in many areas, for instance, or are based on sketchy information.

Arctic Margin

Bathymetry

Given the impracticability of ship operations in the permanent polar pack, most observations consist of spot soundings taken through the ice by helicopter-transported surveyors (Figure 6.4). Measurements were made for the most part with portable echo sounders that featured low power and wide beams; consisting of average depths from their large ensonified footprints, these observations are isolated from other soundings, and so provide only a limited indication of seabed morphology.

The quality and distribution of these observations is uneven: the data base may be adequate for locating the foot of slope and the 2500 metre isobath in some areas. With due regard for the difficulties of bathymetric mapping in this region and to the extent permitted by the available technology, the data base needs upgrading in the deeper waters off the Queen Elizabeth Islands and over the Alpha and Lomonosov Ridges.

Sediment thickness

Canadian observations in the region of interest are scarce, consisting for the most part of seismic refraction profiles over Alpha and Lomonosov Ridges (Figure 6.5).

Given the paucity of information in public Western archives, it may be feasible to try accessing the large data base said to be amassed by agencies of the Former Soviet Union in the decades following the Second World War. For a variety of reasons, the Russians have yet to disclose fully the nature, extent, and quality of their holdings, but it is reasonably certain that they possess a tremendous amount of data that is germane to Canadian interests in domains relating to Article 76, as well as to fundamental earth science. Various data-rescue operations have been proposed or initiated by Western groups with a view to assessing the contents of these Russian holdings, and to providing assistance in their preservation and dissemination to the world scientific community.

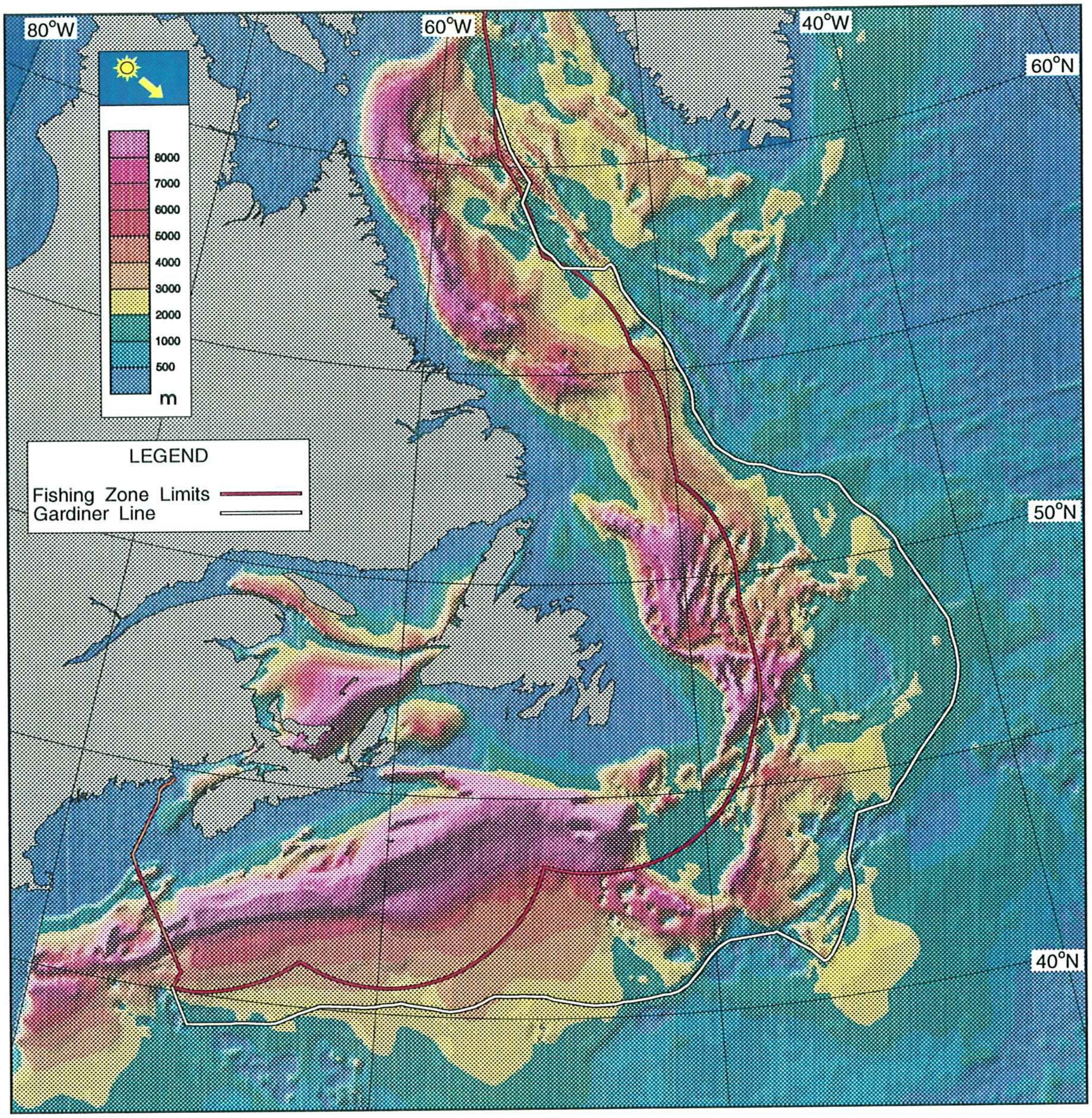


Figure 6.3 *Provisional map showing thickness of sediment beneath the sea bed, compiled from published and unpublished material and illustrating the type of information needed for determining the location of the Gardiner Line. The map offers a general impression of sediment distribution in the Atlantic margin, but there are uncertainties on account of: (a) the many different techniques and assumptions that were used in preparing the original source material; and (b) unknown variations of sound velocity in the region's sediments. Compare with Figure 6.2, which shows the locations of known multichannel profiles. (Map prepared from a data base created at the Atlantic Geoscience Centre of the Geological Survey of Canada; see Oakey and Stark, in Technical Annex)*

