A HISTORY OF NOAA:

BEING A COMPILATION OF
FACTS AND FIGURES
REGARDING THE LIFE AND TIMES
OF THE
ORIGINAL WHOLE EARTH AGENCY

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Notes and Acknowledgements

The following History was begun as NOAA's contribution to a Department-wide effort to produce a Commerce History which would serve as the Department's contribution to the national celebration of the Bicentennial of the Constitution. In addition to serving as source material to staff of the Department's Historical Council, I thought it might be useful to distribute the NOAA History, in the entirety, within the Agency.

Most of the material in the History was drawn from existing documents -- published and unpublished. I have, wherever possible, given credit to the authors responsible for those earlier works - especially in those cases where, as with Dane Konop's history of the National Ocean Survey, highlights of significant historical events were used almost verbatim. I am grateful to these individuals as well as the anonymous authors of the countless internal agency documents used in researching the History. If readers of this document can identify any of these unidentified contributors, I'd appreciate an opportunity to give them due credit!

This History is meant to be an internal agency reference document and there are no plans to publish or distribute it publicly. I learned a great deal about this exciting agency as I compiled the document and thought that others in the NOAA family might find it interesting as well. We are all part of a dynamic organization that continues to touch the lives of every citizen of the United States every day. We can and should take pride not only in our past accomplishments but also in the future promise of this original "whole earth" agency.

I offer my personal thanks to all the people who made this history possible and a special "thank you" to Ms. Julie Campbell, Office of Legislative Affairs, for her invaluable assistance.

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NOAA -- SOME PRE-HISTORY

Introduction

> The oceans and atmosphere are interacting parts of the total environmental system upon which we depend, not only for the quality of our lives, but for life itself.
>
> We face immediate and compelling needs for better protection of life and property from natural hazards, and for a better understanding of the total environment -- an understanding which will enable us more effectively to monitor and predict its actions, and ultimately, perhaps to exercise some degree of control over them.
>
> We also face a compelling need for exploration and development leading to the intelligent use of our marine resources. We must understand the nature of these resources, and assure their development without either contaminating the marine environment or upsetting its balance.
>
> Establishment of the National Oceanic and Atmospheric Administration -- NOAA -- within the Department of Commerce would enable us to approach these tasks in a coordinated way. 1/

With these words, published in July 1970, President Richard M. Nixon proposed the creation of a new agency -- the National Oceanic and Atmospheric Administration (NOAA).

The proposal, which was coupled with the creation of the Environmental Protection Agency, was part of a reorganization effort, which, according to the reorganization plan itself, was designed to unify the nation's widely scattered, piece-meal environmental activities and provide a rational and systematic approach to understanding, protecting, developing and enhancing the total environment. In addition to a specific responsibility for the rational development and conservation of marine fisheries, NOAA was to lead the development of a consolidated national oceanic and atmospheric research and development program and provide a variety of scientific and technical services to other Federal agencies, private sector interests and the general public.

The goals, responsibilities and programs of NOAA today reflect a continued commitment to the philosophy which created it. NOAA's primary mission and the ultimate goal of all its activities is to predict environmental changes on a wide range of time and space scales in order to protect life and property, and provide industry and government decision-makers with a reliable base of scientific information.

Specifically, NOAA is a science-based agency which has the responsibility to predict changes in the oceanic and atmospheric environments and living marine resources, and to provide related data, information, and services to the public, industry, the research community, and other government agencies. These efforts range from warnings of severe events on short time-scales to information on climate shifts over decades or more. The main purpose of these

efforts is to support NOAA's operational environmental warning, forecast, prediction, assessment, and information management responsibilities.

Just as they fulfill NOAA's environmental prediction responsibility, most, if not all, of the Agency's activities also contribute to the major Department of Commerce goal of Stimulating Productivity and Economic Development. Providing reliable forecasts and warnings of changing environmental conditions (like severe weather) protects life and property and enables industry to take appropriate actions. NOAA's programs to predict and assess significant changes in the ocean, coastal and Great Lakes environments ensures the safe, efficient, and cost-effective use of those marine environments and their resources and promotes the development of associated industry. Providing reliable fishery stock assessments and projections can significantly enhance the magnitude of the contribution of the domestic fishing industry to the U.S. balance of trade.

Background

The creation of NOAA was largely the result of an effort which began in June 1966 with enactment of the Marine Resources and Engineering Development Act of 1966 (P.L. 89-454). The Act declared it to be the policy of the United States to:

> develop, encourage, and maintain a coordinated, comprehensive, and long-range national program in marine science for the benefit of mankind, to assist in protection of health and property, enhancement of commerce, transportation, and national security, rehabilitation of our commercial fisheries, and increased utilization of these and other resources.

To ensure the effective implementation of this policy, the Act created a Commission on Marine Science, Engineering and Resources to review and assess existing and planned U.S. marine science activities and recommend the required national oceanographic program and Governmental organizational plan.

The Commission was comprised of fifteen members, appointed by the President, representing Federal and State governments, industry, academia, and other institutions with programs or interest in marine science and technology. The Commission was chaired by Julius A. Stratton, Chairman of the Ford Foundation, and included: Leon Jaworski (then Attorney with Fulbright, Crooker, Freeman, Bates and Jaworski), John H. Perry, Jr. (President Perry Publications, Inc.), John Knauss (Dean, Graduate School of Oceanography, University of Rhode Island), and Robert M. White (Administrator of the Commerce Department's Environmental Science Services Administration). As specified in the Act, the Commission was provided with four Congressional advisors including former Senator Warren G. Magnuson of Washington -- a name which is associated with much of this nation's ocean-related legislation. The "Stratton Commission", as it came to be called, began deliberations in early 1967 and on January 9, 1969 submitted their final report to the President and Congress. That document, Our Nation and the Sea: A Plan for National Action, set the stage for the evolution of this Nation's current programs in marine science and resource development.

Of particular interest was the Commission's recommendation to create a new, National Oceanic and Atmospheric Agency which would administer the Nation's principal civil marine and atmospheric programs. The Commission was largely driven by the need to ensure the "full and wise use of the marine environment" but, in reviewing the need to describe, understand and predict global ocean processes, they recognized the need to address the oceans and atmosphere as interactive components of the global environment. As a result, they recommended that the new Agency incorporate atmospheric science as well.

As envisioned by the Commission, the new independent Agency was to be initially composed of:

- The U.S. Coast Guard;
- The Environmental Science Services Administration of the Department of Commerce;
- The Bureau of Commercial Fisheries and the marine and anadromous fisheries functions of the Bureau of Sport Fisheries and Wildlife of the Department of Interior;
- The National Sea Grant Program from the National Science Foundation;
- elements of the U.S. Lake Survey of the Department of the Army, and;
- The Department of the Navy's National Oceanographic Data Center.

The Commission urged that "Because of the importance of the seas to this Nation and the world, our Federal organization of marine affairs must be put in order." 2/

Reorganization Plan #4

Immediately after publication of Our Nation and the Sea, Congress responded by beginning deliberations on the creation of the new agency. The concept was also incorporated into President's Nixon's Advisory Council on Executive Organization. This Council, appointed in 1969 and chaired by Ray L. Ash (Litton Industries), made a series of recommendations on re-structuring the executive branch. One of those proposals was to replace the Department of Interior with a new Department of Natural Resources. One of the elements of the Department was to be a National Oceanic and Atmospheric Administration which would combine some elements of the Department of Interior with the Environmental Science Services Administration (ESSA) of the Department of Commerce. Then Secretary of Commerce, Maurice Stans, noting that ESSA would comprise more than two-thirds of this new Agency (some 10,000 employees and an estimated FY 1970 budget of approximately $200 million) countered with a proposal to, at least initially, consolidate and house NOAA within Commerce and transfer it to the proposed Department of Natural Resources at a later date. 3/ Prior to the Stans' proposal, the Administration had been considering housing an interim organization in the Department of Interior. The logic of Secretary Stans' recommendation , possibly combined with some political tensions between the White House and Interior Secretary Hickel, lead to a decision in favor of Commerce. Deliberations within the Executive Branch finally resulted in Reorganization Plan No. 4 of 1970 which was proposed in early July and became effective ninety days later in October 1970. President Nixon had concurred with Secretary Stans and, incorporating elements from the Stratton Commission Report, the Ash Council recommendations, and Congressional deliberations, proposed that National Oceanic and Atmospheric Administration be created within the Department of Commerce.

Like the Stratton Commission Report, Reorganization Plan No. 4 proposed that the following programs be transferred to the new agency:

- the Environmental Science Services Administration (ESSA) of the Department of Commerce;
- most of the Bureau of Commercial Fisheries, and the marine sport fishing program of its Bureau of Sport Fisheries and Wildlife;
- The Office of Sea Grant Programs from the National Science Foundation;
- The mapping, charting and research functions of the Army's U.S. Lake Survey; and
- The Navy's National Oceanographic Data Center.

Reorganization Plan No. 4 did not implement the Stratton Commission's recommendation to include the Coast Guard in the new NOAA, but went beyond that Commission's proposed agency by also including:

- The Marine Minerals Technology Center of Interior's Bureau of Mines;
- The Navy's National Oceanographic Instrumentation Center; and
- The National Data Buoy Project from Department of Transportation.

In testimony before the House Committee on Government Operations, Secretary Stans described the creation of NOAA as an extension of the Department's historical science and technology programs:

> We already have in the Department the solid base of science and technology which will buttress the foundation of an exciting and vigorous NOAA...
>
> I believe that the new National Oceanic and Atmospheric Administration will enable this nation in the decades ahead to fully and wisely utilize and understand the oceans and the atmosphere. This new initiative ... will greatly enhance the quality of our environment, our security, our economy, and our ability to meet increased demands for food and raw materials. I regard the establishment of NOAA as an essential step forward. 4/

NOAA's Heritage

In order to understand the consolidated agency, one must look first at the history and programs of its component organizations. In the case of NOAA, those histories are wide and varied and in one case, represent some of the oldest activities of the Department of Commerce -- dating back to 1807! The following sections will provide some insight into the major programs/organizations which, in October 1970, became NOAA.

Environmental Science Services Administration

The Environmental Science Services Administration (ESSA), the largest single piece of the new NOAA, was itself the product of a reorganization plan. In Reorganization Plan No. 2 of 1965, President Johnson proposed the consolidation of two long-standing agencies of the Department of Commerce -- the Coast and Geodetic Survey and the Weather Bureau. In addition, the new ESSA was to include the Central Radio Propagation Laboratory of the National Bureau of Standards. President Johnson's May 13, 1965 message to Congress noted that:

> The new Administration will then provide a single national focus for our efforts to describe, understand, and predict the state of the oceans, the state of the lower and upper atmosphere, and the size and shape of the earth.

