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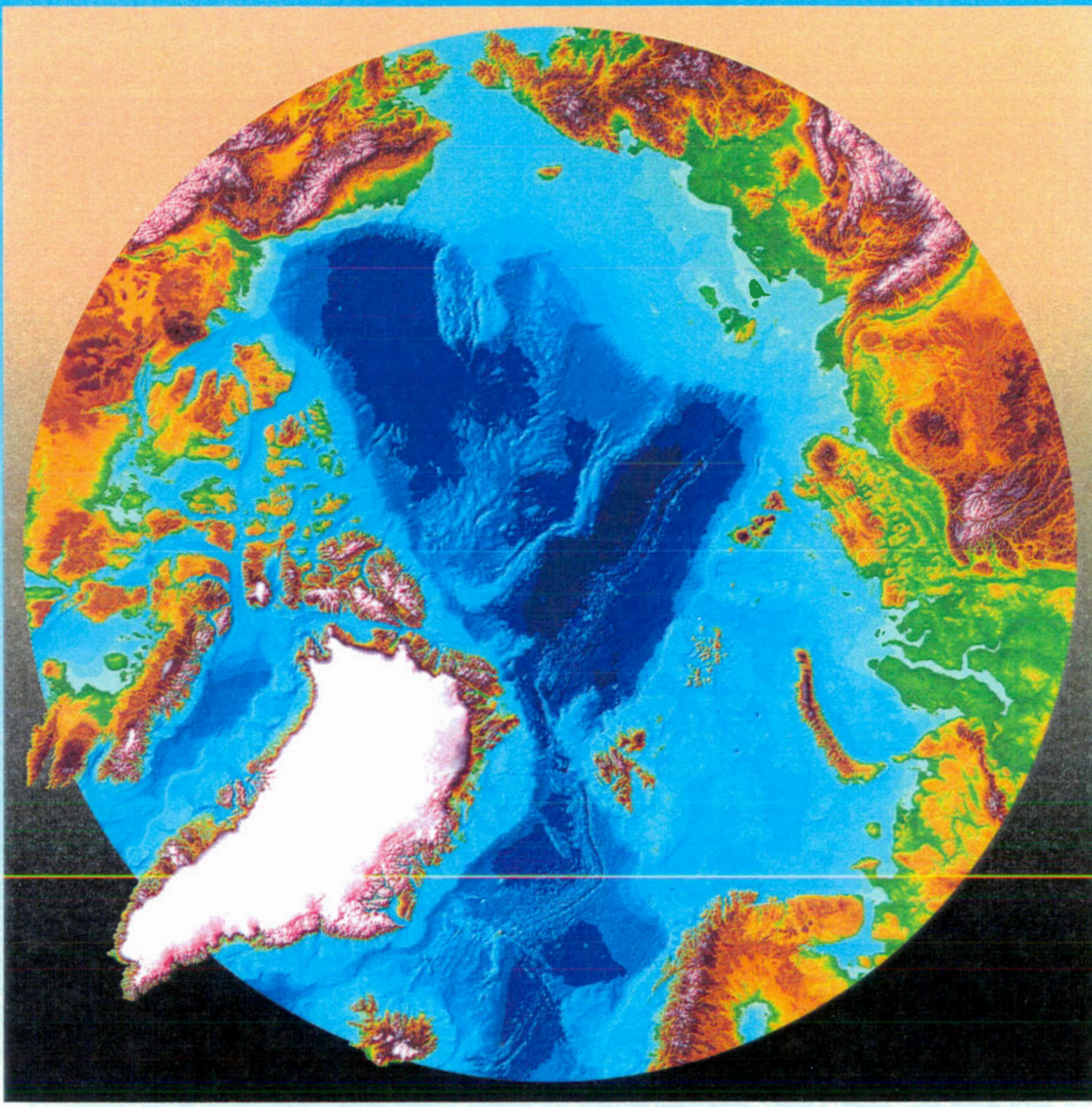
Second Session: Monaco, November 2-4, 1999

IASC



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IOC/IASC/IHO Editorial Board for the International Bathymetric Chart of the Arctic Ocean (EB-IBCAO)

Second Session: Monaco, November 2-4, 1999

Summary of technical presentations
on national contributions

Chairmen:

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Geological Survey of Canada Open File 3893
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Cover figure: *Prototype relief plot of seafloor and land areas north of 64 °N, produced from a provisional grid that defines depths and elevations over a square matrix at intervals of 2.5 km. Land elevations were derived by re-sampling the GTOPO30 1-km grid issued by the US Geological Survey; oceanic depths were produced by combining all available original public-domain bathymetric observations, supplemented by information extracted in contour form from published maps and charts. The grid and the plot were constructed in October 1999 by Martin Jakobsson of Stockholm University, in collaboration with Norman Z. Cherkis of Five Oceans Consultants and with the assistance of John Woodward of the Royal Danish Administration of Navigation and Hydrography, and Jennifer Harding of the Geological Survey of Canada.*

Table of Contents

1. Introduction.

This document summarizes a series of technical reports that were presented at the Second Session of the IOC/IASC/IHO Editorial Board for the International Bathymetric Chart of the Arctic Ocean (EB-IBCAO), which was held at the International Hydrographic Bureau in Monaco, November 2-4, 1999. The business and procedural topics that were discussed during the Session have been summarized in a formal Report that will be circulated in due course by IOC; for readers' convenience, a draft version of that Report has been incorporated in the present document as Appendix A.

Annex 1 of Appendix A contains the Session Agenda, and Annex 2 lists the participants. The primary objectives of the Session were:

- to review the current status of the IBCAO project, and of recent national contributions to the undertaking;
- to discuss in some detail the steps needed to prepare the IBCAO First Edition, and to disseminate its complementary digital products;
- to develop a long-term strategy for preparing subsequent editions of IBCAO, and for updating its data base to accommodate new observations as they become available.

2. The International Bathymetric Chart of the Arctic Ocean (IBCAO).

The IBCAO project was initiated for the primary purpose of constructing a modern digital data base that contains all available bathymetric data north of 64N, for use by mapmakers, researchers, and others whose work requires a detailed and accurate knowledge of the depth and shape of the Arctic seabed. Its conduct is overseen by an Editorial Board whose mandate has been endorsed by three international organizations: the International Hydrographic Organization (IHO), the Intergovernmental Oceanographic Commission (IOC), and the International Arctic Science Committee (IASC). Currently, the Editorial Board's membership consists of bathymetric specialists from eleven countries and international organizations that have interests in Arctic mapping and research: Canada, Denmark, Germany, Iceland, Norway, Russia, Sweden, the USA, the IOC, the IHO, and IASC (see Appendix B).

Additional information of an administrative and technical nature may be found in reports by Macnab and Grikurov (1997), Macnab and Nielsen (1998), and Macnab and Jones (1999). The project also maintains a website at:

http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html

3. *(Canada)* New algorithms for data manipulation

Ron MACNAB, Geological Survey of Canada, Dartmouth NS

A primary objective of IBCAO is to construct a coherent digital data base by assembling and combining numerous disparate sets of bathymetric observations. This is accomplished through an intensive review-and-revise process, during which individual data sets are inspected for errors, corrected, and compared with other data sets to detect discrepancies. The process tends to be iterative, as the procedure usually needs to be repeated several times until the subject data sets show good agreement with other data sets, or until they are rejected as unusable. Performing these tasks with conventional visual and manual techniques is invariably time-consuming and labour-intensive, therefore some effort has been devoted to identifying and evaluating software tools that support automatic data cleaning operations, as well as interactive manipulation and visualization.

The tools that have been evaluated take advantage of the power of the HH (Helical Hyperspatial) data encoding technique (Varma et al, 1990), which has been implemented in a number of data bases as the format of choice for handling and storing large quantities of geospatial and other forms of spatial data. HH Code is multidimensional and expresses dimensions such as latitude, longitude, and time of observation in interleaved binary integer format (Figure 1) in order to achieve high levels of compaction, as well as rapid indexing and retrieval. The latter feature makes it feasible to devise a statistical approach to data cleaning, where individual data points are compared to their nearest neighbours and flagged as good or bad, depending upon their statistical compatibility. This feature also facilitates the extraction of selected data sets for detailed inspection when needed (Figure 2).

A fundamental concept in HH Code is *aggregation*, where neighbouring data points are clustered on the basis of their statistical similarities. For purposes of visualization, aggregated data points may be rendered as multi-dimensional *tiles*; in the case of bathymetry, the seafloor could be represented by a range of tile sizes that vary according to the number of data points that they contain and to the ruggedness of the seabed that they portray (Figure 3). This confers certain advantages in terms of realistic visualization, and of economies of storage.

Following a successful trial in a different geographic region (Harding et al, 1999), software tools that function in the HH environment were applied to some of the constituent data sets in IBCAO, and demonstrated their potential by enabling (a) the efficient storage and fast retrieval of bathymetric observations; (b) interactive data manipulation and visualization; and (c) rapid, automatic cleaning based on a statistical approach.

4. *(Denmark)* Operations around Greenland

Arne NIELSEN, Royal Danish Administration of Navigation and Hydrography, Copenhagen

The population of the depth data base for the waters around Greenland has been completed. The data sets which should comprise all known depths data from the waters around Greenland are presently going through a cleaning and validation process. Steps have been taken to collect more data from the Royal Danish Navy and from offshore activities in the area.

The Greenland Home Rule has asked the Danish Government to extend an invitation to the US Navy to expand its investigations in the Arctic Ocean to include the waters around Greenland. The issue is presently under consideration within the Danish Government.

5. ***(Germany)*** **Activities of RV POLARSTERN in the Arctic in 1999**

Hans Werner SCHENKE, Alfred Wegener Institute, Bremerhaven

Three expeditions were carried out by the German RV "Polarstern" between June and October 1999 in Arctic waters (Figure 4):

1. *ARK XV/1, 23.06.99 – 19.07.99*; physical oceanography in Fram Strait and the East-Greenland Sea. Narrow single-beam echo-sounder data was collected during the entire leg, and will be made available to IBCAO after cleaning.

2. *ARK XV/2, 21.07.99 – 08.09.99*; marine geophysics and geology in Fram Strait, off northern Svalbard and ne Greenland. Multibeam survey using Hydrosweep DS-2 was performed during the entire cruise by trained operators. Systematic surveys were performed over the northern Svalbard continental shelf, the Spitzbergen Fracture Zone, and east of the Yermak Plateau. The data will be available for the IBCAO after postprocessing and publication in mid-2000.

3. *ARK XV/2, 10.09.99 – 14.10.99*; marine biological and oceanographic investigations were performed in Fram Strait and the east Greenland Sea. The multibeam system was operated unattended during the whole leg. The data must be analyzed with respect to quality and reliability before they can be made available to IBCAO.

In general, south of 80°N (within the INMARSAT coverage) the navigation of "Polarstern" was carried out using real-time D-GPS; outside the reach of INMARSAT, GPS in Standard Positioning Service (SPS) was used. In areas of systematic multibeam surveys the Hydrosweep data were processed and cleaned on board "Polarstern". During this leg, systematic surveys were performed in following areas:

a) Spitzbergen Fracture Zone (80°N, 0°30'W and 80°20'N, 2°30'E), an extension of the Fram Strait survey that was performed during previous years (Figure 4).

b) Survey of the Mosby Peak, located at the northern continental slope of Svalbard, east of Yermak Plateau. The relative height of the Mosby Peak is approximately 1000 m (See Figure 5).

c) Box survey covering the area of 81°35'N to 81°55'N, and 15°E and 25°E. This multibeam survey covered the newly-discovered "Polarstern Seamount" (Figure 6) at 81°44'N, 15°30'E, as well as a major part of the continental slope north of Svalbard (Figure 7). The relative height of the seamount, relative to the surrounding seabed, is 1200 m.

d) A small systematic survey northwest of Svalbard, covering the Sophia Trough (Figure 8).

