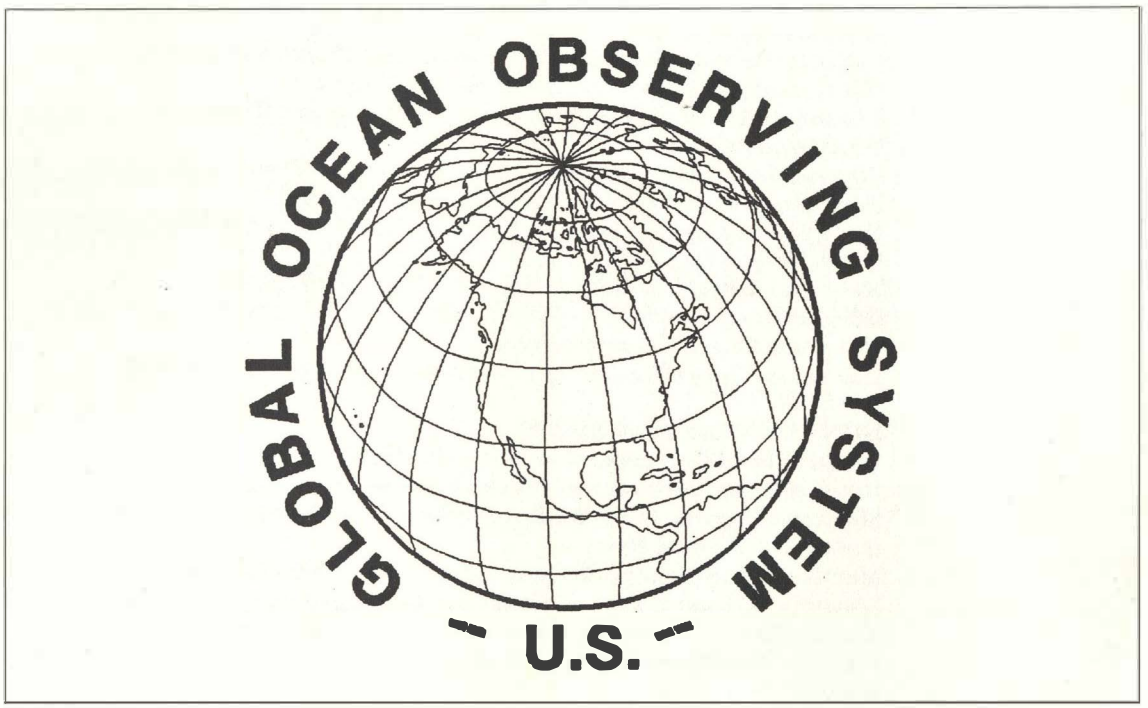
The Coastal Module of the U.S. Global Ocean Observing System: A Strategic Plan



By the Ad Hoc Working Group for Coastal GOOS

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The Ad Hoc Working Group for U.S. Coastal GOOS

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Contents

Background

The Global Ocean Observing System (GOOS) was initiated by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in cooperation with the World Meteorological Organization (WMO), the United Nations Environmental Program (UNEP), and the International Council of Scientific Unions (ICSU). GOOS was conceived as an internationally coordinated system for ocean observations, driven by user needs for improvements in climate forecasting, assessment of the status and health of the marine environment, and development of applied products and services to support coastal managers in their decision-making. GOOS provides a framework for the systematic collection of observational data; timely exchange of data and information; incorporation of data into state-of-the-art predictive models; and technology transfer and capacity building among and within participating member agencies and organizations.

The Panel on International Programs and Interagency Cooperation in Ocean Affairs (PIPICO), chaired by the U.S. Department of State, coordinates all matters pertaining to UNESCO's IOC, including the GOOS initiative.

The U.S. GOOS initiative is overseen by the U.S. Interagency Working Group for GOOS, chaired by the National Oceanic and Atmospheric Administration (NOAA). This working group includes representatives from the U.S. Navy, National Science Foundation, National Aeronautics and Space Administration, Department of Energy, Department of the Interior, Environmental Protection Agency, the Department of State. Agenda 21, the framework for actions agreed to at the United Nations Conference on Environment and Development (UNCED), called for a GOOS initiative and charged developed countries with its funding.

IOC member countries (including the U.S.) have agreed to the creation of five GOOS modules:

1. Climate Monitoring, Assessment, and Prediciton;
2. Monitoring and Assessment of Marine Living Resources;
3. Assessment and Prediction of the Health of the Ocean;
4. Marine Meteorological and Oceanographic Operational Services; and
5. Monitoring of the Coastal Zone Environment and its Changes.

The first four modules are global observation programs (U.S. Interagency Working Group for GOOS, 1993). The coastal module is a geographic cross-cut of the other modules and can be thought of as a synthesis program with observations specific to coastal user needs added as necessary.

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The Importance of U.S. Coastal GOOS

The Coastal Module is one of the most important components of the national Global Ocean Observing System because of the enormous ecological, aesthetic, and economic value of U.S. coastal areas. People are attracted to the coast for a variety of business-related and recreational activities, including fishing, tourism, and commerce. Coastal areas provide critical habitat for commercially and ecologically valuable species, as well as serving as a protective buffer against many forms of natural and anthropogenic hazards. The data, information services, and applied products generated through the Coastal GOOS module will contribute to improved management of the nation's coastal resources, and ultimately to its long-term economic and environmental sustainability. Its operational data products and services will be used to improve the efficiency, safety, accuracy, and planning decisions of U.S. coastal industries and services. In very broad economic terms, Colgan (1985) attributed the worth of the U.S. coastal zone in 1985 to almost $1.3 trillion in Gross National Product (GNP), the current market value of all goods and services, or about one-third of total U.S. GNP.

U.S. coastal waters are of immense economic and environmental importance to the Nation. Almost 95% of the world's commerce is transported by ship through coastal waters; waterborne commerce for the U.S. for 1990 is estimated at $465 billion. Coastal ocean oil and gas deposits currently account for about $16 billion annually. Over 350,000 coastal residents rely directly on commercial fishing for their livelihood, while over 17 million anglers enjoy saltwater fishing each year. The U.S. Department of Commerce (1992) reported that U.S. commercial fisheries produced $3.9 billion in revenue to fishermen at U.S. ports, with a total impact on the GNP of over $50 billion. Recreational fishermen spend about $6.2 billion, and recreational boaters contribute another $17.1 billion annually (Council on Environmental Quality, 1993).

