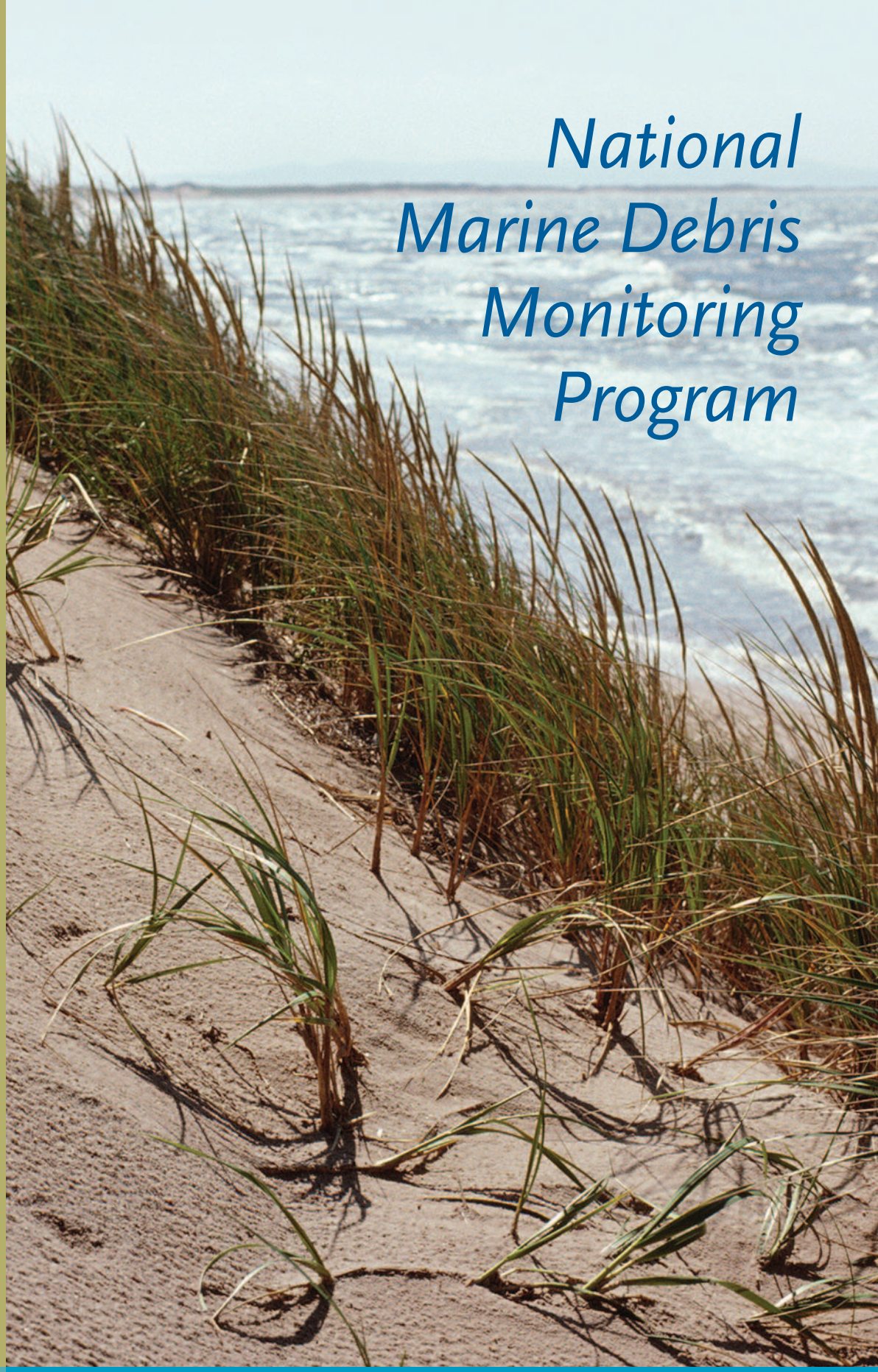
National Marine Debris Monitoring Program



Ocean Conservancy

September 2007

FINAL PROGRAM REPORT, DATA ANALYSIS & SUMMARY

Final project report for grant #-83053401-02

Submitted to:

U.S. Environmental Protection Agency
Office of Water

By:

Ocean Conservancy

1300 19th Street, NW
8th Floor
Washington, DC 20036

Ocean Conservancy

Ocean Conservancy is the world's foremost advocate for the ocean. Through science-based advocacy, research, and public education, we inform, inspire and empower people to speak and act for the oceans. Ocean Conservancy is headquartered in Washington, DC, and has offices in New England, Florida, the Caribbean, the Gulf of Mexico, and California with support from more than half a million members and volunteers.

© 2007 OCEAN CONSERVANCY

For reference purposes, this document may be cited as:
S.B. Sheavly. 2007. "National Marine Debris Monitoring Program: Final Program Report, Data Analysis and Summary."
Prepared for U.S. Environmental Protection Agency by Ocean Conservancy, Grant Number X83053401-02. 76 pp.

