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EARTH SYSTEM MONITOR

Oceanographic database for the study of the Arctic climatic system

One degree statistics, physical and biological data

A guide to NOAA's data and information services

INSIDE

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An oceanographic database of the Arctic Seas is of great significance for the study of the Arctic climatic system. In the second half of the 19th century, when regular commercial ship cruises from Europe to the Kara Sea ports started (Hmiznikov, 1937), it was of practical importance to study the state of the Arctic Seas. During the First International Polar Year (IPY I, 1882-1883) a network of hydrometeorological stations was established beyond the Polar Circle. During this year, data collection and international data exchanges were started when water temperatures were measured at different depths in the Kara Sea (Snellen and Ekama, 1910) and Baffin Bay (Greely, 1888).

In the early 20th century, a comparatively large number of expeditions were held in the Arctic Seas. Let us mention here the largest ones. In 1898-1906, the Russian ships *Pomor* and *Andrei Pervozvanny* carried out studies of the Barents, White, and Kara Seas. An abundant amount of material was collected including deep-sea oceanographic observations of plankton and benthos. In 1910-1915, the Russian ice breakers *Taymyr* and *Vaigach* conducted hydrographic, oceanographic, and hydrobiological studies over the vast area including the Bering Sea in the east and the Barents Sea in the west. So far the fate of most of the material collected then, remains unknown.

During IPY II (1932-1933) in the eastern sector of the Arctic, between the Barents and Bering Seas, more than 1,000 deep-water stations were carried out and a substantial amount of material was collected about plankton and benthos in these regions.

After World War II, commercial fishing expanded in the Arctic and sub-Arctic regions. This resulted in an increased number of expeditions to the Arctic, during which hydrophysical, hydrochemical, and hydrobiological data were collected. For instance, in the 1950s in the Barents Sea, four to eight science ships worked monthly. In the summer months, two to three thousand stations were carried out. Due to a standard section system in the Barents Sea, the material collected has resulted in time series of temperature, salinity, and plankton of a length exceeding 40 years.

At the present time, there is abundant material that can be potentially used for Arctic studies. However, much of this material is preserved as manuscripts, which makes it almost inaccessible

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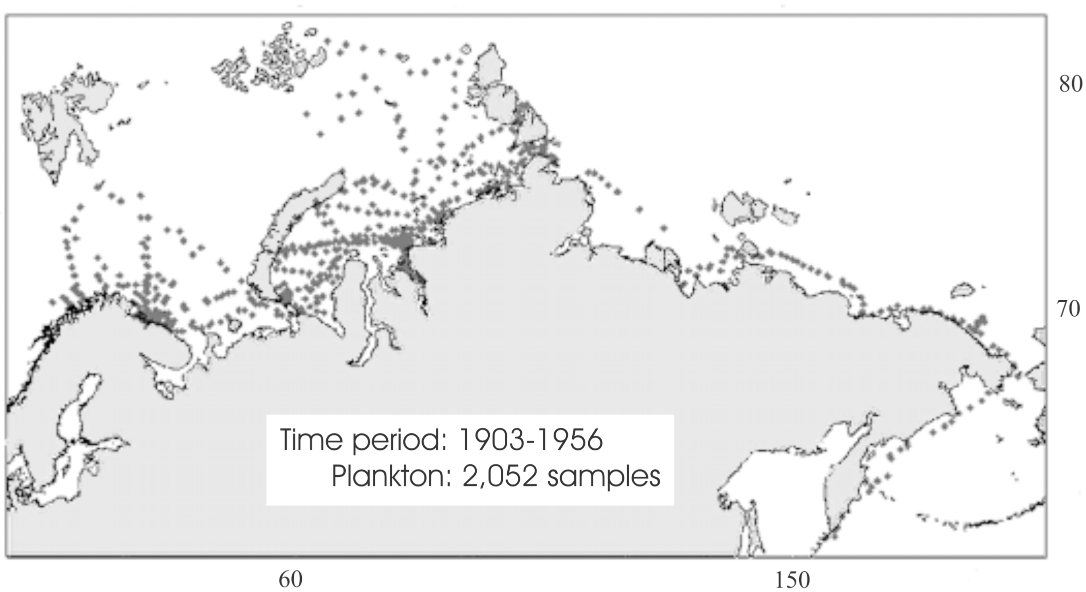

▲ **Figure 1.** Data distribution plot for the product *Arctic Zooplankton 2002*.

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Arctic climatic system, *from page 1*
to the international scientific community. Therefore, the World Data Center for Oceanography - Silver Spring, together with Russian colleagues, is creating an oceanographic database of the Arctic Ocean for use in studying the Arctic climatic system. This article reviews the results of this work, presented as four new products. These products have been prepared in the framework of the International Ocean Atlas and Information Series, which is produced by the World Data Center for Oceanography - Silver Spring.

I. The product ***Arctic Zooplankton 2002*** has been prepared jointly by the NODC Ocean Climate Laboratory, the World Data Center for Oceanography - Silver Spring, and the Laboratory of Marine Research of the Zoological Institute, Russian Academy of Sciences. This product includes physical and biological data for the Arctic and sub-Arctic regions, extending from the Barents Sea to the northwest Pacific. Samples were taken during 25 scientific cruises between 1903 and 1956 (Figure 1). The primary data are presented on a CD-ROM in a standard format along with maps of station locations and a listing of zooplankton taxa collected during these cruises. All the taxonomic descriptions have been compared with the ITIS taxonomic database and other literature sources.

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II. The product ***History of the Arctic Exploration 2003: Cruise Reports, Data*** has been prepared jointly by the Ocean Climate Laboratory, the World Data Center for Oceanography - Silver Spring, and the P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences. This product represents data collected from more than 60 cruises in the Arctic regions in 1850-1940 (Figure 2). The data sets included in this product are based on the articles and books preserved in the NOAA Central Library, the P.P Shirshov Institute library, and multiple public libraries in Russia and the USA.

Incompatibility between modern data and the data collected in the 19^{th} and the early 20^{th} centuries is one of the major problems in analyzing climatic variability. The data quality depends on both the accuracy of measuring instruments and of determining ship's coordinates and observation depths. Therefore, in data comparison,

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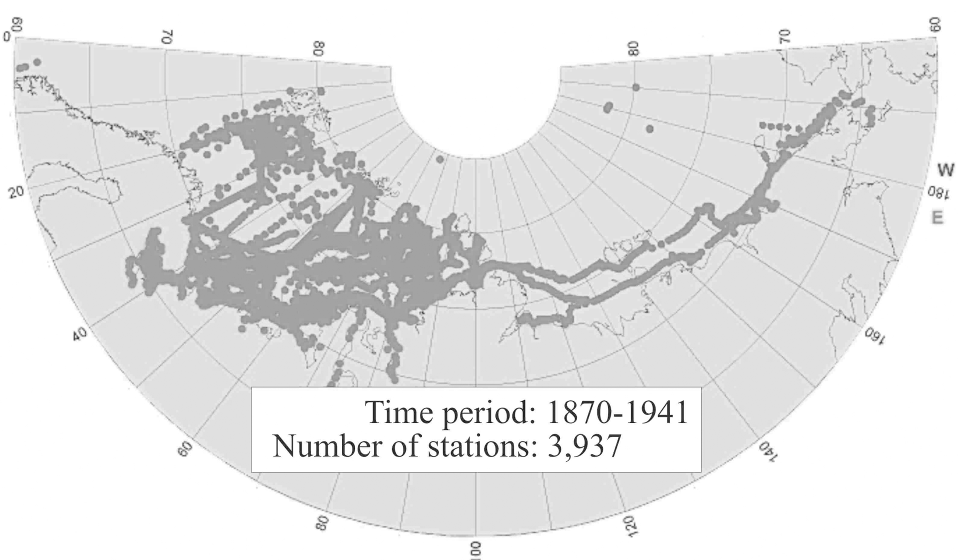

▲ **Figure 2.** Data distribution plot, extending from Norway on the left to Alaska on the right, for the product *History of the Arctic Exploration 2003: Cruise reports, Data.*

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Space Weather Week

Space Weather Week is a time for users of space environment data, forecasts, warnings, and alerts to meet with government and commercial providers of these services. This year the National Geophysical Data Center, in Boulder, Colorado, hosted the annual Space Weather Week on May 19-22, 2003. The principle sessions covered the topics of space weather agency activities, precision Global Positioning System and communications, satellite drag, electric power grids, trapped radiation and magnetospheric plasma, solar radiation storms, modeling and metrics, service providers, space climate, and solar observations and data. Several NGDC staff participated in the sessions, presented posters, and attended the numerous meetings of opportunity.

