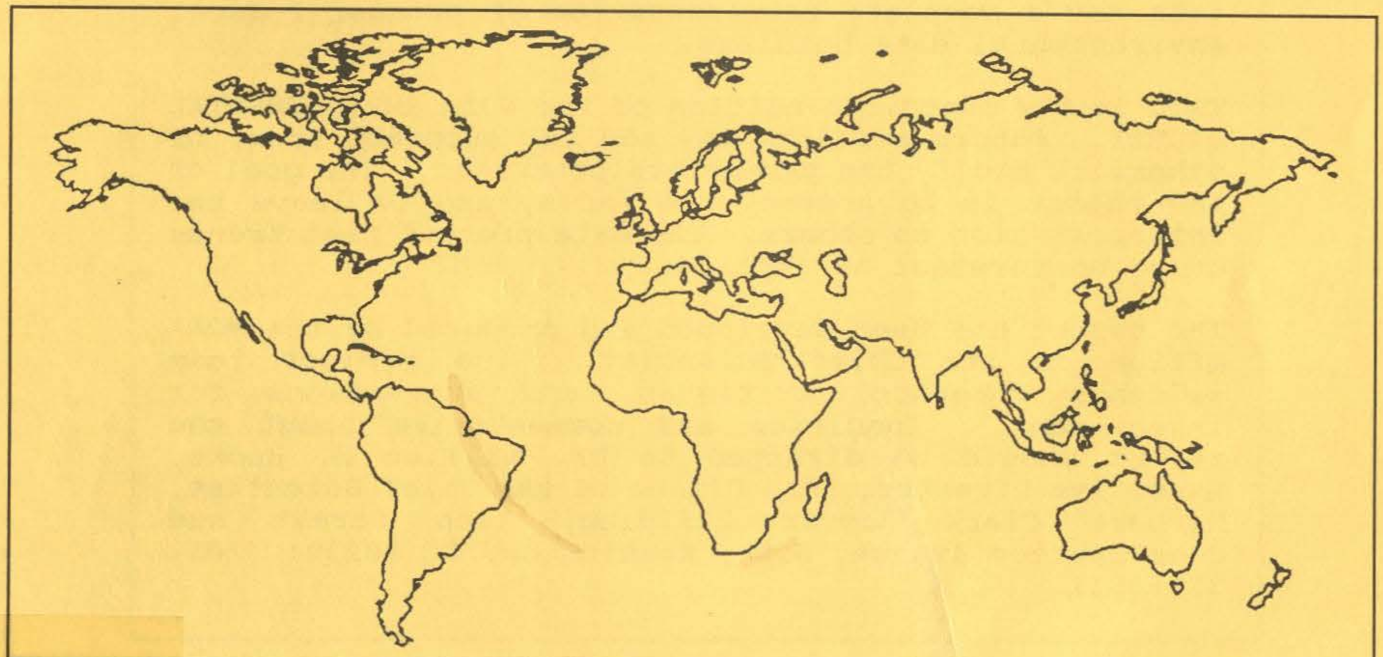
NOAA ENVIRONMENTAL DIGEST

SELECTED ENVIRONMENTAL INDICATORS OF THE UNITED STATES AND THE GLOBAL ENVIRONMENT

September 1990



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of the Chief Scientist

ABOUT THIS REPORT

The NOAA ENVIRONMENTAL DIGEST provides a regular report of environmental data and information collected by NOAA. These data are considered to be useful to the scientific community for a variety of applications. This report attempts to be neither an all-inclusive digest of NOAA data nor a complete representation of broader Federal environmental data holdings.

This is the inaugural edition of the NOAA ENVIRONMENTAL DIGEST. Future editions may add to, subtract from, or otherwise modify the parameters presented. The goal of the report is to present the facts, and to leave the interpretation to others. The data present past trends only; no forecast is implied.

The report has been developed and produced by the NOAA Office of the Chief Scientist. The project team welcomes comments, critiques, and suggestions for improvement. Inquiries and commentaries about the report should be directed to Dr. William H. Hooke, Executive Director, NOAA Office of the Chief Scientist, Herbert Clark Hoover Building, 14th Street and Constitution Avenue, N.W., Washington, DC 20230; (202) 377-0531.

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U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

National Oceanic and Atmospheric Administration
John A. Knauss, Under Secretary

Office of the Chief Scientist
Ned A. Ostenso, Acting Chief Scientist

ACKNOWLEDGEMENTS

This report represents the work of numerous scientists throughout the National Oceanic and Atmospheric Administration (NOAA). Without their cooperation this first edition of the NOAA ENVIRONMENTAL DIGEST would not have been possible. A sincere thanks is extended to the numerous contributors for the excellent summaries provided of their work. Drafts of this report were reviewed by a number of individuals throughout the agency and their constructive comments were of great help. This report was initiated with a suggestion from the NOAA Under Secretary, Dr. John A. Knauss, to the Executive Director of the Office of the Chief Scientist, Dr. William H. Hooke. Within the Office of the Chief Scientist the project team consisted of: Dr. Joseph M. Bishop (Project Leader), Mr. John L. Wickham (Project Coordinator), and Dr. Isobel C. Sheifer (Editor).

INTRODUCTION

The Earth's environment is continually being modified by human activities and natural processes. These changes may have profound effects on our health, global ecology, and the economic welfare of nations.

With the creation of NOAA, the Nation established a unique agency dedicated to the enhancement of knowledge about our environment. NOAA's core mission is to increase our understanding of the total Earth system, an understanding based on effective monitoring of the global environment. NOAA currently monitors the Sun, atmosphere, ocean, biosphere, and cryosphere on regional to global spatial scales and synoptic to climatological time scales.

To assist in the understanding of environmental change, and to aid in the assessment of its global implications, a NOAA ENVIRONMENTAL DIGEST has been instituted. Our overall goal is to present the relevant facts, leaving the interpretation of the information to others. This report has two primary objectives. The first is to document, on a regular basis, changes in selected environmental parameters. The second is to provide information to those engaged in the development of relationships between environmental change and its consequences to society.

The wide diversity of data collected by NOAA is published in numerous reports, bulletins, journals, and the scientific literature. This report was initiated in an attempt to make this diverse collection of data more accessible, publicize its presence, and promote an awarness of environmental variability and climatic change. The NOAA ENVIRONMENTAL DIGEST focuses on selected environmental parameters considered indicators of system variability on regional and global scales.

The material presented in this report has been provided by scientists from each of the five NOAA Line Offices: the National Ocean Service, the National Weather Service, the National Marine Fisheries Service, the National Environmental Satellite, Data, and Information Service, and the Office of Oceanic and Atmospheric Research. A listing of NOAA offices providing additional information on a specific parameter is given in the Appendices.

SELECTED ENVIRONMENTAL INDICATORS

The global environment is an inter-related system that includes the atmosphere, oceans, ice, and biota. These components are coupled through a complex, even chaotic, combination of biological, chemical, and physical processes, occuring over the spectrum of time and space scales. The natural coupling of these processes requires that the Earth be dealt with in an interdisciplinary fashion as a single system with global dimensions. With this in mind, it was nevertheless convenient for the purposes of this report to divide the global environment into the categories of atmosphere, ocean, cryosphere (ice), and biosphere. The parameters presented in this report were chosen because of their influence on the global environment or because they are considered indicators of system change, either on regional or global scales.

In this first edition of the NOAA ENVIRONMENTAL DIGEST a wide-range of parameters have been presented. In the future we hope to add to our list, or perhaps even drop some parameters. The parameters in the four major categories may not seem to be "tied together" in a simple fashion. On the other hand, each parameter within each category describes some characteristic that is considered to have the potential of being an indicator of future environmental trends.

In the atmospheric category we present temperature, trace gases, precipitation, drought, solar activity, severe weather, and the quasi-biennial oscillation as indicator parameters. In the oceanic category sea surface temperature, sea level, the El Nino and Southern Oscillation, ocean transport, and coastal upwelling are the parameters presented. For the cryosphere, we report sea ice and snow cover. For the biosphere, we employ fisheries, shellfish, contaminants, and protected resources data.

The project team hopes to receive your comments, suggestions for additional parameters, and critique on this initial effort.

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I. ATMOSPHERE

The atmosphere is a complex system. It interacts with the other components of the Earth system (oceans, cryosphere, and biosphere). Therefore, a complete understanding of atmospheric processes would require that it be treated as part of the larger system. The atmospheric parameters presented in this report were chosen because they were considered to be those that are sensitive to the total Earth system thereby potentially influencing long-term global climate. These parameters include trace gas distributions and solar activity. Other parameters discussed here can be described as indicators of climate change (e.g., surface and upper air temperature, precipitation, drought, severe weather, and the quasi-biennial oscillation).

AIR TEMPERATURE

Air temperature has been used as the primary indicator of global climate change. Scientists have found significant variability in the long-term record of global mean temperature. Portions of this record indicate periods of stable or even declining temperatures. A warming trend, that started in the late 1970s, has been a recent characteristic of the record. Understanding the variability in this record will be important in separating anthropogenic effects from natural variability.

Global mean air temperature has historically been estimated from surface (land) temperature records. The problems of sparse distribution of observation stations over the Earth's surface, instrumentation changes and relocations, and the influence of urban heating on sites where many long-term measurements exist have added uncertainty to the estimation of the global mean temperature. Upper air (i.e., upper troposphere and low stratosphere) mean temperatures have traditionally been acquired from radiosonde and rocketsonde observations. Satellite-derived global temperature data have been available since 1978 and are providing an additional data base for ocean and upper air temperatures.

a. Surface Air Temperatures

Estimates of the global mean surface temperature for calendar year 1989 indicate a relatively warm year that concludes a warm decade. The estimated value for 1989 is +0.16 °C deviation from the long-term mean (1951-1980). The recent years of 1987 and 1988 had slightly warmer anomalies of +0.22 and +0.26 °C, respectively. These estimates are based on data from roughly 1200 surface observation stations globally.

Figure I-1 shows the time series of 3-month estimated temperature anomalies based on the global network of land stations. The October through December 1989 season produced the first strong negative value in the Northern Hemisphere anomalies since 1985. The Southern Hemisphere is characterized by positive anomalies over the past five years. In general the global temperature anomalies tend to follow the Northern Hemisphere values.

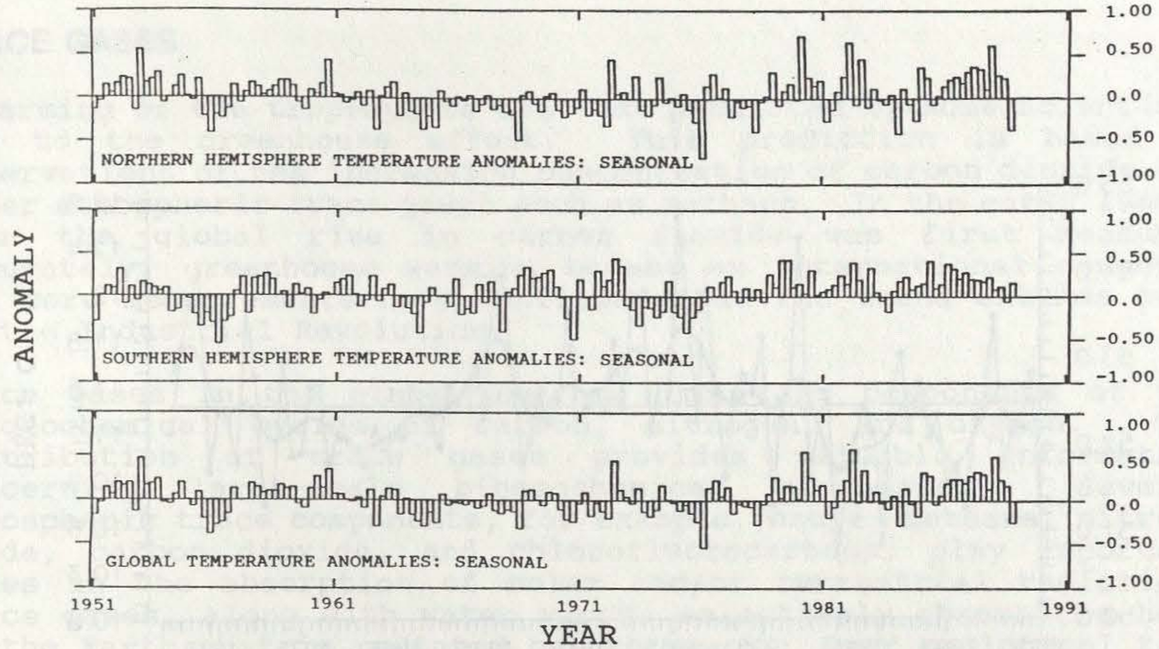


Figure I-1. Time series of seasonal air temperature anomalies (°C) based on 1951-1980 mean using land surface stations for Northern Hemisphere, Southern Hemisphere, and Global. First value in each graph represents January through March 1951 and the last value is October through December 1989. (Courtesy Climate Analysis Center, NOAA National Weather Service)

Like the global record, the average annual air temperature for the contiguous United States from 1895 to 1989 shows significant variability (Figure I-2). The period 1915 to 1935 exhibited a warming trend. There was no significant trend from the mid-1930s until the 1960s. The last ten years have seen a warming since the cool period of the late 1970s.

Data for 1989 indicate that annual mean temperature across the contiguous United States was below the long-term mean. Therefore, 1989 ranks slightly below normal (36th coldest on record [1895-1989]) and continues to follow the downward trend in annual temperature of the last three years.

b. Upper Air Temperatures

Scientists have found that upper air mean temperature variations mirror large-scale global processes. The 500 mb mean-averaged monthly temperature provides a good indicator of significant tropospheric processes (Figure I-3). For example, 500 mb temperature variations have been associated with the Southern Oscillation (SO). The SO is a global-scale pattern of atmospheric pressure fluctuations in the South Pacific Ocean that has been related to global-scale climate changes.

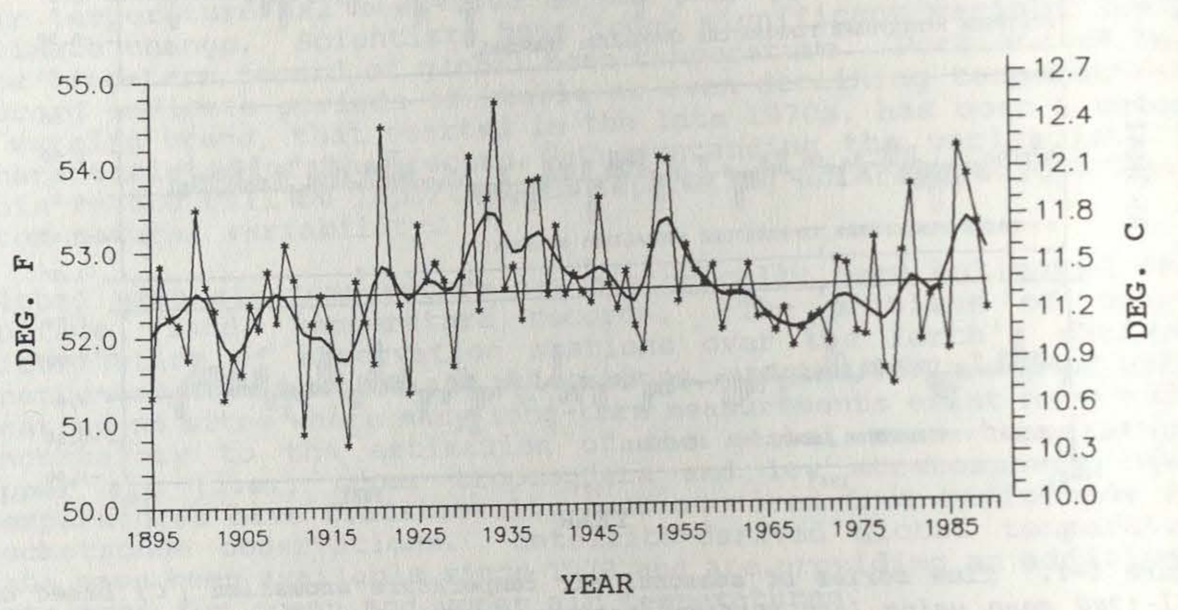


Figure I-2. Contiguous United States annual mean air temperature, 1895-1989. Horizontal line represents long-term mean. (Courtesy Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service)

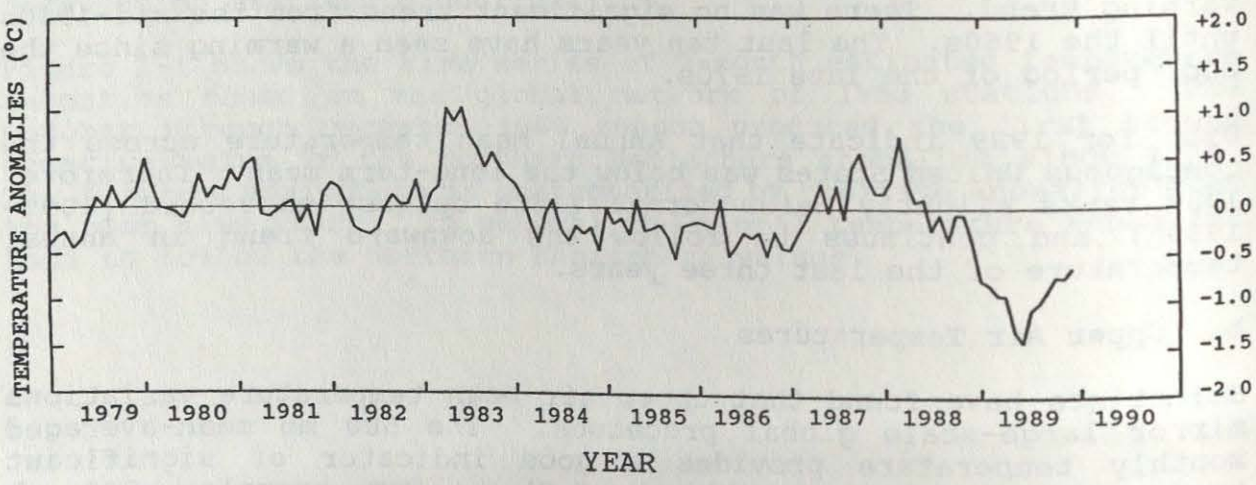


Figure I-3. Zonally averaged 500 mb temperature anomalies for the latitude band 20^o N to 20^o S, 1979-1989. (Courtesy Climate Analysis Center, NOAA National Weather Service)

TRACE GASES

A warming of the troposphere has been predicted by some scientists due to the greenhouse effect. This prediction is based on observations of the increasing concentration of carbon dioxide and other atmospheric trace gases such as methane. In the early 1960s, when the global rise in carbon dioxide was first measured accurately, greenhouse warming became an international concern. Ice core measurements have confirmed that the trend extends back to the Industrial Revolution.

Trace gases in the atmosphere are important components of the biogeochemical cycles of carbon, nitrogen, and oxygen. The distribution of trace gases provides valuable information concerning large-scale biogeochemical processes. Several atmospheric trace components, for example, ozone, methane, nitrous oxide, carbon dioxide, and chlorofluorocarbons, play important roles in the absorption of solar and/or terrestrial radiation. Trace gases, along with water vapor, selectively absorb the heat of the Earth that is radiated out to space. Over geological time trace gases, especially water vapor, have also acted as a thermostat forming a natural greenhouse that allowed Earth's climate to remain favorable for human habitability.

Trace components also have harmful effects in the lower atmosphere. For example, ozone and peroxides can injure vegetation; oxides of nitrogen and sulphur acidify precipitation with damage to plants, aquatic life, and buildings; and aerosols reduce visibility and affect human respiration.

a. Carbon Dioxide

Carbon dioxide is an essential component of the Earth's carbon cycle that governs vital processes in the ocean, atmosphere, and biosphere. The burning of fossil fuels has been linked to the increasing concentration of atmospheric carbon dioxide. In addition to this source, oscillations in atmospheric carbon dioxide concentrations are correlated with seasonal differences in photosynthesis within the biosphere.

As part of the NOAA Climate Monitoring and Diagnostics Laboratory (CMDL) (formerly Air Resources Laboratory/Geophysical Monitoring for Climatic Change Division) program, continuous carbon dioxide measurements have been made since the early 1970's at the NOAA baseline observatories at Barrow, Alaska; Mauna Loa, Hawaii; Pago Pago, American Samoa; and South Pole, Antarctica. These observations are yielding a record of increasing global carbon dioxide concentrations. This trend is illustrated in Figure I-4(a), where the complete record (1958-1989) of carbon dioxide measurements from Mauna Loa is presented. The data through 1972 are from the Scripps Institution of Oceanography (Professor C.D. Keeling) and from NOAA/CMDL thereafter. The increase has been linked to fossil fuel combustion, changes in the amount of carbon dioxide held in standing biomass and soils, and global scale phenomena such as El Nino, which cause interannual variations in the carbon dioxide growth rate. The mean growth rate for the last four years was about 1.75 ppm per year.

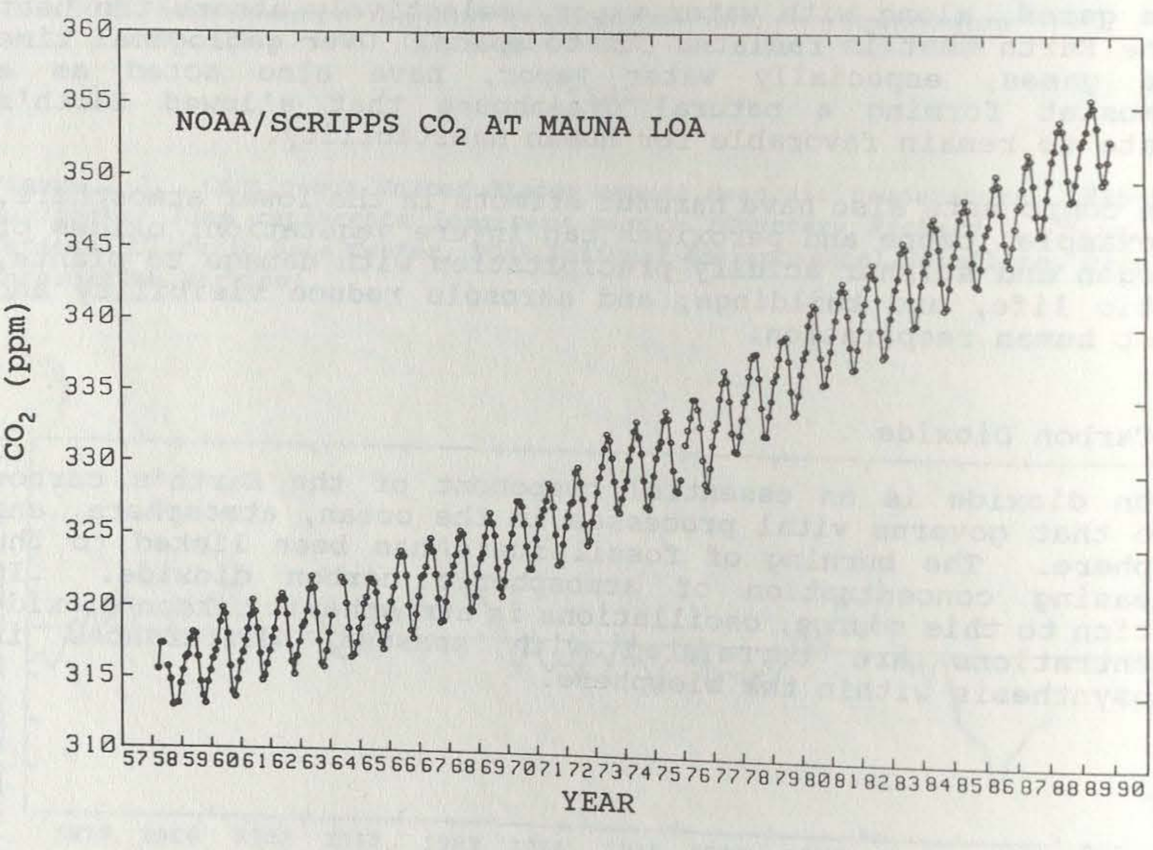


Figure I-4(a). Monthly mean carbon dioxide concentrations (ppm), 1958-1989, at Mauna Loa, Hawaii. (Courtesy Kirk Thoning, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

In addition to measurements at the baseline observatories, NOAA/CMDL collects flasks of air, once per week, at 30 globally-dispersed cooperative sites. The flasks are returned to their Boulder laboratory headquarters for analysis of carbon dioxide concentration; thus all data can be directly intercompared. From these data, a global carbon dioxide growth rate is determined by averaging the growth rates, weighted by latitude, from each of the flask CMDL network stations. The result is shown in Figure I-4(b). A maximum in the growth rate of close to 3 ppm/yr occurred in late 1987, and 1988 had a mean growth rate greater than 2 ppm/yr. Growth rates for individual sites ranged from 2.0 to 3.9 ppm/yr. This peak in growth rate is associated with the El Nino/Southern Oscillation (ENSO) event in 1987. The pattern of the growth rate variation in 1987-1988 is consistent with previous ENSO events, in which high carbon dioxide growth rates followed minima in the Southern Oscillation Index (a measure of global scale changes originating in the tropical Pacific Ocean) by approximately 6 months, and the carbon dioxide growth rate was correlated with sea surface temperature variations. Figure I-4(b) also shows a peak in the growth rate in 1983, following the the strong ENSO event of 1982. Preliminary results from 1989 show a return to more typical growth rates of about 1.5 ppm/yr.

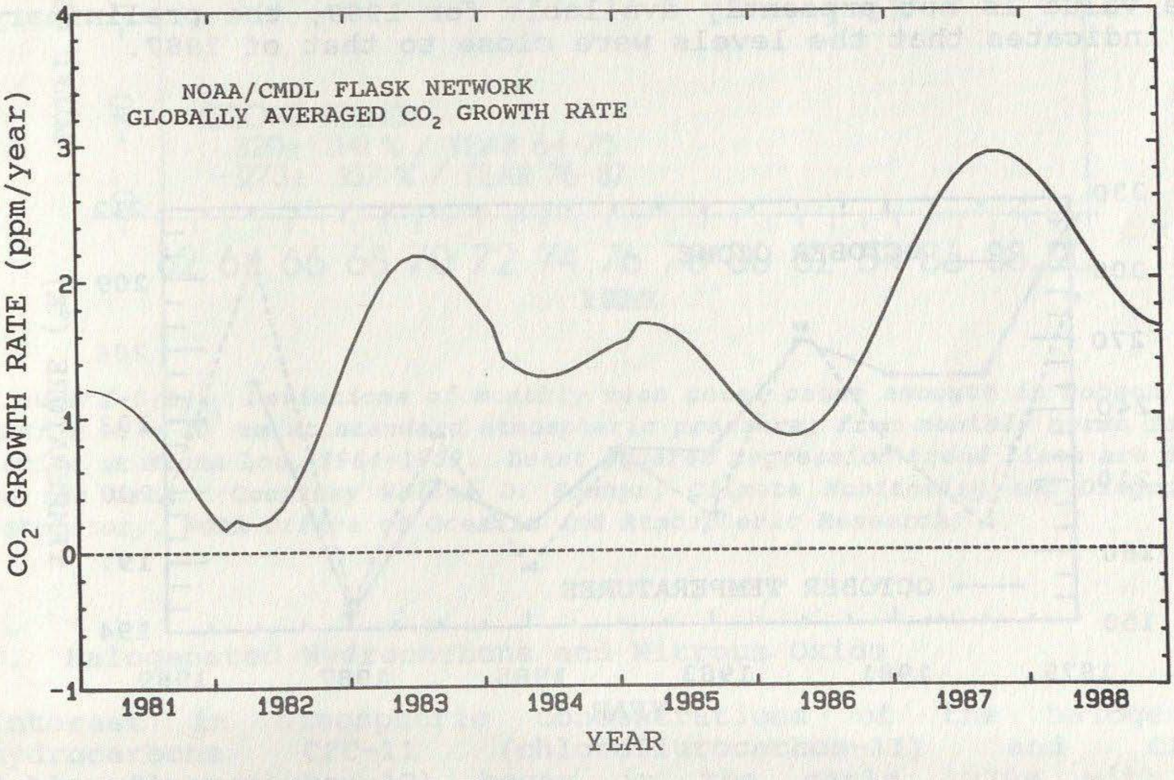


Figure I-4(b). The globally averaged carbon dioxide growth rate (ppm per year), 1981-1988, from the NOAA/CMDL flask network. (Courtesy Thomas Conway, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

b. Ozone

Ozone, produced photochemically, is a form of oxygen present in the Earth's atmosphere in small quantities. About 90% of ozone is found in the stratosphere. Ozone shields the biosphere from the damaging effects of ultraviolet radiation. It also helps to heat the stratosphere, and therefore influences global climate. If the ozone "shield" should be weakened or destroyed, serious human health problems have been predicted, including increased incidences of skin cancer. Additionally, evidence suggests that increase in ultraviolet radiation could adversely affect phytoplankton productivity in the oceans.

After a warm antarctic spring in 1988 with the corresponding rise in ozone levels, both stratospheric temperatures and ozone levels have fallen significantly in 1989. Figure I-5(a) shows October zonal mean total ozone data from the Total Ozone Mapping Spectrometer (TOMS) instrument on Nimbus 7 and October 70 mb zonal mean temperatures from a NOAA National Meteorological Center analysis. The temperature record shows a corresponding decrease to low levels in 1987, while 1988 exhibited the temperature at the highest levels for the period of record. Ozone increased in 1988 in correspondence with the warmer temperatures. While the final ozone value is not presently available for 1989, the preliminary data indicates that the levels were close to that of 1987.

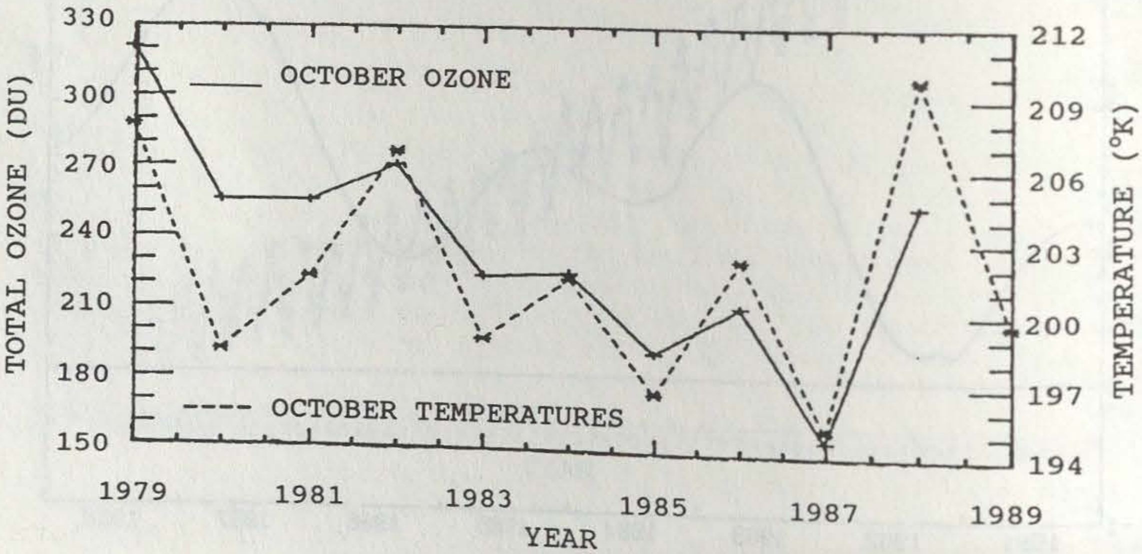


Figure I-5(a). Total Ozone Mapping Spectrometer values (solid line) in Dobson Units (DU) and 70 mb temperatures (dashed line) in °K at 80° S. One DU = 10^3 cm at standard atmospheric pressure. (Courtesy Climate Analysis Center, NOAA National Weather Service)

Long-term ozone trends have been monitored at the NOAA/CMDL observatory at Mauna Loa, Hawaii (MLO) since 1964. Figure I-5(b) is a plot of ozone anomalies (i.e., deviations of ozone monthly means from monthly normals) at MLO for 1964-1989. Quasi-biennial oscillations in ozone are clearly evident in the record. Least-squares linear regression trend lines fitted to the data with 95% confidence limits indicate that ozone at MLO increased on average during 1964-1974, decreased during 1974-1987, but increased again at the end of the record.