Table of Contents

EXECUTIVE SUMMARY 1

ACKNOWLEDGMENTS 5

INTRODUCTION 15

- What Is Marine Debris?
- Why Is Marine Debris a Problem?
- Where Does Marine Debris Come From?
- Why Does Marine Debris Need to be Monitored?
- Federal Mandate for Monitoring Marine Debris

PROJECT BACKGROUND 19

- Workgroups Addressing Marine Debris
- Pilot Study Protocol
- Pilot Program Reviews for Development of the Marine Debris Monitoring Protocol
- Statistical Review of the Pilot National Marine Debris Monitoring Protocol

METHODOLOGY 23

- Study Objectives
- Survey Regions
- NMDMP Survey Regions
- Survey Site Selection Criteria
- Survey Site Preparation
- Data Collection and Processing
- Statistical Procedures and Analyses

DATA AND RESULTS 31

- Change in Debris Items Over Time
- National Analysis
- Continental United States Analysis
- Regional Analysis

DISCUSSION 41

CONCLUSION 45

LITERATURE CITED 46

DATA TABLES 47

APPENDICES 57

List of Tables

Table 1. Average Number of Indicator Items (± SE) Collected Along 500 Meters of Beach from September 2001 to September 2006

Table 2. National and Regional Patterns in Changes of Marine Debris Totals Over Time

Table 3. Total Debris Collected/National

Table 4. Total Debris Collected/Continental U.S.

Table 5. Total Debris Collected/Region 1

Table 6. Total Debris Collected/Region 2

Table 7. Total Debris Collected/Region 3

Table 8. Total Debris Collected/Regions 4 & 5

Table 9. Total Debris Collected/Regions 6 & 7

Table 10. Total Debris Collected/Region 9

List of Figures

Figure 1. National total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 2. Continental U.S. total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 3. Region 1 total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 4. Region 2 total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 5. Region 3 total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 6. Regions 4 & 5 total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 7. Regions 6 & 7 total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

Figure 8. Region 9 total debris indicator items (a) and debris indicator items grouped by source (b) collected per 500 meters of beach from September 2001 to September 2006

List of Appendices

Appendix A. Overview of Related Treaties and Laws That Address Marine Debris Issues

Appendix B. Marine Debris Monitoring Federal Workgroup Members

Appendix C. Indicator Items to be Surveyed in the National Marine Debris Monitoring Workgroup

Appendix D. Descriptions of Regional and Monitoring Sites

Appendix E. Descriptive Statistics of Individual Monitoring Sites Between September 2001 and September 2006

Appendix F. Data from Individual Sites Separated by Sources: Ocean-based, Land-based and General-source Debris Items

Appendix G. Slopes from Linear Regression Model and Average Annual Percent Change Between September 2001 and 2006

Appendix H. Region 8 – Alaska: Monitoring Data Totals and Percent Source of Indicator Debris Items

 © 2007 OCEAN CONSERVANCY

OCEAN CONSERVANCY

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) Office of Water monitors and manages land-based pollution within the nation's beaches and waterways. Acknowledging the need for public education and involvement in solving the marine debris problem, Congress passed the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 (Public Law 100-220, Title II), Section 2204. In addition, Section 2204 of the MMPRCA authorized the EPA Administrator, the National Oceanic and Atmospheric Administration (NOAA) Administrator and the U.S. Coast Guard (USCG) to conduct programs to encourage the formation of volunteer groups to assist in the monitoring, reporting, cleanup and prevention of ocean and shoreline pollution.

Monitoring marine debris is an important component in dealing with this pervasive pollution problem, which impacts every major body of water on the planet. The information obtained from monitoring programs provides a roadmap for addressing the sources of the debris and can also be used to measure the success of programs developed to abate marine debris.

Congress authorized EPA to produce a report to assess the effectiveness of legislation and other methods of controlling marine debris. At the time, the most geographically extensive set of marine debris data was being gathered during annual beach cleanup efforts coordinated by Ocean Conservancy through the International Coastal Cleanup (ICC). The ICC is implemented by volunteer coordinators across the United States and in over 100 countries. Information from this volunteer effort helped form the foundation for EPA's research on the status of marine debris in the United States.

EPA funded Ocean Conservancy to conduct pilot testing of a scientifically valid methodology for monitoring marine debris. The field testing involved local conservation groups and other organizations in monitoring and removing marine debris from New Jersey and Maryland beaches. Information from these pilot studies, and work done in collaboration with the Marine Debris Monitoring Workgroup (formed in 1989 by EPA and comprised of federal agencies, scientists and other groups that were working on marine debris monitoring), resulted in the development and implementation of the **National Marine Debris Monitoring Program (NMDMP),** which was conducted by Ocean Conservancy (Escardó-Boomsma *et al.,* 1995).

Ocean Conservancy, along with the Marine Debris Monitoring Workgroup, developed NMDMP to standardize marine debris data collection in the United States using a scientifically valid protocol to determine marine debris status and trends. The program divided the country into nine regions based on several criteria, including: the types of marine debris previously found in those areas; prevailing currents; and logistical considerations of access and other management concerns. The program identified and randomly selected up to 20 beach sites within each region, which were then monitored by trained teams of volunteers. The purpose of this study was to answer the following research questions:

- Is the amount of debris on U.S. coastlines changing over a five-year period?
- What are the major sources of the debris?

