EARTH SYSTEM MONITOR

A guide to NOAA's data and information services

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IN THIS ISSUE

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

The National Oceanographic Data Center Celebrates 50 Years of Service

Andrew Allegra, Oceanographer, NODC; Kelly Logan, Outreach Specialist, NODC

The National Oceanographic Data Center opened its doors on November 1, 1960, with 29 employees ready to take on the challenge of compiling, sorting, and organizing the disparate collections of oceanographic data into a single system. This was a daunting task, considering that the U.S. Navy had already determined that data were coming in at such a rate that it was nearly impossible to keep up. By order of the Chief of Naval Operations, the National Oceanographic Data Center (NODC) was officially established in the U.S. Navy Hydrographic Office. Within two months, NODC had a place of its own on the 3rd floor of the Naval Weapons Plant in the Washington Navy Yard. The work soon began with a collection of unclassified data that consisted of approximately 2,000,000 machine-punched cards containing about 100,000 stations of oceanographic data. This data consisted of about 3 million observations including temperatures, salinities, dissolved gasses, nutrients, densities, waves, currents, and depths. In a comparison to today, NODC's archive contains over 44 terabytes of data, and the World Ocean Database product alone (one of NODC's most popular) has nearly 10.5 million data casts consisting of 1.5 billion measurements, which can be searched, customized, and retrieved at blazing speeds.

Challenges

Oceanography combines the studies of physics, chemistry, biology, geology, meteorology and climatology, while requiring scientific data and information to be acquired from nearly three fourths of the Earth's surface. It is an environmental science, relying on the observations of natural conditions in the world. In field studies, oceanography is distinct, in that it's impossible to isolate any one variable from interacting with other variables. Because of the constant interaction between the sea and the air, between the biota and the nutrients, and between the waves, currents, and bathymetry the variables are constantly affected and changing. The task of the oceanographer is highly

> *WHEREAS, there is recognized and demonstrated need for the establishment within our Government of a* ***National Oceanographic Data Center*** *organized for the purpose of acquiring, compiling, processing and preserving oceanographic data for ready retrieval, this need for oceanographic data, available at cost, being common to the agencies of Government and to the public and private interests, both foreign and domestic…*
>
> *Original Mission stated by: DEPARTMENT OF THE NAVY, COAST AND GEODETIC SURVEY, BUREAU OF COMMERCIAL FISHERIES, NATIONAL SCIENCE FOUNDATION, ATOMIC ENERGY COMMISSION, WEATHER BUREAU*

complex. Ocean observations must often be made in heavy seas, high winds, and extreme weather. But, when the weather cooperates and the seas are calm, it's a beautiful place to conduct science!

Oceanographic studies are further complicated by sampling instrumentation which must fulfill multiple requirements, is very costly, and can consume a considerable amount of time. The instruments themselves must be accurate and sensitive, while at the same time be capable of operating in a humid and very corrosive environment. Oceanographic data was and continues to be of great value, not only because of the expense it takes to obtain and interpret the data, but because of its global magnitude, widespread distribution, and usefulness in climate studies on an ever-changing planet. Preservation of this data must be guaranteed indefinitely into the future, which eventually led leaders to the idea of a "national center" for oceanographic data.

Origin & Evolution of a Data Center

In the mid-19th century, U.S. Naval officers systematically collected marine and meteorological data from the logs of servicemen and merchant vessels. They were able to collect thousands of observations on winds, currents, and weather information from which they compiled charts. These charts allowed fellow mariners to better navigate the seas. In 1845, the U.S. Coast and Geodetic Survey began systematic studies of the Gulf Stream using scientific methods to collect oceanographic data. This marked the beginning of systematic studies of the world oceans. Other expeditions followed such as the famous British Challenger Expedition (1872-1876), but there were still no concerted efforts to routinely centralize the data and information.

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From the NODC Director

Margarita Conkright Gregg, Ph.D.

Fifty years ago, NODC opened its doors, dedicated to serving the Nation, by acquiring, preserving, and providing access to ocean data and information. During the past 50 years, NODC has been recognized globally as an authoritative long-term archive for ocean data and information, as can be seen from the number of users who routinely access our data and cite our products. NODC contains the world's largest collection of publicly available oceanographic data and its products are used as a leading source to monitor global ocean climate changes.

In this issue, you will read about some of the challenges and early history of NODC. NODC was created with the "*purpose of acquiring, compiling, processing and preserving oceanographic data for ready retrieval, this need for oceanographic data, available at cost, being common to the agencies of Government and to the public and private interests, both foreign and domestic*…". Since November 1st, 1960, NODC has acquired over 44 Terabytes of ocean data and information. As NODC continues to fully meet its original charter, the data are checked for quality, aggregated into common formats, analyzed, and used to generate a history of the oceans. NODC has established a reputation for high quality ocean products, such as the World Ocean Database, which is the largest compilation of *in situ* oceanographic data, and Group for High Resolution Sea Surface temperature (GHRSST) data, which produces the highest quality Sea Surface Temperature maps from satellites. Our central point of access to coastal and ocean data, known as Ecowatch, provides easy access to integrated coastal datasets for resource managers, and our Library provides images of historic documents and maps.

NODC has continued to evolve in finding ways to meet the needs of the ocean community it serves. In 1989, NODC expanded to include the Library and Information Division and in 1993, the Ocean Climate Laboratory was created. The latest addition to the NODC family was the National Coastal Data Development Center (NCDDC), which was added in 2000, and is located in Stennis Space Center, Mississippi. NCDDC is dedicated to building the long-term coastal data record to support environmental prediction, scientific analyses, and formulation of public policy.

