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A guide to NOAA's data and information services

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

Biological atlas of the Barents and Kara Seas

Essential database study of the climatic system of the Arctic seas

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The Ocean Climate Laboratory (OCL) NODC/NOAA and World Data Center for Oceanography, Silver Spring have begun publishing an International Ocean Atlas Series. The first volume in the series (*Climatic Atlas of the Barents Sea, 1998: Temperature, Salinity, Oxygen* and CD-ROM containing 74,256 profiles) was prepared jointly with the Murmansk Marine Biological Institute (MMBI), Russian Academy of Sciences. As an object for study the Barents Sea had been chosen due to the following reasons. First, it is an essential part of the industrial and transport infrastructure of Russia. Second, the Barents Sea is involved in the Florida Current (Gulf Stream) and North Atlantic current system. Thus, a study of the entire current system from the Florida peninsula to the Novaya Zemlya archipelago is of importance for an understanding of the processes in this Arctic region. These factors represent some of the reason for American-Russian cooperation in the study Arctic and sub-Arctic regions.

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Biological Atlas of the Arctic Seas 2000: Plankton of the Barents and the Kara Seas is the second volume of the *International Ocean Atlas Series*. This atlas was published in November 2000 with a companion CD-ROM containing HTML version of the Atlas and primary data. The Atlas and the data are available on the NODC/OCL web-site: *http://www.nodc.noaa.gov/OC5/BARPLANK/start.html*.

Let us consider the main units of the *Biological Atlas of the Arctic Seas 2000: Plankton of the Barents and the Kara Seas* and how it may be used for documenting of changes of the plankton community. The effect of climate change on ecosystems is now one of the major foci of the U.S. Global Change Research Program (U.S. Global Change Research Program, 2000).

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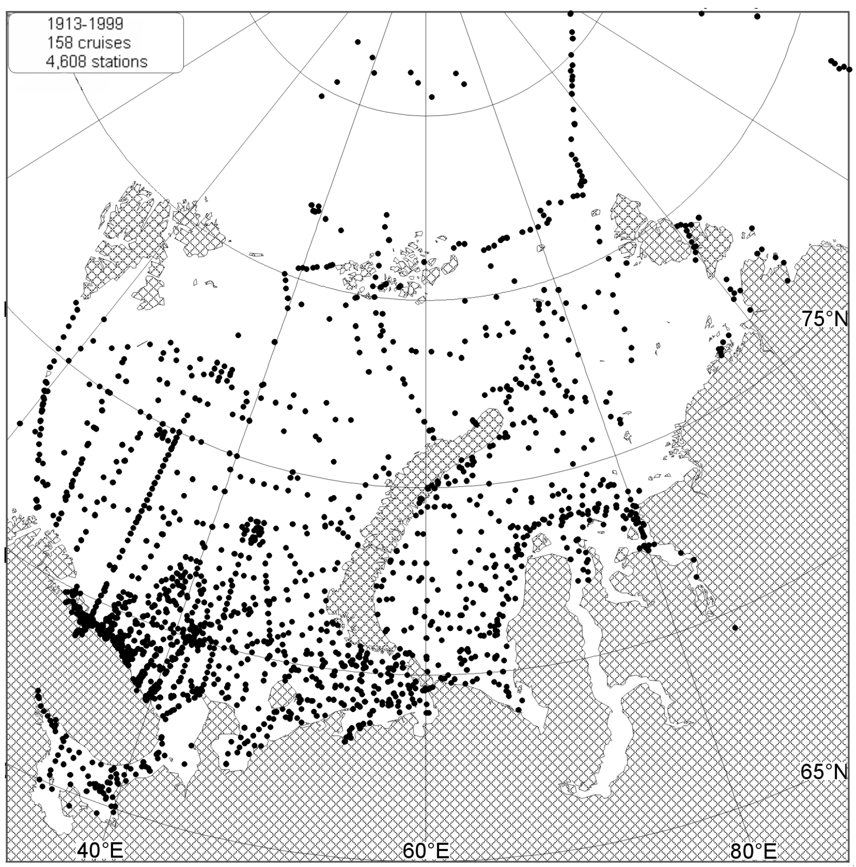

▲ **Figure 1**. Distribution of all 158 data collection sites, from 1913 to 1999.

Biological Atlas, *from page 1*

Database

The MMBI archive is a major contributor of data for the present work. In addition to the information obtained by the MMBI expeditions from 1952 to 1999, this archive includes data measured by researchers of the Murmansk Biological Station in 1920-1940s. The NOAA Central Library (Silver Spring, MD, USA), Slavonic Library (Helsinki, Finland), Dartmouth College Library (Hanover, NH, USA), and the New York Public Library have also contributed data for the period 1913-1964.

Altogether, data from 158 expeditions (Figure 1) carried out in the Barents, White and Kara Seas from 1913 to 1999 are considered in this work. As some expeditions started in the White Sea and finished in the Barents Sea, the White Sea was also included. Among the 158 expeditions, one was carried out on board the American *R/V Tanner* (1963) and one on the German *R/V Polarstern* (1996). Other expeditions were carried out on Russian vessels. In addition to the mentioned data, the database includes phytoplankton samples collected in two bays of the Kola Peninsula during the period of 1968-1989. In both of the bays, samplings were carried out from two to ten times per month at the same point. Nuclear icebreakers were used by MMBI scientists as the ships-of-opportunity to study the phytoplankton and oceanographic conditions of the regions, which had previously been beyond the reach of any studies due the presence of heavy ice. Figure 2 presents the interface which allows the accession of the metadata, the data distribution map, and primary data for each individual cruise.

Data quality control

By now the procedure of measurements of physical and hydrochemical characteristics of seawater is formalized and has been fully automated. The procedure of identification of plankton species has undergone practically no change since the first studies of the science. Now, just as many decades ago, the result of taxonomic analysis of plankton samples depends on a biologist's skills. This clearly demonstrates that hydrobiological data quality control is one of the key components of database development and will determine the success of the implementation into studies of the World Ocean.

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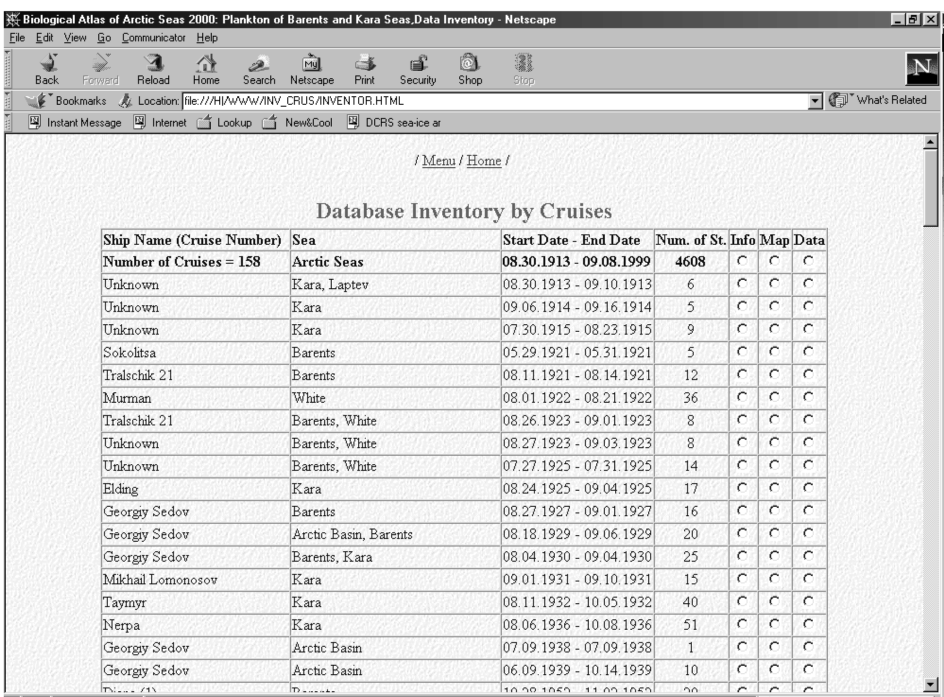

Ship Name (Cruise Number)	Sea	Start Date - End Date	Num. of St.	Info	Map	Data
Number of Cruises = 158	**Arctic Seas**	**08.30.1913 - 09.08.1999**	**4608**			
Unknown	Kara, Laptev	08.30.1913 - 09.10.1913	6			
Unknown	Kara	09.06.1914 - 09.16.1914	5			
Unknown	Kara	07.30.1915 - 08.23.1915	9			
Sokolitsa	Barents	05.29.1921 - 05.31.1921	5			
Tralschik 21	Barents	08.11.1921 - 08.14.1921	12			
Murman	White	08.01.1922 - 08.21.1922	36			
Tralschik 21	Barents, White	08.26.1923 - 09.01.1923	8			
Unknown	Barents, White	08.27.1923 - 09.03.1923	8			
Unknown	Barents, White	07.27.1925 - 07.31.1925	14			
Elding	Kara	08.24.1925 - 09.04.1925	17			
Georgiy Sedov	Barents	08.27.1927 - 09.01.1927	16			
Georgiy Sedov	Arctic Basin, Barents	08.18.1929 - 09.06.1929	20			
Georgiy Sedov	Barents, Kara	08.04.1930 - 09.04.1930	25			
Mikhail Lomonosov	Kara	09.01.1931 - 09.10.1931	15			
Taymyr	Kara	08.11.1932 - 10.05.1932	40			
Nerpa	Kara	08.06.1936 - 10.08.1936	51			
Georgiy Sedov	Arctic Basin	07.09.1938 - 07.09.1938	1			
Georgiy Sedov	Arctic Basin	06.09.1939 - 10.14.1939	10			

▲ **Figure 2.** Portrayal of the interface allowing the access of metadata, the data distribution map, and primary data for each individual cruise.

EARTH SYSTEM MONITOR

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Questions, comments, or suggestions for articles, as well as requests for subscriptions and changes of address, should be directed to the Editor, Roger Torstenson.