As described by President Johnson and, then Director of the Weather Bureau, Dr. Robert White, the creation of ESSA:

- responded to an increasing national need for adequate warnings of severe natural hazards (e.g., tornados, hurricanes, floods);
- responded to technological advances in capabilities to observe the physical environment and communicate and process environmental data; and
- would enable scientists to investigate the physical environment as a "scientific whole" rather than a "collection of separate and distinct fields of scientific interest". 5/

The creation of ESSA was the result of deliberations by a special committee established in May 1964 to review the environmental science service activities and responsibilities of the Department of Commerce. The committee comprised of the heads of the National Bureau of Standards (NBS), the Weather Bureau, and the Coast and Geodetic Survey and supported by a panel of respected scientists from industry and academia, was established by Dr. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology and reflect the Department's longstanding commitment to management efficiency the effective provision of quality public services. 6/

Coast and Geodetic Survey 7/

Often referred to as the Nation's oldest scientific agency, the "Survey of the Coast" was established on February 10, 1807 by President Thomas Jefferson. The increasing importance of waterborne Commerce to the new Nation prompted Jefferson to sign legislation to "cause a survey to be taken of coasts of the United States." 8/ Using officers detailed from the Navy (for the seagoing portion of charting) and from the Army Topographical Bureau, The "Survey" conducted its early activities under the U.S. Department of Treasury where it shared vessels with the Revenue Cutter Service, forerunner of the Coast Guard. The Survey has a rich and interesting history but, since the focus of this volume is recent Department history (post World War II), the early years will be represented by the following highlights of significant events:

- 1816 -- Ferdinand Hassler, first Superintendent of the Survey begins geodetic work to lay the foundation for accurate surveys.

- 1818-1832 -- Survey of the Coast operations suspended; survey work performed by the Navy. During this period, Ferdinand Hassler became the first head of the newly created Office of Weights and Measures. This Office was incorporated in the Survey until, in the early 20th century, it became the National Bureau of Standards.

- 1834 -- first hydrographic survey along the south shore of Long Island;

- 1836-1838 -- the re-named "U.S. Coast Survey" conducts its first topographic surveys of the coasts of New York, New Jersey and Connecticut.

- 1839 -- first nautical chart produced (Newark Bay).

- 1840's -- introduction of the first automatic recording tide gage.

- 1853 -- first issue of the Survey's "Tide Prediction Tables" published.

- 1875 -- Survey began publishing "Coast Pilots" with critical navigation information that cannot be portrayed on charts.

- 1878 -- Survey's name changed to "Coast and Geodetic Survey" to reflect the role of geodesy in the agency's work.

- 1882 -- William Ferrel, a survey mathematician, built an analog tide predicting machine that could produce a curve of future tide motions (used by the Survey until 1914).

- 1901 -- the Survey established a standard datum for the U.S. that provided a unified survey reference system for mapping and engineering work.

- 1904 -- weighted wire-drag surveys introduced in hydrography to reveal the depth and position of submerged rocks and other obstructions.

- 1907 -- Survey completed a line of geodetic levels across the continental U.S. which involved 33,000 miles of first-order levels and the establishment of 13,000 geodetic benchmarks.

- 1914 -- Survey's Rollin A. Harris and E.G. Fischer develop a new tide predicting machine which traced a continuous curve showing tide levels for each day of the year and indicated the time and height of high and low water; this "technical marvel" remained the principal tide predicting device until 1966 when replaced by computers.

- 1917 -- legislation formally creates a Commissioned Officers Corps to meet the Survey's need and expand the strength of the Navy and Marine Corps. Originally created as a specialized body of geodetic and hydrographic engineers, the NOAA Corps now includes biologists, meteorologists, oceanographers and other scientific disciplines. One of the Nation's seven uniformed services, this Corps of scientists and

engineers supports the activities of all elements of the Agency. [9] It is interesting to note that in 1972, the NOAA Corps became the first of the U.S. uniformed services to recruit women on the same basis as men.

- o World War I -- Survey's ships and more than half of its personnel transferred to the Navy and Army to support the war effort.

- o 1926 -- Survey given responsibility for charting the Nation's airways and publishing aeronautical charts.

- o 1927 -- North American Datum established making it possible to connect all surveys and maps on a uniform base.

World War II placed uprecedented demands on the services of the Coast and Geodetic Survey. During the war, nautical chart production increased 10-fold, and aeronautical chart production increased a phenomenal 25-fold. Again, more than half of the Survey's commissioned officers and many civilian employees served in the military. Also, six of the Survey's nine major ships were ordered into duty with the Navy. In fact, the Coast and Geodetic Survey ship Pathfinder narrowly survived a kamikaze hit in the Pacific, and was ultimately scuttled at Bataan in 1942 after taking two hits in the Japanese attack against the Philippines.

In the early 1950's, there was a growing awareness of the need for oceanographic exploration and new methods and equipment for marine research, as well as a growing realization of the importance of the world's ocean resources. The Coast and Geodetic Survey began to meet these new needs for oceanographic information by incorporating new advances in marine technology that grew out of developments made during World War II, such as electronic echo sounding equipment and positioning systems. These new systems did much to improve the speed and accuracy of the collection of hydrographic and oceanographic data. However, because the recording, processing, and plotting of survey data were still performed manually, the Survey's capacity to use the data fully was lagging behind the capability to collect the data. In the 1960's the Survey began a program to develop a computer-assisted system for handling the massive amounts of hydrographic data that were being collected. In 1962, the Survey's Pacific Marine Center produced the first automatically processed and machine-plotted hydrographic smooth sheet--the first step in the marriage of hydrography and automated data processing. Ultimately, this work culminated in the development of the Hydroplot System, which became the mainstay for the Survey's hydrographic survey operations. The system, which is only now facing obsolescence, is considered by many to be the first, and most practical, automated hydrographic survey system--and a major milestone in the history of hydrography.

In the 1960's, the Survey's fleet of 14 ships was replaced with new, larger, and more sophisticated survey ships designed specifically for hydrographic and oceanography work. In 1970, with the formation of the National Oceanic and Atmospheric Administration, the name of this new fleet of ships was changed to the NOAA Fleet. At the same time, the Coast and Geodetic Survey was renamed the National Ocean Survey, and the Lake Survey Center, which was responsible for surveying functions on the Great Lakes, was transferred from the U.S. Army Corps of Engineers to NOS. [10]

Weather Bureau [11/]

The second oldest element of what became the Environmental Science Services Administration was the Weather Bureau. 1991 will mark the 100th anniversary of the civilian weather service which was created on July 1, 1891 when an Act of Congress transferred the weather bureau from the Army Signal Corps to the Department of Agriculture. This action was preceded however by nearly 250 years of weather observation and study in the U.S. Historians agree that the first continuous weather records in the U.S. were kept in 1644 and 1645 by the Reverend John Campanius Holm near Wilmington, Delaware. While many other individuals kept "weather diaries" from time to time around the country, the best known is probably Thomas Jefferson. Jefferson was considered a weather expert in his day and often responded to questions about American weather and climate. The War of 1812 brought the first government collection of weather observations. Responding to growing interest in the effect of weather on health, Dr. James Tilton, the Surgeon-General of the Army, ordered hospital surgeons to observe the weather and keep climatological records. The following highlights, summarize the most significant events during the pre-World War II history of the Weather Bureau:

- 1817 -- a system of weather observations at land offices established by Josian Miegs, Commissioner-General of the Land Office.

- 1825-1850 -- New York University and the State of Pennsylvania operate state networks of weather observations.

- 1849 -- Professor Joseph Henry of the Smithsonian Institution establishes first extensive observation network by supplying weather instruments to telegraph companies. Dr. Henry prepared maps based on simultaneous observations sent to the Smithsonian by telegraph operators and often made predictions based on those maps -- the first published weather forecasts in the U.S. This network was severely disrupted by the Civil War.

- 1865 -- Dr. Henry's annual report urges reorganization of all meteorological observations under a single agency as a means of predicting storms and warning coastal shipping.

- 1869 -- a new weather observation network established by Cleveland Abbe, Director of the Cincinnati Observatory. Using some of the former Smithsonian observers, Professor Abbe issued forecasts which he called "probabilities."

- 1870 -- An Act of Congress (introduced in 1869 by Congressman H. E. Paine of Wisconsin) established a national weather warning service under the Secretary of War. Capitalizing on a widespread telegraph system and the interest of their head, Colonel A. J. Myer, the Army Signal Corps assumed responsibility for taking observations at military stations and warning of storms on the Great Lakes and the Atlantic and Gulf Coasts.

- 1871 -- first daily weather maps appeared in January and weather predictions began to be published regularly in February.

- 1871 -- observing and reporting river stages added to the responsibilities of the Signal Corps.

- 1871 -- Professor Abbe appointed as special assistant to the Chief Signal Officer and directed most of the Service's research on tornadoes, moisture in the air, atmospheric electricity, use of balloons, thermometer exposure, and wet-bulb temperature conversion tables.

- 1874 -- remaining 383 cooperative observers in the Smithsonian's network transferred to the Signal Service.

- 1884 -- weather services for cotton and sugar producers initiated.

- 1885 -- Service began issuing warnings of Atlantic storms (in cooperation with the British Meteorological Office).

- 1884 -- reduced appropriations forced the closure of 18 stations of the Signal Service; due largely to a decrease in the prestige of the Service associated with the 1881 indictment of the service's disbursing officer (Captain Henry W. Howgate) for embezzlement.

- 1890 -- the "Weather Service Organic Act" is passed, transferring the weather service to the new Department of Agriculture; transfer of operations officially accomplished on July 1, 1891.

- 1891-1939 -- public forecasts issued twice a day for the ensuing 36 hours (based on twice daily observations).

- 1896 -- first hurricane warning service established.

- 1902 -- forecasts sent by wireless to ships at sea for the first time; in 1905, the first reports <u>from</u> ships at sea were received (primarily in support of hurricane warnings).

- 1909 -- Bureau began a regular program of free balloon upper air observations.

- 1910 -- Weather Bureau began issuing weekly forecasts.

- 1913 -- first fire weather forecast issued.

- 1914 -- aerological section established within the Bureau to meet the growing needs of aviation (services to aviation actually began in 1902 with a study of surface winds at Kitty Hawk for the Wright Brothers).

- 1918 -- special bulletins and forecasts first issued for military aviation.

- 1919 -- daily "flying weather" forecasts were begun for the Post Office Department and military aviation; the first flight forecast centers were established in 1920 in Chicago, Washington, and San Francisco.

- 1922 -- special fruit frost service began in selected states.

- 1926 -- the Air Commerce Act of 1926 gives the Bureau responsibility for weather services to civilian aviation.

- 1927 -- two Frenchman attach a radio transmitter to a free balloon; a year later a Russian meteorologist (Moltchanoff) achieved the first official flight of a "radio meteorograph" attached to a sounding balloon -- this eventually led to the familiar radiosondes (or "weather ballon").

- 1928 -- first teletypewriter circuits installed, which eliminated the Bureau's dependence on telephone and telegraph.

- 1934 -- Bureau began machine processing of past weather records with the establishment of a tabulating unit in New Orleans; the Bureau began card punching surface and upper air data from airway weather stations in 1936; in 1951, these activities were moved to Asheville, North Carolina with the establishment of the National Weather Records Center.

- 1935 -- improved hurricane warning service established.

- 1936 -- Weather Bureau began operational use of radiosondes which allowed for the routine measurement of atmospheric pressure, temperature, humidity, wind direction and speed.