NMDMP was characterized as a full-scale, national volunteer-implemented monitoring effort. This study involved more than 600 volunteers and groups devoting considerable time and effort to implement and conduct the field monitoring for assessing the status of marine debris along U.S. coasts. Monitoring surveys were conducted every 28 ± 3 days using standardized data cards listing 31 debris indicator items that were grouped according to sources of debris: land-based, ocean-based and general source. The program was implemented progressively, one region at a time, starting in the Gulf of Mexico area in 1996, with full implementation nationwide in the fall of 2001 and ending in 2007. The five-year time frame for this study that was selected for analysis ran from September 2001 to September 2006. The entire range (1996-2007) of data from this study will be available for future analyses and review by the resource management and conservation communities.

During the five years of this national study (September 2001-September 2006), an average of 95.4 ± 28.6 Standard Error (SE) indicator items were removed during each survey. Variability in the number of indicator items between locations was large as noted by a coefficient of variation of 2.05. The most abundant debris items surveyed nationally were straws, plastic beverage bottles and plastic bags (< 1m). Overall, there was no significant change in the total amount

OCEAN CONSERVANCY

Right: Plastic Pellets found at Sea Rim State Park, Texas (Region 5, Site 11).

 © 2007 OCEAN CONSERVANCY

of debris monitored during this study, but when the data was separated by source, however, changes in debris patterns were noted. No significant changes in either land-based or ocean-based indicator items resulted in this study, whereas the amount of general-source debris items significantly increased over the five-year period ($p = 0.028$) with an average annual increase of 5.4%. During the first year, an average of 28.3 ± 6.3 (SE) general-source debris items were collected per survey, while during the fifth year, an average of 31.1 ± 9.5 (SE) general source debris items were collected per survey.

Regionally, total debris (land-based, ocean-based and general source debris combined) increased on the East Coast, specifically north of Cape Cod to the U.S./Canada border. South of Cape Cod, ocean-based debris decreased. In the Gulf of Mexico, general-source debris increased over the five-year study period. There was no significant change in debris totals on the West Coast. The only region to display a significant decrease in total debris during this study was Hawaii. The effects of El Niño weather patterns may have influenced this decrease during the course of this study. Region 8 (Alaska) was not included in the results of this study because an insufficient number of surveys were conducted, which did not meet the required sampling criteria.

This study represents the first significant assessment of marine debris in the United States and will serve as a model for future research and programming for addressing marine debris worldwide. While NMDMP was a success, some aspects of the program – including identifying potential areas for protocol modification and management of volunteer monitoring teams – can be improved. In the future, survey frequency should be reviewed based on local weather and ocean current patterns. In addition, the sampling site selection should also be modified to include stratified monitoring sites at locations that are in the proximity of outfalls and other debris source vectors. These sites may be useful in accessing waste management strategies that have been implemented in these areas.

A re-examination of the volunteer management in the field would also be useful. Working with volunteer monitors was effective, but efficacy could be improved if the

OCEAN CONSERVANCY

monitoring activities were integrated into local resource management programs. This would provide for better communications with the volunteers and aid in maintaining the rigorous survey schedules. In addition, if volunteers are needed for future long-term monitoring effort, considerations should be made to provide some monetary compensation for volunteer transportation costs.

The NMDMP volunteers successfully implemented this program and helped to produce the first national baseline of data for marine debris. The United States can use this information to help build a program designed to prevent and reduce the harmful effects of marine debris. The protocol used in this study has established a sound foundation for the development of future monitoring activities in this country and can serve as a guide for others.

Marine debris monitoring is not a "one size fits all" activity. The diversity in the types and amounts of debris is as varied as the multiple sources. Only through changes in human behaviors and working to improve solid waste management strategies can we hope to combat this global pollution problem. NMDMP – and its results and lessons learned – is a significant step forward in the continuing fight to understand and control marine debris pollution.

OCEAN CONSERVANCY

ACKNOWLEDGMENTS

This project's success lies with the many individuals and organizations that have devoted a considerable amount of their time and energy in the development, implementation and completion of this study. The credit and a tremendous amount of gratitude and appreciation go to the hundreds of volunteers (and their organizations) who devoted many years to the field-testing and implementation of the National Marine Debris Monitoring Program. Their dedication and commitment to this environmental study have been instrumental to the success of this unique research. Without these dedicated and conscientious people, this study would not have been possible.

Ocean Conservancy appreciates having had the opportunity to conduct this research study on marine debris monitoring and work with a wonderful group of over 600 volunteers in 21 coastal states, islands and territories. These efforts will allow the conservation and resource management communities to work more effectively in addressing the issue of marine debris pollution that plagues the world's ocean and waterways.

Above: Charlie Barr, NMDMP project manager, at Ocracoke Island National Seashore, North Carolina (Region 2, Site 19).