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D. James Baker,
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News briefs

ICSU awards grant to Paleoclimatology for mirror site

The International Council for Science awarded $5000 to the World Data Center for Paleoclimatology to establish a new site to mirror paleoclimatic data in Mendoza, Argentina. This will be the fourth mirror site established by WDC-Paleoclimatology. Mirror sites already exist in Toulouse, France; Johannesburg, South Africa; and Nairobi, Kenya. While the former two sites strictly mirror the data and web services of the WDC-Paleoclimatology in Boulder, the Kenyan mirror (*http://wdc.uonbi.ac.ke/*) has a decidedly African flavor. The Argentine mirror site will also provide special services, with the hosts at Centro Regional de Investigaciones Cientificas y Tecnologicas in Mendoza providing Spanish language translation of web pages and documents. Information on the mirror sites can be viewed at: *http://www.ngdc.noaa.gov/paleo/mirror.html*.

NESDIS builds strategic planning database

The National Geophysical Data Center developed a prototype database in Microsoft Access to support Strategic Planning in the Habitat Characterization working group. The database relates programs, activities, and capabilities across NOAA Line Offices and will allow the working group to restructure and plan new programs and to set priorities by ranking criteria. A demonstration and discussion of the database and its structure was conducted between multiple offices in the National Marine Fisheries Services (NMFS) and NESDIS using NetMeeting to interactively display the database over the Web. Later, plans are to mirror the Access databases through the NOAA National Data Center (NNDC) server where all LO participants can access it and update programmatic data.

NBC Nightly News

National Climatic Data Center meteorologists Tom Ross and Richard Heim were interviewed by NBC NIghtly News regarding the record snowfall of 24.9 inches in Buffalo, New York on November 20, 2000. Mr. Heim provided historical snowfall statistics for Buffalo from NCDC's U.S. Snow Climatology CD-Rom and Mr. Ross provided national snowfall statistics for the 2000-2001 season.

New CD-Rom *Climate Atlas of the Contiguous United States*

A new CD-Rom version of the "Climate Atlas of the Contiguous United States" has been produced by NOAA's National Climatic Data Center in Asheville, North Carolina. The atlas is composed of 737 maps which depict temperature, precipitation, snow, and other parameters for all areas of the contiguous U.S. Maps for Hawaii and Alaska will be available on CD-Rom during the Spring of 2001. This atlas replaces the very popular paper copy *Climatic Atlas of the United States*, which was published in 1968.

"The new climate atlas will serve the interests of commercial, industrial, agricultural, research, and educational institutions, as well as those from the general public," said Marc Plantico, a climatologist at the Asheville center. "Its primary purpose is to show the 'normal' or average spatial patterns for the various parameters. Maps of extreme events are also included."

NCDC's partners in the atlas project were the Oregon Climate Service, the Spatial Climatic Analysis Service at Oregon State Univeristy, and the Natural Resources Conservation Service of the U.S. Department of Agriculture. The CD-Rom contains the station data (in DBF format) used to produce the atlas, along with detailed documentation concerning the data used to generate each map and how the statistics were computed. Most atlas products were derived from data from the 1961-1990 period of record.

The new atlas was developed using innovative technology and geographic information systems to objectively generate the maps. The analytical climate model, PRISM (Parameter-elevation Regressions on Independent Slopes Model), which was developed by the Spatial Climatic Analysis Serice was used to generate 4 x 4 km grids for many of the parameters.

Additional maps were generated by NCDC using ESRI's (Environmental Systems Research Institute) ArcView. ESRI's ArcExplorer is used as the map browser and provides some basic GIS features such as zoom and query.

The CD-Rom is available from NCDC at a cost of $130 online at *http://www.ncdc.noaa.gov/*, or $175 (offline), plus $11 shipping and handling charge. For offline orders call 828-2271-4800 or write to National Climatic Data Center, NOAA/NESDIS, Veach-Baley Federal Bldg., 151 Patton Avenue, Asheville, NC 28801-5001.

Nighttime lights collaboration with Italy

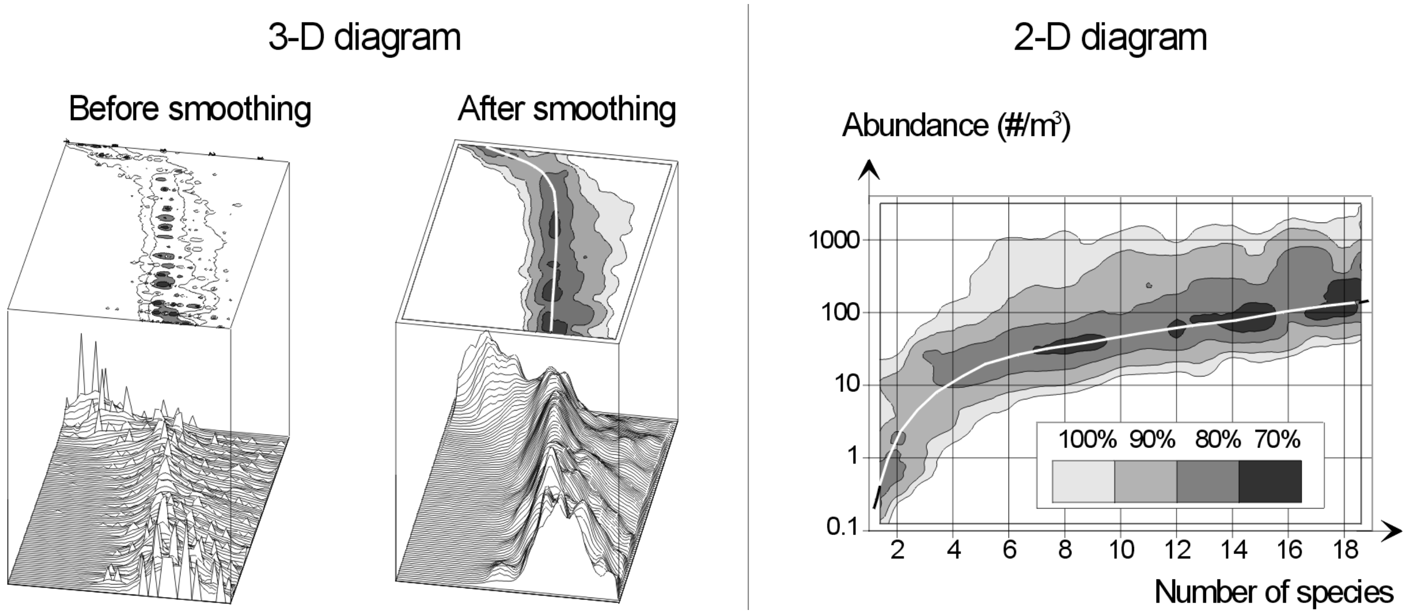
The journal *Nature,* volume 406, August 24, 2000, page 83, features a picture depicting the impairment of astronomical viewing conditions across Europe. The image was generated using NGDC's radiance calibrated Nighttime Lights of the world (1996-97) as input. The model, developed by Dr. Pierantonio Cinzano of the University of Padua, Italy, calculates the downward scatter of light to the earth's surface based on the brightness of the light sources measured at the top of the atmosphere by the DMSP. It is this downward flux of artificial light that adversely impacts the visibility of stars and features such as the Milky Way.

Cinzano has collaborated with Chris Elvidge of NGDC to generate the first global map of light pollution. By combining these light pollution maps with population density grids, Cinzano and Elvidge were able to estimate that 77% of people living in the U.S. are unable to observe the Milky Way from their backyards.

Hydrological forecasting in Central Asia

NGDC's affiliated National Snow and Ice Data Center (NSIDC) hosted an information-sharing session for visitors from Uzbekistan, Tajikistan, Kyrgystan, and Kazakhstan in October 2000. The representatives of hydrometeorological institutes were in the United States as part of a joint U.S. Agency for International Development and NOAA National Weather Service technology transfer project to strengthen snow-pack monitoring, river forecasting, and water management techniques in Central Asia.

NSIDC and NOAA Environmental Technology Laboratory scientists briefed the delegation on snow mapping and runoff modeling as it is being implemented in a NASA-sponsored Southwest Regional Earth Science Applications Center project.



▲ **Figure 3.** Relationship of the number of zooplankton species to their abundance, in the Barents and Kara Seas.

Biological Atlas, *from page 2*

In the present work the quality control of biological data is performed by: 1) the definition of ranges of plankton variables; 2) the preparation of lists of phyto- and zooplankton species, including synonyms; 3) preparation of an album with photographs of living cells of the dominant phytopankton species; 4) preparation of a detailed review of the plankton studies of the Barents and Kara Seas during the period 1890-1999. Herein each is described in more detail:

1) *Ranges of phytoplankton variability*

The annual cycle of phytoplankton development is considered. The phytoplankton condition during spring, summer, fall and winter is described with the following variables: depth of phytoplankton habitats, taxa structure, dominant species, number of phytoplankton cells per a liter of water. In practice, all the data on phytoplankton, included in the database were collected and calculated by the co-authors of the atlas (P. Makarevich, N. Druzhkov, V. Larionov). So, the scheme for an annual cycle of phytoplankton development allows data quality control at the stages of their collecting, treatment and presentation in computer format.

2) *Ranges of zooplankton variability*

The relationship between number of zooplankton species and zooplankton abundance per m^3 has been calculated (Figure 3). The input data were 9,081 zooplankton samples. The shape of the graph on Figure 3 agrees well with a theoretical curve which confirms the data reliability.