Future plans

ARK XVI/1, Year 2000; biological and oceanographic cruise operating off NE Greenland and in Fram Strait. Narrow single-beam echo-sounder data will be recorded.

ARK XVI/2, Year 2000; geophysical/geological cruise to the Morris Jesup Rise and Fram Strait. Multibeam survey.

ARK XVII, Year 2001; marine geological/geophysical leg to the Gakkel Ridge. A joint US and German cruise to obtain multibeam bathymetry.

6. *(Iceland)* Data activities in the vicinity of Iceland

Hilmar HELGASON, Icelandic Hydrographic Service, Reykjavik

Using CARIS software, IHS has begun to digitize sounding records from Iceland's EEZ, and anticipates placing these converted observations at the disposal of IBCAO during the year 2000, in time for inclusion in the First Edition.

7. *(Norway)* Activities during the period 1998-1999

Harald BREKKE, Norwegian Petroleum Directorate, Stavanger

By agreement between the Norwegian Hydrographic Office (SKV) and the Norwegian Petroleum Directorate (NPD), the Norwegian representative to the IB/IBCAO is an affiliate of NPD. NPD holds all geophysical and geological data acquired in the Norwegian offshore areas. The NPD is also given the responsibility to map the outer limits of the Norwegian continental shelf according to UNCLOS, and to prepare the technical documentation of those boundaries to be submitted to the Commission on the Limits of the Continental Shelf. SKV holds all bathymetric data from the Norwegian continental shelf and territorial waters. SKV has the obligation to provide the public with navigation charts and has the resources to put priority on preparing parts of their data in a form suitable for inclusion in projects like IBCAO. However, on the initiative of the NPD, SKV and NPD have entered into a dialogue to investigate possible avenues for preparing a suitable subset of the SKV shallow water database for release to IBCAO. At present, the outcome of this process is not clear, as it involves the consideration of the scope of work and the resources available.

During the summer of 1999, NPD conducted a bathymetric survey around the flanks of the Voring Plateau in the Norwegian Sea between 64°N and 70°N. A total of 70 000 Km^2 of continuous coverage multibeam data was acquired with a Simrad EM 12S multibeam echo sounder. The data will be considered for release to IBCAO after reduction to a suitable resolution.

8. *(Russia)* The HDNO/VNIIO Map of Arctic Relief

Boris FRIDMAN, Head Department of Navigation and Oceanography, St. Petersburg

HDNO, in close cooperation with the Academy of Sciences, with a number of other scientific organizations, and with the active participation of some universities, produces atlases devoted to the nature of the World Ocean. Three volumes of *Sea Atlas* were published in 1953-1963, followed by five volumes of the *Atlas of the Oceans* in 1964-1996:

- I Pacific Ocean
- II Atlantic and Indian Oceans
- III Arctic Ocean
- IV Straits of the World Ocean
- V Man and Ocean

A sixth volume on Antarctica is in press. In addition, important work is being carried out at present on the creation of a new *Atlas of the World Ocean*. It is planned to publish this Atlas in five volumes, each containing charts on one or more related problems, and it is proposed to prepare the Atlas both in printed and electronic (on laser disk) forms.

The first volume of the Atlas will be devoted to the problem of the World Ocean submarine topography. Within the framework of the preparation of this volume by the Chief Editorial Board, eight pages of the first volume portray the bathymetric chart of the Arctic Ocean area at a scale of 1:5,000,000 on a stereographic projection. Colour proofs of these pages were exhibited at the 1998 World Exposition in Lisbon and were of great interest. Subsequently they were published as a single chart (HDNO et al, 1999).

The author's manuscript portraying the bathymetry of the central basin of the Arctic Ocean was compiled by G.D. Naryshkin, Candidate of Geographical Sciences and Research Assistant at VNIIO, using material obtained by expeditions of the Navy Hydrographic Service and stored in the Navy Charts Division.

When preparing the compilation manuscript, the Chief Editorial Board used all available released cartographic material. Bathymetry is shown on the Chart by 50, 100, and 200 metre depth contours, and at 200 metre intervals in deeper water. The depth colour scale was chosen to emphasize the area's bottom features. The coastline was compiled from available cartographic sources, and compared with the World Vector Shoreline extracted from the GEBCO Digital Atlas (file of coastline at scale 1:3,000,000). Contour lines of land relief were reproduced from cartographic material printed at scales similar to those of our chart.

A comparative analysis has shown that in accuracy and amount of detail, our chart surpasses any bathymetric chart that has been published for this region until now. The position of the continental margin in the Arctic Ocean, along with the main morphological and morphostructural features of its provinces, are shown on the chart clearly and unambiguously. On the basis of charting results, the Arctic basin topography is divided into three sub-basins that differ both in relief and in structure of the Earth's crust:

I. *The Eurasian Sub-basin*

1. The Gakkel Mid-Ocean Ridge is the inner mid-ocean ridge of the Eurasian Sub-basin; based on relief, it is not directly connected to the mid-ocean ridge system of the northeast Atlantic.

2. In proximity to the Greenland continental margin, the valley to the west of Gakkel Ridge wedges out in a manner similar to its termination at the continental margin of the Laptev Sea.

3. On morphological grounds, a block about 100 km wide and extending for 350 km between the Lena Valley Lena and the valley to the west of Gakkel Ridge, does not appear to be a component of the latter.

4. According to domestic research materials, a number of seamounts (absolute height 1500-2000 m) have been found on Gakkel Ridge. They are charted for the first time, and have no names as yet.

II. *The Amerasian Sub-basin (Canada Basin)*

1. The sub-basin is characterized by the existence of a relatively flat abyssal plain at a depth that exceeds 3800 m, and which is surrounded by continental margin.

2. Along the considerable extent of Canada Basin, the continental margin is unambiguously located between the shelf edge at depths of 200-400 m, and the base of the continental slope at depths of 3600-3800 m.

3. The eastern sector of the basin is characterized by the continental base, which increases the width of the continental margin proper.

III. *Central Arctic Area of Oceanic Rises (CAAOR)*

The CAAOR is shallower than sub-basins I and II above by 3500 and 2500 m, respectively.

1. By its morphological and bathymetric characteristics that define a single orographic system of positive and negative relief, CAAOR appears to be the natural extension of the continental margins of Eurasia and the Canadian Arctic Archipelago into the Arctic Ocean. Lomonosov Ridge, being a component of the CAAOR system, is the continental margin of the Eurasian Subbasin, while Alpha Ridge, Chukchi Plateau and Northwind Ridge constitute the continental

margin in Canada Basin.

2. CAAOR is linked physiographically to the continental margins of Eurasia and North America, with a distinct break at depths that range from 600 to 1700 m. CAAOR is therefore dissimilar from the continental margin in terms of relief, but not in terms of crustal structure.

3. CAAOR deeps are not basins. Two parallel deep systems are separated by a 500 m step, however similarities in relief suggest a common, deep-seated geological origin.

4. Alpha Ridge has half the linear extent shown on foreign charts.

5. A nameless deep exceeding 2600 m has been located between the southern extremities of the Lomonosov and Alpha Ridges.

6. CAAOR relief includes numerous seamounts, valleys and other features that are unnamed and which are not shown on previous charts.

The chart "Submarine Topography of the Arctic Ocean" was exhibited at the International Cartographic Exhibition in Ottawa (Canada) during the IXX International Cartographic Conference, and was awarded a degree certificate for excellence in cartography.

9. *(Russia)* The VNIIO digital bathymetric compilation

Sergei MASCHENKOV, Research Institute for Marine Geology and Mineral Resources of the World Ocean, St. Petersburg (VNIIO)

Introduction

This report presents several new digital bathymetric models of the Deep Arctic Basin and surrounding continental shelves, and the Norwegian-Greenland Basin of the North Atlantic. A considerable amount of existing bathymetric data have been gathered during systematic surveys carried out by Russian researchers from VNIIO, the Polar Marine Geosurvey Expedition (PMGE), the Murmansk Arctic Geological Expedition (MAGE) and the Head Department of Navigation and Oceanography (HDNO) of the Russian Federation Navy. The collection, editing, adjustment and gridding of these data and their merging with available western data using modern computer technology has been accomplished in VNIIO, and has resulted in a new bathymetric model of the Arctic Ocean. This model reliably characterizes the regional peculiarities of the ocean floor relief and throws new light on its most important features in comparison with earlier published small-scale maps and global bathymetry compilations; it was proposed for use in international digital Arctic bathymetry project (Bocharova et al., 1997; Komaritzyn et al., 1997). New features of the ocean bottom geometry and bathymetry identified from our models have been interpreted together with potential field data for the purpose of studying the lithosphere structure (Daniel et al., 1997; Zayonchek et al., 1998).

Input data

A digital data base of the Arctic Ocean bathymetry was developed using three main types of input data (Figure 9): (a) original analog point observations acquired by the Russian expeditions and digitally captured in the course of this compilation; (b) grids either developed from HDNO data under project supported by Civilian Research and Development Foundation (CRDF) Project RG-221 (principal investigators: J. Brozena, NRL; S. Maschenkov, VNIIO) or obtained from public domain data; and (c) digitized contours from published bathymetric maps.

Original analog observations conducted in the course of Russian geological and geophysical investigations resulted in acquisition of three types of point data: shipborne profiles, on-ice echosoundings and on-ice seismic reflection soundings. The methods of observation, applied technical facilities, and accuracy of navigation and bottom depth estimations were mainly chosen subject to natural features of the study areas. The eastern part of the Russian Arctic Shelf and deep Arctic Basin were covered by aircraft supported surveys with density of landings ranging from 10-15 to 30-40 km. The ice-free Barents and Kara Seas were studied by systematic shipborne surveys with lines and stations spaced at 10-20 km and 3-7 km, respectively. Bottom depth estimations and their adjustment were performed in accordance with commonly accepted hydrographic standards. In the Deep Arctic Basin depth measurements were acquired at 1-3 km intervals from "North Pole" drifting ice-camp stations (Kiselev, 1986). Additional information was provided by German RV "Polarstern" (Futterer, 1992, 1994) in the form of raw digital data; despite continuous digital acquisition along extended observation lines, this set contained a large amount of random errors and was only partly included in our compilation. Characterization of input digital data is given in Figure 9..

Data processing

Data were processed using the software developed at the Geological Survey of Canada (Verhoef et al., 1995) for digital compilation of potential fields and other geophysical data. The processing included the following succession of operations: 1) editing, correlation and preliminary gridding of Russian point observation data; 2) visual comparison of contours derived from Russian gridded point data with other available contours data and developing of intermediate grids; 3) integration of all obtained gridded data sets to a final grid.

Differences in field surveys methods resulted in variety of procedures for editing of initial data. Point observations in the areas of overlapping surveys were sorted manually for mutual compliance. In nearshore zones these observations were additionally examined for conformity with World Vector Shoreline (WVS) data provided with the software. Russian shipborne data were adjusted by means of cross-over analysis. Coherent data were prepared by correcting the depth values to make discrepancies not more than 3-5 m in the depth range less than 100 m and not more than 10-15 m in depths greater than 100 m. After correlation of all shipborne survey data sets, the root mean square error of the surveys conducted within the depth range about 20-600 m accounted for 5 m. German RV "Polarstern" raw data were edited by procedure of detection and removal of spikes using fourth order difference calculation. After correlation all "North Pole" data were included in the data set, whereas RV "Polarstern" data were used mainly in deep sea areas. The edited and adjusted point data sets were gridded by minimum curvature (Smith & Wessel, 1990) and kriging (Cressie, 1990) methods using various grid intervals. The primary grid intervals secured by the real observations density were from 3 to 15 km.