- 1939 -- automatic telephone weather forecast service began.

- 1940 -- first official five-day forecast issued.

Also in 1940, the Weather Bureau was transferred to the Department of Commerce. President Roosevelt's explanation for this reorganization noted that the move would "permit better coordination of Government activities relating to aviation and to commerce generally..."

In fact during and after World War II, the tremendous growth of the Weather Bureau was due largely to the expansion of aviation. Increasing performance capabilities of aircraft required improved observing and reporting networks, communications systems and forecasting organization. After World War II, surplus radars were acquired by the Bureau to track the movement of rain areas, storms and squall lines. In 1942, building on early work on the use of computers for weather prediction, (which the Weather Bureau, the Air Weather Service and the Naval Weather Service supported at the Institute for Advanced Study in Princeton, New Jersey, MIT, and the University of Chicago), a central Analysis Center was created to prepare and distribute master analyses of the upper atmosphere. The Joint Numerical Weather Prediction Unit was established in the Center in 1954 and by 1985, operational computer weather forecasts had became routine. In 1958, this Center became part of the National Meteorological Center which provides guidance to the field stations by preparing weather analyses and forecasts for the Northern Hemisphere. In 1948, the teletypewriter was supplemented by facsimile transmission -- a wirephoto technique used to transmit analyzed maps and charts from analysis centers to field weather stations. In 1954, automatic observing stations, which made weather measurements and transmitted them by teletypewrtier, were first placed in operation. Also during that year, the Bureau began the installation of high-powered radars along the coastline to detect and track

hurricanes. The Bureau began an ongoing study of hurricanes in 1956 with the establishment of the National Hurricane Research Project. In a similar effort to improve forecasts of inland severe storms, the Weather Bureau established a severe storm forecast center in 1952. While Signal Corps officers had attempted to predict the occurrence of tornadoes, early Weather Bureau forecasters were not permitted to issue tornado forecasts for fear of causing panic. The ability to make accurate forecasts of severe storms was only made possible with the development of modern methods of upper air observation and air-mass analysis.

Perhaps the most exciting developments in recent Weather Service history can be traced to April 1960 when NASA launched the first weather satellite. The polar-orbiting TIROS-1 (Television Infra-Red Observation Satellite) built by RCA, provided forecasters with the first view of cloud (i.e., weather) patterns as they developed and moved across the continent. The history of weather satellites like TIROS actually trace their history back to the 1950's when scientists like the Weather Bureau's Dr. Harry Wexler began to push for the development of satellites for weather studies and measurements. Dr. Wexler's 1954 paper "Observing the Weather from a Satellite Vehicle" remains a classic in the field.[12/] The mid-late 1950's saw the development and testing of a number of military-sponsored satellite systems for weather observations. Prior to 1958, these experiments were part of broader satellite experimentation. In 1958, however, the Defense Department began a program to develop a spacecraft specifically for meteorological purposes. This "TIROS" program was transferred to NASA in April 1959.

In 1961, the Weather Bureau, along with colleagues in the military, NASA and the private sector, formally undertook the development and operation of a global weather satellite observing system. Additional polar-orbiting TIROS research satellites were launched over the next several years to test new camera lenses and transmission techniques. TIROS-8, launched in late 1963 successfully tested an automatic picture transmission (APT) system which continually relayed imagery to ground receiving stations anywhere in the world along the satellite's track.

The TIROS-9 satellite, launched into sun-synchronous, near polar-orbit in 1965, gave the first complete daily coverage of the entire sun-illuminated portion of the earth. Launched just a few months earlier, the NIMBUS-1 satellite carried an infrared sensor which permitted the first-ever nighttime pictures from space. The early TIROS spacecraft and NIMBUS-1 proved the feasibility of an operational system of weather-watching satellites. On July 1, 1965, TIROS-10, the first wholly operational meteorological satellite was launched. The more recent history of the Department of Commerce's weather satellite program will be discussed in later sections describing the activities of ESSA and NOAA.

Central Radio Propagation Laboratory [13/]

The third major component of the newly-created ESSA was the Central Radio Propagation Laboratory. This Laboratory, located in Boulder, Colorado, was established in 1946 as the central Federal agency for obtaining and disseminating information on the propagation of electromagnetic waves, on the electromagnetic properties of man's environment, on the nature of electromagnetic noise and interference, and on methods for more efficient use

of the electromagnetic spectrum for telecommunication purposes. The Ionospheric Telecommunications Division of the Laboratory played a key role in the discovery of new models of electromagnetic propagation by the ionosphere and the practical use of such new telecommunication techniques. The Division was responsible for publishing a regular "radio weather" forecast series which predicted the best frequencies for ionospheric radio transmissions.

The Tropospheric Telecommunications Division conducted similar research related to telecommunication activities within the area from the earth's surface up to 5 or 10 miles. Research included the effects of weather and terrain on television and microwave frequencies as well as investigations of the propagation infrared, optical and radio frequencies.

The Space Environment Forecasting Division focused its research on the effects of solar disturbances and how to predict them. This effort was a natural outgrowth of research on techniques to measure changes in the ionosphere which affect radio transmissions. Since most of such changes are the result of solar-associated disturbances, many of the those same techniques could be used to study the nature of the disturbances themselves. Such investigations were critical to support for manned and unmanned space flights.

The Aeronomy Division of CRPL conducted research aimed at understanding the fundamental physical processes controlling the ionosphere. Focusing on gaining a detailed knowledge of the characteristics of the upper atmosphere, the activities of the Division were critical to supporting the Nation's increased space and satellite programs.

NOAA -- AT IT'S CREATION

The Environmental Science Services Administration [14]

Within its first year of existence, ESSA had made significant progress toward its task to describe, understand and predict the state of the oceans, the state of the upper and lower atmosphere, and the size and shape of the earth.[15] Building on the capabilities of the Central Radio Propagation Laboratory, the Institutes for Environmental Research were established in Boulder, Colorado. This represented a revolutionary organizational concept which would continue throughout the history of ESSA and NOAA -- the concept of unified mission support for the Agency's program objectives through environmental science and technology development. In all, four Institutes were organized:

- The Institute for Telecommunications Sciences and Aeronomy -- formed largely of personnel from the old Central Radio Propagation Laboratory and the Geoacoustics Group of the National Bureau of Standards.
- The Institute for Earth Sciences composed of staff from the Research Division of the Coast and Geodetic Survey.
- The Institute for Oceanography also composed of C&GS personnel.
- The Institute for Atmospheric Sciences staffed largely by meteorologists and other staff from the Weather Bureau's Office of Meteorological Research.

In 1967, the Institutes became the ESSA Research Laboratories. The Laboratories, eleven in all, plus one unit still identified as an Institute for Telecommunications Science, and the Research Flight Facility, were the result of a re-structuring designed to more precisely reflect the scope and mission of the individual elements. The eleven laboratories included:

- The Earth Sciences Laboratory
- The Atlantic Oceanographic Laboratory
- The Pacific Oceanographic Laboratory
- The Atmospheric Physics and Chemistry Laboratory
- The Air Resources Laboratory
- The Geophysical Fluid Dynamics Laboratory
- The National Hurricane Research Laboratory
- The National Severe Storms Laboratory
- The Space Disturbances Laboratory
- The Aeronomy Laboratory and
- The Wave Propagation Laboratory.

The National Weather Records Center (established in Asheville, North Carolina in 1951) gave rise to an Environmental Data Center complex with the transfer of the Geodetic and Seismology Data Centers to Asheville in 1966. In many ways, this move and the reorganization of the ESSA laboratories reflect the history of the entire organization during its five years of independent existence. It was a period of "settling in" and "settling down" to the task of addressing an enormous mission -- understanding the global environment.

Much of the excitement associated with that job during the ESSA years involved the beginnings of the operational weather satellite program. During the early years of meteorological satellites, scientists recognized the potential value of a geostationary orbit to provide continuous viewing of weather systems over the U.S. It wasn't until the mid-60's, however, that sufficient rocket power became available to achieve a geostationary orbit. 1966 saw the launch of a NASA operational experiment with early imaging and weather broadcast systems aboard. Joint NASA/ESSA (later NOAA) experimentation would continue until 1974 and 1975 when geostationary weather satellites became an operational reality with the launch of NASA's Synchronous Meteorological Satellites (SMS) 1, 2. These satellites were the prototype for what is now NOAA's Geostationary Operational Environmental Satellites (GOES) -- the so-called "hurricane-tracking" satellites whose images are so familiar to all of us who watch the nightly news on television.

Now let's take a look at the other programs and organizations which were combined with ESSA in 1980 to create the National Oceanic and Atmospheric Administration (NOAA).

Bureau of Commercial Fisheries [16/]

Like the Weather Bureau and the Coast and Geodetic Survey, the Bureau of Commercial Fisheries (BCF) has historical roots that date back to the 19th century. In 1871, President Ulysses S. Grant signed legislation establishing a one-man, U.S. Fish Commission charged to:

> ascertain whether any and what diminution of food fishes of the coasts and lakes of the United States has taken place; and, if so, to what causes the same is due; and also whether any and what protective, prohibitory or precautionary measures should be adopted... (and) report upon the same to Congress.

Thus began the Federal interest in and commitment to the conservation of living marine resources; a commitment and a responsibility that is largely the same today.

In 1903 the Fish Commission became the Bureau of Fisheries in the new Department of Commerce and Labor. The Bureau remained in Commerce until 1939 when it was transferred to the Interior Department. One year later, the Bureau was consolidated with the Department of Agriculture's Bureau of Biological Survey and became the U.S. Fish and Wildlife Service. With passage of the Fish and Wildlife Act of 1956, the Bureau of Commercial Fisheries (BCF) became a separate Bureau in the Department of Interior. The organization created by this law remained largely unchanged until 1970 when, as part of Reorganization Plan No. 4, most of its functions were transferred to NOAA and the Bureau's Pesticides Laboratory in Gulf Breeze, Florida was transferred to the new Environmental Protection Agency.

Like its predecessor organizations, the BCF brought to NOAA a responsibility for developing and managing programs to define and identify solutions to the problems of commercial fisheries. It is important to note that this was essentially a scientific responsibility designed to foster conservation -- the wise use of marine resources. Specific management and conservation responsibilities would not be given to what is now the National Marine

Fisheries until the mid-1970's. Thus what the Bureau brought to the new Agency was largely a program of biological research designed to provide an understanding of the nature, size, behavior, and, most importantly, maximum sustainable yield of commercially-important fish stocks and marine mammals off the coasts of the U.S. Complementing this fundamental research program were Bureau activities designed to assist industry, ensure consumer safety and support U.S. responsibilities under international treaties and agreements. The Bureau conducted resource assessment surveys; maintained a national program of fishery statistics and market news; supported gear development and evaluation studies as well as fishery development research designed to find alternative uses for underutilized fish and shellfish populations; conducted a voluntary grading and inspection program -- paid for by the processor; and maintained a staff of marketing specialists and economists who provided services to Federal and state Governments, industry, and consumer organizations. All of these responsibilities and activities came to NOAA and, in large part, are still part of the Agency's marine fisheries programs.