Yet an appreciation of the full economic value of the nation's coastal resources involves more than evaluating coastal industries. To many Americans, the ecological and aesthetic values of the coastal zone are at least as significant as the economic value. Coastal areas are biologically productive, diverse, stable ecosystems, that provide habitat for critical and endangered species and serve as spawning and nursery grounds for many species, including those of commercial importance. Coastal areas serve as buffer zones with a critical dual role: (1) to protect uplands from storms and flooding, and (2) to act as natural filters for pollutants and other material from the watershed area before they enter the coastal ocean.

Despite the direct and indirect ecomonic and aesthetic benefits of coastal areas, coastal residents and the homes, industry, and infrastructure necessary to accommodate them are subject to significant risks from natural disasters. Currently, there are an estimated 276,000 households in high-hazard areas threatened by storm surge and an additional 2.4 million households located in the flood plain adjacent to this high-impact zone (Subcommittee on U.S. Coastal Ocean Science, 1993). Coastal storms cause billions of dollars in damage and hundreds of deaths every year. According to estimates of NOAA's National Weather Service, the damages of hurricanes Hugo (1989), Andrew (1992), and Iniki (1992) cumulatively caused losses in excess of $40 billion.

Coastal Problems that GOOS Can Help Resolve

The increasing use of coastal areas has produced recurrent symptoms of problems from human activities. Fish kills from harmful algal blooms and anoxic conditions, bacterial-contaminated waters closed to swimming, advisories warning against the consumption of contaminated fish and shellfish, and mortalities of coastal species from accidental discharges of hazardous materials are relatively common in the coastal areas of many

nations, including the United States. Problems that U.S. Coastal GOOS information can help environmental scientists and natural resource managers resolve include:

1. *Habitat loss and degradation* (e.g., decreased areas for fish spawning and juvenile development and general reductions in fish populations; wetland loss; loss of coral reefs, mangrove habitat, and seagrass beds);

2. *Nonpoint sources of pollution* (e.g., reduction in habitat/water quality; harmful algal blooms; nutrient overenrichment and eutrophication; seafood contamination; atmospheric and groundwater transport of pollutants);

3. *Point-source pollution* (e.g., chronic and intermittent spills of hazardous materials; routine discharges from pipes, sewage, waste treatment plants, industrial waste);

4. *Human health risks* (e.g., seafood contamination; beach and swimming area closures; shoreline debris and hazardous materials);

5. *Coastal hazards* (e.g., warnings of storms; sea ice; sea-level changes; tsunamis; underwater obstructions or wrecks).

6. *Decreasing biodiversity* (e.g., invasions of foreign species; decrease in habitat or water quality or quantity; overfishing; reduced stability of ecosystems or habitat);

7. *Multiple-use conflicts* (e.g., balancing the impacts of coastal development (habitat loss, erosion, reduced water quality, changes in circulation patterns) and resource exploitation (fisheries, oil/gas and mineral exploration and development) with sustainable management/protection of natural resources;

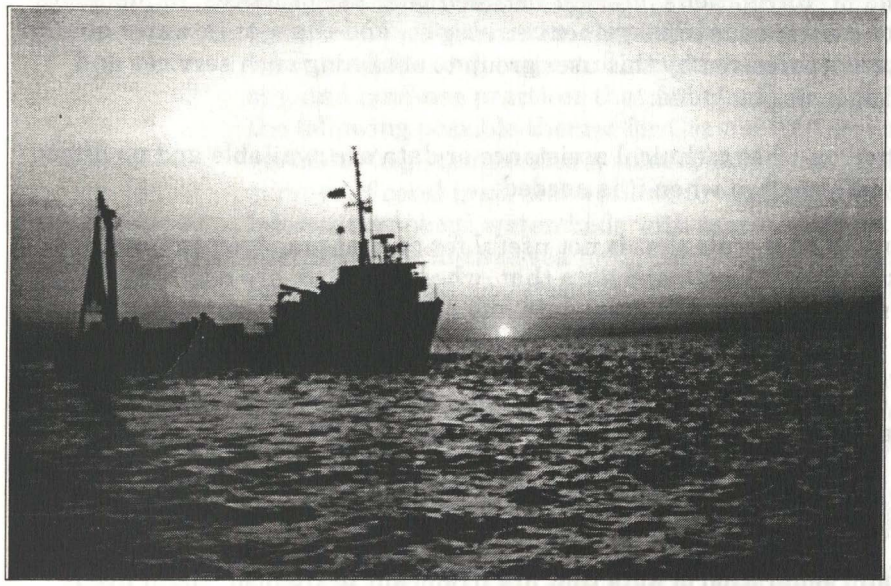
8. *General concern over the lack of integrated coastal managment,* including comprehensive land-use strategies and restrictions on terrestrial coastal zone activities with negative nearshore impacts.

Based on these concerns, specific management and scientific questions that GOOS information could answer have been listed and discussed as part of the strategic planning process for Coastal GOOS. First on the list of management questions is a need to reliably identify and map land-use changes, critical habitats, and species at risk to ensure sustainable use of coastal resources. First on the list of scientific concerns is the desire to improve U.S. capabilities for predicting, forecasting, and detecting coastal hazards such as storms, sea ice, underwater hazards, tidal surges, and making this information available in real-time (i.e., as soon as collected and processed into an electronic format) to Coastal GOOS customers.

The Planning Process

NOAA established a working group in the spring of 1994 to develop a coastal strategy for NOAA and to define its participation in the Coastal GOOS Module. Representatives of this working group presented a progress report to the National Academy of Science's National Research Council (NRC) committee charged with reviewing the U.S. GOOS planning effort. The resulting report (NRC, 1994) recommended that the NOAA working group expand its membership and develop a vision for the U.S. GOOS Coastal Module in partnership with other agencies and nongovernmental organizations (NGOs) using or managing coastal resources.