The next step was to test the contours derived from Russian gridded point data for compatibility with other available bathymetric information. For that purpose the contours plotted from newly developed Russian grids were visually compared with published bathymetric maps (Gorshkov, 1980; Perry et al., 1985; Cherkis et al., 1991, 1994; Matishov et al., 1995) and contours plotted from public domain grids (Oakey et al., 1994, NOAA, 1988). It appeared that, in comparison with isobaths obtained from new Russian grid, the data of Gorshkov (1980); Perry et al. (1985), and NOAA (1988) were much more generalized, whereas maps published by Cherkis et al. (1991, 1994) and the more detailed map of Matishov et al. (1995) demonstrated good agreement and therefore were used in full extent for western Eurasian margin area. This also confirmed the reliability of our new grid and justified using it as the basis for digital compilation in the entire area covered by Russian point observations. Data from Oakey et al. (1994) which were mainly based on digital contours from GEBCO Sheet 5.17 (Jones, 1994) were found less informative, and for that reason this digital set was included in the final compilation only where no other evidence was available.

After selection of all input data sets it was necessary to develop intermediate grids for separate seabed portions differing in principal features of bottom relief. The following specific seabed portions were recognized: (i) nearshore zone, (ii) western shelf and slope, (iii) eastern shelf and slope, (iv) Norwegian-Greenland Basin, (v) Gakkel Ridge, (vi) Alpha-Mendeleev Ridge, (vii) Chukchi Borderland, and, finally, (viii) deep water basins of the Arctic Ocean.

In the nearshore zone straightforward compilation results in appearance of numerous artifacts caused by a jagged configuration of coastline. Hence it was found practicable to form the specific 1.5 km grid in this zone from our input bathymetry data supplemented by land component of NOAA (1988). This allowed us to minimize the discrepancies between zero-depth grid values and WVS data. Deeper and more differentiated western shelf/slope and Norwegian Greenland Basin were gridded using the minimum curvature method with various tension factors at 2.5 km interval; in shallower and flatter eastern shelf/slope the same method was applied with high tension factors. Because of differences in bottom topography and general geometry of the bathymetric highs in the Deep Arctic Basin (Naryshkin, 1995) the respective data sets were processed using individual combination of grid parameters. In all cases directional gridding by kriging was applied at the intervals between 3 and 10 km, which enhanced the anisotropic appearance of these bottom features. Deep water basins were found sufficiently uniform to allow similar processing procedure by minimum curvature method at 10 km interval. The above specific grids were merged in a single gridded data set which was subsequently integrated with the Oakey et al. (1994) data to form a final 5 km grid.

Resulting pictures of Arctic seafloor relief

A color contour image of the digital model of the Arctic Ocean relief is presented in Figure 10. The color depth scale was chosen to portray the main relief features, whereas additional contours display smaller details. A new bathymetry compilation is the next stage of updating the international digital bathymetry of the Arctic Ocean. Our digital model is based on much greater amount of source data than earlier digital compilations, and in our view, offers the opportunity to produce a computer print-out at 1:5,000,000 scale which for the first time will be truly backed by the quality and density of original information. For the Eurasian Arctic shelf the credibility of input data is even higher and allows reliable hard-paper visualization at 1:2,500,000 scale. The control of trustworthiness of our model is provided by its good agreement with newly published manual 1:5,000,000 map (HDNO et al, 1999).

Many features of the Arctic Ocean seabed that are important for regional tectonic interpretations and geopolitical issues (such as delimitation of the outer extent of the continental shelf in Law of the Sea context) but which were only outlined in preliminary form in earlier compilations, can now be recognized with greater confidence. This refers in the first place to the deep water portion of the Arctic basin where coherent geometry of the Gakkel and Lomonosov Ridges and separating basins is combined with clearly expressed segmentation of the Gakkel Ridge and apparent heterogeneity of the Lomonosov Ridge relief. Also noteworthy is the regular interval (500-600 m) in bathymetric highs in the central part of the Arctic ocean. Some new essential details have also emerged in sub-polar part of the Canada Basin.

Conclusion

New digital models of the Arctic Ocean bottom relief has been developed in VNIIO and tested in comparison with both earlier digital compilations and modern manual products. It has also been successfully applied in lithospheric studies based on joint analysis of bathymetry and potential fields (Maschenkov et al., 1999). The model has been proposed by the author as the first step in creating a comprehensive integration of digital Arctic Ocean bathymetry currently undertaken by the Arctic earth science community under IOC/IASC/IHO project (Macnab & Grikurov, 1997) for the purposes of improved cartographic imaging and resource management in the High Arctic.

Acknowledgments

Thanks are extended to colleagues from MAGE, PMGE, HDNO, VNIIO who for many years have been collecting the data used in this compilation. Scientists from the Naval Research Laboratory (USA), the Alfred Wegener Institute (Germany), and the Geological Survey of Canada provided digital data and software. An essential part of this report is included in the paper submitted to the Proceedings of the Third International Conference on Arctic Margins (1998), thanks to the kind assistance of reviewers G. Grikurov and R. Macnab with their constructive and helpful comments on the manuscript (the draft of the paper was distributed to participants of the EB meeting). The work on Arctic bathymetry compilation has been

performed under grant RG1-224 funded by the Civilian Research and Development Foundation and grant of President of Russian Federation to support young professors' teams.

10. ***(USA)*** **Release of historic submarine observations**

Norman Z. CHERKIS, Five Oceans Consultants, Alexandria VA

A comprehensive overview was delivered at the GEBCO Meeting in June 1999, and has been included in the Summary of Presentations prepared for issue as an Open File of the Geological Survey of Canada (Macnab and Jones, in press; draft copies circulated at the meeting).

In essence, the observations have been divided into early (1957 to 1982) and later (1983 to 1988) data sets. The early data sets have been converted to digital form, blunder-checked, and corrected as appropriate. In July of this year, they were formally presented on CD-ROM to the US National Geophysical Data Center for distribution in the public domain, a process that is expected to begin early in the year 2000. These data sets have been included in the provisional grid of Arctic bathymetry, to be described below.

About half of the later data sets have been converted to digital form, blunder-checked, and corrected; while not yet placed into public circulation, they have also been incorporated in the provisional grid.

11. ***(USA)*** **SCICEX 1998, 1999, and beyond**

Margo EDWARDS, University of Hawaii, Honolulu HI
Bernie COAKLEY, Tulane University, New Orleans LA
Robert A. ANDERSON, Arctic Submarine Laboratory, San Diego CA

Bernard Coakley – SCICEX 99 data acquisition

The SCICEX 99 cruise consisted of several surveys spread across the Arctic Ocean (Figure 11). Each phase was completed successfully. The chirp sub-bottom profiler, interferometric swath mapping system, gravimeter and data acquisition system were operated continuously throughout the cruise. Early indications are that the data collected during the cruise are excellent, benefiting from the stable low-noise environment provided by the submarine.

The first part of the cruise was dedicated to mapping on the Chukchi Cap to find peri-glacial features. These features, which seem to indicate the former presence of grounded ice, were observed. A survey was also conducted over the Northwind Ridge(s).

The second survey was conducted on the Alaskan margin, during a physical oceanographic program dedicated to examining fluxes across the shelf. Canyons, sediment channels and mass wasting features were observed. No indications of grounded ice were observed.

A cross-basin transect, consisting of regular expendable CTD launches in support of an acoustic propagation experiment, was conducted while the USS Hawkbill transited from the Alaskan Margin to the Eurasian basin.

Continuous swath data was acquired over three contrasting segments of the Lomonosov Ridge. This data will be used to map the internal structure of the ridge and to function as a site survey data set for a proposed ODP leg.

Continuous swath data was collected along the Gakkel Ridge, filling out the coverage obtained during SCICEX 1998 from the USS Hawkbill. The axis of the ridge has been completely imaged from spreading rates of 1.0 cm/yr to 1.24 cm/yr. Towards Greenland, the western end of the ridge, where the full spreading rates range from about 1.1 to 1.24 cm/yr, the Gakkel has been mapped out to 50 km on either side of the ridge to approximately Anomaly 5.

A survey was conducted at the northeastern tip of the Yermak Plateau, in the Norwegian EEZ, at the invitation of the Norwegian government. Data acquisition was completed when the ship crossed 80 N, southbound for Portsmouth England.

Margo Edwards – SCAMP swath bathymetry data

SCAMP bathymetry data for SCICEX-99 are currently being processed. Processing is accomplished interactively in several steps to improve data quality.

Even at this preliminary processing stage, it's clear that SCAMP performance during SCICEX-99 was excellent. Swath width for bathymetry data ranges between 120° and 140°. On average, 0.5 million reliable soundings were acquired per 24 hours of system operation. In regions of overlapping swaths, comparisons of data falling in the same grid cells suggests that relative system accuracy is ~1% of water depth.

Images of bathymetric data for the Lomonosov and Northwind Ridges demonstrate the high quality of the soundings. In the former set of images, scours with a few tens of meters of relief can be readily resolved on the crest of the Lomonosov Ridge. SCAMP data for the Northwind Ridge depict a series of four sub-parallel ridges, two of which have volcanic components (Figure 12).

The present plan for SCAMP data processing is to produce first-draft maps of the Lomonosov, Gakkel and Northwind Ridges and the Chukchi Cap for the American Geophysical Union meeting this December. Approximately six months after the preliminary bathymetry maps are finished sidescan data processing will also be complete. The sidescan data, because of its wider swath and finer resolution, will be used to renavigate the USS Hawkbill's tracks. The new navigation will subsequently be incorporated into the bathymetry data to produce final gridded data and bathymetry charts.

Bob Anderson – Future of the SCICEX program

The current SCICEX program has been completed (Figure 13). The Navy Plan of Record is to retire the last 637-class submarine in the year 2001, however the US Navy has offered to retain one 637-class submarine in service for seven years, provided that funds can be found to pay for a needed overhaul. George Newton of the U.S. Arctic Research Commission has been in contact with members of Congress and the Office of the Vice President, and is cautiously optimistic that funding may be approved.

12. (Sweden) A bathymetric and topographic model of the Arctic Ocean
Martin JAKOBSSON, Stockholm University, Stockholm

A great deal of bathymetric information has been collected in the Arctic Ocean since 1979, when Sheet 5.17 of the General Bathymetric Chart of the Oceans (GEBCO) was published, depicting the sea floor north of 64°N (Canadian Hydrographic Service, 1979). Using modern digital cartographic techniques, we have assembled all available single and center beam echo soundings and recently-released contour data to create a new grid of bathymetry north of 64°N. The new bathymetry was merged with the USGS topographic model (GTOPO30) and the KMS topographic model covering Greenland, in order to create a grid which covers both bathymetry and topography of the Arctic region.

The bathymetric data includes observations collected during historic cruises of US and UK nuclear submarines (1958-1988), modern SCICEX missions (1993-1999), and icebreaker expeditions (Ymer, 1980; Oden, 1991, 1996; Polarstern, 1990, 1994, 1995, 1997). These observations were complemented by holdings extracted from the digital archives of the Canadian Hydrographic Service, the US Naval Research Laboratory, and the US National Geophysical Data Center. In addition, we used contour information from a new Russian Arctic map (HDNO et al, 1999), and from published NRL and GEBCO charts. Finally, unclassified Russian navigational charts were used for our compilation of the Siberian shelf bathymetry.

After initial processing, all data were converted to an xyz coordinate system for further treatment, including gridding with GMT software. The final product is a Cartesian grid with a grid-cell spacing of 2.5 x 2.5 km. When plotted (Cover Figure), the new grid reveals a far more complex morphology of several major Arctic Ocean under-sea features, including the Lomonosov Ridge, Alpha Ridge and Gakkel Ridge than revealed on previously-published charts. Paleo river channels whose depth variations are on the order of only tens of meters are clearly visible on the enormous Siberian continental shelf.

Acknowledgments.