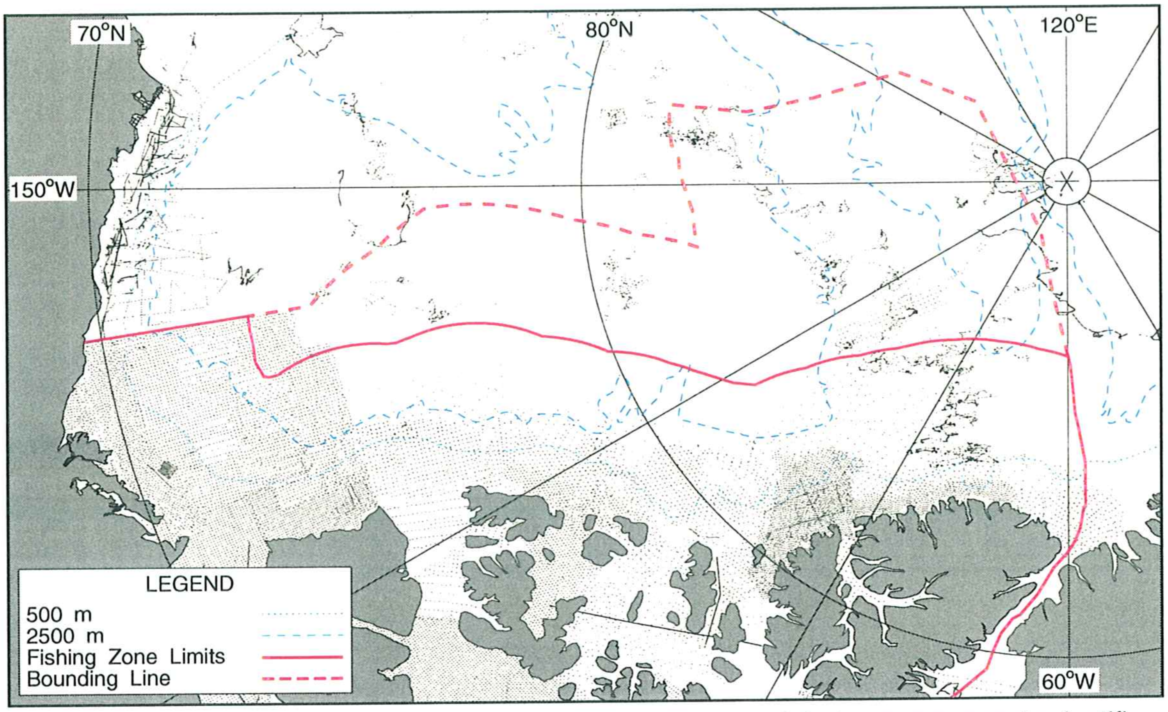


Figure 6.4 Locations where depth of water has been measured during surveys and scientific expeditions by Canadian Government and other agencies, from the 1960s to the present. (Information extracted from the digital archives of the Geophysics Division of the Geological Survey of Canada)

7. CONCLUSIONS

Benefits of Article 76 to Canada

Article 76 of the UN Convention on the Law of the Sea empowers Canada to claim resource jurisdiction over portions of its wide continental margins beyond 200 nautical miles in the Atlantic and Arctic Oceans. Over one million square kilometres in the Atlantic, and nearly three-quarters of a million square kilometres in the Arctic, could be added to Canada's claim to the continental margin beyond 200 nautical miles. This represents an area nearly equal to the three Prairie Provinces.

For Canada, a decision to proceed with the delineation of new limits of the juridical continental shelf could result in two significant benefits: (1) international recognition of resource jurisdiction over substantial portions of the seafloor beyond 200 nautical miles; and (2) formal authority for dealing effectively with environmental issues in the high seas adjacent to the nation's zones of economic interest.

Unknowns

The locations of potential new limits are only provisionally known at this time, as they have been derived from preliminary assessments of incomplete data sets. Substantial work remains to be done: (1) in assembling and rationalizing all remaining information into a coherent data base; and (2) in analyzing the resulting body of information with the purpose of providing a more objective delineation of the edge of the juridical continental shelf.