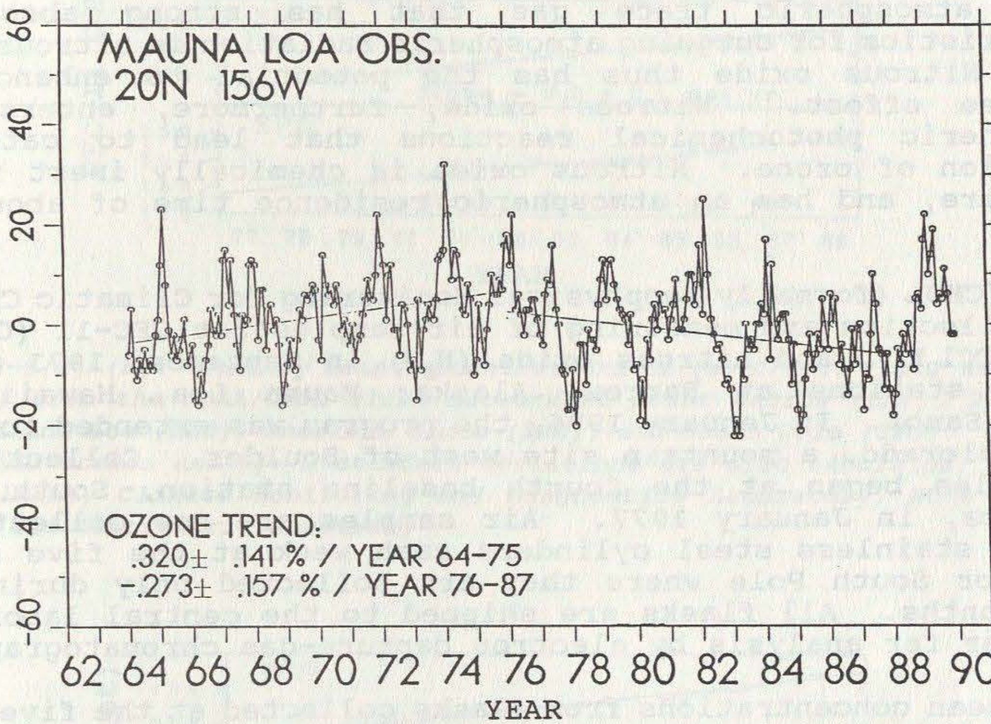


Figure I-5(b). Deviations of monthly mean total ozone amounts in Dobson Units (DU; 1 DU = 10^3 cm at standard atmospheric pressure) from monthly norms for the period at Mauna Loa, 1964-1989. Least squares regression trend lines are fitted to the data. (Courtesy Walter D. Komhyr, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

c. Halogenated Hydrocarbons and Nitrous Oxide

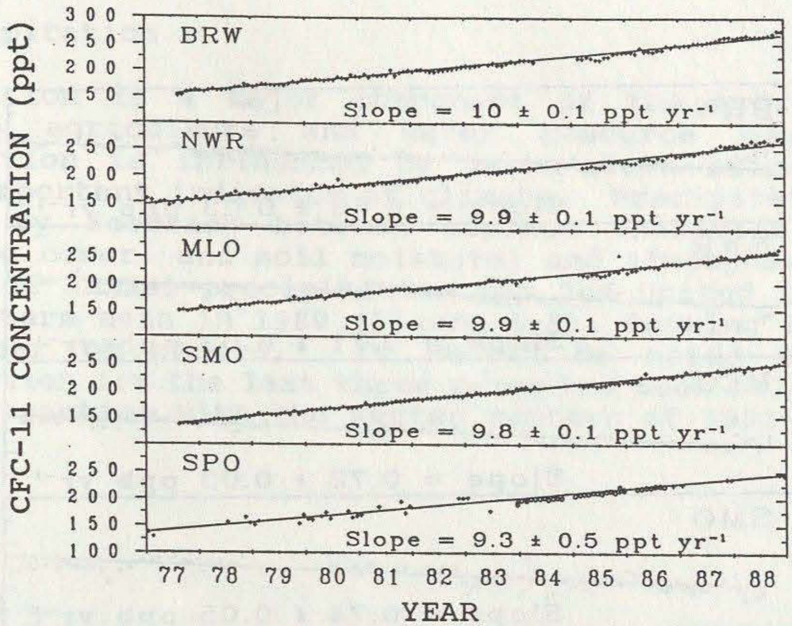
Interest in atmospheric concentrations of the halogenated hydrocarbons CFC-11 (chloroflurocarbon-11) and CFC-12 (chlorofluorocarbon-12) began in the early 1970s with the realization that these compounds are highly inert chemically, have no known natural sources, and therefore are ideally suited as tracers for the study of mass transfer processes in the atmosphere and oceans.

The interest in atmospheric chlorofluorocarbons was heightened in 1974 when it was theorized that they are likely to decompose in the stratosphere, causing destruction of the atmospheric ozone layer. In addition, it has been shown that that these chlorofluorocarbons are potentially capable of influencing the thermal structure of the atmosphere (i.e., enhancing the greenhouse effect), since they possess strong absorption within the wavelengths in which thermal radiation from the Earth's surface and lower atmosphere is transmitted.

Another atmospheric trace gas that has strong absorption characteristics for outgoing atmospheric radiation is nitrous oxide (N_2O). Nitrous oxide thus has the potential to enhance the greenhouse effect. Nitrous oxide, furthermore, enters into stratospheric photochemical reactions that lead to catalytic destruction of ozone. Nitrous oxide is chemically inert in the troposphere, and has an atmospheric residence time of about 150 years.

The NOAA/CMDL (formally Geophysical Monitoring for Climatic Change) began collection and measuring of air samples for CFC-11 (CCl_3F), CFC-12 (CCl_2F_2), and nitrous oxide (N_2O) in September 1973 at the baseline stations at Barrow, Alaska; Mauna Loa, Hawaii; and American Samoa. In January 1976, the program was extended to Niwot Ridge, Colorado, a mountain site west of Boulder. Collection of air samples began at the fourth baseline station, South Pole, Antarctica, in January 1977. Air samples are now collected in pairs of stainless steel cylinders each week at the five sites, except for South Pole where they are collected only during the summer months. All flasks are shipped to the central laboratory in Boulder for analysis by electron capture-gas chromatography.

Monthly mean concentrations from flasks collected at the five sites from 1977 through 1988 are presented in Figures I-6(a), I-6(b), and I- 7 for CFC-11, CFC-12 and nitrous oxide, respectively. Estimated secular trends and plus or minus 2 standard deviations at the 95% confidence level are also given. Analysis of all data shows a mean global growth rate over the period of 9.8 parts per trillion (ppt) per year for CFC-11, 16.1 ppt per year for CFC-12, and 0.68 parts per billion (ppb) per year for nitrous oxide. The CFC-11 and CFC-12 data show that concentrations are rising over the past few years at a rate greater than that seen in the earlier record. Since calibration gas standards have been changed in this period, insufficient time has gone by to determine calibration long-term stability or drift characteristics. It is uncertain whether the greater rise is real, being a response to increased chemical usage and release into the atmosphere, or a vagary of the new standard.



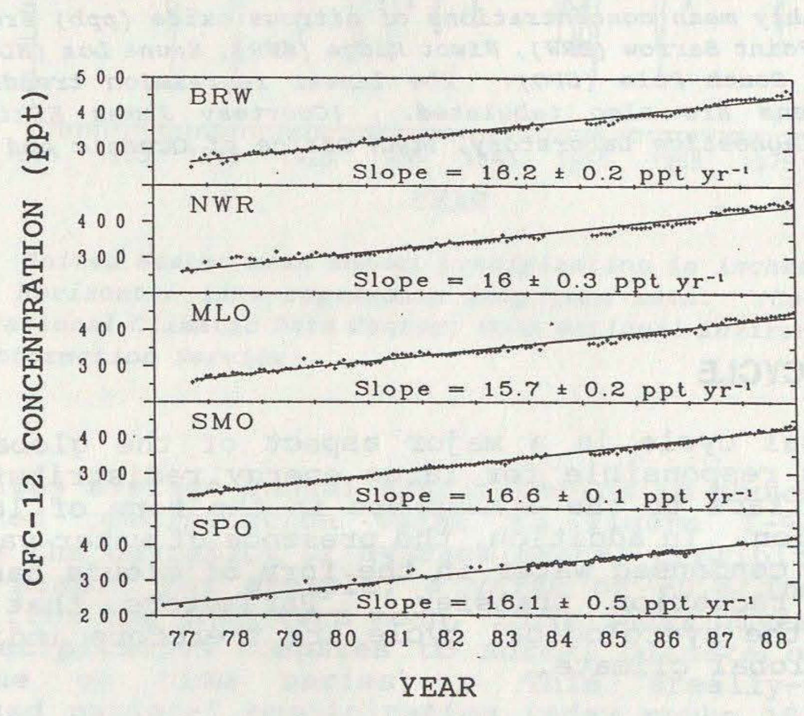


Figure I-6(a)-(b). Monthly mean concentrations of (a) CFC-11 (ppt) and (b) CFC-12 (ppt) from the NOAA/CMDL flask network at Point Barrow (BRW), Niwot Ridge (NWR), Mauna Loa (MLO), American Samoa (SMO), and South Pole (SPO). The linear regression trends and +/- 2 standard deviations are also tabulated. (Courtesy James Elkins, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

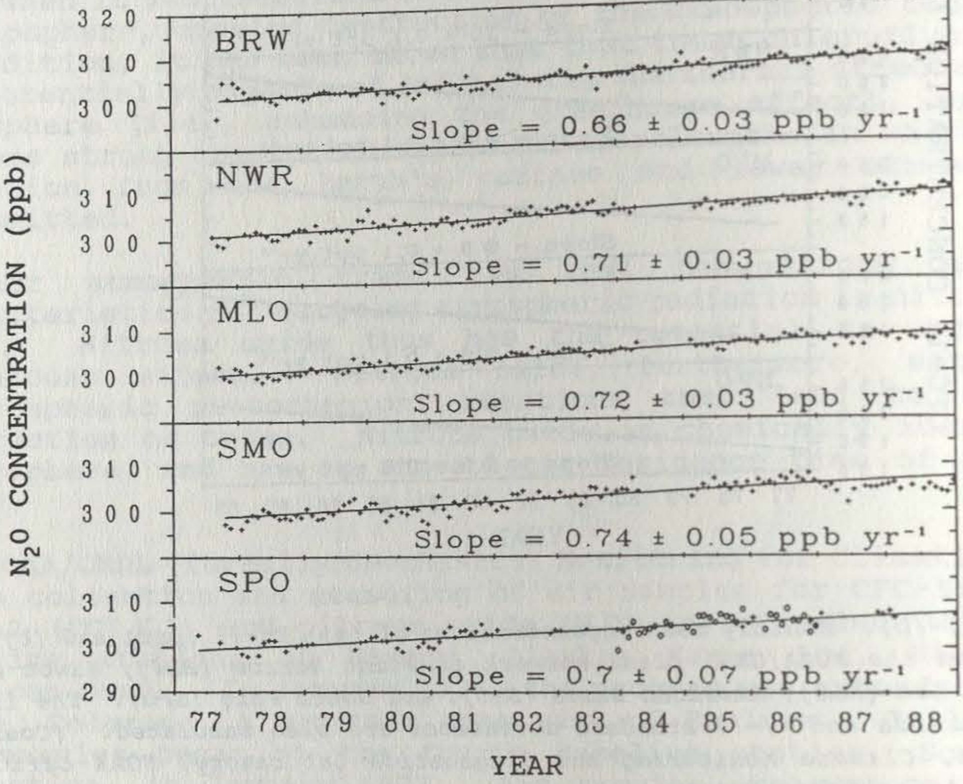


Figure I-7. Monthly mean concentrations of nitrous oxide (ppb) from NOAA/CMDL flask network at Point Barrow (BRW), Niwot Ridge (NWR), Mauna Loa (MLO), American Samoa (SMO), and South Pole (SPO). The linear regression trends and +/- 2 standard deviations are also tabulated. (Courtesy James Elkins, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

HYDROLOGICAL CYCLE

The hydrological cycle is a major aspect of the global climate system. It is responsible for large energy redistributions from the Earth's surface to the atmosphere in the form of latent heat from condensation. In addition, the presence of water vapor in the atmosphere and condensed water in the form of clouds has a strong influence on radiation transfer. Parameters that indicate variations in the hydrological cycle are therefore indicators of regional and global climate.

a. Precipitation

Precipitation is a major component of the hydrological cycle, vital to agriculture and water resource planning. Since precipitation is influenced by large-scale climate changes, it makes a important indicator of climate. Precipitation is strongly affected by feedback between surface characteristics (albedo, vegetative cover, and soil moisture) and atmospheric circulation. The average annual precipitation for the United States was below the long-term mean in 1989 (Figure I-8), ranking 1989 as the 33rd driest year on record. It should be noted that the annual precipitation for the last three years has been below the long-term mean, contrasting with the wetter pattern of 1981-86.

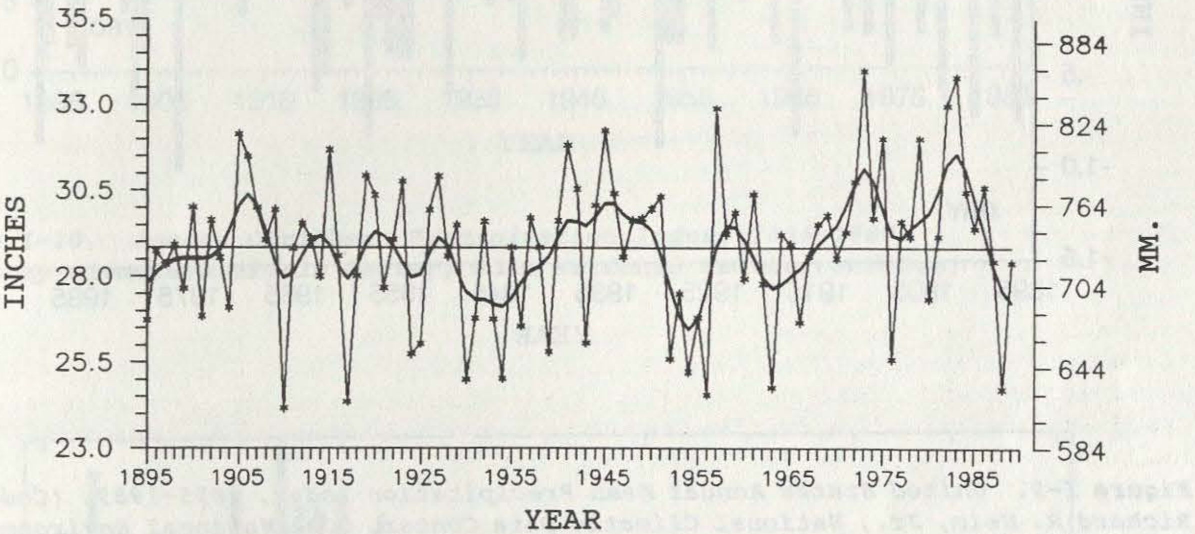


Figure I-8. United States mean annual precipitation in inches and millimeters, 1895-1989. Horizontal line represents long-term mean. (Courtesy Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service)

United States average annual precipitation is shown as a national standardized precipitation value in Figure I-9. The index represents the deviation of average annual precipitation from the long-term mean. For example, a value of +0.5 indicates a +50% deviation from the long-term mean. This index gives an indication of how precipitation compares to normal climate conditions (the zero value on time series). This areally-weighted mean standardized national precipitation index ranks 1989 as the 24th driest year on record.

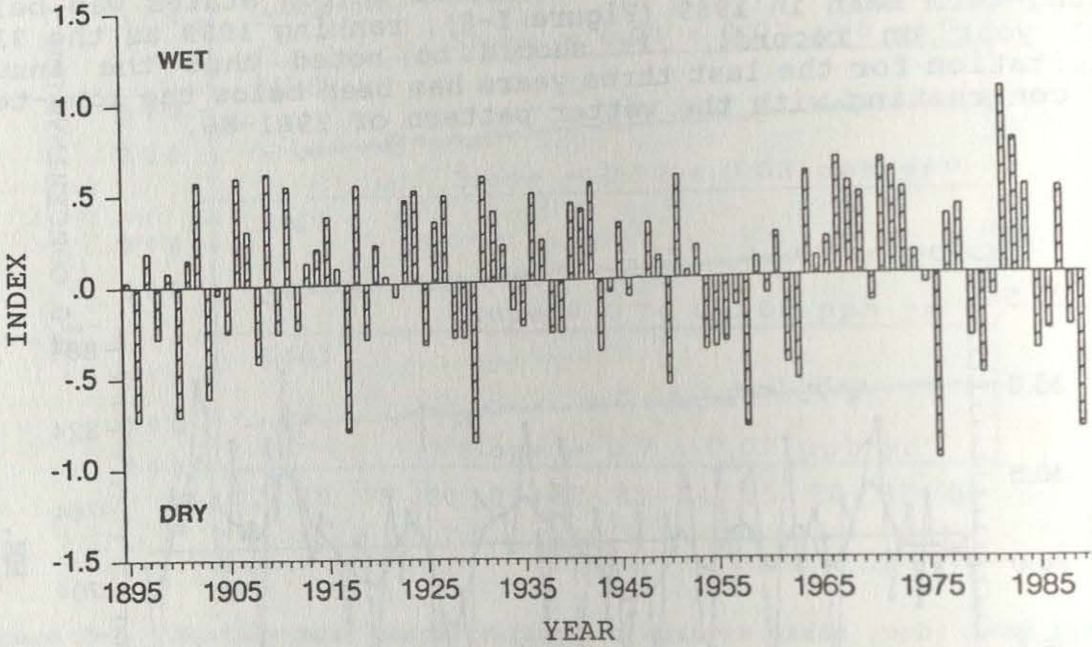


Figure I-9. United States Annual Mean Precipitation Index, 1895-1989. (Courtesy Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service)

Precipitation data in selected geographic regions are presented to give an indicaton of long-term global precipitation trends. For the Caribbean, despite above-normal tropical storm activity, abnormally dry conditions existed in 1989 (Figure I-10). The standardized Caribbean Precipitation Index indicates that 1989 has been the driest year during this century.

In the African Sahel, 1989 was the second consecutive year with rainfall close to the long-term mean. The last time this region had two back-to-back "normal" years was in the 1960s. Figure I-11 is a time series of the standardized precipitation index for the Sahel region of Western Africa.

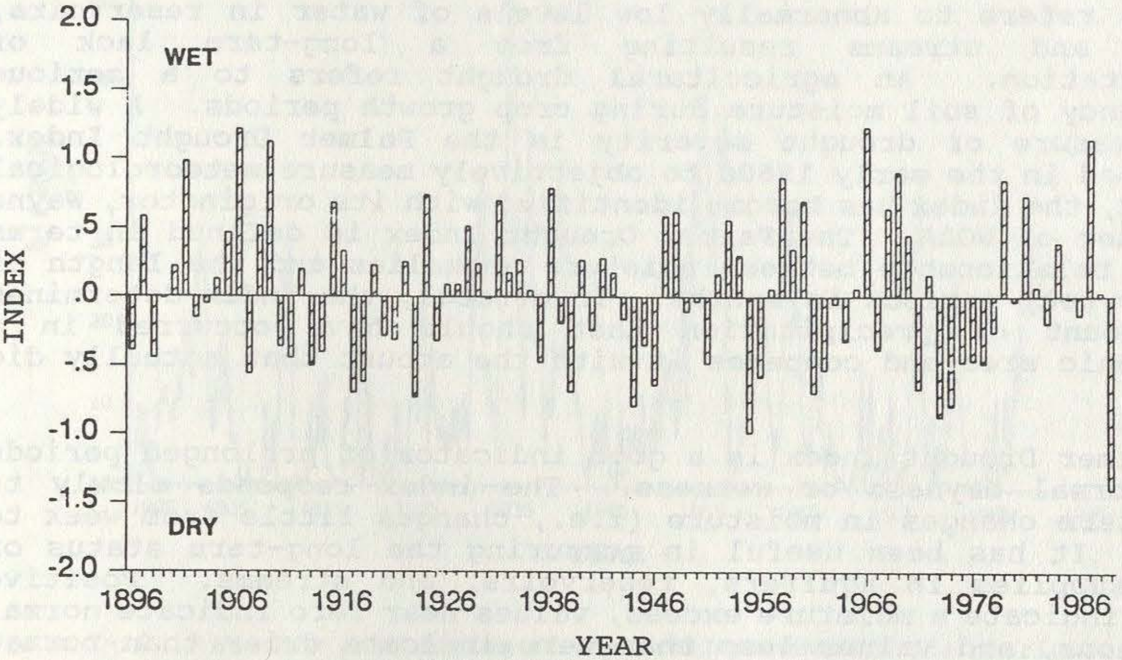


Figure I-10. Annual Caribbean Precipitation Index, 1896-1989. (Courtesy Climate Analysis Center, NOAA National Weather Service)

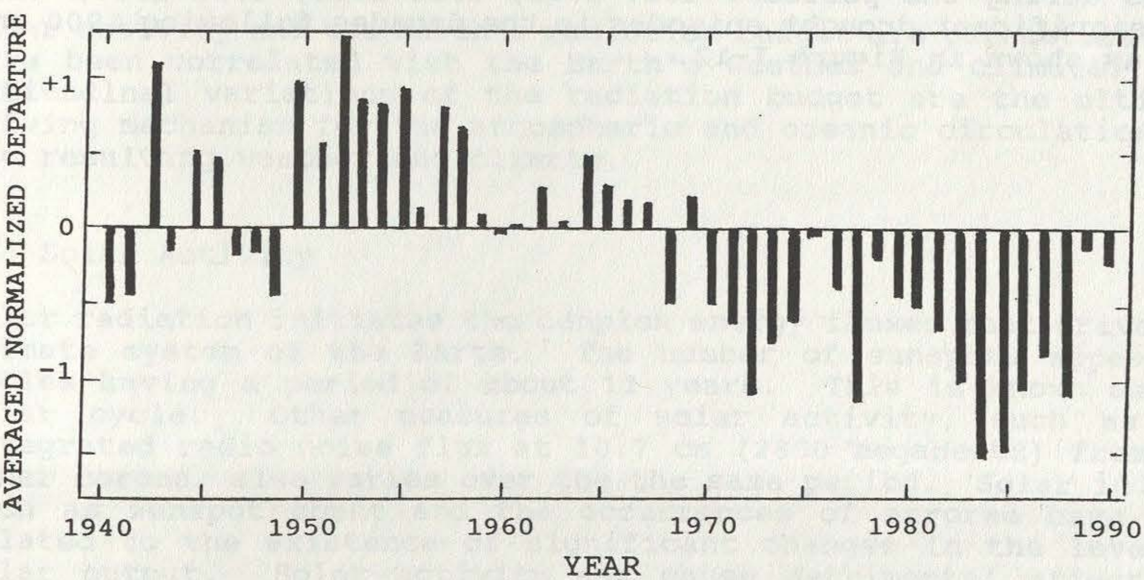


Figure I-11. Annual Africian Sahel Precipitation Index, 1940-1989. (Courtesy Climate Analysis Center, NOAA National Weather Service)

b. Drought

Drought refers to abnormally low levels of water in reservoirs, lakes, and streams resulting from a long-term lack of precipitation. An agricultural drought refers to a serious deficiency of soil moisture during crop growth periods. A widely used measure of drought severity is the Palmer Drought Index. Developed in the early 1960s to objectively measure meteorological drought, the index has become identified with its originator, Wayne C. Palmer of NOAA. The Palmer Drought Index is defined in terms of the relationship between moisture anomalies and the length of dry (or wet) periods in months. In general, the index determines the amount of precipitation that should have occurred in a geographic area and compares it with the amount that actually did occur.

The Palmer Drought Index is a good indicator of prolonged periods of abnormal dryness or wetness. The index responds slowly to short-term changes in moisture (i.e., changes little from week to week). It has been useful in measuring the long-term status of water supplies in aquifers, reservoirs, and streams. Positive values indicate a moisture excess, values near zero indicate normal conditions, and values less than zero indicate drier than normal conditions. An index less than -3 is termed a severe drought, and an index of less than -4 is the worst condition, termed extreme drought. There is evidence of a drought cycle of 18 and 22 years over the central United States, although this pattern of recurrence has not provided a basis for accurate drought predictions.

In the last 100 years, significant droughts occurred in the United States during the periods: 1887-1896, 1933-1936, 1952-1956, with less significant drought episodes in the decades following 1900 and 1960 as shown in Figure I-12.

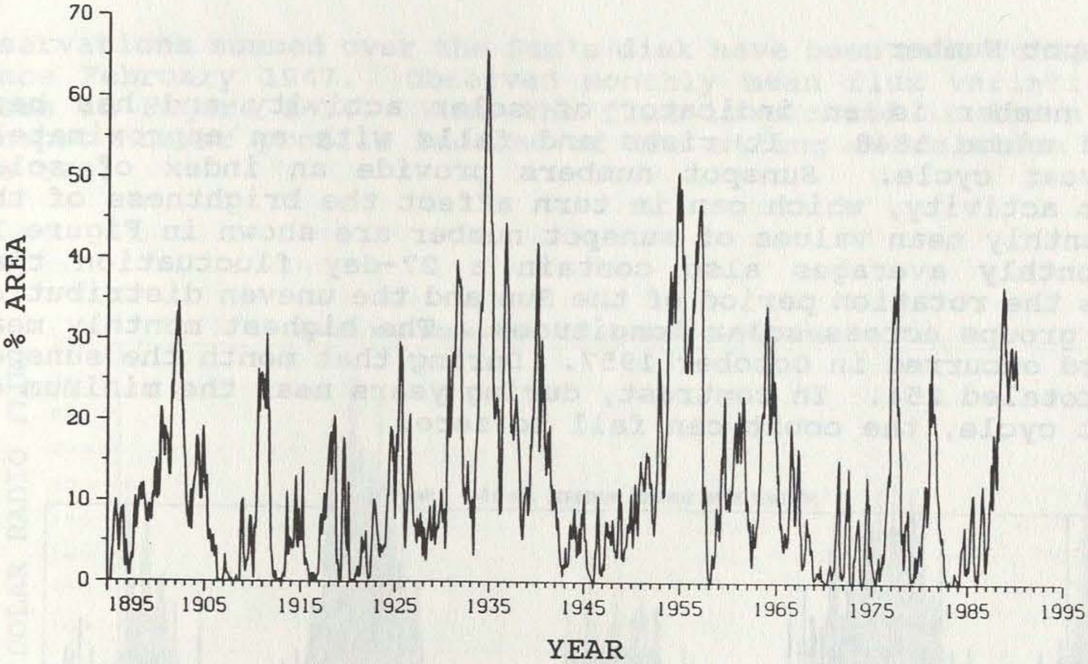


Figure I-12. Monthly time series of the areal percent of the contiguous United States experiencing "severe" or "extreme" drought based on calculations of the Palmer Drought Index, from 1895 to the present. (Courtesy Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service)

SOLAR ACTIVITY AND RADIATION BUDGET

Solar activity and the Earth's radiation budget are parameters that have been correlated with the Earth's weather and climate. The latitudinal variations of the radiation budget are the ultimate driving mechanism for the atmospheric and oceanic circulation and the resulting weather and climate.

a. Solar Activity

Solar radiation initiates the complex energy fluxes that drive the climate system of the Earth. The number of sunspots appear in cycles having a period of about 11 years. This is known as the solar cycle. Other measures of solar activity, such as the integrated radio noise flux at 10.7 cm (2800 megaHertz) from the inner corona, also varies over the the same period. Solar indices such as sunspot count and the occurrences of aurorae have been related to the existence of significant changes in the level of solar output. Solar activity can cause detrimental effects to humans and equipment in space and to Earth-based communication and electrical power networks.

i. Sunspot Number

Sunspot number is an indicator of solar activity and has been recorded since 1848. It rises and falls with an approximately eleven-year cycle. Sunspot numbers provide an index of solar magnetic activity, which can in turn affect the brightness of the Sun. Monthly mean values of sunspot number are shown in Figure I-13. Monthly averages also contain a 27-day fluctuation that reflects the rotation period of the Sun and the uneven distribution of spot groups across solar longitudes. The highest monthly mean on record occurred in October 1957. During that month the sunspot number totaled 254. In contrast, during years near the minimum of the spot cycle, the count can fall to zero.

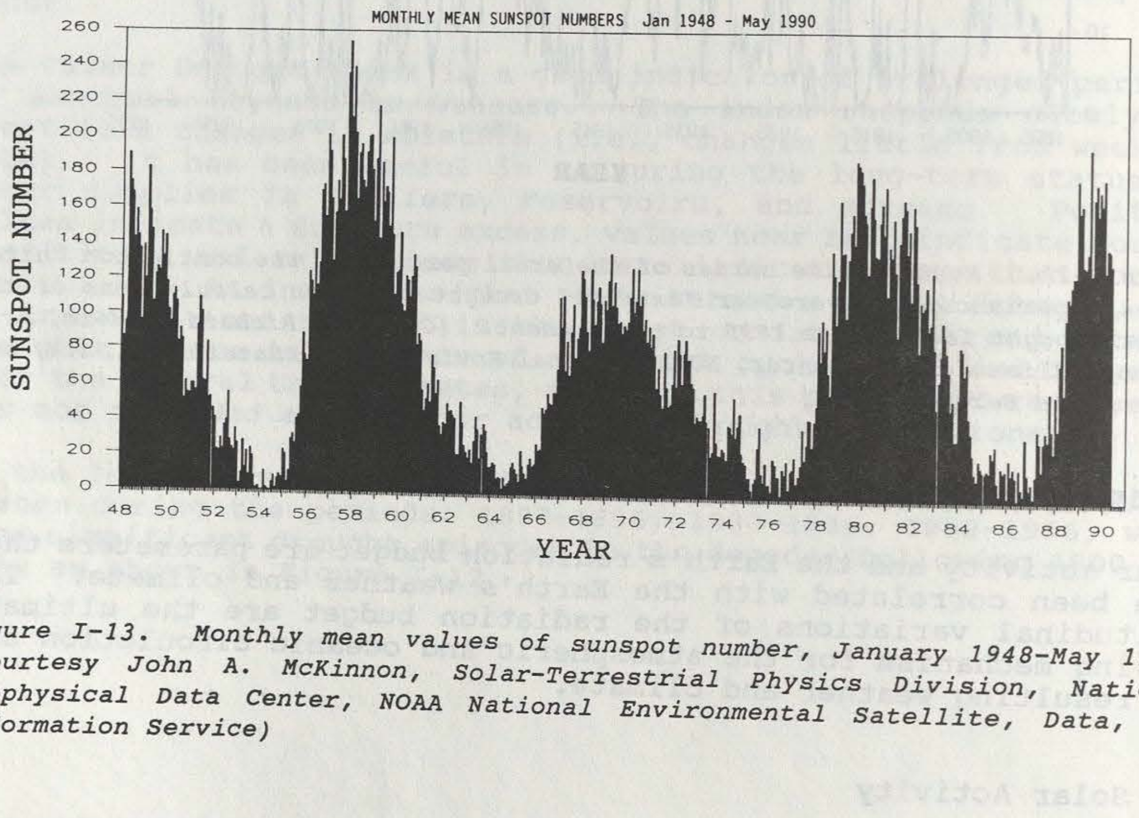


Figure I-13. Monthly mean values of sunspot number, January 1948-May 1990. (Courtesy John A. McKinnon, Solar-Terrestrial Physics Division, National Geophysical Data Center, NOAA National Environmental Satellite, Data, and Information Service)

ii. Microwave Flux

The Sun emits radio energy with a slowly varying intensity. The brightness of the Sun can be measured by the strength of emission at 10.7 cm (2800 megaHertz). This radio flux, which originates from atmospheric layers high in the Sun's chromosphere and low in its corona, changes gradually from day-to-day in response to the number of spot groups on the disk. Radio intensity levels consist of emission from three sources: from the undisturbed solar surface, from developing active regions, and from short-lived enhancements above the daily level. At 2800 megaHertz, flux observations summed over the Sun's disk have been made continuously since February 1947. Observed monthly mean flux variations are shown in Figure I-14. When the flux is plotted it looks like a sunspot number profile because of the strong correlation between the two.

