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BEFORE THE

U.S. COMMISSION ON OCEAN POLICY

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Thank you Chairman Watkins and members of the Commission for providing me with the opportunity to testify at your national meeting here in Washington, DC. For the record, I am Gregory W. Withee, Assistant Administrator for NOAA's Satellite and Information Services. The National Environmental Satellite, Data, and Information Service (NESDIS) is one of five NOAA line offices, along with the Weather Service, Fisheries Service, Ocean Service and NOAA Research. Satellites and data management are both critical tools in addressing NOAA's missions to describe and predict changes in the Earth's environment and to conserve and wisely manage the Nation's coastal and marine resources. NESDIS operates the U.S. geostationary and polar-orbiting operational environmental satellites and is the world's largest civil operational environmental space organization. (See Appendix 1) NESDIS also manages the world's largest collection of atmospheric, geophysical, and oceanographic data. Specifically, the National Oceanographic Data Center (NODC) has been archiving oceanographic data for more than forty years. (See Appendix 2). We support NOAA's mission by providing and ensuring timely access to global environmental data and information from satellites and other sources to promote, protect, and enhance the Nation's economy, security, environment, and quality of life.

Virtually every sector of the Nation's economy relies on rapid and reliable access to environmental data and information. NOAA environmental data form the basis for making decisions that have far-reaching economic consequences at local, regional, and global levels. Today I will provide a brief overview of our satellite and data management programs, and discuss major issues and recommendations regarding these programs. NOAA's plans for the next two decades for satellite observations and data management represent a remarkable opportunity for the ocean community. Full implementation will accelerate the realization of a robust operational oceanographic capability.

<u>Recommendations</u>:

1 **Ocean observation architecture**: The United States and its international partners should

prepare a global ocean observing architecture plan based on shared operational requirements to ensure the system 1) takes full advantage of planned observation systems, 2) orchestrate common intersections towards efficiency, i.e., getting the best ocean observing system with available resources, and 3) actively considers important synergies between satellite and in situ systems. As part of its contribution, the United States should include a plan to transition the R&D ocean satellites of NASA and the Navy to operations and anticipate a continuos infusion of new science and technology. The plan should build on advanced satellite technology opportunities, such as the development of an operational coastal ocean remote sensing program at NOAA, which includes considers applications of Synthetic Aperture Radar(SAR) and a hyperspectral coastal imaging capability.

2. **Utilization of satellite data:** The US should make an investment in finding optimal means to utilize satellite data, in combination with in situ data, in our ocean, and air sea coupled models, demonstrating their utility in an operational setting. The Joint Center for Satellite Data Assimilation, a joint enterprise among NOAA, NASA, the Navy, Air Force and others is a start in this direction. In other ocean areas, NOAA, NASA NSF, and the Navy should encourage academia to participate in applications development using satellite.

3. **Scientific stewardship:** Operational observing systems should be budgeted and implemented as integrated, quality, end-to-end systems that provide sound scientific data. The quality of the data in real time, as well as delayed mode applications from NOAA archives, must be considered. Reprocessing of the long-term satellite record is a prerequisite for climate studies.

4. **University partnerships:** NOAA, in cooperation with the Navy and NSF, should continue to build partnerships with academia, building on such examples as the cooperative institutes. All ocean agencies should emphasize transferring research into operational applications, whether the transition involves algorithm development, model development or other activities. Workforce requirements to address the challenges of operational oceanography should be given particular attention.

5. **Ocean data archive:** Current levels and anticipated increases in the amount of ocean data dictates that the community work together to address data management and archiving. NOAA is uniquely qualified to responsibly archive oceanographic data in the United States.

6. **Access to ocean data:** Access to ocean data is of utmost importance. The Commission should endorse Ocean.US efforts to develop a national strategy for ocean data management. This should include supporting the application of middleware (such as that underlying the National Virtual Ocean Data System, NVODS) to facilitate access to data. The Commission should endorse an ocean data policy of full and open access and encourage the adoption of this policy worldwide.