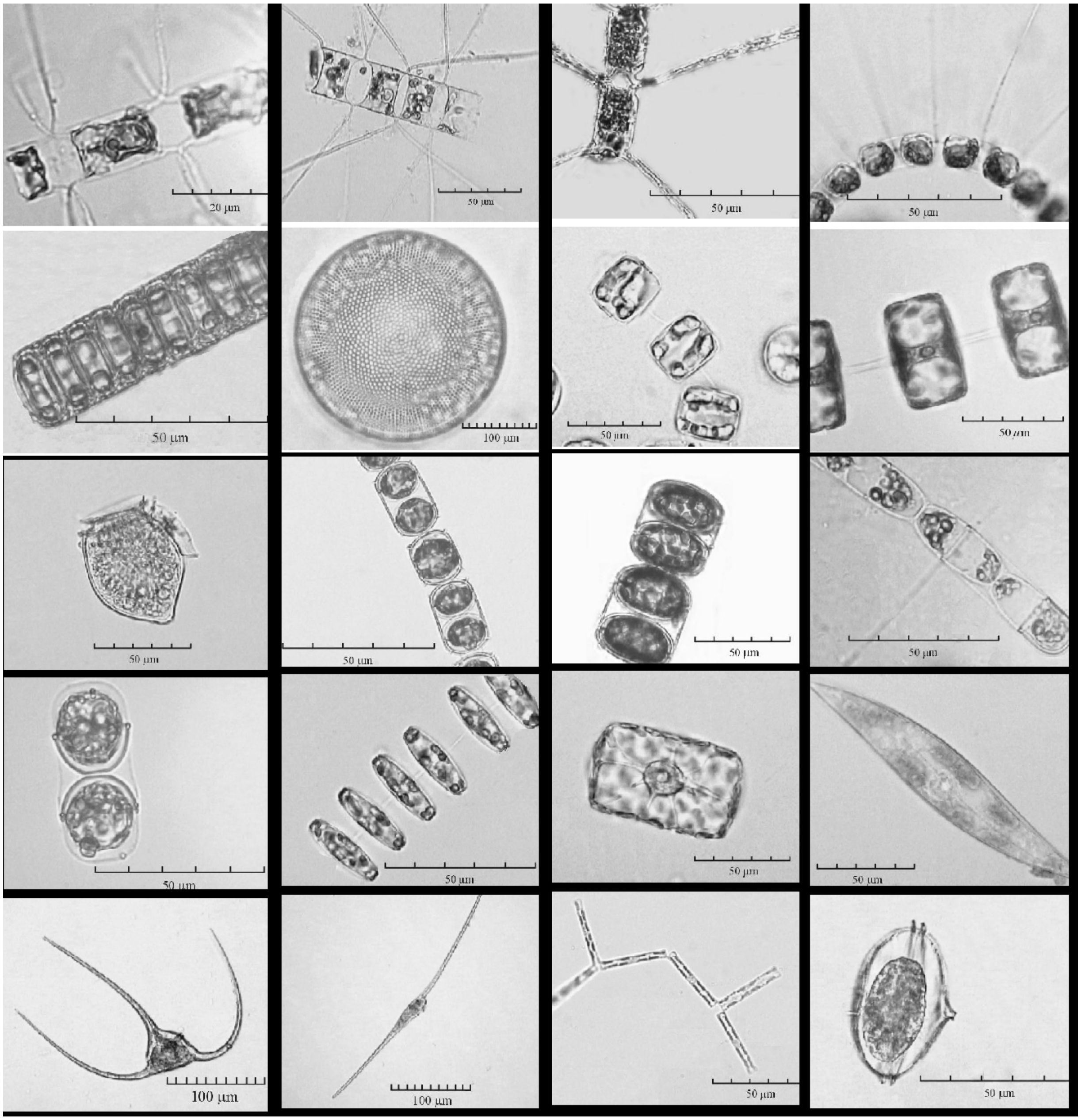
3) *Lists of Plankton Species*

For this atlas, a table was created which contains the taxonomic names of 527 species of phytoplankton, including the synonymy according to the requirements of modern botanical nomenclature. All phytoplankton were separated into 8 taxonomical groups (Bacillariophyta, Chlorophycota, Chrysophyta, Cryptophycophyta, Pyrrophycophyta, Euglenophycota, Haptophyta, Prasinophyta). For each entry, a weight is provided, computed by the method of geometrical similarity of figures. Ecological and phytogeographical characteristics of species are also presented (PG = phytogeographic characteristics; A = arctoboreal species; B = boreal species, C = cosmopolitan species; EG = ecological characteristics; O = oceanic forms; N = neritic forms; P = panthalassic forms; M = microphytobenthos; F = freshwater forms). Taxons are provided with the ITIS and NODC Taxonomic Code.

The list of zooplankton species of the Barents and Kara Seas includes 282 taxonomic names. The table has the following structure: zooplankton are split into groups characterized by taxonomic relationships. A large group of the unicellular zooplankton are separated. Whereas multicellular zooplankton are presented by both holoplankton (Coelenterata, Ctenophora, Rotatoria, Crustacea, Gastropoda, Chaetognatha, Appendicularia) and meroplankton (pelagic larvae of benthic animals). The lists of zooplankton and phytoplankton species are available on the CD-ROM.

4) *Phytoplankton Gallery*

In practice, for the identification of the various species in biological communities, systematic specialists frequently use taxonomic keys containing figures and/or photographs of organisms. The accuracy of the species identification depends on the accuracy of the representation of details in a photograph or drawing. The majority of modern illustrative materials do not present the detailed structure of microalgae cells. That substantially hinders their use for the taxonomic identification of these organisms. This disadvantage brings up the problem of providing more realistic images of phytoplankton cells, as close as possible to the natural appearance.



▲ **Figure 4.** Images of living dominant phytoplankton taxa of the Barents and Kara Seas.

Therefore, the Atlas contains color photographs of phytoplankton dominant species of the Barents and the Kara Sea. Figure 4 illustrates an overview photograph of 40 phytoplankton species. Color photographs of the same species are presented on the CD-ROM.

The history of hydrobiological studies

Studies of the plankton of the Barents and Kara Seas were mainly made by Russian scientists. Their results were published in Russian and are not easily accessible for English-speaking readers. So, the Atlas includes a detailed review of the Russian literature during the period 1890-1999. The reference list is given in alphabetic order and according to the regions which the Barents Sea is divided into. For the convenience of users the review is given on CD-ROM in HTML format which allows one to easily find the necessary reference.

Data visualization

The processes of ice melting, water mass vertical structure, and thermal characteristics of the marine environment determine the dynamics of the Kara Sea and the Barents Sea plankton development. Thus the present work provides the information on climatological ice edge, water vertical structure and temperature and salinity fields. The objective data analysis procedure used for this work generally corresponds to the scheme suggested by Barnes (1973) and the methods for calculating the data spatial distribution and map plotting used by Levitus and Boyer (1994). Additions to the algorithm have been made to account for the anisotropic structure of oceanographic fields in the Barents and Kara Seas.

— continued on page 6

Biological Atlas, *from page 5*

For the calculation of temperature distribution fields at the surface of the Barents and Kara Seas, in the summer a correlation radius of 250 km is used and in the winter this radius was reduced to 180 km. At a depth of 100 m the radius is 35-40% less than at the surface. The values of temperature and salinity are calculated for the grid of 20x20 km for three time intervals: 1920-1940, 1950-1960, and 1980-1990. The choice of these periods is determined by the availability of plankton data, water temperature, and salinity data for these years. For each time interval the following maps were constructed:

Barents Sea — temperature and salinity, surface and depth 100 m, winter and summer;

Kara Sea — temperature and salinity, surface and depth 100 m, summer.

Winter = {January, February, March, April}.
Summer = {July, August, September}.

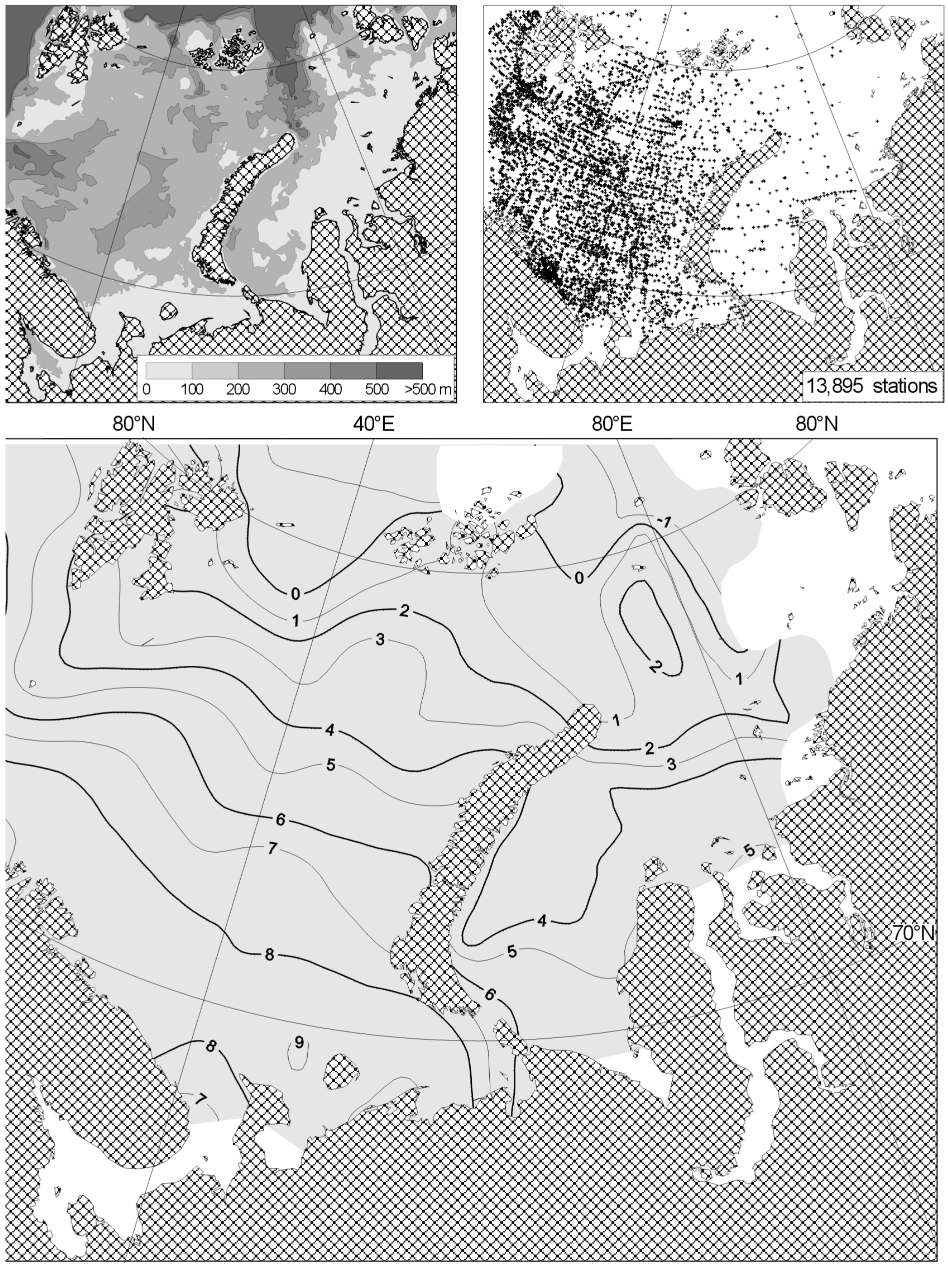
Figure 5 gives an example of a map describing the temperature distribution in the Barents and Kara Seas. The distribution fields (maps) of abundance, biomass, and number of plankton species are used to describe the state of the planktonic communities. Coefficients of biodiversity, calculated based up on the above mentioned characteristics, are used in hydrobiological studies. These coefficients characterize the level of diversity in the plankton community. The Glisson coefficient is used in the present Atlas as biodiversity coefficient:

$Kgl=(N_t-1)/\log(N_i)$

in which: N_i - number of individuals,

N_t - number of species in the sample.