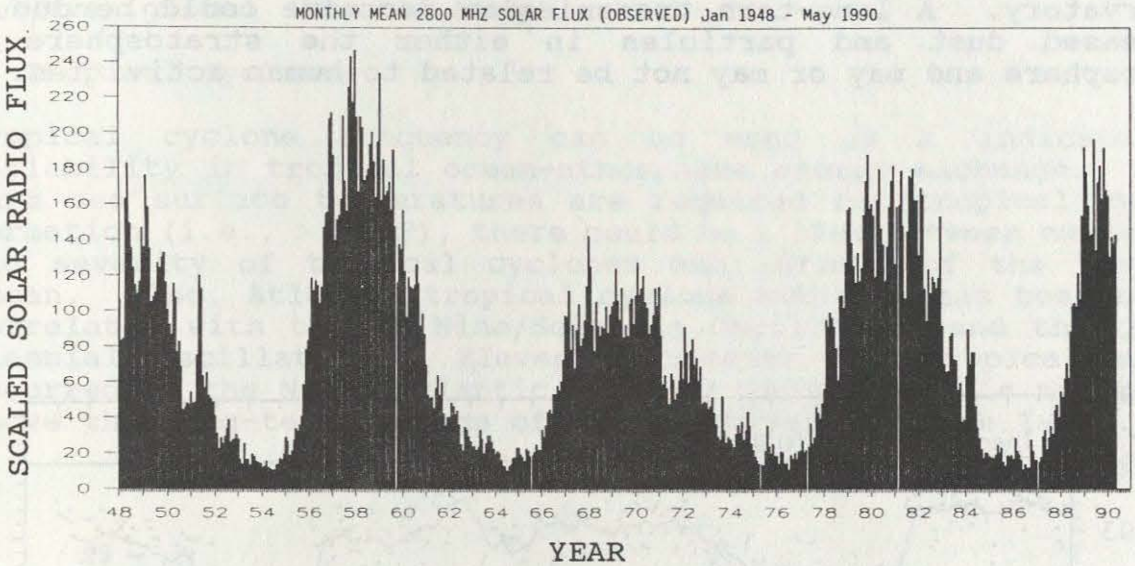


Figure I-14. Solar brightness variations (observed) expressed as monthly means of 2800 megaHertz (10.7 centimeters) microwave flux, January 1948 - May 1990. (Courtesy John A. McKinnon, Solar-Terrestrial Physics Divison, National Geophysical Data Center, NOAA National Environmental Satellite, Data, and Information Service)

b. Radiation Budget - Atmospheric Transmission

Measurements of parameters that affect the Earth's radiation budget are fundamental to the understanding of climate change. These parameters are especially important in determining the amount of downward surface solar irradiance reaching the Earth's surface and the amount of outgoing longwave radiation emitted into the atmosphere.

Atmospheric transmission is a measure of the clearness of the cloud-free atmosphere. At the NOAA/CMDL Mauna Loa, Hawaii, baseline observatory, atmospheric transmission is determined by how well the direct sunlight penetrates the entire atmosphere down to the surface. The observations of atmospheric transmission at the mountain-top observatory are particularly useful for monitoring the "background" transmission of the upper troposphere and the stratosphere because it is located far away from continental sources of pollution, haze, and dust in addition to having a high percentage of cloud-free days. The major sources of variations in the Mauna Loa transmission record (Figure I-15) are large explosive volcanic eruptions like Agung in 1963 and El Chichon in 1982. Although the average transmission for 1989 was less than that in the late 1950's it is not possible to tell if this is due to remnants of El Chichon and other minor eruptions or due to some longer term decrease in the clarity of the atmosphere above the Observatory. A long-term transmission decrease could be due to increased dust and particles in either the stratosphere or troposphere and may or may not be related to human activities.

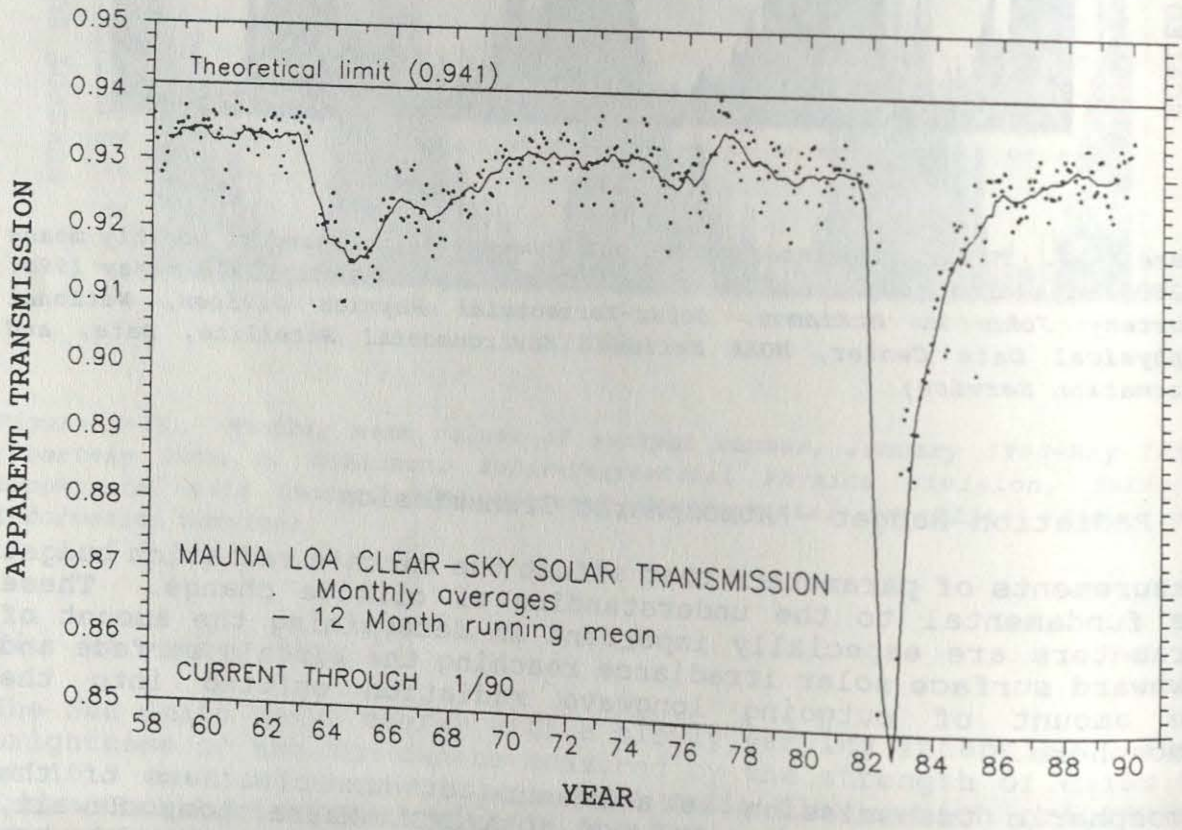


Figure 1-15. Monthly mean values (dots) and the 12-month running mean (solid line) of apparent atmospheric transmission over Mauna Loa Observatory, Hawaii, 1958-1989. (Courtesy Ellsworth Dutton, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

SEVERE WEATHER

Much of the weather that causes loss of life and disrupts economic activity on Earth is related to mesoscale phenomena. Severe weather includes tornadoes, squall lines and thunderstorms, hail storms, flash floods, and heavy snows. Larger-scale severe weather phenomena, such as tropical and extra-tropical storms, are also included in severe weather. Major variations in meso- and large-scale severe weather phenomena may be useful indicators of regional and even global climate change.

a. Tropical Cyclones

Tropical cyclone frequency can be used as a indicator of variability in tropical ocean-atmosphere energy exchange. Since warm sea surface temperatures are required for tropical cyclone formation (i.e., > 80° F), there could be a link between numbers of and severity of tropical cyclones and warming of the tropical ocean. Also, Atlantic tropical cyclone activity has been highly correlated with the El Nino/Southern Oscillation and the Quasi-biennial Oscillation. Eleven hurricanes and tropical storms occurred in the North Atlantic Ocean in 1989, which is moderately above the long-term average of eight per year (Figure I-16).

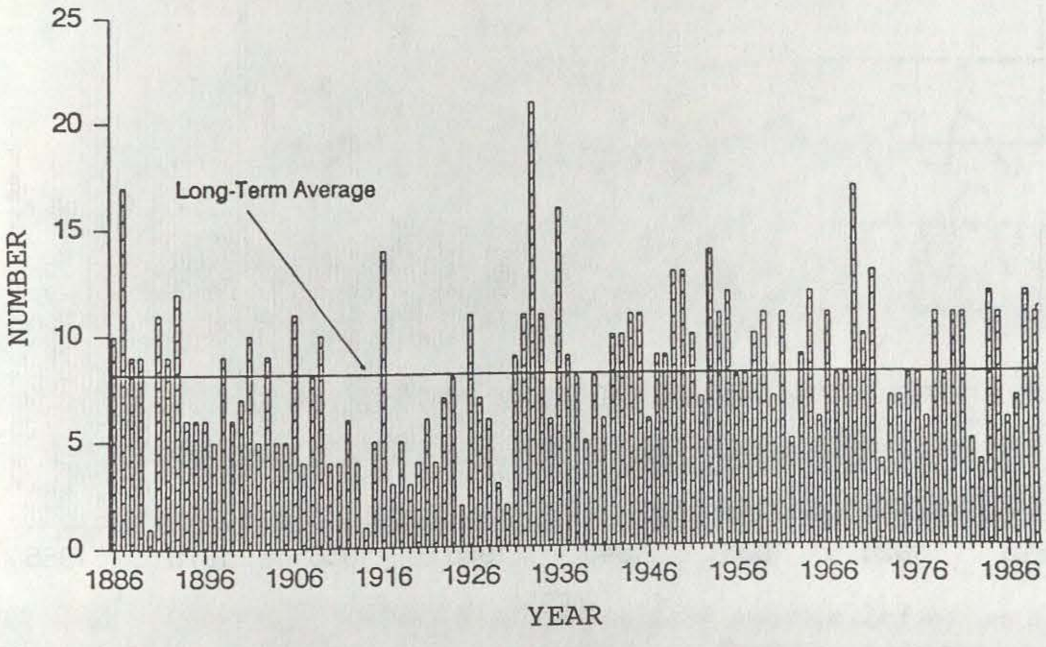


Figure I-16. Annual number of hurricanes and tropical storms, North Atlantic Ocean, 1886-1989. (Courtesy Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service)

b. Tornadoes

Tornadoes are intense local circulation systems with accompanying high winds. They occur most often in the central portion of the Nation. Oklahoma has the highest occurrence of tornadoes followed by Kansas. During 1989, a total of 831 tornadoes was reported in the United States, which was above the 33-year (1953-1985) national average of 749.

Figure I-17 shows the historical record of reported occurrences of tornadoes. Early records reported only large, destructive tornadoes and others which were visually observed. Modern weather observing uses radar in addition to visual sitings to locate tornadoes. Therefore, the latest record (after the 1950s) includes smaller storms and those occurring in remote locations. This change in observational technique has biased the historical record.

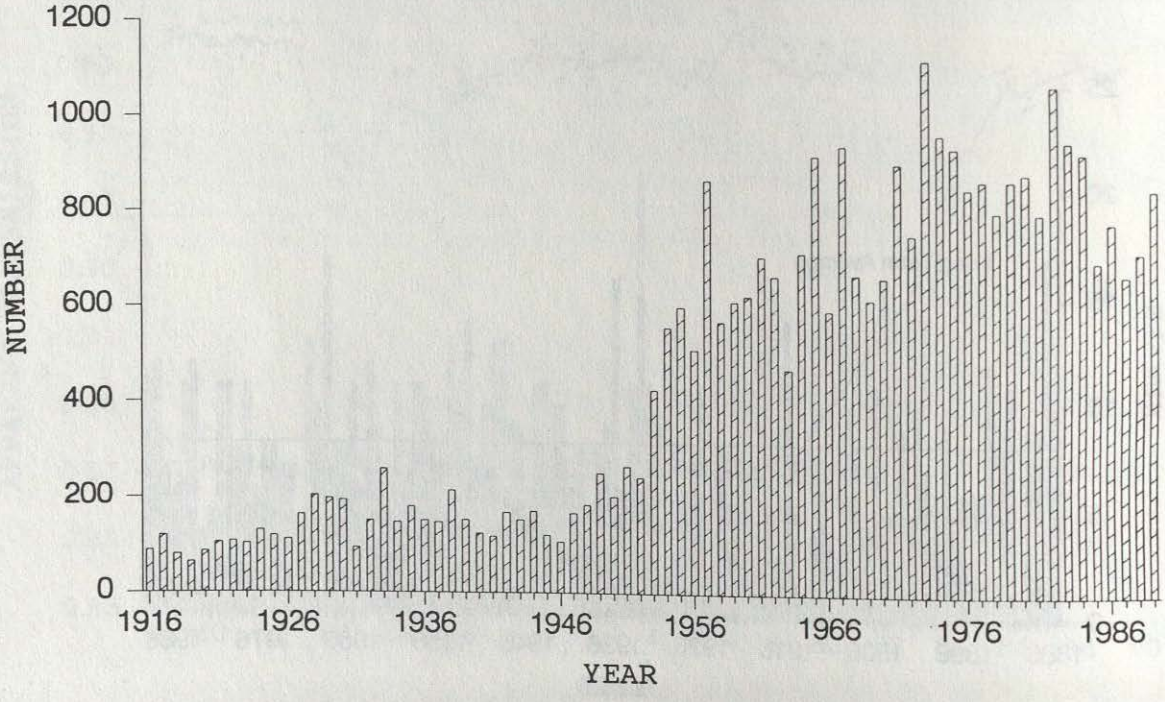


Figure I-17. Number of tornadoes, 1916-1989. (Courtesy Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service)

QUASI-BIENNIAL OSCILLATION

A quasi-biennial oscillation (QBO) of mean zonal winds in the equatorial stratosphere is perhaps the one regular periodic oscillation in the climate system. The QBO, so called because it repeats every 2 to 2.5 years, has been observed since 1950.

The QBO shown in Figure I-18 is based on observations taken at Balboa (Canal Zone), Singapore, and Ascension Island. Recent studies have indicated a statistical relationship between the QBO and surface temperature anomalies and also for relative activity during the tropical cyclone season. The QBO has been recognized for more than 30 years as having its largest amplitude over the tropics and near 30 mb, but a QBO signal has been detected in other meteorological and oceanographic parameters.

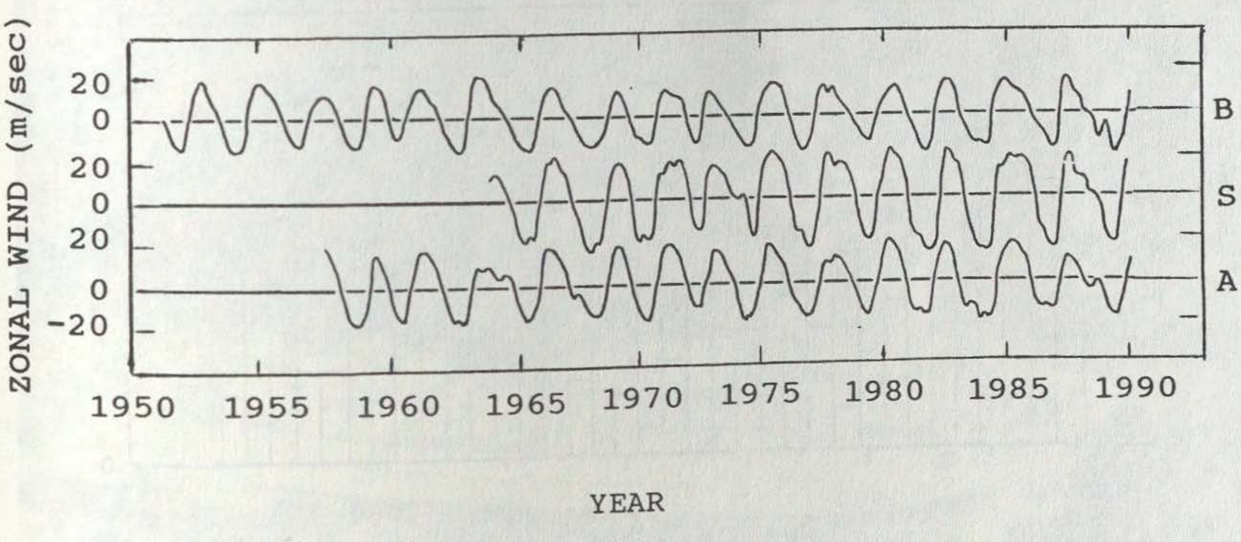


Figure I-18. Variation of the zonal wind (west wind positive) at Balboa (B), Singapore (S), and Ascension Island (A) at 30 mb, based on a weighting of monthly deviations from long-term monthly means. Abscissa tick marks indicate July of the given year. (Courtesy James K. Angell, Air Resources Laboratory, NOAA Office of Oceanic and Atmospheric Research)

The relationship of the QBO to Atlantic tropical storm activity is shown in Figure I-19. Monthly averaged 30 and 50 mb zonal winds at Balboa, Canal Zone, are used to determine objectively the relationship of the QBO to tropical storm activity during the years 1952-86. The largest correlations between storm activity and the 30 mb wind are found in June. Extrapolation and direct calculation confirm a clear relationship between tropical storm activity and the zonal wind at about 50 mb.

When the QBO, as defined by the zonal wind at Balboa near 30 mb, is in the westerly phase of its oscillation during the Atlantic hurricane season, the seasonal number of tropical storms and hurricanes tends to be substantially greater than in the easterly phase.

Figure I-19 also shows the relationship of the El Nino episodes to Atlantic tropical storm activity. Seasons with moderate or strong El Nino episodes tend to occur with periods of low tropical storm activity.

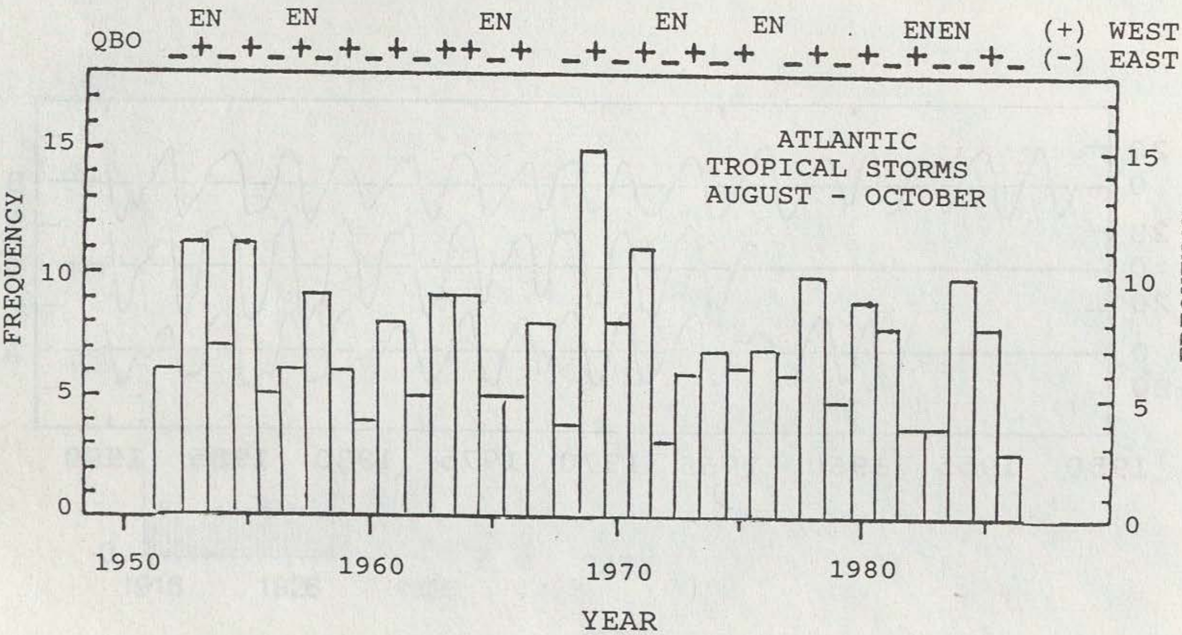


Figure I-19. Atlantic tropical storm activity for August through October 1952-1986. Plus sign (+) indicates a QBO west phase year, minus (-) a QBO east phase year, and no sign a transition year. El Nino years are designated "EN." (Courtesy Lloyd Shapiro, Atlantic Oceanographic and Meteorological Laboratory, NOAA Office of Oceanic and Atmospheric Research)

II. OCEAN

The ocean has a significant influence on climate as the Earth's storehouse for much of its water and vast amounts of its heat. The ocean acts as a buffer, smoothing short-term climate variations and delaying those of longer term. Additionally, the ocean is a major sink in the global carbon cycle and hence the main repository of carbon dioxide. Changes in the ocean can be detected by monitoring a number of indicators, many of which reflect the interaction and feedback of the ocean with the atmosphere, cryosphere, and biota. Indicators such as long-term sea level and mean sea surface temperature are related to changes in global climate. The El Nino/Southern Oscillation phenomenon, once regarded as a Pacific Ocean event, is now considered a global event. Ocean transport and coastal upwelling are indicators of climate change on regional-continental scales.

a. Tide Gauge Data

Sea level, as measured by tide gauges, has been rising along the coasts of the U.S. at the average rate of about 2 mm (0.08 inches) per year (Figure II-2). This is called "relative apparent secular sea level" (i.e., sea level that is apparently nonperiodic, with heights measured relative to adjacent land). Relative apparent secular sea level is generally rising at a rate greater than average along the East and Gulf coasts of the United States, and rising at a less than average rate to no change along the West coast.

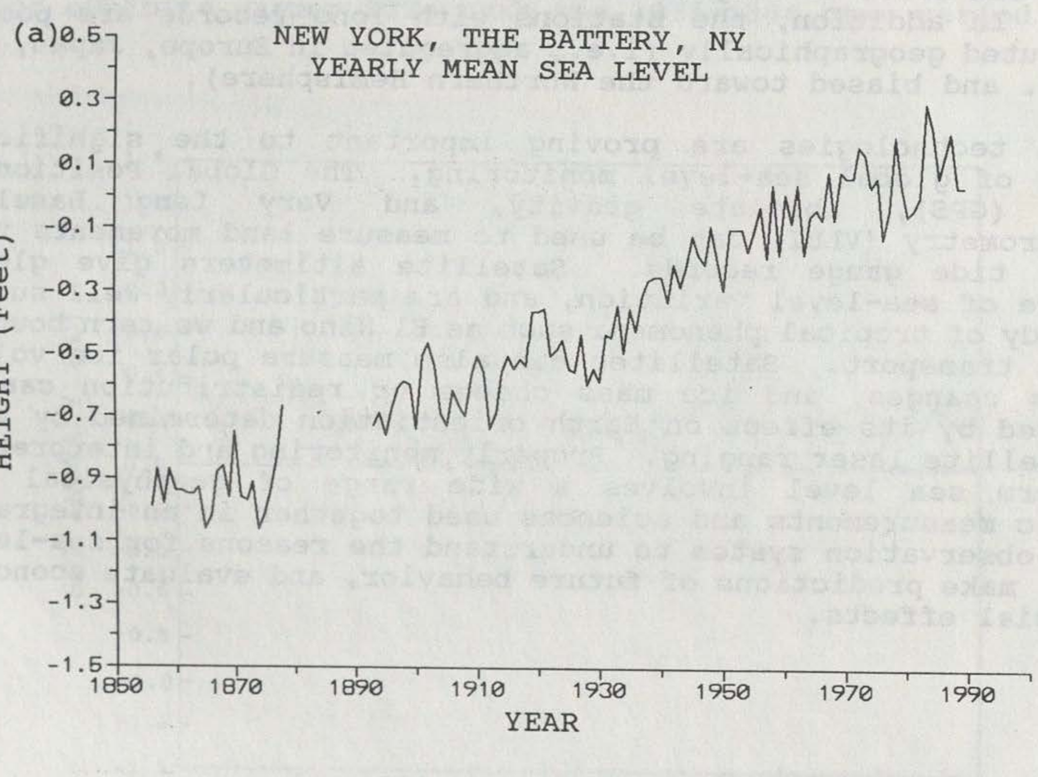
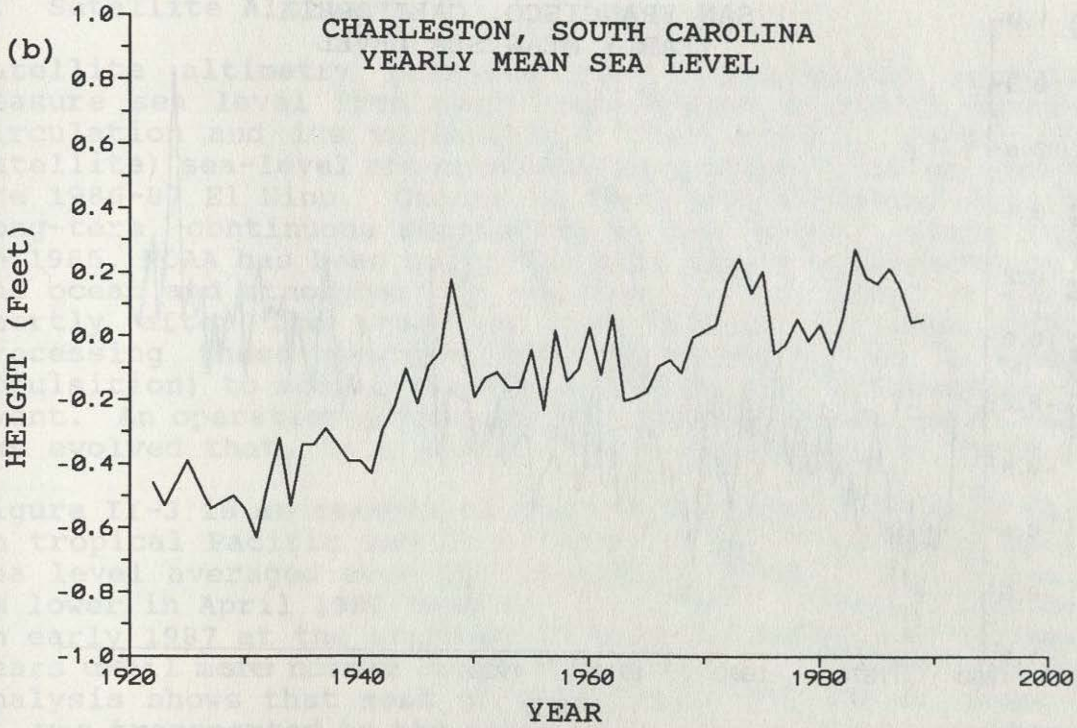


Figure II-2 (a)-(e). United States yearly mean sea levels at representative stations through 1989. (a) New York, The Battery, NY; (b) Charleston, SC; (c) Pensacola, FL; (d) San Francisco, CA; (e) Crescent City, CA. Ordinate normalized to 1960-1978 National Tidal Datum Epoch. (Courtesy Steacy D. Hicks, Physical Oceanography Division, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)



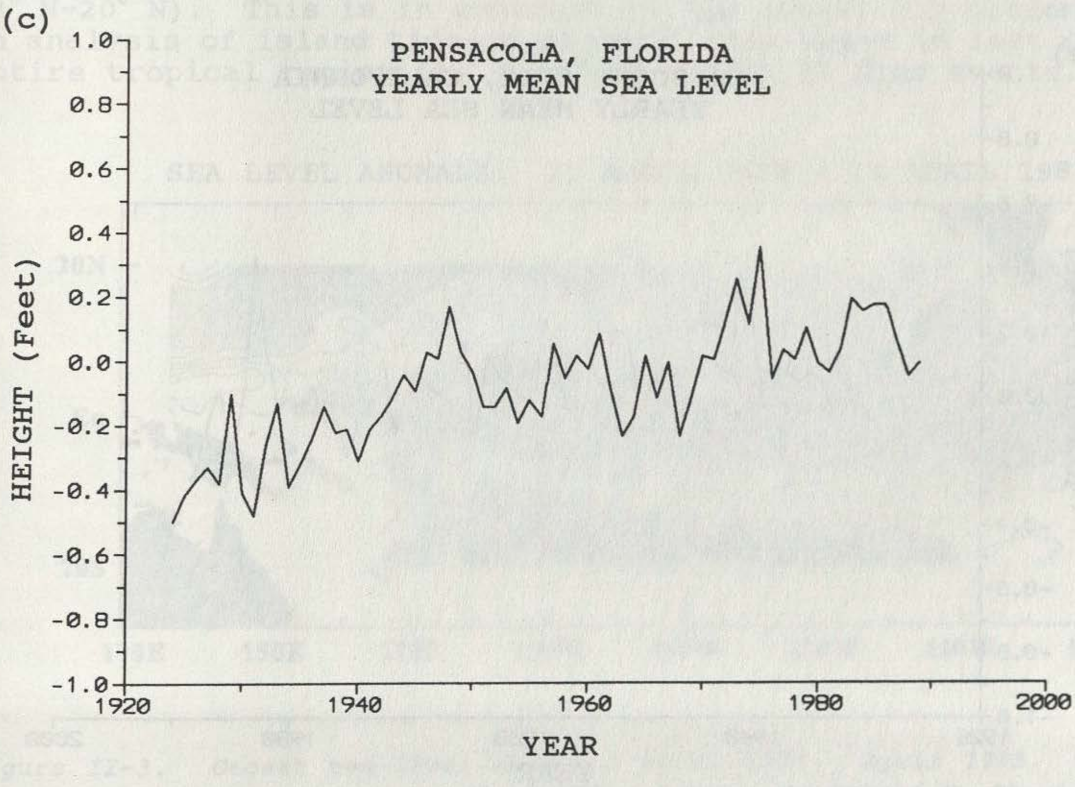
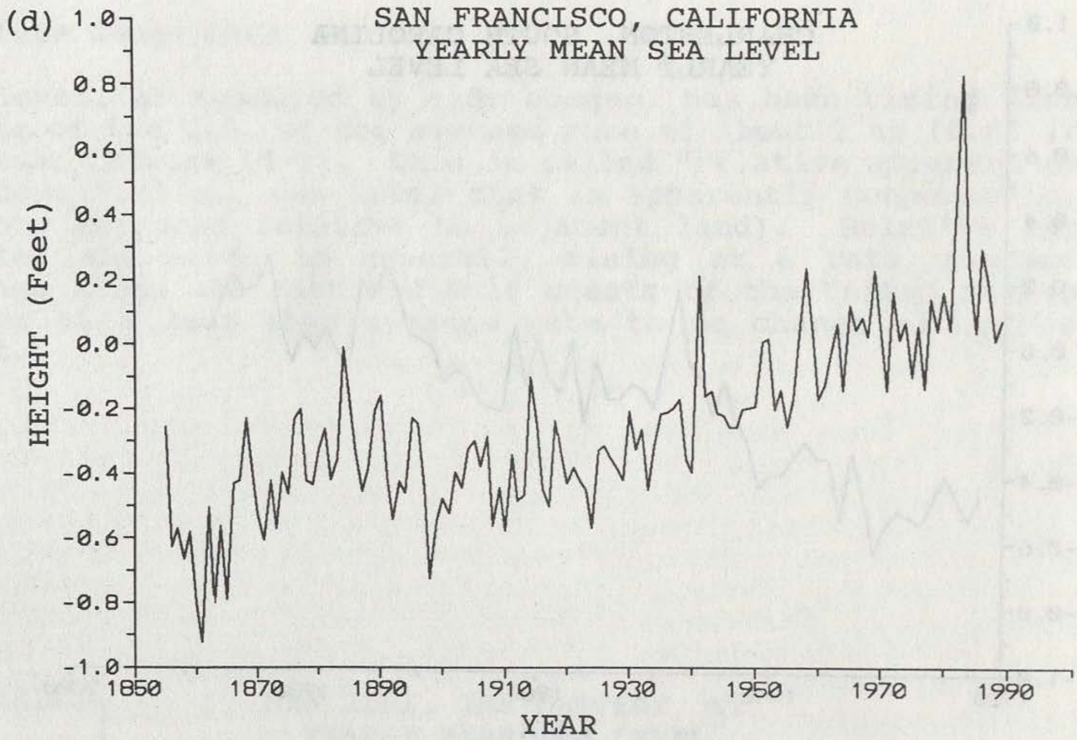


Figure II-2 continued.