Climatology for Southwest Asia

NOAA's National Climatic Data Center (NCDC) has released an upgraded website for Souhwest Asia. The website includes much more climatic information for Iraq and allows for unrestricted distribution of the detailed station-by-station climatic summaries for the area. The Air Force Combat Climatology Center (AFCCC) and the U.S. Navy, co-located with NCDC, gave permission for unrestricted access to the summaries, which had been restricted to ".gov" and ".mil" users.

The website is providing support for many customers, such as the news media, to obtain quick support online rather than having to contact NCDC, AFCCC, or the U.S. Navy by telephone. The URL is: *http://www.ncdc.noaa.gov/oa/climate/afghan/*.

New radome design for ocean ships

A representative for a major U.S. defense contractor contacted NOAA's National Climatic Data Center seeking information regarding extreme minimum temperatures and maximum wind speeds for the major ocean routes around the world. The company is designing a new radome, which will likely replace existing equipment on many ocean-going vessels. There is a concern about how to prevent ice accumulation on the instrumentation. The individual was directed to NCDC's marine database.

News briefs

State of the Climate report

The NCDC released the April 2003 *State of the Climate* report. Above average precipitation from February through April has led to improved drought conditions in many areas. Moderate to extreme drought conditions persisted in 24% of the contiguous United States, down from 37% in January and 50% during Summer 2002. Temperatures during the February-April 2003 period were near average to slightly warmer than average across most of the country. The Northeast was the only region with significantly cooler than average temperatures. The moderate El Nino episode that began in 2002 weakened during the February through April period, while the average global temperature for combined land and ocean surfaces during April was 0.9º F. above the 1880-2002 long-term mean.

GEODAS quality assessment

Dr. Paul Wessel and Michael Chandler, of the University of Hawaii's School of Ocean and Earth Science and Technology (SOEST), met with NGDC personnel to discuss quality assessment of underway marine geophysical data stored at NGDC. Dr. Wessel has received a grant from the National Science Foundation to develop tools and procedures for both along-track, and between-track-crossover, analysis of errors in NGDC's GEODAS marine geophysical trackline data holdings. The primary goal of the proposal is to submit NGDC's trackline geophysical data archive to a rigorous quality assessment and provide corrections where appropriate. A secondary goal is to provide web-based access to a global database of bathymetry, magnetics, and gravity cross-over erros that would be a first quantitative and quality assessment of the data.

Siberian summer temperatures

The NCDC has archived a 4000-year summer temperature reconstruction for northwestern Siberia. The reconstruction was based on tree ring widths taken from hundreds of subfossil logs buried and preserved in river sediments. The data and research summary is at: *http://www.ngdc.noaa.gov/paleo/pubs/hantemirov2002/hantemirov2002.html*.

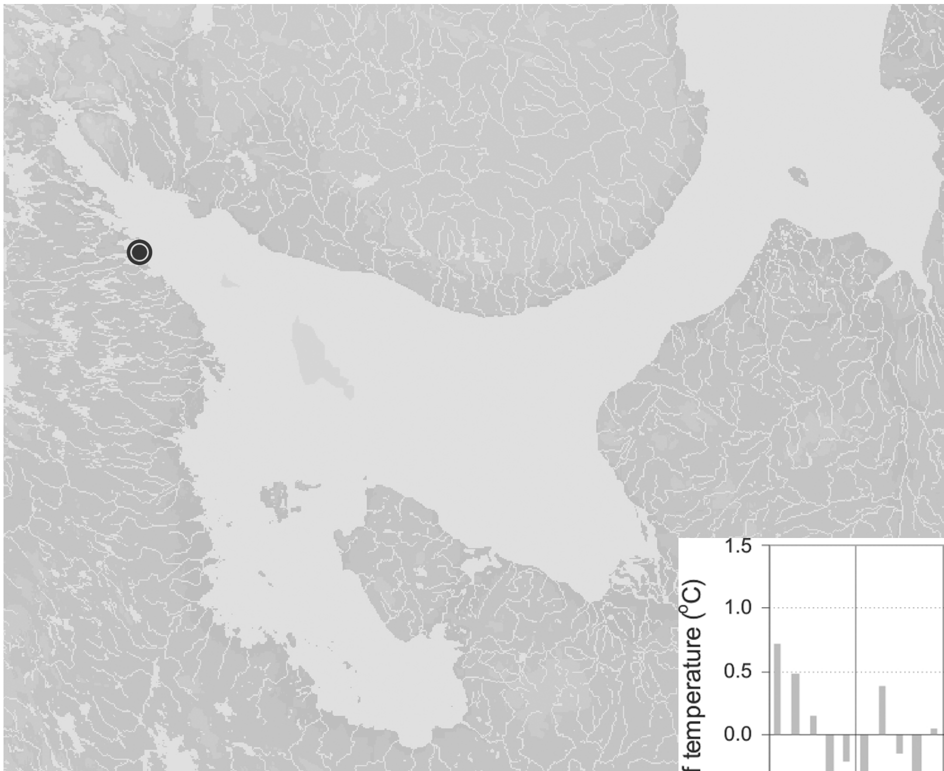
NESDIS' emergency beacons save two U.S. Coast Guard personnel

On April 24, two U.S. Coast Guardsmen were saved in the vicinity of Yaupon Beach, North Carolina when their small vessel took water over the bow and began flooding. The crew manually activated a new type of lifesaving beacon called a Personal Emergency Position Indicating Radio Beacon (PEPIRB) which NOAA's Search and Rescue Satellite Aided Tracking (SARSAT) System detected and located. The SARSAT U.S. Mission Control Center then notified the Atlantic Area Coast Guard Rescue Coordination Center in Portsmouth, Virginia, which launched a 47-foot, high-speed motor lifeboat to the scene, took the crew members on board, and towed the disabled vessel safely back to port.