The Bureau of Commercial Fisheries also brought to the new Agency a number of specialized facilities across the country. These included five regional offices in Seattle, Washington; St. Petersburg, Florida; Gloucester, Massachusettes; Juneau, Alaska; and Terminal Island, California; nearly 30 major laboratories and research centers and nearly 50 smaller installations and offices such as statistics and market news offices. The new Agency's fleet of Coast and Geodetic Survey ships was also significantly expanded by the addition of twenty-five research vessels ranging from 40-footers to the 214-foot MILLER FREEMAN. Many of these vessels are still in operation today.

Marine Sport Fishery Program [17/]

The creation of NOAA also involved another element of the Department of Interior's fishery programs -- the marine game fish research program of the Bureau of Sport Fisheries and Wildlife. Authorized in 1959 by P.L. 86-359, "A Study of Migratory Game Fish", this program represented much of the Interior Department's marine and estuarine research. Like the Bureau of Commercial Fisheries, this program brought significant scientific capability to the new Agency. The Sandy Hook Marine Laboratory, built in 1960, represented a cadre of fishery biologists, conducting research primarily focused on the dependence of certain marine species on the near-shore and estuarine environments. At the time NOAA was created, the Sandy Hook Laboratory had recently begun a research program on the effect of waste disposal on the marine environment -- particularly in the New York Bight, and related investigations of marine fish diseases and their relationship to sewage and other waste effluents.

The Tiburon Marine Laboratory was established in 1962 in several buildings at the former naval base at Tiburon, California. In collaboration with scientists from the Sandy Hook Laboratory, researchers at Tiburon were early pioneers in the use of airborne infrared sensing devices to measure sea surface temperature -- an oceanographic parameter relevant to productivity and often used to locate fish stocks. Most of the Tiburon Laboratory's activities were focused on research on the ecology of shore and reef fish and studies of billfish stocks (e.g., marlin and sailfish), including a major tagging program conducted in cooperation with the Mexican Government and industry associations.

The third facility which this consolidation brought to the new NOAA was the Narragansett Marine Game Fish Laboratory in Rhode Island. Established in 1966, this Laboratory conducted research on big game sharks, the differentiation of races among game fish, experimental aquaculture, and marine game fish statistics. At the time of Reorganization Plan No. 4, scientists at the Narragansett facility were planning to begin broad studies of the impact of environmental factors like currents, temperature and plankton abundance on Atlantic coast game fish and to establish the Laboratory as a center for estuarine research in cold waters.

While a permanent facility was still under construction at the time of the transfer, scientists at the Eastern Gulf Marine Laboratory's temporary facilities in Panama City, Florida were conducting research on estuarine and onshore ecology in the South Atlantic and Gulf regions.

Office of Sea Grant Programs [18/]

In October 1966, the President signed P.L. 89-688, the National Sea Grant Colleges and Programs Act to:

- provide for increased utilization of marine resources, including animal and vegetable life and mineral wealth in United States offshore waters, including the Great Lakes;

- develop skilled manpower, including engineers and technicians, and the equipment necessary to use these untapped resources; and

- provide greater economic opportunities -- including expanded commerce and employment -- for the enjoyment and use of the Nation's marine resources.

Responsibility for the program was assigned to the National Science Foundation which provided support for two types of Sea Grant activities. "Institutional support" was provided to major institutions engaged in comprehensive marine resource programs, including research, education, and advisory services. By 1970, nine universities had received Sea Grant Institutional support: Hawaii, Miami, Michigan, Oregon State, Rhode Island, Texas A&M, Washington, Wisconsin, and the University of Southern California. One of the most unique characteristics of the programs at these institutions was their multi-disciplinary, interdepartmental approach to solving ocean and coastal resource problems. In addition, Sea Grant provided "project support" for individual research efforts in marine resource development at colleges and universities across the country.

Sea Grant support was contingent upon matching funds from non-Federal sources and this aspect of the program had, by 1970, helped entrain over 30 industries and a half dozen state Governments to participate in ocean science and technology programs.

As the name implies, the Sea Grant program was, in many ways, designed to provide an ocean resource counterpart to the Land Grant College Program. The most obvious analog was the establishment of marine extension services similar to long-established agriculture extension services. Also like the Land Grant Program, Sea Grant was actively involved in the support of undergraduate and graduate education of engineers and the training of hundreds of technicians at the two-year college level.

At the time of NOAA's creation, the Sea Grant program was undergoing a period of rapid growth. Funding for the program during its first four years had grown from $5 million in 1968 (although authorized in 1966, specific funding for the program was not provided until 1968) to $9 million in 1970 and the President's budget for fiscal year 1971 proposed a budget of $13 million.

United States Lake Survey [19/]

The incorporation of the United States Lake Survey into NOAA brought another organization with a long and colorful history to the Department of Commerce. This Survey's activities began on March 31, 1841 when, in an effort to support westward expansion, an Act of Congress provided $15,000 for a "hydrographical survey of the Northern and Northwestern Lakes." To do the job, the Lake Survey was created within the U.S. Army Topographical Engineers which was later merged into the U.S. Army Corps of Engineers. Like the Commerce Department's Coast and Geodetic Survey, this Lake Survey had responsibility for the preparation and publication of nautical charts and other navigational aids.

The Survey, housed in Detroit, Michigan, published its first charts in 1852 -- covering all of Lake Erie. By 1882, the Survey had completed the original Congressional mandate, producing some 76 charts. The original Survey was then disbanded. By 1901, however, it became clear that the original survey and charting products required revision. For example, since the deepest draft vessels used in the Great Lakes in the mid-late 1800's drew only 12 feet of water, the Survey's charts only showed depths of 18 feet or less! By the early 1900's, deeper draft vessels were in use which required additional information on waters of the Great Lakes. So, the Lake Survey was re-constituted and its mission expanded to include responsibility for lakes and navigable waters of the New York State Barge Canal System, Lake Champlain and the Minnesota-Ontario Border Lakes. In addition to traditional survey, charting, and navigation information responsibilities, the Lake Survey also brought to NOAA responsibilities for studies on lake levels and associated river flow. Originally initiated to support navigational needs, the stream measuring stations, and Survey's water level and precipitation gages enabled engineers to make six-month forecasts of lake levels and build a data base dating back to 1860 which suported the needs of public planning agencies and private sector interests like construction firms.

The Survey greatly expanded this effort in 1962 with the establishment of the Great Lakes Research Center. At the time of NOAA's creation, the Center was conducting strong programs in coastal engineering (water motion, including tides, currents, waves, seiches, and shore processes, like sedimentation) and water resources (water quality, water quantity and ice and snow conditions).

This work was supported by a suite of facilities including: the Great Lakes Regional Data Center, a Technical Library and Instrument Office, an Ice and Snow Laboratory, a Chemical Laboratory, and a Sedimentation Laboratory. The Lake Survey brought all of these capabilities into the new NOAA.

National Data Buoy Project [20/]

In December 1967, the United States Coast Guard established the National Data Buoy Development Project to develop a national system of automatic ocean buoys to gather oceanic and atmospheric data. By the 1960's, scientists had recognized the need for more detailed information on environmental conditions over vast marine areas which remained largely uncovered except for occassional observations from ships or aircraft of opportunity, oceanographic research expeditions, or the few existing ocean station vessels. As a result, a number of Federal agencies and universities began programs to develop and implement networks of buoys which could routinely and automatically report environmental conditions like temperature, wind speed and direction, etc. Unfortunately, these disparate efforts were largely designed to meet individual agency or research needs.

In 1966, the Panel on Ocean Engineering of the Interagency Committee on Oceanography, convened a group of Federal agency representatives to address the problems and possibilities associated with automated data buoy networks. This group recommended a national system of ocean data buoys and the Committee asked the Coast Guard to conduct a feasibility study. After ten months of work, the study report made the following conclusions:

- extensive requirements exist for oceanographic and meteorological information to satisfy both operational and research needs in the oceanic and Great Lakes environments;

- automatic, moored buoys were capable of meeting a significant portion of those needs; and that

- a network of such buoys, would be an essential element of an overall environmental information and prediction systems. [13/]

The National Council for Marine Resources and Engineering Development (established by the same law which created the Stratton Commission) took these conclusions seriously and in November 1967, asked the Coast Guard to accept lead agency responsibility for the research, development, testing and evaluation required to support future decisions on national data buoy systems. The National Data Buoy Development Project was established to do the job. The Project Office drew on existing capabilities in a number of disciplines from oceanography to communications and began an effort to develop a single, national system capable of providing key observations required to describe conditions the marine environment (including the Great Lakes). Reorganization Plan No. 4 brought this responsibility and challenge to NOAA.

National Oceanographic Data Center [21/]

The National Oceanographic Data Center (NODC) was established by the Department of the Navy in 1960 to aggregate and disseminate the oceanographic data being collected by all Federal agencies. Although established by the Navy, NODC was actually sponsored by the ten agencies with interests in the marine environment: the Atomic Energy Commission; Bureau of Commercial Fisheries; Coast Guard; Coastal Engineering Research Center; the Department of the Navy; ESSA; the Federal Water Quality Administration; the Geological Survey; the Department of Health, Education and Welfare; and the National Science Foundation. Policy and technical direction for NODC was provided by an advisory body of representatives from those agencies and the National Academy of Sciences. Established to provide a mechanism to process, exchange and store global data from Government, industry, academic and research organizations, NODC brought to NOAA the world's largest useable collection of oceanograhic data. Using data received from national and international sources (including a network of liaison offices in key regions of the country), NODC provided a variety of services including: data processing; data reproduction; analyses and preparation of statistical summaries; and data record evaluation on a cost reimbursable basis. The addition of NODC to the ESSA Environmental Data Centers provided the new NOAA with the key components of what would become the Nation's premier environmental data service.

National Oceanographic Instrumentation Center [22/]

Like NODC, the National Oceaographic Instrumentation Center was originally a part of the Department of the Navy. Located in Washington, D.C. the office was established to provide a central Federal service for the calibration and testing of oceanographic instruments. The Instrumentation Center collaborated closely with NODC and the National Bureau of Standards to ensure adequate technique and reference standards for oceanographic instrumentation. At the time of NOAA's creation, the Center was responsible for a wide variety of oceanographic instrument development of work including:

- operation of an instrument evaluation laboratory;
- maintenance of a central proposal and specifications file and information service;
- cooperative programs with other Government agencies, academia and industry to support the development of standards;
- laboratory, field testing and calibration of oceanographic instruments;
- maintenance of instrument performance and deterioration records; and
- a small in-house program of ocean instrumentation development.

Marine Minerals Technology Center [23/]

During the late fifties and sixties, scientists (both in industry and Government) had begun to seriously investigate the possibility of funding ocean-based alternatives to land-based sources of strategic minerals. Dry-land deposits of such minerals were already showing signs of depletion. Scientists were aware that the seafloor contained potentially recoverable deposits of materials rich in such strategic minerals as nickel, cobalt, copper, manganese, gold, tin, platinum, iron, titanium, and chromium. Of particular interest at the time of NOAA's creation were deep seabed deposits of manganese nodules which would, during the seventies and eighties, become the center of substantial debate both in the U.S. Congress and in the international Law of the Sea Treaty negotiations.