OCEAN CONSERVANCY

Recognition is given to Seba Sheavly, project director/consultant, and Charles Barr, project manager, for their skills and expertise in developing, implementing and managing this program. Timothy Henkel, whose field experience and technical knowledge aided in a successful assessment of this study, conducted the final data analysis. Christine Ribic, PhD, USGS Wisconsin Cooperative Wildlife Research Unit, University of Wisconsin-Madison, reviewed the statistical analysis in this report. Seba Sheavly of Sheavly Consultants, Inc. prepared this report on behalf of Ocean Conservancy.

Center for Marine Conservation/Ocean Conservancy staff and consultants who worked on the National Marine Debris Monitoring Program (NMDMP) Study:

- Kathy O'Hara
- Joan Escardó-Boomsma
- Seba Sheavly
- Jill Goodman-Bieri
- Randy Burgess
- Charles Barr
- Lisa Monk
- Laura Titulaer
- Adina Rose
- Bertha Walker
- Timothy Henkel
- Brian Edwards
- Christine Woolaway
- Sheavly Consultants, Inc.

Ocean Conservancy would also like to thank the Environmental Protection Agency (EPA) for their continued support and guidance over the past 12 years. EPA has been involved in the development of the National Marine Debris Monitoring Program since its inception; EPA was the key federal agency involved in collaborating with Ocean Conservancy to design, develop and implement NMDMP. In addition, EPA has been the sole funder of the National Marine Debris Monitoring Program through an EPA grant to Ocean Conservancy. Without the support of EPA, the National Marine Debris Monitoring Program could not have been completed.

EPA staff who managed the grant and collaborated on the development of the protocol and implementation of the NMDMP Study:

- David Redford
- Kathleen Hurld
- James Woodley
- Javier Vélez-Arocho
- Katherine Weiler

OCEAN CONSERVANCY

Top: Volunteers, Ossabaw Island, Georgia (Region 3, Site 8). Right: Volunteers, Fort Morgan, Alabama (Region 4, Site 1).

 © 2007 OCEAN CONSERVANCY

U.S./Canada border to Provincetown, MA

Region One

Volunteer NMDMP Survey Directors who participated in this study

OCEAN CONSERVANCY

SITE 1 South Lubec Beach, ME
Robin Gautier, Regional Medical Center; Tina Wormell and Erin Chalmers, Lubec Consolidated School

SITE 2 Jasper Beach, ME
Dr. Gayle Kraus, University of Maine-Machias

SITE 4 Pemaquid Beach, ME
Wayne Rathbun, Lincoln Academy; Linda Archambault, Erin Jordan and Ashley Atwood, Pemaquid Watershed Association

SITE 5 Saco Beach, ME
Dwayne Bond and Laura Hill, Environmental Schools

SITE 6 Wells Reserve, ME
Jessica Caron, B. J. Royer, Jeremy Goulet and Nancy Viehmann, Wells Reserve

SITE 7 Pirates Cove Beach, NH
Ted & Paula Merritt, University of New Hampshire Docent Volunteers

SITE 8 Seabrook Beach, NH
Steve Haberman, Seacoast Anti-Pollution League; Linda Scherf, St. Mary's School; Verna DeLauer, New Hampshire Coastal Program; Jen Kennedy, Blue Ocean Society for Marine Conservation

SITE 9 Devereaux Beach, MA
Elizabeth Dawson, Marblehead Environmental Coalition; Heather Gallay, Blue Marbles

SITE 10 Thompson Island Beach, MA
Thomas Hayden and Suzanne Orlando, Willauer School

SITE 11 Jenness Beach, NH
Jen Kennedy, Blue Ocean Society for Marine Conservation

SITE 12 Duxbury Beach, MA
Joe Cravalho, Dave and Angela Coggan and Richard Newbert, Massachusetts Beach Buggy Association

SITE 13 Plymouth Beach, MA
Joe Cravalho and Richard Newbert, Massachusetts Beach Buggy Association

SITE 14 Sandy Neck, MA
Chuck Lawrence and Charles Pires, Upper Cape Cod Technical School

SITE 15 Sears Island, ME
Sharon Sneed, Pen Bay Stewards

SITE 16 North Hampton Beach State Park, NH
Mike Caron and Susan Reynolds, North Hampton Junior High School

SITE 17 Plaice Cove, NH
Jen Kennedy, Blue Ocean Society for Marine Conservation

OCEAN CONSERVANCY

Top: Volunteers, Plymouth Beach, Massachusetts (Region 1, Site 13). Right: Volunteer, Isabela, Puerto Rico (Region 4, Site 14).