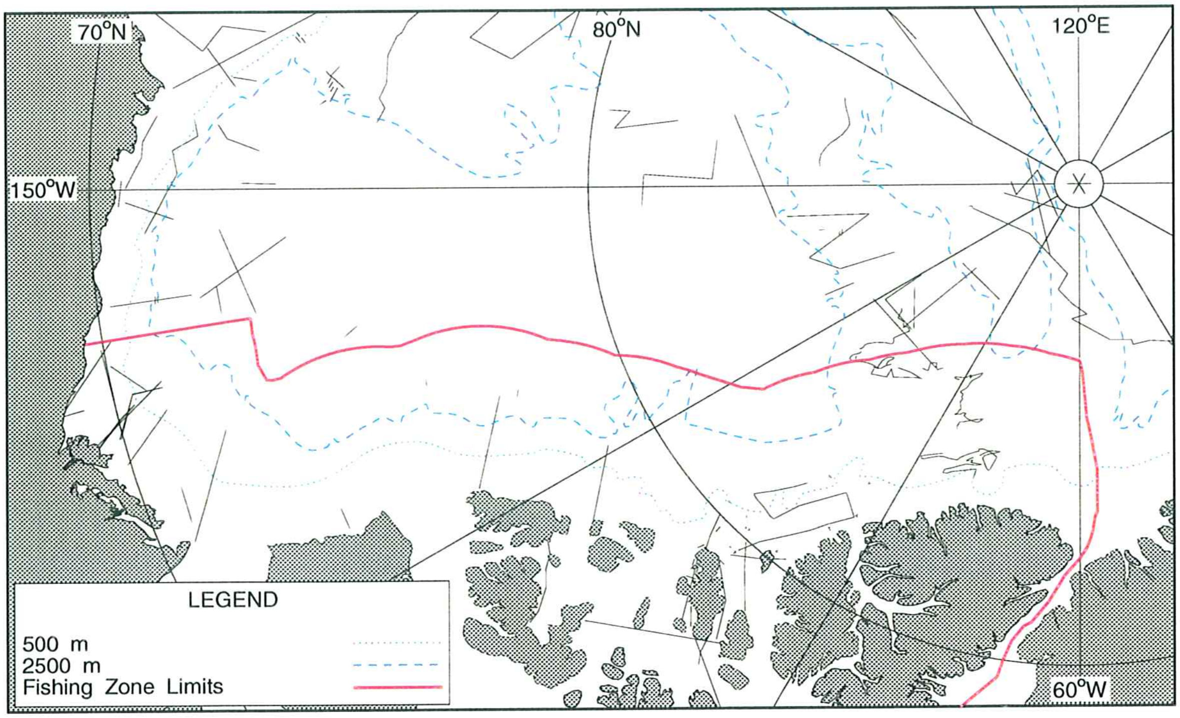


Figure 6.5 *Locations of seismic refraction experiments performed by agencies of the Canadian Government, operating from camps established on the permanent polar pack ice. (Information extracted from the digital archives of the Atlantic Geoscience Centre of the Geological Survey of Canada)*

At this juncture, we possess a mixed knowledge of the resource potential of the extended shelf areas, due to uneven and incomplete programs for appraising the different types of resources. For instance, our quantitative knowledge of the hydrocarbon potential is fairly good in the Atlantic margin on account of a long-standing program for assessing the gas and oil reserves in this region: there are clear indications that claiming jurisdiction to the limit permitted by Article 76 will considerably improve Canada's position in the respect. Except for the Beaufort Sea, our equivalent knowledge in the Arctic is poor to zero. The potential for gas hydrates is very promising in both the Atlantic and the Arctic, but it is based on general formulae that have been derived from their inferred occurrence in other parts of the world.

Under the terms of Article 76, the exploitable fishery is restricted to bottom-dwelling species with a number of restrictions. In the Atlantic, this potential is only partially understood because: (1) the ecology and populations of the extended shelf are poorly known; and (2) the Canadian fishing industry does not have a strong history of harvesting the allowable species in the deeper waters of the extended shelf. In the Arctic, we have practically no understanding of the potential because the region has never supported a commercial fishery.

Deep-sea mineral resources remain an unknown quantity in the extended shelf area, in large part because the worldwide downturn in mining has provided next to no incentive for prospecting the offshore for potential new deposits.

8. CITATIONS

Gardiner, P. R. R. 1978. Reasons and methods for fixing the outer limit of the legal continental shelf beyond 200 nautical miles. Iranian Review of International Relations, Nos. 11-12, Spring 1978, p. 145-170.

Hull, P., Carrera, G., and Macnab, R. 1989. The territorial sea baselines and fishing zone limits of Canada, in digital form. GSC Open File 2000, Geological Survey of Canada, Dartmouth, Nova Scotia, 14 p.

Royal Society. 1982. A guide to the provisions of the 1982 United Nations Convention on the Law of the Sea relating to marine scientific research, p. 25. [Reproduced in International Hydrographic Organization, A Manual on Technical Aspects of the United Nations Convention on the Law of the Sea, 1982, 2nd edition (Monaco: International Hydrographic Bureau, 1990), p. 110.]

Appendix A

ARTICLE 76 OF THE LAW OF THE SEA: DEFINITION OF THE CONTINENTAL SHELF

1. The continental shelf of a coastal State comprises the sea-bed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance.

2. The continental shelf of a coastal State shall not extend beyond the limits provided for in paragraphs 4 to 6.

3. The continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the sea-bed and subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof.

4. a) For the purposes of this convention, the coastal State shall establish the outer edge of the continental margin wherever the margin extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by either:
   (i) a line delineated in accordance with paragraph 7 by reference to the outermost fixed points at each of which the thickness of sedimentary rocks is at least 1 percent of the shortest distance from such point to the foot of the continental slope; or
   (ii) a line delineated in accordance with paragraph 7 by reference to fixed points not more than 60 nautical miles from the foot of the continental slope.
   b) In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient at its base.

5. The fixed points comprising the line of the outer limits of the continental shelf on the sea-bed, drawn in accordance with paragraph 4 (a) (i) and (ii), either shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured or shall not exceed 100 nautical miles from the 2,500 metre isobath, which is a line connecting the depth of 2,500 metres.

6. Notwithstanding the provisions of paragraph 5, on submarine ridges, the outer limit of the continental shelf shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured. This paragraph does not apply to submarine elevations that are natural components of the continental margin, such as its plateaux, rises, caps, banks and spurs.

7. The coastal State shall delineate the outer limits of its continental shelf, where that shelf extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by straight lines not exceeding 60 nautical miles in length, connecting fixed points, defined by coordinates of latitude and longitude.

8. Information on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted by the coastal State to the Commission on the Limits of the Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendations to coastal States on matters related to the establishment of the outer limits of their

continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.

9. The coastal State shall deposit with the Secretary-General of the United Nations charts and relevant information, including geodetic data, permanently describing the outer limits of its continental shelf. The Secretary-General shall give due publicity thereto.