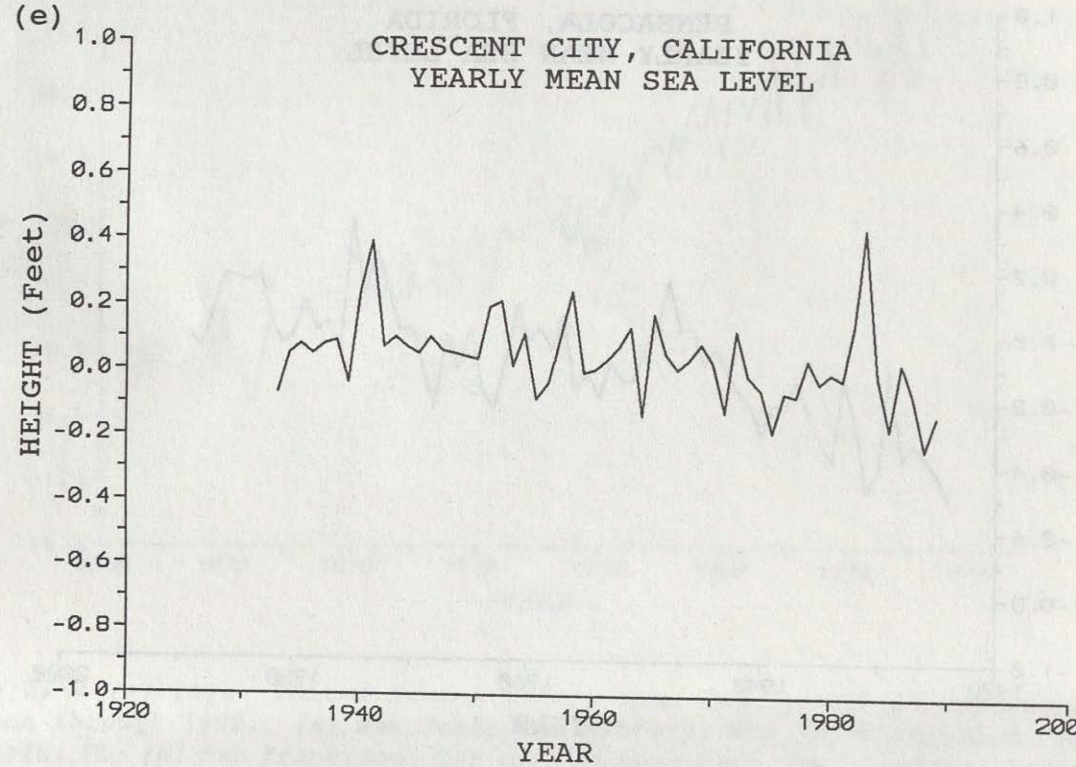


Figure II-2 continued.

b. Satellite Altimetry

Satellite altimetry provides the technological capability to measure sea level from space and determine global ocean-surface circulation and its variability. For example, Geosat (Geodetic Satellite) sea-level observations are presently being used to study the 1986-87 El Nino. Geosat is the first altimeter data used for long-term, continuous monitoring of sea level. Since its launch in 1985, NOAA has been using the data to study connections between the ocean and atmosphere in the tropical Pacific. In early 1987, shortly after the onset of the 1986-87 El Nino, NOAA began processing these data in near-real-time (1 to 2 weeks after acquisition) to monitor sea level during this interesting climatic event. An operational NOAA program of monthly sea-level monitoring has evolved that, as a result, now encompasses all three oceans.

Figure II-3 is an example of the NOAA analyses, showing the change in tropical Pacific sea level between April 1985 and April 1988. Sea level averaged over the equatorial band 7° S-7° N was about 5 cm lower in April 1988 than in April 1985. This deficit developed in early 1987 at the start of El Nino and persisted for nearly two years until more normal conditions returned in 1989. The altimeter analysis shows that most of this equatorial water, about 2×10^{14} m^3, was transported to the relatively narrow, north equatorial band (8° N-20° N). This is in contrast to the prevailing notion, based on analysis of island tide-gauge data, that water is lost from the entire tropical region (15° S-15° N) during El Nino events.

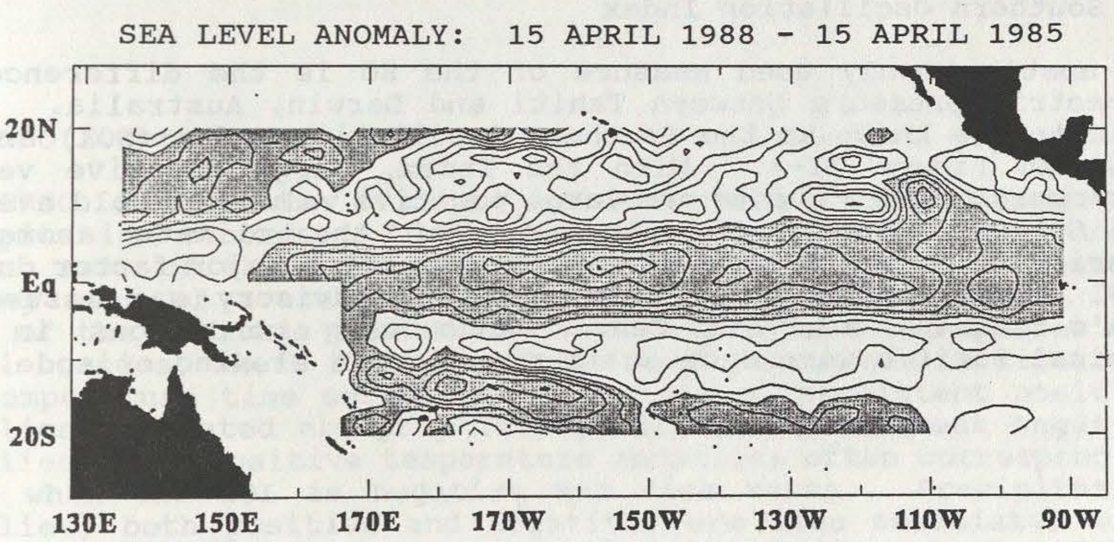


Figure II-3. Geosat sea-level anomaly, April 1988 - April 1985. Countour interval is 4 cm (negative areas shaded). (Courtesy Robert E. Cheney, Chief, Satellite and Ocean Dynamics Section, Charting and Geodetic Services, NOAA National Ocean Service)

EL NINO/SOUTHERN OSCILLATION (ENSO)

El Nino is an episodic warming of the eastern tropical Pacific Ocean which interrupts the normally biologically productive upwelling process along the coast of South America. El Nino events have been associated with extensive climatic and economic impacts around the world. An El Nino (named for the Christ Child, because it frequently corresponds with the Christmas season) happens after the normally strong trade winds of the Eastern Pacific have transported massive amounts of water westward. The winds occasionally slacken, and when they do, warm water moves eastward back across the ocean. Eventually this water replaces upwelling along the coast of South America, killing marine life and influencing global weather and climate patterns.

El Nino is part of the Southern Oscillation (SO), a global-scale pattern of atmospheric pressure and oceanic circulation fluctuations occuring between Indonesia, North Australia and the southeast Pacific. The El Nino/Southern Oscillation (ENSO) episodes lead to changes in the rainfall of the tropics, bring drought to large areas and heavy rains to normally arid regions. Unusual weather conditions sometimes extend as far as New Zealand and the United States. The El Nino of 1982-83, for example, brought unprecedented wind, wave, and water damage to coastal property along the west coast of the United States. These same storms led to record snowpacks on the Rocky Mountains and record springtime flooding.

a. Southern Oscillation Index

The most commonly used measure of the SO is the difference in barometric pressure between Tahiti and Darwin, Australia. This indicator is known as the Southern Oscillation Index (SOI) and is shown in Figure II-4. With the Index, large negative values correspond to warm events and large positive values to cold events. The SO was associated with many of the climate anomalies experienced during 1987 and 1988, but was not a major factor during 1989. However, early ln 1990, an ENSO Advisory was issued by NOAA's Climate Analysis Center announcing conditions in the tropical Pacific were once again ripe for an El Nino episode.

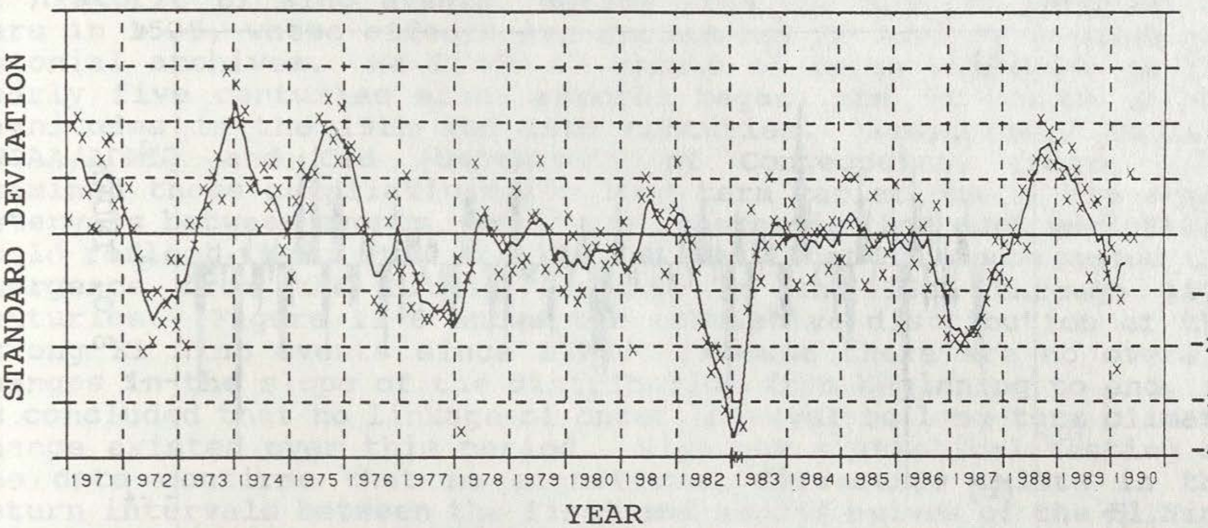


Figure II-4. Five-month running mean of the difference between the standardized sea-level pressure anomalies at Tahiti (17° 33'N, 149° 37'W) and Darwin, Australia (12° 26'S, 130° 52'E). Values are standardized by the mean annual standard deviation. Xs are individual monthly means. Base period for standard deviation: 1951-1980. (Courtesy Climate Analysis Center, NOAA National Weather Service)

b. ENSO Events

The ENSO signal is evident in continental temperature and precipitation records. Figure II-5 shows a long-term five-month running mean of the SOI together with a corresponding five-month running mean of average monthly temperature anomalies for land areas of the latitude zone 25° N-25° S. This area encompasses the global tropics, where the core of the ENSO phenomenon is situated. The temperature time series shows periods of persistent positive anomalies separated abruptly from periods of persistent negative anomalies. The positive temperature anomalies often correspond to times when the SOI is negative and vice versa. Precipitation anomalies, both positive and negative, are also associated with warm and cold ENSO events over many other parts of the globe. Typically, warm events are associated with drier than normal values over the tropics, with wetter than normal seasons often accompanying cold events.

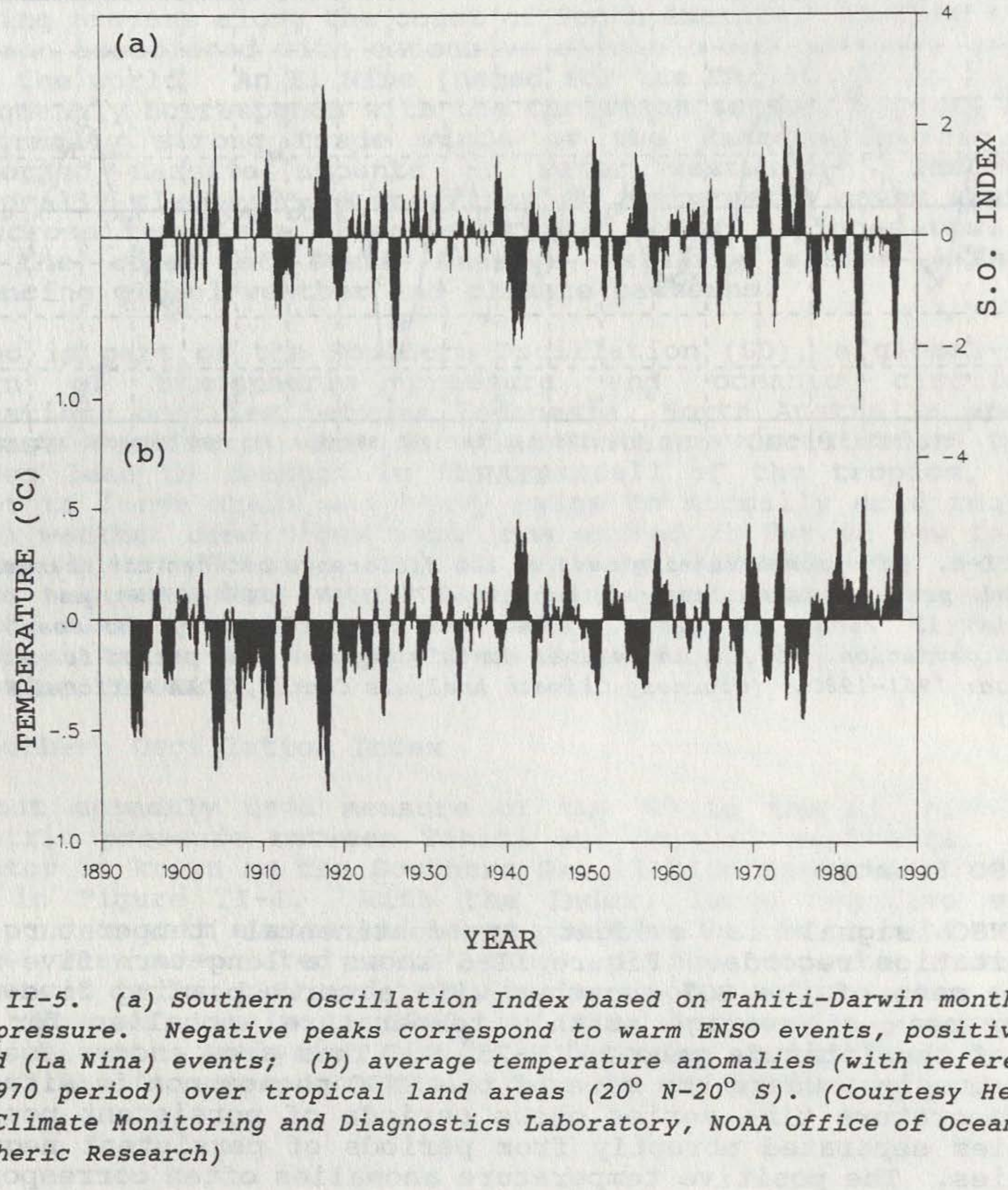


Figure II-5. (a) Southern Oscillation Index based on Tahiti-Darwin monthly sea level pressure. Negative peaks correspond to warm ENSO events, positive ones to cold (La Nina) events; (b) average temperature anomalies (with reference to 1951-1970 period) over tropical land areas (20^o N-20^o S). (Courtesy Henry F. Diaz, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research)

c. El Nino Events

Professor W.H. Quinn of Oregon State University has compiled a list of historic El Nino events, dating from the Spanish conquest of Peru in 1525, whose effects are documented in various Spanish and colonial archives. He finds 47 events of large magnitude in the nearly five centuries since records began, and 50 events of all magnitudes in the 19th and 20th centuries. Researchers Enfield (NOAA/AOML) and Cid (University of Conceopcion, Chile) have examined these compilations for long term variations in the onset intervals between events, under the hypothesis that such variations could reflect the change in global climate that has accompanied the emergence from the Little Ice Age of the 16th through 18th centuries. Figure II-6 shows the cumulative distribution of the strong El Nino events since 1525. Because there are no overall changes in the slope of the distribution from beginning to end, it is concluded that no linkage of onset interval to long-term climate change existed over this period. Rigorous statistical testing of the data confirms that no significant difference exists in the return intervals between the first and second halves of the El Nino record. Researchers note, however, that cyclical changes in the return interval of El Nino events are suggested by the long-term changes in the slope of the distribution.

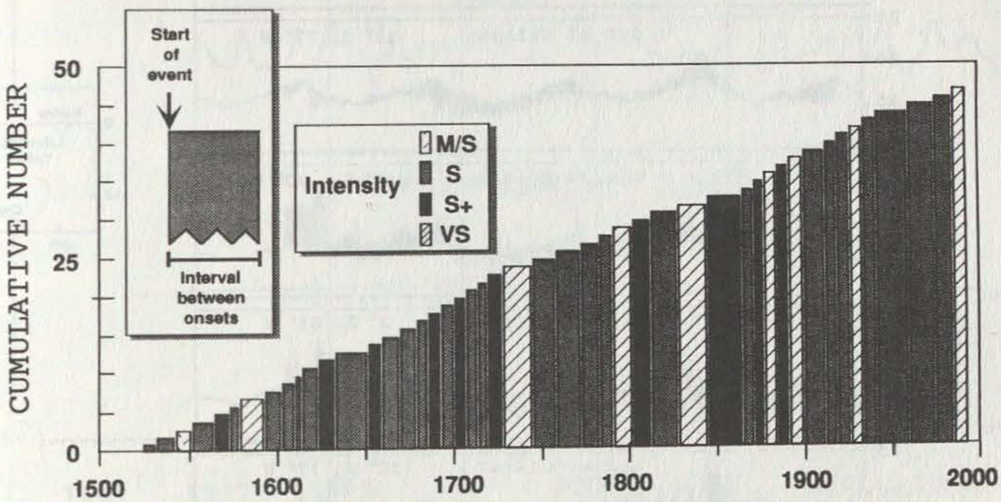


Figure II-6. Occurrences of El Nino since historical records began in 1525. The width of each bar represents the time interval between successive onsets of El Nino, and the height is the cumulative number of events. Intensities shade-coded in the legend are moderate-to-strong (M/S), strong (S), quite strong (S+), and very strong (VS). (Courtesy David B. Enfield, Atlantic Oceanographic and Meteorological Laboratory, NOAA Office of Oceanic and Atmospheric Research)

Figure II-7 shows five-day averages of sea surface temperature and sea level height. Through cooperative arrangements with South American institutions, the Tropical Ocean Global Atmosphere (TOGA) Program has maintained a network of nine tide stations and four meteorological stations in Ecuador, Peru, and Chile since the mid-1980s. The hourly data are transmitted to down-link stations via GOES satellite in real time and processed at the end of each month. The format gives an effective means of monitoring coastal conditions at critical stations with good resolution and compact data volume. The anomalies in Figure II-7 show a sequence of cool and warm years in the eastern tropical Pacific. Generally, the combination of warm conditions with high sea levels indicates a warm episode (El Nino), as in the period from mid-1986 until early 1988. The opposite tendency for the rest of 1988 and part of 1989 was a manifestation of an extreme cold event. Throughout most of 1989 and 1990 sea levels have been high but SST has not risen to above-normal levels.

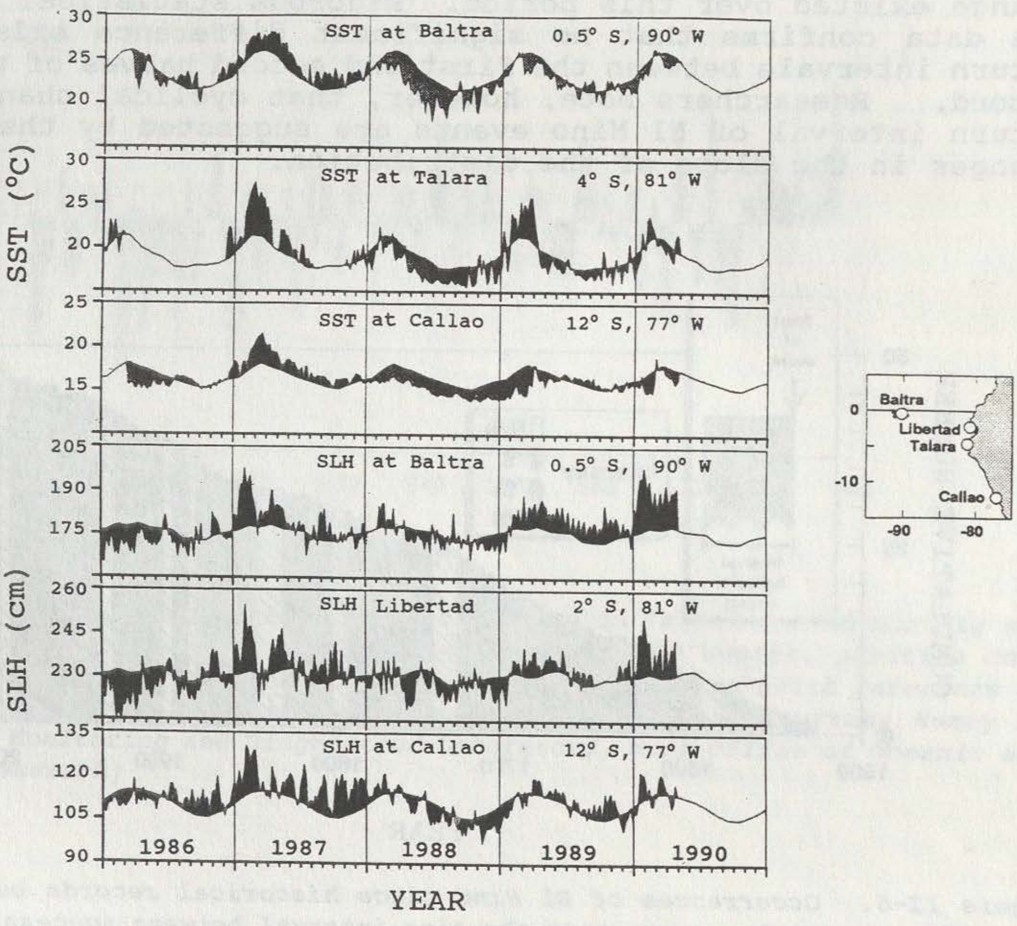


Figure II-7. Five-day averages of sea surface temperature (SST,°C) and sea level (SLH,cm) at east Pacific stations. Map insert shows station locations. (Courtesy David B. Enfield, Atlantic Oceanographic and Meteorological Laboratory, NOAA Office of Oceanic and Atmospheric Research)

OCEAN TRANSPORT

Ocean circulation is an indicator of global climate variability on the decadal time scale. The role of ocean circulation in transporting heat and modifying the effects of global climate change is not well understood. Recent research has identified the Atlantic Ocean latitude band 20° N to 30° N. as having the largest poleward heat flux in the North Atlantic basin. Figure II-8 shows the variability within the Florida Current as indicated by changes in ocean transport. This monitoring was done using measurements of the cross-stream voltage between Florida and Grand Bahama Island, generated by the flow of the Florida Current through the Earth's magnetic field as measured through two submarine cable segments along the seafloor. The fluctuations in the 30 day running mean of the transport (Figure II-8, upper curve) show that there are large seasonal changes in transport and that these fluctuations are larger in some years than others. It is not known at this time whether these fluctuations are an indicator of climate variability or long-term change. The yearly average values for six-month increments (Figure II-8, bottom curve) do not show significant change in the yearly mean transport of 32 Sverdrups.

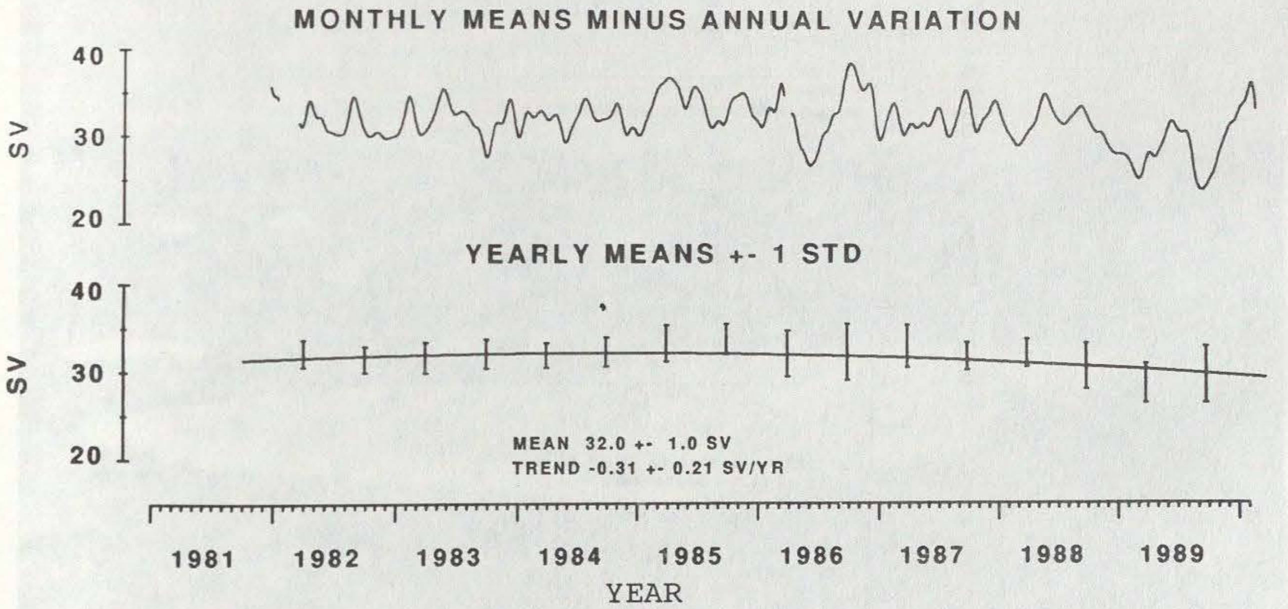


Figure II-8. Monthly mean transport for Florida Straits (27° N) derived from cable measurements made between Settlement Point, Grand Bahama Island, and near Jupiter Inlet, Florida, using cable voltages. Monthly means minus annual variation (top curve), and yearly means by 6-month increments (bottom curve) are given. SV = Sverdrups (10^6 m^3/sec). (Courtesy Jimmy C. Larsen, Pacific Marine Environmental Laboratory, NOAA Office of Oceanic and Atmospheric Research)

COASTAL UPWELLING

Upwelling regions are among the most biologically productive areas of the ocean. The most important upwelling areas are the eastern boundary currents off California, Peru, Northwest Africa and Southwest Africa. Not only are upwelling regions of high economic importance (yielding up to 50% of the world's fish catches), but they strongly influence adjacent coastland weather and climate. Increasing alongshore wind stress, which drives coastal upwelling, has been linked to long-term climate variation and change, and even global warming. Changes in the rate of coastal upwelling can therefore be used as an indicator of climate variability. No routine observations of upwelling are available. Accordingly, a coastal upwelling index based on an estimate of the alongshore wind stress (i.e., the driving force for upwelling) has been used to indicate variations of intensity of upwelling (Figure II-9).

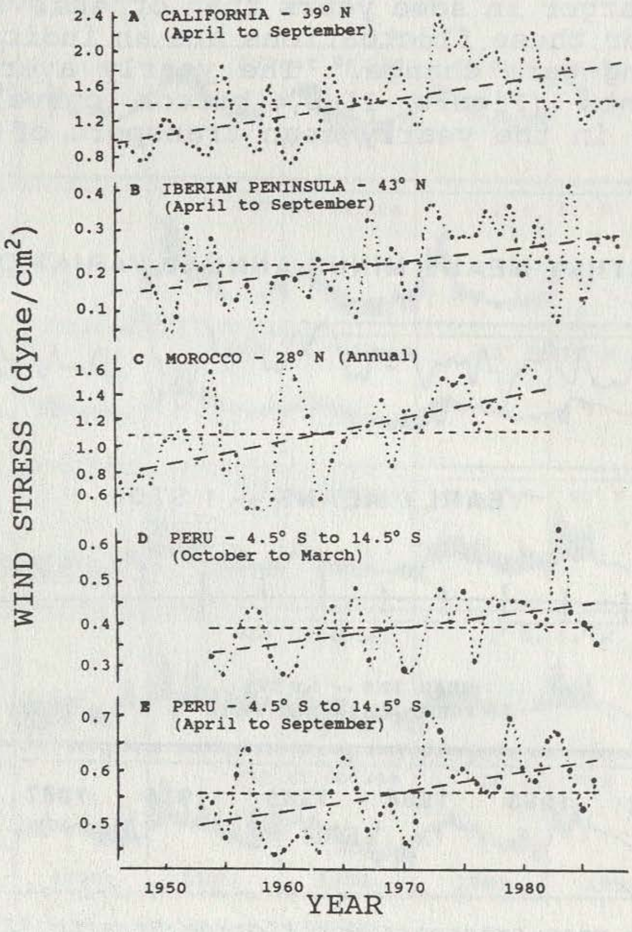
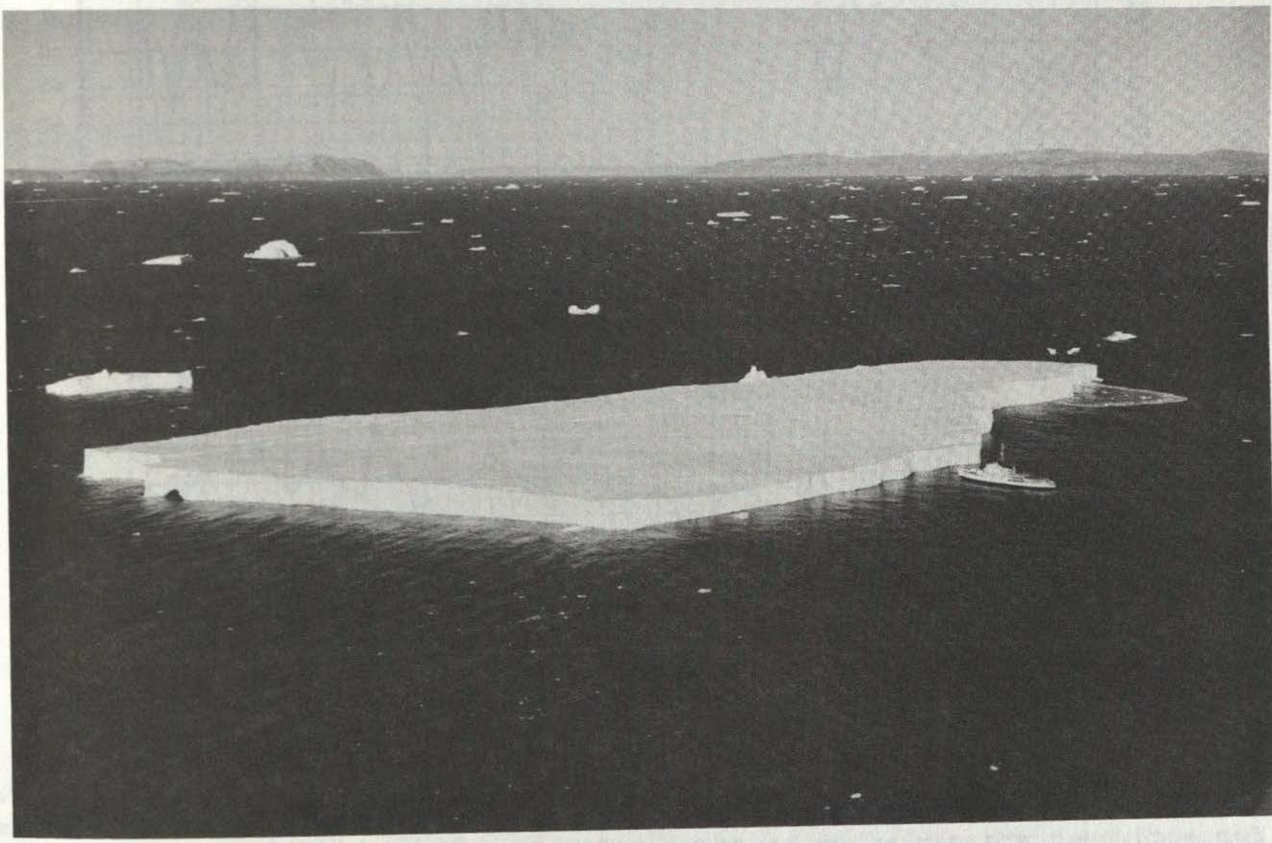


Figure II-9 (a)-(e). Monthly estimates of alongshore wind stress off (a) California, (b) the Iberian Peninsula, (c) Morocco, and (d) and (e) Peru. Short dashes indicate long-term mean. Long dashes indicate linear trend fitted by least squares method. (Courtesy Andrew Bakun, Chief, Pacific Fisheries Environmental Group, NOAA National Marine Fisheries Service)

III. CRYOSPHERE

Sea ice and snow cover are important factors related to the Earth's heat budget and in determining the amount of solar energy reflected back into space (planetary albedo). Latitudinal variations in the Earth's albedo help determine atmospheric circulation and consequently the heat transferred from equator to pole. The processes that accommodate this flux of heat influence both short-term weather and long-term climate. Change in the volume of ice is an indicator of global temperature change as are the long-term seasonal amounts and extent of snow cover and sea ice.