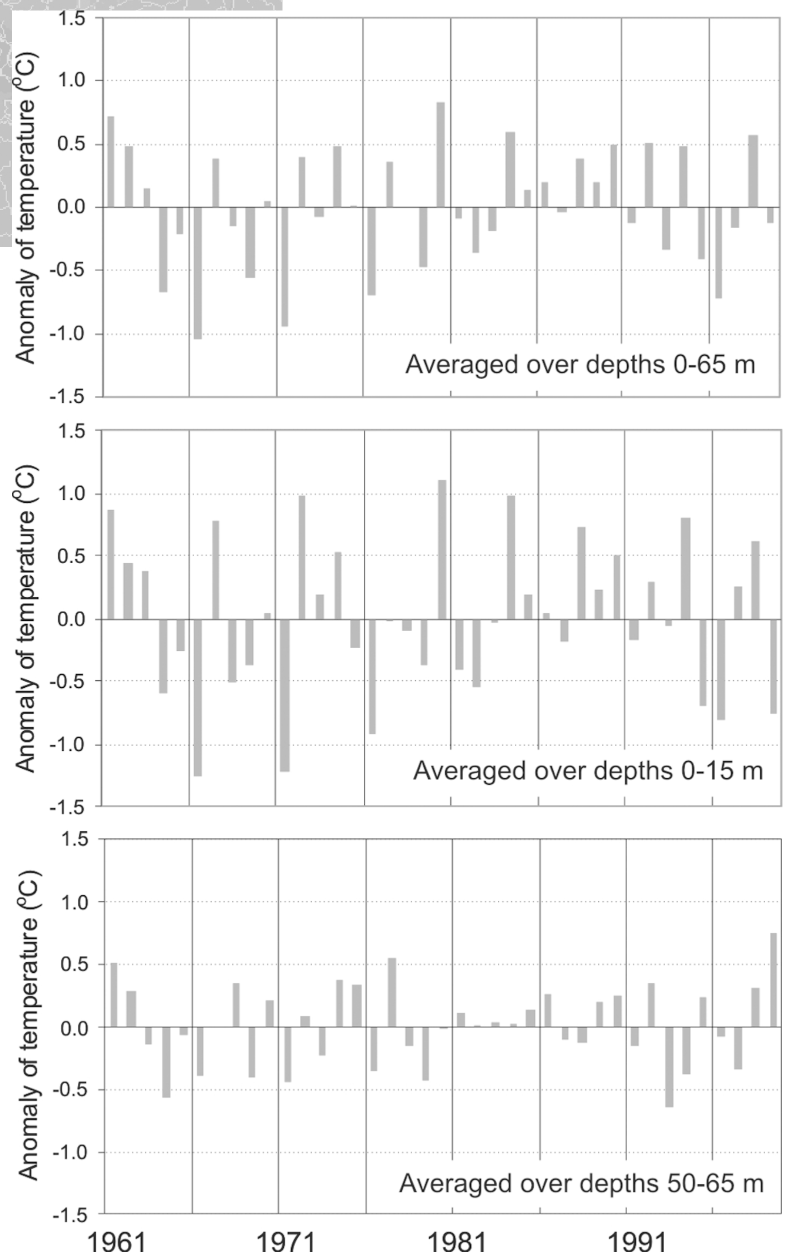
This summer, NOAA's fleet of ships and small boats will take advantage of a similar version of the new PEPIRB technology which will provide for near-instantaneous distress alert notification. In a cooperative safety initiative NOAA's Marine and Aviation Operations, NOAA's Small Boat Program, and the SARSAT Program have been working together to equip the men and women who crew NOAA's array of small boats with an even more advanced version of the PEPIRBs. The new NOAA beacons will include integral global positioning system units that provide a quicker locating function. The PEPIRBs are designed to be carried with a crew member at all times and are manually activated should a distress or accident occur where help cannot be raised otherwise, anywhere in the world.

New Paleoclimatic Great Barrier Reef sediment record

The National Climatic Data Center has archived an interpretation of river-borne sediment flux based on coral cores to the Great Barrier Reef, Australia. The research indicates that land-use practices, such as clearing and overstocking following European settlement of Australia have led to major degradation of the semi-arid river catchments, resulting in substantially increased sediment loads entering the inner Great Barrier Reef. The data were published by McCulloch *et al.* in *Nature*, 13 February 2003, and can be found on the Paleoclimatology website at: *http://www.ngdc.noaa.gov/paleo/pubs/mcculloch2003/mcculloch2003.html*.



▲ **Figure 3.** Position of stations for the long-term data sampling.



▲ **Figure 4.** Time series of the anomaly of temperature of the White Sea.

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it is very important for a researcher to have detailed information about the methods of data collection and processing. Such information is contained in cruise reports and ship diaries. Many cruise reports prepared before the mid-20th century are published as articles and books now classified as *rare books,* and are nearly inaccessible to the international scientific community.

In this connection, the ***History of the Arctic Exploration 2003: Cruise Reports, Data*** includes full texts of articles and books used as a data source for this product. These documents include metadata about the process and instruments used to make oceanographic measurements.

III. The product ***36-Year Time Series (1936-1998) of Zooplankton, Temperature, and Salinity in the White Sea*** has been prepared jointly by the Ocean Climate Laboratory, the World Data Center for Oceanography - Silver Spring, and the White Sea Biological Station of Zoological Institute, Russian Academy of Sciences. This study is based on a long-term data series obtained at one location at 65-m depth in Kandalaksha Bay (Chupa Inlet of the White Sea, 66^0 19.5'N, 33^0 39.4'E; Figure 3). Throughout 1961-1998 hydrological observations were made on a regular basis every 10 days. In 1963, water plankton sampling commenced in addition to oceanographic observa-

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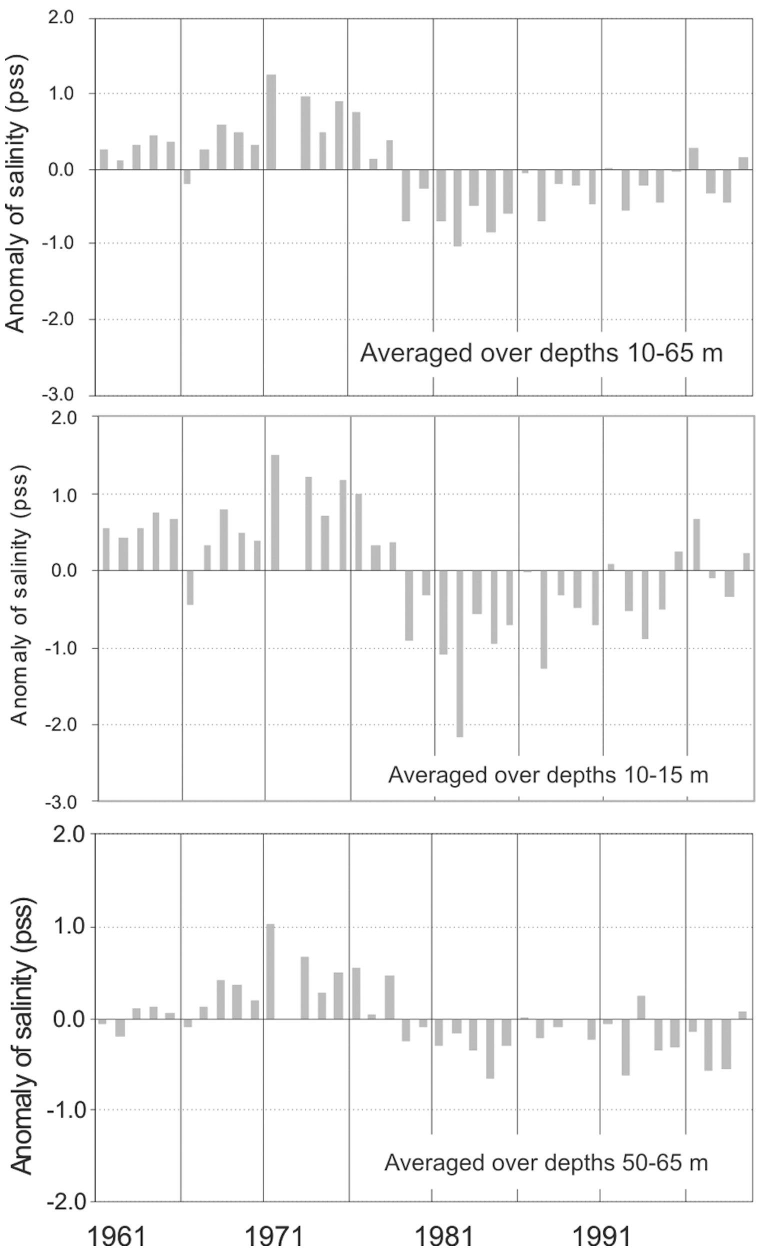


▲ **Figure 5.** Time series of the anomaly of salinity of the White Sea.