10. The provisions of this article are without prejudice to the question of delimitation of the continental shelf between States with opposite or adjacent coasts.

Appendix B

CHRONOLOGICAL ORDER OF THE FIRST SIXTY RATIFICATIONS OF OR ACCESSIONS TO THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

	Date	State/Entity		Date	State/Entity
1.	10 Dec 1982	Fiji	31.	25 Aug 1986	Guinea-Bissau
2.	07 Mar 1983	Zambia	32.	26 Sep 1986	Paraguay
3.	18 Mar 1983	Mexico	33.	21 Jul 1987	Yemen
4.	21 Mar 1983	Jamaica	34.	10 Aug 1987	Cape Verde
5.	18 Apr 1983	Namibia	35.	03 Nov 1987	Sao Tome/Principe
6.	07 Jun 1983	Ghana	36.	12 Dec 1988	Cyprus
7.	29 Jul 1983	Bahamas	37.	22 Dec 1988	Brazil
8.	13 Aug 1983	Belize	38.	02 Feb 1989	Antigua and Barbuda
9.	26 Aug 1983	Egypt	39.	17 Feb 1989	Zaire
10.	26 Mar 1984	Cote d'Ivoire	40.	02 Mar 1989	Kenya
11.	08 May 1984	Philippines	41.	24 Jul 1989	Somalia
12.	22 May 1984	Gambia	42.	17 Aug 1989	Oman
13.	15 Aug 1984	Cuba	43.	02 May 1990	Botswana
14.	25 Oct 1984	Senegal	44.	09 Nov 1990	Uganda
15.	23 Jan 1985	Sudan	45.	05 Dec 1990	Angola
16.	27 Mar 1985	Saint Lucia	46.	25 Apr 1991	Grenada
17.	16 Apr 1985	Togo	47.	29 Apr 1991	Micronesia (Fed. States of)
18.	24 Apr 1985	Tunisia	48.	09 Aug 1991	Marshal Islands
19.	30 May 1985	Bahrain	49.	16 Sep 1991	Seychelles
20.	21 Jun 1985	Iceland	50.	08 Oct 1991	Djibouti
21.	16 Jul 1985	Mali	51.	24 Oct 1991	Dominica
22.	30 Jul 1985	Iraq	52.	21 Sep 1992	Costa Rica
23.	06 Sep 1985	Guinea	53.	10 Dec 1992	Uruguay
24.	30 Sep 1985	Tanzania	54.	07 Jan 1993	St. Kitts and Nevis
25.	19 Nov 1985	Cameroon	55.	24 Feb 1993	Zimbabwe
26.	03 Feb 1986	Indonesia	56.	20 May 1993	Malta
27.	25 Apr 1986	Trinidad/Tobago	57.	01 Oct 1993	St. Vincent, the Grenadines
28.	02 May 1986	Kuwait	58.	05 Oct 1993	Honduras
29.	05 May 1986	Yugoslavia	59.	12 Oct 1993	Barbados
30.	14 Aug 1986	Nigeria	60.	16 Nov 1993	Guyana

Appendix C

CANADA'S OFFSHORE AND ONSHORE REGIONS: AREA COMPARISONS

Offshore areas
(millions of square kilometres)

< 200 nautical miles:		
Pacific	.42	
Arctic	1.05	
Atlantic (incl Hudson Bay, Gulf St. Lawrence)	3.15	
Sub-total		4.62
> 200 nautical miles (max. claimable area)		
Arctic	.73	
Atlantic	1.03	
Sub-total		1.76
TOTAL OFFSHORE AREA		6.38

Onshore areas
(millions of square kilometres)

Atlantic Provinces	.54	
British Columbia	.95	
Ontario	1.07	
Quebec	1.54	
Prairie Provinces	1.96	
Yukon and Northwest Territories	3.91	
TOTAL ONSHORE AREA		9.97