South of Cape Cod, MA to Beaufort, NC

Region Two

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 Newcomb Hollow Beach, MA
Carl Rasmussen and Russell Moehlich, Friends of Cape Cod National Seashore; Dorothy Dolan, Wellfleet Conservation Commission

SITE 2 Horseneck Beach State Reservation, MA
John Hill, Lloyd Center; Gay Gillespie, Westport River Watershed Alliance

SITE 3 Cape Pogue Reservation, MA
Mary Merges, Suzan Bellincampi and Sarah Trudel, The Trustees of Reservation

SITE 4 Charlestown Beach, RI
Anne Doyle and Martha Hosp, Salt Pond Coalition

SITE 5 Crescent Beach, RI
Scott Comings, The Nature Conservancy

SITE 6 Hither Hills State Park, NY
Larry Penny and Lisa D'Andrea, New York Department of Natural Resources

SITE 7 Westhampton Beach, NY
Charles Hedberg, Citizens of Westhampton

SITE 8 Robert Moses State Park, NY
Bob Grover and Jack Isaacs, Audubon Society

SIDE 9 Jones Beach State Park, NY
Angie Kapellaris and Amy Keyishian, Hofstra University; Annie McIntyre, Audubon Society; Maria Siorella-Conti and David Gasper, Nassau County Soil & Water District

SITE 10 Gateway National Recreation Area, NJ
Barbara Boyd and student teams – Kristin Beyczi, Lisbeth Blaisdell, Lauren Trio, Nicole Harms, Kevin Gill, Lisa Connors, Margot Zaccardi, Alyssa Tuccillo, Michelle Berson, Alexandra Widmer, Jessica Lettieri, Amanda Kees and James Rozanski, Marine Academy of Science and Technology

SITE 11 Island Beach State Park, NJ
Carol Elliott and Tom Sherman, Alliance for the Living Ocean; John Wnek, Marine Academy of Technology and Environmental Sciences

SITE 12 Cape Henlopen State Park, DE
Jim Alderman, Cape Henlopen High School; Suzanne Thurman, Carmine Environmental Center (Camp Arrowhead)

SITE 13 Fenwick Island State Park, DE
Todd Fritchman, Indian River High School

SITE 14 Delaware Seashore State Park, DE
Earl & Faith Chamberlin, Delaware Mobile Surf Fishermen, Inc.

SITE 15 Strathmere, NJ
Bill Lewis, Strathmere Fishing & Environmental Club

SITE 16 Chincoteague Island National Wildlife Refuge, VA
Fred Pulis and Geralyn Mirales, Chincoteague National Wildlife Refuge; Steven Stein, R. W. Beck, Inc.

SITE 17 Back Bay National Wildlife Refuge, VA
Beth LaPine, Corporate Landing Middle School; Kimberly John, Nexcom; Charles Barr, Ocean Conservancy, Marian Childress and Jennifer Jeffers, Marine Science Stranding Center

SITE 18 Pea Island National Wildlife Refuge, NC
Gail Lawrenson, Girl Scouts of the Outer Banks

SITE 19 Ocracoke Island National Seashore, NC
Jennifer Garrish, Ocracoke Combined School

SITE 20 Cape Lookout National Seashore, NC
Lynn Barker, North Carolina Maritime Museum; Natalie Woods, Cape Lookout Environmental Education Center

SITE 21 Bradley Beach, NJ
Rich Held, Bradley Beach Environmental Commission

 © 2007 OCEAN CONSERVANCY

Morehead City, NC to Port Everglades, FL

Region Three

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 Shackleford Banks, NC
Dr. Gail Cannon, Zoë Meletis and student team - Kris Pickler, Erin White, Emily Gooding, Tancred Miller, Debbie Wojcik, Joseph Sewell, Carl Gouldman, Angela Corridore and Jesse Marsh, Duke Marine Laboratory; Matthew Godfrey, North Carolina Wildlife Resources Commission

SITE 2 Carolina Beach, NC
Molly Elmo, Caroline Wicks and Hannah Renwick, University of North Carolina at Wilmington – Environmental Concerns Organization

SITE 3 Huntington Beach State Park, SC
Tonya Spires, Waccamaw Audubon Society; Tammy Maher, Eric Wright and student team - Alison Dean, Erica Dazey, Jessica Hausman, Teresa Burns, Caren Cutright, Michael Slattery, Matt Hanna and Casey Hale, Coastal Carolina University - Society for the Undersea World

SITE 4 Cape Romain National Wildlife Refuge, SC
Larry Davis, Sewee Visitors Center

SITE 5 Edisto Beach State Park, SC
Mara Lake, Charleston Natural History Society; Judith Blancett, Edisto Beach State Park Volunteer

SITE 6 Folly Island, SC
Prissy Todd, Girl Scouts; Ken Leighton, Cub Scouts

SITE 7 Sapelo Island, GA
Fred Hay, National Estuary Reserve – Department of Natural Resources; Susan Johnston, Wylie Philler, Ron & Mary Brown and Brook Vallaster, Sapelo Island National Estuarine Research Reserve

SITE 8 Ossabaw Island, GA
Hank Barrett and Clete Bergen, Clean Coast

SITE 9 Cumberland Island National Seashore, GA
Louise Millette and Go Go Ferguson, Cumberland Island Resident Association

SITE 10 Amelia State Recreational Area, FL
Kim Snyder, Keep Nassau Beautiful

SITE 11 Little Talbot Island State Park, FL
Roger Clark, Duval Audubon Society; Jeanette Devine, Stacy Shelton, Arlene Spilker, Cheryl Stevens, Janice Dubose and Pier Chatman, Prudential Insurance Company; Tom Harding, Florida Department of Environmental Protection