This meeting was hosted by the International Hydrographic Bureau in Monaco. IHB President Rear Admiral Guiseppe Angrisano and his staff contributed to the smooth conduct of the meeting through effective technical and logistical support. Through the intermediary efforts of Dmitri

Travin, the Intergovernmental Oceanographic Commission and the US National Geophysical Data Center underwrote the bulk of the EB Members' attendance costs. The US Office of Naval Research International Field Office - Europe, and the International Arctic Science Committee provided travel support for the team that convened previously at Stockholm University to develop the provisional grid of Arctic bathymetry. Mike Lamplugh of the Canadian Hydrographic Service, and Dave Greenberg of the Ocean Sciences Division of the Department of Fisheries and Oceans (both at the Bedford Institute of Oceanography) reviewed a draft of the manuscript and made valuable suggestions for improvement. Gary Grant of the Geological Survey of Canada constructed the report's front cover.

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APPENDIX A

Abbreviations and Acronyms used in main body of Open File report

CAAOR	Central Arctic Area of Oceanic Rises
CARIS	Computer Aided Resource Information System
CD-ROM	Compact Disk Read-Only Memory
CRDF	Civilian Research and Development Foundation
CTD	Conductivity-Temperature-Depth
D-GPS	Differential Global Positioning System
EB-IBCAO	Editorial Board for the International Bathymetric Chart of the Arctic Ocean
EEZ	Exclusive Economic zone
GEBCO	General Bathymetric Chart of the Oceans
GMT	Generic Mapping Tool
GPS	Global Positioning System
GSC	Geological Survey of Canada
GTOPO30	Global two-minute topographic grid
HDNO	Head Department of Navigation and Oceanography, Russian Federation Navy
HH	Helical Hyperspatial
IASC	International Arctic Science Committee
IBCAO	International Bathymetric Chart of the Arctic Ocean
IHB	International Hydrographic Bureau
IHO	International Hydrographic Organization
IHS	Icelandic Hydrographic Service
INMARSAT	International Maritime Telecommunications Satellite
IOC	Intergovernmental Oceanographic Commission
KMS	Kort & Matrikelstyrelsen (Danish Cadastre and Mapping Agency)
MAGE	Murmansk Arctic Geological Expedition
MB	Megabyte
NOAA	National Oceanographic and Atmospheric Administration
NPD	Norwegian Petroleum Directorate
NRL	(US) Naval Research Laboratory
ODP	Ocean Drilling Program
PMGE	Polar Marine Geosurvey Expedition
RV	Research Vessel
SCAMP	Seafloor Characterization And Mapping Pod
SCICEX	Science Ice Exercise
SKV	Norwegian Hydrographic Service
SPS	Standard Positioning Service
UNCLOS	UN Convention on the Law of the Sea
USGS	United States Geological Survey
USS	United States Ship
VNIIO	All-Russia Research Institute for Geology and Mineral Resources of the World Ocean
WVS	World Vector Shoreline

APPENDIX B

DRAFT SUMMARY REPORT: SECOND SESSION OF THE EDITORIAL BOARD FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN, INTERNATIONAL HYDROGRAPHIC BUREAU, MONACO, 2-4 NOVEMBER 1999

2. OPENING OF THE SESSION

The Session opened at 0930 with Ron Macnab of the Geological Survey of Canada (GSC) and Neil Guy of the International Hydrographic Bureau (IHB) serving as Chairman and Co-Chairman, respectively. Welcoming remarks were delivered on behalf of IHB by President Rear Admiral Guiseppe Angrisano and Director Rear Admiral Neil Guy, and on behalf of the Intergovernmental Oceanographic Commission (IOC) by Dmitri Travin. Members, observers, and Secretariat representatives who participated in the Session are listed in Annex 2.

3. CONDUCT OF THE SESSION

The agenda was adopted as contained in Annex 1. Norman Cherkis was appointed as rapporteur.

4. EB-IBCAO: COMPOSITION AND FINANCIAL SITUATION

The Chairman noted changes to the membership of the Editorial Board since the last Session: David Divins of the US National Geophysical Data Center (NGDC) has been recruited to retain the representation of a US Government Agency; Neil Guy of IHB and Dmitri Travin of IOC were identified as ex-officio Members representing their respective organizations. It was noted that the International Arctic Scientific Committee (IASC) has not designated an official representative to EB-IBCAO, and it was agreed that advice would be sought from that organization on how it wished to be represented.

EB-IBCAO is funded by the sponsoring organizations, but also relies to a considerable degree upon voluntary efforts and in-kind contributions from Members and associates. To date, funding to support meetings and other activities has been acquired as follows:

IOC sponsored the Second Session of EB-IBCAO, with technical facilities provided by IHB.

IASC partially supported an exploratory Workshop that was held in St. Petersburg, Russia in October 1997, where the IBCAO project was initiated. IASC also provided funds to underwrite part of the cost of a work session at Stockholm University in August 1999.

The US Office of Naval Research International Field Office - Europe (ONRIFO-E) provided Conference Support Grants to partially defray the costs of the First EB-IBCAO Session in Copenhagen, Denmark in October 1998, and a special Arctic Bathymetry Session during the General Bathymetric Chart of the Oceans (GEBCO) Meetings in Halifax, Canada in June 1999; these two events resulted in follow-up work sessions (also partially supported by ONRIFO-E) at Stockholm University in February 1999 and again in August 1999.

NGDC provided the remainder of the funding for covering participation by EB Members in the present Session.

While contributions from the above organizations were and are deeply appreciated, the Chairman expressed his view that a more stable source of funding will be necessary to ensure that the EB continues to operate effectively and to deliver products in a timely fashion. He also expressed his intention to investigate the feasibility of identifying a source of funding that would support the activities of the EB for a period of one to two years, or at least until the completion of the IBCAO First Edition.

5. REVIEW: IBCAO DEVELOPMENTS SINCE THE LAST SESSION

The Chairman briefly described the activities that occurred following the October 1998 Session in Copenhagen:

In February 1999, Martin Jakobsson hosted Norman Cherkis at Stockholm University, where together they constructed a bathymetric grid that covered half of the IBCAO area.

In May, the new map "Bottom Relief of the Arctic Ocean" was published by the Head Department of Navigation and Oceanography (HDNO) with the cooperation of the All-Russia Research Institute for Marine Geology and Mineral Resources of the World Ocean (VNIIO).

In early June, a poster describing the overall IBCAO project and its current status was shown in the Ocean Sciences Session of the Spring Meeting of the American Geophysical Union (AGU) in Boston, USA, alongside several other posters prepared by EB-IBCAO Members (Cherkis, Coakley, Jakobsson, Maschenkov) and associates that presented specific aspects of the project.

In late June, a special Arctic Bathymetry Session was organized as part of the GEBCO Meetings in Halifax, which offered some EB Members an opportunity to acquaint the GEBCO community with the scope and objectives of the project, and to discuss means of incorporating the new IBCAO in forthcoming products such as the GEBCO Digital Atlas

In July, EB-IBCAO was invited to present a poster in the Special Session on Polar Geophysics at the International Union of Geodesy and Geophysics (IUGG) Assembly in Birmingham, England, and to describe progress at a concurrent meeting of the International Association for Geodesy (IAG) Project Group for the Gravity Map of the Arctic. The Chairman thanked Hans Werner Schenke for his intermediary services at these events on behalf of the EB.

In August, Martin Jakobsson again hosted Norman Cherkis at Stockholm University, along with John Woodward of the Royal Danish Administration of Navigation and Hydrography (RDANH) and Jennifer Harding (GSC), who together continued the work begun in February and constructed a bathymetric grid that covered the remaining half of the IBCAO area, using all available data.

6. NATIONAL CONTRIBUTIONS: ACTIVITIES SINCE THE LAST SESSION

Speakers outlined the progress that was achieved by their respective organizations since the last Session was held in Copenhagen in October 1998. Their presentations are listed below in point form; text and figures will be circulated in a supplementary volume that will be issued as an Open File of the GSC.

Canada New algorithms for data manipulation (Macnab)

Denmark	Operations around Greenland (Nielsen)
Germany	Activities of RV POLARSTERN in the Arctic in 1999 (Schenke)
Iceland	Data compilations and operations off Iceland (Helgason)
Norway	Activities during the period 1998-1999 (Brekke)
Russia	The HDNO/VNIIO Map of Arctic Relief (Fridman) The VNIIO digital bathymetric compilation (Maschenkov)
USA	Release of historic submarine observations (Cherkis) SCICEX 1998, 1999, and beyond (Edwards, Coakley, Anderson)
Sweden	A bathymetric and topographic grid model of the Arctic Ocean (Jakobsson)

6. REVIEW OF THE PROVISIONAL VERSION OF IBCAO, AND STEPS FOR ADVANCING ITS DEVELOPMENT

The provisional version of IBCAO was produced by Martin Jakobsson in collaboration with Norman Cherkis, John Woodward, and Jennifer Harding. It exists in digital form only, consisting of a cartesian grid with a spacing of 2.5 km constructed on a Polar Stereographic Projection based upon the WGS 1984 ellipsoid.

All available data were used in the product. Bathymetric measurements used in constructing this grid include all declassified data collected by US and UK submarines between 1958 and 1982, by RV POLARSTERN, and by SCICEX, as well as all values contained in the NGDC, Naval Research Laboratory (NRL), Kort & Matrikelstyrelsen (KMS), RDANH, and GSC public data bases. To supplement the various measurements, information was extracted from the new HDNO/VNIIO bottom relief map, as well as from 52 HDNO published charts at various scales of the Siberian shelf. Data cleaning was accomplished continously as information was assimilated into the map; this process will continue as discrepancies are detected, and as new data sets replace older ones. The coastline is generally the World Vector Shoreline (WVS) and topographic heights are derived from GTOPO30, however a new coastline and topography grid were provided by KMS for use in northern Greenland.

A new bathymetric contour set was compiled by Norman Cherkis for the northern and eastern regions off Greenland, and from Nares Strait east and south to Cap Farvel at the southern tip of Greenland. Additional contouring was done on the western side of Greenland, but is not yet processed and is not in the present version of IBCAO.

Martin Jakobsson demonstrated different views available by means of computer-generated shaded relief models; by using directional shading, he was able to emphasize features with as little as 10 meters of relief on the Siberian continental shelf, including paleo river valleys and small periglacial features.

To improve the map, Hans Werner Schenke and Harald Brekke offered new data collected in 1999 by their respective institutions. In addition to new multibeam data in the Fram Strait and the eastern Greeenland margin, AWI has numerous single beam data sets collected from RV POLARSTERN by groups that were not engaged in bathymetric or geological studies; as soon as these data sets are processed and blunder-checked, they will be added to the database for future upgrades. The Norwegian Petroleum Directorate (NPD) very recently collected new data from the contracted multibeam sonar vessel MV SEA SURVEYOR. These data are from the central continental margin off Norway, showing excellent coverage on the Voring Plateau and the Storegga landslide region. Small tributary landslides were observed for the first time. These data will be made available to Martin Jakobsson by the end of November 1999 for inclusion in the IBCAO database.

7. ACTION PLAN FOR CREATING THE IBCAO FIRST EDITION AND ASSOCIATED PRODUCTS

The following operations were identified as necessary for the completion of the First Edition:

1. Addition of new data

New data sets offered by NPD will be provided to Martin Jakobsson for incorporation in the provisional grid.

2. Refinement of the provisional grid

Martin Jakobsson will conduct a thorough visual examination of all sectors of the grid with a view to detecting residual errors and applying appropriate corrections.

3. Documentation/publication

Martin Jakobsson has commenced the preparation of documentation for cataloguing constituent data sets, and for describing the procedures employed in their handling and processing. This information will describe in some detail the techniques used to produce the IBCAO. This will serve two purposes: (1) to instill in IBCAO users a sense of confidence in its credibility; and (b) to facilitate future efforts to upgrade the map and its associated products. To be completed with the assistance of EB Members, this documentation is expected to be relatively voluminous, and will likely be distributed in digital form.