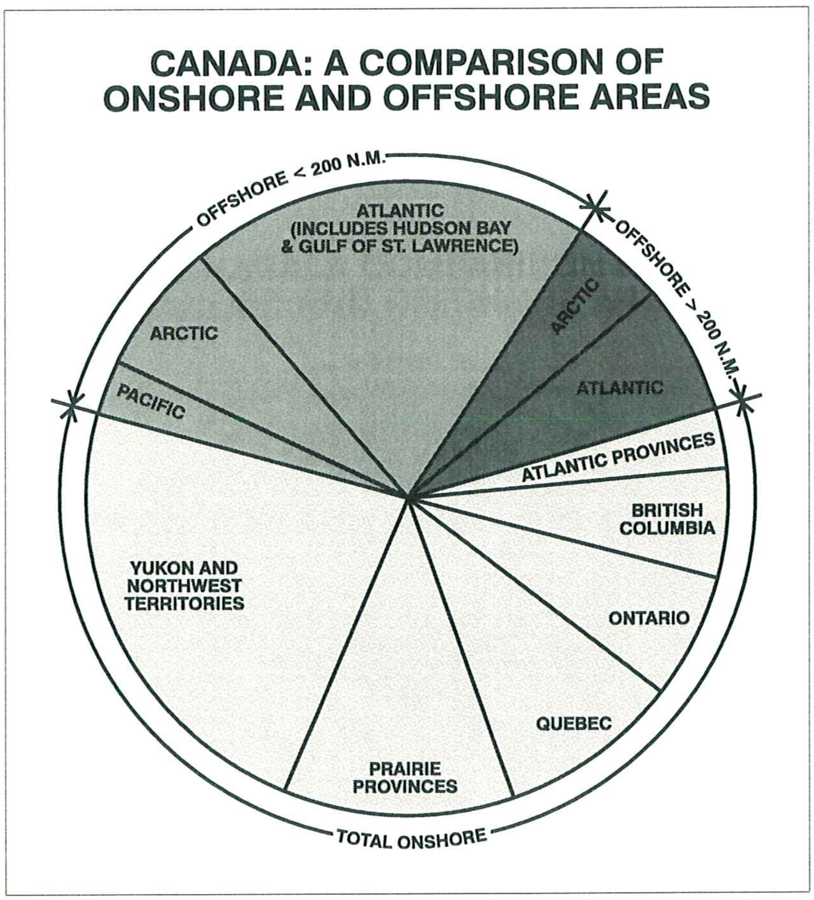


Figure C.1 *A provisional calculation based on existing information shows that the total size of the zone of jurisdiction beyond 200 nautical miles in the Arctic and Atlantic Oceans would cover an area nearly equal to Canada's Prairie Provinces.*

Appendix D

CANADA'S TERRITORIAL SEA BASELINES, THE 200 NAUTICAL MILE LIMIT AND THE FISHING ZONE LIMIT

The territorial sea baselines of Canada consist of: (1) straight lines that join listed points on the mainland coast or on offlying islands, reefs, and islets; and (2) curved lines that trace the low-water line along selected coastal segments. These baselines are used to define two legal limits: (1) the outer limit of the territorial sea; and (2) the 200 nautical mile limit (Figure D.1).

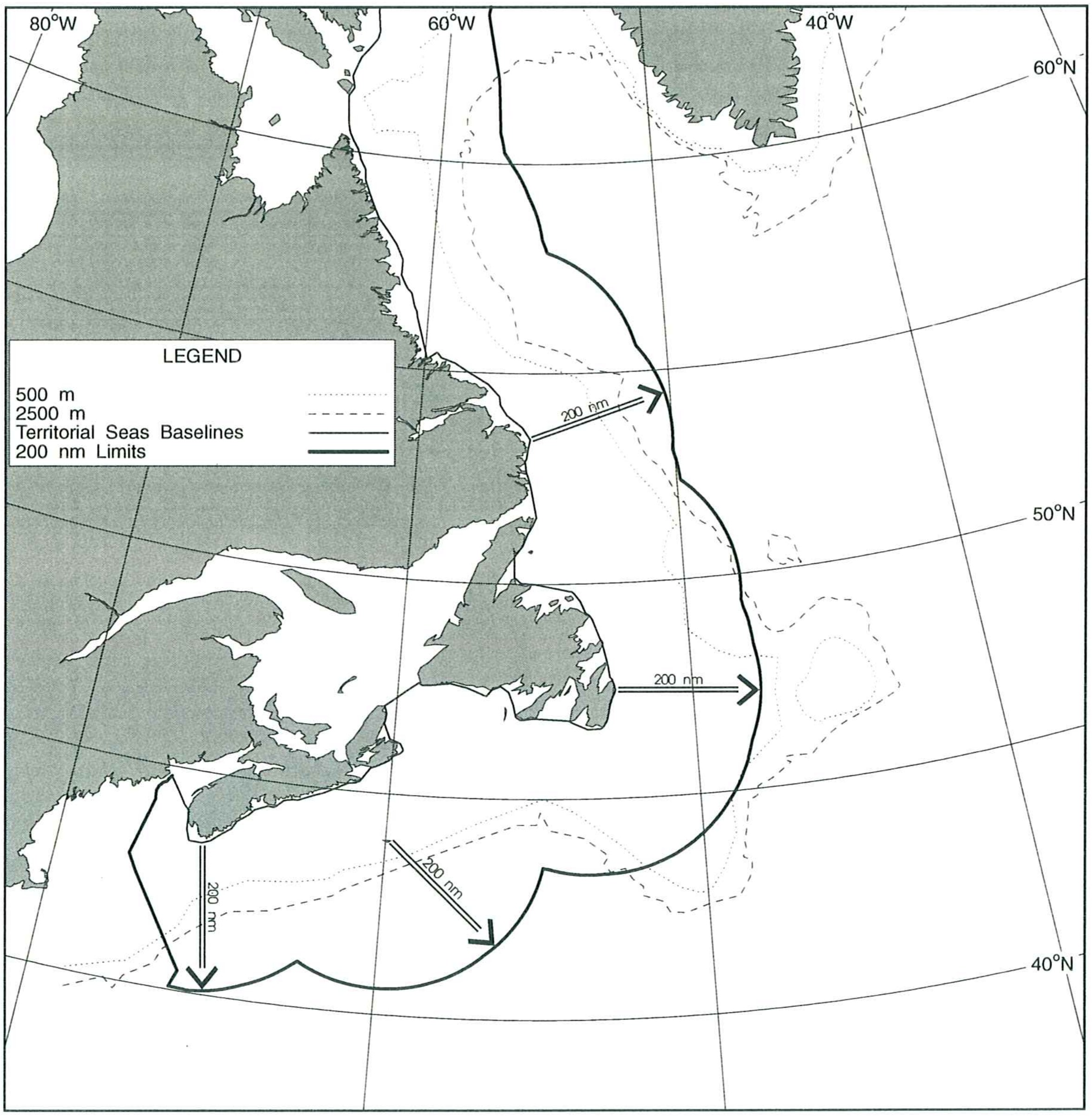


***Figure D.1** Relationship between the territorial sea baselines and the 200 nautical mile limit*

The territorial sea is a belt of water 12 nautical miles wide, measured seaward from the baselines. Subject to the rules of international law, Canada's sovereignty extends to the outer limit of the Territorial Sea, to its sea-bed and subsoil, and to the air space above it.