By 1970, industry had already adapted land extraction techniques to develop ocean minerals like oil, gas, sulfur, sand, and gravel valued at over $2 billion. Industry was already, similarly, involved in commercial dredging of oyster shells and the extraction of chemicals and salts from sea water. Many of these activities, and the anticipated open ocean mining associated with recovery of deposits like manganese nodules, carried potentially significant environmental impacts (e.g., oil spills, sedimentation, and increased turbidity which could disrupt biological productivity).

The Department of Interior had responded to the challenge of increased ocean mineral development by establishing the Marine Minerals Technology Center in Tiburon, California. The Center, part of the Bureau of Mines, had two principal objectives.

- assuring that any ocean mining systems ultimately developed would minimize damage to the marine environment; and

- providing the tools and techniques required to accurately delineate marine mineral deposits.

By the time of NOAA's creation, the Center was already conducting a number of cooperative programs with embryonic ocean mining industry groups to evaluate a number of specific new mining techniques including new drilling technologies. At the same time, the Center's marine resource investigations were beginning to build the scientific and environmental impact knowledge base on which future legislative and regulatory actions would be based -- including the issuance of exploration licenses for manganese nodule mining which has been a NOAA responsibility since 1980.

With these rich, diverse and extensive capabilities now in place, this new agency called NOAA was ready to address the challenges expressed in President Nixon's reorganization statement including the exercise of "leadership in developing a national oceanic and atmospheric program of research and development."

In addition to "management and conservation," the MFCMA carries with it a charge to enhance the "development" of domestic U.S. fisheries. In many cases, this involves the increased utilization of species not traditionally harvested by U.S. fishermen. NOAA responded to this charge in the late 1970's by significantly enhancing their work with other Federal agencies, state and local governments, industry and consumers to develop such "underutilized" species. This effort has involved, among other activities:

- o continued research on seafood product quality and safety;
- o the provision of information on domestic and international market conditions;
- o collaborative efforts with the State Department to remove barriers to U.S. exports; and
- o support for the development of new technologies.

Since the late seventies, NOAA and the Department of Commerce have remained committed to an appropriate partnership with industry and the States in the development of U.S. fishery resources.

The era of heightened environmental awareness which characterized the 1970's brought with it a greater understanding of the critical role that coastal and estuarine habitats play in the life support system of many commercially important fish stocks.

Accordingly, the seventies saw the establishment of a strong "habitat protection" program in NOAA. The nature of NOAA's activities in this area have largely been determined by statutory requirements for NOAA analyses and comments on the environmental impacts of federal activities including: Environmental Impact Statement requirements of the National Environmental Protection Act, construction projects by the Army Corps of Engineers; dredge and fill permits associated with coastal development; and waste discharge permits under the Clean Water Act. Fulfilling these requirements involved the development and maintenance of strong NOAA research programs on the habitat requirements of important species and consistent monitoring of the quality of the marine environment.

Marine Mammals and Endangered Species

With enactment of the Marine Mammal Protection Act (1972) and the Endangered Species Act (1973), NOAA was given specific responsibility for the conservation of marine mammals and endangered marine species. The Marine Mammal Protection Act charged the Department of Commerce/NOAA with federal functions required to ensure the protection of marine mammals and imposed a U.S. moratorium on the taking and importation of marine mammals. The NOAA Administrator serves as the U.S. representative to the International Whaling Commission and over the years has made significant progress in developing and implementing substantial reductions in worldwide whaling activities.

The Endangered Species Act charged the Departments of Commerce/NOAA and Interior with responsibility for the conservation, protection and propogation of species and subspecies of fish and wildlife that are presently threatened with extinction, which are endangered, or are likely to become endangered.

With enactment of the legislation in 1973, NOAA became responsible for most marine species of mammals and fish, reptiles, and invertebrates. Administering these responsibilties required the development and implementation of both: control measures (e.g. surveillance to stop illegal imports and exports of marine mammals and endangered species and regulation of the incidental take of marine mammals like porpises in commercial fisheries); and strong supporting research programs. Since 1973, significant activities in this area have included:

- o administration of the Pribilof Islands in the Bering Sea -- a special reservation for the conservation and management of a herd of North Pacific fur seals under a four-nation agreement supervised by the United States;

- o major improvements in our understanding of the life history and behavior of sea turtles and cooperative efforts with industry to develop a "turtle excluder device" to help protect sea turtles from fish trawls;

- o a colloborative effort with industry to design and implement an escape device which allows fishermen to rescue porpoises caught in tuna nets; and

- o substantial improvements in our understanding of the nature and current status of whale stocks worldwide.

Ocean and Coastal Resources

In 1972, Congress recognized a pressing need to conserve the Nation's coastal lands and shorelines and passed the Coastal Zone Management Act (CZMA). With the President's signature, this Act established a significant partnership between the Federal Government and coastal states -- a partnership which recognized joint responsibility for a program to ensure the wise use of coastal resources.

Responsibility for the Federal share of this partnership was assigned to NOAA. Under the CZMA, states were encouraged to develop individual management plans for their coastal zones. The Federal Government, through NOAA, was to establish general guidelines for such plans and provide financial and technical assistance to the states as they developed and began implementing the resulting coastal zone management programs. Planning grants were provided to states through 1979. Once a plan was approved, the Act authorized NOAA to provide direct financial support, also in the form of grants, to assist states in administering their new programs. By 1979, all thirty coastal states and four of the five eligible territories had participated in the program and coastal programs in 19 states, covering 68% of the Nation's shoreline, had received Federal approval.[27] By 1986, ninety precent of the U.S. coastline would be covered by approved Federal plans in twenty-nine states and territories. Federal responsibility to encourage participation in this voluntary program has been successfully pursued.

In addition to direct financial assistance, NOAA has administered an additional incentive for state participation in the program. Known as the "consistency provisions," Section 312 of the Act requires that, once a program is approved, Federal actions directly affecting a state's coastal zone must be consistent with that approved program. NOAA remains responsible for continuous monitoring and evaluation of state programs to ensure their conformance to the CZMA and, therefore, the ability of the states to require Federal consistency.

The 1976 amendments to the CZMA established a ten-year, $1.2 billion Coastal Energy Impact Program to provide financial assistance to coastal states and communities affected by coastal energy activity. These amendments recognized the fact that the coastal zone provides an attractive site for much of the Nation's energy activities, including power plants, refineries and offshore oil and gas development. NOAA was responsible for administering this program which was designed to help states with approved coastal zone programs deal with the economic, social and environmental costs associated with energy development.

Section 315 of the CZMA authorized NOAA to participate with states in a 50/50 cost-sharing program to acquire and manage special, relatively undisturbed estuarine areas set aside to serve as natural field laboratories in which to study and gather data on the natural and human processes occurring within those critical environments. NOAA began immediatley to establish a nationwide network of biologically and geographically unique estuarine "reserves" and, by September 30, 1980, nine such sanctuaries were already in operation in: Oregon, Georgia, Hawaii, Ohio, Florida, California, Washington, and Rhode Island.

A similar program to protect unique areas of ocean waters was authorized by Title III of the Marine Protection, Research and Sanctuaries Act (MPRSA) enacted in 1972. This legislation authorizes the Secretary of Commerce, with the approval of the President, to designate ocean waters as marine sanctuaries for the purpose of preserving or restoring their conservation, recreational, ecological or esthetic value. The first such marine sanctuary, was designated in 1975 in waters off Cape Hatteras, North Carolina, to protect the wreckage of the Civil War iron-clad ship USS Monitor. As of September 30, 1980, two other sanctuaries had been designated:

- the Key Largo Coral Reef Marine Sanctuary near Miami, Florida which protects a 100-square mile coral reef area adjacent to the John Pennekamp Coral Reef State Park; and

- the Northern Channel Islands Marine Sanctuary off the California coast designated to protect an area vital to a number of species of marine birds and mammals.

Throughout the seventies and eighties, NOAA has continued to implement the marine sanctuaries program to provide long-term, comprehensive management for these special marine areas focused on resource protection, public education and research/assessment aimed at improving marine resources management decisions and encouraging maximum public use consistent with resource protection.

In the area of marine pollution, Congress enacted two principal pieces of legislation in the 1970's which guided NOAA activities in this area. The 1972 Marine Protection, Research, and Sanctuaries Act, in addition to establishing the marine sanctuaries program, charged NOAA with monitoring and research on ocean dumping activities as well as research on the possible, long-range effects of pollution, overfishing, and man-induced changes in ocean ecosystems.

The Ocean Pollution Research and Development and Monitoring Planning Act of 1978 (known as the Ocean Pollution Planning Act) recognized the need for a national program to investigate the fates and effects of pollutants on the marine environment and charged NOAA with lead-agency responsibility for developing and implementing a continuous five-year plan for such a program. Throughout the seventies and into the eighties, NOAA responded to these charges with a number of activities including:

- o dumpsite investigations and supporting laboratory research to determine the consequences of ocean dumping of dredged material and municpal and industrial wastes;
- o a comprehensive program of research to detect man-made changes in the ocean and Great Lakes environments which may have long-term, adverse consequences;
- o multi-disciplinary studies in selected coastal regions including the New York Bight, Puget Sound, Gulf of Mexico, and Great Lakes to improve understanding of the dynamics of these ecosystems and strengthen a capability to predict the effects of pollutants and other man-induced changes to those ecosystems;
- o scientific support to the Coast Guard in the event of a spill of oil or other hazardous material in coastal waters;
- o providing financial support for ocean pollution research development and monitoring projects under Section 6 of the National Ocean Pollution Planning Act; and
- o developing, and updating biannually, the comprehensive five-year Federal Ocean Pollution Research, Development and Monitoring Plan and ensuring Federal agency compliance with that Plan.

Research and Development

Throughout the seventies NOAA strengthened its research and development programs aimed at improving our understanding of the oceanic and atmospheric environments and applying that knowledge to the solution of environmental problems. Highlights of activities in the seventies (in addition to the marine pollution research described previously) include:

- o participation in the Global Weather Experiment conducted in 1978-1979; this "world's largest experiment" [28] involved 140 countries, five international organizations 5,000 technicians, and satellites from the United States, U.S.S.R., Japan and the European Space Agency. The Experiment was designed to produce a better understanding of atmospheric

conditions and processes in order to develop realistic extended range forecast models; assess the limits of predictability for weather systems; and design a global observing system for routine numerical prediction;

- o accelerated research on hurricane intensity and movement, including Project STORMFURY - an experiment designed to determine whether destructive hurricane winds could be reduced by cloud seeding;

- o the Florida Area Cumulas Experiment to test a hypothesis that stimulating cumulus cloud growth, through seeding, could produce significant increases in tropical rainfall;

- o a Federal-state cooperative program to evaluate the effectiveness of weather modification in the States of Utah and North Dakota; in a related area, pursuant to the Weather Modification Reporting Act of 1972, NOAA assumed responsibility for recording all non-federally supported weather modification activities in the U.S.;

- o accelerated research to determine the extent to which climate can be predicted and the extent of man's influence on climate. In addition to continuing activities like the Geophysical Monitoring for Climatic Change program, NOAA's involvement in climate-related activities was enhanced in 1978 with passage of the National Climate Program Act, which charged the Agency with developing a National Climate Program Plan and coordinating the work of Federal and non-Federal participants to estimate climate trends and predict future changes;

- o expansion of participation in the National Sea Grant College Programs. By 1980, fourteen institutions had achieved Sea Grant College status and NOAA was supporting marine research, education and advisory services at over 100 instititions around the Nation.