Table 1. Inventory of temperature and salinity measurements

Years	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Total
1961	1	1		1	1						1				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			25
1962			1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1	1	31
1963	1	1	2	1	1	1	1	1	1	1	1		1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	34
1964	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1			32
1965	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	34
1966	1	1		1	1	1	1			1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			32
1967		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	33
1968			1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	2	1	1	1	1			36
1969			1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1		31
1970		1			1			1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1			1		1		27
1971		1		1					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1										20
1972																				1	1	1	1	1	1	1	1	1	1								10
1973													1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					19
1974		1			1					1				1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1			1		21
1975		1			1				1		1			1		1	1	1	1	1	2	1	1	1	1	1		1	1	1	1	1			1		23
1976		1			1			1			1			1		1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1				24
1977					1			1			1					1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			23
1978			1		1			1			1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1		25
1979		1			1			1			1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		26
1980				1	1		1	1		1	1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1		27
1981					1		1	1						1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		24
1982	1		1		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			30
1983					1			1	1		1	1		1	1	1	1	1	1	1	1	1	1		1	1	1	2	1	1	1	1					24
1984		1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1			1		26
1985					1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					25
1986		1			1			1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1			1		26
1987		1			1			1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							23
1988		1			1			1		1					1	2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1					22
1989			1		1			1			1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							22
1990		1				1		1		1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					23
1991		1			1	1		1		1				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1				1	24
1992					1					1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						18
1993											1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1					20
1994							1	1			1					1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1					19
1995																1	1	1	1	1	1	1		1	1	1	1	1	1	1		1		1			16
1996	1					1			1			1				1	1	1	1	1	2	1	1	1	1	1	1	1	1								19
1997															1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						17
1998				1				1			1					1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1					19
1999			1	1				1		1					1	1	1	1																			8

Total 938 stations

Table 2. Inventory of zooplankton measurements

Years	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Total
1963																									1		1	1	1		1		1	1			7
1964		1	1	1	1		1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		30
1965			1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1			1	28
1966					1	1	1	1	1	1	2	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1			1	1	1	1	1			28
1967		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	33
1968			1	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		1			28
1969			1				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1			27
1970		1			1			1	1	1	1	1		1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1			1		1		27
1971		1		1					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										21
1972																				1	1	1	1	1	1	1	1	1	1								10
1973													1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					19
1974		1			1					1				1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1			1		21
1975		1			1				1		1			1		1	1	1	2	1	1	1	1	1	1	1		1	2	1		1			1		23
1976		1			1			1			1			1		1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				24
1977					1			1			1	1				1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1			25
1978			1		1			1			1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1		25
1979		1			1			1			1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		26
1980				1	1		1	1		1	1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1		1					24
1981					1		1							1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1		22
1982								1			1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1				22
1983					1		1				1	1		1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1						21
1984		1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1			1		26
1985				1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					26
1986		1			1			1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1			1		26
1987		1			1			1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	2	1	1	1	2	1		1					26
1988		1			1			1		1					1	1	2	1	1	1	1	1	1		1	1	1	1	1	1	1	1					22
1989			1		1			1			1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					23
1990		1				1		1		1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					23
1991		1			1	1		1		1				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					23
1992					1					1						1	1	1	1	1	1	1	1	1	1		1	1	1	2	1						18
1993														1	1		1	1	2	1	1	1	1	1	1	1	1	1	1		1	1					18
1994																1	1	1	1	1	1	1	1	1	1	1	1	1	1		1						15
1995																1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		1			17
1996						1			1			1				1	1	1	2	1	1	1	1	1	1	1	1	1	1	1		1				1	21
1997					1											1	2	1	1	1	1	1	1	1	1	1	1	1	1	1		1					18
1998				1				1			1					1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1					19

Total 812 stations

Arctic climatic system, *from page 5*

tions. Sampling dates varied depending on the weather conditions. This work includes analyses of 938 temperature and salinity profiles (Table 1) and 812 stations where zooplankton was sampled (at three levels for a total number of 2,514 samples, Table 2).

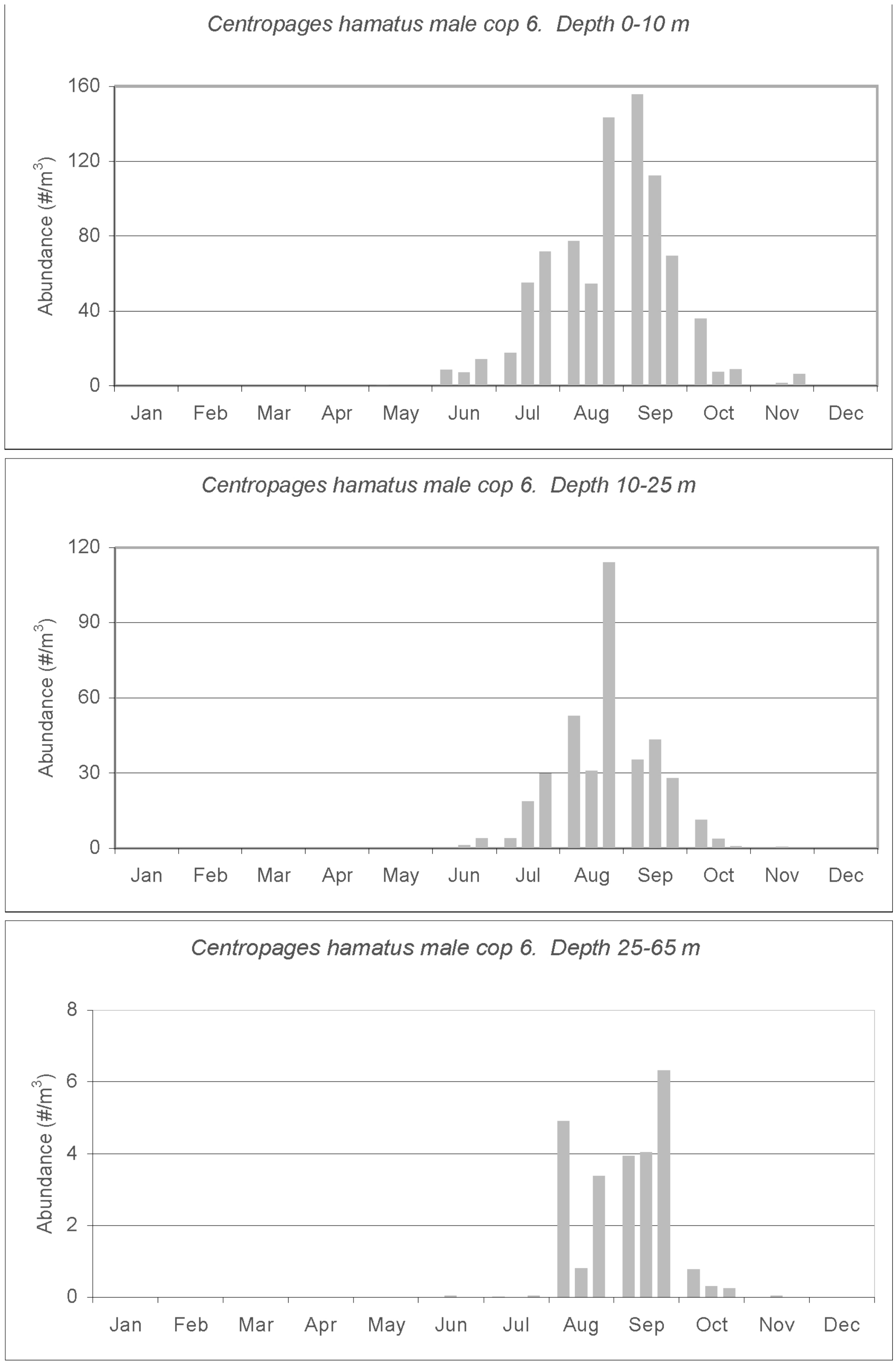
One of the problems to be solved in this study is to identify zooplankton species most sensitive to changes in water temperature and salinity. The algorithm for its solution is as follows:

a) Anomalies of temperature (Figure 4) and salinity (Figure 5) are calculated for every year; these are shown on pages 4 and 5.
b) For every zooplankton species available in the database, calculation is made for:
- annual climatic cycle of the abundance (Figure 6); and
- annual cycle of the abundance averaged over years with positive/ negative temperature/salinity anomaly.
c) Figure 7 shows the diagrams of numbers of zooplankton species most sensitive to changes in temperature and salinity. As seen, the long-term observations in the White Sea showed that zooplankton is more sensitive to changes in salinity rather than temperature.

IV. The product ***Climatic Atlas of the Arctic Seas 2003. Part I. Database of Barents, Kara, Laptev, and White Seas: Oceanography, Plankton, Benthos*** has been prepared jointly by the Ocean Climate Laboratory, the World Data Center for Oceanography - Silver Spring, the Murmansk Marine Biological Institute, and the Institute of Numerical Mathematics, Russian Academy of Sciences.