The 200 nautical mile limit consists of: (1) arcs of 200 mile circles centred on listed points on the mainland coast or on offlying islands, reefs, and islets; and (2) lines that are everywhere 200 nautical miles distant from the nearest points on selected segments of the territorial sea baseline. In certain regions, these lines are linked to straight or geodetic lines that join listed points in constricted waters or along bilateral boundaries. Taken together, the lines define the outer limits of the Fishing Zones where Canada exercises exclusive control over fisheries. It is important to note that Fishing Zones are not equivalent to Exclusive Economic Zones (EEZs).

In the context of Article 76, the territorial sea baselines are also used to define the 350 nautical mile limit: this is combined with two other parameters - a line 100 nautical miles beyond the 2500 metre contour, and bilateral/equidistant boundaries with neighbouring nations - to define a bounding line that circumscribes the maximum extent of the juridical continental shelf.

Legal descriptions of the above listed points and selected coastal regions are promulgated as lists of geographic co-ordinates in Government Orders-in-Council, or as graphical depictions on charts published by the Canadian Hydrographic Service; see Hull et al. (1989) for a compilation of sources.

Appendix E

THE FOOT OF THE CONTINENTAL SLOPE

The procedure for determining the location of the foot of the continental slope is open to uncertainty because the seafloor in this particular zone may take on a rugged aspect, with slumps, channels, and other features originating from a variety of processes. As portrayed in successive profiles perpendicular to the foot of the slope, the size and distribution of these features vary considerably along each profile, and from profile to profile. Moreover, the wording "in the absence of evidence to the contrary" implies that other criteria, such as the geometry of sub-bottom structures, may be applied in locating the foot of the slope.

Article 76 offers no practical guidance on how to determine where the maximum change of slope occurs. It is not clear whether the regional change is significant, or small local perturbations in the general slope. Figure E.1 shows how the location of the maximum gradient change can be affected by local and regional factors. Clearly the scale of the analysis has an important bearing on the outcome of the interpretation. Nor does Article 76 stipulate what to do when a maximum change in gradient is observed at two or more points along a profile, or when there is a rise and subsequent fall in the slope, with an inner and an outer change of maximum gradient.

The lack of such criteria for resolving these questions leads to a range of possible locations for the foot of the slope. This is illustrated in Figure E.2, which portrays the results of two unpublished analyses on the Atlantic margin, by Somers in 1983 and Gray in 1993 (both in Technical Annex). In both studies, bathymetric profiles were extracted from existing charts and examined to detect points of maximum gradient change: the lack of agreement between the two resulting foot of slope lines is indicative of variations between information sources, as well as the investigators' different interpretive criteria. The shaded zone illustrates a range of possible locations for the foot of the slope derived by Somers. Analysis of a different data set, or analysis by a different investigator, could well place the foot of the slope (and hence the outer limit of the continental shelf) in another location.

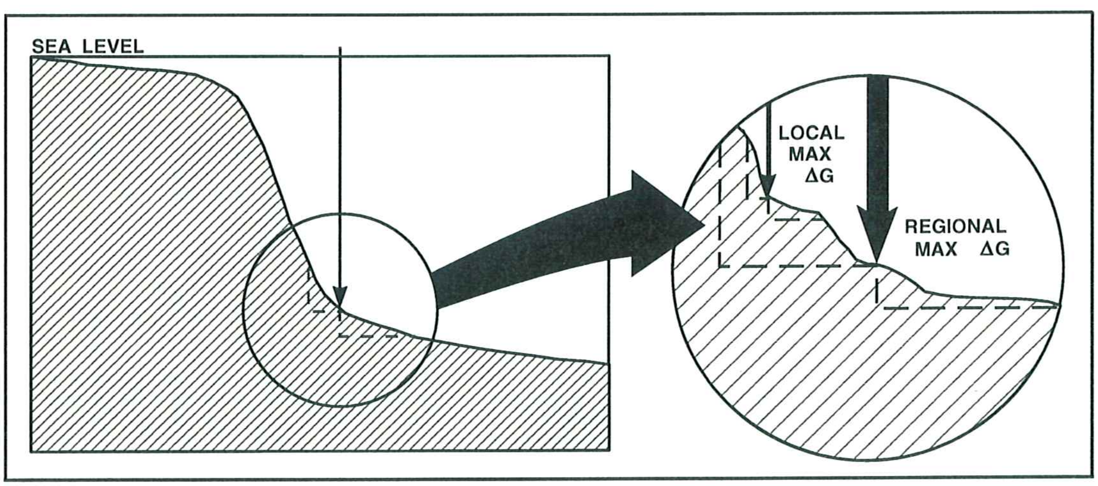


Figure E.1 *The foot of the continental slope is defined as the location of the maximum change on bottom gradient. As shown in the enlarged section, this location may vary according to the range over which the gradient is calculated, i.e. the feature may be determined on a local basis (thin arrow) or a regional basis (thick arrow).*

An investigation (see Vanicek, Wells and Hou, in Technical Annex) examined the feasibility of using digital depth information to determine the foot of the slope through a semi-automatic process based on well defined mathematical and geometric criteria. Their work has revealed that analysis of a highly detailed data set does not necessarily lead to an improved determination of the foot of the slope: rather it tends to contribute to the ambiguity of the situation by identifying many small, disconnected features that fail to trace a continuous foot of slope. A more promising approach is first to generalize the depth information by a process of numerical filtering that removes small local features, and then to process the remaining information that incorporates only the regional bathymetric variations. More work is needed to develop criteria for separating 'local' from 'regional'.