Forty-three representatives from 12 federal bureaus and agencies (National Oceanic and Atmospheric Administration, Minerals Management Service, National Biological Service,



Federal, state, and local agencies want access to an integrated data-sharing system with acceptable quality assurance and control standards, real-time observations, and long-term measurements on watersheds and coastal waters.

U.S. Geological Survey, U.S. Environmental Protection Agency, Department of State, National Aeronautics and Space Administration, Department of Energy, National Science Foundation, Department of the Navy, U.S. Coast Guard, and the Army Corps of Engineers) agreed to develop, in partnership with other governmental and NGO representatives, a strategic plan and cooperative budget initiative for U.S. Coastal GOOS. The Ad Hoc Working Group for Coastal GOOS was formed to reflect the interests of a broad array of coastal users and to represent user needs in the planning, implementation, and performance review of the U.S. GOOS Coastal Module. Organizations were asked to provide a representative with technical understanding of ongoing coastal environmental studies and user needs. Additionally, more than 30 members from non-federal agencies and other organizations representing coastal industry, research, resource management, and professional societies have joined the Working Group. U.S. Coastal GOOS will continue to forge partnerships among organizations to link programs, integrate data, and make coastal information available to GOOS national and international partners and customers (see Appendix 1).

The Needs of Partners

Coastal managers. Federal partners of the Working Group were unanimous in wanting ready access to coastal data and information from other agency and NGO observation programs. These federal bureaus and agencies are involved to a varying degree with monitoring, interpreting, predicting, or mitigating the responses of coastal ecosystems and finding solutions for some of our most difficult coastal problems (such as maximizing fisheries harvests and minimizing anthropogenic impacts). For improved management of coastal ecosystems, federal, state, and local agencies want access to an integrated data-sharing system with acceptable quality assurance and control standards, real-time observations, and long-term measurements on watersheds and coastal waters. To prevent and mitigate against negative impacts to coastal ecosystems, agency managers need GOOS observational data interpreted and translated into reliable and easy-to-understand coastal assessments.

In the fall of 1993, 34 Coastal Zone Program managers were surveyed by NOAA (NOAA Integrated Coastal Management Committee, 1995). The coastal managers identified the products and services they needed but did not perceive as available as: (1) scientifically supported methodologies for addressing development impacts, (2) some type of informa-

tion clearinghouse, and (3) correlations/linkages between land-use practices, implementation of nonpoint source coastal zone management strategies, and changes in water quality parameters. The obstacles perceived by this user group to obtaining such services and products from federal agencies included:

- a lack of information on what technical assistance or data are available and no direct mechanism to get information when it is needed;
- information generated on a scale that is not useful for coastal management (watershed as opposed to national level), and data that, when provided, are aggregated (coastal managers need site-specific, local data, not site-averaged, regional/national aggregates);
- no input into the design of research, monitoring, and assessment projects to ensure that coastal management problems are addressed;
- a perception that federal expertise is insufficient in certain fields (e.g., wetlands protection and biodiversity); and
- a focus on issues and generation of data that are irrelevant to tropical island needs.

Coastal scientists. The Committee on the Environment and Natural Resources Research (CENR), one of nine National Science and Technology Council committees, is formulating U.S. research and development strategies on issues such as global change, biodiversity and ecosystem dynamics, and resource use and management. One of CENR's subcommittees, the Water Resources and Coastal Marine Environments Research Subcommittee, asked the NRC's Ocean Studies Board to conduct a study to identify high-priority science to meet national coastal needs related to two principal issues being addressed by the Subcommittee: (1) water quantity and allocation, and (2) ecosystem integrity. The overarching NRC (1994) recommendation is that an integrated scientific framework should be established that (1) facilitates systematic applicaton of research results from individual studies in specific coastal regions to address resource management problems occurring in other regions, (2) encourages cooperative interagency activities, and (3) is based on a strong commitment to fundamental research.

NRC recommendations are organized under five priority research areas that are now being used in the CENR Subcommittee's framework: (1) integrated monitoring, (2) water availability and flow, (3) water quality and aquatic ecosystem functions, (4) ecological restoration and rehabilitation, and (5) predictive systems management. Other recommendations within the five priority research areas relevant to U.S. Coastal GOOS are to (1) develop and implement observation systems that focus on interactions among atmosphere, land, and water dynamics at time and space scales relevant to ecological, physical, and socioeconomic processes; (2) implement observation and prediction systems founded on near real-time measurement of physical properties and processes in selected coastal environments that lead to environmental forecasts useful for ecosystem protection, resource management, and human safety; and (3) link regional and national monitoring to improve the comparability and utility of local, regional, and national monitoring programs. Finally, the NRC specified that the Water Subcommittee should identify mechanisms to promote intellectual exchange and scientific coordination with relevant international coastal science efforts such as the Land-Ocean Interactions in the Coastal Zone Initiative and the Global Ocean Observing System.

The NRC's Ocean Studies Board was also asked by the Under Secretary of Commerce for Oceans and Atmosphere to lead a group composed of members nominated by all relevant NRC boards to assess U.S. activity in the development of GOOS and the U.S. role in international GOOS. The NRC (1994) recommended that the Monitoring of the Coastal

Zone and its Changes module of GOOS gather coastal data to develop the basic, long-term baseline information that will be needed to interpret the observations made by other modules and support observations of coastal physical oceanography, beach morphology, and land-use practices that are not planned by other modules. The NRC suggested the following possible themes for Coastal GOOS: long-time series of coastal data for basic variables (e.g., temperature, salinity, nutrients), habitat change analysis (e.g., routine surveys of coral reefs and wetlands), watershed-habitat systems (e.g., observations to link information about watersheds with marine habitat information), and seaports (e.g., operational, real-time sea level, current and wind measurements). Appendix 2 lists the top management and scientific questions driving Coastal GOOS; Appendix 3 outlines priority research and observation needs.