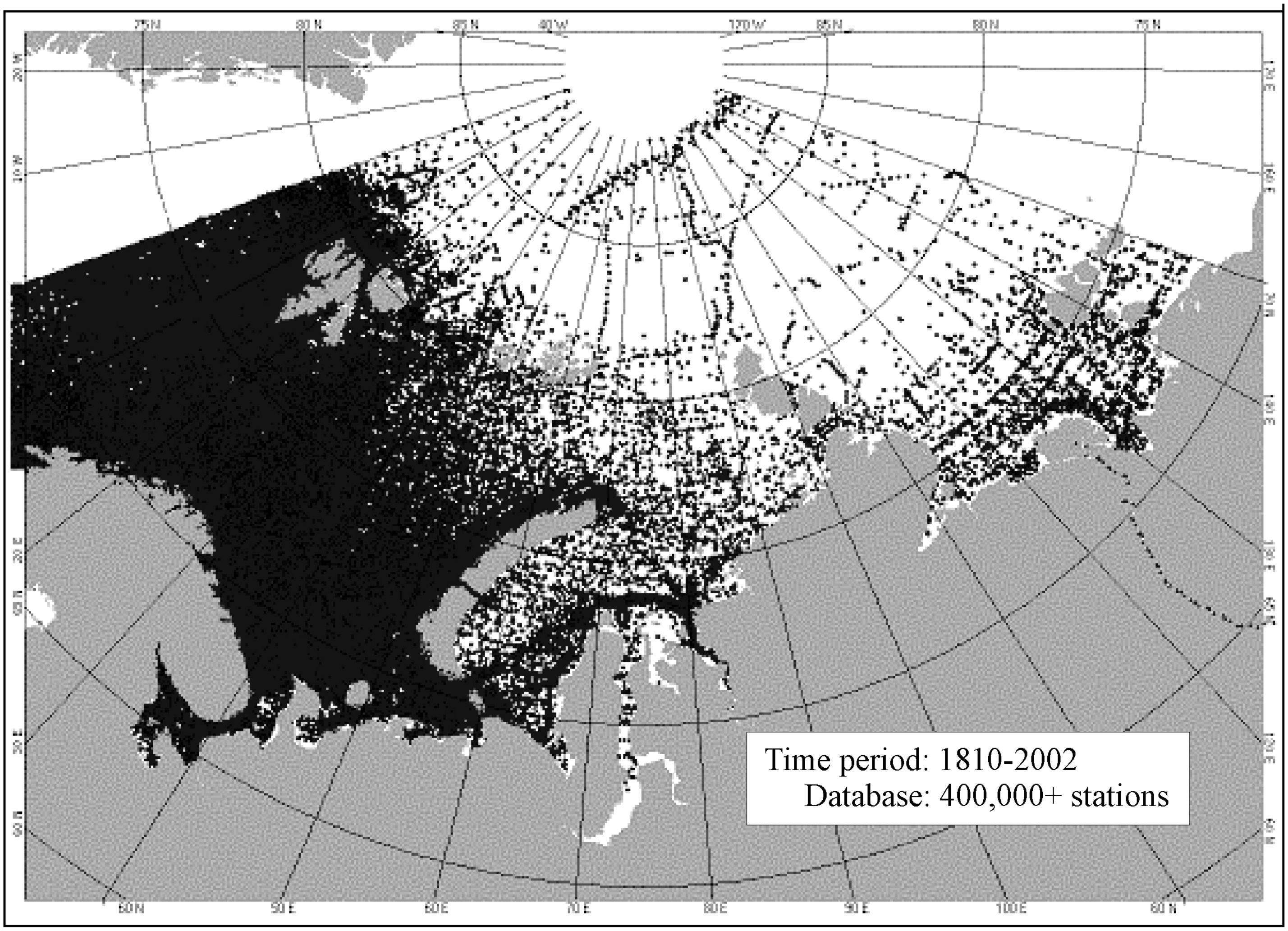
This study will consist of two parts. The first part, to be published in late 2003, will discuss the formation

— continued on page 10



▲ **Figure 6.** Annual climatic cycle of zooplankton development.

▲ **Figure 7.** Zooplankton species most sensitive to the variability of temperature and salinity.



▲ **Figure 8.** Data distribution plot for the product *Climatic Atlas of the Arctic Seas 2003. Part I. Database of Barents, Kara, Laptev, and White Seas: Oceanography, Plankton, Benthos.*

Arctic climatic system, *from page 8*
of the primary database and data quality control procedures, provide access to the primary data, and describe methods for the calculation of the temperature and salinity climatological fields. The second part will use the database for documenting climate change in the Arctic Seas for 1880-2002. Let us consider the contents of the first volume.

The database contains about 400,000 oceanographic stations (Figure 8) from 1810 to 2002; there are more than 20,000 plankton samples including 260 plankton samples collected during cruises of nuclear icebreakers in the regions previously inaccessible for studies in the wintertime. The database also includes about 100 benthos samples collected along the Kola Meridian (68^0 30' – 74^0N, $33^0$30'E) between 1921 and 1922 and in 1977.

All data are sorted by months (Figure 9) and within every month - by one-degree squares. For every individual month and every one-degree square, calculations have been made of the statistical characteristics of the parameters measured in this very square, and the profiles built for the depth distribution of hydrophysical and hydrochemical variables. This information, including the primary data, is accessible through a clickable chart. Figure 10 depicts the clickable chart for August, and Figure 11, ***page 12***, shows the characteristics for a one-degree square.

All of these four products will be distributed via CD-ROMs, DVD, and the Internet. The website is: *http://www.nodc.noaa.gov/OC5/indprod.html#inter.*

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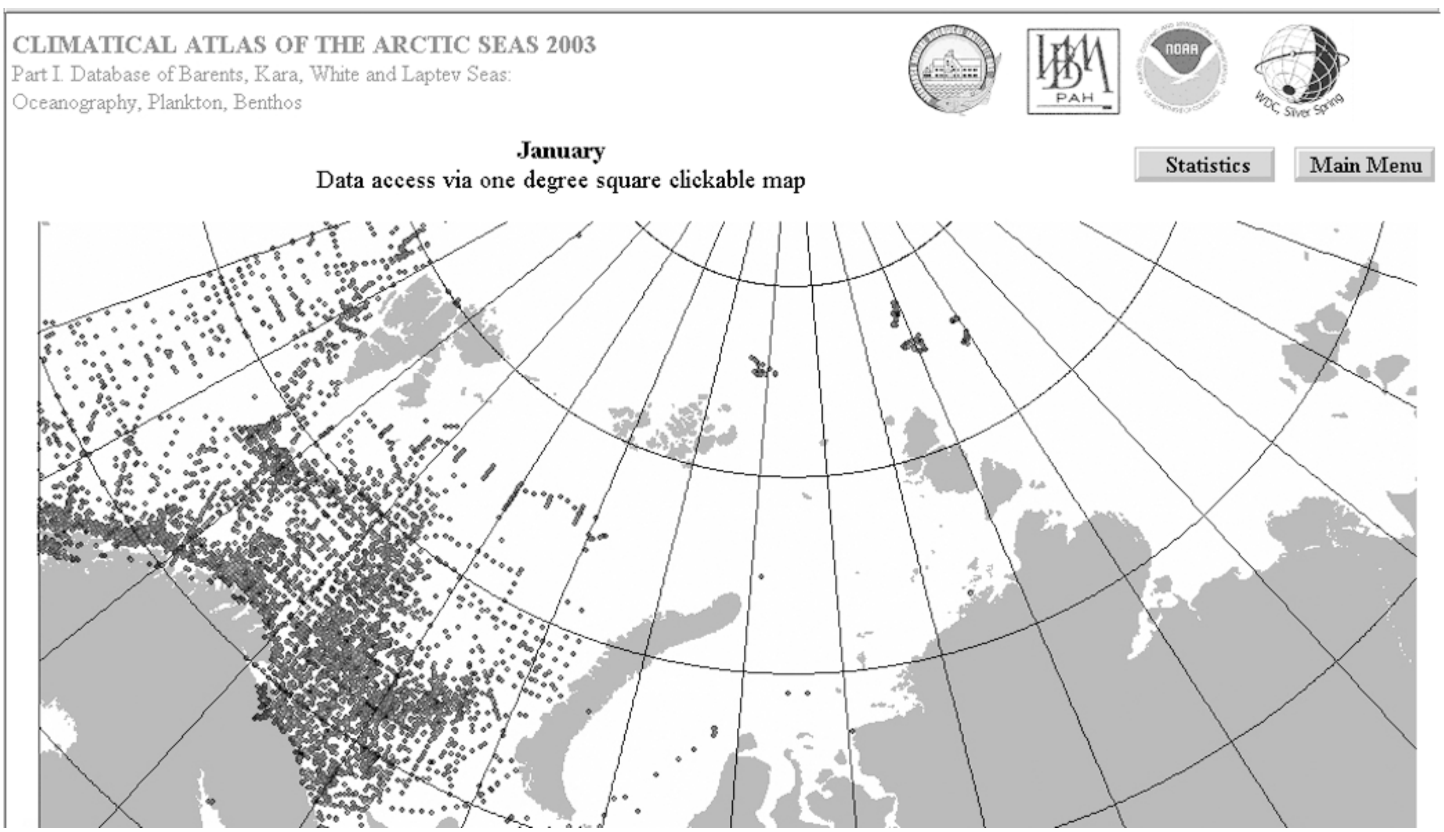
CLIMATICAL ATLAS OF THE ARCTIC SEAS 2003
Part I. Database of Barents, Kara, White and Laptev Seas:
Oceanography, Plankton, Benthos

