Category: Geographic Information Systems/Oceanography

Arc Marine

GIS for a Blue Planet

At a time when the health of our oceans is seen as crucial to our very existence, marine researchers have developed a data model that supports seafloor mapping, fisheries management, marine mammal tracking, monitoring of shoreline change, and water temperature analysis. Our ability to measure change in oceans and along coasts has increased as marine GIS has grown more complex. *Arc Marine: GIS for a Blue Planet* presents the initial results of a successful effort to create and define a data model for the marine community—academic, government, military, and private oceanographers, resource managers, conservationists, geographers, nautical archaeologists, and others who support better management of complex spatial analysis in marine applications. The data model not only provides structure to storing and analyzing marine data but helps users create maps and 3D scenes of the marine environment in ways invaluable to decision making. The standards and best practices that emerged from the case studies in *Arc Marine* form a diverse set of resources to draw from as the marine community strives to understand, illuminate, chart, and explore the unknown depths. As a teaching tool, *Arc Marine* serves as a perfect starting point for the intermediate student or as a resource for the expert in marine GIS and its implementation.

It has been exciting to work with the Arc Marine team over the past few years to further the application of a marine data model: the GIS of the ocean. The construct presented in this book will enhance all ocean management resources.

Margaret Davidson, Director, NOAA Coastal Services Center

Combining an in-depth coverage of theory and practice, illustrated with case studies, this book provides valuable practical insight into the role and importance of data models in general, as well as being the most comprehensive source of information on the Arc Marine data model for anyone who needs to know more.

David R. Green, Director, Marine and Coastal Resource Management Programme, University of Aberdeen, Scotland, UK

It is now possible to see the ocean—and thus the world—with new eyes, owing largely to the wondrous new ways of managing and accessing data that are eloquently described in this valuable new guide for professionals.

Sylvia Earle, National Geographic Explorer-in-Residence

We have reached an exciting crossroads where our ability to measure ocean phenomena is met by new ways to represent them. The data model presented here supports the vital work of marine researchers in mapping the uncharted territories, monuments, and sanctuaries so that we can build solutions for our oceans and seas.

Jack Dangermond, President, ESRI

Visit the accompanying Web sites:
http://dusk.geo.orst.edu/djl/arcgis and the marine link at
http://support.esri.com/datamodels

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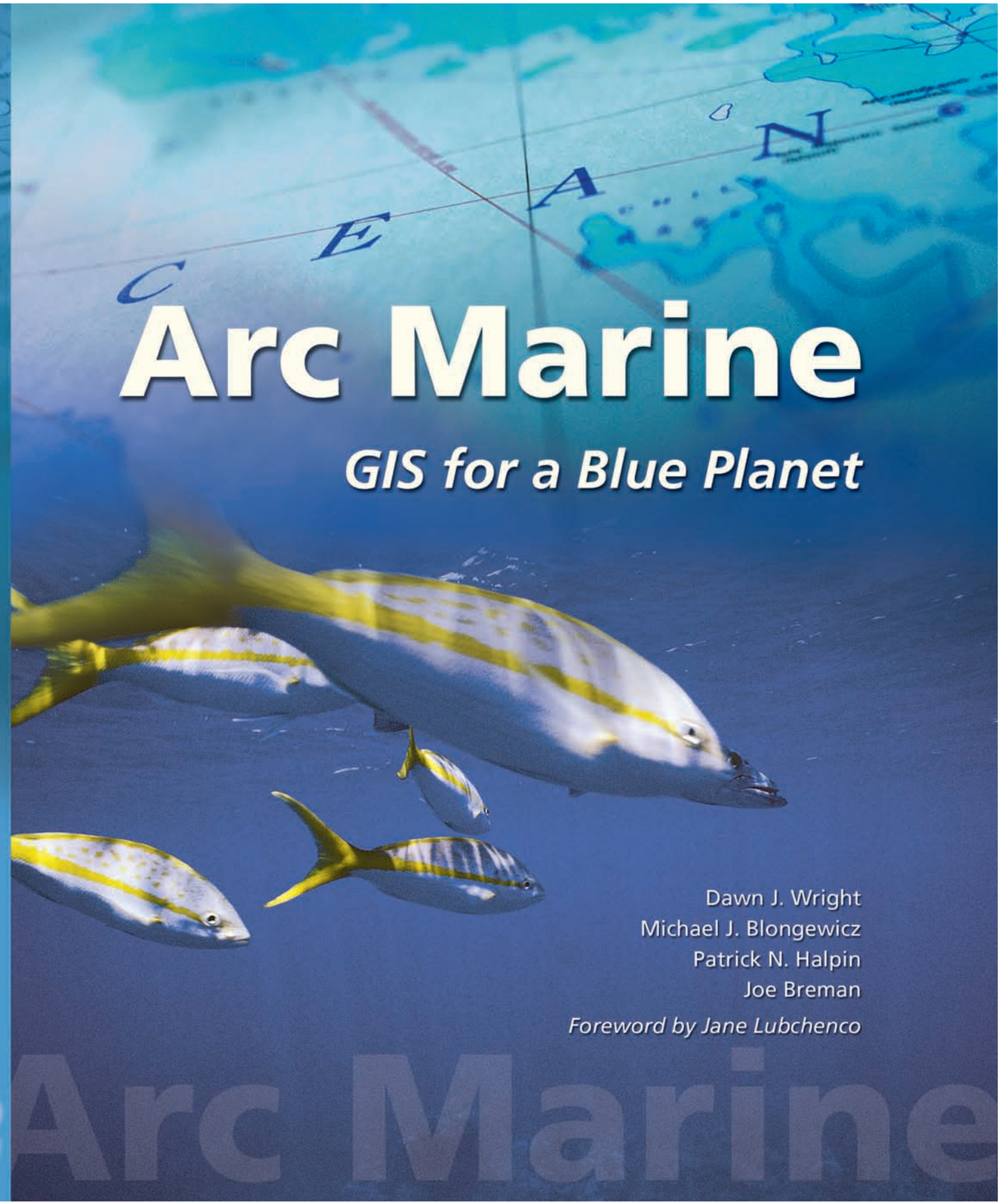

