The Meteorological Buoy and Coastal Marine Automated Network for the United States

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Board on Atmospheric Sciences and Climate Commission on Geosciences, Environment, and Resources

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Preface

In late April 1997, the National Oceanic and Atmospheric Administration (NOAA) asked the National Research Council's (NRC's) Board on Atmospheric Sciences and Climate (BASC) to examine its meteorological data buoy program and the Coastal Marine Automated Network (C-MAN) for, primarily, their value in analyzing current weather conditions and in providing weather forecasts and warnings. As 1997 began, 33 of the 118 buoy/C-MAN stations managed by NOAA no longer had the funds required to remain in operation. NOAA asked the NRC to recommend a distribution of observing platforms that would maintain essential weather and forecast capabilities.

Professor Lance F. Bosart, from the Department of Earth and Atmospheric Sciences, State University of New York at Albany, and a member of BASC, is the principal investigator and author of this report. Dr. Bosart was assisted quite serendipitously by the scheduling of four meetings during the course of the study: the American Meteorological Society Colloquium on Coastal Environmental Information Services, May 29, 1997; the 1997 Gordon Research Conference on Coastal Ocean Circulation held June 15-17, 1997, at Colby-Sawyer College in New London, New Hampshire; the U.S. Weather Research Program (USWRP) Scientific Coordinating Committee workshop held in Washington, D.C. in September 1997; and the National Association of State Universities and Land Grant Colleges Action Committee discussion with the NOAA Undersecretary on Oceans and Atmosphere in Washington, D.C. on May 13, 1997. Discussions at these meetings provided opportunities to assess applications of the meteorological buoy/C-MAN system with representatives of commercial shipping, the insurance industry, the United States Navy and Coast Guard, the National Oceanic and Atmospheric Administration, and academic research groups. Many of the people who participated in these gatherings provided invaluable information for this study.

The BASC staff met several times with NOAA headquarters and National Weather Service personnel to assemble information. On November 5 and 6, 1997, a public workshop was held with the principal investigator and NRC staff. The workshop provided an opportunity for interested parties to submit comments or information relevant to the study and an opportunity for open discussion of issues. Many comments were received from coast to coast, and from various interests including scientists, private industry, fishermen, weather forecasters, and news reporters. It is hoped that this report will prove useful not only to NOAA, but also to other federal and state agencies with responsibilities in the coastal zone, as well as to those whose livelihoods depend on the safe and sustainable use of our coasts.

The counsel and written contributions on marine and coastal observations and forecasting of Professor Leonard J. Pietrafesa of North Carolina State University have proven to be invaluable for this study. The NOAA Offices of the Chief Scientist and the National Weather Service's Data Buoy Center, Office of Meteorology, and National Centers for Environmental Prediction were very helpful in providing essential data and information. Others deserving special thanks for their contribution are Robert A. Adriance, Jr. from BOAT/U.S., Dr. Peter G. Black from NOAA's Atlantic Oceanographic and Marine Laboratories Hurricane Research Division, Dr. Wendell A. Nuss from the Naval Postgraduate School, Dr. Franklin B. Schwing from NOAA Pacific Fisheries Environmental Groups, Dr. P. Ted Strub from Oregon State University, and Dr. Floyd Hauth of the NRC's Committee on the National Weather Service Modernization. There were many more who responded to our call for information and ideas, and many more who, upon hearing that this study was being conducted, wrote of their concerns and provided further useful information. A list of individuals who contributed by mail, telephone, fax, and e-mail is provided in Appendix A. Tenecia A. Brown, the study's research assistant and point of contact for many contributors, and Celeste A. Iovinella, the study's point of contact in Albany, New York, also are acknowledged for adeptly managing a flood of information while assembling data and preparing manuscripts.