Data access
via one degree square clickable monthly map

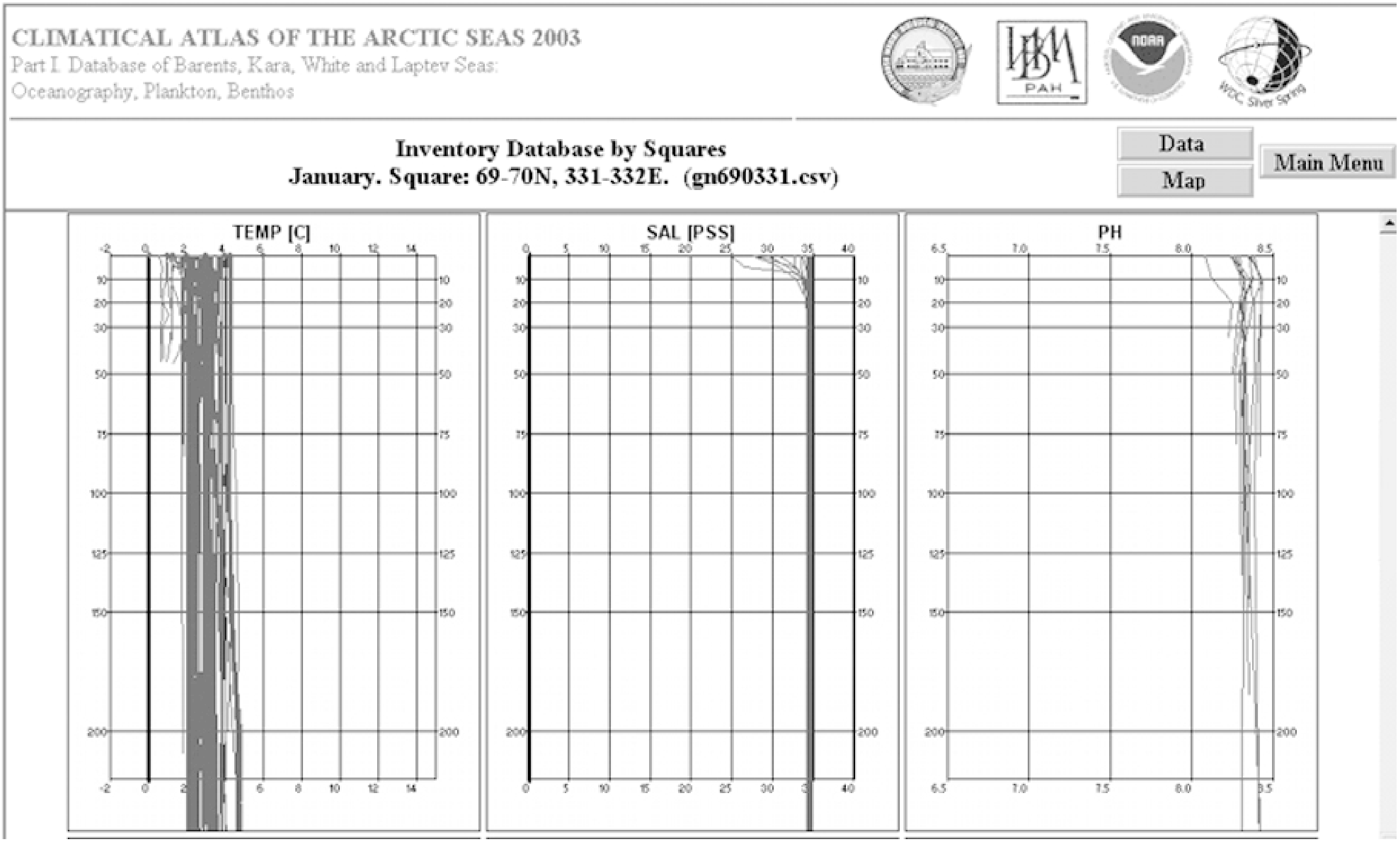
Main Menu

Month	Number of one degree squares	Number of stations	Time period	Monthly statistics	Monthly map
January	507	14,902	1899 - 1996	→	→
February	476	14,012	1899 - 1996	→	→
March	561	21,656	1899 - 1996	→	→
April	575	22,343	1894 - 1996	→	→
May	622	24,733	1893 - 1997	→	→
June	638	35,165	1893 - 1998	→	→
July	991	32,732	1891 - 1998	→	→
August	1,230	44,209	1811 - 1998	→	→
September	1,183	39,488	1893 - 1998	→	→
October	883	23,107	1894 - 1996	→	→
November	617	12,100	1898 - 1996	→	→
December	525	13,798	1999 - 1996	→	→
Total	**8,808**	**391,042**	**1811 - 1998**	→	→

▲ **Figure 9.** Monthly inventory.



▲ **Figure 10.** Interface for the data access via one-degree clickable map.



▲ **Figure 11.** Characteristics of the one degree square.

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The NESDIS Operational Significant Event Image metadata system

Describing and viewing weather phenomena around the globe

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The NESDIS Operational Significant Events Imagery (OSEI) program produces compelling near real-time views of phenomena occurring all over the planet. These images are used on the NOAA homepage to increase awareness of these phenomena and NOAA's role in observing them. They are also available from the OSEI image archive at *http://www.osei.noaa.gov*.

The OSEI Archive is similar to many NOAA systems and data collections created to address a limited set of requirements from a well-known set of customers. This approach, when followed throughout an enterprise, leads to a situation dominated by specialized systems that end up making it difficult to share data and technologies. This endpoint is well developed throughout NOAA and overcoming it is a critical organizational and technological challenge.

OSEI and National Geophysical Data Center (NGDC) staff met during the summer of 2002 to explore the potential of increasing access to the OSEI images by creating metadata compliant with the Federal Geographic Data Committee Metadata Content Standards (FGDC, *http://www.fgdc.gov/metadata*) and by providing interactive mapping access to the images on the World Wide Web (WWW). The primary goal of this work was to document the OSEI images in a standard way and to increase user options for discovering images based on that documentation.

The project also addressed a broader goal of evolving NESDIS operational processes to include creation of metadata compliant with national and international standards. This evolution is a critical step toward realizing the full potential of current and future satellite data and improving understanding of the environment through outreach, two important strategic goals for NESDIS. It is also a critical step toward integrating NESDIS data into the global environmental decision making process.

