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A NOAA Perspective on a Coastal Ocean Forecast System

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Abstract

The elements involved in the establishment of a comprehensive Coastal Ocean Forecast System (COFS), the philosophy of approach towards achieving this goal, and the existing components of NOAA's coastal marine observational, analysis and forecast services are described. A COFS will enable NOAA to meet its requirements to issue timely warnings and forecasts to coastal communities to reduce loss of life and damage to property, as well as to provide the necessary information for management of coastal resources, the environment, and commercial and recreational activities. In this paper, the existing capabilities of NOAA in meeting several of these needs are presented, including a description of the operational components of its coastal marine observation network and of its marine forecasts and services. Also included are a summary of the NOAA vision and long-range strategy for development of a COFS, as well as a discussion of some near-term, on-going development activities.

Introduction

The coastal zone in the United States is under an ever increasing stress because of the mounting pressures brought about by the migration of population to coastal areas. The migration is of such magnitude that this narrow strip of land now contains nearly half of the U.S. population, with current projections adding another 60 million people to this region by the year 2050 (NRC, 1989). Protection of life and property, environmentally sensible and productive use of coastal resources, and maintenance of economic activities such as marine commerce demand major advances in our understanding of the coastal environment and in our ability to observe this environment and to predict its changes. Major storms, with the attendant high waves and storm surges,

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can inflict enormous economic loss and human suffering, hazardous material spills can have severe impacts on the local ecology and human health, and disruptions in local sea traffic due to bad weather, high seas, fog, or ice can now have an impact that can be felt at national and international levels in the transportation industry.

Coastal zone management and regulation, long-range planning, and daily operational activities require knowledge of the weather (pressure, winds, precipitation, visibility, temperature), water levels (tides, surges, seiches), waves (height, period), water temperatures and currents (dispersion), chemical composition (salinity, nutrients, pollutants), and biology (species composition, abundance and distribution) in the coastal domain (COPS, 1990). Major strides have been made in weather observation and prediction over the continental U.S. in the last 30 years, yet this does not translate to equivalent improvements in coastal weather observation or prediction, nor to corresponding capability in the coastal ocean. In addition, our ability to link the weather and the physical condition of the coastal ocean to biochemical and ecological responses is even more tenuous.

The ultimate Coastal Ocean Forecast System (COFS) required to serve the above needs will link the atmosphere and the coastal ocean in an interactive manner producing forecasts of physical variables to be used in coupled biochemical and ecological models. At NOAA we see the development of such a COFS as an evolutionary process, a long-term investment that will take many years to fulfill. A preliminary quantitative estimate of the benefits and costs of a COFS (Kite-Powell et al., 1994) suggests that a modest investment in this effort would generate annual benefits on the order of tens of millions of dollars in the commercial shipping and recreational boating and fishing sectors alone.

In fact, a number of operational activities do now exist within NOAA that constitute a rudimentary COFS. These include an observational network providing data from conventional platforms such as ships, buoys, coastal stations, water level gauges and radar, as well as remotely-sensed ocean surface data from operational satellites. Also available routinely are operational marine forecasts of sea level pressure, winds, air temperatures, precipitation, fog, visibility, surface waves, storm surge, and tidal heights and tidal currents. However, these are available on space and time scales that are too coarse for many coastal applications. Particularly lacking is any routine information on the state variables in the interior of the coastal ocean.

This chapter describes the NOAA perspective on a COFS. In Part 2 we summarize NOAA's long-range strategy for development of a COFS (NOAA, 1993), including what we consider to be the fundamental conceptual elements, the basic components, and the developmental evolution of a COFS. Part 3 describes the existing operational components of NOAA's coastal marine observation network and of its marine forecasts and services. And in Part 4 we summarize a number of research and development activities currently underway to enhance the existing operational system.

As increasingly reliable coastal predictions become available, the U.S. population that lives in or near our coastal zones, and the entire Nation, will find them a necessary part of daily life.

The Development of a Coastal Ocean Forecast System

The NOAA goal is "to create and maintain an effective COFS that meets today's requirements and that can be rapidly updated and enhanced as new requirements,

knowledge, and technologies emerge" (NOAA, 1993). This goal is supported by a long range strategy that seeks to build upon existing oceanic, atmospheric, and biologica services that serve a wide range of coastal interests by improving existing services, fillin service gaps, and creating new services. This strategy includes what we consider to b the fundamental conceptual elements of any forecast system, the basic components of th system, and the developmental evolution of a COFS.

Conceptual Elements

The long-range goal is "to improve our ability to observe, understand, and predic coastal environmental phenomena that impact public safety and well-being, the nationa economy, and environmental management" (NOAA, 1993). This statement contains th three fundamental conceptual elements of any forecast system, namely *observations knowledge,* and *models*. Based on observations, we form hypotheses and develo models to predict the future evolution of the system. The skill of the predictions is measure of how well we understand the system and shortcomings in our ability t observe and describe the important properties of the system. The measurements knowledge, and models may be quite different for different disciplines (e.g. physical chemical, biological), yet all disciplines share these common elements. The interactio between the atmosphere, ocean, and living marine resources in the coastal environment i of paramount importance, but significant differences in time and space scales, as well a the basic laws of behavior, make the integration of these disciplines a considerabl challenge.

Thus, our strategy is to achieve and maintain a balance between the conceptua elements of a COFS, keeping in mind that there are large disciplinary differences i knowledge and by directing resources and attention at the weaker elements in each of th relevant disciplines. We must recognize and build on the existing separate data an knowledge bases within the disciplines represented in the coastal domain, and emphasiz interdisciplinary measurements, studies, and prediction modeling that deal with the tota coastal ecosystem.

System Components

Any forecast system has a natural flow of information beginning with fundamental observations and ending with decisions by users. Although a forecast system can be broken down into a large number of sub-components, the basic system has three broad generic components: *research and development, operations,* and *dissemination*. NOAA's present capabilities contain some of the elements of the desired system, but new thrusts will be needed to address the full range of system requirements. These basic system components, and some of the characteristics that are unique to operations in a COFS, are briefly expanded upon here.

Research and development is the underpinning of a technically sound operational system. At NOAA several ongoing research and development activities (see Section IV) promise to produce some of the required technology and understanding. New efforts are required, however, to support both current and future needs for: (a) system design - to determine COFS mission requirements and to define new observational and modeling technologies to meet those requirements; (b) observation system development - to design