SITE 12 Guana River State Park, FL
William McQuilkin, Jr. and Bert Charest, St. Johns County Audubon Society; Jennifer Hooker

SITE 13 Mickler's Landing, FL
William McQuilkin, Jr. and Bert Charest, St. Johns County Audubon Society; Robert Powers and Wayne Hartley, Allen D. Nease Senior High School

SITE 14 North Peninsula State Recreation Area, FL
Cathy Marsh and Ann Arnold, Volusia Flagler Sierra Club

SITE 15 Canaveral National Seashore, GA
Liz Melvin and Jim Kriewaldt, Keep Brevard Beautiful

SITE 16 Patrick Air Force Base
Michael Camardese and Wesley Westphal, Patrick Air Force Base

SITE 17 Sebastian Inlet State Recreation Area, FL
Ruth Davies and John Rine, Pelican Island Audubon Society: David Flagherty

SITE 18 Jungle Hut Park, FL
Jorjann Kuypers, Buddy Taylor Middle School

SITE 19 Hobe Sound National Wildlife Refuge, FL
Mary Ann Farah, Hobe Sound Nature Center

SITE 20 Blowing Rocks Preserve, FL
Lynn Emerson and Andrea Povinelli, The Nature Conservancy, Blowing Rocks Preserve

Northern jetty of Port Everglades, FL, Puerto Rico, U.S. Virgin Islands to Gulf Shores, AL

Region Four

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 Fort Morgan, AL
Cathy Schimmel Barnette and Amy King, Alabama Department of Conservation and Natural Resources – State Lands Coastal Section; Jeff Jordan, Daulphin Island Sea Lab

SITE 2 Perdido Key, FL
Sonya Wood Mahler, Escambia County Extension Service/Sea Grant; D. J. Schreiber, Gulf Coast Littoral Research Services

SITE 3 Pensacola Beach, FL
Enid Sisskin, Gulf Coast Environmental Defense

SITE 4 Top Sail Hill State Preserve, FL
Richard Butgereit, Florida Park Service; Dale Shingler, Top Sail Hill State Preserve; Tom Godbold, South Walton Turtle Watch; Jennifer and Dan Edwards

SITE 5 Santa Rosa Island, FL
Debby Atencio, Dan Robeen, Andrew Yost, Jennifer Mathers and Erica Schnarr, Eglin Air Force Base

SITE 6 Fort DeSoto Park, FL
Bob Browning, Fort DeSota Park; Ken Christensen; Tim Batson, Pas-a-Grille Wave Runners

SITE 7 Honeymoon Island Park, FL
Lette Pascoe, Don Gallagher and Shawn Yeager, Florida State Parks; Bob & Jean McNicholas; Ron & Debbie Royon

SITE 8 Holmes Beach, FL
Ingrid McClellan, Keep Manatee Beautiful; Patricia Bergen; Julie Krokroskia, Island Middle School

SITE 9 Bradenton Beach, FL
Ingrid McClellan, Keep Manatee Beautiful; Nancy Eastman, Green Dream Team

SITE 10 Sanibel, FL
Jackie & George Cooper; Megan Tinsley and Sandy Boyle, Sanibel-Captiva Conservation Foundation

SITE 11 Bonita Beach, FL
John & Elaine Wall, Citizen's Association of Bonita Beach

OCEAN CONSERVANCY

SITE 12 Vanderbilt Beach, FL
Amy Lawson, Naples High School Environmental Club

SITE 13 Long Key State Recreation Area
Carmen Kelley and David Makepeace, Coral Shores High School

SITE 14 Isabela PR
Rafael Jusino-Atusino, University of Puerto Rico – Aquadilla Campus; Beth Zotter, Ariana Morgan and Kathy Hall, N. W. Ecology League

SITE 15 Mayagüez, PR
Milagros Justiniano Rodriguez, Departamento de Recursos Naturales y Ambientales

SITE 16 Guánica, PR
Robin Walker and Samuel Davila, Interamericana Universidad de Puerto Rico

SITE 17 Cañalejo, PR
Lesbia Montero, Universidad de Puerto Rico

SITE 18 Half Penny Bay, USVI
Marcia Taylor and Paige Rothenberger, University of the Virgin Islands

SITE 19 Chenay Bay, USVI
Germaine Florent, University of the Virgin Islands

SITE 20 Playa Largo, PR
Mayra S. Velaz, University of the Virgin Islands; Steve Prosperman, University of the Virgin Islands - MacLean Marine Science Center

Top: Volunteers at Bradenton Beach, Florida (Region 4, Site 9).