One of the most exciting aspects of NOAA's research in the seventies involved undersea science. NOAA support for undersea research to address the Agency's scientific responsibilities began in 1971 with the establishment of the Manned Undersea Science and Technology Office (MUS&T). From 1971 to 1980, MUS&T conducted a program of support for submersible and habitat-based research designed to address three principal objectives (MUS&T Annual Report, FY 1972):

- provide manned underwater and operational support for NOAA investigations involving marine resources and environmental problems which require human subsurface observations and data collection;

- foster and coodinate manned undersea science projects with other federal and state agencies, industry, research institutions, and universities; and

- develop scientific and technical criteria for civilian undersea facilities and platforms through the experience gained by using available habitats and submersibles.

Pursuant to this third objective, and with a fiscal year 1976 appropriation of $1.5 million, MUS&T concentrated its efforts on completion of a feasibility study and conceptual design for OCEANLAB - a proposed large, mobile saturation submersible that could operate autonomously in a variety of underwater environments. The potentially high cost of such a multi-purpose facility, however, forced MUS&T, in consultation with the Department of commerce, the Office of Management and Budget, Congress and the undersea research community, to re-evaluate the OCEANLAB concept. Pursuant to this 1978 review, which included an analysis of the scientific needs and requirements of the research community conducted by the National Research Council's Ocean Science Board, NOAA re-directed the MUS&T/OCEANLAB program. Instead of constructing a single, government-owned laboratory, NOAA's program,in cooperation with university-based research institutions, was to increase the use of existing habitats and to encourage scientists to use additional underwater tools and techniques such as saturation diving, submersibles and remotely operated vehicles. The policy guidance for ths new direction was described in a 1980 document entitled "The Undersea Research Program of the National Oceanic and Atmospheric Administration." 29/

In 1977, NOAA established the first regional underwater research facility. The underwater habitat, HYDROLAB, located in St. Croix, which had recently been acquired and refurbished by NOAA from the Perry Foundation, became the focal point of undersea research in the Caribbean. By the 1980's, NOAA was supporting a three-tiered undersea research program composed of:

- o five National Undersea Research Cooperative Programs including the St. Croix program;
- o NOAA's share of support for the deep submersible ALVIN (jointly funded with the Navy and the National Science Foundation) and a cooperative program to provide scientists with access to shallow-water submersibles and remotely-operated vehicles; and
- o pursuant to section 21(e) of the Outer Contintental Shelf Lands Act Amendments of 1978, a program of research and development related to diver safety.

Operational Weather Satellites

NOAA's operational meteorological satellite program became a reality during the 1970's. The geostationary satellite experiment begun in 1966 was established as a continuous, operational program in 1974/75 with the launch of NASA's Synchronous Meteorological Satellites (SMS) 1 and 2; these satellites were the prototype for NOAA's Geostationary Operational Environmental Satellites (GOES). GOES-1, the first NOAA-owned and operated geostationary satellite, was launched on October 16, 1975. The first NOAA-funded satellite in the NOAA system of polar-orbiting environmental satellites was launched in June 1979. Throughout the seventies NOAA began to establish itself as a world leader in application of space-based observing systems to operational environmental forecasting and related services.

In November 1979, a Presidential directive assigned NOAA with responsibility for the development of an operational earth remote sensing program. LANDSAT, an experimental earth sensing satellite system, was initiated in 1972 with the launch of LANDSAT-1 by the National Aeronautics and Space Administration as a research and development program. NOAA was directed to assume operational responsibility for the system beginning in 1983. With enactment of the Land Remote Sensing Commercialization Act of 1984, the Secretary of Commerce was authorized to commercialize the LANDSAT system and, in September 1985, a contract was signed with the Earth Observation Satellite Company (EOSAT). EOSAT's original objective is to establish LANDSAT as a commercially unable civil remote sensing industry in ten years. EOSAT took responsibility for the operation of the current LANDSAT system October 18, 1985.

Conclusion

All of these examples illustrate the breadth and excitement of NOAA's experience during the seventies. This experience was preparing the new organization to emerge as a mature, cohesive agency focused on the science and services associated with predicting and responding to changes in the global earth environment.

NOAA IN THE EIGHTIES

The 1980's have, similarly, been an exciting time for NOAA. Along with continuing commitment to control Federal spending, NOAA has remained committed to serving the Nation. The agency organization chart for NOAA in 1980 reflected many of the changes in responsibility and programmatic responsibilities wrought during the seventies. Five principal line offices had been created (largely as the result of an agency reorganization in 1977) to address major elements of the Agency's responsibilities:

- The Office of Fisheries -- responsible for: managing and conserving fishery resources within 200 miles of the coast; protecting vital fish and marine mammal habitats; and promoting the economic development of the U.S. fishing industry.

- The Office of Coastal Zone Management -- responsible for: the establishment of national policies on the use and protection of coastal areas; support to states for the development and implementation of coastal zone management programs (pursuant to the CZMA); and the protection of unique coastal areas through establishment of estuarine or marine sanctuaries.

- The Office of Oceanic and Atmospheric Services -- responsible for: the issuance of weather forecasts and warnings; the preparation of nautical and aeronautical charts and other navigational aids; management of the NOAA fleet; and operation of the largest environmental data storage and retrieval system in the world.

- The Office of Research and Development -- responsible for: the support (in NOAA laboratories and in the academic community) for environmental research to support NOAA program needs; implementation of the Sea Grant program; and Federal leadership for interagency, international research programs like the Global Atmospheric Research Program (GARP).

- The Office of Satellites -- responsible for: management of the Nation's operational weather satellite program; and the transition of the experimental land remote sensing (LANDSAT) program to an operational program.

A new Office of Ocean Minerals and Energy, charged with implementing new statutory responsibilities for the regulation of deep seabed mining and ocean thermal energy conversion systems, was established in 1980. NOAA responsibilities to coordinate and develop five-year plans for marine pollution and climate activities throughout the Federal Government were carried out by the National Marine Pollution Program Office and the National Climate Program Office both housed within an Office of Policy and Planning which reported directly to the Administrator.

NOAA entered the eighties with a number of unique physical assets including:

- The Nation's largest civil oceanographic research and hydrographic survey fleet as well as a fleet of research and weather reconnaissance aircraft.

- o The Nation's only civilian operational satellite system including: geostationary satellites which, in orbit 22,000 miles above a fixed point on the equator, provide continuous monitoring of environmental conditions like hurricanes and tropical storms; polar-orbiting satellites which orbit 522 miles above the earth and monitor global environmental conditions such as atmospheric temperatures, snow and ice fields, and cloud cover; and the land remote sensing satellite (LANDSAT) system which was initiated as an experimental system by NASA in 1972.

- o An extensive computing capability across the country with the principal, large-scale, advanced computing facility located in Suitland, Maryland in support of meteorological and satellite programs; and

- o A major national asset in the form of a network of research laboratories across the country including:

  - the Environmental Research Laboratory (ERL) system (headquartered in Boulder) which, managed four atmospheric, two oceanographic and five multi-disciplinary laboratories;

  - twenty National Marine Fisheries Service laboratories supporting biological and ecological research; and

  - ten other laboratories and facilities for applied research and development focused on the need for new technology applications to improve NOAA services.

Thus, NOAA entered the 1980's well-prepared to start a second decade committed to fulfilling it's numerous statutory responsibilities including those enacted during the height of the environmental movement in the 1970's; and exercising the mandate of Reorganization Plan No. 4 as the Nation's lead oceanic and atmospheric science and service agency.

During the 1980's, NOAA leadership has worked to more clearly focus the agency's attention on the highest priority Federal responsibilities in environmental science and services. Agency management was refined with an eye towards simplicity and the efficient management and direction of related programs. For example, the National Environmental Satellite, Data, and Information Service was created to consolidate NOAA's satellite and data management activities. Similarly, NOAA's ocean and coastal resource management activities were combined with mapping, charting and geodetic programs into the National Ocean Service. The old Office of Research and Development has evolved into the Office of Oceanic and Atmospheric Research which now manages major research efforts to support improvements to NOAA's service arms, and fulfill the agency's responsibilities for leadership in science to improve our understanding of the oceanic and atmospheric components of the global earth system. Throughout the 1980's, management and programmatic decisions have all focused on successful fulfillment of NOAA's primary mission and ultimate goal -- the prediction of environmental changes on a wide range of time and space scales in order to protect life and property and provide industry and government decision-makers with a reliable base of scientific information. The following sections summarize some of the highlights of this dynamic agency's recent history.

Weather Services

Since the National Weather Service probably touches the lives of more of our citizens each day than any other element of NOAA, or Commerce for that matter, let's start there. The 1980's have seen NOAA and the Department of Commerce embark on a billion dollar effort to modernize the National Weather Service. The modernization is largely founded on the implementation of three new technologies referred to as NEXRAD, AWIPS and ASOS. These programs will provide tomorrow's forecasters with advanced tools for observing and forecasting small-scale, fast breaking weather events like tornados, severe thunderstorms, and flash floods -- weather events which annually claim an average of 60 lives and hundreds of millions of dollars in damage in this country alone.

The weather radar is a valuable instrument for detecting and monitoring the movement and development of severe storms. It is a byproduct of the radar technology developed during the second World War in the 1940's. But the units in today's national radar network are limited in that they cannot routinely detect weather phenomena indicative of tornado development. Nor can they detect accurate rainfall amounts or precise areal coverage of rainfall. Because of their age and limited spare parts, these radar units are difficult to service.

Formal efforts to procure a national next generation radar -- NEXRAD -- system began in fiscal year 1983 with funding for technology validation. The Weather Service hopes to begin deployment of the radar by 1990. It will incorporate technology that is expected to advance tornado warnings from one to two minutes to more than 20 minutes. NEXRAD also will provide valuable precipitation rate and areal information to improve flood and flash-flood warnings and water management forecast services when used with computer models of drainage basins.

A key feature of the NEXRAD radars is the application of the so-called "Doppler Effect," named after the Austrian physicist Johann Christian Doppler who determined that moving objects shift the frequency of sound, light or radio waves that they emit or reflect. An example of a Doppler frequency shift is not real, only apparent, as in the case of a blaring automobile horn that is first high and then drops in pitch as the car approaches and then passes an observer.

In its application to weather radar, the "Doppler Effect" allows the operator to "see" a storm's wind-carried rain that is moving away from or towards the radar. This unprecedented view of winds gives a direct and clear indication of wind rotation and hence tornadoes in their development stage.