<u>Rationale and Discussion</u>

1 **Ocean observation architecture**:

Requirements and Architecture

An integrated observing system will promote improved understanding of the oceans and climate with immediate applications for addressing a ranging of pressing problems ranging from agriculture to severe storms. The system must be designed to meet the requirements of user communities and include end-to-end services from observations and data collection to data processing, product distribution and archiving. NOAA is developing a requirements-based architecture for its range of space and surface-based observing systems. This is essential to ensure that additional observing capabilities fill gaps and do not duplicate the existing architecture. A similar approach is needed nationally and internationally to build a complete inventory of capabilities and design a truly integrated and dynamic ocean observing system. The importance of satellite observations and the need for integrated global observing were themes in the Declaration and Plan of Implementation for a global observing system issued at the recent World Summit on Sustainable Development in Johannesburg, South Africa.

NOAA is a member of the Integrated Global Observing Strategy (IGOS), which was founded in 1998 to focus on observation gaps and identify the resources to address observational needs. IGOS brings together the operators of major global observing systems as partners in a strategic planning process that links research, long-term monitoring and observational programs, data producers and users. IGOS has produced an Ocean Theme Report that addresses key deficiencies and duplications. Further work is underway on carbon, water, atmospheric chemistry, geohazards, and potentially on coasts.

The United States and its international partners should prepare a global ocean observing architecture plan based on shared operational requirements to ensure the system 1) takes full advantage of planned observation systems, 2) orchestrate common intersections towards efficiency, i.e., getting the best ocean observing system with available resources, and 3) actively considers important synergies between satellite and in situ systems.

Transition from research to operations.

NASA, DoD, and NOAA are working together to support an improved national capacity for ocean remote sensing. Operational systems, such as NPOESS (see Appendix 1), require research, development and operational stages and components, which are provided by each of these agencies. NOAA and NASA are supporting a study by the National Academy of Sciences to further improve the research to operations transition process.

The NPOESS program has fostered integration of the requirements of different users in sensor development and design. For example, the Visible and Infrared Imaging Radiometer Suite (VIIRS) is a twenty-two channel sensor which will fly on the NPOESS Preparatory Project (NPP) and all NPOESS platforms. VIIRS will serve the military, civil operational, and science communities by meeting the multi-spectral, accuracy, and near-constant resolution requirements of all three communities. Currently, each entity relies on different systems. For example, the military community relies on the Operational Line Scanner (OLS) on the DMSP satellites, the civil operational community relies on the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA POES satellites and the science community is exploiting the MODerate Resolution Imaging Spectroradiometer

(MODIS) on the EOS Terra and Aqua satellites. NASA has asked NOAA to assume operational responsibility for the QuikScat satellite system, which provides ocean measurements such as wind speed and height.

A number of activities are underway to better integrate the academic and industrial remote sensing communities with NOAA's capabilities. NOAA and NASA are using Broad Agency Announcements (BAAs) under the National Oceanographic Partnership Program (NOPP) to solicit investigations requiring partnerships between academic researchers and NOAA operational organizations. Examples include: combining altimetry and scatterometry data to develop an operational ocean surface current product; and the development of operational ocean surface wind products based on scatterometry.

NOAA is upgrading and enhancing its processing capabilities in order to acquire and exploit data from the MODerate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Infrared Sounder (AIRS) on the NASA EOS Terra and Aqua missions. The MODIS instrument is very similar to the Visible/Infrared Imager Radiometer Suite (VIIRS), and the AIRS instrument is similar to the Cross-track Infrared Sounder (CrIS); both new instruments will be flown on the NPP mission and on the operational NPOESS spacecraft.

Similar efforts are underway to build the capability to handle and process data from the Conical-scanning Microwave Imager/Sounder (CMIS) that will be flown on NPOESS. CMIS will measure the ocean surface vector wind field and other parameters. Current efforts at NOAA and Navy address the operational and tactical uses of ocean surface vector winds from active scatterometer missions (e.g., SeaWINDS). In January 2003, the joint Navy/IPO/Air Force Coriolis/WindSat mission will be launched, and NOAA processing capabilities for SeaWINDS will be redirected to processing and utilizing these new data streams.

Building on these opportunities, an ocean observing architecture should include transition the R&D ocean satellites of NASA and the Navy from R&D to operations.

Coastal

One area where technology development holds great promise is remote sensing of coastal regions. NOAA established the Ocean Remote Sensing (ORS) program which consists of internal and external research efforts, and the NOAA CoastWatch program. Through an annual competitive process, ORS awards grants to academics and others to support ocean remote sensing research relevant to the NOAA operational satellite oceanography mission. The NOAA CoastWatch program also provides operational links with research and industry. The value-added commercialization which occurs within this program directly supports NOAA's objectives of providing operational oceanography support to users. These commercial entities enhance the user base and help to define the underlying requirements. Another aspect of industry involvement in operations is the purchase of ocean color data from commercial companies, such as OrbImage, the operator of the

SeaWiFS satellite instrument. The costs of purchasing the imagery precludes more frequent use of this approach, but we are working with other civilian agencies and the commercial community to address these issues.