SEA ICE

Sea ice influences global climate through its effect on planetary albedo. Additionally, it influences energy transfers of heat between the atmosphere and oceans and affects the temperature and salinity structure of the ocean. The melting and freezing that occur at the margins of sea ice produce effects on water stability and circulation that promote mixing, upwelling, and nutrient enhancement. These "ice edge effects" act to enhance biological productivity. Measurements of sea-ice extent, type, movement, surface temperature, and albedo are important indicators of climate change. Time series of monthly sea-ice extent are shown in Figure III-1. The monthly values are standardized by subtracting the monthly mean (1973-1989). The year-to-year decrease in Antarctic sea ice that occurred during the the 1970s was associated with a large open area in the Weddell Sea that appeared during the Southern Hemisphere winter.

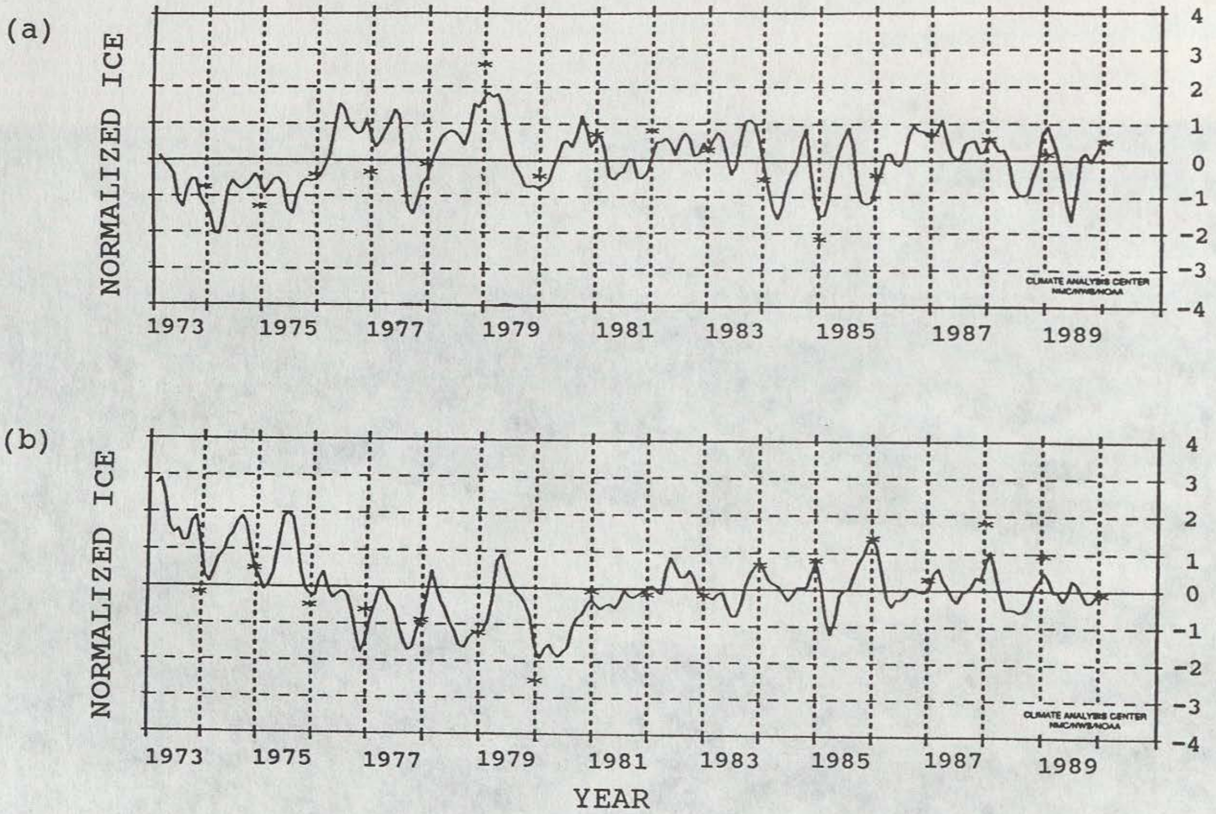


Figure III-1 (a)-(b). Mean monthly standardized sea-ice extent for (a) the Arctic and (b) the Antarctic, for 1973 to 1989. The December standardized values for each year are marked by an "". Solid lines represent a 3-month running mean. (Courtesy Climate Analysis Center, NOAA National Weather Service)*

SNOW COVER

The extent of snow cover is an important factor in the planetary radiation budget. In addition, measurements of the extent, depth, density, and liquid content of snow are important for determining global precipitation and run-off volumes. Satellite-derived snow cover estimates have been available since the 1960s. These values were not considered suitable for use in scientific analysis until 1973. The record indicates that the late 1970s were marked by a sequence of years with considerably above-normal snow cover. This prompted theories of a rapid possible return to Ice Age conditions. The 1980s have witnessed less snow cover and a general return to the pre-1970s conditions (Figure III-2).

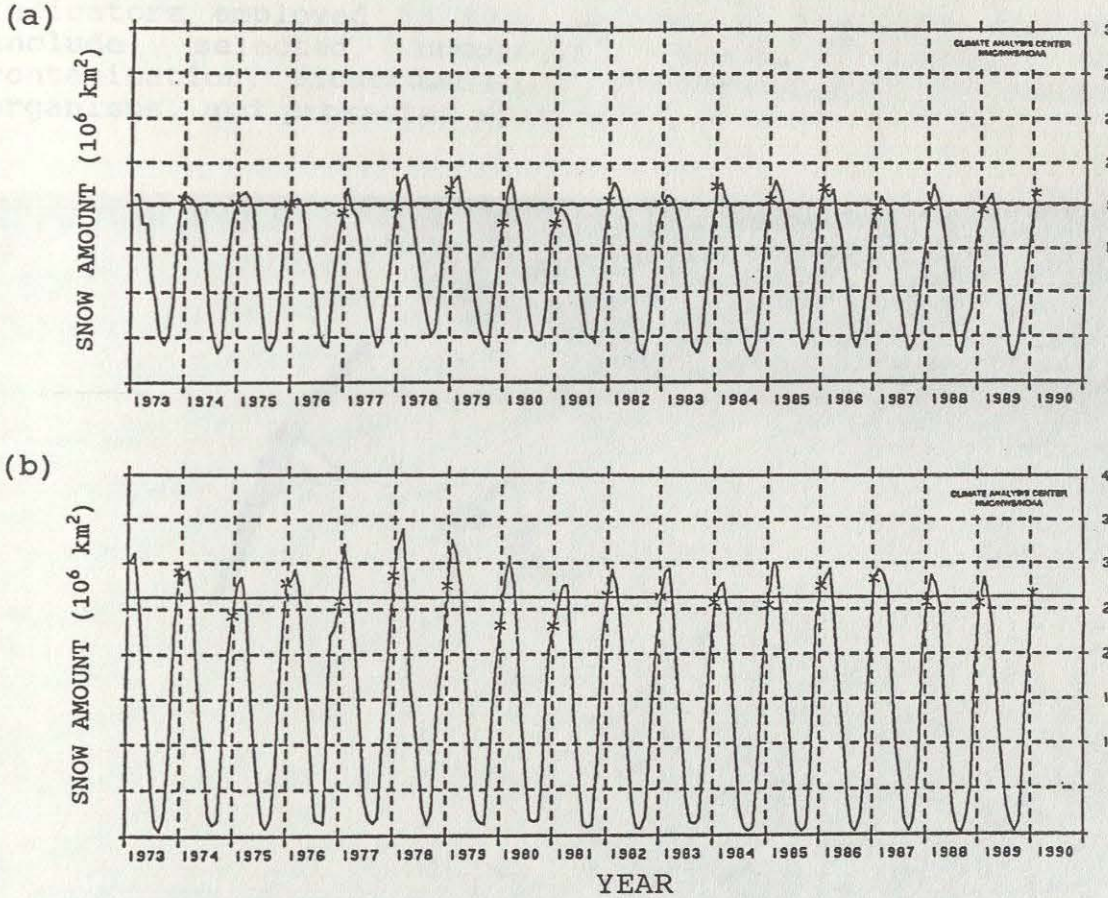


Figure III-2 (a)-(b). Monthly extent of snow cover (in 10^6 km^2) for (a) North America and (b) Eurasia. The December snow cover extent is designated by an "" for each year. Solid horizontal lines represent 1973-89 mean snow cover extent. (Courtesy Climate Analysis Center, NOAA National Weather Service)*

IV. BIOSPHERE

Life has continually adapted to changes in the Earth's climate since its first appearance billions of years ago. Natural selection has eliminated many species and allowed genetically adaptable life forms to evolve. Not only has life adapted to variations in climate, but the presence of life itself has influenced climate. Natural processes, biological interactions, and increasingly, human activities have caused changes in the global ecosystem, changes in species abundance, and modification of habitats. Some of these changes have negative consequences.

Indicators employed in this section to represent the biosphere include selected commercial fisheries data, shellfish contamination, bioaccumulation of contaminants in sediments and organisms, and protected species.

SELECTED U.S. FISHERIES DATA

Fish are an important part of the American diet. Our fishery resources support the large commercial and recreational fishing industries, providing food, income, employment, and recreation. In the United States commercial landings of fish and shellfish have a value of billions of dollars. On a global basis, commercial fisheries harvest only a few of the thousands of species of fish in the oceans.

Most fishery resources are products of coastal waters and adjacent estuaries, areas that are increasingly subject to pollution, habitat loss, and over-fishing. In the United States, two-thirds of the commercial fisheries harvest is estuarine dependent. Regional stocks of the most popular species are declining and species composition, size, and abundance are being changed.

Indicators presented in this section are fish population status and trends, and landings for selected commercial and sport fish. These examples represent both fishery-dependent indicators (e.g., commercial catch- and effort-data) and fishery-independent indicators (e.g., research vessel trawl surveys, plankton surveys for young fish, etc.). The examples provide information not only for fishery-management applications, but also for the use of fisheries data as indicators of changing marine environmental conditions.

a. Northeastern Fisheries

In the Northeastern United States there are approximately 21 species of groundfish, pelagic fish, mollusks and crustaceans currently under management by the Regional Fishery Management Councils. Statistics gathered by the Northeast Fishery Managemment Council indicate that the most severe management problems are with groundfish and flounder, where catches have declined substantially. As an example of changes in these fisheries during the past 25 years, the species composition and abundance of finfishes on the Georges Bank has changed dramatically. Figure IV-1 depicits a 25-year trend in the abundance of all fish species caught by research vessel trawl surveys. It shows the remarkable change in the system over that period, change from a system dominated by commercially valuable ones to a system dominated by very-low-valued non-marketed species. This change is attributable to severe overfishing of commercially important stocks (haddock, yellowtail flounder, cod), combined with fisherman avoidance of the non-marketed species (dogfish, skates), and possibly a biological response of the non-marketed stocks. This phenomenon is currently the subject of a very active research program within NOAA.

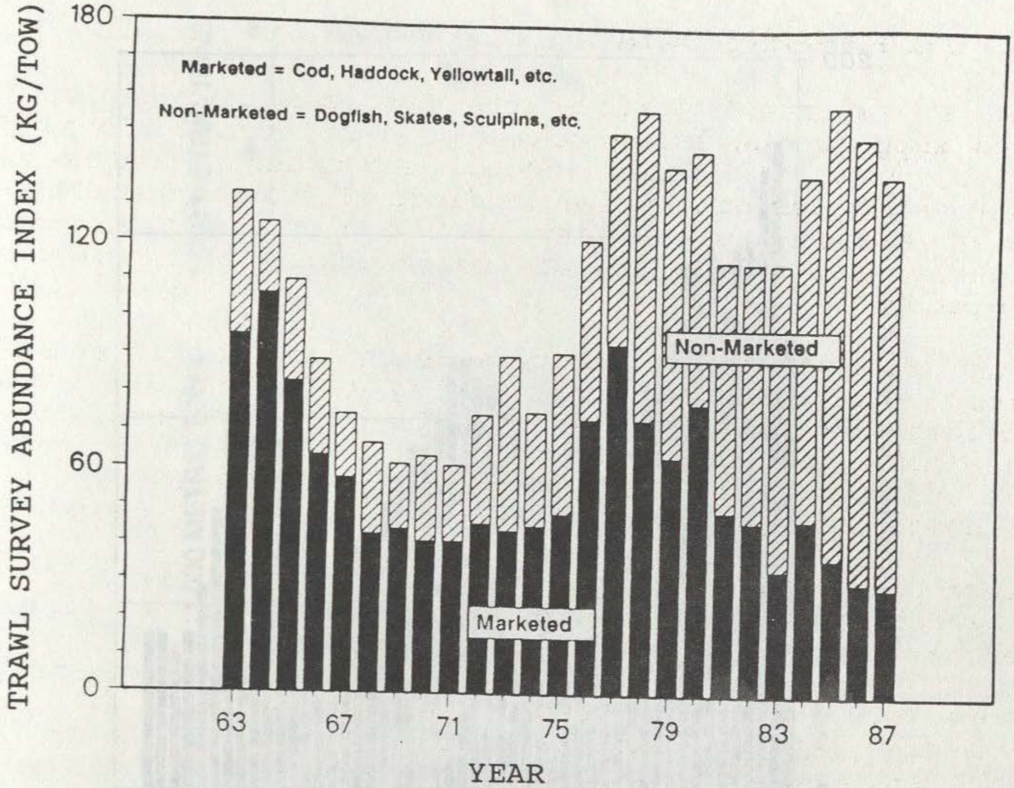


Figure IV-1. Bottom trawl survey data (kilograms/tow) for total mixed-species catches on Georges Bank, 1963-1987. (Courtesy Steven A. Murawski, Conservation and Utilization Division, Northeast Fisheries Center, NOAA National Marine Fisheries Service)

Figure IV-2 depicts a 50-year time series of commercial landings data for four of the most important groundfish species of the northeast region. The virtual collapse of the haddock, redfish, and yellowtail flounder stocks has left cod as by far the main contributor to northeast groundfish landings. Species diversity in landings has declined substantially, as have aggregate species landings, and the underlying stocks that support the fisheries. Landings of these species from United States waters peaked during World War II, as government price supports fueled effort. Landings declined substantially following this period, as price supports were lifted, and some of the stocks declined in abundance. Significant overfishing of these stocks occurred in the late 1960s-early 1970s, as distant-water factory fleets intensively fished in the United States continental shelf waters. Recent landings data for these species are indicative of declines in the underlying resources, as these stocks have been seriously overfished.

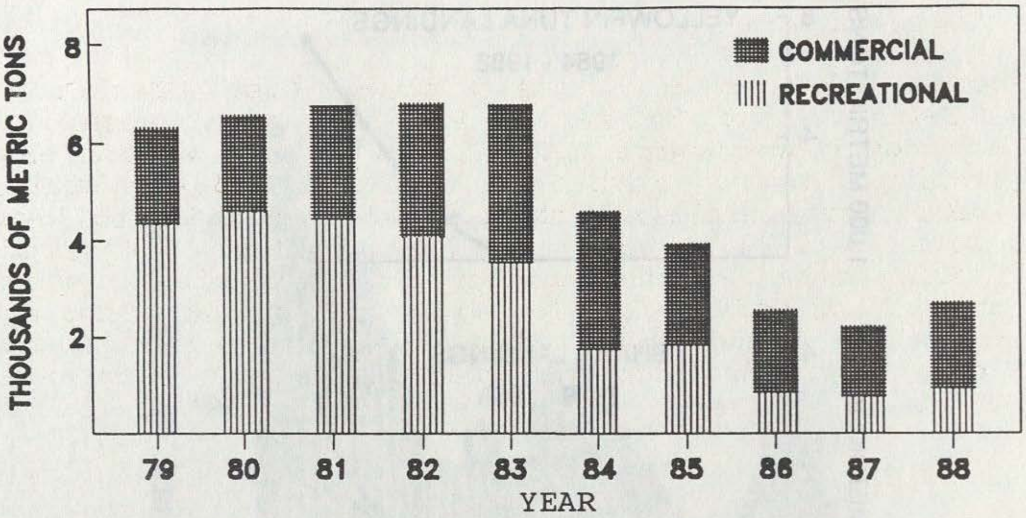


Figure IV-4. Decline in recreational and commercial landings of the reef-fish red snapper in the Gulf of Mexico from 1979 to 1988. (Courtesy Joan A. Browder, Miami Laboratory, Southeast Fisheries Center, NOAA National Marine Fisheries Service)

Shrimp fishing results in an extensive bycatch of bottomfish species such as Atlantic croaker and spot, most of which are killed and discarded. The increased intensity of shrimp trawling in the northern Gulf of Mexico may be responsible for the decline in bottomfish biomass observed in resource surveys (Figure IV-5).

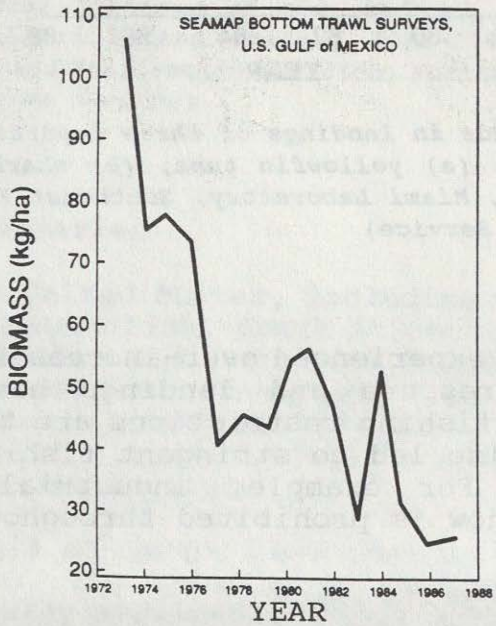


Figure IV-5. Decline in bottom finfish biomass (kilograms/hectare), Gulf of Mexico. (Courtesy Joan A. Browder, Miami Laboratory, Southeast Fisheries Center, NOAA National Marine Fisheries Service)

c. Other Selected Data

United States landings of Pacific trawl fish (Pacific cod, flounders, Pacific hake [whiting], Pacific ocean perch, Alaska pollock, and rockfishes) were 3.0 billion pounds, an increase of 68% in quantity compared with 1988. Alaska led all states in volume of commercial landings with 4.1 billion pounds, followed by Louisiana with 1.2 billion pounds. Alaska pollock, with landings of 2.4 billion pounds, was the most important species in quantity in 1989, accounting for 28% of the commercial fishery landings in the United States. Landings of Alaska pollock in 1989 increased 88%, more than five times higher than the 1984-1988 5-year average (Figure IV-6).

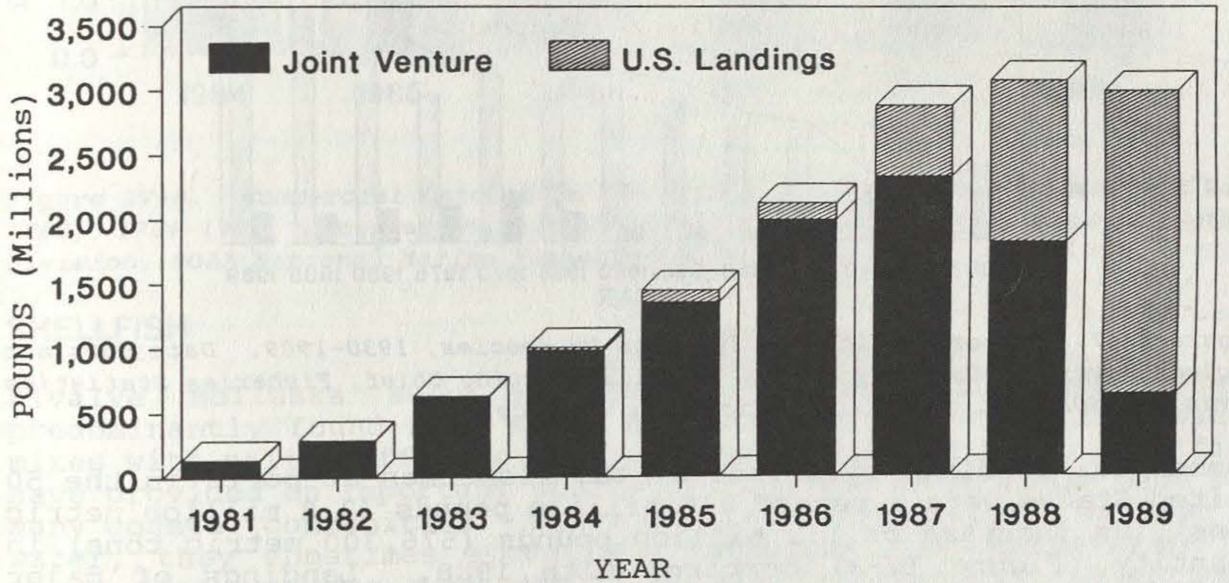


Figure IV-6. United States commercial catch of Alaskan pollock, 1981-1989. See Appendix C for definition of joint venture. (Courtesy Mark C. Holliday, Acting Chief, Fisheries Statistics Divison, NOAA National Marine Fisheries Service)

American lobster landings in 1989 were 52.9 million pounds, an increase in quantity of 4.3 million pounds in quantity (9%) compared with 1988 (Figure IV-7). Maine led in landings for the eighth consecutive year with 23.3 million pounds, up 1.5 million pounds (7%) from 1988. Massachusetts, the second leading producer, had landings of 16.2 million pounds, an increase of 719,000 pounds (5%) compared with 1988. These two states combined to produce 74% of the total national landings.

United States landings of spiny lobster in 1989 were 8.1 million pounds, an increase of 959,000 pounds (13%) in quantity compared with 1988 (Figure IV-7). Florida, with landings of 6.5 million pounds, accounted for 80% of the total catch. This was an increase of 1.1 million pounds (20%) in quantity compared with 1988.

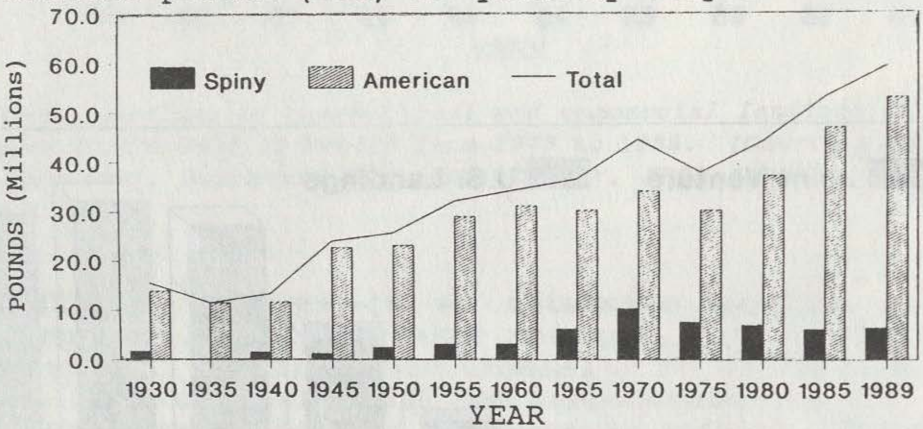


Figure IV-7. Historical lobster landings by species, 1930-1989. Data does not include Hawaii. (Courtesy Mark C. Holliday, Acting Chief, Fisheries Statistics Division, NOAA National Marine Fisheries Service)

Commercial landings by United States fishermen at ports in the 50 United States were a record 8.5 billion pounds (3.8 million metric tons), an increase of 1.3 billion pounds (576,300 metric tons) in quantity (Figure IV-8) compared with 1988. Landings of major finfish species such as Atlantic and Pacific cod, Alaska pollock, and salmon increased. Finfish accounted for 84% of the total landings. but only 53% of the total value of finfish and shellfish. Joint venture catches by United States fisherman unloaded onto foreign vessels were 1.7 billion pounds (771,000 metric tons) (Figure IV-8). This was a 47% decrease in quantity over 1988, when 3.2 billion pounds (1.5 million metric tons) were caught. The major species were cod, flounders, Pacific hake, and Alaska pollock. The foreign catch of fish (excluding tunas) and shellfish in the United States Exclusive Economic Zone (EEZ) was 82.1 million pounds (37,200 metric tons) in 1989 (Figure IV-8), a 40% decrease compared with 1988 and 94% below the average for the preceding 5 years. The foreign catch off the North Atlantic United States EEZ supplied the largest share of the total (99%). There were no foreign catches in the United States EEZ off California, Oregon and Washington in 1989.

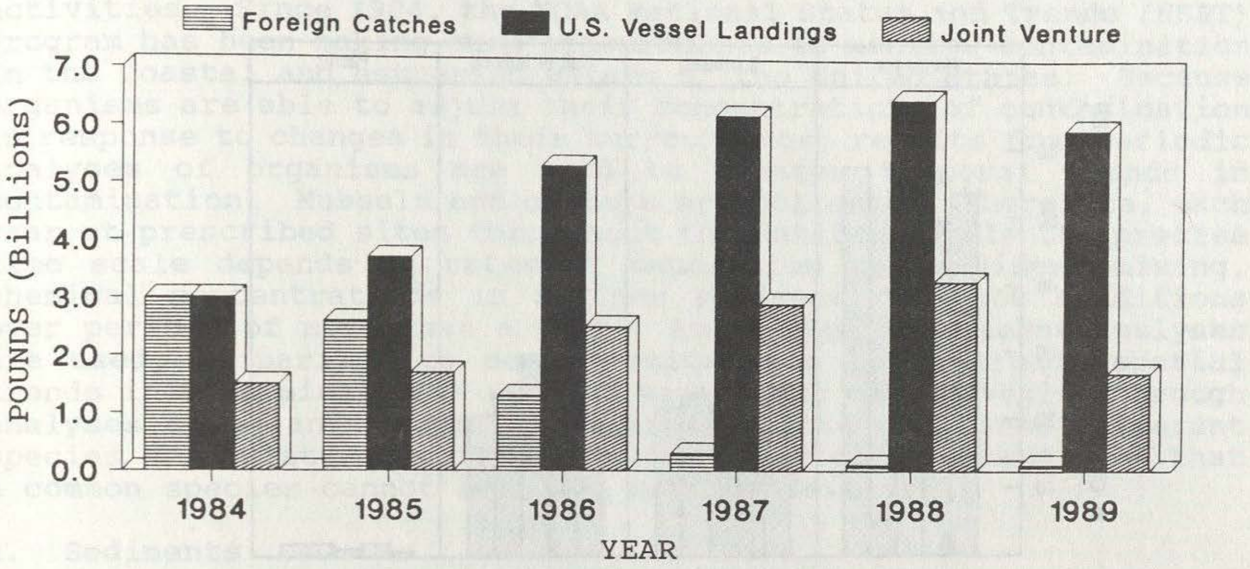


Figure IV-8. Commercial catches in the United States Exclusive Economic Zone (EEZ), 1984-1989. (Courtesy Mark C. Holliday, Acting Chief, Fisheries Statistics Division, NOAA National Marine Fisheries Service)

SHELLFISH

Bivalve mollusks such as oysters, clams, and mussels are predominantly found near shore and in estuaries where freshwater mixes with saline offshore waters. Since colonial times shellfish have provided an important source of food and an economic base for many coastal communities. Since shellfish filter large volumes of water, they sometimes accumulate pathogens and contaminants in their tissues. As many shellfish are traditionally eaten raw, contaminated products could be a significant public health problem. The states place shellfish waters in 5 classifications based on sanitary surveys. The five classes are approved, prohibited, conditionally approved, restricted, and nonshellfish/nonproductive. Classification of shellfish growing waters is based on the presence of actual or potential pollution sources and levels of coliform bacteria in surface waters.

The National Shellfish Register of Classified Estuarine Waters is produced by NOAA. Previous inventories of the National Shellfish Register have been conducted in 1966, 1971, 1974, 1980, and 1985. The latest inventory began in February 1990 and will include a field survey of classified shellfish waters in 24 states. The survey will quantify the changes since 1985, identify the reasons for the changes, and the sources of pollution affecting harvest limited waters. Results will be published in January 1991. Figure IV-9 illustrates the regional trends (1966-1985) in approved waters during the period these inventories have been conducted. Trends in prohibited acreage (1966-1985) are shown in Figure IV-10.