Martin Jakobsson has also begun to draft a report for publication in EOS. This short paper will present the provisional (but refined) version of IBCAO, outline its methods of production, identify its creators, announce the availability of the provisional grid, and solicit input of additional data from the community. Completing this report is seen as a priority, as its publication must precede any external release of IBCAO and its associated products. EB Members will be enlisted as appropriate to assist with the preparation and submission of this draft.

4. Presentation to prospective users

Pending completion of IBCAO, every opportunity should be taken to give the project a high profile, particularly among researchers e.g. oceanographers, geophysicists, and Article 76 specialists, whose investigations will benefit from an improved portrayal of the seabed north of 64°N. This action will serve the dual purpose of alerting prospective users to the imminent release of IBCAO, and of soliciting feedback on its anticipated contents, format, and mode(s) of distribution. EB Members and Associates are therefore encouraged to give publicity to the undertaking in all appropriate contexts.

5. Development of printed and digital products.

Significant discussion focussed on the nature and the format of printed and digital products. It was recognized that the project serves two marine mapping communities - GEBCO and IOC - which have different needs and specifications. It was also recognized that the use of digital technology throughout the project makes it a relatively straightforward matter to satisfy these needs, which are slightly divergent but not incompatible.

For meeting GEBCO objectives, there has been a commitment right from the beginning of the undertaking that IBCAO would be used to construct a modern and more accurate version of Sheet 5.17. This would be created as a digital product, however for the sake of consistency, the EB agreed that this new version should be developed in a style that is compatible with the GEBCO Fifth Edition; at the same time, it was agreed that variants of this Sheet, such as shaded relief presentations, would be produced to suit specialized or esthetic requirements. Left aside for the time being was the question of whether these new Sheets should be printed in quantity, or on demand. Along with the 2.5 by 2.5 km cartesian grid, other derivative digital products will also be developed for distribution in the GEBCO Digital Atlas (GDA) 2000, e.g. a 2.5 by 2.5 minute grid for inclusion in the new global bathymetry grid that is being developed by the GEBCO Gridders' Group; isobaths suitable for presentation at a 1:1,000,000 scale; a data density grid; etc.

For meeting IOC objectives, the Board recognized that the production of numerous individual sheets at a 1:1,000,000 scale in Mercator Projection would serve little practical purpose in the Arctic Ocean. It agreed, however, that contour lines can be easily provided in digital form, allowing users to produce paper sheets at different projections and scales, including the 1:1,000,000 scale. Therefore the Board decided to produce two elements of the IBCAO: a 1:2,500,000 paper map (probably in four sheets), and a CD-ROM with contour lines covering the whole of the Arctic Ocean. The Board welcomed the generous offer of the Russian Federation to print the 1:2,500,000 chart at HDNO.

8. LONG-TERM STRATEGY FOR DATA MANAGEMENT AND MAINTENANCE

In addressing the need to ensure the maintenance of IBCAO beyond the production of its First Edition, the Chairman expressed his view that it will be necessary to find a "home" for the project where it will benefit from ongoing institutional interest and from a stable allocation of resources. He asked Members and associates to consider options in this regard, in the hopes of identifying by mid-2000 an organization that would be willing to provide a base of operations for the undertaking. To this end, he listed the desirable attributes of such an arrangement:

I. An institutional commitment to seeing the work done

II. A strong scientific/technical framework for placing the work in a broader context

III. An adequate infrastructure, e.g. computer and communications facilities, etc.

IV. Sufficient human resources

V. Stable long-term funding

9. PROMOTING PUBLIC AWARENESS OF IBCAO

Pending the release of the IBCAO First Edition, the Chairman stressed the importance of informing prospective users of its preparation, and he encouraged Members and associates to avail themselves of every opportunity to do so. An obvious first step is to proceed as quickly as possible with the completion of a manuscript that will be submitted for early publication in EOS.

It was recommended that a standard kit of textual and graphical material be developed for distribution to Members and associates for their use in describing the project at meetings, etc. The communications facilities and Websites of IOC, IHO, and IASC should also be enlisted to give prominence to the undertaking, particularly in connection with the release of the next edition of the GDA.

The Chairman agreed to take appropriate action. Attendees also suggested a number of international meetings that are scheduled over the next several months, where it was agreed that IBCAO presentations would be very appropriate: AGU Fall Meeting (Dec 1999); American Association of Limnology and Oceanography (ASLO) (Jan 2000); IHO Conference (Mar 2000); IASC Arctic Summit (Apr 2000); European Geophysical Society (EGS) (Apr 2000); GEBCO Meeting (May 2000); IAG (Jul 2000).

10. RELATED MAPS AND PRODUCTS

The Chairman noted that bathymetry represents but one facet of the Arctic, and that IBCAO will serve as both an adjunct and a backdrop to other types of information. The following types of information were noted as being highly complementary to the IBCAO and amenable to regional portrayal in products that already exist, which are in production, or which are the topic of exploratory discussion:

I. Tectonics (overlaid on 1996 magnetic anomaly): completed 1998

II. Magnetic anomaly (updated): due for completion in 2000

III. Crustal thickness: due for completion in 2000

IV. Gravity anomaly (Free-Air and Bouguer): due for completion in 2001

V. Sediment distribution: proposed

VI. Also suggested were: seismicity, stress, neotectonics, morphology, periglacial

11. FUTURE EVENTS AND PRESENTATIONS

(This was dealt with under Item 9)

12. ELECTION OF VICE-CHAIRMAN, CHIEF EDITOR, AND CO-EDITORS

Hans Werner Schenke was elected Co-Chairman. In keeping with the IOC practice of designating a Chief Editor from the institution that is charged with producing paper maps, Valery Fomchenko was elected to that position. To assist with the transfer of IBCAO contours to HDNO and with their preparation for printing at a scale of 1:2,500,000, Martin Jakobsson and Sergei Maschenkov were elected as Co-Editors

13. DATE AND PLACE OF NEXT SESSION

The Third Session will take place in October or November of next year, the precise date to be decided according to circumstances. The Board thanked Hilmar Helgason for the invitation issued by the Icelandic Hydrographic Service to stage the event in Reykjavik, and noted also the willingness of AWI, as expressed by Hans Werner Schenke, to host the meeting eventually at its facility in Bremerhaven

14. REVIEW AND APPROVAL OF THE REPORT

The Board reviewed and approved the Report. The Report was formally adopted.

15. CLOSING OF THE SESSION

The Chairman thanked all the participants for their work and attendance at the meeting, and IOC and IHB for their support and technical assistance.

ANNEX 1

AGENDA: SECOND SESSION OF THE EDITORIAL BOARD FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN

1. Opening of the session
2. Conduct of the Session:
   - Adoption of the Agenda
   - Administrative matters
   - Documentation
3. EB-IBCAO: composition and financial situation
4. Review: general developments since the last Session
5. National contributions: activities since the last Session
6. Review of the provisional version of IBCAO, and steps for advancing its development
7. Action plan for creating the IBCAO First Edition and associated products
8. Long-term strategy for data management and maintenance
9. Promoting public awareness of IBCAO
10. Related maps and products
11. Future events and presentations
12. Election of Vice-Chairman, Chief Editor, and Co-Editors
13. Date and place of next Session
14. Review and approval of the report
15. Closing of the Session

ANNEX 2

LIST OF PARTICIPANTS: SECOND SESSION OF THE EDITORIAL BOARD FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN

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ANNEX 3

LIST OF ACRONYMS: SECOND SESSION OF THE EDITORIAL BOARD FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN

AGU	American Geophysical Union
ASLO	American Society of Limnology and Oceanography
AWI	Alfred Wegener Institute for Polar and Oceanographic Research
EB-IBCAO	Editorial Board for the International Bathymetric Chart of the Arctic Ocean
EGS	European Geophysical Society
GDA	GEBCO Digital Atlas
GEBCO	General Bathymetric Chart of the Oceans
GSC	Geological Survey of Canada
HDNO	Head Department of Navigation and Oceanography
IAG	International Association for Geodesy
IASC	International Arctic Science Committee
IBCAO	International Bathymetric Chart of the Arctic Ocean
IHB	International Hydrographic Bureau
IOC	Intergovernmental Oceanographic Commission
IUGG	International Union of Geology and Geophysics
KMS	Kort & Matrikelstyrelsen
NGDC	National Geophysical Data Center
NPD	Norwegian Petroleum Directorate
NRL	Naval Research Laboratory
ONRIFO-E	Office of Naval Research International Field Office – Europe
RDANH	Royal Danish Administration of Navigation and Hydrography
VNIIO	All-Russia Research Institute for Marine Geology and Mineral Resources of the World Ocean

APPENDIX C

Members of the Editorial Board for the IBCAO

November, 1999

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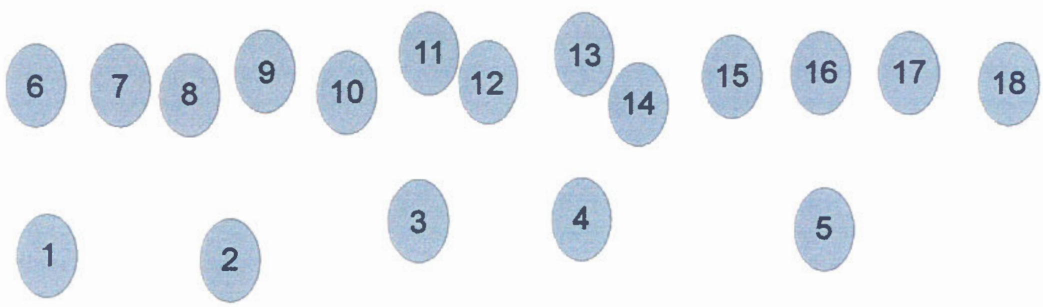

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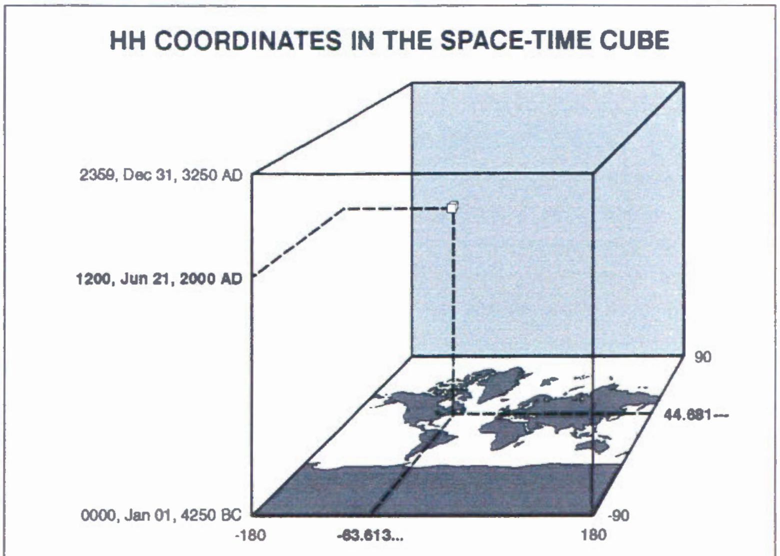
2	Gunter GIERMANN	11	David DIVINS
3	Ron MACNAB	12	Arne NIELSEN
4	Robert ANDERSON	13	Hilmar HELGASON
5	Dmitri TRAVIN	14	Margo EDWARDS
6	Sergei MASCHENKOV	15	Norman CHERKIS
7	Michel HUET	16	Bernard COAKLEY
8	Hans Werner SCHENKE	17	Harald BREKKE
9	Martin JAKOBSSON	18	Boris FRIDMAN



COORDINATE	DECIMAL VALUE	BINARY VALUE (32 BITS)
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LONGITUDE	-63.613...	0101...
TIME	2.11828e+14	0001...
INTERLEAVED COORDINATES: 010100010111... (96 BITS)		

RM, Nov 1999

Figure 1. The location of a data point in the space-time cube, along with attributes and observations at that point, can be expressed by a single number. This leads to a significant compression of positional information, along with important efficiencies in data storage and retrieval (Macnab).