The most promising technologies to better respond to the requirements of coastal users are operational SAR and hyperspectral sensors. We have documented operational requirements for all-weather, day-night, imagery which could be used by the National Ice Center, NWS Alaska Region and to other users such as the U.S. Coast Guard and the Alaska Department of Fish and Game. These data are very useful for analysis of global and coastal ice, regional and coastal wind determination, vessel detection, oil spill, flooding, and shoreline mapping. Better spectral resolution from hyperspectral remote sensing platforms will help us better meet coastal user requirements in application areas ranging from river plumes and outflows, harmful algal blooms, aquaculture, and coastal water quality, wetlands assessment and mapping, and coastal geomorphology.

The ocean observing system architecture plans should build on the satellite technology opportunities including the development of an operational coastal ocean remote sensing program at NOAA, including consideration for a Synthetic Aperture Radar(SAR), and a hyper spectral coastal imaging capability.

2. Utilization of Satellite Data:

The US should make an investment in finding optimal means to utilize satellite data, in combination with in situ data, in our ocean, and air sea coupled models, demonstrating their utility in an operational setting. NASA and NOAA have formed a collaborative Joint Center for Satellite Data Assimilation (JCSDA) to improve the exploitation of current satellite data and to prepare for more timely integration of future data in operational weather forecasts. DoD has recently been invited to become a partner in JCSDA, and both Navy and Air Force have accepted. JCSDA will promote the development of common weather forecast models for research and operations. A recent accomplishment of JCSDA is the inclusion of the operational implementation of QuickSCAT wind and Tropical Rainfall Measuring Mission (TRMM) precipitation data in NOAA Weather Service operational models. This accomplishment represents the fist time NOAA has used data from research satellites controlled by NASA within the operational data stream used by NOAA's Weather Service. Future efforts will lead to development of new and powerful mathematical techniques to assimilate current and NPOESS-era satellite data into numerical weather prediction models, improving the accuracy and extending the time range of weather and climate forecasts.

In other ocean areas, NOAA, NASA, NSF and the Navy should encourage academia to participate in applications development using satellite and in situ data. In the area of climate, open-ocean and coastal data assimilation, NOAA will soon be issuing a Request For Proposals on behalf of NOPP to implement the initial, pre-operational U.S. contribution to the Global Ocean Data Assimilation Experiment (GODAE). This effort is intended to be a pilot project under the interagency Ocean.US office, and will lead to

sustained operational efforts supported by U.S. Federal agencies. This process represents a very important step in transitioning activities from research to operations. Funds to support this project are coming from four NOAA Line Offices, as well as from ONR and NASA.

In order to receive the maximum return on our investments, Government should encourage data utilization endeavors such as the Joint Center and GODAE.

3. Scientific Stewardship

Operational observing systems should be budgeted and implemented as integrated, quality, end-to-end systems that provide sound scientific data. The quality of the data in real time, as well as delayed mode applications from NOAA archives, must be considered.

NESDIS is implementing a scientific stewardship program to provide management tools for an end-to-end systematic observing program for remote sensing systems, atmospheric in-situ networks, and oceanic observing. The goals of this program are to:

- ***Provide real-time monitoring of observing system performance.*** **Subtle spatial and temporal biases can create serious problems in future use of the data. Tracking tools necessary for the detection of biases in the observational record must be developed and implemented to minimize or eliminate distortions in the data.**
- ***Document Earth system variability and change on global, regional, and local scales.*** **Building and maintaining a high quality base of data and establishing the best possible historical perspective is critical to effective analysis and prediction. The creation of long-term, consistent records requires a long-term commitment of resources.**
- ***Provide the necessary algorithms, in collaboration with the user community, to ensure that understanding of key climate processes can be derived from space-based systems, and the combination of space-based and in-situ systems.*** **An active program engaging the research community and industry and increasing interactions with local and regional decision makers will lead to improved understanding of climate and global change.**
- ***Optimize data and information services in order to make research easier and more effective by ensuring those services are simple, straight forward, direct, and responsive.*** **End-to-end accountability will be established for long-term, scientifically valid and consistent records for scientific studies. Data and information will therefore be available to the maximum number of users.**
- ***Enable and facilitate future research.*** **Basic information technology, hardware, telecommunications, and software support will be provided to guarantee that data can be safeguarded and communicated broadly in the future, which will facilitate ocean and climate research for the long term.**