The rise in the biodiversity level is induced by additional energy in the ecosystem, the source of which is determined by the regional features of the investigated ocean region. For example, in the Kara Sea it can be the incoming flux of the Atlantic waters or the discharge of the Ob or Yenisey rivers. In the Barents Sea it can also be the flux of Atlantic waters coming from the Norwegian Sea or an influx of fresh water resulting from ice melting. Thus, the fields of distribution of the plankton characteristics can be used not only as an indicator of the state of the plankton community, but also as a tool of study of the water masses of the Barents and Kara Seas. Figures 6, 7, 8 give some examples of maps of the phyto- and zooplankton distributions in the Barents and the Kara Seas.



▲ **Figure 5.** Surface temperatures, in Celsius, for August and September, 1980-1990.

Changes of the plankton community

To document changes of the plankton community in the Barents and Kara Seas, two groups of the data were chosen: (i) data collected during the period of sharp Arctic warming of 1920-1930 (Fu *et al.*, 1999); (ii) data collected since 1950, during the period of more severe climatic conditions (Fu *et al.*, 1999). Let us consider some results of the data comparison.

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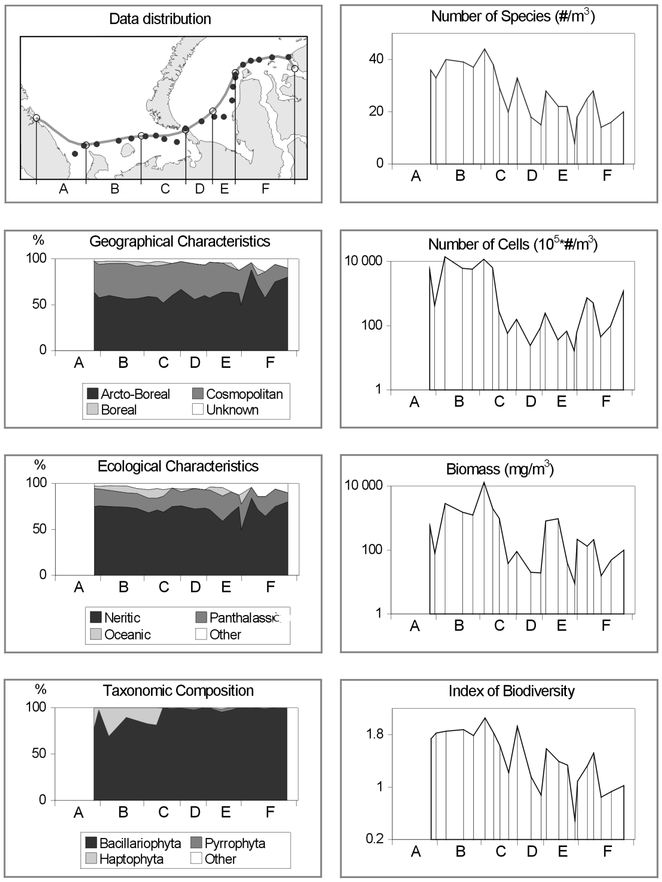
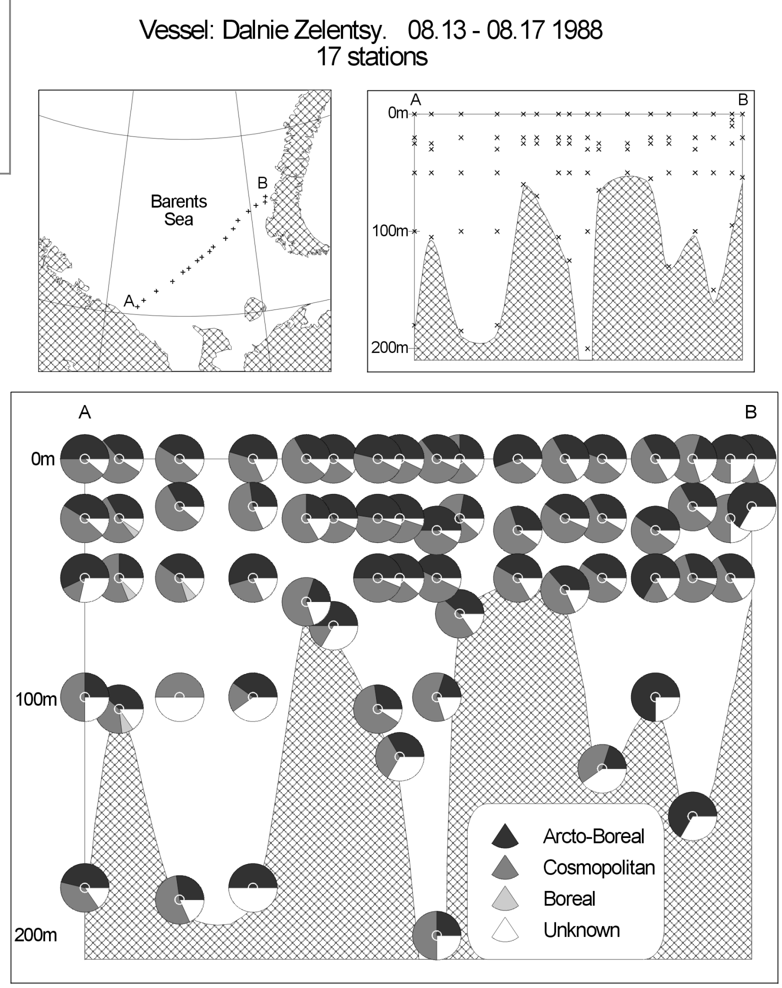
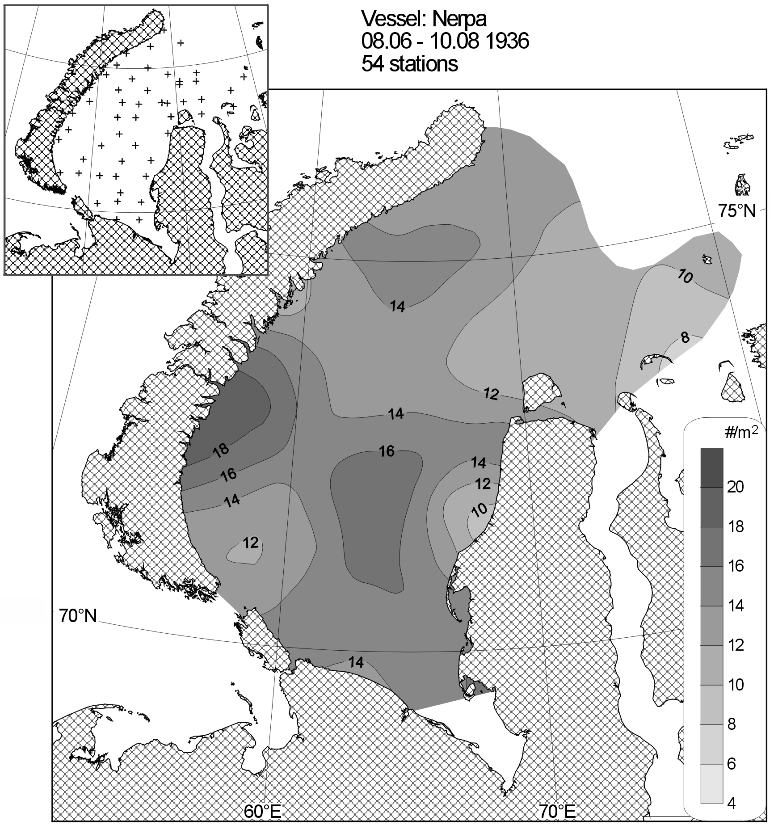


▲ **Figure 6.** Phytoplankton surface data, from the nuclear icebreaker *Arctica,* April - May 1996.



▲ **Figure 7.** Phytoplankton geographical characteristics, from August 1988.



▲ **Figure 8.** Zooplankton (surface to bottom) number of species; August - October, 1936.

Biological Atlas, *from page 6*

from page 6

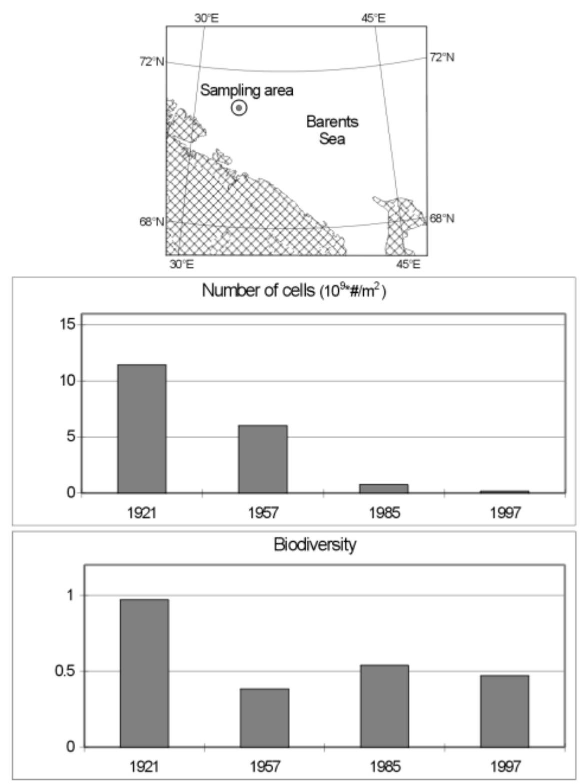
Phytoplankton. Barents Sea: 1921, 1957, 1985, 1997 (Figure 9).
Data: Data collected during April-May of 1921, 1957, 1985 and 1997 within the region with a 15 mile radius and a central point with coordinates 71°N 33°30'E. 37 samples from 8 stations were collected.
Characteristics: April-May mean values of biodiversity coefficient (the Glisson coefficient) and phytoplankton cells abundance are calculated under m^2 for the years 1921, 1957, 1985, and 1997. This figure shows that values were greater in 1921 than in the years 1957, 1985, and 1997.
Conclusion: Conditions for phytoplankton growth in April-May of 1921 were more favorable than in similar periods of 1957, 1985 and 1997.