It is hard to imagine what the world was like 50 years ago and the scientific, technological, and communications challenges our founders had to face. It is equally difficult to project the next 50 years and imagine the products and services NODC will be generating. Currently, at the start of the 21st century, NODC is incorporating the latest advances in technology to ensure easy, flexible, access to our vast data holdings. We are also providing data at little or no cost in a secure environment, and using our scientific and data expertise to meet the growing demands for quality data, products and services.

I want to thank the staff who worked at NODC during its early years, and those who are currently at NODC for their dedication to our mission -- the *scientific stewardship of marine data and information*. I invite everyone to help us celebrate our success, and I especially want to thank the ocean community for making us a relevant part of their research and entrusting us with the preservation of their ocean data collections. We look forward to forging stronger ties with the ocean, coastal, climate, and fisheries resource managers, as well as researchers around the globe. ■

Margarita

EARTH SYSTEM MONITOR

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Comments should be directed to Andrew Allegra, Managing Editor.

E-mail: esm@noaa.gov
Phone: 301-713-3277 x152
Fax: 301-713-3302

Editing and Layout
Kelly Logan, Marc Pulliam, Ryan Quick, Paula Goddard

The mailing address for the *Earth System Monitor* is:
National Oceanographic Data Center
NOAA/NESDIS E/OC
SSMC3, 4th Floor
1315 East-West Highway
Silver Spring, MD 20910-3282

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

(NODC continued from page 1)

The first cooperative effort in the United States began in 1927. The National Academy of Sciences established a Committee in Oceanography, which led to other government agencies and academic institutions actively working to learn more about the oceans. Unfortunately, this increase in curiosity produced its own problems: too many data sets were being collected too fast for the existing processing techniques. In 1931, the U.S. Navy Hydrographic Office started using the technique of placing data on punch cards. This began the onset of machine tabulation of ocean data.

The importance of the oceans had been well known for centuries, becoming invaluable for strategic purposes during times of war. However, what was not known was how fragmented our knowledge of the ocean was. This became evident during World War II, particularly for weather forecasts and submarine warfare. The navies of the world joined the rest of the data collecting community by increasing their efforts in order to increase the success of their operations. As multiple federal agencies joined in on this effort, the lack of coordination became obvious. In 1954, at the 2nd Annual Eastern Pacific Oceanic Conference (EPOC), Dr. Oscar S. Sette, of the Bureau of Commercial Fisheries, called for the establishment of a national repository that would centralize and disseminate ocean data. This first call went unheeded for several years.

As the countries of the world recovered from the war, cooperative efforts and research began to take hold. In 1957, the International Council of Scientific Unions established the World Data Center (WDC) system. It proved to be an important avenue to obtain data. In 1959, the Working Group of Data Recording and Standardization of the Coordinating Committee on Oceanography (CCO) met at the U.S. Navy Hydrographic Office to announce early proposals for a national oceanographic data center. The U.S. Navy Hydrographic Office was a logical place to start, as staff there was experienced in acquiring, assembling, processing, and disseminating data. The office also held the largest collection of machine catalogued oceanographic data in the world.

In 1959, Senator Magnuson sponsored a Senate Bill, "to advance the marine sciences, to establish a comprehensive ten year program of oceanographic research and surveys;" and for the "establishment of a national oceanographic records center to assemble, prepare and disseminate all scientific and technical oceanographic and closely related data…" The Senator also called for the center to be created within the Department of Commerce. In 1960, a bill was introduced by the House, "To establish with the United States Coast and Geodetic Survey, a National Oceanographic Data Center". Its function was "to acquire, assemble, process and disseminate all scientific and technological and oceanographic and related environmental data, including but not limited to physical, biological, fisheries, hydrographic, coastal surveys, meteorological, climatological and geophysical data." However, perhaps because of security concerns, the Chief of Naval Operations instructed the Hydrographer of the Navy to "establish at the earliest practical date a National Oceanographic Data Center", which would initially remain in the Navy.

Official Establishment and Dedication

On November 1, 1960 the National Oceanographic Data Center (NODC), began operating at the U.S. Navy Hydrographic Office in Washington, DC. In January of 1961, NODC was formally dedicated by the Honorable James H. Wakelin, Jr., the Assistant Secretary of the Navy for Research and Development. Three hundred guests were present, including members of Congress and representatives of the supporting agencies.

Navy Secretary Wakelin at the dedication of NODC, January 1961

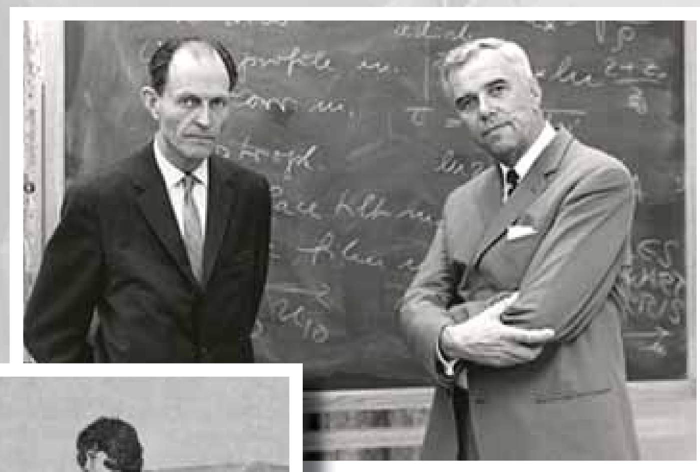
While NODC was administered by the U.S. Navy Hydrographic Office, its operations were guided by an Advisory board comprised of representatives from various federal agencies which conducted or promoted marine science, as well as one or more advisors from academia.

NODC's Mission

The initial mission of NODC directed the center to receive, compile, process and preserve oceanographic data; to be held responsible for acquiring data; to establish procedures to insure the accuracy and quality of the data; to prepare data summaries and tabulations showing annual and seasonal oceanographic conditions; prepare and make available indexes of data holdings and other information requested; to promote and encourage routine collection of time series and ocean survey data; and to exchange or sell data summaries prepared by the Center. Today's shorter version reads: To provide scientific stewardship of national and international marine environmental and ecosystem data and information.