Calibration

Calibration of the sensor systems is a critical part of remote sensing. Instrument

manufacturers carefully determine the relationship between known radiances and detector counts prior to deployment of the instruments in space. It is more difficult to monitor the sensor system's calibration after deployment, but it is extremely important to do so because electronic systems age in unpredictable ways. The ultimate objective of satellite remote sensing systems is to accurately relate the numbers returned from these instruments to the physical state of the environment being sensed. Therefore, it is critical to maintain a rigorous in-situ calibration/validation or ground truth program.

NOAA, NASA, and ONR funded the initial development of a Marine Optical Buoy (MOBY) to support the Earth Observing System (EOS). MOBY was deployed in 1994 off the coast of Lanai, Hawaii. The primary purpose of MOBY is to measure visible and near-infrared radiation entering and emanating from the ocean. Variations in the visible region-reflected radiation are referred to as ocean color. Other quantities, such as phytoplankton abundance, can be derived from ocean color measurements. At 50-feet in length, MOBY is the world's largest marine optical device. MOBY was calibrated prior to deployment according to National Institute of Standards and Technology (NIST) traceable standards. It also contains an internal calibration system which helps to maintain accuracy once the system is deployed. By measuring ocean color, MOBY provides a time-series database for bio-optical algorithm development. It also serves as a calibration reference station for satellite instruments such as SeaWIFS and MODIS

Building the Long-term Continuous Climate and Ocean Records

In the satellite area, reprocessing of long term record is a prerequisite for climate studies. Several recent reports issued by the National Academy of Science raised concerns about the ability to monitor climate variations and emphasized the need for a program of long-term, sustained observation of the Earth's changing climate. A major challenge for NOAA will be to ensure that we meet the required levels of accuracy, continuity, calibration, stability, and documentation that are essential for climate change detection.

More than 20 years of satellite data and over 150 years of in-situ data are now available for climate analyses and detection of climate trends. The construction of a seamless climate record incorporating data from historical records, the current satellites systems, and NPOESS is a very important and difficult challenge. The NPOESS system will have new weather and climate monitoring instruments, as well as new instruments for monitoring ozone. The NPP mission will provide coincident climate observations between the old and new satellite instruments.

During the past 20 years, NOAA and DoD operational meteorological satellites have provided measurements of ocean parameters such as sea surface temperature, wind speed, and ice concentration. Standardized algorithms and products used to support numerical weather forecasting and climate change assessments were developed from this time series of global ocean observations collected from a consistent set of instruments. Just as for the atmospheric parameters, it is critical to continue construction of the long-time record of ocean observations, incorporating measurements from historical and current satellites and in-situ platforms, as well as from new instruments such as those on NPOESS.

Answering these challenges will take a concerted effort. There must be extensive collaboration between the research and operational communities. Computer scientists, climatologists, oceanographers, and archivists will need to provide a sound and effective means to ensure that all necessary data are preserved, and are accessible in easy-to-use formats. It will take a long-term commitment to provide the resources necessary for the preservation of the climate and ocean archives from the first generation satellite systems, through the transition-satellite systems of the EOS era, to the second generation of operational systems in the future NPOESS era.

In order to achieve our Scientific Stewardship goals, we must maintain support for the above activities.

4. University Partnerships

It is very important to provide training and educational opportunities in the use of new satellite data and products for NOAA's large and diverse user community. Users already have access to our data and many of our operational products through the Internet. NOAA invests in classroom and computer-based training through the Cooperative Program for Operational Meteorology, Education and Training (COMET); and a joint NESDIS/NWS and Cooperative Institute program called the Virtual Institute for Satellite Integration Training (VISIT). The VISIT program uses Internet technology to provide distance learning. In addition to the VISIT interactive classroom, NESDIS maintains a Virtual Institute with satellite tutorials, a wide assortment of case studies, and technical information and documents.