The OSEI archive

The OSEI image archive (*http://www.osei.noaa.gov*) includes thousands of images created over the last five years. There are several metadata elements associated with each image: a title, a brief description of the observed phenomena, the date and time of the

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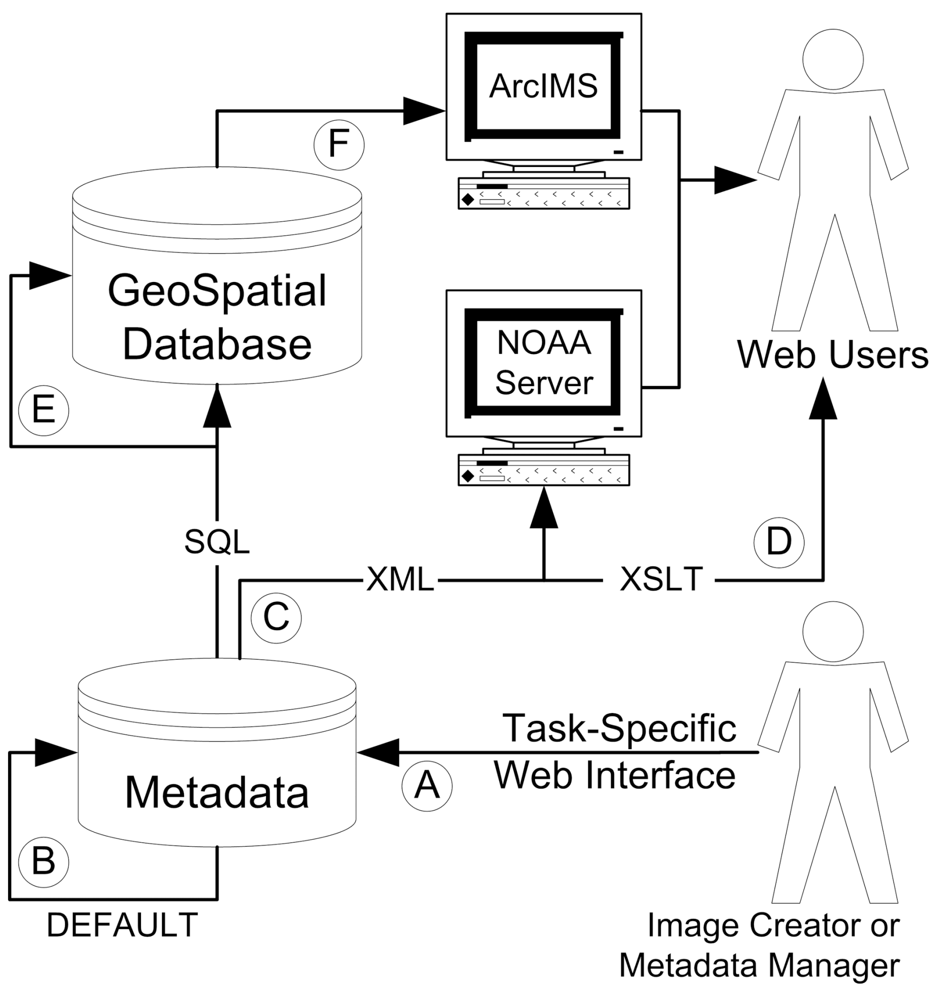

▲ **Figure 1.** Overall System Architecture

***OSEI database system**, from page 13*
image, the category for the image and the satellite and spectral bands that provided the data. The images are sorted into categories and are then available by category and region. Recent images are available regardless of category. Some descriptions are available as a series of reports that can be displayed on the WWW, but they are not available for searches.

FGDC metadata can support text searches of titles and descriptions as well as spatial and temporal searches. In addition, creating FGDC compliant metadata would make it possible for users to find the images using metadata search engines such as NOAAServer, the NASA Global Change Master Directory (*http://gcmd.gsfc.nasa.gov*), and the FGDC Data Clearinghouse. This paper describes the system that resulted from the collaboration between the OSEI team and the Geospatial Data Services Group at NGDC.

System requirements / Architecture

The requirements for the OSEI metadata system were driven by the characteristics of the metadata and by the importance of fitting metadata creation into the existing operational process. The FGDC Metadata standard includes some fields that are different for each OSEI image (spatial and temporal extent, URL) and some that are appropriate for the entire collection (contact and distribution information), so the system had to allow for the creation, management, and merging of both types of fields. The OSEI group produces imagery at the Satellite Services Division in Camp Springs, Maryland, and the metadata repository is in Boulder, Colorado, so remote tools for metadata creation and management were required. In addition, these tools had to be easy to use in order to minimize the impact on the image creation and documentation process. Figure 1 shows the architecture of the system and each element of the system is described below.

Metadata creation

NGDC manages metadata using a repository implemented using tools developed by Blue Angel Technologies (*http://blueangeltech.com*). This repository supports two types of WWW interfaces for creating and editing metadata. The first type of interface provides access to all of the metadata fields for a particular record (the comprehensive interface). This interface is useful for the metadata manager that is familiar with the metadata standards being used and wants to be able to manage metadata in the context of those standards. The second type of interface (task-specific) presents only those metadata fields that are relevant to a specific task (i.e. defining the spatial extent of a dataset). These interfaces require no knowledge of the metadata standards and are generally easier to use. They can also be integrated into other WWW pages as components.

The OSEI metadata system provides an excellent example of a task specific interface. The complete metadata records are made up of image specific and default fields. The page created for entering metadata for a new image is a task-specific interface (Figure 2), it includes fields that describe each specific image: descriptive material, an URL, and spatial extent and theme keywords. The keywords were selected from the Global Change Master Directory to