Early Data

In the past, data were collected based on the needs of the data collector. The idea of a secondary data user was not considered. Because of this, some scientists seldom trusted data from another source. Since they regularly received funds for research, they saw little reason to submit their data to the data center. Exchange agreements with foreign countries became the major sources of data, while relatively few data sets were acquired from U.S. sources. Also, government agencies were eager to cooperate and send data, institutions were not.



Top: Dr. Woodrow C. Jacobs, NODC 1st Director (left) Bottom: Dr. Jacobs, NODC Director, inspecting CALCOMP magnetic tape plotting system, used to store data.

Early data processing proved to be a great challenge for NODC. Standardized formats were unheard of. NODC had been directed to manage data types, each consisting of an array of formats. Priority was given to the most common data types (physical and chemical) and the most easily processed. In the early days of existence, NODC had to cope with a large range of media, especially for its physical oceanography datasets. Data came as photographs, coding sheets, punch cards, publications, log sheets, and glass slides, among other formats. Cruise information was often in other languages, so methodology and other pertinent information had to be translated and interpreted before the data could be processed. This ancillary information is now known as "metadata". Metadata is still used and must be placed into a standardized format for easier searching and use in new Web services applications. The process for obtaining data has also been revised. NODC's Marine Data Stewardship Division works directly with data submitters, requiring specific Submission Agreements.

NODC had a great early advantage in being able to select its own codes and technical requirements, as it was the first oceanographic data center to be established. The Intergovernmental Oceanographic Commission, the coordinating body within the United Nations for marine science and related activities, promptly adopted NODC's codes. As additional instruments were developed and being used, NODC faced new problems: Will the new data be combined with data already in the archive, and will the rate of acquisition overwhelm the processing capabilities? Formats had to be developed for each data type, and they had to be approved by the oceanographic community. Over the years, these problems were solved by faster computer processing, larger disk space, and policies that allowed for original digital data to remain "as is" in the official archive, while labs at NODC created standardized data sets and products from those data.

Throughout its history, NODC moved through various data acquisition processes using databases and acronyms only government employees could remember. The constant influx of data made it necessary to have a centralized inventory to track the data received. NODC specialists were requesting data through correspondence or personal visits to institutions, and attendance at meetings. NODC emphasized quality control procedures in its data processing techniques and created fully automated models based on observed regional oceanographic parameters. It was also beneficial for international data collectors to submit data to NODC, so that they could participate in data exchanges.

When NODC published its guidebook, "Computer Programs in Oceanography", the idea was that by facilitating the exchange of computer programs, the standardized tabulation of oceanographic data will be improved. In a search for more efficiency, NODC began using the vast amount of punch cards to prepare magnetic tapes. NODC compiled descriptions of available computer programs for oceanographic research and data processing in order to encourage the use of computers among data producers, and to facilitate computer usage in oceanography in general. Then, beginning in 1968, data began to arrive on magnetic tape from the collectors. As the workload increased, the center realized its current resources were not sufficient. A new computer system was purchased which allowed simultaneous processing of several jobs, reducing the time needed to service requests. Because of this, NODC was able to provide computer generated products not available elsewhere. Over the years, NODC continued to up-

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The NOAA Central Library – 200 Years and Counting

Captain Albert E. Theberge, Jr. NOAA Corps (ret.), Acting Chief of Reference, NOAA Central Library

What NODC division is celebrating its 200th Anniversary in 2011, has at least 600,000 volumes on site, has five centuries worth of scientific information, and has fisheries, weather, climate, oceanographic, and other related information from well over 100 nations, every continent, and every ocean? If you answered the ***NOAA Central Library*** and its affiliated regional libraries, you would be correct.

The NOAA Central Library traces its lineage to 1811 when Ferdinand Hassler went to Europe to procure books and instruments for the Survey of the Coast, NOAA's oldest ancestor agency. This led to the foundation of the Coast and Geodetic Survey Library, while NOAA's two other major ancestor agencies, the Division of Telegrams and Reports of the Army Signal Service (forerunner of the National Weather Service) and the Commissioner of Fish and Fisheries, both started developing their own libraries shortly after their formation in the early 1870s.

Throughout the years prior to NOAA's formation in 1970 these libraries, and in some cases their satellite libraries, went their separate ways developing their own collections and cataloging them according to individual requirements and philosophy. When the NOAA Central Library was formed, an anomalous situation arose that involved eight different cataloging systems from the Bureau of Commercial Fisheries library, the Weather Bureau libraries, and the Coast and Geodetic Survey library. Fortunately, all of these cataloging systems are being superseded today with the Library of Congress cataloging system. Growth of the various libraries is difficult to track, but a 1949 article stated that the Weather Bureau library had exactly 2,802 volumes in 1873, 16,000 volumes in 1891, and approximately 100,000 in 1949. Today, there are well over 600,000 volumes in the NOAA Central Library encompassing millions of individual documents.

Personnel associated with the various NOAA libraries are difficult to track, but there are a few notable individuals. The first among these was Army Lieutenant Edward Bissell Hunt. Working with the Coast Survey in the 1850s, he was tasked with producing a bibliography of all known publications related to the Survey. While compiling approximately 30,000 entries, Hunt noted the lack of consistency in bibliographic citations and suggested the adoption of uniform standards. In doing so, not only did he produce one of the earliest professional papers concerned with information science in the United States, but he also displayed remarkable foresight in realizing that the issue was all the more urgent: "In 1856 we should bear in mind that the year 2000 is to come, and that then the records of science will be found under at least a myriad of separate periodical titles…."