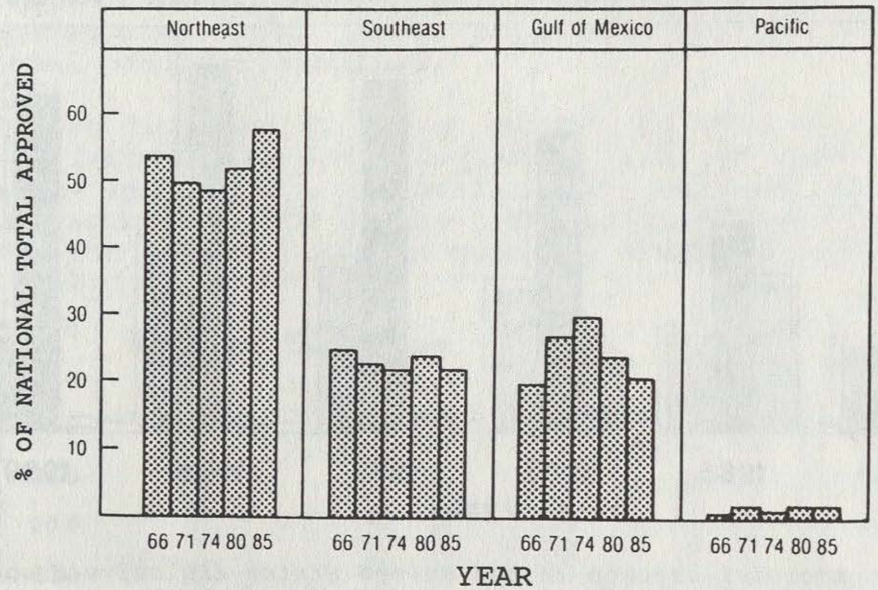


Figure IV-9. Approved shellfish waters by region, 1966-1985. (Courtesy Dorothy L. Leonard, Strategic Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)

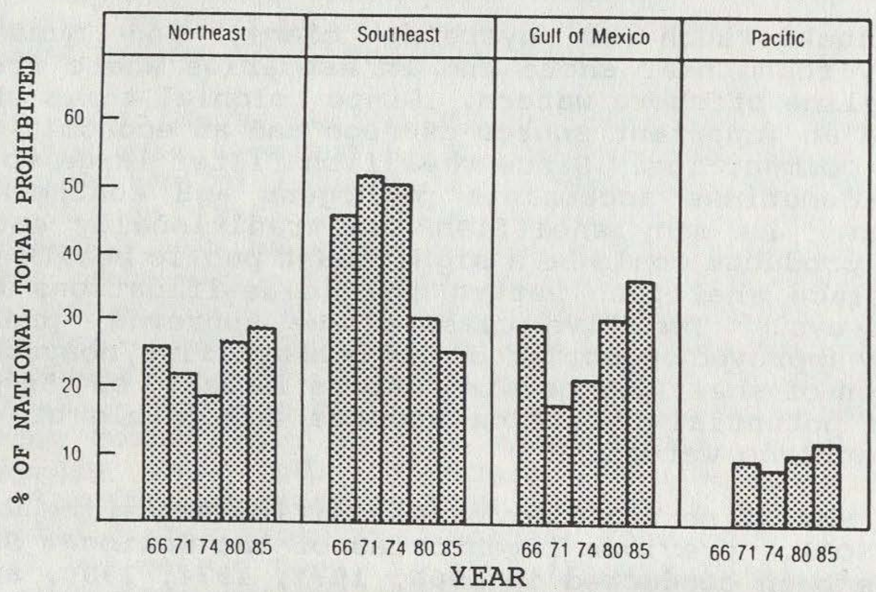


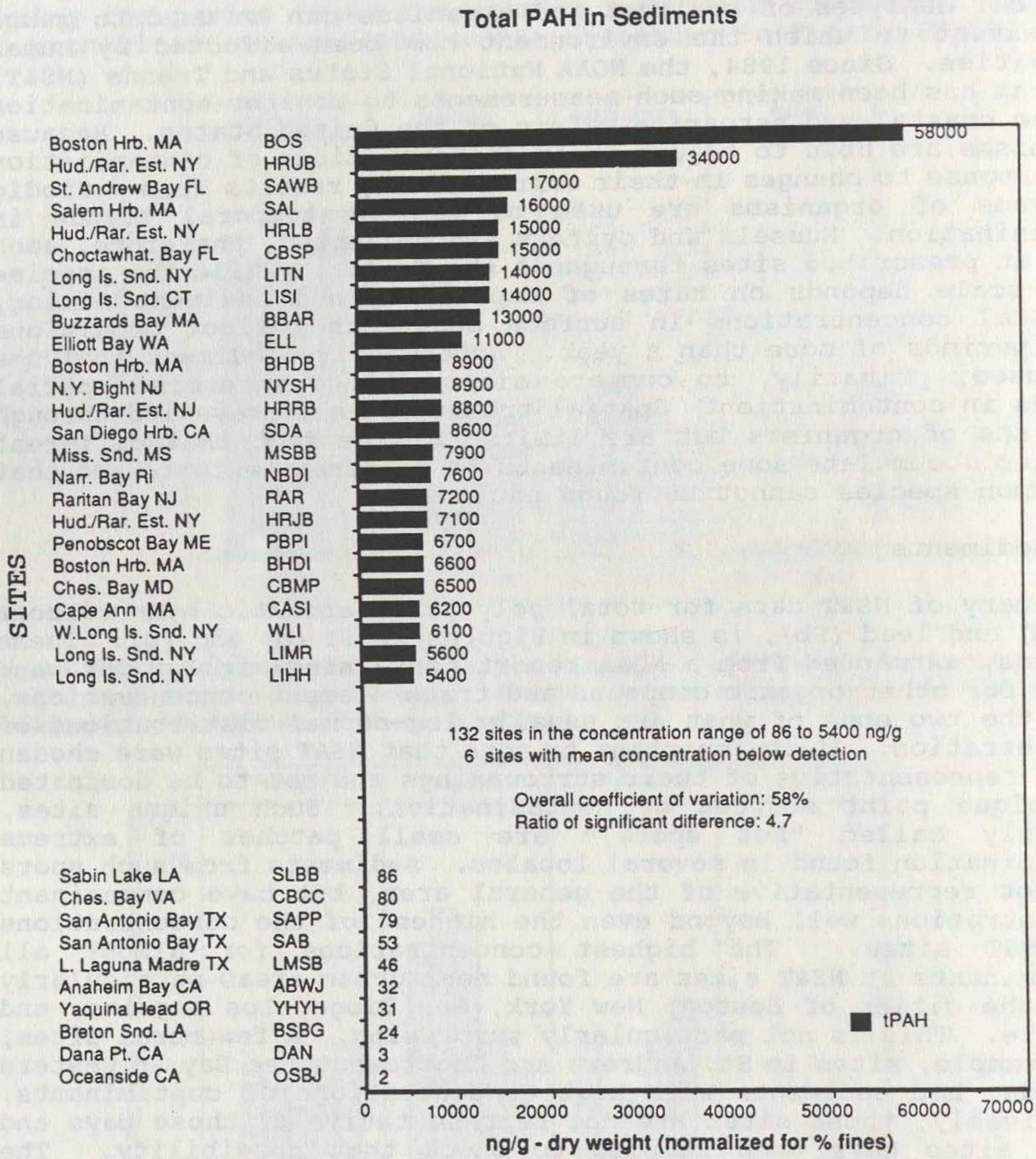
Figure IV-10. Prohibited shellfish waters by region, 1966-1985. (Courtesy Dorothy L. Leonard, Strategic Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)

CONTAMINANTS

Chemical analyses of sediment and organisms can be used to gauge the extent to which the environment has been affected by human activities. Since 1984, the NOAA National Status and Trends (NS&T) Program has been making such measurements to monitor contamination in the coastal and estuarine waters of the United States. Because organisms are able to adjust their concentrations of contamination in response to changes in their surroundings, results from periodic analyses of organisms are used to monitor temporal trends in contamination. Mussels and oysters are collected, therefore, each year at prescribed sites throughout the Nation. While the precise time scale depends on rates of deposition and sediment mixing, chemical concentrations in surface sediments reflect conditions over periods of more than a year. Accordingly, sediment analyses are used, primarily, to compare sites and to determine spatial trends in contamination. Spatial trends are also revealed through analyses of organisms but are limited by the fact that different species accumulate some contaminants to different extents and that a common species cannot be found nationwide.

a. Sediments

A summary of NS&T data for total polycyclic aromatic hydrocarbons (tPAH) and lead (Pb), is shown in Figures IV-11 (a) and (b). These figures, extracted from a NOAA report containing similar data and plots for other organic compound and trace element concentrations, show the two ends of what are usually log-normal distributions of concentration. It is important to note that NS&T sites were chosen to be representative of their surroundings and not to be dominated by unique point sources of contamination. Such unique sites, commonly called "hot spots," are small patches of extreme contamination found in several locales. Sediments from such spots are not representative of the general area, but have contaminant concentrations well beyond even the highest of the concentrations at NS&T sites. The highest concentrations for almost all contaminants at NS&T sites are found near urban areas particularly near the cities of Boston, New York, San Diego, Los Angeles, and Seattle. This is not particularly surprising. A few rural sites, for example, sites in St. Andrews and Choctawhatchee Bay in western Florida, had sediments with high concentrations of contaminants. Conceivably, those sites are not representative of those bays and other sites have been sampled to check that possibility. The sediment data alone do not indicate whether contamination has reached a point where it is exerting a biological effect. There are data, however, on results of sediment bioassays and chemical analyses implying that contaminant levels found in "hot spots" can cause biological effects but that levels at NS&T sites are usually not high enough to do so. A similar conclusion follows from the NS&T data showing a very low frequency of occurrence of liver tumors in bottom fish collected at NS&T sites.



CONCENTRATIONS

Figure IV-11 (a). Plot of ranked contaminant concentrations for total polycyclic aromatic hydrocarbons (tPAH) in nanograms/gram (ng/g) observed in sediments collected in 1984-1987. (1 nanogram = 10^{-9} g) (Courtesy Thomas P. O'Connor, Coastal and Estuarine Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)

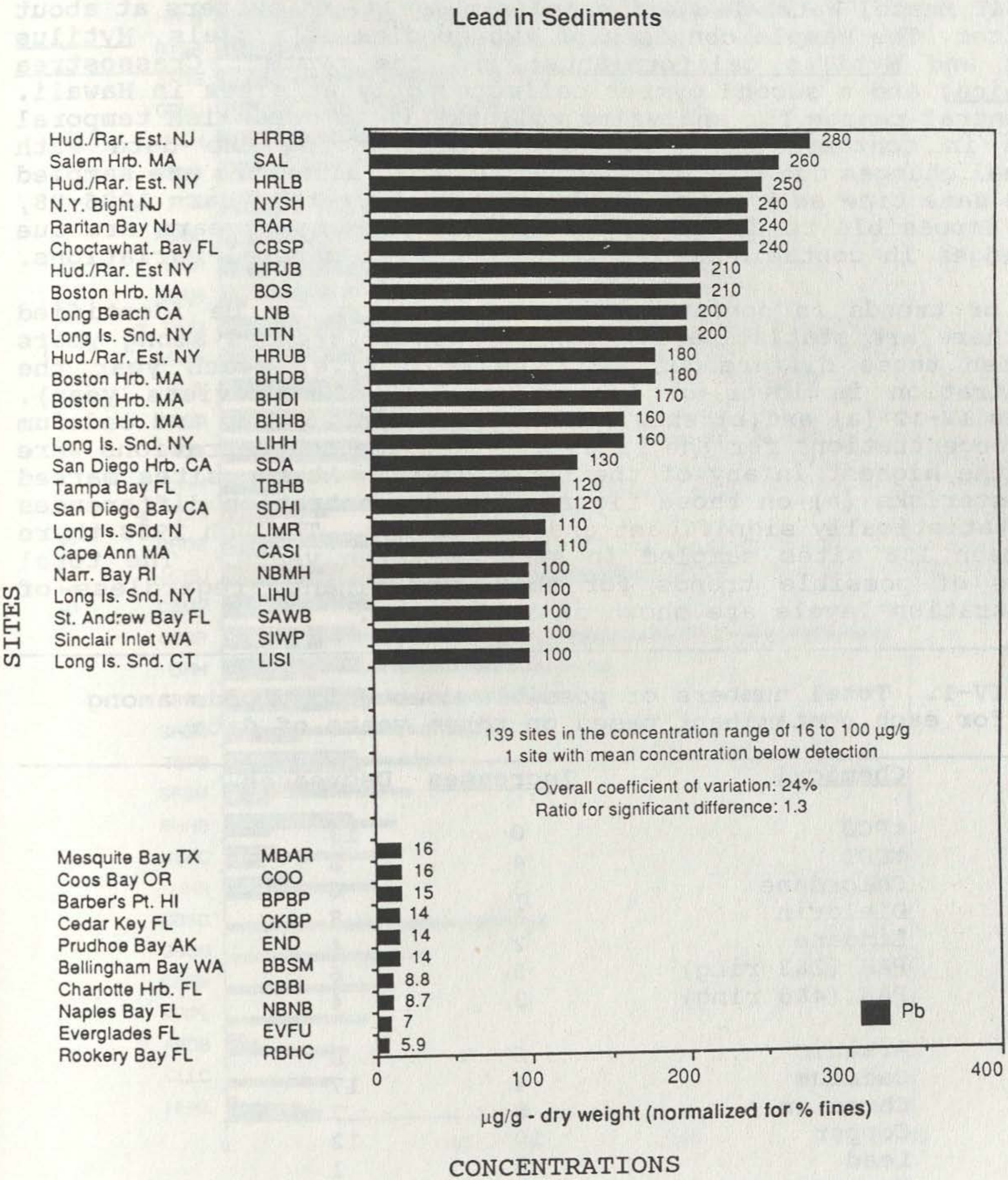


Figure IV-11 (b). Plot of ranked contaminant concentrations for lead (Pb) in micrograms/gram in sediments collected in 1984-1987. (1 microgram = 10^{-6} g) (Courtesy Thomas P. O'Connor, Coastal and Estuarine Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)

b. Bivalve Mollusks

The NS&T Mussel Watch Project samples mussels and oysters at about 150 sites. The sample consists of two species of mussels, Mytilus edulis and Mytilus californianus; and the oyster, Crassostrea virginica; and a second oyster collected only at sites in Hawaii. The central reason for analyzing mollusks is to establish temporal trends in contamination. To avoid confounding the data with seasonal changes due to molluscan physiology, all sites are sampled at the same time each year. With data only for the years 1986-88, it is impossible to declare that differences among years are due to changes in contaminant inputs rather than natural variations.

Hints of trends in contaminant concentrations can be identified when there are statistically significant differences among years and when those differences are monotonic (i.e., each year the concentration is lower or higher than in the previous year). Figures IV-12 (a) and(b) show three years of chlordane and cadmium (Cd) concentrations for the sites at which the concentrations were among the highest in any of the three years. At the sites marked with asterisks (*) on those figures the concentration differences were statistically significant and decreasing. Through 1988 there have been 136 sites sampled in each of three years. The total numbers of possible trends for each contaminant, regardless of concentration levels are shown in Table IV-1.

Table IV-1. Total numbers of possible monotonic trends among sites for each contaminant based on three years of data.

Chemical	Increases	Decreases
tPCB	0	13
tDDT	4	8
Chlordane	3	6
Dieldrin	1	8
Lindane	2	4
PAH (2&3 ring)	5	6
PAH (4&5 ring)	3	4
Arsenic	6	8
Cadmium	4	17
Chromium	8	7
Copper	10	12
Lead	5	1
Mercury	11	4
Nickel	7	9
Selenium	12	2
Silver	11	13
Zinc	7	10

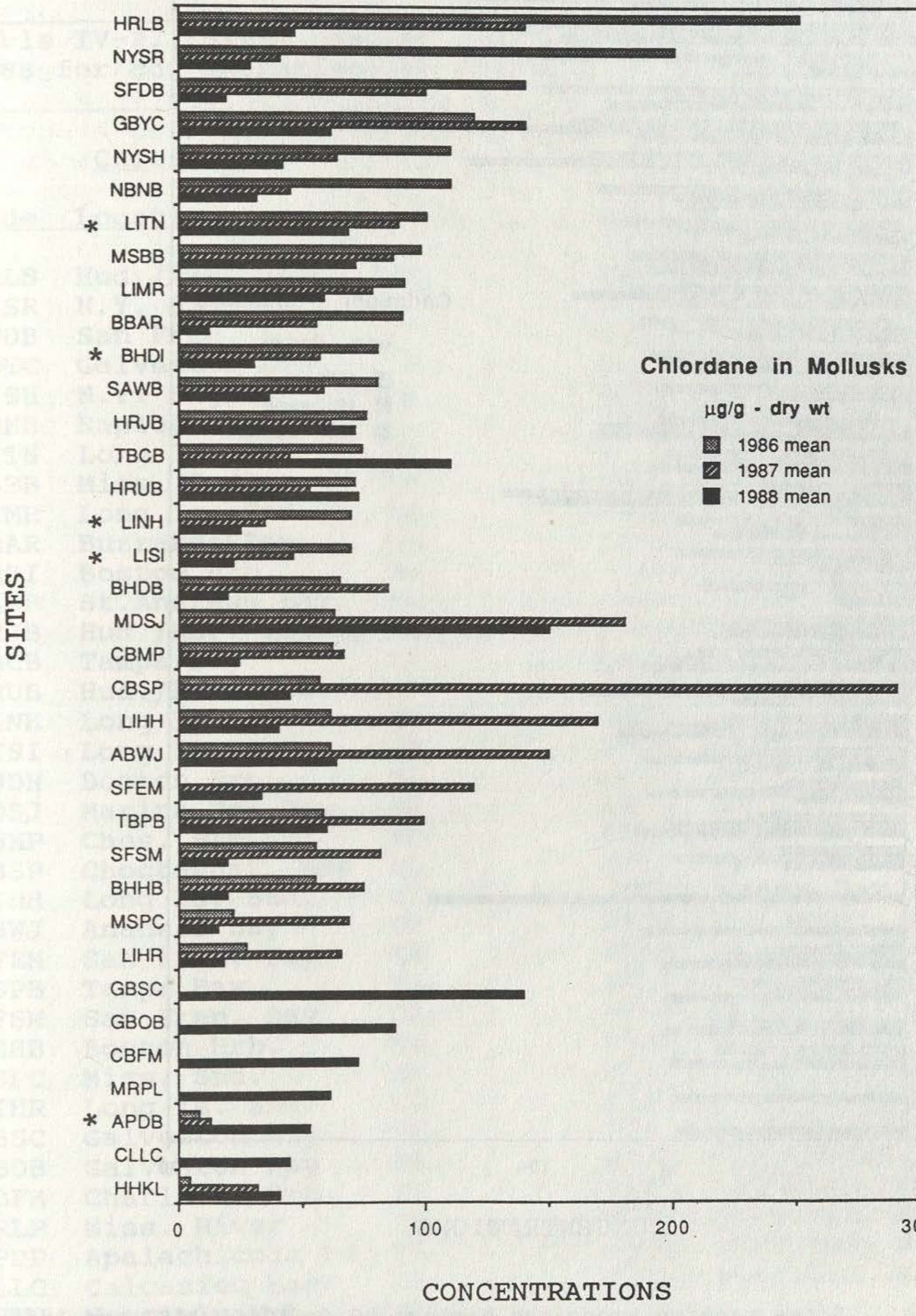


Figure IV-12 (a). Sites ranking among the highest 20 in 1986, 1987 and 1988 for concentrations (micrograms/gram) in mollusks of total chlordane. See Table IV-2 for site abbrevations. (*) indicates statistically significant and decreasing. (Courtesy Thomas P. O'Connor, Coastal and Estuarine Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)

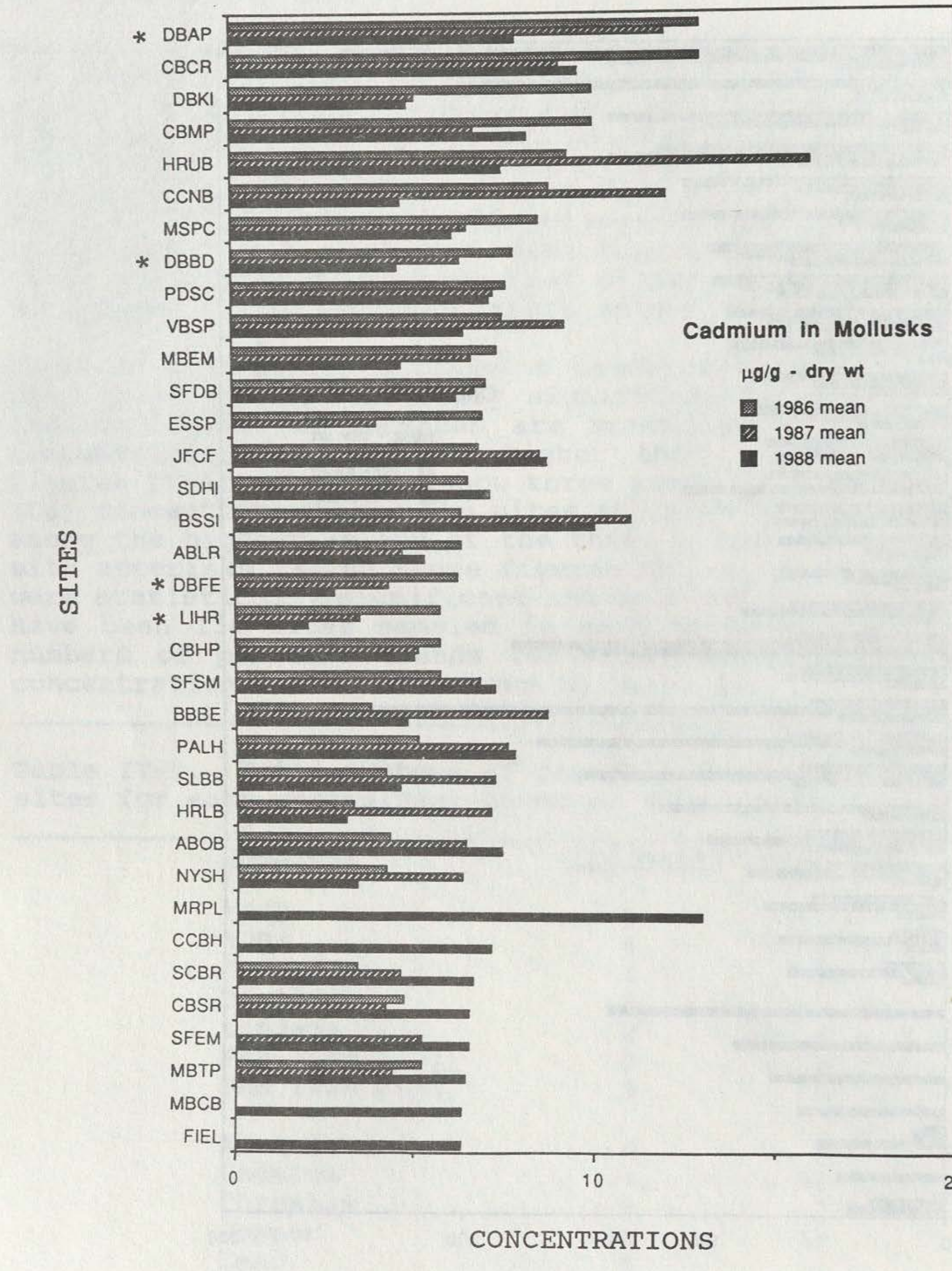


Figure IV-12 (b). Sites ranking among the highest 20 in 1986, 1987 and 1988 for concentrations (micrograms/gram) in mollusks of cadmium. See Table IV-2 for site abbrevations. (*) indicates statistically significant and decreasing. (Courtesy Thomas P. O'Connor, Coastal and Estuarine Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service)

Table IV-2. Sites sampled among the highest 20 in 1986, 1987, 1988 for concentrations in mollusks of chlordane and cadmium.

Chlordane			Cadmium		
Code	Location	State	Code	Location	State
HRLB	Hud./Rar. Est.	NY	DBAP	Delaware Bay	DE
NYSR	N.Y. Bight	NJ	CBCR	Copano Bay	TX
SFDB	San Fran. Bay	CA	DBKI	Delaware Bay	DE
GBYC	Galveston Bay	TX	CBMP	Ches. Bay	MD
NYSH	N.Y. Bight	NJ	HRUB	Hud./Rar. Est	NY
NBNB	Naples Bay	FL	CCNB	Corpus Christi	TX
LITN	Long Is. Snd	NY	MSPC	Miss. Snd.	MS
MSBB	Miss. Snd.	MS	DBBD	Delaware Bay	DE
LIMR	Long Is. Snd.	NY	PDSC	Pt. Delgada	CA
BBAR	Buzzards Bay	MA	VBSP	Vermillion Bay	LA
BHDI	Boston Hrb.	MA	MBEM	Matagorda Bay	TX
SAWB	St.Andrews Bay	FL	SFDB	San Fran. Bay	CA
HRJB	Hud./Rar. Est.	NY	ESSP	Espiritu Santo	TX
TBCB	Tampa Bay	FL	JFCF	S. Juan de Fuca	WA
HRUB	Hud./Rar. Est.	NY	SDHI	San Diego Bay	CA
LINH	Long Is. Snd.	CT	BSSI	Breton Snd.	LA
LISI	Long Is. Snd.	CT	ABLR	Aransas Bay	TX
BHDH	Boston Hrb.	MA	DBFE	Delaware Bay	DE
MDSJ	Marina Del Rey	CA	LIHR	Long Is. Sound	CT
CBMP	Ches. Bay	MD	CBHP	Ches. Bay	MD
CBSP	Choctawhat. Bay	FL	SFSM	San Fran. Bay	CA
LIHH	Long Is. Snd.	NY	BBBE	Bodega Bay	CA
ABWJ	Anaheim Bay	CA	PALH	Pt. Arena	CA
SFEM	San Fran. Bay	CA	SLBB	Sabine Lake	TX
TBPB	Tampa Bay	FL	HRLB	Hud./Rar. EST	NY
SFSM	San Fran. Bay	CA	ABOB	Atchafalaya Bay	LA
BHHB	Boston Hrb.	MA	NYSH	N.Y. Bight	NJ
MSPC	Miss. Snd.	MS	MRLP	Miss. River	LA
LIHR	Long Is. Snd.	CT	CCBH	Corpus Christi	TX
GBSC	Galveston Bay	TX	SCBR	S. Catalina Is.	CA
GBOB	Galveston Bay	TX	CBSR	Choctawhat. Bay	FL
CBFM	Charlotte Hrb.	FL	SFEM	San Fran. Bay	CA
MRLP	Miss. River	LA	MBTB	Matagorda Bay	TX
APDP	Apalachicola Bay	FL	MBCB	Matagorda Bay	TX
CLLC	Calcasieu Lake	LA	FIEL	Farallon Is.	CA
HHKL	Honolulu Hrb.	HI			

These are relatively few possible trends. As annual monitoring continues these indications of trends will be tested and the rigor of trend identification itself will improve.

Temporal trends in contamination can be viewed over longer scales by comparing NS&T data with data from earlier years. For example, the U.S. Environmental Protection Agency (EPA) sponsored a Mussel Watch project in the late 1970s and there are 50 sites common to both that project and to the NS&T program. Comparisons of concentrations of trace metals in mussels or oysters from those sites show that, over the 10 years between programs, lead and cadimum levels have declined and copper concentrations have increased. Concentrations of nickel, silver, and zinc, on the other hand did not show any national trends.

Large decreases in concentrations of synthetic chlorinated hydrocarbons in mollusks and other organisms occurred in the 1970s and are apparently continuing now at a lower rate.

c. Fish

The National Benthic Surveillance Project (NBSP) of the National Status and Trends Program is designed to assess and document the status of and long-term changes in the environmental quality of the Nation's coastal and estuarine waters. Specific objectives of the NBSP are to measure concentrations of chemical contaminants in sediments and species of bottom-dwelling fish at selected sites in urban and nonurban embayments, to determine prevalences of diseases (liver lesions and fin erosion) in the same fish species, and to evaluate temporal trends in these parameters.

One expected, but nevertheless significant, finding from the west coast portion of the NBSP is that the highest concentrations of aromatic hydrocarbons and chlorinated hydrocarbons were observed in the sediments of the highly urbanized areas. In addition, these contaminants were generally correlated with levels of these compounds in fish. The highest prevalences of pathological conditions in fish were found at sites with the highest levels of contaminants. These conditions included fin erosion and lesions of the liver.

Of all the sites sampled, the most contaminated were located in Boston Harbor (MA), Salem Harbor (MA), Raritan Bay (NJ), San Diego Bay (CA), Commencement Bay (Tacoma, WA), Elliott Bay (Seattle, WA), and San Pedro Bay (Los Angeles/Long Beach, CA). Intermediate levels of contaminants were detected at the sites in Baltimore Harbor, (MD), Western Long Island Sound (NY), and in Santa Monica and San Francisco Bays (CA). The sites in Alaska and Oregon were among the least contaminated of those sampled. Figure IV-13 presents examples of findings organized around the major classes of chemical contaminants (Figure IV-13 [a]-[b]) and prevalences of liver lesions (Figure IV-13 [c]) in selected bottom-feeding fish.

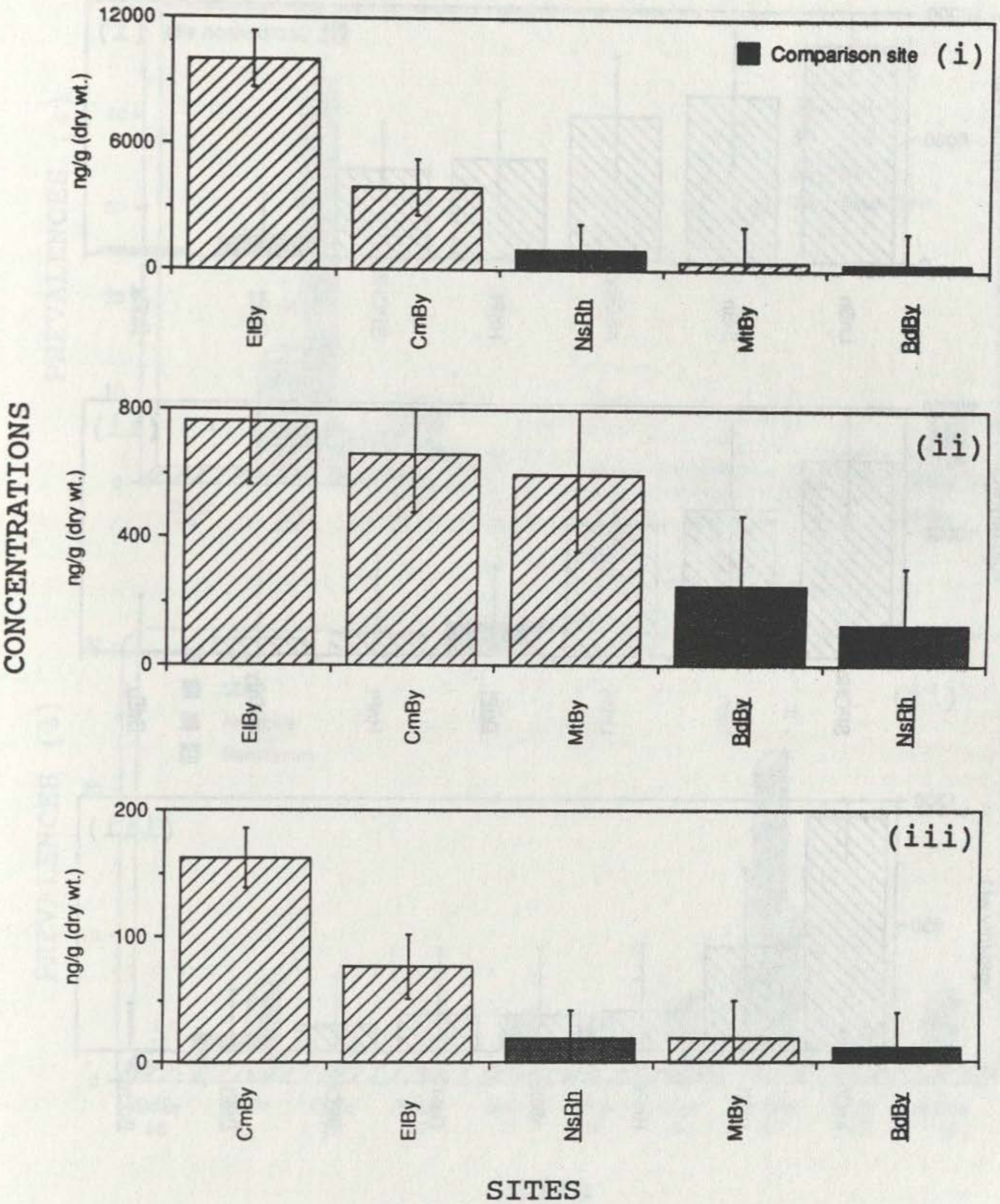


Figure IV-13 (a). Mean concentrations (nanograms/gram, dry weight) plus or minus comparison intervals of PCBs (i), DDTs (ii), and chlordanes (iii) in livers of English sole from each of the sites. The sites are ranked in order of concentration. See Table IV-3 for site abbrevations. (1 nanogram = 10^{-9} gram) (Courtesy Usha Varanasi, Director, Environmental Conservation Division, Northwest Fisheries Center, NOAA National Marine Fisheries Service)

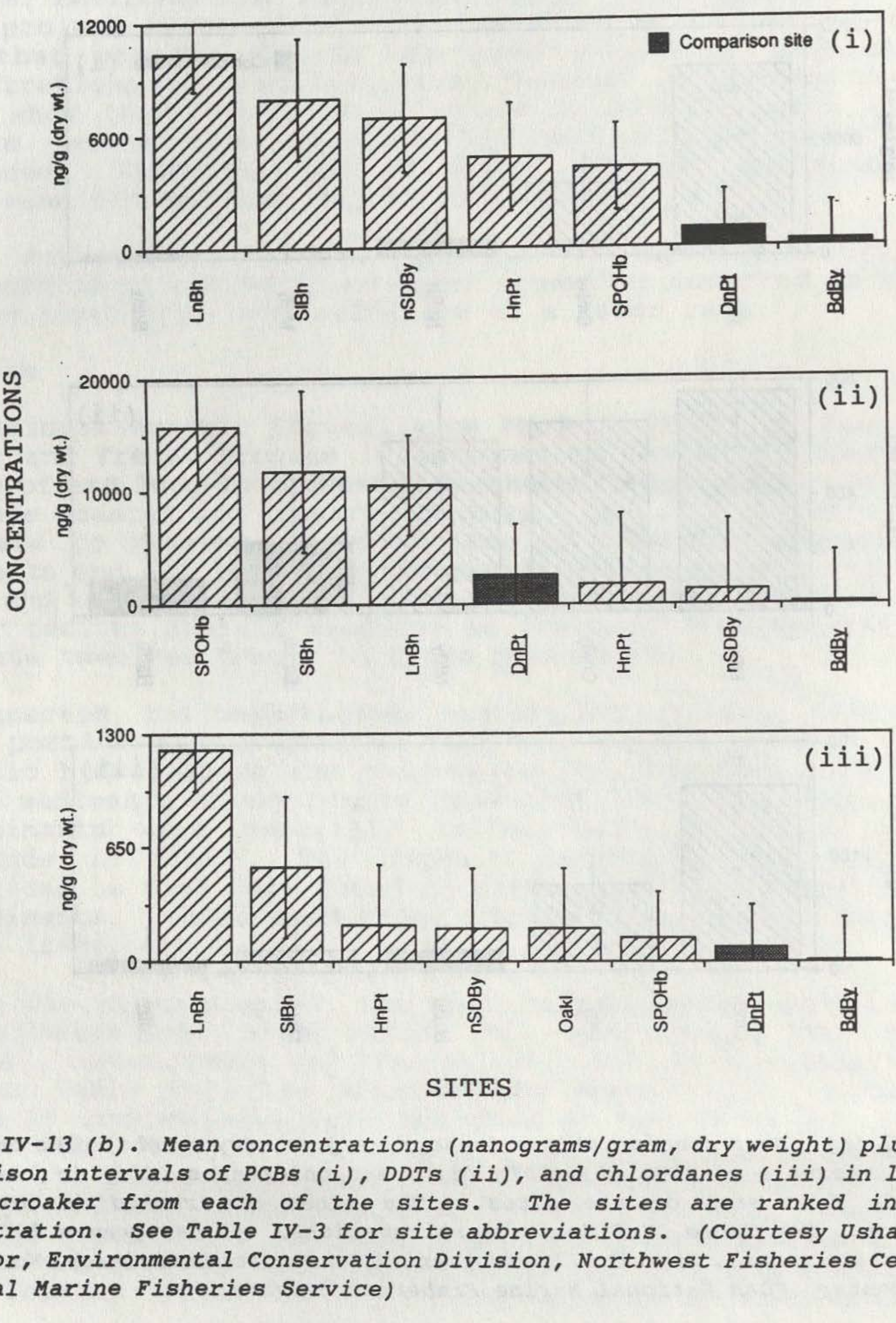


Figure IV-13 (b). Mean concentrations (nanograms/gram, dry weight) plus or minus comparison intervals of PCBs (i), DDTs (ii), and chlordanes (iii) in livers from white croaker from each of the sites. The sites are ranked in order of concentration. See Table IV-3 for site abbreviations. (Courtesy Usha Varanasi, Director, Environmental Conservation Division, Northwest Fisheries Center, NOAA National Marine Fisheries Service)

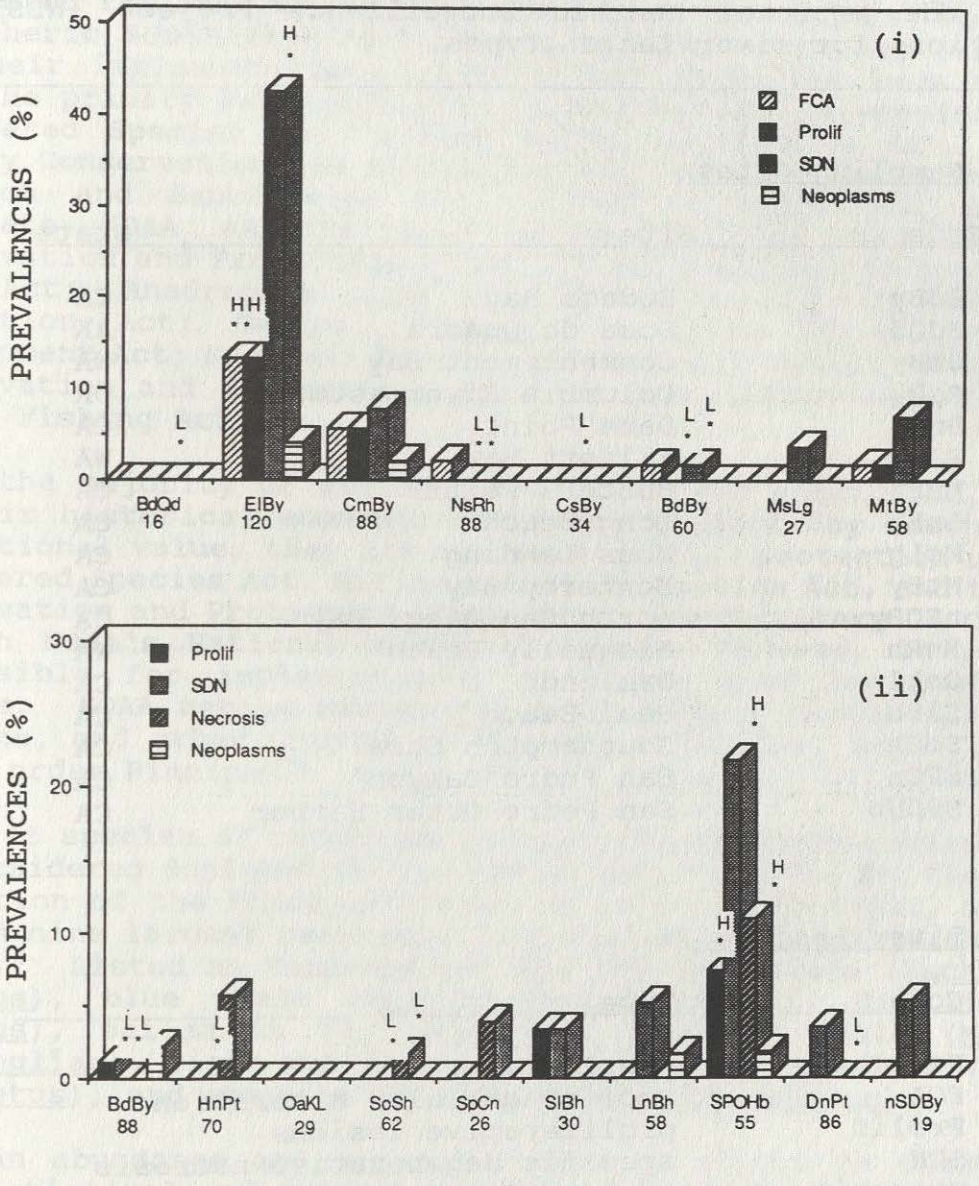


Figure IV-13 (c). Prevalences of pollution-associated liver lesions in English sole (i) and white croaker (ii). The number of fish examined per site is given below each site abbreviation. See Table IV-3 for definitions. "" indicates where lesion prevalences were significantly higher (H) or lower (L). (Courtesy Usha Varanasi, Director, Environmental Conservation Division, Northwest Fisheries Center, NOAA National Marine Fisheries Service)*

Table IV-3. West coast sites sampled in 1984, 1985, or 1986 as part of the National Benthic Surveillance Project (NBSP) and abbreviations for liver lesion types.