 © 2007 OCEAN CONSERVANCY

Dauphin Island, AL to U.S./Mexico border

Region Five

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 South Padre Island, TX
Donna Light, United States Coast Guard Auxiliary; Sandy Salazar and Tori Torres, Gladys Porter Zoo; Deborah Fisher, Sunny Beaches

SITE 2 Padre Island National Seashore, TX
Sylvia Balentine, Texas A&M; Deborah Fisher, Sunny Beaches

SITE 3 Padre Island, Kleberg County, TX
Leigh Pohlmeier, Texas State Aquarium; Graham Jesse, Tom Browne Middle School; Nicki Sohn, Flour Bluff Senior High School; David Rainey, John Silva, Chris Vasquez, Mammie and Amanda de La Rosa, AMERICORP; Deborah Fisher, Sunny Beaches

SITE 4 Mustang Island, TX
Christina Longacre, Ellen Swepston, Texas A&M – Science Club; Pam Greene, Keep Port Arkansas Beautiful

SITE 5 San Jose Island, TX
James R. Jones, Baker Middle School; Pam Greene, Keep Port Aransas Beautiful; Annette Lessmann, Girl Scouts Troop 834

SITE 6 Matagorda Beach, TX
Meredith Keelan, Van Vleck High School

SITE 7 Surfside, TX
Rick Boyko, Ray Brown and Mike Clausen, United States Coast Guard Marine Safety Office; Georgia Keeney, Clare Dunn, Kammie Shay and Kathy Laird, Save Our Beach Association

SITE 8 Galveston Island State Park, TX
Jeanne Cato, St. Christopher Youth Group; Kelly Drinnen, Moody Gardens; Gary Schero, Clean Galveston

SITE 9 San Luis Pass, Galveston Island, TX
Madeline Woods, San Luis Pass Volunteers

SITE 10 High Island, TX
David Linville and Monica Bergeron, United States Coast Guard Marine Safety Office; Janice & Scott Freile

SITE 11 Sea Rim State Park, TX
Terri Clark, Monsignor Kelly High School; Rick Gist, Lamar University; Carlo Defrancis and Steven Fredeman, Sea Rim Estates Association

SITE 12 Hog Bayou, LA
Frankie Broussard, Phillips Petroleum Company

SITE 13 Rutherford Beach, LA
Mike LaVergne, Louisiana Cooperative Extension Service

SITE 14 Holly Beach, LA
Georgia Broussard, Sulfur High School; Kathy Richard

SITE 15 Fourchon, LA
Chris Schneidau, Aquarium of the Americas; Carolyn France and Ray Savoie, Americorps on the Bayou

SITE 16 Breton Island, LA
Traci Landry-Huey and Blaine Seguna, Kerr McGee Corporation

SITE 17 Ship Island, MS
Cathy Holloman and Chris Lagarde, Mississippi State University

SITE 18 Horn Island, MS
Jennifer Buchanan, Department of Marine Resources; Cathy Hollomon, Mississippi State University

SITE 19 Petit Bois Island, MS
Lee Harbison, Chevron Products Company

SITE 20 Dauphin Island, AL
Alma Wagner and Ann DiPlacido, Forever Dauphin Island

SITE 21 Elmer's Island, LA
D. J. Schreiber, Gulf Coast Littoral Research Service

SITE 22 Deer Island, MS
Christine Johnson, Department of Marine Resources; and Cathy Hollomon, Mississippi State University

SITE 23 Bayou Cassotte, MS
Lee Harbison, Chevron Products Company

U.S./Mexico border to Point Conception, CA

Region Six

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 St. Augustine Beach, CA
Judy Sahm, Hollister Ranch Owner's Association - Group Effort – We Care; Cynthia Ward, Vista De Las Cruces School

SITE 2 El Capitan State Beach, CA
Roger Sorro, Boy Scouts of America

SITE 3 Coal Oil Point Natural Reserve, CA
Lee Moldaver, Santa Barbara Audubon Society; Craig Rewell and Sarah Richmond, University of California, Santa Barbara; Dan Fontaine, Alex Kane and Alice Kinner, Isla Vista Surf Rider Foundation

SITE 4 University of California, Santa Barbara Campus Beach, CA
Kristin Eschleman – University of Santa Barbara – CA Project Interest Research Group, Jessica Altstatt, Santa Barbara Channel Keepers

SITE 5 Rincon Beach County Park, CA
Sura Hart and Anne Lohse, Girls Inc. of Carpinteria; Sharon Buczaczer, Wilderness Youth Project

SITE 6 Rincon Parkway Beach, CA
Jim Davis, Rudy Lopez and Zach Walker, Juvenile Restitution Program

SITE 7 Surfers Knoll Beach, CA
Bruce MacDonald, Corlund Electronics Corporation; Rose Quinn and Brian Halvorsen, Patagonia Stewart/Brown

SITE 9 Will Rogers Beach, CA
Ray Millette

SITE 10 Thornhill Broome Beach, CA
Janine McCluskey, Las Posas 4-H

SITE 11 Leo Carrillo State Beach, CA
Jean Ballantine, Cub Scouts

SITE 12 Escondido Beach, CA
Kelsy Maruyama, West Valley Boys & Girls Club; Bryan Kim, Deloitte and Touche

SITE 13 Crystal Cove State Park, CA
Gary Brown, Raymond Hiemstra, Leslie Sorrells and Pam Dosch, Orange County Coastkeepers

SITE 14 Capistrano Beach, CA
Linda Blanchard and Annette Shoemaker, Orange County Maine Institute; Julie Foxhoven, Capistrano Beach Volunteers

SITE 15 Trestles Beach, CA
Cindy Thompson, California State Parks

SITE 16 San Onofre State Beach, CA
Vicki Wiker and Cindy Thompson, California State Parks

SITE 17 Torrey Pines, CA
Patrick Zabrocki, Surf Rider Foundation; Paul Chillar, Alex Foster and Sarah Witten, University of California, San Diego – Ocean Awareness Club; Rose Quinn and Brian Halvorsen, Torrey Pines Volunteers; Lisa Dieu, University of California, San Diego; Megan Pierson

SITE 18 Silver Strand State Beach, CA
Joe Carrey, San Diego Bay Keepers; Melissa White

OCEAN CONSERVANCY

Right: Student volunteers, Padre Island, Kleberg County, Texas (Region 5, Site 3).