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Foreword by Jane Lubchenco

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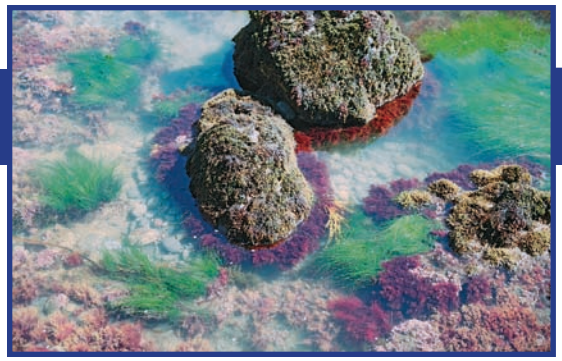

Foreword

The oceans are so vast and bountiful that for most of human history they have been thought of as infinitely resilient and inexhaustible. The mantra "Dilution is the solution to pollution" characterized attitudes toward oceans as convenient places for waste disposal. The mere idea that oceans could be overfished or disrupted was inconceivable. Fast-forward to the present. Evidence of disrupted ocean ecosystems abounds: A quarter of the world's most important fisheries are vastly depleted; 90 percent of the large fishes have disappeared due to overfishing; hundreds of "dead zones" (areas with oxygen levels too low to support most marine life) have appeared in the last few decades due to nutrient pollution from agriculture, livestock operations, and sewage; harmful algal blooms are increasing due to this nutrient pollution and the introduction of nonnative species, for example, via ballast water; sea level is rising, oceans are warming, and storm intensity is increasing because of climate change; and the oceans are becoming more acidic as they absorb about half of the carbon dioxide being released from the burning of fossil fuels and clearing of forests. In a very short period of time, the bounty of oceans has been depleted and ocean ecosystems have become seriously disrupted.

Because this depletion has serious social and economic consequences, there is increasing interest in devising solutions to recover the bounty and resilience of ocean ecosystems. In the United States, the Pew Oceans Commission and the U.S. Commission on Ocean Policy have made comprehensive recommendations on solutions. The Joint Oceans Commission Initiative and others are taking up the challenge of implementing these recommendations. Many states and other nations are evaluating their own policies and practices.

Emerging evidence indicates that some solutions are both feasible and effective—for example, modifying fishing gear to reduce habitat destruction and inadvertent impacts on nontarget species; establishing networks of fully protected "no take" marine reserves to protect habitat and allow fishes and invertebrates to recover, mature, and produce immense numbers of young; reducing land-based sources of pollution; protecting critical coastal wetlands from development; reducing introduction of nonnative species; aligning the economics of fishing with conservation interests; improving ocean governance; and more.