Sampling Sites

Code	Site	State
BdBy	Bodega Bay	CA
BdQd	Boca de Quadra	AK
CmBy	Commencement Bay	WA
CsBy	Columbia River estuary	OR
DnPt	Dana Point	CA
ElBy	Elliott Bay	WA
HnPt	Hunters Point	CA
LnBh	Long Beach	CA
MsLg	Moss Landing	CA
MtBy	Monterey Bay	CA
nSDBy	north San Diego Bay	CA
NsRh	Nisqually Reach	WA
Oakl	Oakland	CA
SlBh	Seal Beach	CA
SoSh	Southampton Shoal	CA
SPCn	San Pedro Canyon	CA
SPOHb	San Pedro Outer Harbor	CA

Liver Lesions

Code	Type
Neoplasms	neoplasia
FCA	foci or cellular alteration
Prolif	proliferative lesions
SDN	specific degenerative necrosis
Necrosis	nonspecific necrosis

PROTECTED RESOURCES

Our fish and wildlife are valuable economic, aesthetic, and recreational assets and, as such, are protected from detrimental foreign and domestic exploitation. Numerous legislative actions have been taken in the United States to conserve and protect living resources. Many of the laws that deal with marine species have designated the Secretary of Commerce (via the National Oceanic and Atmospheric Administration) as the Federal authority responsible for their implementation. Significant among the laws that give NOAA the primary responsibility to protect marine species are the Endangered Species Act, Marine Mammal Protection Act, Magnuson Fishery Conservation and Management Act, and the Marine Protection Research and Sanctuaries Act. Other conservation laws that designate NOAA as the lead Federal agency are the Whale Conservation and Protection Study Act; Whaling Convention Act; Fur Seal Act; Anadromous Fish Conservation Act; Atlantic Tuna Convention Act; Central, Western & South Pacific Fisheries Development Act; Northern Pacific Halibut Act; Salmon and Steelhead Conservation and Enhancement Act; and the Sockeye Salmon or Pink Salmon Fishing Act.

While the majority of marine mammals are not endangered, because of their historical economic value and present-day aesthetic and recreational value, they are accorded special protection under the Endangered Species Act, Marine Mammal Protection Act, and the Whale Conservation and Protection Study Act. The Secretary Of Commerce, through NOAA's National Marine Fisheries Service, is primarily responsible for implementation of these acts for most marine mammals. NOAA marine mammal responsibility includes all whales, dolphins, and other species of the order Cetacea, and all species of the order Pinnipedia (seals and sea lions, excluding walruses).

Of the 45 species of cetaceans found in United States waters, eight are considered depleted to the extent that they require the special protection of the Endangered Species Act. These eight, among the world's nine largest cetaceans, are collectively called the "great whales." Listed as "endangered" are the gray whale (Eschrichtius robustus), blue whale (Balaenoptera musculus), fin whale (B. physalus), sei whale (B. borealis), humpback whale (Megaptera novaeangliae), right whale (Balaena glacialis), bowhead whale (B. mysticetus), and sperm whale (Physeter macrocephalus).

Cetacean abundance and general status of stocks is often biased with statistical and sampling errors, leading to overestimation or underestimation of the true population size. The estimation of population size for large whales has traditionally been based upon information derived from exploitation (e.g., catch per unit effort, mark-recapture, or related data). Because of the recent decline in exploitation of marine mammals, assessment techniques based upon sighting surveys are increasing in importance. The annual migration of the California stock of gray whales makes it especially well suited to assessment by means of sighting surveys. Each year during the northern winter the California stock of gray whales migrates from feeding waters in the Bering and Chukchi Seas, south along the west coast of North America, to calving areas in Mexican waters and returns to the Arctic in the spring. In many places along the route, whales pass close to land. Ninety-two percent pass within 1.4 km of Cape Sarichef, Unimak Pass, Alaska, and ninety-four percent pass within 1.6 km of the Monterey-Point Sur area of California. Thus it is feasible to census the migrating whales visually from strategic points along the shore.

Systematic censuses of southward migrating gray whales were initiated during the winter of 1967-68 at the Monterey-Point Sur, California area. There was a significant, positive rate of change in gray whale population size of 2.5%/yr during the 1967-1980 observation period. The annual estimates are plotted, along with 95% confidence limits, in Figure IV-14. A full gray whale census was conducted in 1987-88. The National Marine Mammal Laboratory assisted by the Southwest Fisheries Center conducted a double counting experiment and aerial surveys to determine the proportion of missed whales. Using a new model, the estimate of absolute abundance is 21,113 (standard error 688). Final analysis of the 1987-88 census, including sampling discrepancies and trends in abundance, was reported at the 1990 International Whaling Commission meeting.

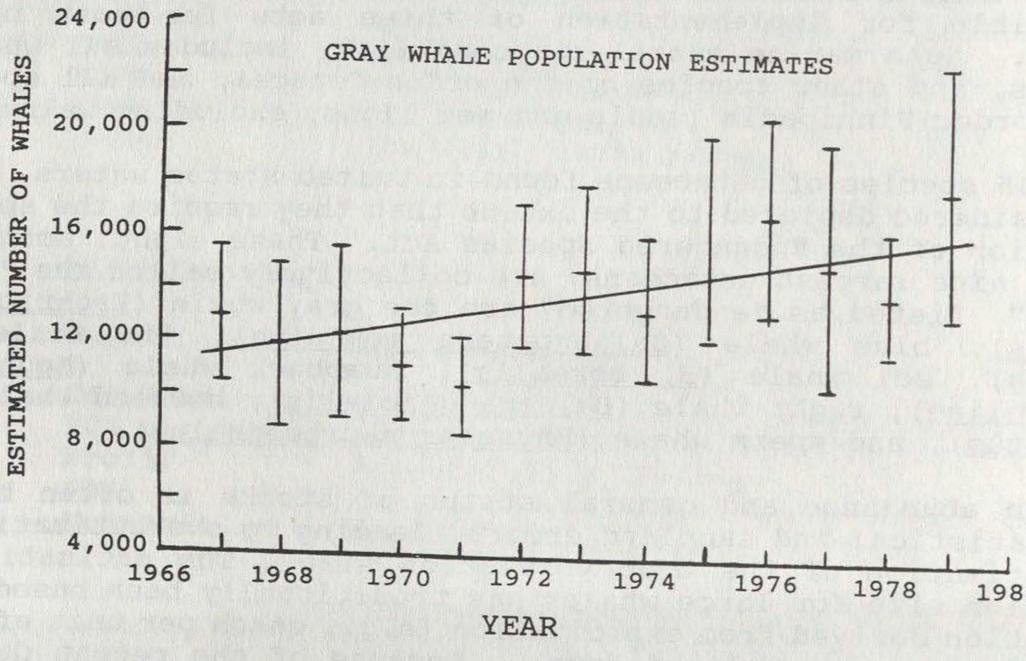


Figure IV-14. Population estimates for the California stock of gray whales for 13 years (1967-68 to 1979-80) with 95% confidence intervals. Fitted line is from exponential regression weighted by variances. (Courtesy Stephen B. Reilly,

APPENDICES

A. CONTRIBUTORS

B. SOURCES OF ADDITIONAL INFORMATION

C. GLOSSARY OF TERMS

D. RELATED REPORTS AND PUBLICATIONS

APPENDIX A: CONTRIBUTORS

The following scientists were primary contributers to the NOAA ENVIRONMENTAL DIGEST. Their efforts are greatly appreciated.

Dr. James K. Angell, Air Resources Laboratory, NOAA Office of Oceanic and Atmospheric Research, SSMC-2, 1335 East-West Highway, Silver Spring, MD 20910; (301) 427-7684; for Quasi-biennal Oscillation and upper air temperatures

Dr. Andrew Bakun, Chief, Pacific Fisheries Environmental Group, NOAA National Marine Fisheries Service, P.O. Box 831, Monterey, CA 93942; (408) 646-3311; for upwelling

Dr. Joan A. Browder, Miami Laboratory, Southeast Fisheries Center, NOAA National Marine Fisheries Service, 75 Virginia Beach Dr., Miami, FL 33149; (305) 361-4225; for fisheries

Mr. Robert E. Cheney, Chief, Satellite and Ocean Dynamics Section, Charting and Geodetic Services, NOAA National Ocean Service, 11400 Rockville Pike, Room 426A, Rockville, MD 20853; (301) 443-8556; for satellite derived sea level

Dr. Thomas Conway, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303; (303) 497-6650; for global carbon dioxide

Dr. Henry F. Diaz, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303, (303) 497-6878; for El Nino/Southern Oscillation

Dr. Ellsworth Dutton, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303; (303) 497-6650; for solar radiation budget

Dr. James Elkins, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303; (303) 497-6650; for halogenated hydrocarbons and nitrous oxide

Dr. David B. Enfield, Physical Oceanography Division, Atlantic Oceanographic and Meteorological Laboratory, NOAA Office of Oceanic and Atmospheric Research, 4301 Rickenbacker Causeway, Miami, FL 33149; (305) 361-4300; for El Nino/Southern Oscillation

Dr. Richard R. Heim, Jr., National Climatic Data Center, NOAA National Environmental Satellite, Data, and Information Service, Federal Building, Asheville, NC 28801; (704) 259-0476; for land temperature and precipitation, severe weather

Mr. Steacy D. Hicks, Physical Oceanography Division, Office of Oceanography and Marine Assessment, NOAA National Ocean Service, 6001 Executive Blvd., Rockville, MD 20853; (301) 443-8938; for tide gauge sea levels

Dr. Mark C. Holliday, Acting Chief, Fisheries Statistics Division, NOAA National Marine Fisheries Service, SSMC-1, 1335 East-West Highway, Room 8313, Silver Spring, MD 20910; (301) 427-2328; for fisheries statistics

Dr. Walter D. Komhyr, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303; (303) 320-6331; for ozone

Dr. Jimmy C. Larsen, Pacific Marine Environmental Laboratory, NOAA Office of Oceanic and Atmospheric Research, 7600 Sand Point Way, N.E., Bldg #3, Bin C 15700, Seattle, WA 98115-0070; (206) 526-6239; for ocean transport

Ms. Dorothy L. Leonard, Strategic Assessments Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service, 6001 Executive Blvd., Room 305, Rockville, MD 20853; (301) 443-8843; for shellfish

Mr. Stephen D. Lyles, Physical Oceanography Division, Office of Oceanography and Marine Assessment, NOAA National Ocean Service, 6001 Executive Blvd., Room 608, Rockville, MD 20853; (301) 443-8467; for tide gauge sea levels

Dr. John A. McKinnon, Solar-Terrestrial Physics Division, National Geophysical Data Center, NOAA National Environmental Satellite, Data, and Information Service, 325 Broadway, Boulder, CO 80303; (303) 497-6323; for solar activity

Dr. Steven A. Murawski, Northeast Fisheries Center, NOAA National Marine Fisheries Service, Woods Hole, MA 02543; (617) 548-5123; for fisheries

Ms. Helen Mustafa, Northeast Fisheries Center, NOAA National Marine Fisheries Service, Woods Hole, MA 02543; (617) 548-5123; for fisheries

Dr. Thomas P. O'Connor, Coastal and Estuarine Assessment Branch, Office of Oceanography and Marine Assessment, NOAA National Ocean Service, 6001 Executive Blvd., Rockville, MD 20853; (301) 443-8655; for contaminants in sediments and bivalves

Dr. James T. Peterson, Deputy Director, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303; (303) 497-6074; for trace gases, aerosols, radiation budget

Dr. Stephen B. Reilly, Southwest Fisheries Center, La Jolla Laboratory, NOAA National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92038; (619) 546-7000; for marine mammals

Dr. David R. Rodenhuis, Director, Climate Analysis Center, National Meteorological Center, NOAA National Weather Service, 5200 Auth Road, Camp Springs, MD 20233; (301) 763-8167; for air and sea surface temperatures, precipitation, sea ice, snow cover

Dr. Lloyd Shapiro, Atlantic Oceanographic and Meteorological Laboratory, NOAA Office of Oceanic and Atmospheric Research, 4301 Rickenbacker Causeway, Miami, FL 33149; (305) 361-4400; for Quasi-biennial Oscillation

Dr. Kirk Thoning, Climate Monitoring and Diagnostics Laboratory, NOAA Office of Oceanic and Atmospheric Research, 325 Broadway, Boulder, CO 80303; (303) 497-6650; for carbon dioxide

Dr. Usha Varanasi, Director, Environmental Conservation Division, Northwest Fisheries Center, NOAA National Marine Fisheries Service, 2725 Montlake Blvd. East, Seattle, WA 98112-2097; (206) 442-7737 for contaminants and biological effects in fish

APPENDIX B: SOURCES OF ADDITIONAL INFORMATION WITHIN NOAA

Parameter	NOAA Source Code*
1. Surface & Upper Air Temperature	ARL, CAC, CMDL, NCDC, SDSD, SRL
2. Trace Species	AL, ARL, CAC, CMDL, SDSD, SRL
3. Hydrological Cycle	CAC, HRL, NCDC
4. Solar & Radiation Budget	ARL, CMDL, NGDC, SDSD, SEL
5. Severe Weather	NCDC, NSSL, NHC, AOML
6. Quasi-Biennial Oscillation	AOML, ARL, CAC
7. Sea-Surface Temperature	CAC, COAP, NODC, OPC, SDSD, SRL
8. Sea Level	GRDL, NODC, POD
9. El Nino/Southern Oscillation	CAC, CMDL, GFDL
10. Ocean Transport	AOML, PMEL, SDSD, SRL
11. Coastal Upwelling	PFEG, SDSD, SRL
12. Sea Ice	CAC, JIC, NSIDC, OPC, SDSD, SRL
13. Snow Cover	CAC, NSIDC, SDSD, SRL
14. Fisheries	AFC, NEFC, NWFC, SEFC, SWFC
15. Shellfish	NSR
16. Contaminants	NS&T
17. Protected Resources	NMML, OPR, SEFC, SWFC

* See following pages for definitions.

AFC Alaska Fisheries Center
NOAA National Marine Fisheries Service
7600 Sand Point Way, N.E.
BIN C15700 - Bldg. 4
Seattle, WA 98115-0070
(206) 526-4000, FTS 392-4000

Expertise: AFC plans, develops, and manages programs designed for better comprehension of living marine resources as well as habitat quality. Recommendations are made for utilization, conservation or protection, consistent with national needs and goals. A principal function of the AFC is to serve as technical advisor to the regional Fishery Management Councils and U.S. Commissions or groups involved in fisheries and marine mammal negotiations with foreign countries. Research is conducted on composition, distribution, abundance, productivity and interactions of marine fish and shellfish in waters of the northeastern Pacific Ocean; fishing and sampling gear performance, techniques on selective fishing; ecology, population dynamics, and economic aspects of fisheries; the nature and extent of pollution in marine environments and potential impact on the viability of marine organisms; distribution, abundance, survival of anadromous fish in Alsaka; handling and preservation of fish catches appropriate to a fishery, aboard ship and in shore processing plants; use of underutilized species and microbiology and safety of products. Technical support is provided for Center scientists in areas of mathematics, experimental design, editing/graphics, and library and computer services. The AFC consists of the Auke Bay Laboratory, the National Marine Mammal Laboratory, the Resource Assessment and Conservation Engineering Division, the Resource Ecology and Fisheries Management Division, and the Office of Fisheries Information Systems.

AL Aeronomy Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
325 Broadway
Boulder, CO 80303
(303) 497-3218, FTS 320-3218

Expertise: The chemical and physical processes of the Earth's atmosphere are studied to advance the capability for monitoring, predicting, and controlling of the quality of the atmosphere. Research concentrates on the stratospheric and tropospheric regions of the atmosphere but also involves the mesosphere and thermosphere. Research methods involve both in-situ and remote measurement of critical atmospheric parameters, including chemical composition and dynamic properties such as wind velocities, turbulence, and wave motions. Theoretical programs in atmospheric photochemical modeling and in atmospheric dynamics and transport support the observation program. An experimental chemical kinetics program supports the theoretical photochemical modeling program and also supplies input for the development of new atmospheric monitoring and measurement technology. The major focuses of research are air quality and climate. Several environmental issues are currently addressed: stratospheric ozone depletion (global, arctic and antarctic), tropospheric ozone production by pollutants, greenhouse effect, acid rain, El Nino/Southern Oscillation, and climate change.

AOML Atlantic Oceanographic and Meteorological Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
4301 Rickenbacker Causeway
Virginia Key
Miami, FL 33149
(305) 361-4300, FTS 350-1300

Expertise: AOML is organized to pursue basic and applied research programs in oceanography and tropical meteorology. Oceanographic investigations center on fluxes of energy, momentum, and materials through the air-sea interface; the transport and composition (thermal and chemical) of water in the ocean volume; and hydrothermal processes of mineralization at seafloor spreading centers. Meteorological research is carried out to improve the description, understanding, and prediction of hurricanes. The AOML research program is enhanced by the Cooperative Institute for Marine and Atmospheric Studies (CIMAS), a joint enterprise with the Rosenstiel School of Marine and Atmospheric Science of the University of Miami. CIMAS enables NOAA and university scientists to collaborate on problems of mutual interest and facilitates the participation of visiting scientists. AOML's current research program concerns processes relating to global climate and air quality, weather observation and prediction, marine observation and prediction, and marine resources.

ARL Air Resources Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
Silver Spring Metro Center - 2
1335 East-West Highway
Silver Spring, MD 20910
(301) 427-7684, FTS 427-7684

Expertise: ARL research is geared to needs of users, frequently other Federal agencies, with related missions. These include the Department of Energy, the Nuclear Regulatory Commission, and the Environmental Protection Agency. ARL is the official government source for information on atmospheric transport and diffusion to guide emergency responses. The general areas of study are air quality and climate, which include turbulence and diffusion in the atmosphere, global transport of pollutants, meteorology of air pollution, acid rain, global climate change, and monitoring of atmospheric constituents. The work includes observational and theoretical studies as well as instrument development. ARL consists of the Headquarters Group located in Silver Spring, MD; the Field Research Division in Idaho Falls, ID; the Atmospheric Turbulance and Diffusion Division in Oak Ridge, TN; and the Atmospheric Sciences Modeling Division in Research Triangle Park, NC.

CAC Climate Analysis Center
National Meteorological Center
NOAA National Weather Service
World Weather Building
5200 Auth Road
Camp Springs, MD 20233
(301) 763-8167, FTS 763-8167

Expertise: CAC, as a major element of the NOAA Climate and Global Change Program, applies new technology and new approaches to the analysis, diagnosis, and projection of short-term climate fluctuations on a regional and global basis. It maintains awareness of current climate anomalies and provides information on these anomalies and their projected changes to users within and outside the government who are responsible for coping with problems caused by short-term fluctuations, such as those of energy, food supply, water resources and health. CAC cooperates and coordinates its activities with other elements of the National Meteorological Center and other parts of NOAA; with other government agencies (e.g., Department of Agriculture); with interests in the private sector; with research and academic institutions; and with climate agencies in other nations and with the World Meteorological Organization. CAC also supports research studies in climate diagnosis and prediction at universities, private research organizations, and other government agencies.

CMDL Climate Monitoring and Diagnostics Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
325 Broadway
Boulder, CO 80303
(303) 497-6074, FTS 320-6074

Expertise: CMDL plans and conducts observational and monitoring programs and research necessary to measure and predict climate fluctuations and trends. The Laboratory analyses atmospheric and oceanic data to determine relationships, budgets, sources, sinks, and trends; and applies this information to develop real-time climate indices, predictive techniques, and evaluations of predictions. CMDL operates four baseline atmospheric monitoring stations of NOAA. The four observatories are located at Barrow Alaska; Mauna Loa, Hawaii; American Samoa; and South Pole Station, Antarctica. Since the early to mid-1970's, continuous measurements of atmospheric parameters have been made at the four CMDL observatories. Monitored parameters include carbon dioxide, methane, nitrous oxide, halogenated halocarbons, aerosols, ozone, and solar and thermal radiation. CMDL consists of the Climate Research Division, the Sun-Climate Staff, and the Geophysical Monitoring for Climatic Change (GMCC) Division.

COAP Center for Ocean Analysis & Prediction
Office of Ocean Services
NOAA National Ocean Service
2560 Garden Road
Monterey, CA 93940
(408) 467-4241

Expertise: COAP, colocated with the Navy's Fleet Numerical Oceanography Center, is responsible for the development, exchange, integration, and dissemmination of biological, chemical, and physical oceanographic products and services. COAP supports government, industry, and academic institutions responsible for effective management of the Nation's living marine resources. The facility is staffed by personnel from the National Ocean Service, National Marine Fisheries Service, National Weather Service, Office of Oceanic and Atmospheric Research, and the National Environmental Satellite, Data, and Information Service. COAP's particular focus is to develop and disseminate a unique series of environmental and living marine resource analyses, forecasts, and assessments that describe and predict the condition and variability of biological, chemical, and physical oceanic phenomena, as well as the processes affecting them. The Center also provides and facilitates easy access to existing information produced by other parts of NOAA or Federal/state/academic institutions concerning living marine resources, habitat, coastal zone management, offshore dumping and pollution, and ocean climate processes.

FSD Fisheries Statistics Division
Office of Research and Environmental Information
NOAA National Marine Fisheries Service
1335 East-West Highway, Rm. 8313
Silver Spring, MD 20910
(301) 427-2328, FTS 427-2328

The NMFS Fisheries Statistics Division manages the collection and compilation of recreational and commercial fisheries statistics for the United States and foreign catches in the U.S. Exclusive Economic Zone. Information is tabulated and prepared for publication in Fisheries of the United States, Fishery Statistics of the United States, and other NMFS fishery statistics publications. NMFS field offices, in cooperation with various Federal agencies, states, the United Nations, and foreign countries, compile data on U.S. commercial landings and processed fishery products.

GFDL Geophysical Fluid Dynamics Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
P.O. Box 308
Princeton, NJ 08542
(609) 452-6502

Expertise: GFDL is engaged in comprehensive research fundamental to NOAA's mission. The goal of this research is to expand the scientific understanding of the physical processes that govern the behavior of the atmosphere and the oceans as complex fluid systems. These fluids can then be modeled mathematically and their phenomenology studied by computer simulation methods. In particular, GFDL research concerns the following: predictability of weather on large and small scales; structure, variability, predictability, stability, and sensitivity of global and regional climate; structure, variability and dynamics of the ocean over its many space and time scales; interaction of the atmosphere and oceans and how they influence and are influenced by various trace constituents; and the Earth's atmospheric circulation within the context of the family of planetary atmospheric types. The scientific work of the Laboratory encompasses a variety of disciplines, including meteorology, oceanography, hydrology, classical physics, fluid dynamics, chemistry, applied mathematics, and numerical analysis. GFDL research is enhanced by the Atmospheric and Sciences (AOS) Program, which is a collaborative program at GFDL with Princeton University. Under this program, regular Princeton faculty, research scientists, and graduate students participate in theoretical studies, both analytical and numerical, and in observational experiments in the laboratory and in the field. The program is supported in part by NOAA funds. AOS program scientists may also be involved in GFDL research through institutional or international agreements, or through temporary Civil Service appointments.

GRDL Geodetic Research and Development Laboratory
Charting and Geodetic Services
NOAA National Ocean Service
Rockwall Building
11400 Rockville Pike, Rm. 424
Rockville, MD 20853
(301) 443-8858, FTS 443-8858

Expertise: GRDL is a part of NOAA's National Geodetic Survey and is responsible for conducting research and development activities to improve the methods of collecting and disseminating geodetic data. The Laboratory provides leadership at the Federal level to develop specifications, standards, and instrumentation for geodetic surveys. The Laboratory specializes in satellite geodesy and oceanography, and the geodetic aspects of climate and global change.

HRL Hydrologic Research Laboratory
Office of Hydrology
NOAA National Weather Service
Gramax Building
8060 13th Street, Rm. 530
Silver Spring, MD 20910
(301) 427-7619, FTS 427-7619

Expertise: HRL conducts studies into the application of new knowledge to hydrologic forecasting and related water resources problems. HRL sponsors and conducts research on physical processes and phenomena in all phases of the hydrologic cycle. HRL makes recommendations on the type and extent of NOAA's hydrological research, and reviews and evaluates the results.

JIC Navy-NOAA Joint Ice Center
Office of Ocean Services
NOAA National Ocean Service
Federal Building 4
Suitland and Silver Hill Roads
Suitland, MD 20746
(301) 763-5524, FTS 763-5524

Expertise: The Navy-NOAA JIC, colocated with the Navy's Polar Oceanography Center, prepares and issues global analyses and forecasts of sea ice for polar regions, regional ice analyses, forecasts for Alaska and the Great Lakes, and tailored local products, as required. These products have proven useful to U.S. marine transportation and industry. The facility is staffed by personnel from the National Ocean Service, the National Weather Service, and the National Environmental Satellite, Data, and Information Service, as well as the U.S. Navy. The JIC's functional responsibilities include: (1) improved and/or interactive analyses/forecasts of sea ice coverage, concentration and thickness/age; (2) development/operation of state-of-the-art analysis systems to integrate conventional polar ice observations with aircraft and satellite data; and (3) evaluation and verification of analyses/forecasts. JIC's personnel represent NOAA on a variety of national and international technical working groups, such as: the U.S.- Canada Ice Technical Working Group; the validation/calibration working group of the Committee for Earth Observing Satelites; and several NASA-NOAA technical committees. The Center directly supports a broad NOAA constituency including: major numerical modeling centers; other operational National Centers; and NOAA's Climate and Global Change Program, Coastal Ocean Program, and Data Management Program.

NCDC National Climatic Data Center
NOAA National Environmental Satellite, Data,
and Information Service
Federal Building
Asheville, NC 28801
(704) 259-0476 (-0682 for data), FTS 672-0682

Expertise: NCDC acquires, manages, archives, and distributes meteorological and climatological data collected for operational purposes by the National Weather Service, the weather services of the Air Force and Navy, the Federal Aviation Administration, and the Coast Guard. It also serves as the World Data Center-A for Meteorology. While the primary mission of NCDC is to document the climate of the United States, data holdings include the global surface and upper air meteorological observations of the World Meteorological Organization. Climatic information available includes: hourly surface observations, from land stations and moving ships; daily climatological observations from cooperative observing stations; upper air observations; radar observations; satellite observations; hourly and daily solar radiation data; selected maps and charts; and derived and summary data. Data and information are available in several media including subscription publications, paper copies, photographs, film loops, microfilm, microfiche, computer diskette, and magnetic tape.

NEFC Northeast Fisheries Center
NOAA National Marine Fisheries Service
Water Street
Woods Hole, MA 02543
(617) 548-5123, FTS-840-1011

Expertise: NEFC conducts research directed toward resource conservation, management, and utilization, and for habitat quality and maintenance through four program areas at seven research laboratories and 13 field stations. Laboratories are located in Gloucester and Woods Hole, MA; Narragansett, RI; Milford, CT; Sandy Hook, NJ; Washington, DC; and Oxford, MD. The program areas are divided into a Conservation and Utilization Division, Fisheries Ecology Division, Environmental Processes Division, and National Systematics Laboratory. The Environmental Processes Division and National Systematics Laboratory develop basic information on physical, chemical, and biological characteristics of resource species and their habitats. The Fisheries Ecology Division uses that information,along with information it acquires independently, to develop information on the ecological processes that control composition, distribution, abundance, and productivity of the resources. The Conservation and Utilization Division uses that information, along with information it acquires independently, to develop applied products and information on the effects of fishing, fish habitat alterations, and fisheries management practices on the status, harvests, and utilization of the resources.