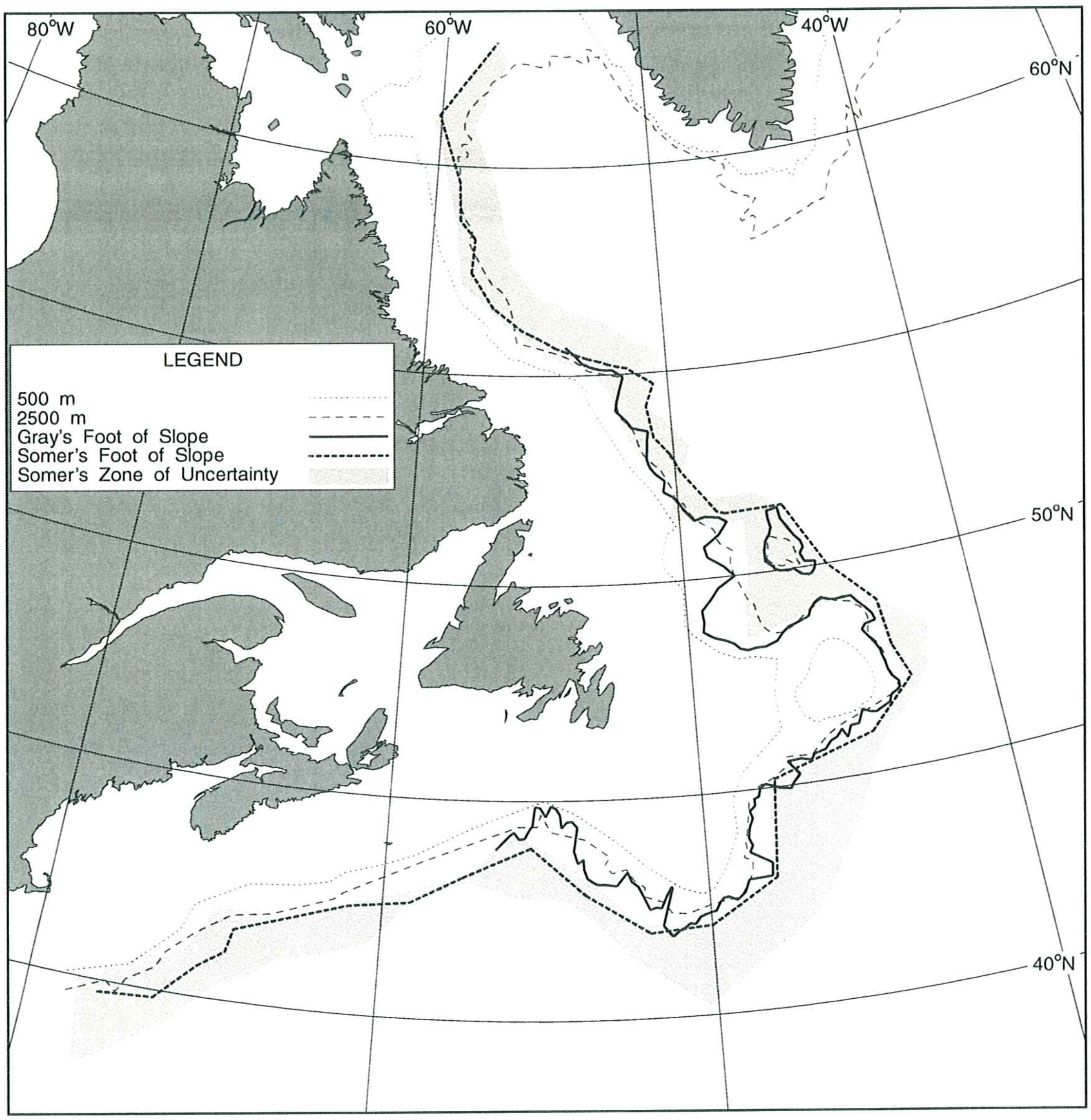


Figure E.2 *Differences between two versions of the foot of the continental slope (and the zone of uncertainty for one of them) illustrate how different interpretive criteria can affect the inferred location of this feature. Errors in locating the foot of the slope can seriously impact the determination of the outer limit of the Juridical Continental Shelf.*

Appendix F

THE GARDINER LINE

The location of the Gardiner Line is defined by a series of straight lines joining fixed points no more than 60 nautical miles apart, with each fixed point designating a location where sediment thickness equals one percent of the distance back to the foot of the slope. This concept is based on the assumption that the sediment layer has a more or less wedge-shaped cross-section, with its thick end lying near the foot of the slope and its thin end at some distance seaward.

There are three significant problems with this method of defining the Gardiner Line. The first reflects an inherent limitation in the seismic reflection technique, which requires a reasonably accurate knowledge of the velocity of sound in sediment for converting observed acoustic travel times to reliable values of sediment thickness. In most instances, the velocity of sound is not perfectly known, which can translate into significant uncertainties in the measurement of sediment thickness.

The second problem is to distinguish between sediment and underlying crystalline basement. On many seismic profiles, it is difficult to tell the difference between types of material: both rock types may occur together in some stratigraphic units, with overlap in the ranges of their sound velocities. The practical issue is to decide which horizon on the seismic record represents the true base of sediment.

The third problem is to select the one percent point in a seismic record that portrays a rugged basement. On many profiles, the basement offers an aspect reminiscent of buried mountain ranges, and it then becomes necessary to decide whether to measure sediment thickness at the peaks of the mountains, in the valleys, or at some arbitrarily defined reference surface. This particular problem may be appreciated from an examination of Figure F.1.