Coastal industries. The industry sub-group of the Ad Hoc Working Group for Coastal GOOS identified and prioritized its coastal problems and agreed that accuracy of mid-range weather forecasts is the most important coastal problem, with a primary need for the real-time global ocean data used to make those forecasts. In descending order of priority, this group also identified the following needs of coastal industry: accurate real-time water level measurements, modeling to better determine sustainability of coastal development, reliable estimates of the impacts of nonpoint sources of contamination (especially atmospheric contributions), and ice forecasting products.

Accurate forecasts are important to the safety of life and property. Primary users of coastal real-time oceanographic information and a mid-range coastal forecast system would be pilots, commercial carriers, port authorities, fishermen, recreational boaters, and insurers focusing on hazardous cargo, especially oil. In the case of offshore drilling rigs, for example, these large structures are often designed to be moved, but with the legs up they are very unstable and vulnerable to damage in bad weather. Since these rigs can only be towed at very slow speeds, it often takes several days to complete a relocation. The move will be deferred until a favorable mid-range (5-7 days) weather forecast is available, but in the past these forecasts have not been as reliable as needed. The industry believes that the technology is available to create more reliable forecasts if more input data can be acquired. In a similar fashion, the fishing industry has suffered with the necessity of often having to fish in bad weather because management agencies have established a very short season to protect the resource. Since fishing vessels are inherently small and vulnerable to bad weather, it is manifestly unsafe to fish under such circumstances. Improved mid-range forecasting would enable authorities to shift the open fishing dates with some lead time if unsuitable weather were forecast.

The second most important need of industry is accurate real-time water level measurements. Because channel depth varies with the tide and with wind conditions as well as shoaling bottom conditions, ships must be careful not to load beyond a draft level that ensures a safe clearance over the bottom in virtually any water level that might be encountered in the destination port. There is obviously a significant economic payoff in being able to take on more cargo if the destination port is equipped with a real-time water level monitoring system that would enable the ship to enter safely with a deeper draft. Successful demonstrations of this concept have proven beneficial to the industry and to the environment. This is of particular interest in the United States, which has a large number of rather shallow ports that must be dredged regularly to maintain commerce. The problem is not limited to the ports, however; in the large bays and in the Gulf of Mexico, offshore channels have been dredged to permit safe approaches to ports, and significant offshore groundings have occurred. The data must be accessible to ships on a real-time basis to be effective, and systems to accomplish this have been demonstrated.

With reliable predictions and real-time coastal information, ocean industries could operate with the best mix of economic and sustained use of coastal resources. Because of

the vulnerability of ocean industries to environmental conditions, tangible economic benefits can be realized by both better weather and water level predictions.

Other coastal users. Other potential users of GOOS information include Congressional committees, the news media, and the public. Educators could use Coastal GOOS' easy-to-understand translations from the raw scientific data to prepare curricula for students from elementary through graduate school, thereby helping to train better stewards of coastal resources. Anyone concerned with U.S. human health or environmental risks from coastal areas or use of coastal resources would have more complete and reliable information prepared from GOOS coastal observation data.

Coastal GOOS: Purpose, Mission, Scope and Strategies

Coastal GOOS can be thought of as combining the data elements of other GOOS modules that are relevant to coastal problems with supplemental information, both from in-situ and satellite observations, critical to the sustained use of coastal resources. The purpose of Coastal GOOS is to support the collection of important coastal observations through time, identify critical information gaps, coordinate the collection of new observations to fill in these gaps, and disseminate coastal information to managers and scientists. Coastal GOOS is not research, not a short-term project, not another costly new government program, and definitely not an activity of a few scientists or a particular agency. It is the collection of many coastal monitoring activities within the United States for the use of coastal managers and scientists, and ultimately for the exchange of information with other nations.

The mission of the U.S. GOOS Coastal Module is to establish an operational system that integrates and facilitates access to in-situ and satellite-based coastal observations for reliable assessment, prediction, and management of national, regional, and local coastal resources.

The geographic scope of U.S. Coastal GOOS is broad and includes marine, terrestrial, and atmospheric environments. The spatial extent of observations is defined as the U.S. coastal zone from the continental shelf break, or 200 nautical miles offshore (the seaward extent of the exclusive economic zone), to the shoreline and up coastal rivers to the head of tidal influence. This range includes coastal and shelf waters, estuaries, estuarine drainage areas, wetlands, flood plains, lagoons, beaches, and the overlying atmosphere. Scales of application for the GOOS Coastal Module include national, regional, and, at some sites, local levels.

The strategic implication of U.S. Coastal GOOS is potentially significant. No single organization has the resources to effectively tackle and resolve our major coastal problems, yet in partnership through Coastal GOOS, scientific data and information needs can be identified and available data can be assimilated into a "one-stop" electronic directory. This directory will be designed to guide the user as to (1) data availability, data collecting time and location, data collecting methods, (2) tools available for analyzing the data, their boundary conditions, and application, and (3) data requirements and sources of the above if they cannot be accessed directly from GOOS. In general, each agency only has enough resources to collect data in response to its mandates. Data needed for defining the baseline and conducting trend analyses are often missing. GOOS can identify such data gaps and collect the needed data. Coastal GOOS will make data and tools readily accessible for predicting impacts and managing coastal resources and ecosystem health.

Goals and Near-term Priorities

The ultimate goal of GOOS is to ensure global, permanent systematic observations adequate for forecasting climate variability and changes, and for assessing the health or state of the marine environment and its resources. The functions of each module under U.S. GOOS are shown in Figure 1. Different coastal observations are needed for different purposes.

The primary goal established for the U.S. Coastal GOOS Module is to integrate and facilitate access to observation systems for the management of coastal resources, sustainable economic development, and healthy and diverse coastal ecosystems. Given the resources constraint, five major issues have been selected for immediate action by U.S. Coastal GOOS. They are:

- access to long-term coastal data and information, especially as it relates to
- real-time seaport water level and mid-range coastal forecasts
- watershed and coastal habitat changes
- the quantity and quality of contaminant fluxes through coastal areas, and
- linking coastal resource use to habitat change for sustainable use of living marine resources and healthy coastal ecosystems.

Accordingly, the Working Group established the following short-term goals and objectives for its governmental and NGO partners to facilitate access to information and tools for addressing these issues. These goals and objectives will be reassessed annually according to evolving needs.