Unfortunately, the Coast Survey never published this bibliography. Hunt died during the Civil War conducting experiments related to the development of a "sea miner," a weapon that bears some resemblance to today's submarine torpedo. On the sunnier side, Charles Fitzhugh Talman, who served as librarian of the Weather Bureau for 28 years, beginning in 1908, was so knowledgeable that he was given the position of Meteorological Consultant to the Chief of the Weather Bureau while retaining his position as head of the library. He spoke several languages and was a prolific author of popular meteorological books. He also produced over 3,000 two minute radio essays for a syndicated service called Science Service in the last 10 years of his life. He did more to publicize the work of the Weather Bureau than any other individual up to the mid-20th Century. In honor of his work and legacy, the NOAA Central Library named its rare book room, "The Charles Fitzhugh Talman Special Collections Room." Over 6,000 documents have been placed for special keeping in the Talman Room, the oldest being a Latin translation of a treatise by Hippocrates discussing the effect of climate on health, printed in 1485.

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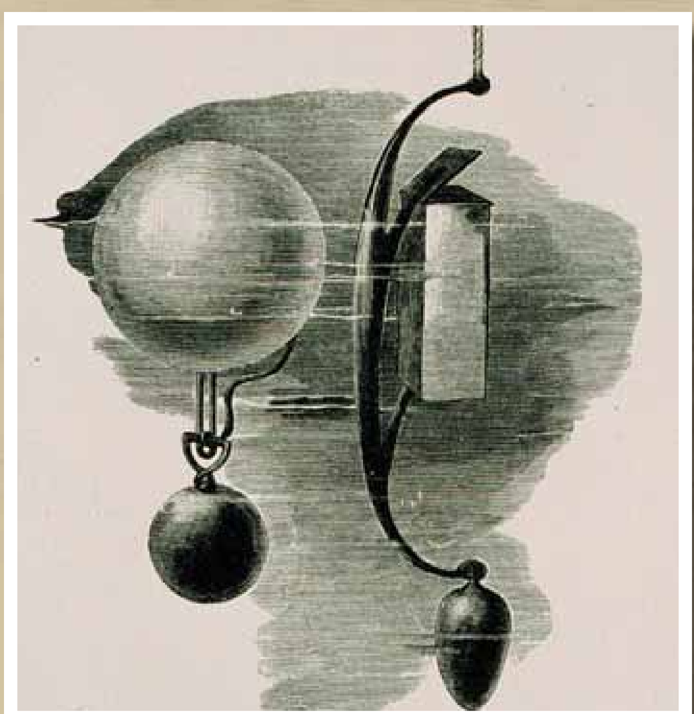
Digitized book jackets and magazine cover, which can be found at the NOAA Library. From left to right: Jacket of Thalassa: an essay on the depth, temperature, and currents of the Ocean by John James Wild, 1877; Scientific American magazine cover, May 1922; Jacket of Das Meer by M.J. Schleiden, 1804-1881.

A Short History of the Development of Oceanographic Instrumentation through the Nineteenth Century

Captain Albert E. Theberge, Jr. NOAA Corps (ret.), Acting Chief of Reference, NOAA Central Library

With the exception of a few sporadic observations of various oceanographic phenomena, oceanography as a science can be said to have begun in the mid 19th Century. However, prior to that time, significant ocean observations had already been made. Aristotle studied the sea in classical times; both techniques for sounding relatively shallow waters of the near shore and means to determine the character of the bottom had been known for at least three millennia; for at least the past millennium there had been an awareness of the moon being associated with tides; and, on a local scale, there was hard won rudimentary knowledge of the flora and fauna of the sea.

In his first voyage to the New World, Columbus used his sense of taste to compare the “saltness” of the waters in his new found islands to that of the waters of the Mediterranean Sea and eastern Atlantic Ocean. In an attempt to determine the depth of the Mid-Atlantic, he lowered a line 200 fathoms into the ocean. Of course he didn’t find bottom, but he did note the angle of the sounding line and correctly surmised that a current was setting to the west, a first indication of the bottom limb of the North Atlantic gyre. He observed small crabs and other fauna in the sargassum weed of the western Atlantic, leading him to incorrectly believe that he was relatively close to land. However, most of these early observations were made for the pragmatic purposes of navigation as opposed to studying the ocean for its own sake.



Sounding machine devised by Robert Hooke: drop glass ball with weight over side. Ball disengages when the weight hits bottom. Unfortunately, this instrument never worked correctly.

In addition, early observations were hindered by very crude and primitive instrumentation and tools. With the exceptions of the ability to measure depth by means of leadline or sounding pole, determine rough estimates of current velocities, or make rudimentary measurements of tide ranges, there were no instruments able to accurately measure temperature, salinity, or chemical components of sea water. The tiny creatures and plants of the sea remained hidden from view until the invention of the microscope. Furthermore, the technology did not exist to obtain samples or make any observations much below the first 100 meters or so of the oceanic depths, and, if they had been made, the errors inherent in early navigation would have made them of minimal value.

The concept of studying the science of the ocean did not begin evolving until the late 17th Century, and even then it was studied infrequently. The English scientist Robert Hooke invented water sampling bottles, sounding instruments that he hoped with misplaced optimism would produce depth measurements in the deep sea, and peered through his microscope at some of the plants and tiny “animalculae” of the oceanic waters. Sir Isaac Newton explained the tides within the context of his law of universal gravitation in 1687, perhaps for the first time explaining an oceanic phenomenon within the context of scientific theory.

By 1725, the Italian nobleman Count Luigi Marsigli had conducted numerous studies of the Mediterranean and published the first text on oceanography. The 18th Century also saw Benjamin Franklin use a thermometer to measure surface water temperature as he crossed the Atlantic and also use information gathered from his cousin, a Nantucket whaling captain, to map the Gulf Stream. The Englishman, John Harrison, invented the marine chronometer during this century as well, which improved the accuracy of positioning at sea by at least an order of magnitude.