However, the diversity of drivers causing ocean changes and the different scales of ocean processes present challenges in understanding and evaluating problems and solutions. Civil society, managers, policy makers, business and industry, and scientists need better tools to visualize, examine, manipulate, and evaluate data and information. Scientific data and information play critical roles, but they must be organized and presented in ways that are understandable, relevant, useable, and credible. For the oceans, GIS has been a powerful tool because it integrates many kinds of data (for example, marine geology with marine biology, chemistry, ocean currents, etc.) in order to see the larger picture. It can turn the numbers that data represents into interpretations that help people understand what is happening and what different solutions would accomplish. This book is about applying GIS to the ocean, more efficiently and effectively than before, by using the latest available approaches in this exciting, evolving technology.

The power of GIS lies in its flexibility for both scientists and nonscientists. The organized structuring and layering of data allows accurate representations of information that can be tailored to the needs and interests of users by location, spatial extent, and type of information desired. Oceanic and coastal features, including natural and built structures, can be visualized and manipulated. For scientists, a data model such as Arc Marine is invaluable in enabling better management and sharing of data with other scientists, policy makers, and the public.

The publication of *Arc Marine: GIS for a Blue Planet* comes at a critical time. Oceans, and indeed the entire planet, are changing at faster rates, over broader scales, and in fundamentally new ways. As documented in the Millennium Ecosystem Assessment, these environmental changes have immediate consequences to human well-being. Hence, there is great urgency in addressing these problems and making a transition to sustainability. Scientific information is vital in helping society understand what is happening and the likely consequences of possible solutions. This is especially true for the oceans that to most people are normally represented simply as large blue areas on a map. New tools such as those described in this book provide unified approaches to and frameworks for processing, mapping, and sharing critical information about the oceans. These tools will inform and guide impending decisions and determine whether we can indeed recover the lost bounty and resilience of oceans.

Jane Lubchenco
Oregon State University Distinguished Professor of Zoology and Wayne and Gladys Valley Professor of Marine Biology; Member, Pew Oceans Commission and Joint Ocean Commission Initiative (http://www.jointoceancommission.org/); Convening Lead Author, Millennium Ecosystem Assessment (http://www.MAweb.org)

Preface

During the past several years, ESRI, with significant user-community input, has been building application-specific data models for ArcGIS software in many industries and scientific disciplines. Notable for the marine GIS community is the marine data model initiative, also called Arc Marine. Other industry data models have common touch points to Arc Marine, such as Arc Hydro, Groundwater, Climate and Weather, Petroleum, and the S-57 for Electronic Navigational Charts. In tandem with these efforts, the marine GIS community has grown significantly during the past few years. "Marine GIS community" is defined as users who apply GIS to the coasts, estuaries, marginal seas, and deep ocean. The community includes academic, government, and military oceanographers; coastal resource managers and consultants; marine technologists; nautical archaeologists; marine conservationists; marine and coastal geographers; fisheries managers and scientists; ocean explorers/mariners; and others.

This book reports the initial results of a successful effort to create and define a data model for this community, one that supports better management of complex spatial analyses within a variety of marine applications. Included are descriptions of database projects that focus on mapping the ocean floor, fisheries management in the water column, marine animal tracking in the water column and on the sea surface, nearshore and shoreline change, temporal analysis of water temperature, and the integration of numerical models. Our goal has been to create a database design that facilitates the collection of dynamic and multidimensional data from the oceans, seas, and coasts, and to provide a more logical way to represent these in the object-oriented world of the geodatabase.

The development of common, interoperable GIS tools based on such a framework can be immensely valuable: tools for data input, distributing or serving data, improved performance in data processing and analysis, and creating new information from the data. Designed with the data model in mind, these tools combined create useful ways to work with marine sensor data and human observations.

The data model improves our ability to manage and exchange large marine datasets using a framework that can be shared and implemented across many platforms and applications. The standards and best practices that have emerged from the case studies, lessons

learned, and tutorials combine to form a diverse set of resources for the marine GIS practitioner to draw from.

As you use this book as a reference or laboratory manual, please refer to and download the many resources, including the core Arc Marine data model, at the accompanying mirror Web sites: http://dusk.geo.orst.edu/djl/arcgis/ and the Marine link at http://support.esri.com/datamodels. These sites include the Arc Marine design templates, the Arc Marine reference poster, a tutorial on using Arc Marine, sample datasets, background documents, Microsoft PowerPoint files, and links to Arc Marine tools.

Dawn J. Wright, Oregon State University
Michael Blongewicz, DHI Water & Environment
Patrick N. Halpin, Duke University
Joe Breman, ESRI

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