Goal 1: Collection, dissemination, and long-time continuity of coastal data.

Objective 1. Begin immediately to identify, describe, and prepare a directory to ongoing, historical baseline information and tools available that are relevant to resolving problems in the nation's coastal regions (e.g., temperature, salinity, currents, wind direction and speed, nutrients, contaminants, plankton productivity, fisheries harvest statistics, human population).

Objective 2. Cooperatively identify the gaps in coastal observations and propose new observation programs needed to manage coastal ecosystems for sustained development of resources.

Objective 3. Form an interagency task force to begin developing an Internet-based system for access to Coastal GOOS data and information products.

Objective 4. With international cooperation, establish a program to collect standardized data on a global basis to enhance the usefulness of data described in Objective 1.

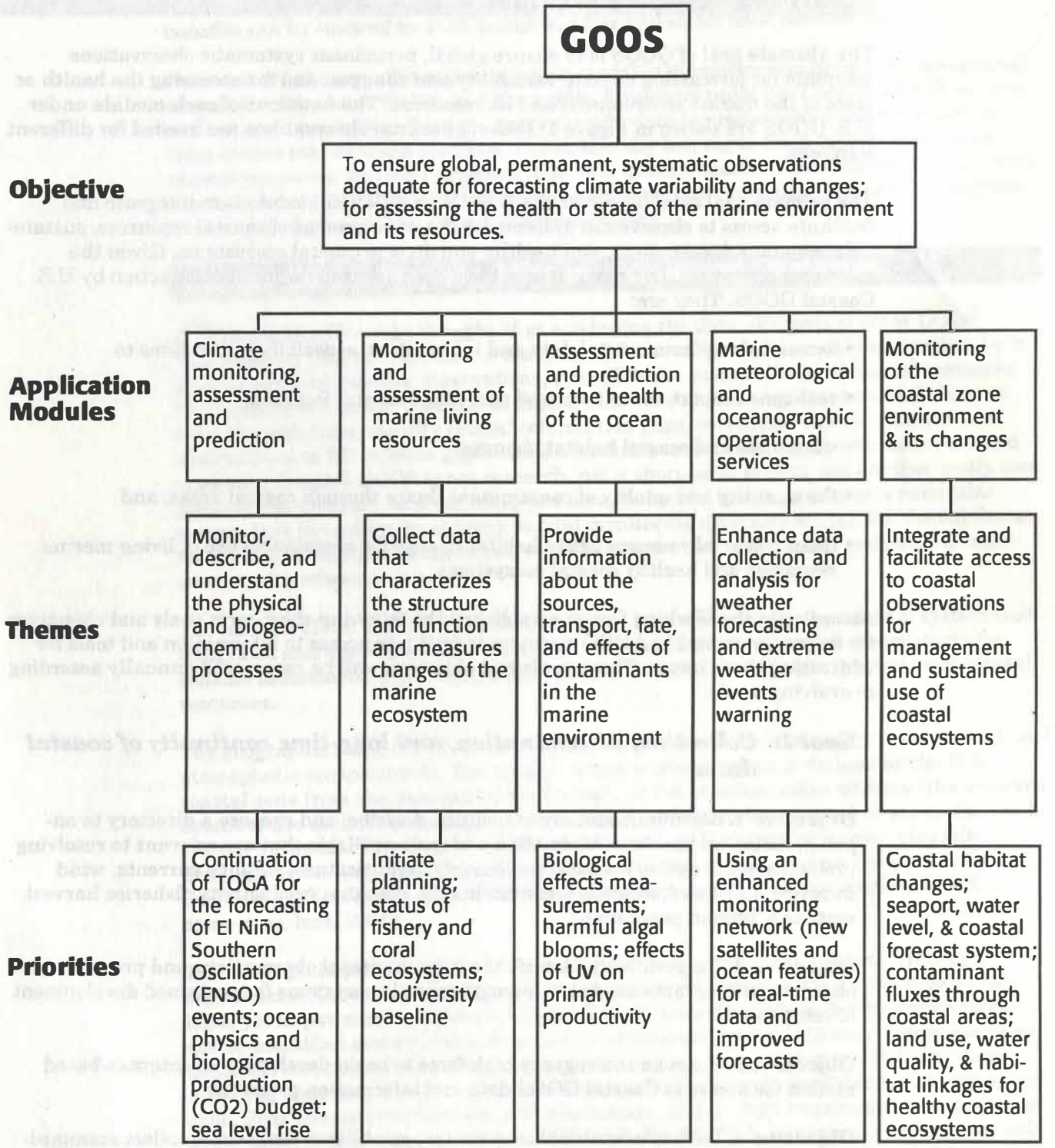


Figure 1. The functions of each module of the U.S. Global Ocean Observing System (GOOS).

Goal 2: Integrate real-time seaport water level observations with digitized coastal bathymetric and navigational hazards information and a coastal forecast system for mariners.

Objective 1. Encourage the expansion of activities for improved short-range and mid-range (5-7 day) marine weather forecasts and a system to deliver these forecasts to mariners to enhance the safety of life and property in U.S. coastal regions, including Alaska and the Great Lakes.

Objective 2. Encourage completion of the conversion of the domestic nautical charting data base from analog to digital format and to implement a process for collecting updated bathymetry in the areas of greatest need including a sustainable resurvey program to achieve and maintain a reasonably current data base.

Objective 3. In cooperation with the GOOS Marine Weather and Oceanographic Services Module, integrate data sets and help develop a system to deliver real-time water level and other related oceanographic information, digitized coastal charts, and a mid-range coastal forecast system to selected U.S. ports.

Goal 3: Improve the information base for assessing the impact of habitat changes (especially important coral reefs, mangrove shorelines, wetland marshes, and beds of submerged aquatic vegetation) on coastal ecosystems and sustainable development.

Objective 1. Begin immediately to identify, integrate, and provide access to those data sets that detect watershed and coastal subtidal habitat change or have special application for assessing the status of coral, mangroves, and submerged aquatic vegetation.

Objective 2. In partnership with the Intergovernmental Oceanographic Commission's Coral Reef Initiative (CRI), work with other countries to help identify and collect needed data, and make relevant data and information available to CRI partners and Coastal GOOS users.