Captain James Cook was the first to use the chronometer for scientific purposes and determined the boundaries of the Pacific Ocean and constrained the possible extent of an Antarctic continent. Contemporaneous with Cook’s second voyage, Constantine Phipps on HMS RACEHORSE commanded an expedition in search of a Northeast Passage. During this cruise he managed to take a sounding in 683 fathoms in the Norwegian Sea, a modest beginning to defining the bathymetry of the deep sea.

A few years later, in 1782, James Six invented a maximum-minimum thermometer that was used for both oceanographic and meteorological purposes. Six's thermometer was not able to record the depth from which either the maximum or minimum temperature was obtained and was not pressure protected. In the 1760's, the Danish scientist Otto Muller invented the naturalist's dredge for bringing up specimens of bottom-dwelling life. This was a modification of the common oyster dredge which had been used earlier by Marsigli for studying benthic life.

The 19th Century saw progress on all fronts of oceanographic observations. Improved and insulated water sampling bottles were developed. The French scientist Georges Aime invented a number of instruments prior to 1850. The most significant of these included an early reversing thermometer, a mechanical messenger for "flopping" these thermometers at depth that allowed recording both the temperature of the water precisely at pre-determined depths as well as the ability to build a temperature/depth profile.

Aime also invented a wave-measuring device and current meters that utilized impellers and direction recording devices. He was also the first to study carbonic acid in sea water and the effects of oceanic pressure on chemical reactions. During this same time frame, British naturalist Edward Forbes became the leader of the scientific-dredging movement in Great Britain. Discoveries and theories developed by Forbes led directly to American efforts in oceanography and to the Challenger expedition.

A quarter century after Aime's death, London instrument-making firm Negretti and Zambra developed an improved pressure protected reversing thermometer that was used on the Challenger Expedition. Similar instruments, as well as improved insulated water bottles, became the standard methods for deep sea temperature measurement for the next 70 years. However, even at this early stage, a glimpse of the electronics-dominated future was provided by the Siemens electrical thermometer, which was based on the principle of change of resistance of a conductor with temperature. A thermometer based on this principle was tested on the Coast and Geodetic Survey steamer BLAKE in 1881 and found to give satisfactory results.

Sounding instrumentation was improved in the 1870's with the introduction of the Thomson piano-wire sounding machine (invented by Sir William Thomson, a.k.a. Lord Kelvin) which was approximately three times faster and more accurate than the old hemp rope sounding methods. Variations of this machine included the Sigsbee Sounding Machine developed on the BLAKE and the Lucas Sounding machine used by British surveyors. The BLAKE also was the first to use steel rope for over-the-side oceanographic operations increasing the speed, safety, and reliability of return of oceanographic instruments.

The last quarter of the 19th Century also saw the development of many improved bottom dredges, trawls, traps, and ever-finer mesh nets for the capture of the tiny drifting flora and fauna of the ocean, named "plankton" in 1887 by Victor Hensen of the German NATIONAL expedition. It should be noted that the use of steam-powered vessels, beginning in the mid-19th Century, with vastly improved station-keeping capabilities and with various steam-powered systems replacing human muscle power, was also a major factor in the development of modern oceanography.

"Sounding the abyss with piano wire." This image is among the most realistic representations of sounding with the Sigsbee Sounding Machine. Most of the deep-sea soundings made prior to the advent of acoustic systems were made with piano-wire sounding machines. "The United States Fish Commission", by Richard Rathbun. Century Magazine, Vol. 43, Issue 5.1892.

The short history above only captures some of the highlights of two centuries of ocean scientists who struggled to understand aspects of what we call oceanography today. They struggled with imperfect, although ever-improving, instruments and mechanical systems to comprehend the immensity of the ocean – both its physical and biological characteristics. Today's oceanography is built on their efforts. [Part I of two articles: The next issue of the ESM will include an article on the evolution of oceanographic instrumentation in the Twentieth Century.] ■

NEWS BRIEFS

NOAA Unveils Special Collection of Civil War Maps and Nautical Charts

In honor of the 150th anniversary of the Civil War in 2011, NOAA has assembled a special historical collection of maps, charts, and documents prepared by the U.S. Coast Survey during the war years. The collection, "Charting a More Perfect Union," contains over 400 documents, available free from NOAA's Office of Coast Survey web site.

U.S. Coast Survey cartographers traveled with Union forces to produce battlefield maps during the Civil War (Map of the Battlefield of Chickamauga).

"People are planning now for their visits to Civil War sites next year, and we want to give them an opportunity to visualize the terrain, ports, and coasts as they were from 1861 to 1865," said Meredith Westington, NOAA's chief geographer. "Most people wouldn't think of turning to NOAA for historical Civil War documents, but the agency has an amazing legacy."

Coast Survey's collection includes 394 Civil War-era maps, including nautical charts used for naval campaigns, and maps of troop movements and battlefields. Rarely seen publications include Notes on the Coast, prepared by Coast Survey to help Union forces plan naval blockades against the Confederacy, and the annual report summaries by Superintendent Bache as he detailed the trials and tribulations of producing the maps and charts needed to meet growing military demands.

In the nation's early years, the United States lost more ships to accidents than to war. In 1807, President Thomas Jefferson established the Survey of the Coast to produce the nautical charts necessary for maritime safety, defense and the establishment of national boundaries. By 1861, Coast Survey was the government's leading scientific agency, charting coastlines and determining land elevations for the nation. Today, the Office of Coast Survey still meets its maritime responsibilities as a part of NOAA, surveying America's coasts and producing the nation's nautical charts.

