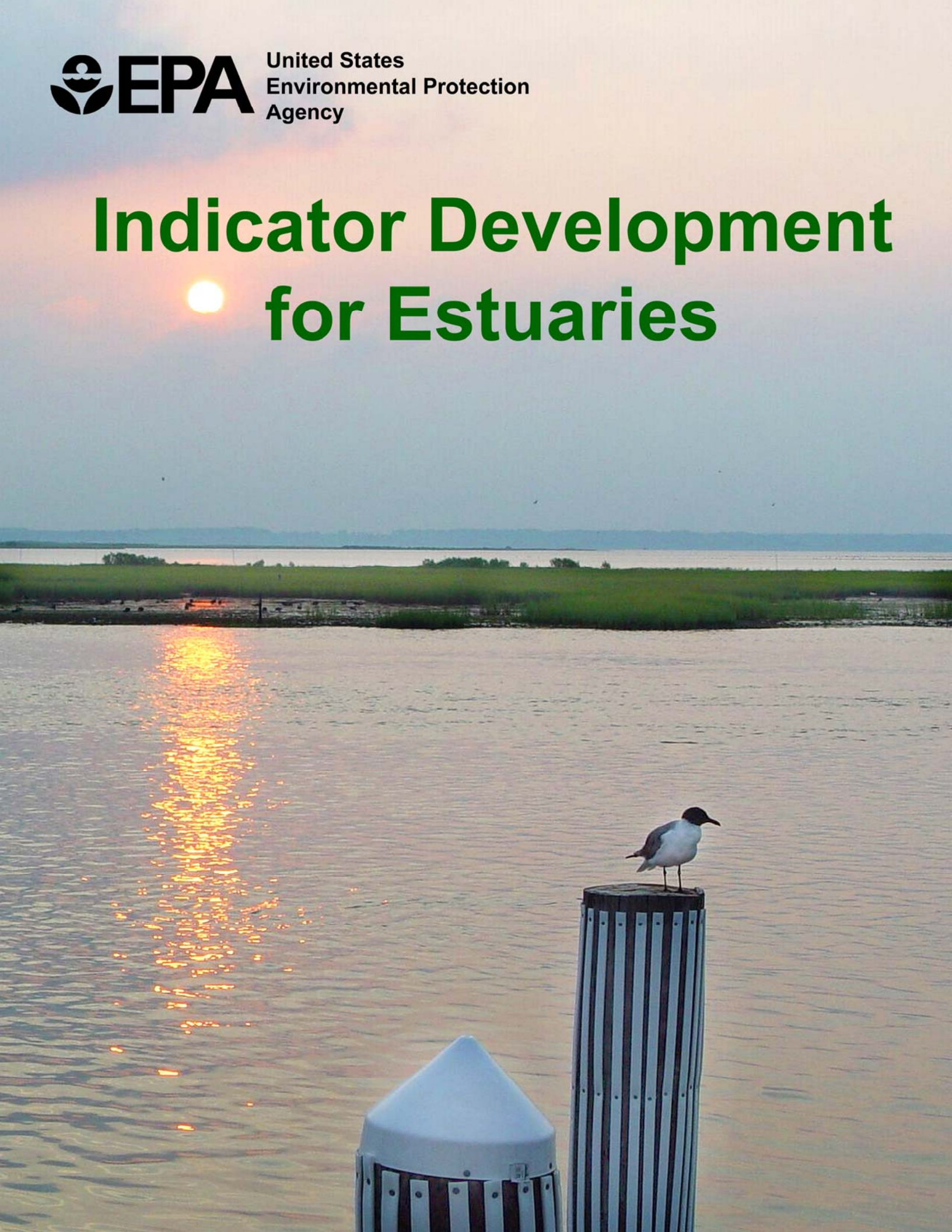
This document contains the report cover, and front matter, including the Acknowledgments, Table of Contents, Appendices, Figures, Tables, and Acronyms for the Indicator Development for Estuaries report. EPA-842-B-07-004. The remainder of the document can be downloaded from: http://www.epa.gov/owow/estuaries/indicators/

Indicator Development for Estuaries

February 2008

United States
Environmental Protection
Agency

Indicator Development for Estuaries



Maryland Coastal Bays photo by Joe Hall

ACKNOWLEDGEMENTS

This *Indicator Development for Estuaries* manual was prepared by the U.S. Environmental Protection Agency (EPA), Office of Water (OW) with contract support from Lynn McLeod, Battelle. The EPA Project Manager for this document was Joe Hall, who provided overall management, guidance and project coordination. The document was reviewed by the National Estuary Programs, EPA Regions and Headquarters staff. Special appreciation is extended to Kerry St. Pe' and Dean Blanchard for their assistance with the Barataria-Terrebonne NEP Case Study and Philip Trowbridge and the new Hampshire NEP for assistance in preparing their case study. Thanks go to the National Estuary Program (NEP) Directors and their staff for contributing information and data and the following reviewers, who provided written materials, technical information, reviews and recommendations throughout the preparation of this document.