Objective 3. Encourage and assist the CRI in developing and testing protocols for determining economic and other impacts on coastal resources (fish and wildlife) due to habitat changes in selected coastal regions.

Goal 4: Improve the information base and integrate observations relating to the quantity and quality of contaminant fluxes through the coastal region so that users can quantify and predict the fates of contaminants in coastal waters.

Objective 1. Begin immediately to identify and integrate data and information products from long-term federal, regional, and state monitoring of the fate and effects of contaminants (e.g., NOAA's National Status and Trends Monitoring, EPA's Estuaries Component of its Environmental Monitoring and Assessment Program, USGS's National Water Quality Assessment Program, Gulfwatch for the Gulf of Maine, California Mussel Watch Program).

Objective 2. Integrate, encourage the collection of improved estimates, and add to other Coastal GOOS information, the identification and estimation of the quality and quantity of contaminants from point and non-point sources in coastal watersheds, including atmospheric, groundwater, and surface water loadings (e.g., NOAA's National

Coastal Pollution Discharge Inventory, the Toxic Release Inventory, other industry discharge data).

Objective 3. Assess the gaps in critical information needed to reliably identify and quantify contaminant sources, fates, biological effects, or fluxes through coastal waters, and propose the collection of new observations.

Goal 5: Improve the information base and make new observations available to identify cumulative impacts and to link demographic, watershed land use, and coastal resource use to habitat changes to manage the sustained and safe human use of coastal resources, and diverse and healthy coastal ecosystems.

Objective 1. Begin immediately to identify, integrate, and provide access to demographics (e.g., natural resource economic valuations).

Objective 2. Begin immediately to identify, integrate, and provide access to watershed land-use data sets that could be useful for regulating freshwater inflow and contaminant concentrations (e.g., anthropogenic toxics, nutrients, carbon dioxide, etc.).

Objective 3. Begin immediately to identify, integrate, and provide access to data sets necessary for assessing the state of coastal living marine resources, including fisheries harvests, plankton productivity, marine biological diversity, habitat change.

Objective 4. Identify several characteristic watershed-estuary systems and conduct cooperative land-use inventories (aircraft and satellite-based), determine anthropogenic contaminant impacts (atmospheric,terrestrial and marine contributions) to the watershed, survey and map habitat changes, and conduct seasonal inventories of biological diversity to link changes in land use, water quality, and habitat suitability and assess ecosystem health and sustainability.

Costs of Coastal GOOS and Economic Return to the Nation

Many regular observations of the ocean are done by research programs with limited funding, limited duration, and limited objectives. Other regular observations are made by operational agencies for specific short- and long-term purposes but occur in limited parts of the coastal ocean, typically have only sparse coverage, and measure a limited set of variables. Much of NOAA's routine monitoring is done on commercial and recreational finfish species in offshore waters. Relatively few long-term studies are available on invertebrate estuarine and near-shore species, ecosystem assemblages, natural population variability, and trends. Generally, data on coastal land use and contaminant sources is considered incomplete, unreliable, and has not been integrated for coastal managers to use in routine planning and assessment activities. The requirements of the customers of Coastal GOOS demand coastal coverage and scientifically designed, cost-effective, long-term, routine and systematic observations. Existing observation systems cannot do the job being demanded of them.

The Coastal GOOS partnership has been formed in an environment of government deficits, unfunded mandates, workforce streamlining, reinvention, and "doing more with less." Working in this new context, the mutual benefits to the partnerships will be high. For example, EPA's National Estuary Program (NEP) uses data provided by NOAA's National Estuarine Inventory to make decisions on the designation of estuaries to be brought into the NEP. In turn, the designated NEPs can use NOAA's data to characterize their individual estuaries. New data collected by the NEPs will feed back to NOAA to

update its Inventory. By working together, everyone contributes and everybody benefits. A compelling case can be made in the Federal budget process that each participating agency supports the Coastal GOOS request of the other agencies and has direct benefits to coastal users and the Nation.

The initial costs are low for Coastal GOOS and will always remain a sound investment since partner organizations share investment costs by maintaining their own ongoing programs and databases. GOOS is relatively unique in that it builds on existing, long-term observation systems and incorporates information from a variety of sources (federal, state, and local agencies, oceanographic institutes, academic institutions, regional environmental programs, and industrial long-term monitoring) for application to coastal zone problems. Fifty observation programs have already been designated as part of Coastal GOOS and described in an information directory. Although the geographic scale of most of this observational data is regional or global, most sites are permanent and data are site-specific, geo-referenced, and repeatedly sampled through time. Thus, site-specific coastal GOOS data can be used by local managers for decision-making or combined with other monitoring data sets and research studies for insight into the environmental characteristics or ecological status of a coastal estuary or watershed.