This report has been reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRCs Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the authors and the NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The content of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report: Eric J. Barron, Pennsylvania State University Robert C. Beardsley, Woods Hole Oceanographic Institution Carl A. Friehe, University of California-Irvine James R. Holton, University of Washington George M. Hornberger, University of Virginia Christopher N. K. Mooers, University of Miami Wendell A. Nuss, Naval Postgraduate School James J. O'Brien, Florida State University John M. Wallace, University of Washington James A. Westphal, California Institute of Technology Robert M. White, University Corporation for Atmospheric Research

While the individuals listed above have provided many constructive comments and suggestions, responsibility for the final content of this report rests solely with the authors and the NRC.

> **WILLIAM A. SPRIGG** *Study Director*

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Executive Summary

The meteorological buoy and Coastal Marine Automated Network (C-MAN) systems along U.S. coasts are designed to detect hazardous weather before it strikes the shore. Although the suite of observations from individual platforms may vary, these systems generally report information on air and water temperature, air pressure, and wind and wave conditions. Weather forecasters and researchers interested in coastal weather and ocean processes rely extensively on the data provided by the National Oceanic and Atmospheric Administration (NOAA) operated buoy/C-MAN network. Realtime observations from these stations are used by public and private weather forecasters to provide information on possible hazardous wind, sea-state, and water-level conditions to public safety officials, public and private marine interests, shipping companies, fishing and recreational interests, and the general public. These systems collect information under conditions of weather too severe for human observers, and thus provide vital information, not only for public warnings and forecasts but for research that will lead to better understanding of storm characteristics and improved forecasts.

This study responds to a request from the Administrator of NOAA to examine the meteorological buoy/C-MAN system for, primarily, its value in analyzing current weather conditions and in providing weather forecasts and warnings, and to recommend a distribution of observing platforms that would maintain essential weather forecast capabilities. Prompting this request was a shortfall in funding that places 33 of the 118 buoy/C-MAN stations in jeopardy. In further discussion with the Administrator and NOAA's chief scientist and staff, it was recognized that identification of specific platform placements would have to be done taking factors into account that were beyond the scope of this study, such as identification of populations most at risk to coastal weather-related hazards. The study nonetheless identifies such factors and defines a strategy, based on scientific principles, for ultimately determining these platform locations.

It is important to note that quantitative studies of the value of specific components of the surface (land and marine) observational network (in-

cluding the buoy/C-MAN system) do not exist. There is no rigorous study that has evaluated the impact of forecast quality for a specific surface station. Ongoing studies in conjunction with the North American Observing Strategy (NAOS) are trying to evaluate this issue quantitatively, but no definitive results have yet been established. While some experimental results do demonstrate that marine observations have a positive impact on numerical initialized analyses and forecasts, the research necessary to prove their value remains to be done. Without more extensive numerical analyses, recommendations to expand the network of observing sites are admittedly, largely judgmental, but are based on many years of forecaster experience. Therefore, the recommendations that follow are based on the value of the buoy/ C-MAN system to the preparation of storm watches and warnings, the demonstrated value to public safety and recreational and commercial uses, the needs of the research community, and the importance of surface observations to calibrate (or "ground truth") observations made remotely from space-based instruments.

PROPOSED CORE BUOY/C-MAN NETWORK

The rapidly increasing U.S. coastal population is particularly vulnerable to the disruptive effects of coastal flooding, storm surges, intense extratropical storms, and tropical cyclones (TCs); therefore, it depends on accurate and timely warnings of severe weather. Coastal weather forecasters at the National Weather Service (NWS) rely extensively on the data provided by the NOAA operated buoy/C-MAN network. Researchers also depend on the buoy/C-MAN network for data that will lead to better understanding of storm characteristics and improved forecasts.

This study recommends that a core buoy/C-MAN network be established and maintained.

Such a core network could be based on NOAA's 1995 Marine Observation (MAROB) plan. The MAROB plan is founded on the concept that the observational data density coverage from buoy/C-MAN locations has to be increased in recognition of the growing marine (coastal and offshore) responsibilities of the modernized and restructured NWS. The MAROB plan calls for the present number of observing platforms to be increased by approximately 200 stations (above the current base-funded total of 69 C-MAN and moored buoy stations) to provide adequate support for weather forecasting operations. In essence, the study herein agrees with that assessment. However, while the MAROB plan appears reasonable, the exact