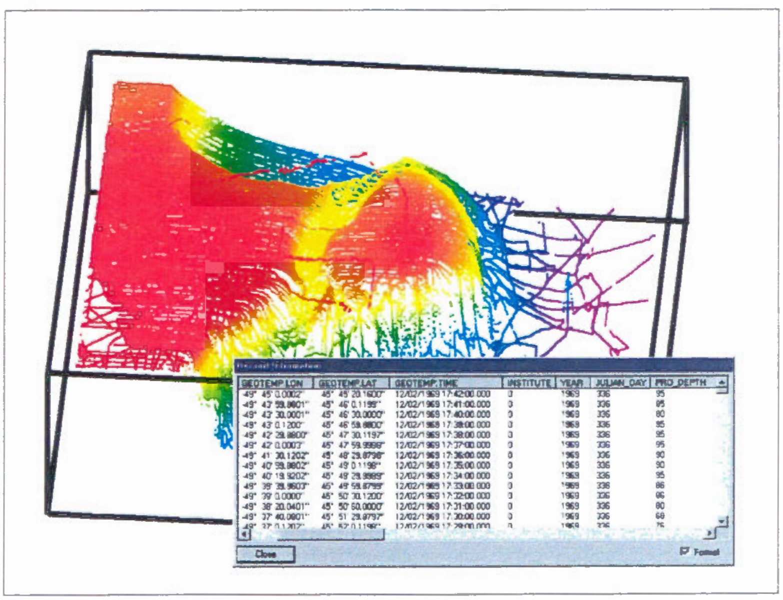

Figure 2. Main image: an oblique view of uncorrected, HH-encoded bathymetric data over a continental margin, portraying the distribution of ship tracks which are colour-coded according to observed values of depth at each point of observation. A few bad profiles stand prominently clear of the coherent data points in the background. Inset: a listing of the values and attributes of the bad profiles, following selection by the user (Macnab).

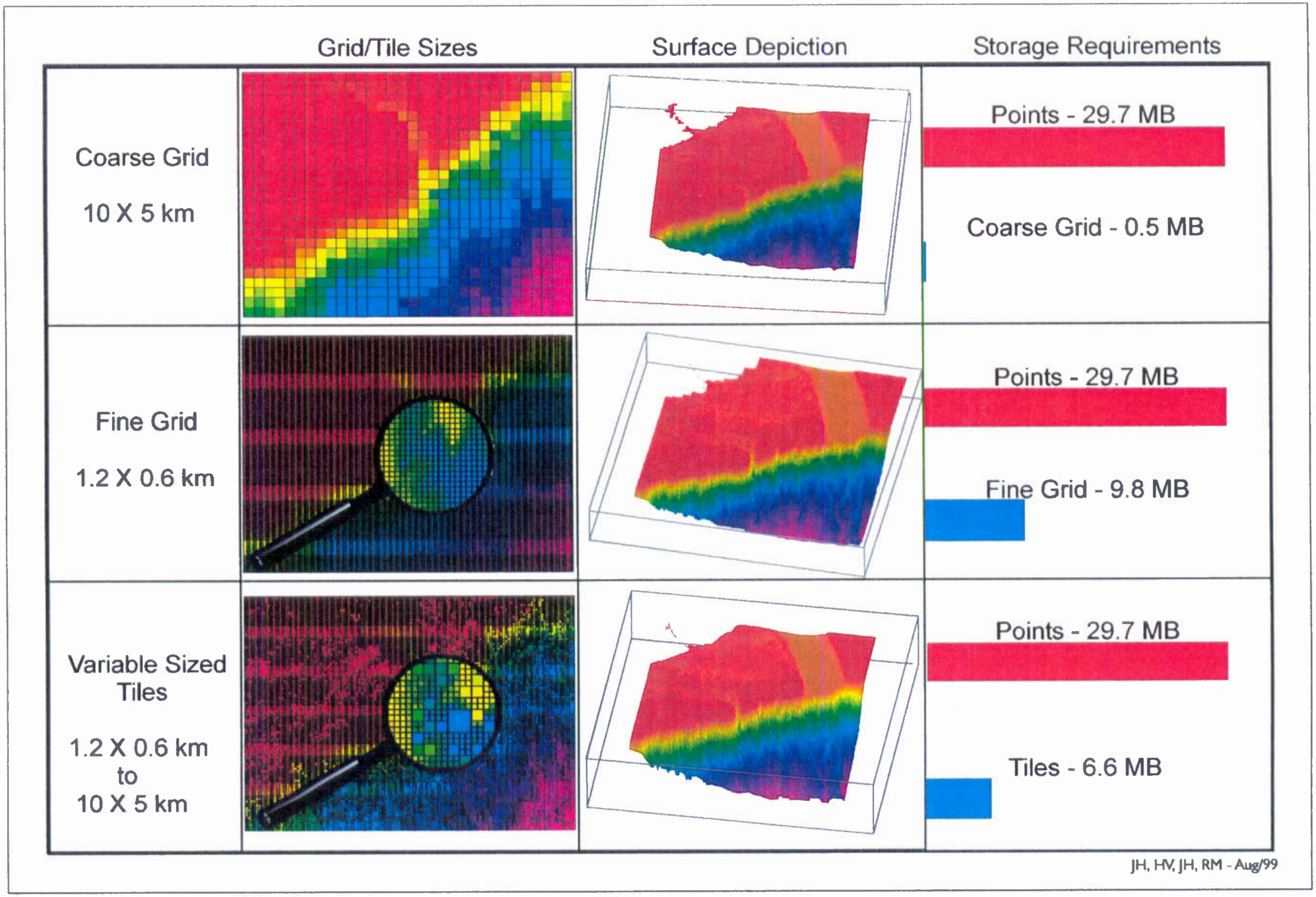

Figure 3. To illustrate differences in compression techniques, a sample set of bathymetric observations that requires nearly 30 megabytes of storage in original form has been reduced to a coarse grid, to a fine grid, and to variably-sized tiles. Coarse grid: storage requirement decreases by a factor of 60, but sea floor resolution is significantly degraded. Fine grid: storage diminishes to about a third, with acceptable sea floor resolution. Variably-sized tiles: storage reduced to nearly a fifth, with no change in sea floor resolution (Macnab).

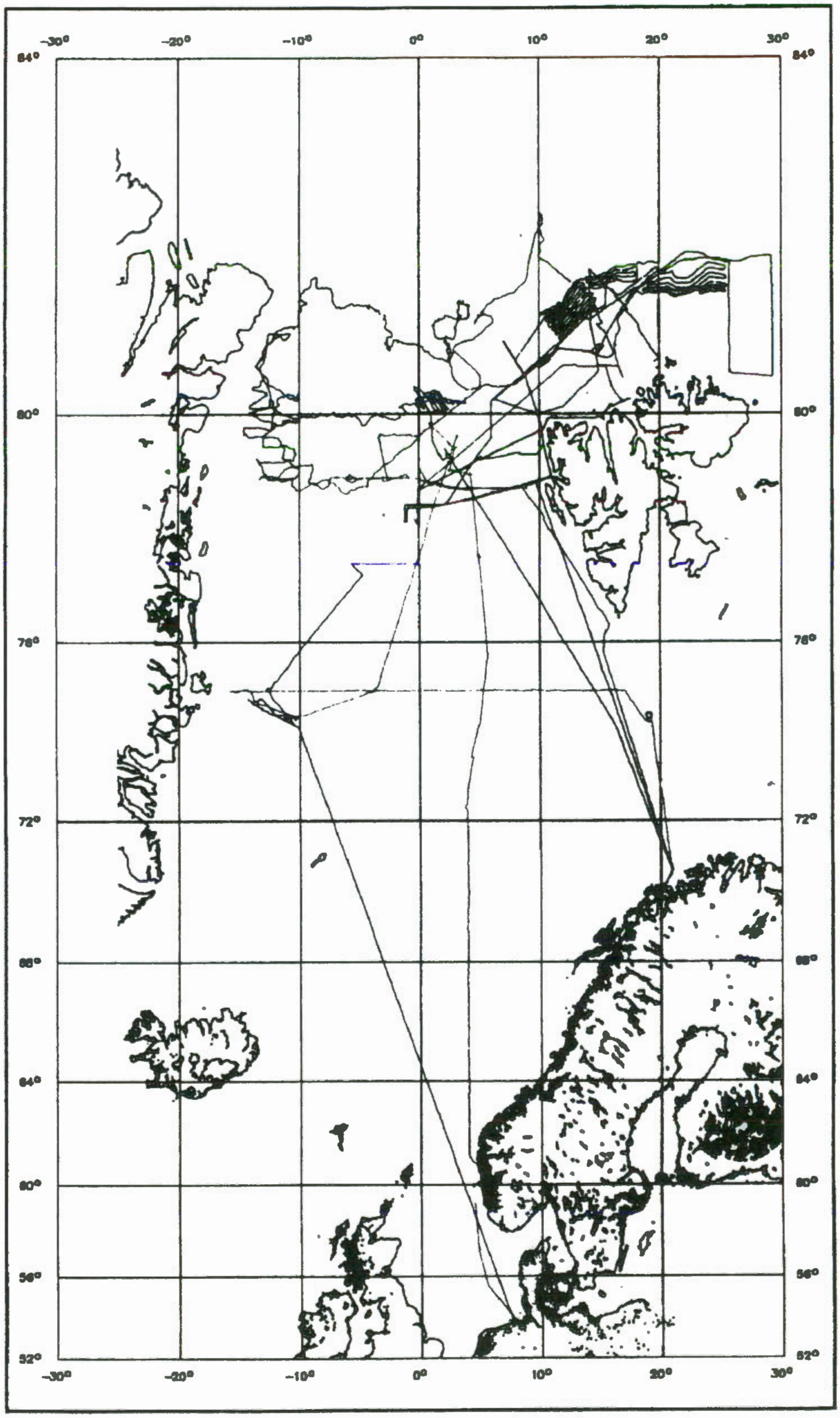

Figure 4. Expeditions of the RV "Polarstern" between June and October 1999 (Schenke).

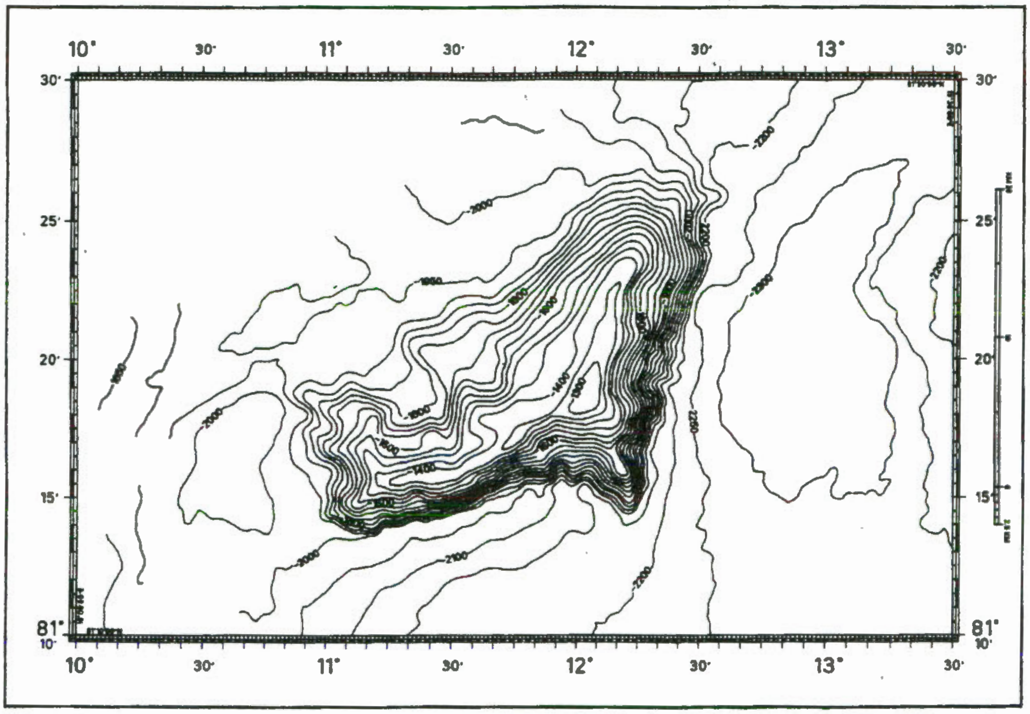

Figure 5. Survey of Mosby Peak, east of the Yermak Plateau (Schenke).