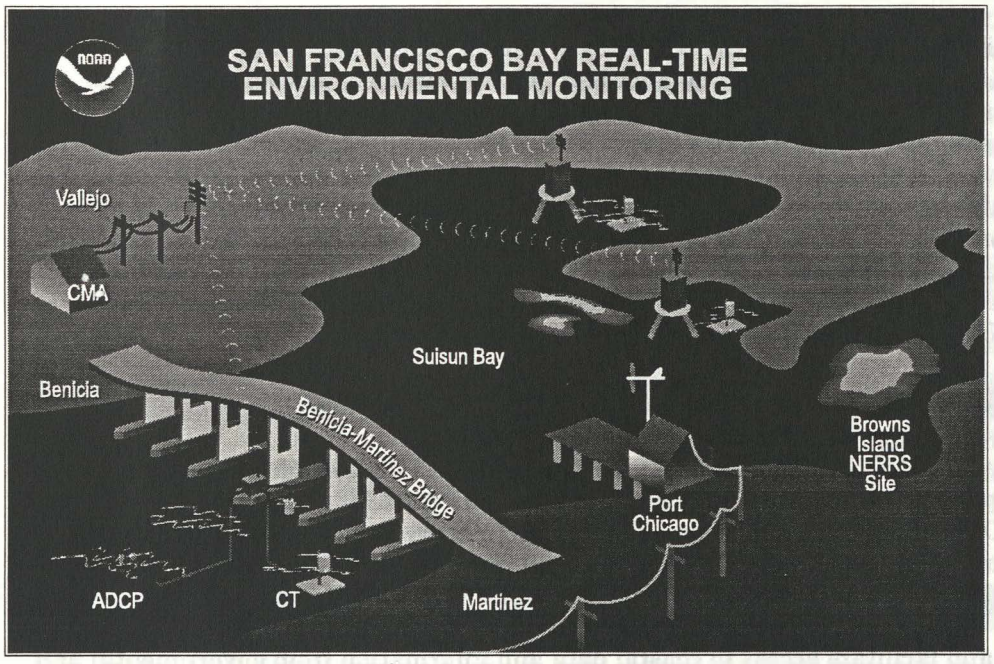


Figure 2. NOAA's Physical Oceanography Real-Time System (PORTS), which provides in-situ oceanographic data, is one of several observational technologies available to GOOS partners and customers.

Much of the investment to acquire the sophisticated, costly tools and in-situ instruments required to make global ocean observations; to monitor with real-time, repetitive measurements; and to display the data have already been made by each of the organizations involved. Some of the tools to display data that have been refined in recent years are now available to GOOS partners and customers. These include:

- color-enhanced satellite and aerial imagery;
- in-situ ceanographic data acquisition such as NOAA's Physical Oceanographic Real-time System (PORTS) (Figure 2);
- computer-digitized shoreline and bathymetric maps;
- Global Positioning System (GPS) and Geographical Information System (GIS) capabilities; and

- gap analysis methods developed for terrestrial and freshwater ecosystems by the U.S. Fish and Wildlife Service and National Biological Service in cooperation with state scientists and others (used to predict species assemblages and habitats at risk for extinction).

Organizational Structure

Coastal GOOS partners will be those agencies and NGOs that are signatories to cooperative agreements. The Working Group will include at least one representative from each partner organization. The Coastal GOOS organizational structure will consist of (1) a multi-organizational Advisory Board with representation from coastal industry, research, and management; and (2) the full Working Group with various subcommittees for program planning, implementation, and evaluation, and task teams responsible for specific projects. The Advisory Board of 8-20 members should have no more than one member from each federal agency with about a third of its membership selected from non-federal coastal industry, management, and research partner organizations. Board members should have term limits of three to four years. The Board should elect its chairman to serve no more than two years, and should meet regularly to oversee the overall operation of Coastal GOOS.

Administrative responsibilities are to be shared among the governmental and NGO partners of U.S. Coastal GOOS. Coastal GOOS partner agencies, in cooperation with NOAA's National Ocean Service, will build and maintain an electronic information sharing system. Governmental partners of Coastal GOOS will (1) maintain their information systems and make them accessible to Coastal GOOS users, (2) meet periodically for program evaluation and guidance, and (3) cooperatively identify and develop budget initiatives for Coastal GOOS. Coastal GOOS is not planning to conduct its own outreach but will develop an education component and utilize existing agencies with coastal networks (i.e., Coastal Zone Managers, National Estuarine Research Reserves, Sea Grant, the National Estuarine Program).

Data and Information Management

The U.S. Coastal GOOS partnership has identified what is needed by the coastal user community to resolve ecosystem-level problems and has defined the scope of what Coastal GOOS will provide to its users. To meet its primary goals of providing information for the management of coastal resources, sustainable economic development, and healthy and diverse coastal ecosystems, the GOOS Coastal Module will, in the near-term:

1. Integrate and facilitate access to coastal data and information from governmental and NGO observation programs, identify the need for and support the collection of new observations, and maintain critical long-term observation collections useful for tracking trends for predictive modeling and coastal management;

2. Develop a "one-stop center" for coastal users that builds upon existing systems rather than creating a new, all-encompassing system, and facilitates easy access to:

- *real-time observations* on coastal ocean and weather (e.g., tides, currents, water levels, mid-range coastal forecasts);
- *monitoring data* on anthropogenic impacts (e.g., toxics, nutrients, contaminant bioeffects);
- *baseline information* on natural variability in coastal ecosystems (beach erosion, salinity, seasonal and annual fluctuations in living marine resources); and

- *socioeconomic statistics* on coastal resource use (e.g., human populations, economic, and land-use changes);

3. Facilitate access to tools for the synthesis, interpretation, and effective transfer of scientific and technical information to coastal zone managers, policy-makers, and the public;

4. Encourage data comparability by the development of standardized metadata for measurements and collection methods;

5. Support the exchange of information on U.S. activities of international consequence to other nations; and

6. Facilitate the collection of data that will be used by multiple users when none of the users has sufficient resources to collect them alone.

Coastal GOOS will make data available to its users through electronic Internet access. This data will include local, regional, national, and international data from satellite, airborne, and ground-based remote sensing observations, as well as both short- and long-term in-situ measurements. NOAA's National Ocean Service and National Environmental Satellite, Data and Information Service, in partnership with other Coastal GOOS partners and other GOOS modules, will help develop and maintain the coastal information system. The availability of data and information products will be announced through the Internet and some direct marketing. The system could be operated as a fee-for-service enterprise to ensure that it remains dynamic and well managed, and that critical observation systems and data sets are supported. Coastal GOOS information will remain available from the member organizations that synthesized and interpreted the data.

International Dimensions

Many of the concerns and problems in the coastal regions of the United States are common to many sites and countries. At this point in the international planning process, three fundamental themes underscore the globalism of the GOOS Coastal Module: (1) common concerns, problems and solutions (e.g., transboundary movements of marine pollution); (2) regional concerns that need international attention and help; and (3) the way in which global phenomena affect coastal areas (e.g., the response of natural systems of coastal areas to El Niño Southern Oscillation events).