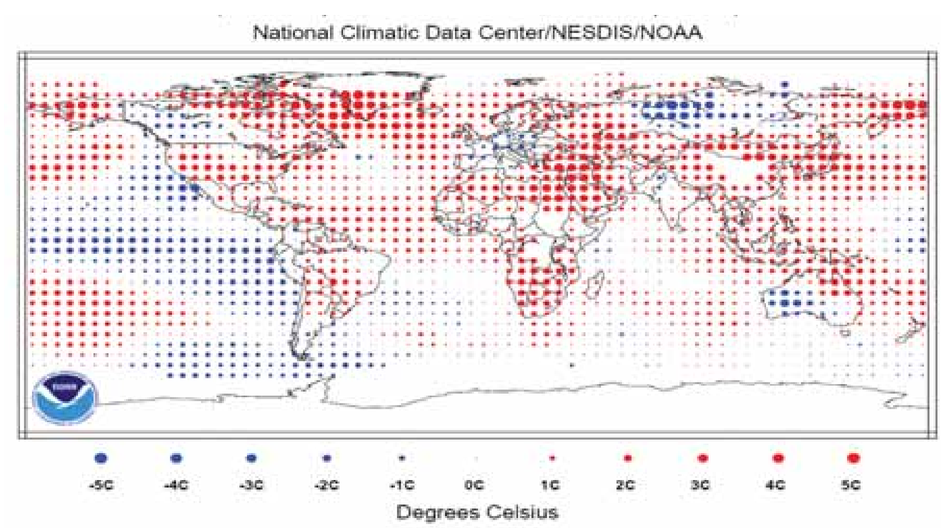
Global Temperature Highlights

The first nine months of 2010 tied with the same period in 1998 for the warmest combined land and ocean surface temperature on record. The global average land surface temperature for January-September was the second warmest on record, behind 2007. The global ocean surface temperature for January–September was also the second warmest on record, behind 1998. For the year-to-date, the global combined land and ocean surface temperature of 58.67 F (14.75 C) tied with 1998 as the warmest January-September period on record. This value is 1.17 F (0.65 C) above the 20th century average.

The analysis from NOAA's National Climatic Data Center is based on records going back to 1880, and is part of the suite of climate services NOAA provides government, business and community leaders, so they can make informed decisions.

Arctic sea ice reached its annual minimum on Sept. 19, according to the National Snow and Ice Data Center. The average extent of 1.89 million square miles (4.90 million square kilometers) was the third lowest September sea ice extent on record (30.4 percent below average). The annual record was set in 2007 (38.9 percent below average). This year also marked the 14th consecutive September with below-average Arctic sea ice extent.

Scientists, researchers and leaders in government and industry use NOAA's reports to help track trends and other changes in the world's climate.

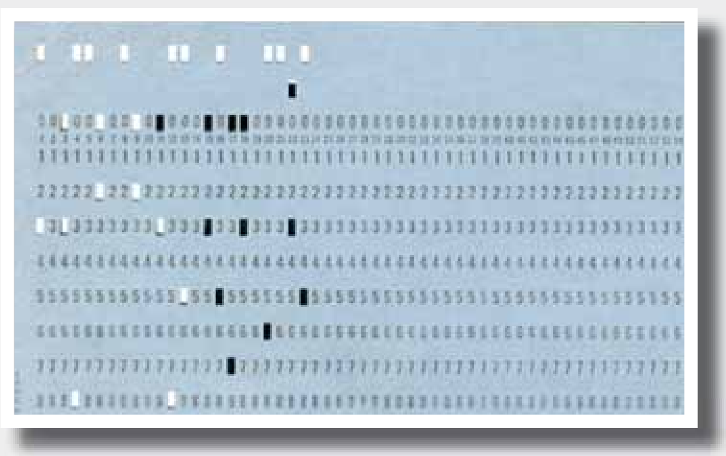


Temperature anomalies for September 2010 (with respect to a 1971-2000 base period).

(NOAA Central Library continued from page 4)
grade its systems in order to serve the nation, and transformed to a high capacity data base management system with increased CPU power. The challenges remained the same, however: how to process and organize the ever increasing volumes of different environmental data types of varying formats, handle a greater number of requests for data and information, and finally provide users with data products applicable to complex interdisciplinary problems. Today, these problems are made easier by our powerful Web services and online applications, which allow data downloads with ease, at an ever-increasing pace. Due to the foresight of the Marine Data Stewardship Division, NODC's present day archive management system is capable of archiving any type of oceanographic data in the world.

Being Proactive with Data Producers

In 1967, in order to initiate a more proactive relationship with U.S. data collectors, Benjamin Richmond, a former WDC Assistant Director, was appointed as a NODC Liaison Officer (L.O.) to the New England states. He was stationed at the Woods Hole Oceanographic Institution. The role of the L.O. was to acquire new data sets in the region, as well as help scientists and industry obtain the data needed for their projects. The L.O. network was further extended with regional officers placed in other strategic locations (Miami, La Jolla, Seattle, Anchorage, and Honolulu). The L.O.'s role transitioned into that of a Regional Science Officer, identifying and acquiring data sets from the regional coastal agencies. Today, NODC has 4 Regional Science Officers located across the country.



Data was keyed onto a punch card, which machines would then tabulate.

Important Pieces to NODC's Puzzle

The NOAA Central Library can trace its history back to 1807 when the Survey of the Coast was established. In 1978, the Library and Information Services Division was established within NOAA in order to manage the multiple Library systems. In 1989, the Library became an important information-filled division under the NODC umbrella. For more information on the NOAA Central Library, please see the "Library" article on page 5 of this issue.

The Ocean Climate Laboratory (OCL), another important division of NODC, arrived in 1993. OCL relies on our international and national partners for the data and quality control that result in the generation of key products such as World Ocean Database and World Ocean Atlas. These products provide the foundation for understanding the impact of climate on our oceans, including global ocean heat content. See page 10 of this issue for more on NODC's Ocean Climate Laboratory.