A competitive process was initiated to establish the NOAA Cooperative Institute for Remote Sensing, led by the City University of New York and NESDIS. The Cooperative Institute for Ocean Remote Sensing is designed to capitalize on academic research relevant to operational oceanography. It is expected that the Cooperative Institutes will help to identify longer-range research questions/issues and provide guidance to NOAA for planning and development

NOAA should continue to build partnerships with academia, building on such examples as the Cooperative Institute for Ocean Remote Sensing. All ocean agencies should increase their investment in transferring applications research into operational applications, whether the transition involves algorithm development, model development or other. NOAA should increase its investment, in cooperation with the Navy and NSF, in funding academic opportunities. The Nation needs to expand the current small operational ocean workforce through training and education.

5. Ocean Data Archive

In a report to Congress last year, NOAA identified the principal challenges facing the national data centers, and possible solutions. The NODC is addressing these issues, but we recognize that more remains to be done. The challenges include:

- *Larger more diverse data sets.* The volume of data from anew environmental observation and measurement technologies is growing rapidly. The paradigm for ocean observation data has shifted from large, internally-consistent data sets from a few major programs to even larger heterogeneous data sets from many independent observational efforts.
- *New user communities with new requirements.* The Internet has made data and associated data products more accessible to traditional and new user communities. It has also generated new requirements from these users for improved on-line access, as well as for development of consistent, integrated data sets drawn from diverse sources.
- *Complex Multi-disciplinary Data.* Today, an increasing amount of oceanographic data are produced in digital form, facilitating automated processing, archiving, and on-line access. However, there continue to be important oceanographic and coastal marine observations that are not readily automated for digital processing (e.g., biological and ecosystem data). Standards for ocean and coastal observations need to be defined to facilitate data exchange, archive, and analysis, as in the meteorology community.
- *An Established National Infrastructure.* The oceanographic research community has been successful in exploiting emerging new information technologies, with a concomitant reduction in observational costs, and an increase in observational data output. There has not been a corresponding capital investment in national data archive and management systems, which have struggled to stay abreast. This disparity in investment is exacerbated by the costs of competing with the private information technology sector for talented workers.

The Comprehensive Large Array-data Stewardship System (CLASS)
The ability to ensure scientific stewardship for NOAA's environmental data and information will only be possible through extensive modernization and optimization of data and information services. This goal will be met through the CLASS initiative. CLASS is being designed to handle the data flow from current satellite-based (e.g., GOES, DMSP, and POES), and ground-based (e.g., NEXRAD) observing systems. It will be structured to handle the large increases in data that will come from planned satellite launches, including the METOP, NPOESS, NPP, and some EOS missions.

CLASS includes the development and implementation of a standardized archive management system. This system will be integrated with a robust, large-volume, rapid-access, storage and retrieval system capable of storing the incoming large-array environmental data, in-situ data, and operational products. It will also be capable of automatically receiving and processing data requests from users, and providing the requested data on the most appropriate media. CLASS will provide standardization in media, interfaces, formats, and processes for the very large datasets produced by satellites and radars. Additionally, the system will facilitate ongoing migration, preservation, and validation to new technology and media.

CLASS will be modular in design, built to integrate with automated real-time or near-real-time systems for data delivery. Transaction processing will be implemented to enable an essentially “hands-off” operation and, where appropriate, allow users to pay for data or services through credit card or automated billing. Data storage and retrieval systems will continue to be upgraded to support effective and efficient access.

The target architecture goal will use life cycle replacements and upgrades to bring the current NOAA National Data Centers into a single archive and access architecture that will be under formal configuration management control. This architecture will eliminate duplication of effort, minimize stand-alone systems, build the infrastructure to accommodate the large array data sets, and reduce the overall operational and system maintenance costs. The foundation system that is being used is the highly successful Satellite Active Archive (SAA). SAA is recognized as a stable, modular, well-built system. The central tasks are upgrading communications capabilities; increasing computer storage and power; exploiting commercially available modular hardware and software; and expanding Internet access to the data and information through new or enhanced database management, search, order, browse, and sub-setting techniques.

Standardization
A case in point for standardizing and facilitating access and archiving is NPOESS. The NPOESS users identified product interoperability as a Key Performance Parameter in the Integrated Operational Requirements Document (IORD). Fifty-five weather/environmental data products from the NPOESS system will be delivered to four national meteorological/environmental centers, the NESDIS long-term archive, and the software processing applications of field terminals around the world.