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Appendix 1. Partnerships

Coastal GOOS will seek to link government and nongovernment observational programs and create effective partnerships among coastal organizations such as the following:

- The National Research Council's Ocean Studies Board and five other Science Boards convened a group of scientists in June 1994, to provide scientific guidance on the U.S. GOOS effort and for implementing a U.S. GOOS Coastal Module.
- The Core Project on Land Ocean Interactions in the Coastal Zone (LOICZ), an International Geosphere-Biosphere Programme of the International Council of ICSU. LOICZ studies will be directed toward understanding fluxes of carbon and sediment transport across the continental shelf.
- Research issues and implications involving the U.S. Coastal GOOS Module will be linked with the National Science Foundation and the National Research Council.
- Coastal managers (e.g., all coastal state and territorial agencies); Sea Grant; federal coastal parks, sanctuaries, and research reserves; regional programs, such as those for the Gulf of Mexico, Gulf of Maine, and Great Lakes; Marine Fish Commissions; Fishery Management Councils; and local Water Control and Shellfish Sanitation Boards).
- Professional societies (e.g., American Fisheries Society, American Crustacean Society, American Malacological Union, Estuarine Research Federation, The Ocean Society, Coastal Society, Wetland Society, North American Benthological Society, Marine Technology Society, American Systematics Collections, National Association of Marine Laboratories).
- Nongovernmental organizations (e.g., Joint Oceanographic Institutes, Council on Ocean Research and Education, The Nature Conservancy and its Heritage Program, Center for Marine Conservation, Marine Spill Response Corporation).
- Industry organizations such as the National Ocean Industries Association, American Petroleum Institute, Offshore Operators Commission, Association for Independent Petroleum Producers.
- Other interagency committees and task forces with implications for coastal zone initiatives (e.g., the Office of Environmental Policy's Interagency Ecosystem Management Initiative, Interagency Working Group on Sustainable Development Indicators, Committee on the Environment and Natural Resources Subcommittee on Biodiversity and Ecosystems, the Interagency Ecosystem Coordination Group, Interagency Taxonomy Committee, and the Interagency Committee on Environmental Trends).

Appendix 2. National and International Management and Scientific Questions Driving Coastal GOOS (in decreasing order of priority)

1. Could coastal land-use changes, threatened species/assemblages, critical habitats, and population trends be predicted, and mapped by a geographic information system? Can management strategies be designed and implemented to ensure sustainable use of coastal zone resources and minimize negative impacts on coastal landowners and ecosystems?

2. How can we improve our capabilities for forecasting coastal hazards (e.g., storms, underwater obstructions and wrecks, sea ice, sea level) that threaten shipping, fisheries, and recreational boaters? Can we (1) establish a now-casting network, (2) build coupled atmosphere/watershed models for accurate forecast prediction, and (3) make this information accessible in real-time to GOOS customers?

3. What are the shore-side and atmospheric sources of nutrient overenrichment, the fluxes through coastal waters, and the extent of related eutrophication problems?

4. What standard methods, formats, codes, and metadata will be required to ensure data quality, compatibility, and comparability for all users of the diverse data sets collected by the nations participating in GOOS?

5. What are the consequences of degradation or loss of coastal habitat, especially wetlands, coral reefs and other critical areas, in individual nations for sustainable use of multinational fisheries stocks?

6. What are the coastal sources and fluxes of long-lived anthropogenic substances (e.g., DDT, PCBs, nuclear waste), and accumulations over time, from coastal zones to the world's ocean basins?

7. Is there a set of reliable indicators for sustainable use of coastal resources that could be monitored and modeled to predict adverse resource impacts?

8. What multinational, coastal zone information is required to establish an information delivery system to support improved cleanup of hazardous materials and restoration of habitats?

9. What observations are needed to detect, monitor, report, and predict eutrophication, fish kills, noxious and harmful algal blooms in the coastal waters of concerned nations?

10. What are the consequences of changes in marine biological diversity (i.e., species translocations and harvesting practices) on the function of coastal ecosystems? Are there controls to mitigate this problem that could be agreed on among Coastal GOOS partners?

11. What underlying basic research is needed to provide a firm basis for addressing these and future questions?

Appendix 3. Coastal GOOS Observations Needed

1. Coastal population impacts

- Human population statistics
- Land-use changes in coastal/fluvial zone
- Economic development trends
- Contaminant sources
- Contaminant fates in coastal sediments and priority food web indicator species
- Contaminant effects in selected ecosystem indicators
- Overenrichment (e.g. NO_3, PO_4, NH_4, NO_2, O_2) sources
- Vessel traffic
- Hazardous spills from shore sites, pipelines, and vessels
- Identification and mapping of critical habitats and species at risk from human overuse

2. Habitat changes (also biogeomorphologic)

- Shoreline erosion; beach/dune position (especially need baseline data for damage assessment)
- Bathymetry and topography
- Coastal hazards
- Sediment types, grain size, porosity
- Coastal habitat loss, especially wetland alterations
- Geobiological structures (mangroves, coral reefs, saltmarshes, submerged aquatic vegetation)
- Transport of sediments, down-river or along coast; resuspension events

3. Living marine resources:

- Fisheries harvest statistics
- Biotic inventories for baseline biodiversity information
- Seasonal migrations and distributions of living resources
- Introduced species impacts
- Satellite coastal ocean color photography to estimate and track seasonal phytoplankton blooms, dissolved organic matter, chlorophylls, harmful and noxious bloom events
- Phytoplankton growth, biomass, and species composition
- Zooplankton biomass, abundance, and species composition
- Fecal coliform, bacterial, and viral monitoring of shellfish growing areas and public beaches
- Trawling and aquaculture impacts on the benthos

4. Oceanic observations:

- Temperature, salinity, and currents
- Sea level change
- Waves, tides, seiches, sea state, tsunamis
- Ice edge and extent, coastal icebergs
- Detritus, clarity, sediment load, spectral properties
- Water quality and pollution fluxes through the coastal zone
- Offshore/coastal environmental events (e.g., dissolved oxygen slumps)
- Water chemistry (e.g. POC, DOC, PCO_2 DIC)

5. Atmospheric measurements and weather prediction:

- Meteorological monitoring (e.g., air temperature, precipitation, winds)
- Atmospheric/oceanic fluxes of aerosols, gas exchange, photosynthetically available radiation (PAR)
- Atmospheric deposition
- Coastal meteorological events (hurricanes, storm surges)