Forecasters will gain a new perspective of dangerous storms by viewing them over their entire life cycle with NEXRAD radar units and the higher resolution sensors carried by the new GOES-NEXT satellites. Thus, they will be able to pinpoint the severe weather events more precisely from space, and they will have a better idea of what is going on inside them.

Before 1978, forecasters at National Weather Service field offices communicated with the National centers and each other only via slow-speed teletype and facsimile circuits. Gathered information was prepared in the

forecast offices on clear acetate charts which separately depicted the various components of weather such as barometric pressure, wind, and rainfall. These charts would be overlaid on a light table so the forecasters could visually assimilate the "big picture" upon which to base their forecasts.

Today, the forecasters rely on a computer-based system called Automation of Field Operations Services (AFOS) for communications and data display. AFOS utilizes high-speed computers, data bases supported by mini-computers at each field office, and the manipulation of data displayed on screens. This system is outdated, however, and will be obsolete by 1990. It lacks the capability to integrate the large-scale guidance material, supplied by the National Centers, with radar and satellite imagery for the local forecaster's area of responsibility. This limitation of the AFOS system is becoming even more severe as the quantity and quality of the fine-scale data continue to increase and improved methods of processing, displaying and analyzing these data continue to emerge. According to Richard Hallgren, Director of the Weather Service, "a keystone of the modernization effort at the National Weather Service is the Advanced Weather Interactive Processing System for the 1990's, otherwise known as AWIPS-90, which will replace the AFOS system."

AWIPS will provide weather forecasters at field offices and the National Centers with the capability to access, overlay, and interactively process meteorological and hydrological guidance products and data, including Doppler radar and new satellite imagery.

Providing substantial support for the evolution of AWIPS was a NOAA research effort know as the Program for Regional Observing and Forecasting Services (PROFS) which began in 1980/81. The mission of PROFS is to improve operational weather services by testing and transferring advances in science and technology. PROFS, using the results of atmospheric and systems research, develops operationally-feasible forecast technology that incorporates observations, computer processing, and human interaction. PROFS integrates capabilities into specific systems, then tests and evaluates those systems in forecasting exercises. PROFS works closely with the three major operational weather services, NWS, FAA and the U.S. Air Force Air Weather Service. In 1986 PROFS initiated the Denver AWIPS Risk Reduction and Requirements Evaluation (DARRE) project; by designing, installing and operating an advanced interactive forecaster workstation at the Denver Weather Service Forecast Office (at Denver airport), PROFS is providing the National Weather Service with a test-bed for many of the functional capabilities planned for the AWIPS system.

Observations describing the current state of the atmosphere and or river conditions are the basis of severe weather and flood warnings as well as fair weather forecasts. Daily, the National Weather Service collects a multitude of such observations from surface and upper-air stations across the country. Satellites, offshore buoys, aircraft, volunteers aboard seagoing vessels, and other sources contribute many more thousands of observations. The collected data is exchanged with most of the other countries in the world who collect similar observations.

Currently, complete weather observations are collected at 260 National Weather Service facilities by some 1,200 people who contribute at least part of their time to this effort. Scheduled observations routinely absorb a significant amount of staff time; but the workload increases dramatically during severe weather, just at a time when the observer needs to devote more time to the preparation and dissemination of warnings and special statements.

The goal of the Automated Surface Observation Systems (ASOS) program (also begun in the early 1980's) is to develop and implement a flexible and modular unit to monitor the weather automatically. Using modern technology, these systems, expected to be deployed across the country by the early 1990's, will automatically acquire, process, store, format, and distribute weather observations like atmospheric pressure, temperature, visibility and precipitation.

A key component of the automated weather observing systems of the future will likely be the result of a NOAA research program begun in the mid-1980's to develop a ground-based system to continuously measure vertical profiles of atmospheric conditions like wind speed and direction, temperature and humidity. In 1986, NOAA signed a major, multi-million dollar contract with the Sperry Corporation to build a 30-unit demonstration network of the first components of such a system -- the Wind Profiler. Once operational testing of this system is completed in the early 1990's, NOAA expects that the Wind Profiler could complement (and in some areas, replace) the labor-intensive weather balloon network and become an integral part of the modernized Weather Service.

In addition to the development of new technologies, the 1980's have seen significant improvements in weather forecast skills as a result of advances in computer modeling. Advanced models, developed by NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) and the Weather Service's National Meteorological Center (NMC), can now be run on new Class VI supercomputers. A particularly promising recent development in the area of weather modeling was a GFDL model which couples atmospheric and oceanic conditions and processes into a single interactive model designed to simulate and then predict average weather conditions out to 30 days.

Oceanic and Atmospheric Research

NOAA has also made considerable progress in the related area of climate research and prediction during the 1980's. Probably the most visible, and most significant, effort in this area is the international Tropical Ocean-Global Atmosphere (TOGA) program which officially began in fiscal year 1984. This program, and predecessor supporting research initiated in the 1970's, is designed to provide an understanding of the role that the tropical Pacific ocean plays in determining climate changes over North America. The principal focus of the program is the El Nino, an unusually strong warming of equatorial Pacific waters which, when coupled with an atmospheric phenomenon known as the Souther Oscillation, (a global-scale see-saw in atmospheric pressure between Indonesia-North Australia and the Southeast Pacific), can cause dramatic changes in the earth's climate patterns. The 1982/1983 El Nino-Southern Oscillation (ENSO) event was the strongest in history and as newspaper and television reports told us, was responsible for nearly $20 billion in economic losses worldwide - from flooding in coastal California to droughts in Africa

and Australia. NOAA's scientific foresight and planning enabled the Agency to track and document the '82/83 event in greater detail than ever before and establish the foundation for a monitoring network and computer modeling capability which will allow scientists to recognize the signals of and eventually predict the phenomenon. High on NOAA's scientific priority list, the development of such a predictive capability will not only produce considerable economic savings but, will also be one of the most significant scientific achievements of modern times.

NOAA's research in the 1980's is also leading the way in the area of studies on longer-term climate changes and air quality. Building on a strong history of research in atmospheric chemistry, NOAA took another bold step forward in 1985 with the initiation of a research program referred to as Radiatively Important Trace Species (RITS). NOAA had, for years, been a leader in research on the causes and potential effects of carbon dioxide on the earth's climate (the so-called "greenhouse warming" problem). In the early eighties, however, NOAA researchers led the way for the scientific community by recognizing the fact that there are also other so-called "greenhouse gases", like methane and the chlorofluorocarbons currently implicated in the debate over stratospheric ozone depletion, which also appear to be increasing in the atmosphere. NOAA scientists estimate that the global greenhouse warming from these gases could be as great as, and additive to, that expected from carbon dioxide. NOAA was the first to justify the need to understand the reasons for the increasing abundances of these gases and develop a capability to predict the potential climatic and chemical consequences of such changes. The RITS program remains the principal coordinated, agency attack on this scientific challenge and environmental problem.

A scientist from NOAA's Aeronomy Laboratory led an Antarctic Ozone Expedition to McMurdo Base in late 1986 to investigate the Antarctic ozone hole. The results showed highly elevated abundances of reactive chlorine compounds, reduced levels of nitrogen oxides, and 40 percent depletion of ozone at 12-20 km altitude. The role of the chlorinated and brominated compounds now seems somewhat more likely and that of the solar cycle seems less likely. Since the cause of the ozone hole had not been established with certainity, NOAA also led a second expedition in 1987 and a NOAA scientist has also been chosen as mission scientist for an interagency aircraft observation program to fly through the ozone hole in 1987.

These examples illustrate NOAA's role as the Federal Government's principal operational climate observing, prediction and information management agency. These activities characterize NOAA's unique role and contribution to an evolving national and international scientific program to understand and predict natural and man-made changes in the global environment. Joining the other principal U.S. participants in these effort, NASA and NSF, NOAA has chosen to focus on the global climate system because changing climate confronts us with significant economic, health and safety, and national security implications. Involving activities across the agency, current NOAA programs in oceanic and atmospheric observations, monitoring, data processing, research, predictive modelling, and information management represent a substantial and unique Federal capability and will serve as the foundation for NOAA's global environmental predictions programs in the 1990's and beyond.

The National Acid Precipitation (Acid Rain) Act of 1980 brought yet another leadership role for NOAA. NOAA, along with DOE and EPA, co-chairs the interagency National Acid Precipitation Task Force which oversees the ten-year research effort to address this serious problem. The Act designated NOAA as "Director of Research" and specifically assigned the Agency with research responsibility in three areas:

- natural sources and causes of acidity;

- defining and assessing the relevant atmospheric processes that link emissions of pollutants with acid deposition; and

- interpreting the deposition mechanisms that bring acidic pollutants to the earth's surface and assessing the severity and extent of such acid deposition.

NOAA scientists have made significant progress in this area and, to ensure further progress toward solving the acid rain problem, established a formal NAPAP Research Office in the fall of 1985.

During the 1980's, NOAA continued a variety of research activities designed to improve our understanding of the marine and Great Lakes environments in order to promote safety and economy in maritime activities and develop a sound scientific basis for management decisions associated with the development and utilization of ocean and Great Lakes waters and their resources. Currently, these activities include:

- o marine ecosystem assessment research to provide improved forecasts and assessments of natural oceanic and Great Lakes systems and the impacts of human-induced stresses on those ecosystems;

- o marine resource assessment research which focuses primarily on: developing an improved understanding of the physical, geochemical and biological processes associated with sites of active seafloor spreading; and developing a capability to predict more accurate forecasts of marine fish stocks by studying the environmental factors controlling recruitment; and

- o marine hazards and lake hydrology research to improve forecasting skills, environmental information, and advisory services associated with hazardous coastal winds and waves; storm surges, seiches, and tsunamis; lake levels; and ice growth, movement and breakup.

Significant advances were made in all three areas during the early eighties and NOAA remains committed to strong programs in ocean, coastal and Great Lakes assessment and prediction activities designed to ensure safe, efficient and cost-effective use of those environments and promote the development of marine resources and associated industry.

The 1980's brought the National Sea Grant College Program to a significant stage in it's development. The designation of the South Carolina Sea Grant College Program in 1986 brought to twenty-one the number of academic programs to achieve that status nationwide. Since its inception in 1966, Sea Grant has supported the establishment of premier programs in marine science, education

and technology transfer in most of the coastal and Great Lakes states as well as Guam and Puerto Rico. This network, and more than three hundred individual institutions which have participated in the program now constitute this Nation's primary, university-based marine resource program.

The mid 1980's was a special time for the National Undersea Research Program. In July 1985, the HYDROLAB habitat facility in the U.S. Virgin Islands was decommissioned and in May 1986, NOAA donated HYDROLAB to the Smithsonian where it now serves as a permanent museum tribute to the scientists who contributed to the research conducted in the Nation's oldest, continuously operating underwater habitat.

Ocean Services

The 1980's have also brought significant opportunities for growth and progress in oceanic science and services. In 1980, Congress enacted two pieces of legislation which added new regulatory responsibilities to NOAA's ocean programs. P.L. 96-283, the Deep Seabed Hard Mineral Resources Act, gave NOAA responsibility for licensing exploration for and, eventually, permitting commercial recovery of manganese nodules from the deep seabed. In addition to the development of associated rules and regulations and the actual processing of applications, NOAA is responsible for Environmental Impact Statements associated with the issuance of such licenses and permits and, with the State Department, the negotiation of reciprocal agreements with other nations likely to conduct commercial mining of manganese nodules from the seabed.