Zooplankton. Southern Barents Sea: 1952-1959. (Figure 10)
Data: Data of 84 cruises carried out during the period 1952-1959 (1630 stations, 7137 samples).
Characteristics: The graphs characterizing variation of biomass, abundance, biodiversity index (the Glisson coefficient), and temperature anomaly during the period 1952-1959 are plotted. The tendency toward decrease in the values of 1952-1959 parameters is demonstrated.
Conclusion: The period from 1953-1955 had more favorable conditions for zooplankton development in comparison to the period from 1956-1958. One of the possible explanations for this phenomenon comes from the observed positive temperature anomalies in the period from 1953-1955.

The listed examples demonstrate that more favorable conditions for plankton development in the investigated Arctic region existed in the period during 1920-1930 than during 1960-1980. This conclusion agrees with existing observations of Arctic warming during the period 1920-1930 (Fu *et al.*, 1999).

CD-ROM version

The accompanying CD-ROM, available January 2001, contains original data, auxiliary tables, figures and text of the Atlas in MS doc and HTML formats. The HTML version of the Atlas consists of the following sections:



Data
Data processing covers the data collected during April-May of 1921, 1957, 1985, 1997 within the region with a 15-miles radius and a central point with coordinates 71oN, 33o30'E. Totally 37 samples from 8 stations were collected.

Characteristics
Summer average values of biodiversity and number of cells are calculated under m2.

Conclusion
The conditions for phytoplankton growth in April-May of 1921 were more favorable than in the similar period of 1957, 1985, and 1997.

▲ **Figure 9.** Phytoplankton samples from Barents Sea in 1921, 1957, 1985, and 1997.

Documentation. This Section contains the text of The Biological Atlas of the Arctic seas-2000 (the Barents Sea and the Kara Sea Plankton in Russian and English).

History. The list of publications of the Barents Sea phytoplankton and zooplankton is presented. The maps specifying locations of benthos stations carried out in the Barents Sea are attached.

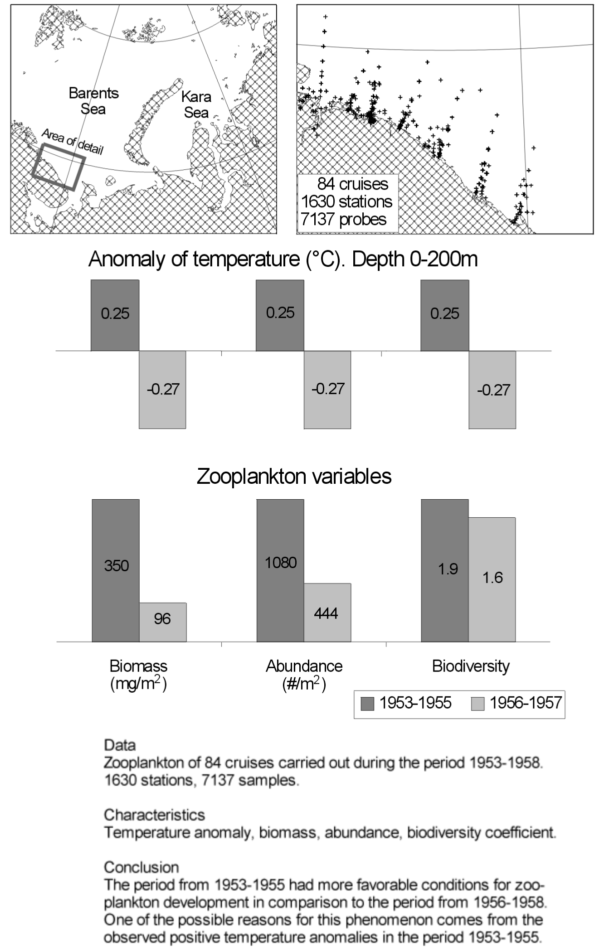
Plankton taxa. Phytoplankton and zooplankton species of the Arctic seas are listed in alphabetical order. The geographic and ecological characteristics are given for each species. Search capability by taxonomic group is provided.

Photo Gallery: includes photographs and drawings of 50 dominant phytoplankton species of the Arctic Seas and photographs of plankton sampling during the expedition of MMBI on the nuclear icebreaker Soviet Union in the Barents and Kara Seas; March-April, 1998.

Database. Data distribution maps are exhibited. The technique for review of the data obtained during each cruise is provided. The CD-ROM contains the primary data on the expeditions in two different formats. The first format practically coincides with the format adopted by OCL.

The second format presents the cruise data in the form of a table, which rows correspond to plankton species, and columns correspond to the stations numbers. Such form of data presentation is widely used in hydrobiological publications. The CD-ROM also contains data on continuous temperature, salinity and chlorophyll measurements made in the upper layer in the Barents Sea during June 1992.

Marine environment. This section incorporates maps and graphs describing the distribution of various characteristics of the plankton, and maps of the temperature and salinity, monthly mean ice-edge positions, and vertical structure of the Barents Sea water.



▲ **Figure 10.** Zooplankton samples from the Barents Sea, 1953-1955 vs. 1956-1957.

Plankton community changes. Comparisons between the structure of the plankton in the 1930's, 1950's, and 1990's are presented. Observed changes are related to the variability of the Arctic climate.

Authors. Names of the authors, their addresses, telephones, and email addresses are listed.

Future work

The database development and documentation of fluctuations in hydrobiological characteristics of the Arctic seas is a priority for future work. We plan to continue developing the database through the improvement of the quality control procedures for hydrobiological characteristics and detailed descriptions of the methods and gears.

References

Barnes, S. L., 1964: A technique for maximizing details in numerical weather map analysis. J. App.Meteor., 3, 396-409

Fu, C., H.F. Diaz, D. Dong, J.O. Fletcher, 1999: Changes in atmospheric circulation over northern hemisphere oceans associated with the rapid warming of the 1920s. Intnl Journal of Climatology, 19, 581-606.

Levitus, S., and T.P. Boyer, 1994: NOAA Atlas NESDIS 4, World Ocean Atlas 1994, vol.4. Temperature. NODC/OCL, Washington, 118pp.

U.S. Global Change Research Program, 2000:Our Changing Planet. The FY 2001 U.S. Global Change Research Program, Washington D.C., 74pp. (Available from *http://www.usgcrp. gov*) ■

The original fit of Africa, Madagascar, and East Antarctica

Discovering new clues to the Gondwana problem

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NOAA/NESDIS

While it is well-known that Africa, Madagascar, and East Antarctica (Figure 1) were once welded together as part of the supercontinent called Gondwana, the details of their original fit remain controversial. For example, some plate tectonic reconstructions (e.g., Lawver *et al.*, 1987, Muller *et al.*, 1998, Roeser *et al.*, 1996) align the African Zambezi coast (36°- 40° E) with the Princess Astrid coast (5°- 20° E) off of Queen Maud Land, Antarctica (Figure 2a). These models avoid the overlap of the continental Mozambique ridge onto Antarctica by fitting it into the eastern Weddell Sea instead. Further, the eastern scarp of the Mozambique ridge and the western scarp of the Explora Escarpment are thought to have been contiguous features that were sheared apart along a transform during the Middle Jurassic. A by-product of this alignment is that Madagascar is placed into the eastern Riiser-Larsen Basin.

A radically different configuration is realized if East Antarctica is shifted slightly counter-clockwise relative to Africa, so that the African Zambezi coast is aligned with the Princess Ragnhild coast (20°- 34° E) off of Queen Maud Land (Figure 2b) (e.g., Bergh, 1987, Segoufin and Patriat, 1980, Livermore and Hunter, 1990). In these reconstructions, the eastern scarp of the Mozambique ridge abuts the Astrid fracture zone, which precludes an origin of the Mozambique ridge in the eastern Weddell Sea. Tikku *et al.* (2000) identified an extinct seafloor-spreading center in the northern Natal Valley (north of the Mozambique ridge), and when this spreading is taken into account, the Mozambique ridge does not