The DoD Joint Technical Architecture document provides a limited list of common data file formats that can be used to ensure interoperability. The file formats which come closest to satisfying NPOESS reporting requirements are GRid in Binary (GRIB), and Binary Universal Form for Representation (BUFR). However, neither is fully capable of conveying the large, high-resolution data files which will be produced by NPOESS instruments. The IPO is working closely with TRW Inc. (the recently selected NPOESS prime contractor) and the Defense Information Systems Agency (DISA) to add a new non-proprietary standard which can accomplish this task.

Current levels and anticipated increases in the amount of ocean data dictates that the community work together to address data management and archiving. NOAA is uniquely qualified to responsibly archive oceanographic data in the United States.

6. Access to Ocean Data
Development of a national strategy for the data management component of the Integrated and Sustained Ocean Observing System (IOOS) can help us to address the data management challenges faced by the ocean community. NODC and other parts of NOAA are working in partnership with Ocean.US to help lead the national team formulating this strategy. The team includes federal, academic, industry and state agency representatives. Key aspects of the strategy include:

- A plan for an enhanced, distributed (virtual vs. monolithic) oceanographic data management and dissemination system that links diverse user communities with observational, data management, and product development systems;

- The development of national standards, protocols and formats to improve data access, management, distribution, and subsequent archive;
- The development of oceanographic "middleware" protocols to enable seamless access to heterogeneous, multi-disciplinary data (the National Virtual Ocean Data System has been recommended as a possible middleware solution for IOOS);
- Use of existing federal standards for metadata descriptions of oceanographic data to facilitate data discovery (e.g., using Internet—based data discovery applications); and
- Use of improved data transport protocols (e.g., Internet language based protocols) to simplify user access to data.

While these discussions are continuing at the national level, NODC is moving forward to implement many of the emerging recommendations to develop a national, flexible, virtual oceanographic data management system within an IOOS framework. For example, data collection and archive processes at NODC are being revised and integrated into an Internet-compatible environment. This environment supports: capture and archive of Internet-accessible oceanographic data from geographically distributed sources; more automated capture of metadata; and a significantly shortened "time-to-archive" (in the order of hours instead of months). NODC has implemented electronic data security key technology derived from the Internet banking industry. This technology helps to ensure the long-term integrity of federally-archived oceanographic data. The improved ability to capture oceanographic metadata, will lead to more efficient data discovery by search engines available on the Internet and through the National Spatial Data Infrastructure Initiative.

Access to ocean data is of utmost importance. The Commission should endorse Ocean.US efforts to develop a national strategy for ocean data management. This should include supporting the application of middleware (such as that underlying the National Virtual Ocean Data System, NVODS) to facilitate access to data. The Commission should endorse an ocean data policy of full and open access and encourage the adoption of this policy worldwide.

Internationally, NODC and NOAA are working towards the development of international oceanographic data exchange and communication standards through the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) and the Global Climate Observing System (GCOS). A national policy of full, and unrestricted access to oceanographic observational data is critical. Such a policy will significantly improve the access to ocean data, and facilitate their long-term archive and stewardship. NOAA's national data centers are responsible for the future security of the long-term oceanographic observational record. This responsibility transcends individual activities, programs and agencies. Meaningful partnerships among government, academia, industry, and the public (such as those fostered under NOPP) are critical to the successful development of national oceanographic data exchange standards and protocols

The Commission on Ocean Policy should endorse a US data policy of full and open access and encourage the adoption of this policy worldwide.

Conclusion

Since the first regional meeting held by the Commission on Ocean Policy, more than 200 leaders and experts have testified on a wide range of critical ocean issues spanning all aspects of science, technology, commerce, policy, and security. I can appreciate the complexity and challenge that the Commission faces as it considers all the issues before it and develops recommendations. The final thought I would leave with the Commission is that observations and data management are essential foundational issues that underpin the Nation's ability to respond to the challenges you have heard about. We need a national commitment to data management and archiving which is consistent with the investment in observing systems. Decision makers, scientists, and university researchers need credible, long-term, easily accessible global, regional, and local ocean data and products to address the issues facing us today. In this regard, as I've described, NOAA has many plans underway for satellite and in situ ocean observations and data management.