The late seventies was also a period of interest in alternative energy sources. One of the alternatives is ocean thermal energy conversion (OTEC) -- a process that uses the heat energy stored in the warm surface waters of the world's oceans to produce electricity or other energy-intensive products. P.L. 96-320, the Ocean Thermal Energy Conversion Act of 1980, gave NOAA lead responsibility for licensing the construction, ownership, location and commercial operation of OTEC plants.

When President Reagan proclaimed a 200-mile Exclusive Economic Zone (EEZ) around the U.S. in 1983, he increased the Nation's sovereign area by 3.4 million square miles. The historic act also posed a major challenge for NOAA -- mapping a "new territory", the seafloor of the EEZ which encompasses an area greater than the land area of the U.S. and its territories. NOAA and its predecessor organizations have provided maritime products in support of the Nation's commerce since President Jefferson created the Survey of the Coast in 1807. Over the years, as technology has advanced, the agency has maintained a leadership position in marine mapping, applying that technology to its programs. NOAA, in cooperation with the U.S. Geological Survey of the Department of Interior now is conducting surveys of selected high priority areas of the EEZ, using new multibeam swath technology. Development of the multibeam sonar system, advances in computer technology, applications of heave-roll pitch sensors to account for ship motion, and improved marine positioning accuracy all contribute to our improved ability to map the seafloor.

NOAA is engaged in a program to produce 1:100,000 scale detailed bathymetric maps (for example, 179 such maps would be required to cover the west coast EEZ). Bathymetric maps are topographic maps of the seafloor which are basic tools for scientific, engineering, and marine environmental studies. Detailed

bathymetry off our shores will form the basis for private sector exploration and subsequent development of EEZ resources. The compiled maps also will be contained on digital data tapes. It should be noted, however, that the high resolution bathymetric data acquired by NOAA's multibeam swath survey systems is viewed by the Department of Defense (DOD) as a potential threat to national security. The issue has not been fully resolved, at the time of this writing, between NOAA, DOD and the National Security Council, so only limited release of the information is being made.

Since 1984, NOAA has conducted the largest and most comprehensive national monitoring program of coastal marine environmental quality ever undertaken in the U.S. The objective of the program is to determine the existing status and the long-term, general trends of environmental quality in estuarine and coastal areas throughout the U.S. Essentially, the program is measuring levels of toxic chemicals in bottom-feeding fish, mussels and oysters, and sediments. Known as the National Status and Trends Program this effort has two field sampling and analysis components: (1) the Benthic Surveillance Project, completing a third year of collection at 50 sites; and (2) the Mussel Watch Project, with sample collection completing its first year at 150 sites. Samples are collected once a year at each site and analyzed to determine levels of synthetic chlorinated compounds (e.g., DDT, polychorinated biophenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), and toxic trace elements e.g., mercury and lead). Other key elements of the Program are a "specimen bank" to store samples for analysis in the future; extensive and rigorous quality assurance, calibration and standardization procedures; and collection of historical data on indicators of environmental quality over the past 40 years. The principal product of the Program will be a high quality, national data base, that contains information on environmental quality in coastal and estuarine areas.

The Ocean Assessments Division of NOAA's National Ocean Service also is building a number of other "first of their kind" comprehensive national data bases to aid resources managers of decisionmakers in interdisciplinary, strategic assessments. Strategic Assessment Data Atlases are being produced to synthesize the best available information on important characteristics of each geographic region of the EEZ (East Coast, 1980; Gulf of Mexico, 1986; Bering, Chukchi and Beaufort Seas, 1987; and West Coast and Gulf of Alaska, 1988). The National Coastal Pollutant Discharge Inventory represents the first attempt to develop a comprehensive, national assessment of pollutant discharges entering the estuarine, coastal and oceanic waters of the contiguous states. The National Estuarine Inventory will provide assessment capability for comparison and analysis of estuarine resources. It includes 92 estuaries of over 32,000 square miles accounting for 90% of the estuarine surface water and fresh water inflow; and will eventually contain data on physical and hydrologic characteristics, adjacent land use, living marine resource distribution, and data from the other inventories, as well as the Status and Trends Program. Other inventories and data bases being developed by this unique Federal program are: (1) National Shellfish Register; (2) National Coastal Wetlands Data Base; (3) Economic Survey of Outdoor Marine Recreation; and (4) Living Marine Resources.

Geodesy is the science of accurately determining the location of points on the earth's surface, the earth's gravity field, and its orientation in space. NOAA's National Ocean Service provides the Nation with the fundamental

geodetic reference system which is the foundation of all surveying, mapping and charting. Reference points in the two control networks (horizontal and vertical) are the base starting points for land surveyors, engineers, planners, scientists and tax authorities. Example applications of geodetic data include transportation; utilities routing; dam and water projects; and positioning and tracking of defense weapon systems and satellites. NOAA also plays a leading international role in application of new technologies to geodetic and other earth science problems.

The 1980's will see completion of an eleven-year effort for readjustment of the North American Horizontal Geodetic Reference System. Because the geodetic control network has been established and expanded across the country since 1807, discrepancies and inconsistencies have accumulated from connection of new surveys to old. To correct the resulting wide variations in reliability and accuracy, NOAA is readjusting each point in the network (250,000) in reference to nationwide datums, by complex mathematical processes. The adjustment of the network will provide a geodetic position accuracy of $1\frac{1}{2}$ inches.

Space age technology is causing revolutionary changes in geodesy, with accuracies improved 100-to 1,000-fold over classical techniques. These precise measurements can be used to verify continental drift theories. Plate tectonics, glacial rebound, global sea level rise, polar motion, and global atmospheric phenomena now can be monitored for research, and the development of possible mitigating responses to these changes in the global earth system. NOAA has taken the lead in the application of these new technologies which will require close cooperation with other Federal and international organizations.

Safe marine and aerial navigation are vital NOAA objectives. Steady progress has been made in the automation of charting. In 1985 alone, nearly 3 million copies of 1500 different nautical maps and related publications for coastal and Great Lakes waterways, plus daily tide predictions for 6200 ports and harbors, were issued.

Nearly 10.5 million copies of more than 7500 aeronautical charts and related publications were issued to help assure safe navigation in the U.S. airspace system. The satellite-aided global positioning system can now routinely determine positions of points on the national geodetic reference system at one-fifth the cost of conventional methods.

The 1980's brought the Coastal Zone Management Program to a significant stage in it's development. In 1986, the State of Virginia became the twenty-ninth state or territory to develop Federally-approved coastal zone management programs. Ninety percent of the U.S. coastline is now covered by state-operated costal programs designed to ensure the protection and rational development of the Nation's vital shorelines.

Fisheries

Increasingly, we turn to the oceans for food, and U.S. fishermen take a larger share of the total catch within the 200-mile U.S. zone created by the Magnuson Fishery Conservation and Management Act. Currently, thirty-three (33) management plans developed pursuant to the MFCMA now cover most of the commercial stocks of edible and industrial fish and shellfish. American fishermen are taking increasingly larger shares of fish, with a steadily growing lead over catches by the formerly dominant foreign nations.

Joint venture harvests by American fishermen, who sell their catches at sea to foreign processing vessels, continued to grow in the 1980's. Such harvests in 1984 involved nearly 1.5 billion pounds of fish, valued at $79 million.

The U.S. traditionally has been in the forefront of marine mammal protection. Careful regulation has sheltered the stocks of sea turtles, seals and porpoises under NOAA's protection, and, thanks in large part to the efforts of the U.S. Commissioner to the International Whaling Commission -- NOAA's Administrator -- commercial whaling, worldwide, soon will be a thing of the past.

Closely allied to the conservation of fish stocks and marine mammals is the protection of their habitats. NOAA took a major step forward in 1983 when close alliances were forged with the Army Corps of Engineers, the coastal states, and regional fishery management councils to improve cooperation and research related to fishery habitats. Since then, the habitat program has signed agreements with oil companies, developers and city governments to create habitat "mitigation banks" -- allowing undeveloped land to be used as "credit" to the trade off elsewhere. In October 1985, NOAA and the Corps of Engineers announced a plan to collaborate on a three-year pilot study of restoring and creating habitat in the southeast and southwest. The Fisheries Service envisions a system that will create and improve marshes, upgrade water circulation, rehabilitate marine vegetation and shellfish beds, and create artificial reefs.

Fish is growing in popularity by leaps and bounds as a dinner-table delicacy--just witness the blackened redfish craze, which threatened the redfish stock before the Commerce Department stepped in. Underlying this burgeoning popularity is an increasing evidence that fish--especially the oil-rich fish once shunned by dieticians--are good for the heart. In cooperation with the National Institutes of Health, National Marine Fisheries Service researchers are studying the possibility that the unique oils in seafood may not only reduce heart disease but some inflammatory ailments as well.

NOAA works vigorously and continuously to expand the export of fish as well as promoting its consumption at home. The Fisheries Service has collaborated with the International Trade Administration to expand exports and develop joint procedures for marketing activity.

Satellite and Information Services

In August 1980, the National Earth Satellite Service (NESS) was removed from the Office of Oceanic and Atmospheric Services and became a principal agency line organization with an Assistant Administrator who reported directly to the Administrator. This move reflected the increasing importance of satellite

observations to NOAA's environmental science and service responsibilities. The move was largely precipitated by a decision in November 1979 to assign NOAA management responsibility for all civil operational remote sensing from space -- including the development of an operational land remote sensing program now known as LANDSAT. The fulfillment of NOAA's responsibility for operational weather and earth sensing satellite systems remains a major focus of agency attention in the 1980's.

At NESDIS, a new generation of geostationary orbiting satellites is being developed to provide more frequent and higher resolution imagery simultaneous with improved atmospheric soundings. Called GOES-NEXT, the first of three such satellites will be available by mid-1989. This procurement will ensure continuity of the hurricane-spotting GOES system through the 1990's. The timeliness and quality of the combined polar and geostationary satellite data have been greatly improved by computer installations, upgraded ground facilities, and data sharing agreements with military weather services. They beam over 2½ billion bits of information to earth daily--information vital to weather forecasters.

A boon to pilots and mariners in distress the world over, the international COSPAS/SARSAT search-and rescue satellite system has nearly 600 "saves" to its credit. In the 1980's, NOAA took over management of SARSAT operations from NASA, and intensive efforts are underway to reduce a high incidence of false alarms, caused by improper handling of the system's radio beacons. These highlights demonstrate that the 25th anniversary of weather satellites in 1985 was celebrated with a commitment to the future.

Conclusion

As these few examples attest, the goals, responsibilities and programs of NOAA today reflect a continued commitment to the philosophy that created it. Recognizing that the oceans and the atmosphere are closely-linked, interactive components of a global earth system, NOAA's primary mission and the ultimate goal of all its activities remains the prediction of environmental change to protect life and property, and provide industry and decision makers with a reliable base of scientific information on the world in which we live.

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