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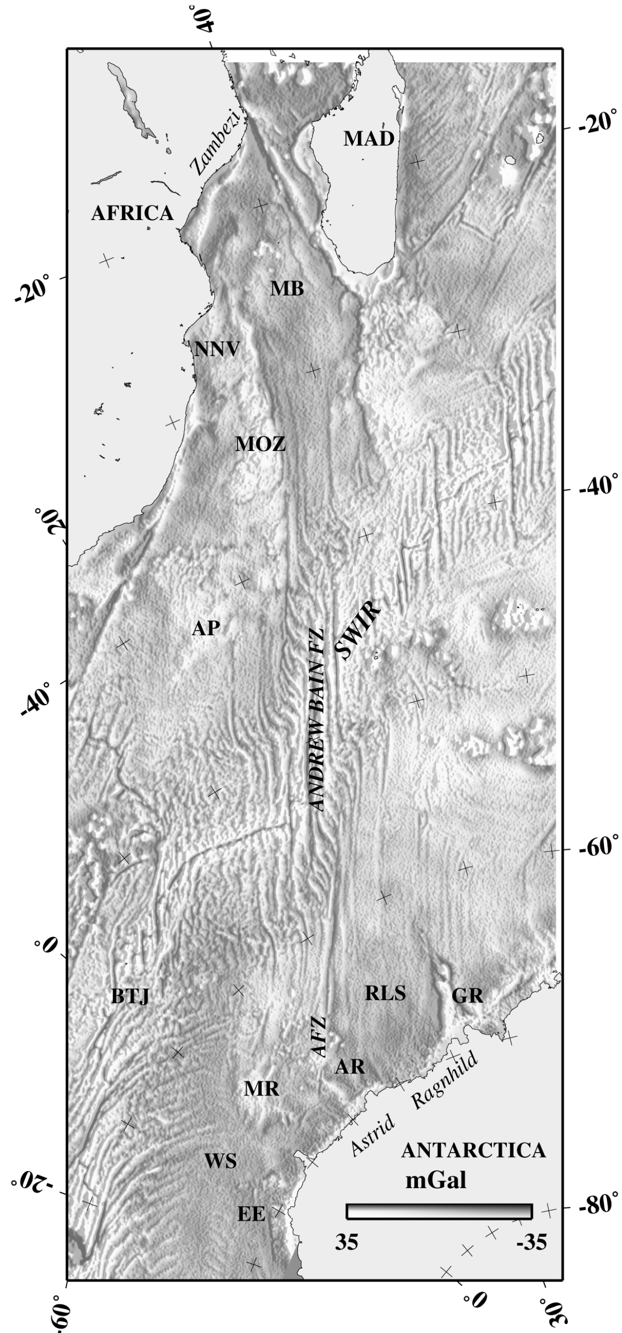
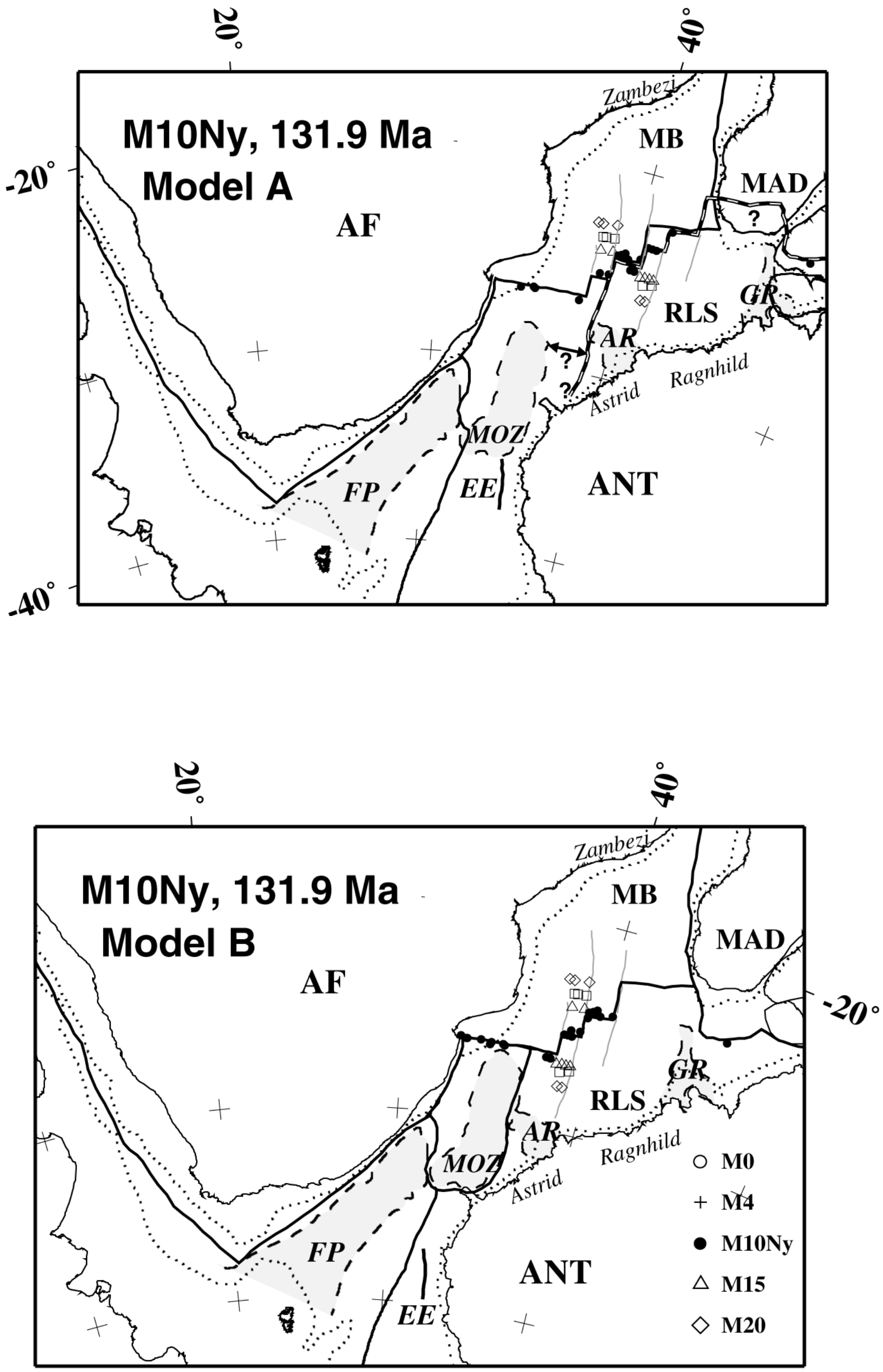


▲ **Figure 1.** Gray shaded-relief image of gravity anomalies computed from Geosat and ERS-1 satellite altimeter data over the Southwest Indian Ocean (Sandwell and Smith, 1997). Gravity anomaly amplititudes range between ≤ -35 mGal (black) and ≥ 35 mGal (white). Features are: Zambezi coast (Africa), Astrid and Princess Ragnhild coasts (Antarctica), Mozambique Basin (MB), Riiser-Larsen Sea (RLS), Weddell Sea (WS), northern Natal Valey (NNV), Mozambique ridge (MOZ), Agulhas Plateau (AP), Maud rise (MR), Astrid ridge (AR), Astrid fracture zone (AFZ), Gunnerus ridge (GR), Explora Escarpment (EE), Bouvet triple junction (BTJ), and Southwest Indian ridge (SWIR).



▲ **Figures 2a,b.** Alternate reconstruction models at chron M10Ny. Model A (top) produces large fracture zone offsets; Model B (bottom) aligns fracture zones and magnetic anomalies. Heavy black lines are isochrons; chain-line on (a) is an isochron on the Antarctic plate. The Mozambique ridge is an independent microplate in (b). In (a), Madagascar lies west of Gunnerus ridge, which is inconsistent with fracture zone and magnetic anomaly constraints. Fracture zones are gray lines, the continental shelf (1000 m contour) is a dotted line, relevant plateaus and tectonics ridges are shaded gray. Magnetic anomaly symbols are identified in (b).

overlap onto Antarctica. These models place Madagascar east of the Gunnerus ridge.

The ability to resolve which model may accurately reflect the original fit has been limited by the paucity of magnetic anomaly data, particularly in the eastern Weddell Sea and in the Mozambique and Riiser-Larsen Basins. This is further complicated by much of the seafloor in these basins being generated during the Cretaceous long normal period (~83-120 Ma) in which magnetic anomalies cannot be identified. Moreover, the young (<83 Ma) sinuous twists in the fracture zones crossing the Southwest Indian ridge (see Figure 1) make it hard to trace spreading corridors from one basin into the other.

Method

To overcome these problems, we used the novel approach of Marks and Stock (1997) to create reconstructions that can finally determine which models are likely correct. In this method, anomalies overlying seafloor younger than a selected time are removed, and the remaining (older) anomalies are wound back via appropriate finite rotations to form an image of how the marine gravity anomaly field would have appeared during the early separation of Africa, Madagascar, and East Antarctica. We compiled magnetic identifications from ship data as well as published isochrons, and used these to demarcate regions of younger seafloor. Because fracture zones and other tectonic features embedded in the seafloor are mapped by gravity anomalies, it is possible to locate the available magnetic anomaly identifications with respect to the fracture zones, and in this way resolve conjugate spreading compartments that existed in the Mozambique and Riiser-Larsen Basins (Figure 3).

There is the advantage too that the confused pattern of twisted fracture zones that are associated with younger seafloor generated on the Southwest Indian ridge are removed. Our ability to resolve the conjugate spreading corridors that existed during the Cretaceous places powerful constraints on the original fit of Africa, Madagascar, and East Antarctica.