Appendix 1

NOAA's Operational Environmental Satellites

GOES

NOAA operates two environmental satellites in geostationary orbit above the Equator, known as the Geostationary Operational Environmental Satellites (GOES). They monitor North and South America, and most of the Atlantic and Pacific Oceans. The two GOES satellites operate day and night to provide satellite images and critical data to users throughout the Western hemisphere. To keep pace with the growing needs for GOES data and products, NOAA is enhancing its geostationary remote sensing capabilities through the development of GOES-R, scheduled for launch in 2012. The GOES-R series will provide greater temporal and horizontal resolutions, improved product accuracies, and extended geographical coverage.

POES

Polar-orbiting Operational Environmental Satellites (POES) continuously circle the Earth in sun-synchronous orbit, and support global weather and marine forecasts. The POES satellites operate as a pair, ensuring that observations for any region of Earth are no more than 6 hours old.

NPOESS

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will fulfill the Nation's responsibility for continuity of operational polar-orbiting satellites. GOES, POES, and NPOESS are all critical building blocks in the development of an integrated observing system for the 21st century. Nearly a third of the NPOESS data products will support ocean observing requirements. They will expand NOAA's current ocean remote sensing capabilities to include: surface vector winds, ocean color, sea-ice edge motion and sea-ice age, sea-surface stress, sea-surface heights and topography, and wave heights at a higher resolution and decreased data latency than is currently available. NOAA will use data from NPOESS to improve short-term weather warnings and forecast services for protection of life and property, longer-term climate change assessment and prediction, and a variety of other real-time applications.

The NPOESS program is a $6.5 billion, 24-year activity, extending from 1995-2018. NPOESS development and implementation are managed through a tri-agency partnership among the Department of Commerce/NOAA, the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA). Requirements for NPOESS are fully defined by the user community. NPOESS satellites will replace the polar-orbiting meteorological satellites currently operated by NOAA (POES) and DoD (Defense Meteorological Satellite Program (DMSP)), and will save the taxpayers an estimated $1.6 billion over the life of the program. The U.S. is also partnering with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and the National Space Development Agency of Japan (NASDA) to complete its NPOESS mission of providing long-term continuity of observations from polar-orbiting satellites.

The NPOESS program plans call for procurement and launch of 6 satellites, and the integration of 13 new instruments: 11 environmental sensors and 2 subsystems. Table 1 provides a description of the 13 instruments, and Table 2 provides a list of the main environmental data records to be generated from NPOESS data streams.

Appendix 2

NOAA/NESDIS National Data Centers

NESDIS operates four national data centers that are recognized as global resources. They receive, collect, distribute, and archive data about climate, Earth geophysics, the U.S. coast, and the global oceans. Billions of dollars are spent each year collecting these data. The long-term stewardship of this "national treasure" has been entrusted to NESDIS. NOAA's data and information services provide the basis for sound policy and decision-making on the environment, its resources, and the economy. People around the world and in every sector of the economy benefit from authoritative, well described, easily accessible, long-term environmental data and information services. The NESDIS archives are composed of data from NOAA; other Federal, state, and local agencies; academia; the private sector; and foreign governments and institutions. These holdings have quadrupled during the 1990's and are expected to be eight times greater by the year 2005. In 2000, the NESDIS archives (all data types) exceeded one petabyte (10^{15}) in size.

The Data Centers serve a wide variety of customers, including community planners, scientists, policy makers, engineers and architects, national security analysts, and businesses. NESDIS must meet growing customer demands, both on-line and traditional, for meaningful and accurate environmental data sets and products. Continuous user feedback is required to ensure the usefulness of these data, data products, and services.

On the international side, the national data centers operate World Data Centers, each specializing in a specific scientific discipline, which are components of a global network of sub-centers that facilitate exchange of scientific data. Originally established during the International Geophysical Year of 1957-58, the World Data Center System functions under the guidance of the International Council of Scientific Unions (ICSU). WDC for Oceanography, Silver Spring, is collocated with, and operated by, the U.S. National Oceanographic Data Center (NODC). In accordance with principles set forth by ICSU, WDC for Oceanography acquires, catalogues, and archives data, publications, and data inventory forms and makes them available to requesters in the international scientific community. To improve user access, the WDC provides copies of data it receives to its counterparts, World Data Center for Oceanography (Obninsk, Russia) and World Data Center for Oceanography (Tianjin, China). Oceanographic data contributed to the WDC become automatically available to scientific investigators in any country. Since international efforts are periodically underway to restrict data sharing, NOAA must be vigilant in its advocacy for the full and open international exchange of data and information.