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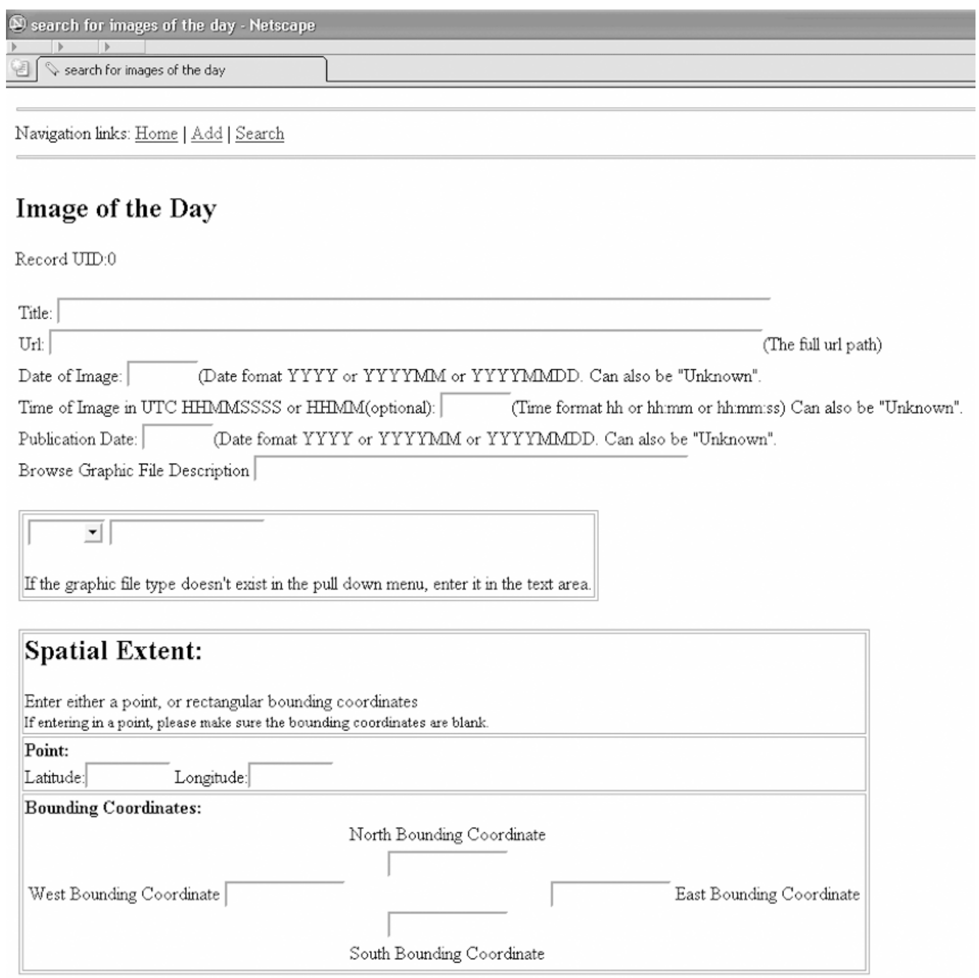
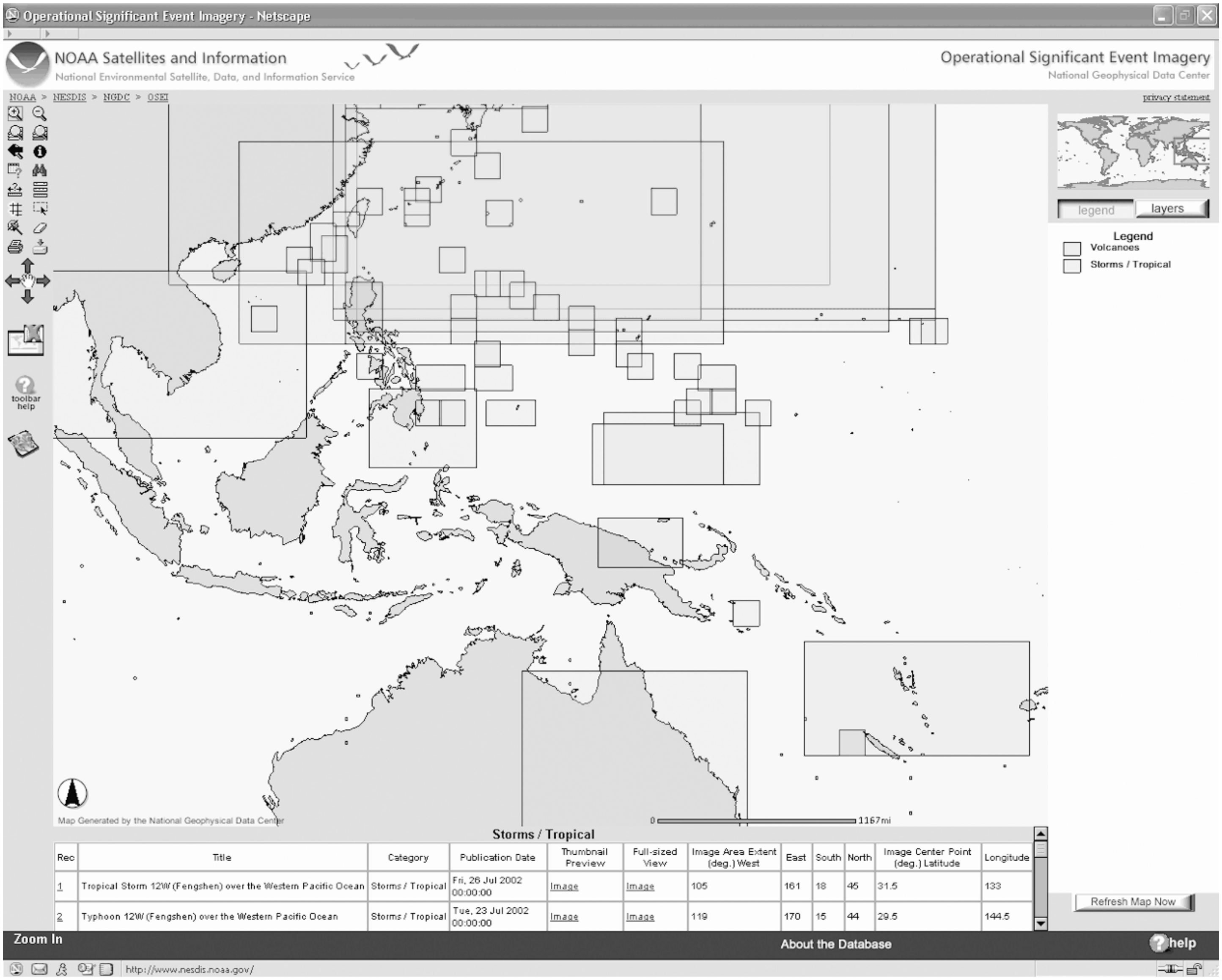


▲ **Figure 2.** Task-specific metadata input page used in Camp Springs and Boulder.



▲ **Figure 3.** Interactive map showing locations of Tropical Storm (darker) and Volcano (lighter) images. The bottom of the map shows the results of an identify query that includes links to the images.

correspond to the categories that already existed for OSEI images. This interface is used during the image creation process in Camp Springs and by staff in Boulder that have created metadata for over 5000 archive images (A in Figure 1). The information collected on this page is ingested directly into the Oracle database used for the metadata repository in Boulder.

Once the image specific information is collected, the repository automatically adds the default information (B in Figure 1). This default information includes all additional fields that are required to create an FGDC compliant record around the image specific information. Once the default information is added, the record is ready to publish.

Metadata publishing

The content of publishable records is exported from the repository in several ways. First, it is written as an XML file (C in Figure 1) that is transferred to NOAAServer where it is indexed and made available to the NASA Global Change Master Directory and to FGDC Clearinghouses managed by the NOAAServer team. The transfer of metadata to NOAAServer is done automatically using an open source utility for synchronizing directories (rsync). This XML can also be used to support viewing of the metadata on the WWW using several standard stylesheets (XSLT, D in Figure 1).

Second, the spatial elements of the metadata are extracted from the repository into a geospatial database using Structured Query Language (SQL). Once

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***OSEI database system**, from page 15*
that extraction is done, the records are spatially enabled, using tools developed at NGDC (E in Figure 1). This makes the records compatible with Geographic Information Systems (GIS) and they can be mapped using ESRI's internet map server (ArcIMS, F in Figure 1). The interactive map (Figure 3, *http://map.ngdc.noaa.gov/website/osei*) shows locations of the images in a layer for each category that can be turned on and off by the users. In Figure 3 the Volcano and Tropical Storm layers are visible. The center points of the images are shown when the map is zoomed out and the approximate extent of the images appear as transparent boxes as the user zooms in.

The interactive map also presents the user with a wide variety of standard search tools. The text search tool can be used to do case sensitive searches of the image titles, the rectangular search tool allows the user to select a group of images for a specific region, and the identify tool allows users to click on an image to retrieve information from the database for that image that includes a link to the URL in the metadata (see bottom of Figure 3).

Future plans

The extended OSEI team has already accomplished several of their goals. First, they created a working relationship between two disparate NESDIS groups. Second, they created an end-to-end metadata system that is compliant with national standards and integrated that system into an existing operational process. These organizational goals need to be explicitly stated and considered when evaluating cross-cutting projects like this one. Achieving such goals is many times more difficult than achieving technological goals.

The work done so far builds a strong and flexible foundation for future work. The first step is to add a full-text search of the image descriptions (F in Figure 1). This interface is similar in approach to the one supplied by NOAAServer but it searches only the OSEI records and displays the results in an OSEI specific display. Implementing this interface is part of a larger goal to integrate searches of standards compliant metadata into NOAA websites rather than only providing those searches in the context of a NOAA-wide capability like NOAAServer.

At present only the outlines of the OSEI images are available to geographic information systems. This is because the present approach involves embedding descriptive material and logos directly into the images. A powerful next step is to georeference the images themselves and to integrate them directly into interactive mapping sites. This will enable overlays of multiple reference datasets as well as other NOAA observing systems on these images. Our hope is to build a system featuring the OSEI images as a gateway to other NOAA data. This gateway would include direct overlay of NOAA observatories, as well as searches of other metadata collections using the spatial outline of the OSEI image as a geospatial criteria. ■

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