— continued on page 12

Gondwana, *from page 11*

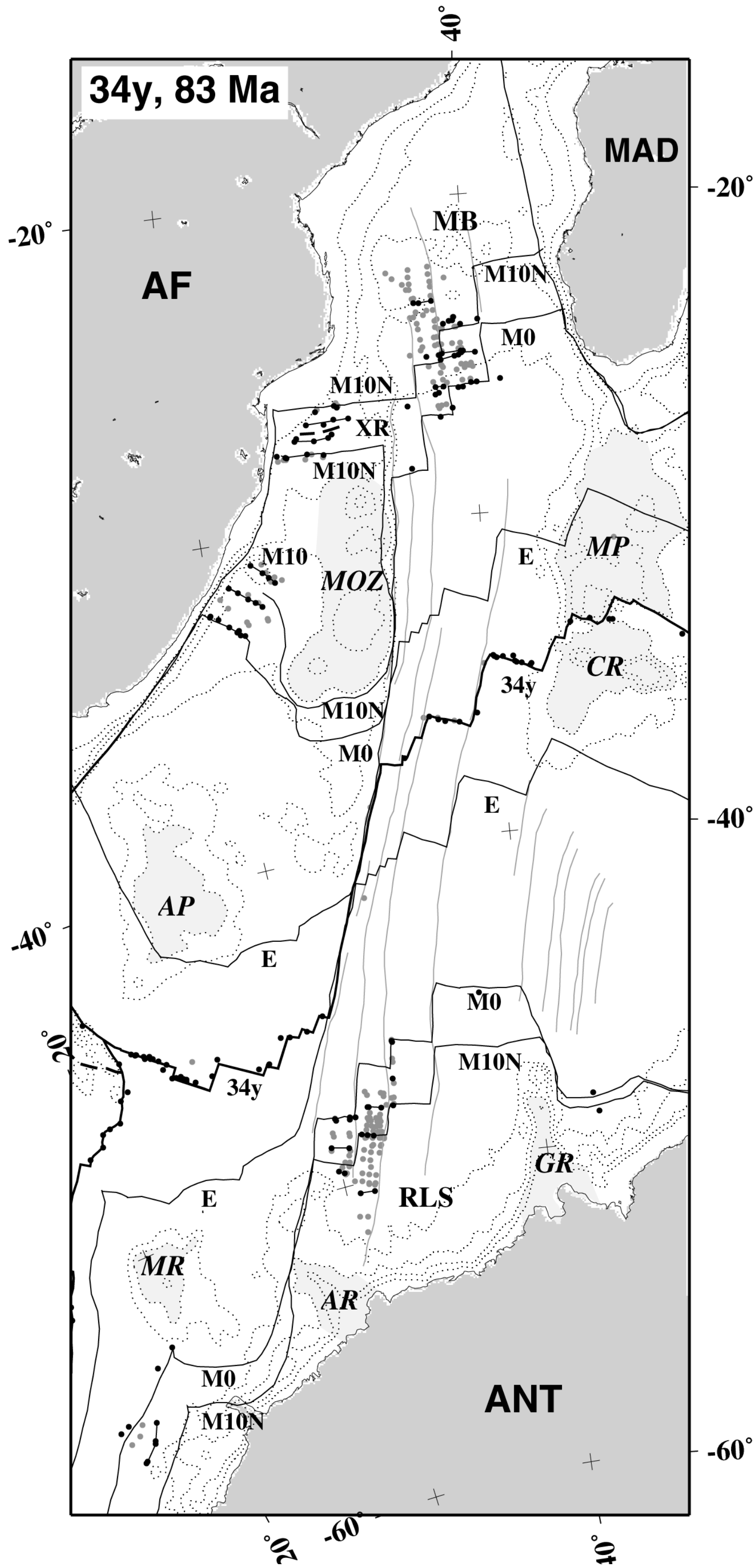
Results

Our most telling gravity reconstruction is that of chron 34y (83 Ma) (Figure 4). Because there are many 34y magnetic anomaly identifications on the Antarctic, South American, and African plates (Figure 3), the finite rotations used to wind back seafloor spreading are well-determined. Fracture zones and magnetic anomalies in the Mozambique Basin match up exceeding well with their counterparts in the Riiser-Larsen Basin, confirming they share a common origin on the Southwest Indian ridge. Significantly, the eastern scarp of the Mozambique ridge, and the Astrid fracture zone, are clearly connected via the nascent Andrew Bain fracture zone.

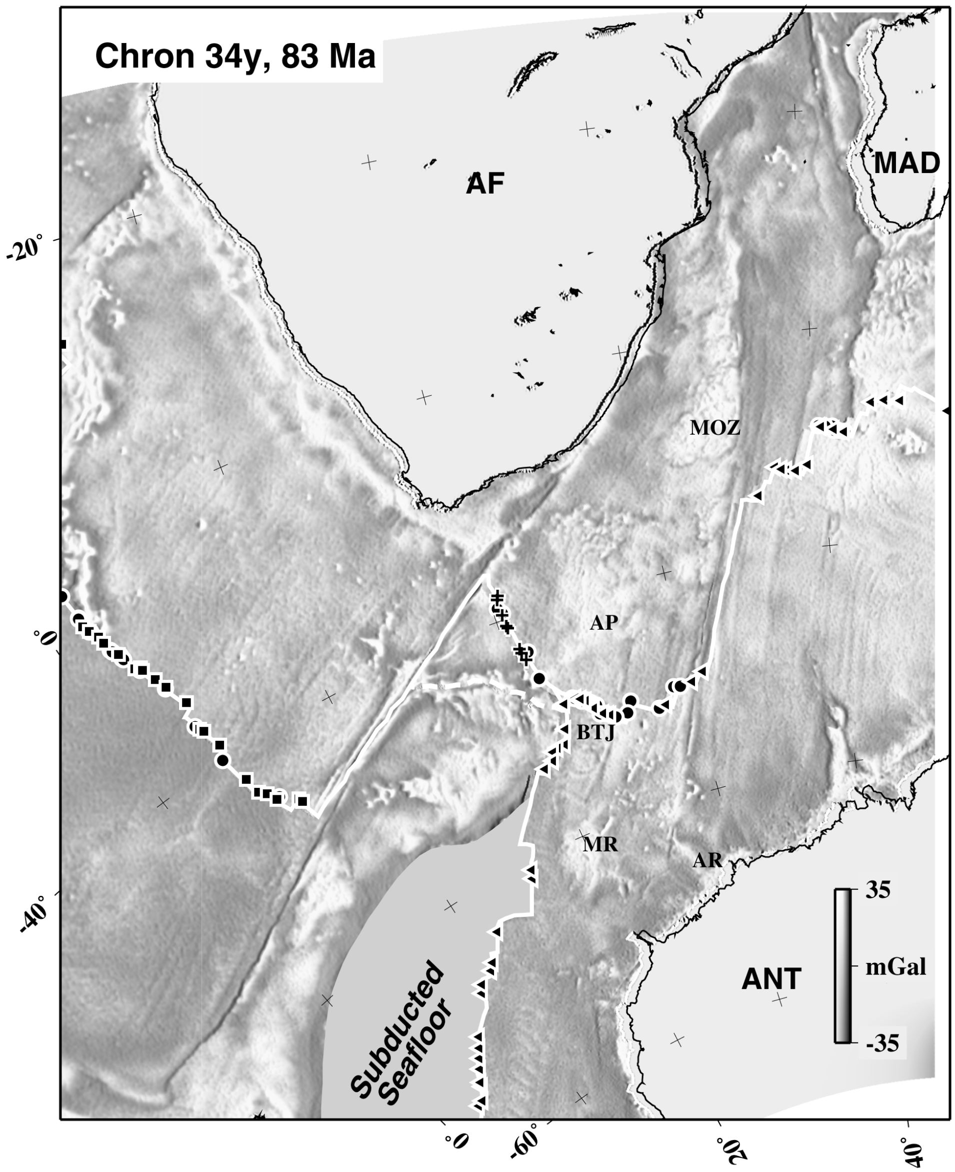
There are also two prominent fracture zones, one extending from the southeastern margin of the Agulhas Plateau to the northeastern margin of the Maud rise, the other from the shallow seafloor east of the Agulhas plateau to the shallow seafloor between the Maud rise and Astrid ridge, that trace the separation of these regions by seafloor spreading on the portion of the Southwest Indian ridge between the Andrew Bain fracture zone and the Bouvet triple junction. An origin of the Mozambique ridge in the eastern Weddell Sea is incompatible with these findings. The well-defined spreading compartments that can be traced from the Mozambique Basin into the Riiser-Larsen Basin, and conjugate magnetic anomaly identifications, reveal there is no room for Madagascar to have an origin in the eastern Riiser-Larsen Sea. Instead, Madagascar separated from Antarctica east of the Gunnerus ridge.

Conclusions

Our method of reconstructing state-of-the-art marine gravity fields in combination with magnetic anomaly data can yield powerful constraints on models that attempt to describe the early opening of the Southwest Indian Ocean. In our chron 34y reconstruction we have, for the first time, accurately mapped the fracture zones and spreading compartments in the conjugate Mozambique and Riiser-Larsen Basins.



▲ **Figure 3.** Isochron (thin black lines, 96 is Ma), fracture zone (gray lines), and magnetic anomaly compilation (black circles are 34y, M0, M4, M10Ny, and M17 identifications; gray circles are others) plotted on chron 34y reconstruction. Topography contours are dotted lines, the 34y spreading center is a heavy black line, and the extinct ridge in the northern Natal Valley (XR) is a dashed line. Relevant tectonic features are shaded.



▲ **Figure 4.** Gravity field reconstruction for chron 34y. The African plate is held fixed, and the image is "illuminated" from the east. M10Ny magnetic anomalies are circles on the African plate, triangles on the Antarctic plate, squares on the South American plate, and crosses on the Malvinas plate. Plate boundaries are white lines. Labels are the same as for Figure 1.

Correct reconstruction models are those consistent with our findings that 1) the eastern scarp of the Mozambique ridge and the Astrid fracture zone are connected by the proto-Andrew Bain fracture zone and 2) Madagascar separated from Antarctica east of the Gunnerus ridge. These results also imply that the original fit of Madagascar and East Antarctica to Africa was not as tight as some researchers have postulated.

References

Bergh, H. W., Underlying fracture zone nature of Astrid ridge off Antarctica's Queen Maud Land, J. Geophys. Res., 92, 475-484, 1987.

Lawver, L. A., J.-Y. Royer, D. T. Sandwell, and C. R. Scotese, Evolution of the Antarctic continental margins, in: M. R. A. Thomson, J. A. Crame, J. W. Thomson (Eds.), Geological Evolution of Antarctica, Cambridge University Press, Cambridge, pp. 533-539, 1987.

Livermore, R. A., and R. J. Hunter, Mesozoic seafloor spreading in the southern Weddell Sea, in: B. C. Storey, E. C. King, R. A. Livermore (Eds.), Weddell Sea tec tonics and Gondwana break-up, Geol. Soc. Spec. Pub. 108, 1996, pp. 227-241.

Marks, K. M., and J. M. Stock, Early Tertiary gravity field reconstructions of the southwest Pacific, Earth Planet. Sci. Letts. 152, 267-274, 1997.

Müller, R. D., D. Mihut, and S. Baldwin, A new kinematic model for the formation and evolution of the west and northwest Australian margin, in: P. G. Purcell, R. R. Purcell (Eds.), The sedimentary basins of western Australia 2, Proc. Western Australian Basins Symp., 1998, pp. 55-71.

Roeser, H. A., J. Fritsch, and K. Hinz, The development of the crust off Dronning Maud Land, East Antarctica, in: B. C. Storey, E. C. King, R. A. Livermore (Eds.), Weddell Sea tectonics and Gondwana break-up, Geol. Soc. Spec. Pub. 108, 1996, pp. 243-264.

Sandwell, D. T., and W. H. F. Smith, Marine gravity anomalies from Geosat and ERS-1 satellite altimetry, J. Geophys. Res. 102, 10,030-10,054, 1997.

Segoufin, J., and P. Patriat, Existence d'anomalies mesozoiques dans le bassin de Somalie. Implications pour les relations Afrique-Antarctique-Madagascar, C. R. Acad. Sc. Paris 291, 85-88, 1980.

Tikku, A. A., K. M. Marks, and L. C. Kovacs, An early Cretaceaous extinct spreading center in the northern Natal Valley, Tectonophysics, 2000, submitted. ■

New book features Global Environmental Databases

A new book series has been created to assess the current state of global environmental databases, and to recommend practical solutions to existing imperfections in such databases. The first volume of this series debuted in July. **Authors are sought for a second volume, which is anticipated for publication at the end of 2001.**

"Global Environmental Databases - Present Situation; Future Directions" is a project of the International Society for Photogrammetry and Remote Sensing (ISPRS) Working Group (WG) on Global Databases Supporting Environmental Monitoring. The series is edited by Ryutaro Tateishi (Chiba University Japan and WG Chairman) and David Hastings (NOAA/NESDIS National Geophysical Data Center and WG Co-Chairman). The first volume was published by the Geocarto International Centre in Hong Kong (*http://www.geocarto.com/B001.html*).