An important regional coastal center was added to the NODC family in September 2000, and is located in Stennis Space Center, Mississippi. Known as the National Coastal Data Development Center, NCDDC is dedicated to building the long-term coastal data record to support environmental prediction, scientific analyses, and formulation of public policy. NCDDC brings together diverse coastal data from a variety of sources and provides users access to the data in formats specific to their needs. This also includes a full range of metadata services and training, record generation, and publishing to national and regional repositories.

Conclusion

Today, NODC continues to provide world class access to the most comprehensive sources of marine environmental data and information. NODC maintains and updates a national ocean archive with environmental data acquired from domestic and foreign activities, and creates products and research from these data which help monitor global environmental changes. The archive provides access to over 86,000 original datasets. These data are derived from *in situ* oceanographic observations, satellite remote sensing of the oceans, and ocean model simulations. NODC personnel directly interact with Federal, state, academic, and industrial oceanographic activities, and represent NOAA on various interagency domestic panels, committees, and councils.

Understanding the oceans in a changing climate requires historical as well as real time ocean data and information. As the possibilities for data use are endless, a price tag cannot be placed on its value. NODC will continue to make the data available to customers in a useful way, and will continue its important partnerships to meet NOAA's goals for data stewardship. ■

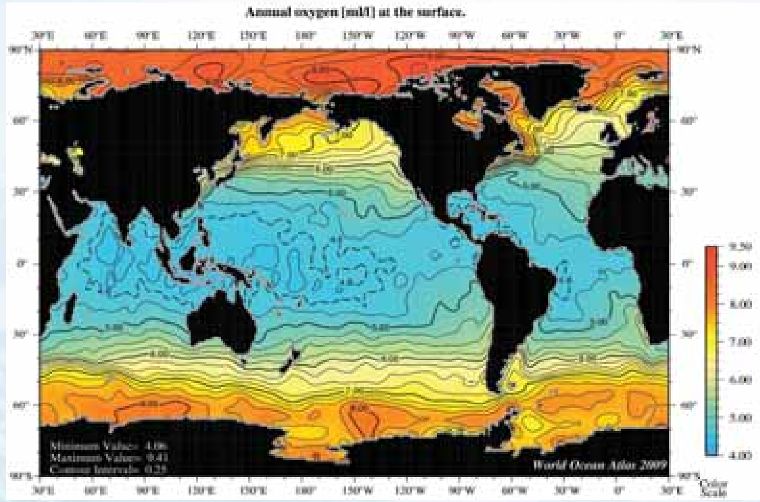
NODC Impacts on the Oceanographic Community

- Recognized globally as the authoritative long-term archive for ocean data & information
- Provides oceanographic researchers around the world a place to preserve valuable ocean data for the benefit of future generations
- NODC's products are used as a leading source to monitor global ocean climate changes
- Preserves the largest collection of publicly available oceanographic data

Ocean Climate Laboratory

Sydney Levitus, Chief of Ocean Climate Laboratory, NODC

The history of the NODC Ocean Climate Laboratory (OCL) can be traced to a review of NODC that was conducted from September 11-12, 1990 by the "Committee of Geophysical and Environmental Data" (CGED) of the National Research Council (NRC). Oceanographer Sydney Levitus had just joined NODC from the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) where he had published his electronic atlas, "Climatological Atlas of the World Ocean". The atlas consisted of objectively analyzed gridded fields of temperature, salinity, and oxygen for the world ocean at various depths, and quickly became popular among the research community.



Annual oxygen [ml/l] at the surface; World Ocean Atlas 2009

As a result of the NRC/CGED recommendations, NODC established the OCL, in August of 1993. Its objectives remain: 1) develop improved ocean climatologies for annual, seasonal, and monthly compositing periods; 2) investigate interannual-to-decadal ocean climate variability using historical oceanographic data; 3) build scientifically, quality-controlled global oceanographic databases; and 4) facilitate international exchange of oceanographic data. This work has been used frequently and cited by the research community thousands of times, which testifies to the importance of NODC's mission.

OCL focuses on three complementary activities: physical oceanography and marine meteorology; biological and chemical oceanography; and operations of the World Data Center for Oceanography. It also includes the International Data Exchange Group that conducts programs related to international affairs and oceanographic data exchange. Operated under the auspices of the U.S. Academy of Sciences, WDC is one of the U.S. discipline sub-centers within the World Data Center system. There are 2 other World Data Centers for Oceanography: one located in Obninsk, Russia and the other in Tianjin, the People's Republic of China.

OCL also directs the international "Global Oceanographic Data Archaeology and Rescue" (GODAR) project, initiated by the Intergovernmental Oceanographic Commission (IOC). The GODAR project has the goal of locating and rescuing oceanographic data. This has resulted in an increase of over three million historical ocean temperature casts, hundreds of thousands of plankton casts, as well as many other pre-1991 data sets. All data are made available internationally without restriction. The OCL has also considerably expanded the NODC biological oceanography databases that include chlorophyll, primary productivity, plankton biomass and taxa. In addition, the OCL leads the "World Ocean Database" project on behalf of the IOC, which has the goal of increasing the exchange of modern oceanographic data and the preparation of regional oceanographic atlases.