NGDC National Geophysical Data Center
NOAA National Environmental Satellite, Data, and Information Service
325 Broadway
Boulder, CO 80303
(303) 497-6215, FTS 320-6215

Expertise: NGDC collects, manages, archives, and distributes data on solid-earth geophysics, marine geology and geophysics, and solar-terrestrial physics. NGDC data sources include NOAA, data from universities, other government agencies and foreign organizations. NGDC also serves as World Data Center-A for the above disciplines. Available data include: in Earthquake Seismology, data include strong-motion accelerograph data, tsunami marigrams, photographs of earthquake and tsunami damage, and historical earthquake epicenter data; in Solid Earth Physics, extensive files of common depth point seismic reflection, gravity, and topgraphy data; in Geothermics, holdings encompass data and maps on volcanoes, geothermal energy, and world heat flow; in Marine Geology and Geophysics, gravimetric, magnetic, bathymetric, and seismic data, as well as geotechnical, textural, petrologic, and paleontologic analyses and descriptions of sediment and rock samples; archieved Geomagnetic Data showing both changes in direction and strength of Earth's magnetic field; Solar-Terrestrial Data come from domestic observatories and worldwide sources under international exchange agreements; in Solar Activity Data, records of solar flares, solar radioemission events, and sudden ionospheric disturbances, as well as some satellite-monitored measurements of solar wind and ultraviolet, X-ray, and particle emissions; Ionospheric Data are received from worldwide sources and include vertical soundings, topside soundings from satellites, electron density profiles total electron content ionospheric scintillations, and atmospheric radio noise; and in Glaciology Data, the National Snow and Ice Data Center being an information-retrieval center for snow and ice research, glacier changes, and paleoglaciology. NGDC can provide specialized data services on a reimbursable basis using geographic information systems and tabular data-base processing.

NHC National Hurricane Center
NOAA National Weather Service
IRE Building, Rm. 631
1320 S. Dixie Highway
Coral Gables, FL 33146
(305) 666-4612, FTS 350-5547

Expertise: NHC develops and manages a collection of environmental data for predicting tropical cyclone developments and movements. Related effects of hurricanes, such as high seas and storm surges, are studied. Tropical cyclone effects on coastal rivers and lakes, including an area's specific geography, are modeled and predicted for coastal areas. Methods for predicting growth and movement of tropical cyclones are developed. The Center investigates the accuracy of satellite interpretation of tropical cyclones and conducts studies on the operational accuracies of satellite-based tropical-cyclone estimates of position, intensity, and forecasting.

NMML National Marine Mammal Laboratory
Alaska Fisheries Center
NOAA National Marine Fisheries Service
7600 Sand Point Way, N.E.
BIN C15700 - Bldg. 4
Seattle, WA 98115-0070
(206) 526-4172, FTS 392-4047

Expertise: NMML was established in 1978 to study marine mammals worldwide in response to international commitments and domestic legislation. Research by the Laboratory addresses specific management problems and theoretical questions about the biology and ecology of marine mammals. Work of the Laboratory is carried out in the Antarctic, Arctic, Bering Sea, Gulf of Alaska, North Pacific High Seas and California Current ecosystems. Four areas of specialized study have been identified: fisheries conflicts and interactions; status of depleted and recovering species; marine mammal oceanographic investigations; and ecosystem dynamics and assessments. Specific long-term studies underway to meet identified research and management needs are: population dynamics, life-history strategies, and effects of fisheries on northern fur seals and Steller sea lions in the Bering Sea and Gulf of Alaska; community ecology and effects of El Nino warm-water events on California sea lions, northern fur seals, elephant seals, and harbor seals at San Miguel Island, California; reproduction, feeding ecology, and trends in abundance of Antarctic fur seals, elephant seals, crabeater seals, and penguins of the Antarctic Peninsula; incidential take of harbor porpoise, Dall's porpoise, northern fur seals, and other marine mammals in coastal and high seas fisheries in the North Pacific; and the status and recovery of gray, bowhead, and humpback whales relative to subsistence whaling, habitat use, and industry activities along the Pacific coast.

NODC National Oceanographic Data Center
NOAA National Environmental Satellite, Data, and Information Service
1825 Connecticut Avenue, N.W.
Washington, DC 20235
(202) 673-5549, FTS 673-5549

Expertise: NODC acquires, manages, archives, and distributes data on physical and chemical oceanography, marine pollution, and marine biology. NODC data sources include NOAA, universities and research organizations, and institutions. NODC also operates World Data Center A for oceanography. Available data include: oceanographic station data measured by both bottle casts and electronic sensors, mechanical and expendable bathythermograph temperature profiles, coastal wave data, sea surface meteorology and wave spectra, ocean current data, marine toxic substances and pollution data, pressure gauge data, and sea level data. In addition, NODC maintains selected files on marine chemistry and marine biology, which include intertidal organisms, benthic organisms, phytoplankton, zooplankton, and fish and shellfish surveys. NODC also manages the Ocean Pollution Data and Information Network (OPDIN), a cooperative effort to facilitate access to ocean pollution data and information generated by the 11 participating Federal departments and agencies. NODC data products are provided on a reimbursable basis.

NSIDC National Snow and Ice Data Center
National Geophysical Data Center
NOAA National Environmental Satellite, Data, and Information Service
325 Broadway
Boulder, CO 80303
(303) 492-5171, FTS 320-5311

Expertise: NSIDC, established in 1982, functions as a national information and referral center for the snow and ice research community. The subject matter includes avalanches, freshwater ice, glaciers, ground ice and permafrost, ice sheets, paleoglaciology, sea ice, and snow cover. The Center is colocated with the World Data Center-A for Glaciology (Snow and Ice) and is operated by contractual agreement between NOAA and the University of Colorado, Cooperative Institute for Research in Environmental Sciences. NSIDC is organizationally located within the National Geophysical Data Center.

NSR National Shellfish Register of Classified Estuarine Waters
Strategic Assessment Branch/Office of Oceanography and Marine Assessment
NOAA National Ocean Service
Washington Science Center, Bldg. 1, Rm. 305
6001 Executive Blvd.
Rockville, MD 20853
(301) 443-8843, FTS 443-8843

Expertise: The NOAA National Shellfish Register is a compilation of the classified shellfish growing waters of 24 coastal states. It serves as a resource for Federal and state agencies, researchers, the shellfish industry, and private interests in the evaluation of their policies and programs. The first Register was produced in 1966 by the Food and Drug Administration (FDA), and has been published each five years thereafter. In 1985, the Register was jointly produced by NOAA and the FDA. Beginning in 1990, the Register project will be conducted by NOAA with the cooperation of agencies in the shellfish producing states. The 1990 register will compare the changes in water quality and the attendent pollution sources. NOAA has made the Register a part of the National Estuarine Inventory and the Geographic Information System. The latter will produce digitized maps for the Register classifications. Through this effort, future Registers and interfaces with numerous other data bases will be facilitated. The Register is one of a very few complete data bases on coastal resources of the United States.

NSSL National Severe Storms Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
1313 Halley Circle
Norman, OK 73069
(405) 366-0427, FTS 736-3427

Expertise: NSSL develops improved means for weather forecasting through studies of mesoscale weather processes, numerical and conceptual modeling of storm phenomena, and applications of new technologies such as remote sensing. Technological developments, scientific discoveries, and new requirements are reflected in changing approaches to achieving the goals of accurate, ground-based Doppler radar, field observations gathered with an instrumented mobile laboratory, and light-mapping system. During the past two decades NSSL has examined individual storm events to increase our knowledge of the physical processes that occur in convective storms. Research efforts now address the important problem of improving forecasts of mesoscale weather phenomena and precipitation in a time frame of 3-36 hours. In coming years, increasing emphasis will be given to larger-scale meteorological phenemona, to the use of modern meteorological work stations, to incorporation of wind profiler and digital satellite data into case study analyses, and to blend and use data from diverse observing systems in mesoscale numerical prediction models. Laboratory expertise resides in the following areas: synoptic and mesoscale meteorology, fluid dynamics, numerical modeling, severe storm structure, aviation meteorology, radar engineering, microwave propagation, and signal processing.

NS&T National Status and Trends Program
Ocean Assessments Division
Office of Oceanography and Marine Assessment
NOAA National Ocean Service
Washington Science Center, Bldg. 1, Rm. 323
6001 Executive Blvd.
Rockville, MD 20853
(301) 443-8655, FTS 443-8655

Expertise: The objective of the NS&T Program is to determine the status and long-term trends of toxic chemicals and trace elements in bottom-feeding fish, shellfish, and sediments at 200 coastal and estuarine locations throughout the U.S. This program is the first to use a uniform set of techniques to measure coastal and estuarine environmental quality rationally. A "specimen bank" of samples taken each year at about 10% of the sites is maintained at the National Institute of Standards and Technology for future, retrospective analyses. A related program of directed research is examining the relationships between contaminant exposures and indicators of biological responses (e.g., lesions) in fish and shellfish in areas that are shown by the NS&T monitoring results to have high levels of toxic chemicals. The major initiatives incorporating the objective of the NS&T Program are the Benthic Surveillance Project and Mussel Watch Project.

NWFC Northwest Fisheries Center
NOAA National Marine Fisheries Service
2725 Montlake Blvd. East
Seattle, WA 98112-2097
(206) 442-1872, FTS 399-1872

Expertise: NWFC conducts research and provides technical information on the life history of the Pacific Northwest's aquatic species and examine ways to enhance their production and utilization. The scope of NWFC research responsibilities extends from rivers and coastal waters of California, Oregon, and Washington to the western Pacific Ocean. NWFC scientists estimate the size and value of commercial fishery resources, monitor foreign fishery operations, provide information on protected species, and study the physical properties of freshwater, estuarine, and marine environments, and the effects of physical alteration and chemical contaminants on aquatic biology. Scientists also interact with their counterparts in Canada, Japan, the U.S.S.R., Republic of Korea, Taiwan, and other nations to jointly preserve and conserve the area's resources. The NWFC is made up of the Coastal Zone and Estuarine Studies, Environmental Conservation, and Utilization Research Divisions.

OPC Ocean Products Center
Office of Ocean Services
NOAA National Ocean Service
5200 Auth Road
Camp Springs, MD 20233
(301) 763-8030, FTS 763-8030

Expertise: OPC, colocated with NOAA's National Meteorological Center, prepares and disseminates marine analyses and forecast guidance material in support of NOAA field offices responsible for safeguarding life and property at sea. The facility is staffed by personnel from the National Ocean Service, National Weather Service, and the National Environmental Satellite, Data, and Information Service. OPC collects and quality controls marine weather and oceanographic data for the purpose of initializing operational forecast models, and disseminates packaged data/information sets to NOAA offices and the private sector. Products currently produced or under development fall into four basic categories: marine weather and boundary layer phenomena; waves and wave dynamics; ocean thermal structure and dynamics; and polar meteorology and ice dynamics.

OPR Office of Protected Resources
NOAA National Marine Fisheries Service
1335 East-West Highway, Rm. 8268
Silver Spring, MD 20910
(301) 427-2332, FTS 427-2332

Expertise: OPR provides advice and guidance on the conservation and protection of those marine mammals and endangered species under the jurisdiction of the Secretary of Commerce, and on matters regarding the environmental impact of human activities on living marine resources and their habitats. OPR prepares regulations and other public notices, conducts public hearings, prepares and reviews management plans, issues permits, assists in coordinating enforcement programs, and provides technical support for international negotiations and the Marine Mammal Commission. Other duties include assessments of effects of energy production, coastal zone development, and other similar activities on living marine resources and their habitats. OPR also maintains oversight of the fishery ecology aspects of NMFS marine fisheries resource programs.

PFEG Pacific Fisheries Environmental Group
Southwest Fisheries Center
NOAA National Marine Fisheries Service
P.O. Box 831
Monterey, CA 93942
(408) 646-3311

Expertise: The PFEG Laboratory is a part of NOAA's Southwest Fisheries Center organization. The Group's mission is to provide environmental information in support of biological and fisheries programs at the NOAA National Marine Fisheries Service research centers. The work concerns ocean climatology, monitoring, modeling, and forecasting with emphasis on large-scale events and ocean variability.

PMEL Pacific Marine Environmental Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
Bin C 15700
7600 Sand Point Way, N.E.
Seattle, WA 98115-0070
(206) 526-6810, FTS 392-6800

Expertise: PMEL conducts interdisciplinary scientific investigations in oceanography, marine meteorology, and related subjects. Current PMEL programs focus on climate, marine observation and prediction, marine resources, and marine environmental assessment. Studies are conducted to improve understanding of the physical and geochemical processes that determine the extent of human effect on the marine environment; to define the forcing functions and the processes driving ocean circulation and the global climate system; and to improve environmental forecasting capabilities and other supporting services for marine transportation and fisheries. PMEL enhances its research efforts through two cooperative institutes: the Joint Institute for Study of the Atmosphere and Ocean, with the University of Washington; and the Joint Institute for Marine and Atmospheric Research, with the University of Hawaii. These institutes were established to provide a bridge between the academic community and PMEL scientists working in climate dynamics, environmental chemistry, tsunami propagation, and estuarine processes.

POD Physical Oceanography Division
Office of Oceangraphy and Marine Assessment
NOAA National Ocean Service
Washington Science Center, Bldg. 1, Rm. 317
6001 Executive Blvd.
Rockville, MD 20853
(301) 443-2357, FTS 443-2357

Expertise: POD of the Office of Oceanography and Marine Assessment (OMA) collects, analyzes, and disseminates a wide range of data and information that describe the physical properties of the oceans, coastal waters, estuarine waterways, and the Great Lakes. Through its National Water Level Observation Network (NWLON), POD monitors water levels at about 225 coastal, estuarine, and Great Lakes sites throughout the U.S., predicts the times and heights of high and low tides, and provides information that is critical to national defense, safe navigation, marine boundry determination, environmental quality management, and coastal engineering. About 30 of the NWLON stations have telephone telemetry and provide real-time water level data for navigation, tsunami, and storm-surge warning. The division's historical water-level data base is the longest, continuous geophysical data set available for assessing an important indicator of climate change. New technological advances in water level measurements are being developed and by POD. They include: the Next-Generation Water Level Measurement System (NGWLMS) Program consisting of acoustic water-level sensors, microprocessor-based data acquisition and collection field units, telephone and satellite telemetry communications links, and a central data collection, processing, and dissemination system. NGWLMS will become fully operational by 1992; the Global Absolute Sea-Level Monitoring Program, a global network of monitoring stations that combines use of the NGWLMS data system with space-based radio-telemetry/satellite-surveying techniques which provide gepdetic control. Twenty-eight sites are now operational throughout the continental U.S., Alaska, Hawaii, and the U.S.-associated Caribbean and Pacific Islands.

SDSD Satellite Data Services Division
National Climatic Data Center
NOAA National Environmental Satellite, Data, and Information Service
Princeton Executive Center
5627 Allentown Rd., Rm. 100
Washington, DC 20233
(301) 763-8402, FTS 763-8402

Expertise: SDSD is a source of information gathered by a series of Earthwatching spacecraft that began in 1960. Images in a variety of forms (negatives, film loops, digital data on magnetic tape) received for quality control and archiving are available for retrospective use. Over 8 million separate images, 50,000 computer-compatible tapes, and 800 mass-storage tapes from 30 satellites are now archived. Satellite data files contain imagery from the early TIROS series of experimental spacecraft and the operational ESSA and NOAA series of spacecraft. Imagery gathered by NASA's experimental geostationary Applications and Technology Satellites, Synchronous Meteorological Satellites, and the current NOAA operational Geostationary Operational Environmental Satellite (GOES) is also available. SDSD maintains magnetic tapes containing digital data from many of these satellites that can be used quantitatively in computerized research and analysis programs. Data from the newest satellites are the fastest-growing portion of the Division's holdings.

SEFC Southeast Fisheries Center
NOAA National Marine Fisheries Service
75 Virginia Beach Drive
Miami, FL 33149
(305) 361-4284, FTS 350-1284

Expertise: SEFC conducts research in support of Federal laws and international agreements related to living marine resources in waters adjacent to southeastern United States, Puerto Rico, and the U.S. Virgin Islands. Center headquarters office are in Miami, FL, and research laboratories are located in Beaufort, NC; Charleston, SC; Miami, FL; Panama City, FL; Stennis Space Center and Pascagoula, MS; and Galveston, TX. At-sea research is conducted from the 170-foot NOAA ship, Oregon-II and the 127-foot NOAA ship, Chapman, berthed at Pascagoula. Scientific and technical information developed by the laboratories is used for fishery management and development and by research organizations. Research programs focus on species that support major commercial and recreational fisheries within the Southeast region.

SEL Space Environment Laboratory
Environmental Research Laboratories
NOAA Office of Oceanic and Atmospheric Research
325 Broadway, Rm. 3050
Boulder, CO 80303
(303) 497-3311, FTS 320-3311

Expertise: SEL activities are directed toward understanding, monitoring, and forecasting solar and geomagnetic events that have undesirable, harmful, and costly effects on activities on and near Earth. SEL activities encompass real-time collection of solar-terrestrial data; dissemination of indices and data; forecasts, alerts, and warnings of adverse solar-terrestrial conditions; archiving and processing of global data from satellites and observatories; and development of a better understanding of the behavior of the solar-terrestrial environment. Space environment services are provided by the Space Environment Services Center (SESC), the center of the U.S. solar-terrestrial services. Operated jointly by SEL and the U.S. Air Force Air Weather Service in Boulder, CO, SESC provides real-time monitoring and forecasting services to meet a wide variety of civilian, military, commercial, and Federal requirements.

SRL Satellite Research Laboratory
Office of Research and Applications
NOAA National Environmental Satellite, Data, and Information Service
World Weather Building
5200 Auth Road, Rm. 712
Camp Springs, MD 20233
(301) 763-8078, FTS 763-8078

Expertise: SRL applies satellite observations to solving problems in the atmospheric, oceanic, and land sciences and in climate research and monitoring. The Laboratory develops methods for remote sensing of the Earth and its atmosphere; performs research on the Earth and its atmosphere using satellite observations; supports such research activities at university and private research organizations; and participates with the university community in joint research projects. SRL plans and coordinates research and development activities and applications of research results with other parts of NOAA and other U.S. government agencies, universities, and international groups; and carries out experiments which are intended to either improve the products which NOAA NESDIS derives from operational satellite data, or are intended to demonstrate initiatives for new operational products. Analysis and validation of satellite data is a necessary part of the laboratory effort conducted by SRL.

SWFC Southwest Fisheries Center
NOAA National Marine Fisheries Service
P.O. Box 271
La Jolla, CA 92038
(619) 546-7000, FTS 893-7000

Expertise: At the SWFC headquarters and La Jolla Laboratory, research efforts are focused on tuna/porpoise; coastal marine mammals; high seas ecosystems; and Pacific tuna conservation and management programs. Also studied are biological assessment of marine fish stocks important to California fisheries; management advice, including economic analysis of regulatory schemes and fishery models; recruitment mechanisms of coastal pelagic fishes of California; and distribution, availability and migratory patterns of albacore. The Honolulu Laboratory has four research groups: the Insular Resources Program and Resource Assessment Investigation of the Mariana Archipelago Program; the Pelagic Resource Investigation, composed of the Experimental Ecology of Tunas Program, the Pelagic Ecosystem Program, and the Pelagic Stock Assessment Program; the Fishery Management Research Program; and the Marine Mammals and Endangered Species Program. The Tiburon Laboratory directs three programs: underutilized fisheries resources, fish communities, and physiological ecology. The research programs deal with recreational and commercial fishes and their fisheries and with predator/prey studies. The Pacific Fisheries Environmental Group's mission is to provide environmental information in support of biological and fisheries programs at the National Marine Fisheries Service research centers. The work concerns ocean climatology, monitoring, modeling, and forecasting with emphasis on large-scale events and ocean variability.

APPENDIX C: GLOSSARY OF TERMS

aerosol -- Very small particles of a liquid or a solid which are suspended in air or another gas. Examples include smoke, dust, and fog.

albedo -- The fraction of incident light reflected from a surface.

biosphere -- The portion of the Earth inhabitated by living organisms, including the land masses, oceans, and atmosphere.

chlorofluorocarbons -- Group of organic compounds analogous to hydrocarbons, in which all or most of the hydrogen atoms of a hydrocarbon have been replaced by fluorine or chlorine; see halogens.

condensation nuclei -- Aerosol which serve as the nuclei upon which water vapor condenses. Cloud condensation nuclei occur in the atmosphere.

DDT -- A persistent insecticide which is a mixture of isomers of dichlorodiphenyltrichloroethane, a chlorinated hydrocarbon.

Dobson units -- Unit of measurement ozone concentration in atmosphere. Represents the amount of ozone in a vertical column of the atmosphere at standard atmospheric pressure. 1 Dobson unit = 10^3 cm at a standard atmosphere. Named after G.M.B. Dobson, English inventor of ozone spectrophotometer and first to establish a routine ozone-observing program in 1924.

EEZ -- See Exclusive Economic Zone.

electromagnetic sensing -- Remote sensing of ocean transport using naturally occuring electric currents caused by flow through the Earth's magnetic field. Measurements of induced electric fields and resulting currents are made from submarine cables, towed electrode systems, and free-fall profilers.

El Nino -- Anomalous warming of the eastern tropical Pacific Ocean that occurs at 2-10 year intervals and is frequently associated with far-reaching climatic and economic impacts around the world.

ENSO -- El Nino (q.v.)/Southern Oscillation (q.v.) (ENSO) -- term used to describe the oceanic-atmospheric interactions of El Nino events.

ERL -- The Environmental Research Laboratories (ERL) are organized within NOAA's OAR (q.v.) and have their headquarters in Boulder, CO. ERL consists of 10 research laboratories and 7 joint/cooperative research institutes throughout the U.S.

Exclusive Economic Zone -- Coastal ocean under limited U.S. legal jurisdiction. By law, the Exclusive Economic Zone (EEZ) is defined as contiguous to the territorial sea of the U.S. and extending seaward 200 nautical miles measured from the baseline from which the territorial sea was measured. Under the Magnuson Fishery Conservation and Management Act, the U.S. has exclusive management authority over all living marine resources in the EEZ.

Florida Current -- A North Atlantic Ocean western boundary current (q.v.) setting northward along the southeast coast of the United States. A segment of the Gulf Stream System, the Florida Current extends from the Straits of Florida to the region off Cape Hatteras, NC. Part of the general, surface circulation of the oceans.

GEOSAT -- GEOdetic SATellite. U.S. Navy altimeter satellite launched in 1985 used to collect global altimeter data.

GOES -- New NOAA system of Geostationary Operational Environmental Satellites (GOES), which will enter service in 1990.

greenhouse effect -- Theory associated with increase in "greenhouse gases" (e.g., carbon dioxide, methane, nitrous oxide, tropospheric ozone, chlorofluorocarbons) and their ability to absorb thermal infrared radiation increasing atmospheric temperatures.

halogens -- The five elements fluorine, chlorine, bromine, iodine, and astatine. Organic compounds formed from these include chlorofluorocarbons, chlorinated hydrocarbons, and various plastics.

joint venture -- An operation authorized under the Magnuson Fishery Conservation and Management Act in which a permitted foreign vessel receives fish in the U.S. Exclusive Economic Zone from a U.S. vessel. The fish received from the U.S. vessel are part of the U.S. harvest.

La Nina -- Periods between El Nino events in the eastern tropical Pacific characterized by normal ocean/atmospheric conditions (i.e. a "cool" event).

methane -- The simplest hydrocarbon, found in natural gas and as a degredation product of carbonaceous materials, and thus occurs in association with petroleum, coal, bogs, and marshes. The second most abundant greenhouse gas, after carbon dioxide.

micron -- A unit of measurement (symbol:u) in the metric system equivalent to one-millionth meter (10^{-6} meter). Also called a micrometer.

microwaves -- Portion of electromagnetic spectrum lying between the far infrared and radio frequencies, i.e., wavelengths from 1 to 1000 millimeters.

millibar -- Commonly used unit of pressure (symbol: mb) in meteorology (1 mb = 10^3 dynes/cm^2). 1013 mb is regarded as the standard atmosphere pressure at sea level.

nanogram -- One-billionth of a gram. The prefix nano (symbol: n) means one-billionth part (10^{-9}).

NESDIS -- National Environmental Satellite, Data, and Information Service (NESDIS). Office responsible for NOAA's environmental satellite and data management programs.

nitrous oxide -- A greenhouse gas (N_2O) of primarily biogenic origin. N_2O absorbs in the thermal infrared spectrum and contributes to warming of the atmosphere.

Nimbus-7 -- Satellite used to fly the Coastal Zone Color Scanner (CZCS) and Total Ozone Mapping Spectrophotometer (q.v.).

NMFS -- National Marine Fisheries Service. Office responsible for the integrated NOAA marine fisheries programs.

NOS -- National Ocean Service. Office responsible for the integrated NOAA ocean services and coastal zone management programs.

NWS -- National Weather Service. Office responsible for the integrated NOAA weather service programs.

OAR -- Office of Oceanic and Atmospheric Research. Office responsible for the integrated NOAA oceanic and atmospheric research and development programs.

ozone -- Photochemically produced form of oxygen (symbol: O_3). Ozone shields the Earth from solar ultraviolet radiation and acts as a strong oxidizing agent for chemical reactions involving other biogenic gases.

Palmer Drought Index -- Index of dryness (drought) developed by Wayne C. Palmer of the NWS to quantify negative meteorological moisture anomalies.

precipitation index -- Statistically derived index that depicts average precipitation (moisture) over long time periods and large geographic areas.

Quasi-Biennial Oscillation -- Equatorial east-west oscillation of stratospheric winds. The quasi-biennial oscillation (QBO) has a period of about 26 months and has largest amplitude near 30 mb pressure. The QBO shows a strong relationship with Atlantic tropical storm activity.

radiosonde -- Meteorological instrument that records and transmits atmospheric temperatures and humidity with altitude. Carried aloft by balloon.

rawinsonde -- Meteorological instrument that records and transmits atmospheric temperatures and wind direction/speed with altitude. Usually carried aloft by ballon.

rocketsonde -- Radiosonde (q.v.) or rawinsonde (q.v.) carried aloft by rocket.

Sahel -- Geographical area in north central Africa (Mauritania to Chad) between the Sahara desert of North Africa and the forested regions of equatorial Africa. This region is arid with sparse vegetation and is susceptible to desertification.

sea level -- Level of the ocean surface in relation to adjacent land (secular sea level) or satellite at a known altitude (absolute sea level).

SEAMAP -- Southeast Area Monitoring and Assessment Program. State/Federal/university program for collection, management, and dissemination of fishery-independent data and information in the southeastern United States.

shellfish -- Any aquatic invertebrate possessing a shell, especially any edible mollusk or crustacean, as oysters, clams, lobsters, and shrimps.

solar irradiance -- The total solar radiation received on a surface per unit area.

southern oscillation -- An intermittent 2-10 year quasi-periodicity observed in atmospheric pressure, surface wind, sea surface temperature, cloudiness, and rainfall over a wide area of the Pacific Ocean and adjacent coastal areas, south of the equator.

stratosphere -- The upper portion of Earth's atmosphere, above the troposphere (from 8-20 km) and below the mesosphere (to around 45 km), characterized by relatively uniform temperatures and horizontal winds (jet stream).

sunspot -- Dark areas seen on the Sun's surface that are regions of cool gas. Their presence is associated with local variations in the Sun's magnetic field. Appear to have cycles having a period of 11 years.

Sverdrups -- Unit of measurement (symbol: SV) used to quantify the ocean volume transported . 1 sverdrup = one million cubic meters per second.

TOGA -- Tropical Ocean and Global Atmosphere Program. Part of the 10-year (1985-1995) international World Climate Research Program established by the World Meteorological Organization. NOAA is an active participant in TOGA.

TOMS -- Total Ozone Mapping Spectrophotometer. Instrument flown aboard Nimbus-7 satellite, used to remotely measure stratospheric ozone.

tornado -- Intense, funnel-shaped wind phenomena usually associated with fast-moving cold fronts.

tropical cyclone -- Intense, circular, cyclonic storms formed in ocean regions.

troposphere -- The lowest layer of the Earth's atmosphere extending from the surface to the tropopause (10-20 km depending on latitude and time of year). Temperature decreases steadily with increased altitude, turbulence is greatest, and most weather phenomena occur in this region.

upwelling -- An upward flow of subsurface water due to divergences, offshore winds, and wind-driven transport away from shore.

visible wavelengths -- The continuous spectrum of visible radiation lying in the wavelength range between 380 and 780 nanometers. Seven colors are usually distinguished in the continuous variation of visible wavelengths: violet, indigo, blue, green, yellow, orange, and red.

western boundary currents -- Currents of the major ocean gyres flowing along the eastern coasts of all continents. These currents are fast, narrow, and, in some regions, meander unpredictably. Two examples of these currents are the Kuroshio in the Pacific Ocean and the Florida Current (q.v.) and Gulf Stream in the Atlantic Ocean.

wind stress -- Frictional drag at the boundary between the air-sea interface. One of the physical forces influencing ocean circulation.

APPENDIX D: RELATED REPORTS AND PUBLICATIONS

A number of publications, both governmental and private, present regular analyses of the Earth's environment and natural resources. In addition, there are numerous special reports and scientific journals that deal with global environmental issues periodically. Examples of significant publications related to this report are:

Climate Assessment for 1990: Selected Indicators of Global Climate -- Published jointly by NOAA's Climate Analysis Center and National Climatic Data Center, this yearly report provides an annual summary (including historical perspectives) of selected atmospheric and oceanic parameters including sea ice and snow cover. Global coverage is emphasized although regional and United States conditions are also highlighted.

Climate Diagnostics Bulletin -- Published by NOAA's Climate Analysis Center, Camp Springs, MD, this report is a summary of worldwide monthly meteorological data such as sea surface temperature, sea surface pressure, winds, and ocean currents. Anomalies are noted and summaries for each parameter are discussed.

Environmental Trends -- A publication of the Council on Environmental Quality which focuses on selected U.S. "indicators" chosen by an Interagency Advisory Committee on Environmental Trends. Statistical series are compiled from data available through government agencies, private studies, or the literature of each discpline. Chapters concern minerals, energy, water, climate, air quality, land resources, wildlife, wetlands, protected areas, population, transportation, environmental hazards.

Fisheries of the United States -- Published yearly by NOAA's National Marine Fisheries Service (NMFS), Fisheries Statistics Division. The publication is a preliminary report giving annual statistics on commercial and recreational fisheries of the United States and foreign catch in the U.S. Exclusive Economic Zone. Final data are published in Fishery Statistics of the United States and other NMFS statistical publications. Data are provided on U.S. employment, prices, and production of processed products. Worldwide data are also included. In addition, the Food and Agriculture Organization of the United Nations Committee on Fisheries produces reports on The State of World Fishery Resources. The report gives details on world fish production, notes changes in major fish stocks, and reviews global environmental problems as they relate to fisheries management.

Geophysical Monitoring for Climatic Change Summary Report -- This is an annual report published by the Geophysical Monitoring for Climatic Change Division of NOAA's Climate Monitoring and Diagnostics Laboratory. The report contains scientific information on a number of geophysical parameters monitored at NOAA's baseline observatories. These parameters include: atmospheric aerosols, solar radiation, atmospheric turbidity, carbon dioxide, ozone, water vapor, and other atmospheric parameters of climatological significance.

The Global Climate System Monitoring Bulletin -- The report, published bi-annually by the World Meteorological Organization, is a review of global climate conditions based on current scientific understanding and worldwide observations of the climate system. It is intended to provide a basis for monitoring global change. The report is compiled from readily available scientific literature, has an extensive bibliography, and is highly informative.

Report to Congress on Ocean Pollution, Monitoring, and Research --This is an annual report published by the Office of Oceanography and Marine Assessment of NOAA's National Ocean Service. The publication details NOAA pollution-related programs including the National Coastal Pollution Discharge Inventory, National Estuarine Inventory, National Status and Trends Program, and special reports on water quality issues of national significance.

State of the World: A Worldwatch Institute Report on Progress Toward a Sustainable Society -- This is an annual report by Lester Brown et al. of the World Watch Institute. The report discusses global environmental problems that especially affect peoples' lives, including: deforestation, toxic pollution, overpopulation, species extinction, and energy uses. The publication also covers political issues such as military buildup and the nationalistic policies of various countries. The report is translated and published in all major languages.

U.S. Environmental Quality -- The annual report of the Council on Environmental Quality. The report is submitted to Congress and highlights selected environmental issues. These selected topics are discussed in considerable depth. The focus is on the United States. Appendices identify activities of the Council, highlight specific environmental legislation, and provide numerical data in tabular form together with the President's Message to Congress.

World Resources: A Guide to the Global Environment -- This annual report by the World Resources Institute, Washington, D.C., was first published in 1986. The publication reviews global environmental issues such as population and health, food and agriculture, forests and rangelands, atmosphere and climate, oceans and coasts, wildlife and habitats, and global systems. In addition, the report provides quantitative information on issues related to economic indicators, population, public health, land and water use, etc.

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