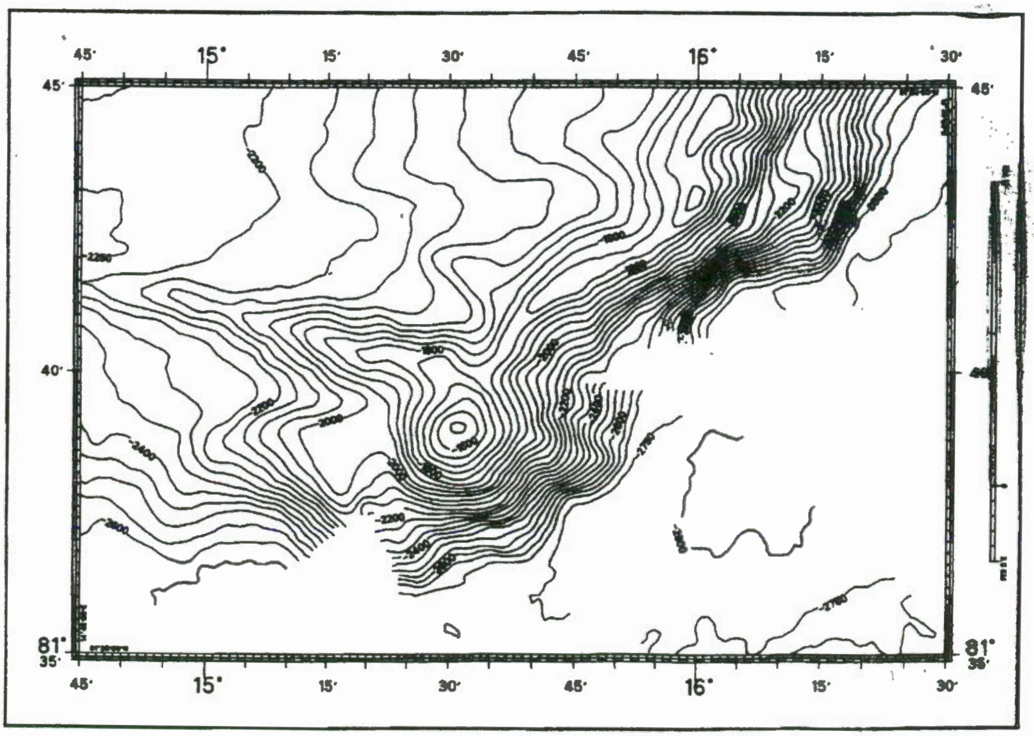

Figure 6. Survey of Polarstern Seamount (Schenke).

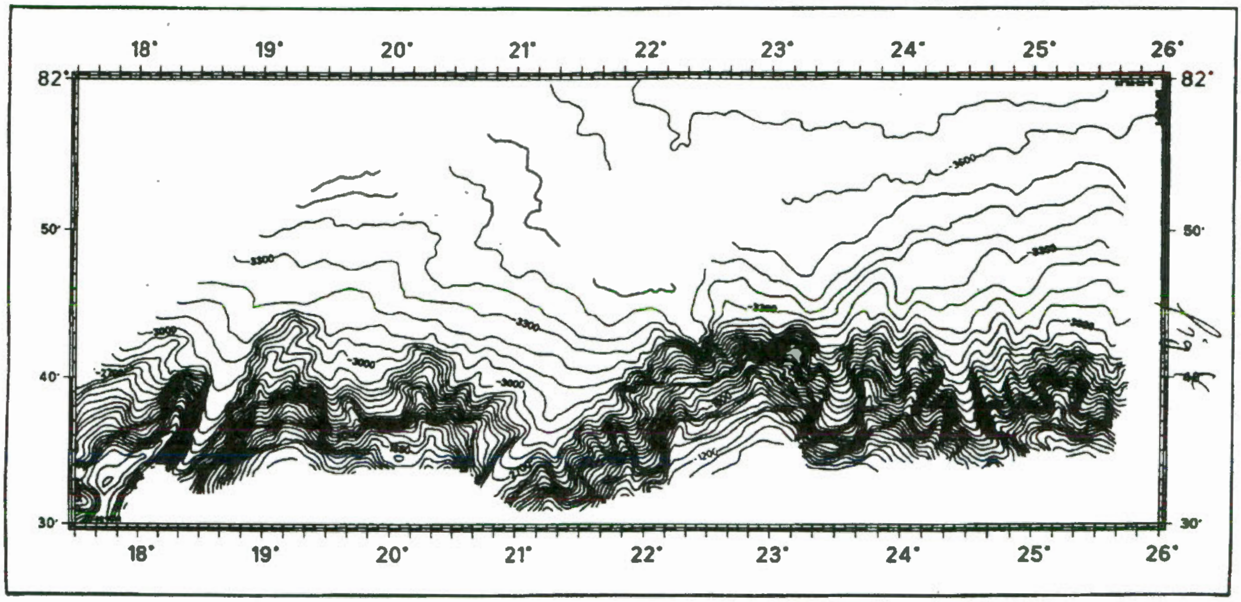

Figure 7. Survey of the continental slope north of Svalbard (Schenke).

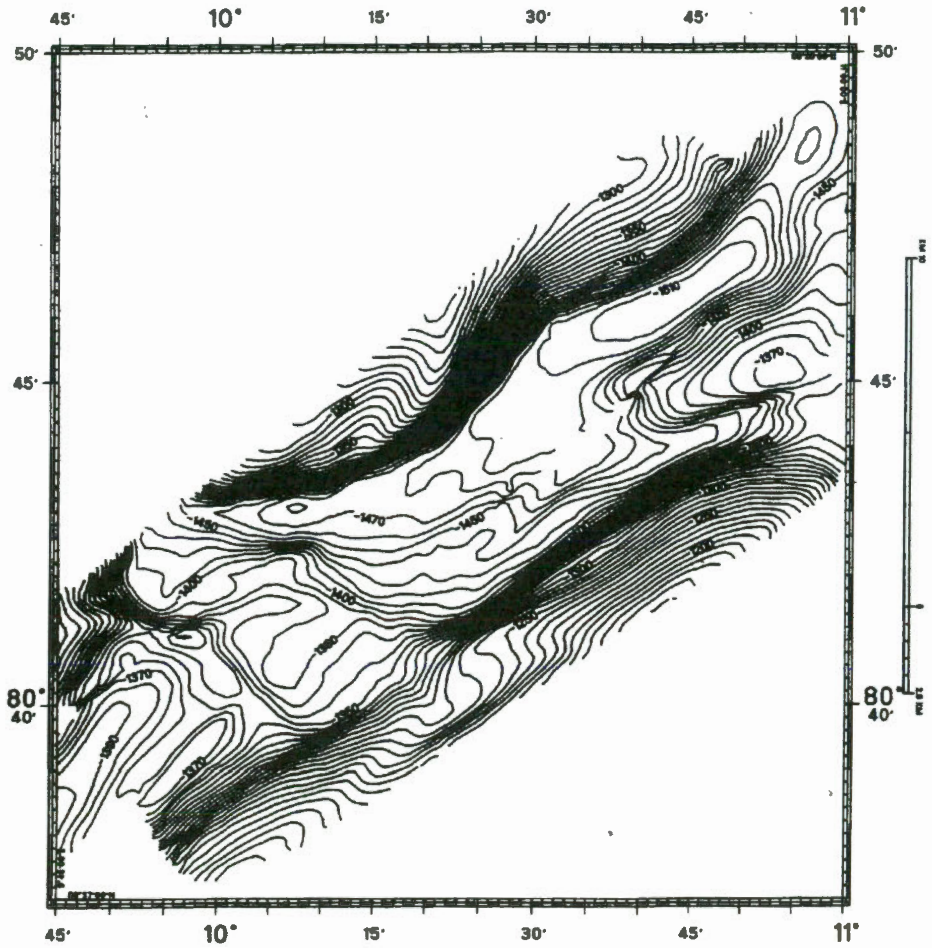

Figure 8. Survey of Sophia Trough (Schenke).

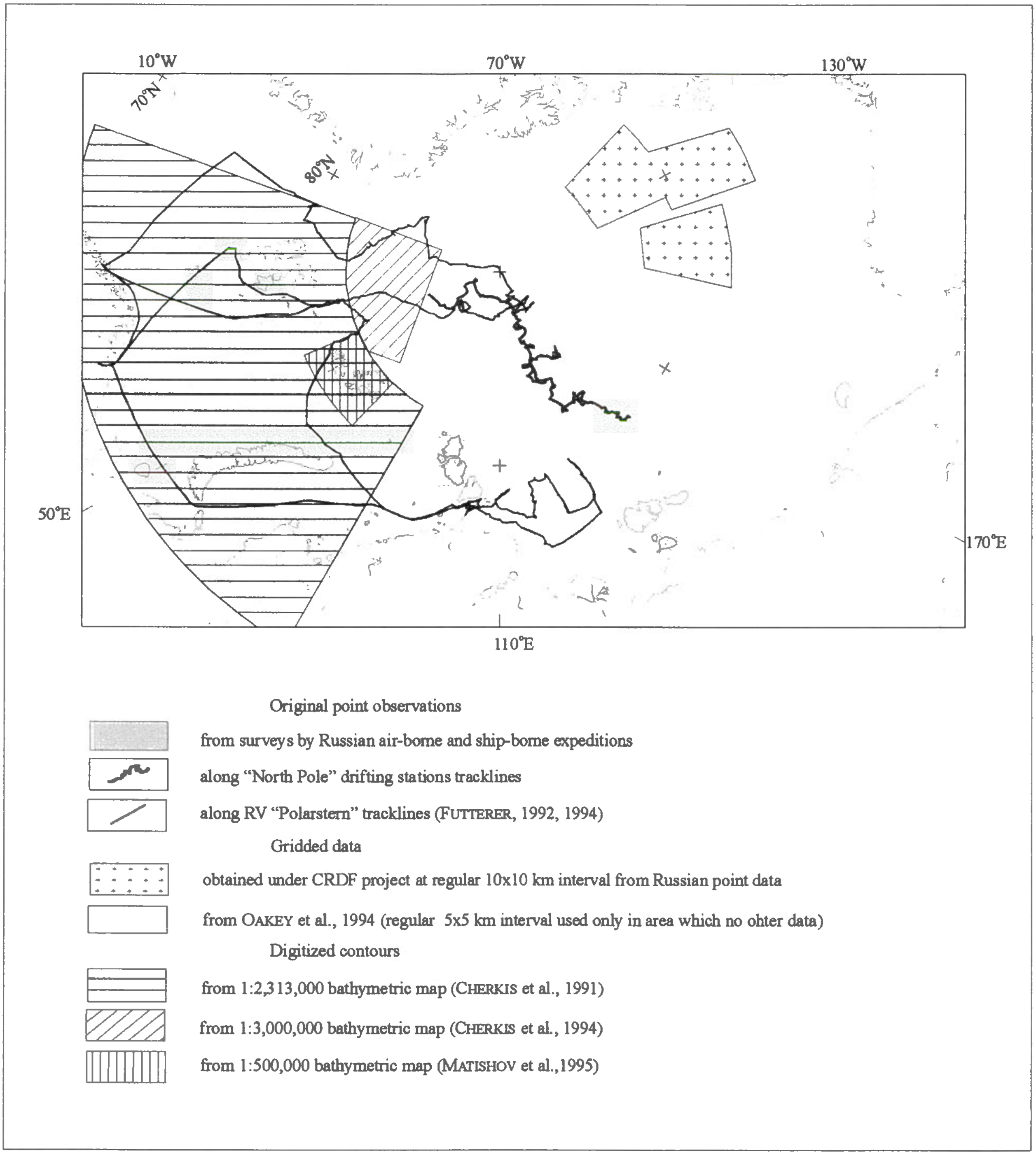

Figure 9. Location diagram for input data used in the VNIIOkeangeologia bathymetric model (Maschenkov).