The book is written for the intelligent specialist in another field of environmental data. The editors and authors agree that more rigorous presentations are possible for the relatively small number of specialists in their own discipline's data — but that most other specialists already are, or should be, aware of such issues. The editors and authors believe that there is a much larger community of users of such data for other fields of science, policy-making, education, and public awareness. Those users need a more readable treatment of such data than normally appears in project proposals or reports, or in specialist publications. This book series attempts to fill that gap.

The book made its debut at the 18th Congress of ISPRS in Amsterdam, where copies were given to each national delegation. The reception for the book has been overwhelmingly positive.

The editors solicit groups of recognized experts in individual topics to write chapters in three general sets of issues:

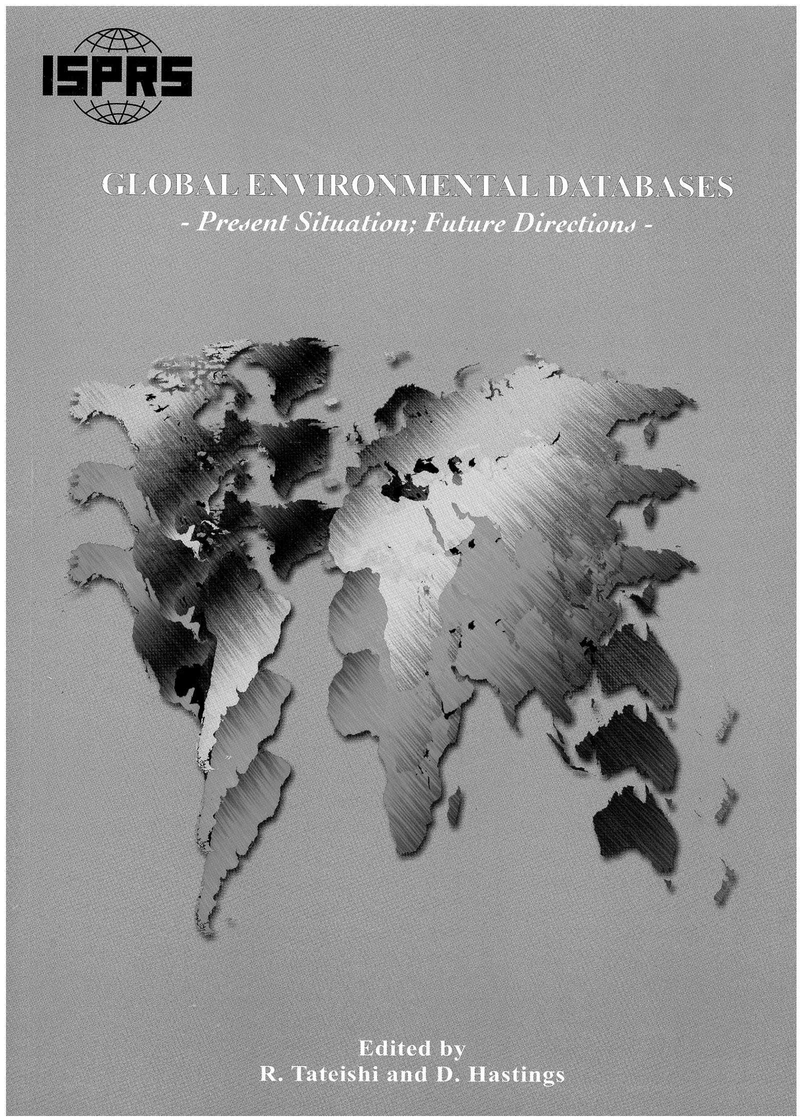
1. Thematic Domains

These chapters treat types of databases. General chapter contents include (a) an introduction which describes the importance, producers and uses of such data, (2) the present situation of such data, including historical and current states of development, (3) current challenges faced by such data (e.g. imperfections in, and predicaments faced by, such data), (4) the way ahead (suggestions and recommendations for improving such data). Built upon this fundamental general outline may be other discussion topics deemed appropriate for a given type of data.

The first volume of this series treated the following seven thematic topics: reference framework (base map), topographic, oceanographic, large-area land cover characterizations, biodiversity, soil resources, and hydrological data.

Hoped-for chapters in future volumes include meteorological, climatic, population and demographic, socioeconomic, forestry, cryogenic data, and other topics.

— continued on page 16



New Engineering Weather Data collaborative CD-ROM

The National Climatic Data Center (NCDC) and the Air Force Combat Climatology Center (AFCCC) have collaborated in the development of a new CD-ROM containing Engineering Weather Data for nearly a thousand worldwide locations. This product is for sale in the NNDC (NOAA National Data Centers) Online Store at a cost of $75. This is an update of a very popular publication that was first printed by the Air Force in 1967. As compared to the publication, the new interactive CD-ROM data base contains updated meteorological tables, new summarized parameters and graphical displays.

Applications of this product are intended for the design and construction industry with emphasis on heating and cooling systems. Design values, medians, and extremes of dry and wet bulb temperatures are included as well as various humidity parameters. Numerous other weather summaries are presented in tabular and graphical form which include binned temperature data, degree days, solar radiation, and wind roses. The AFCCC developed the data base and interface. NCDC published the CD-ROM and will distribute it to users.
Contact: NCDC

New interactive paleoclimate publication

A new article in the online journal "Global Temperature Patterns in Past Centuries: An interactive presentation" by Mann, M.E., Gille, E., Bradley, R.S., Hughes, M.K., Overpeck, J.T., Keimig, F.T., and Gross, W. (*Earth Interactions*, 4-4, 1-29, 2000) includes data and animations of global temperatures from paleoclimatic records starting in 1730, up through 1993 instrumental data. A major contribution is the first spatial reconstruction of temperature patterns through time that blends both paleoclimate reconstructions and instrumental data.

The online format of the journal allows readers to examine the data directly, to use web tools to view and compare periods of interest, and to view animations of the changing structure of the temperature patterns through time. The publication is available in pdf form at *http://www.ngdc.noaa.gov/paleo/ei/ei pdf.html.*
Contact: NGDC

Data products and services

Weather disaster report update

The National Climatic Data Center (NCDC) has updated the "Billion Dollar U.S. Weather Disaster" report for 1980-2000. It now includes two additional events from the 1980s, two events for 2000, and several updated statistics for 1980-1999 events. The two events for this year are the drought/heat wave in the south-central and southeastern states and the fire season in the west. The web page may be accessed at: *http://www.ncdc.noaa.gov/o1/reports/billionz.html*.

The web page also links to Technical Report 2000-02, "A Climatology of Recent Extreme Weather and Climate Events," which goes into more detail on these extreme events and relates them to population/societal trends and climate change.
Contact: NCDC

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Multibeam bathymetric data received

The National Geophysical Data Center (NGDC) received 15.8 gigabytes of multibeam bathymetric data from 11 cruises collected and contributed by Woods Hole Oceanographic Institute (WHOI). WHOI plans to send NGDC similar amounts of multibeam data annually as the two-year proprietary hold period is lifted. In 1999, NGDC received 32 gigabytes of multibeam data from 20 cruises. These data are collected worldwide using a SeaBeam 2100 system.
Contact: NGDC

Climate change papers placed online

The National Climatic Data Center has placed six scientific papers online: Observed Variability and Trends in Extreme Climate Events; Temporal Changes in the Relationship between Cloud Cover and Surface Air Temperature; Changes in the Probability of Heavy Precipitation; Recent Changes in Cloud Type Frequency and inferred Increases in Convection; Heavy Precipitation and High Streamflow in the Contiguous U.S.; and, The Relationship of Cloud Cover to Near-Surface Temperature and Humidity. Each of the papers is accessible through the global climate change page via *http://www.ncdc.noaa.gov/o1/climate/severeweather/extremes.html*.
Contact: NCDC

Index to Marine Geological Samples database

Oregon State University hosted the Curators group in September 2000, in Corvallis, Oregon. Carla Moore of the National Geophysical Data Center led a discussion on databases and web sites, and gave a status report on the Index to Marine Geological Samples database, which NGDC manages on behalf of the group. Data for over 10,000 seafloor samples was added during 2000. Dr. Guy Rothwell of the Southampton Oceanography Centre (SOC) presented the status of "Eurocore," a database of samples in European repositories and patterned after that of NGDC. Eurocore is funded at a level of 1.6 million dollars over three years. NGDC and SOC are discussing ways to share data and information.
Contact: NGDC

Environmental Databases, *from page 14*

2. Cross-Cutting Issues

These chapters treat topics that affect many types of data. The first volume treated the following two cross-cutting issues: geometric registration, ground control points and co-ordinate systems; and metadata.

Hoped-for chapters in future volumes include effects of current proposal/funding processes, peer review, cultural bias in database design and implementation, proprietary vs. open-access, projection and datum, spatial and thematic resolution, and other issues on data quality and usability.

3. Case Histories

These chapters are intended to document the situations of major producers/users of such data. Overall mission of the organization, objectives for producing/using such data, institutional culture, resources (and resource shortages), methods for producing, distributing and using such data, and assesments of successes and challenges are appropriate topics for such chapters.

To date, no such chapters have been published, though several authors have considered preparing such case histories.

Incidentally, authors of chapters already published are invited to submit updates and reassessments, as appropriate for publication in subsequent volumes. In this manner, topics covered in the series can remain current.

This book series evolved from initial discussions between the editors and other interested parties. These ideas evolved into a week-long workshop, conducted in November 1999 at the East-West Center in Honolulu. At that workshop, about two dozen interested scientists gathered to provide real-time peer-review of each others' chapter ideas, as well as of the overall book concept itself. The idyllic but invigorating atmosphere at the workshop set the stage for a compressed schedule for manuscript submission, traditional peer review, and publication of the book.

For the second volume, this intense schedule will be relaxed a bit. However, if you are interested in preparing a chapter for the 2nd or 3rd volume of this series, you are asked to contact the editors promptly at:

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