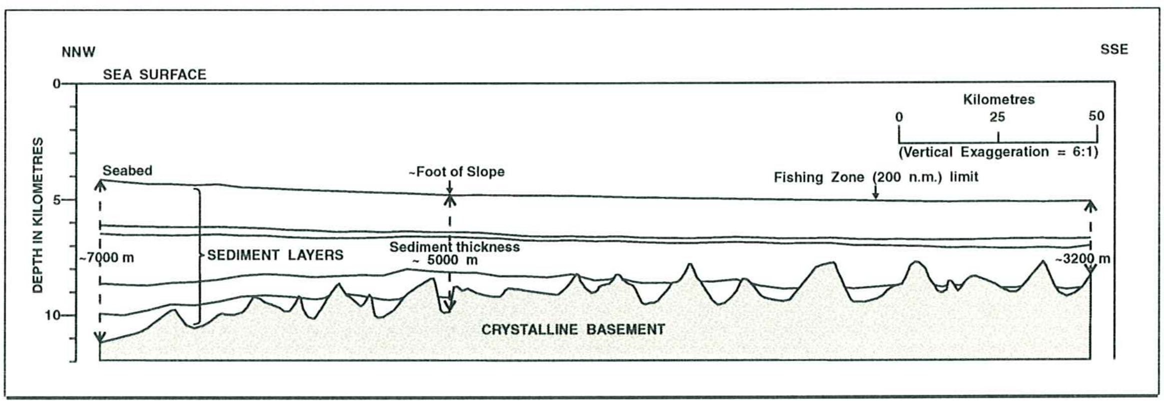


Figure F.1 *Representative profile of basement irregularities beneath the sediment on the Atlantic margin, simplified from a seismic reflection record supplied by C. Keen of the Atlantic Geoscience Centre. The ruggedness of the crystalline basement rocks casts doubt on the workability of the formula for calculating the Gardiner Line, which is supposed to join the points where sediment thickness equals one percent of the distance to the foot of the slope.*

Appendix G

PROSPECTIVE WIDE MARGIN STATES

Angola	India	Norway
Argentina	Indonesia	Portugal
Australia	Ireland	Russia
Brazil	Japan	Seychelles
Canada	Madagascar	South Africa
Fiji	Mauritius	Spain
France	Mexico	Surinam
Ecuador (Galapagos)	Micronesia	Tonga
Denmark (Greenland)	Myanmar	United Kingdom
Guinea	Namibia	United States of America
Iceland	New Zealand	

Source: Definition and limits of the continental shelf: an examination of the relevant provisions of the United Nations Convention on the Law of the Sea (background paper for the meeting of the group of experts). United Nations, Office of Legal Affairs, 1992.

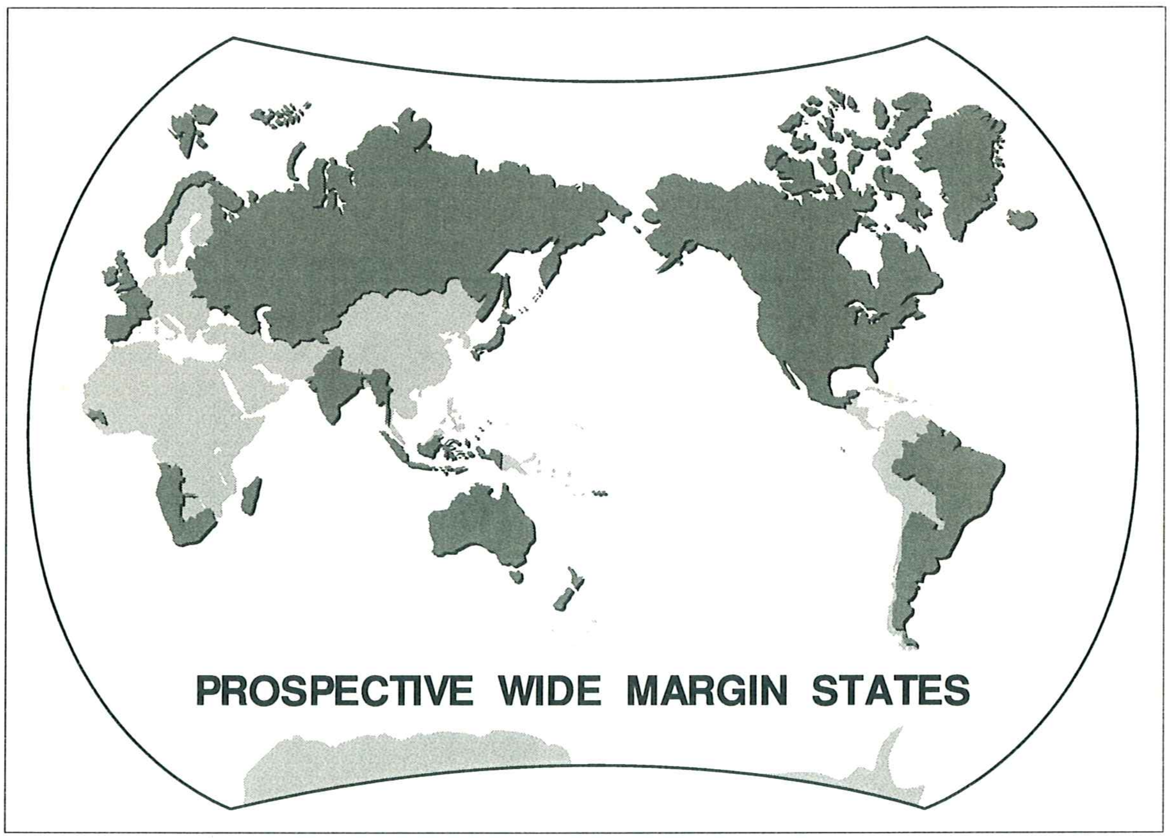


***Figure G.1** According to UN estimates, over thirty wide-margin nations could be entitled to claim jurisdiction over seabed resources beyond 200 nautical miles under the terms of Article 76 of the 1982 UN Convention on the Law of the Sea.*