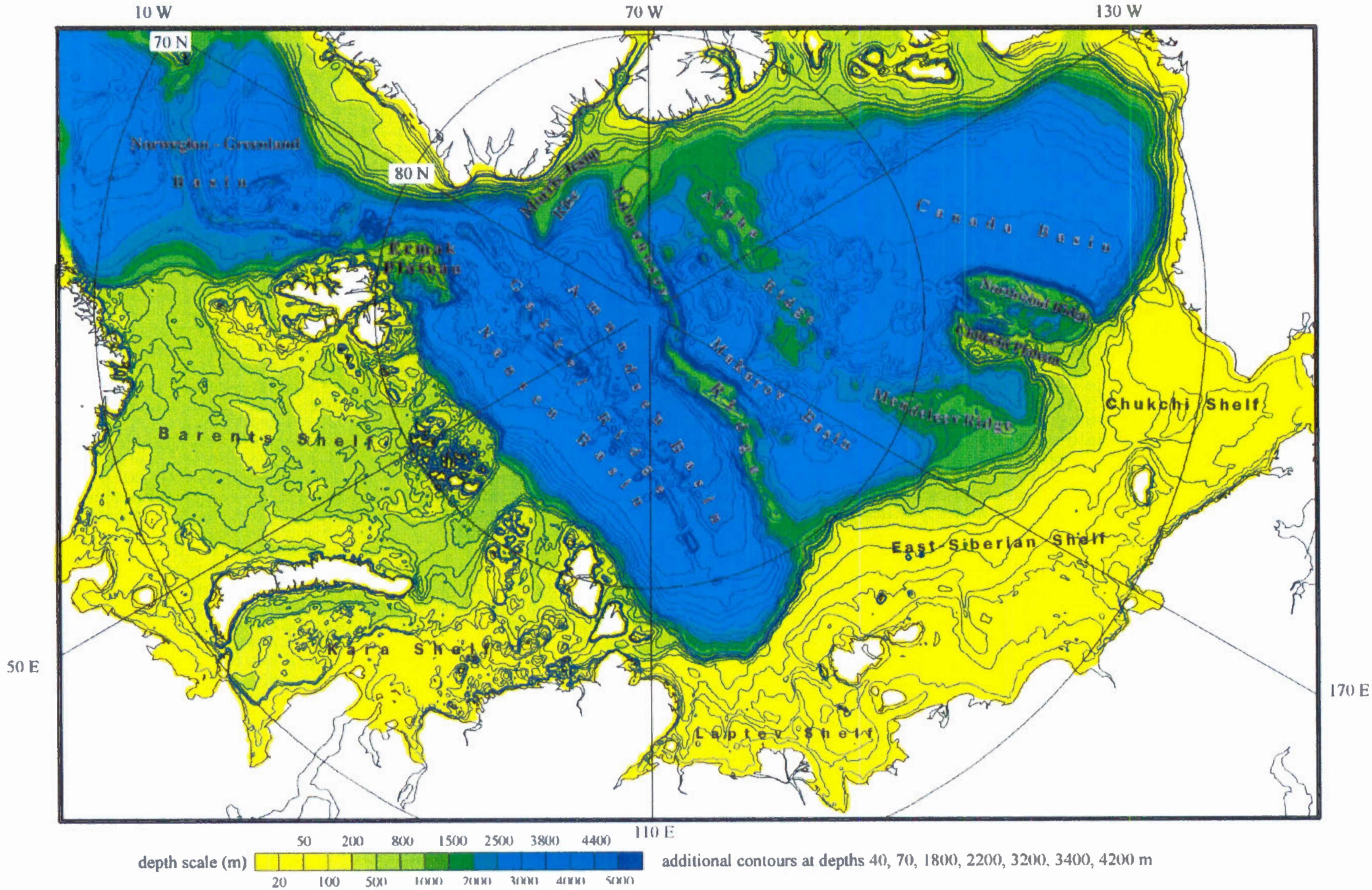

Figure 10. Colour rendition of the VNIIOkeangeologia bathymetric model (Maschenkov).

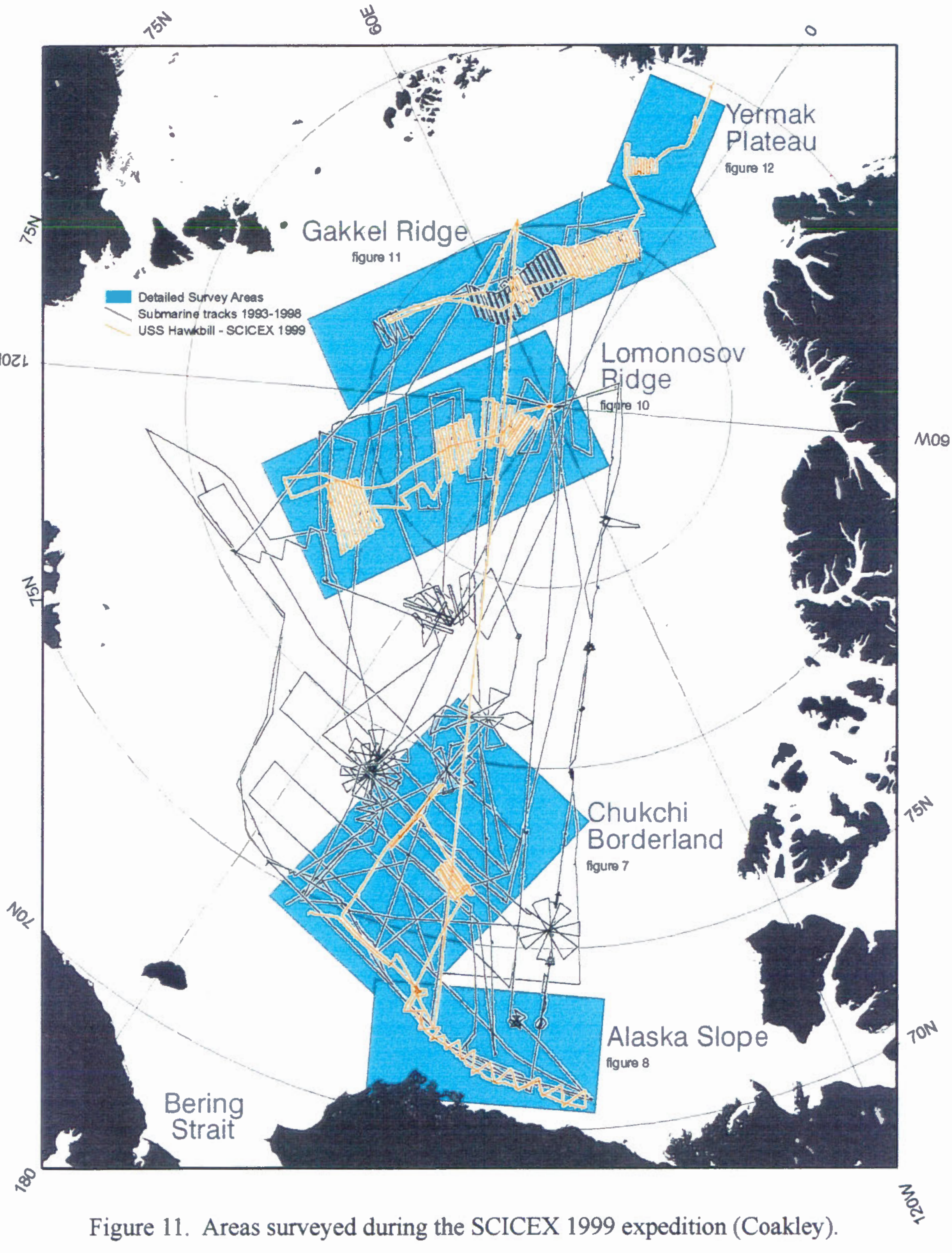

Figure 11. Areas surveyed during the SCICEX 1999 expedition (Coakley).

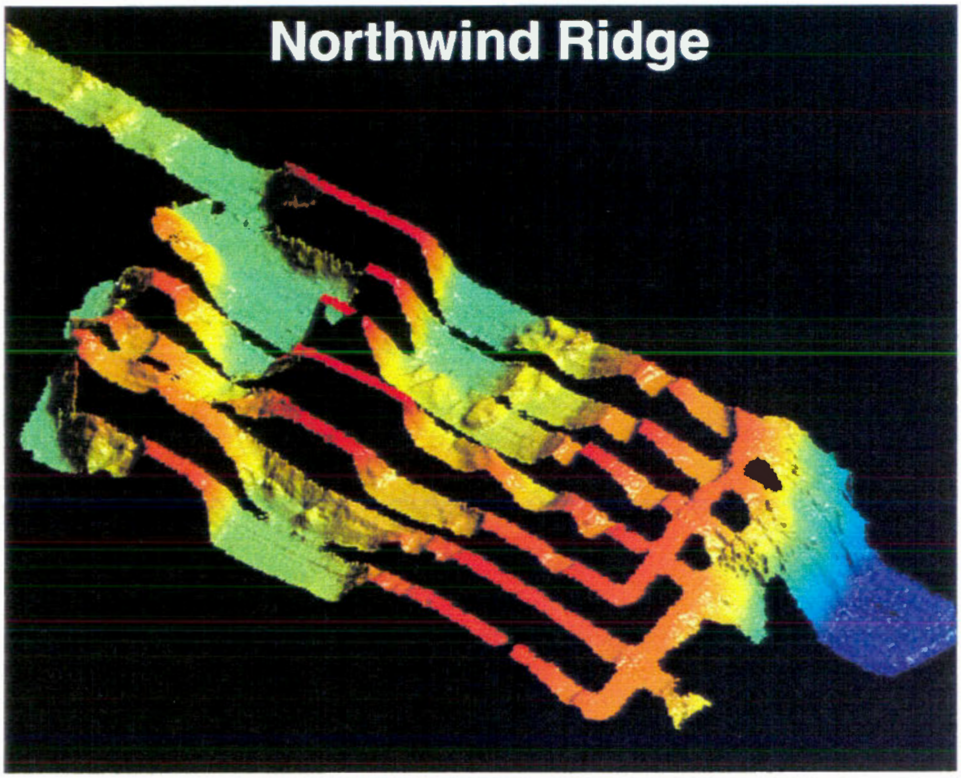

Figure 12. SCAMP data collected over the Northwind Ridge during SCICEX 1999 (Edwards).

Figure 13. USS HAWKBILL surfacing through the polar pack ice during SCICEX 1999 (Anderson).