The OCL has continued publication of its series with releases of the World Ocean Database (WOD) in 1998, 2001, 2005, and 2009. Concurrent with each WOD release, there has been a release of updated climatologies known as the World Ocean Atlas (WOA) series, which was first released in 1994. Additions and corrections to WOD are now made available online every three months. The OCL has also developed and made available regional atlases that are collectively published as part of the "International Ocean Atlas and Information" series. ■

(NOAA Central Library continued from page 5)

With the exception of the sheer physical bulk of the collections, many aspects of today's NOAA Library would be recognizable to those who passed before. However, the philosophy of customer service has been significantly altered. The Library staff is now able to bring the Library's contents to the desks of its patrons, while in the past; patrons have had to come to the Library. Just 30 years ago, the Library was proud of being able to display citations for 72,000 articles to its user community through terminals located in the Library. Today, that number is in the tens of millions through personal computers. The Library is able to deliver hundreds of thousands of digital documents to the NOAA user community, an unimagined service in the early 1980s. The Library has changed, as has the user community. But the basic function of the Library remains the same – to provide NOAA and the public community with the best possible access to the information needed by scientists, engineers, and environmental decision-makers. ■

NODC TIMELINE

1959 Working Group on Data Recording and Standardization of the Coordinating Committee on Oceanography recommends that a NODC be established at the U.S. Navy Hydrographic Office.

1960 On November 1, NODC begins operating in the U.S. Navy Yard. NODC is officially established under the administration of the U.S. Navy Hydrographic Office.

1961 NODC is formally dedicated; Dr. Woodrow C. Jacobs becomes the first NODC Director.

1962 The World Data Center A for Oceanography becomes a part of NODC.

1963 NODC is elevated from Division to Department within the U.S. Naval Oceanographic Office.

1967 Development of Liasion Officers network.

1968 Data begins to arrive at NODC on magnetic tape.

1970 NODC is transferred to the Environmental Data Services, a line office under the newly formed National Oceanic and Atmospheric Administration (NOAA).

1982 The National Environmental Satellite, Data and Information Service is organized, the NOAA Line Office of which NODC became a part of.

1989 The NOAA Library is added to NODC.

1990 NODC hosts an international workshop on "Data Archaeology", formalizing the need to search for irreplaceable historical data sets.
Email becomes possible among all of NODC's personal computers.

1993 The Ocean Climate Laboratory is created as a new Division.

1994 NODC provides information regarding data holdings, products and services online.

1996 NODC moves to its present location in Silver Spring, Maryland.

2000 The National Coastal Data Development Center is created as a new division.

2001 NODC starts managing the Coral Reef Information System (CoRIS) for NOAA's Coral Reef Conservation Program.

2002 The NODC Satellite Oceanography Group is created.

2003 NODC's present-day Archive Management System is developed, capable of archiving any type of oceanographic data in the world.

2006 The first automated data ingest stream made it into the archive, with no human intervention.

2010 The BioChem Team is created to address the need for a modern biochemical database of Essential Climate Variables.

Poster Designed by: Kelly Logan

U.S. Department of Commerce | NOAA
National Oceanographic Data Center
SSMC 3, 4th Floor
1315 East-West Highway
Silver Spring, MD 20910-3282

NODC Responds to the Deepwater Horizon Incident

Kelly Logan, Outreach Specialist, NODC

The National Oceanographic Data Center (NODC), as the national archive for marine environmental data and information, obtained historical Gulf of Mexico data from its online archive and compiled it for direct public access in support of NOAA's Deepwater Horizon (DWH) response. Subsequent steps included the creation of a historical climatology across the well head for temperature, salinity, and oxygen as well as an ocean currents web page that portrays ocean current meter data from present and historical moored buoys for the Gulf.

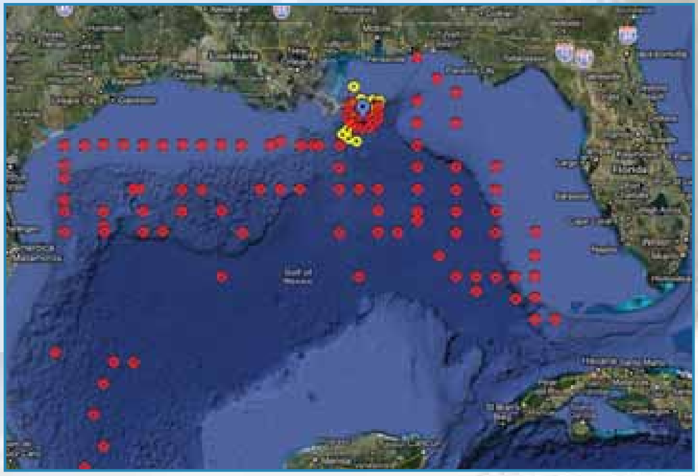
As new data from the DWH cruises began to stream into the data center, NODC staff instituted archive procedures and a data management and web site plan for permanent archive and access of the data. User friendly access and data availability via Google Earth and Google Maps were added to the Ocean Profile Data Support page. This allowed users to view data gathered from the aircraft, ships, gliders, and floats actively deployed in the Gulf.

Staff at the National Coastal Data Development Center (NCDDC), a division within NODC, collected and quality controlled data from NOAA's Office of Response & Restoration (OR&R). As NCDDC is located at the Stennis Space Center, Mississippi, they were able to provide valuable support to the interagency Joint Analysis Group (JAG) for Surface and Sub-Surface Oceanography, Oil, and Dispersant Data by maintaining and hosting its web site.

NCDDC, together with the Mississippi-Alabama Sea Grant Program, created the DWH Oil Spill Research and Monitoring Activities Database, a single web site for uploading and accessing information regarding research and monitoring activities.

Staff of the NOAA Library, also a part of NODC, compiled an online bibliography titled *Resources on Oil Spills, Response and Restoration*. This comprehensive online publication contains documents, web sites, video links, and citations. The NODC Satellite Oceanography Group created a view of sea surface anomalies, climatologies, and significant wave heights for the Gulf.

NODC continues to support NOAA's ongoing effort to provide timely, quality information regarding the Gulf of Mexico oil spill. ■



Google Map presentation of data collected by the NOAA Ship Gordon Gunter in the vicinity of the BP Deepwater Horizon oil spill.