Barry Burgan, Office of Water
Dean Carpenter, Albemarle-Pamlico National Estuary Program
Diane Gould, Northeast EPA Region
Barbara Keeler, Region 6
Cheryl McGovern, Region 9
Shana Miller, Peconic Estuary Program

[This page left intentionally blank]

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1

INTRODUCTION 1
What are Indicators? 1
Why Should Indicators be Developed? 4
Who is Developing Indicators? 5
Who Should Use Indicators? 9
Lessons Learned During Previous Efforts Toward Indicator Development 13
Indicator Development Process 15

PLANNING THE PROGRAM 17
Step 1: Determine the Spatial Scale of the Program 19
Step 2: Establish a Steering Committee 20
Step 3: Identify the Purpose and Need for Indicators 21
Step 4: Identify the Key Issues 22
Step 5: Conduct a Baseline Assessment of Each Issue 25

CONCEPTUAL MODELS DEVELOPMENT 27
Use of Conceptual Models in Indicator Development 28
Development of Conceptual Models 29

INDICATOR SPECIFICATION 35
Conceptual Relevance 40
Feasibility of Implementation 40
Response Variability 41
Interpretation and Utility 42

MONITORING PLAN DEVELOPMENT AND MODIFICATION 47

INDICATOR IMPLEMENTATION 53
Formal Adoption and Funding 53
Communication Among Organizations 54
Monitoring Plan Implementation 55
Data Collection and Analysis Plans 56
Communication of Indicator Findings 56

INDICATOR REASSESSMENT 65

SUMMARY 67

REFERENCES 71

APPENDICES

APPENDIX A-1 BARATARIA-TERREBONNE PROGRAM CASE STUDY A-1
APPENDIX A-2 NEW HAMPSHIRE ESTUARIES PROJECT CASE STUDY..... A-9
APPENDIX A-3 NORTHEAST COASTAL INDICATORS WORKSHOP CASE STUDY A-17
APPENDIX B INDICATORS DEVELOPED BY VARIOUS GROUPS B-1
APPENDIX C RESOURCES ON INDICATORS C-1

FIGURES

FIGURE 1. MAP OF THE ESTUARIES IN THE NATIONAL ESTUARY PROGRAM (NEP) AND NATIONAL ESTUARINE RESEARCH RESERVE (NERR) SYSTEM 7
FIGURE 2. NATIONAL COASTAL ASSESSMENT SYNTHESIS OF WATER CLARITY DATA ... 13
FIGURE 3. INDICATOR DEVELOPMENT PROCESS..... 15
FIGURE 4. EXAMPLE OF A COMMON ECONOMIC INDICATOR—DOW JONES INDUSTRIAL AVERAGE FROM 1975 TO 2005 28
FIGURE 5. CONCEPTUAL MODEL OF ESTUARINE ECOSYSTEM WITH MULTIPLE STRESSORS AND RESPONSES 29
FIGURE 6. THE PSR CONCEPTUAL MODEL 30
FIGURE 7. EXAMPLE OF A PSR CONCEPTUAL MODEL FOR NUTRIENT INPUTS AND ASPECTS OF EUTROPHICATION. 32
FIGURE 8. EXAMPLE OF A PSR/E CONCEPTUAL MODEL FOR NUTRIENT INPUTS AND ASPECTS OF EUTROPHICATION. 32
FIGURE 9. EXAMPLE OF MULTIPLE LEVELS OF INDICATORS ASSOCIATED WITH EUTROPHICATION AND THE INPUTS OF NUTRIENTS 36
FIGURE 10. FIVE STEPS IN DESIGNING A MONITORING PROGRAM 48
FIGURE 11. MULTISTAGED OR TIERED SAMPLING DESIGN OF THE MWRA WATER QUALITY MONITORING PROGRAM 52
FIGURE 12. CASCO BAY ESTUARY PARTNERSHIP 2005 STATE OF THE BAY REPORT 58
FIGURE 13. SAN FRANCISCO REPORT CARD 1996-1999 59
FIGURE 14. MWRA 5 YEAR PROGRESS REPORT 2000-2004 61

TABLES

TABLE 1. EXAMPLES OF VARIOUS INDICATOR EVALUATION GUIDELINES 39
TABLE 2. SAMPLING OF INDICATORS AND THEIR RESPECTIVE ASPECTS UNDER THE FOUR CRITERIA—RELEVANCE, FEASIBILITY, VARIABILITY, AND UTILITY ... 44

ACRONYMS

ANCMS	Atlantic Northwest Coastal Monitoring Summit
BOD	biological oxygen demand
BTES	Barataria-Terrebonne Estuary System
BTNEP	Barataria-Terrebonne National Estuary Program
CBBEP	Coastal Bend Bays Estuary Program
CBEP	Casco Bay Estuary Partnership
CCMP	Comprehensive Conservation Management Plan
CHNEP	Charlotte Harbor National Estuary Program
CPUE	catch-per-unit-effort
CSO	combined sewer overflow
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DDE	dichlorodiphenylethylene
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GBEP	Galveston Bay Estuary Program
GIS	geographic information system
GLNPO	Great Lakes National Program Office
GOM	Gulf of Maine
GOMOOS	Gulf of Maine Ocean Observing System
GPRA	Government Performance and Results Act
LISS	Long Island Sound Study
LSU	Louisiana State University
LTEI	Long Term Environmental Indicators
MOU	Memorandum of Understanding
MWRA	Massachusetts Water Resources Authority
NCA	National Coastal Assessment
NCCR	National Coastal Conditions Report
NCIW	Northeast Coastal Indicators Workshop
NEP	National Estuary Program
NERR	National Estuarine Research Reserve

NGO	non-governmental organization
NHEP	New Hampshire Estuaries Project
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	National Research Council
OCPD	Oceans and Coastal Protection Division
OCRM	Ocean and Coastal Resource Management
OECD	Organisation for Economic Co-operation and Development
ORD	Office of Research and Development
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PSR	Pressure-State-Response
PSR/E	Pressure-State-Response-Effects
QA/QC	quality assurance/quality control
SCCWRP	Southern California Coastal Water Research Project
SFEI	San Francisco Estuary Institute
SJBE	San Juan Bay Estuary
SOLEC	State of the Lakes Ecosystem Conference
TAC	Technical Advisory Committee
TBT	tributyltin
TEP	Tillamook Bay Estuary Program
U.S.	United States
USGS	U.S. Geological Survey
VSP	visual sampling plan