 © 2007 OCEAN CONSERVANCY

North of Point Conception, CA to U.S./Canada border

Region Seven

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 Pacific Beach State Park, WA
Patrick Gaffney and Ken Loomis, North Beach Senior High School

SITE 2 Twin Harbors State Park, WV
Victor Garcia, Ocosta High School

SITE 3 Leadbetter Point State Park, WA
Fred Dust, Alternative High School

SITE 4 Fort Stevens State Park, OR
Vanetta West, Knapper High School; Neil Maine, Warrenton Middle School

SITE 5 Nehalem Bay State Park, OR
Beth Gienger, Neah-Kah-nie Hig

SITE 6 South Beach State Park, OR
David Henderson, South Beach State Park; Don Kennedy, Oregon State University; Margaret Kennedy

SITE 7 Beachside State Park, OR
Cathy Ille, Waldport Middle School

SITE 8 Bullards Beach State Park, OR
Dawn Edmison and Tom Forgatsch, Brandon High School-Key Club; Diane Mahoney, Harbor Lights Middle School; Gary Montesano, CoastWatch

SITE 9 Crescent Beach, CA
Ted Souza, Friends of Del Norte and Del Norte School District; Andrew Hufford, College of the Redwoods

SITE 10 Gold Bluff Beach, CA
Duane Smith, Daniel Close and Jordan Serin, California Conservation Corps

SITE 11 Stone Lagoon, CA
Tony LaBanca, Friends of the Dunes; Chris Kent, Americorps; Matt Strickwerda, Jayna Schaaf and Mike Fleming, Humboldt State University - Marine Biology Club; Karen Oeth, California Conservation Corps

SITE 12 Samoa Dunes Recreation Area, CA
Tony LaBanca, Friends of the Dunes: Howie Schnabolk, Cadre of Corps; Michelle Meisner, Humboldt Bay Service Corps; Talena Dehmel, Humboldt State University – Oceanography Society

OCEAN CONSERVANCY

Top: Volunteers at Matagorda Beach, Texas (Region 5, Site 6).

SITE 13 Manchester State Beach, CA
George Hartwell, Manchester School

SITE 14 Salon Creek Beach, CA
Ruby Herrick and Amy Smith, Stewards of Slavianka; Annie Cresswell, Keary and Sally Sorenson, Stewards of the Coast and Redwoods

SITE 15 Rodeo Beach, CA
Don Jolley, Bolinas School; Darren Fong, Golden Gate National Recreation Area; Ann Bauer; Graham Charles, Karen Taussig, Patrick Schmitz and Jacquie Hilterman, The Marine Mammal Center

SITE 16 Pescadero State Beach, CA
John Kucera, June Langhoff and Susan Danielson, Save Our Shores; Wayne Johnson, Pescadero High School

SITE 17 Manresa State Beach, CA
Barney Levy, Renaissance High School

SITE 18 Carmel River State Beach, CA
A. J. Jordan, Monterey County Surfrider; Mardo & Ron Collins and Marty Renault, Point Lobos State Reserves

SITE 19 Morro Bay City Beach, CA
Fayalla Chapman, Morro Bay High School

SITE 20 Montana de Oro State Park, CA
Brett Biebber, Sheli Silver and Jacques Drapeau, Cades of Corps; Ann Kitajma, Morro Bay National Estuary Program

SITE 21 Clatsop County Beach, OR
Jann Luesse, CoastWatch

SITE 22 N. Yachats (mile 196), OR
Albert Johnstone, CoastWatch

Alaska (southern coast and Aleutian Islands)

Region Eight

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 North Beach, St. Paul Island, AK
Karin Holser, Pribilof Islands Stewardship Program – St. Paul

SITE 3 Front Beach, Unalaska, AK
Brenda Tellman

SITE 4 Monashka Bay, Kodiak, AK
Dave Allen, Area Wide School; Jacqueline Landry and Marcus Stewart, Kodiak Youth Services Center

SITE 5 Buskin Beach, Kodiak, AK
Master Chief Kirk LeClare, U.S. Coast Guard Air Station Kodiak

SITE 6 Diamond Creek Beach, Homer AK
Marilyn Sigman, Center for Alaskan Coastal Studies, Inc.

SITE 7 Airport Beach, Seward, AK
Marc Swanson, Seward Elementary School

SITE 8 Hartney Beach, Cordova, AK
Aaron Lang, Prince William Sound Service Center

SITE 9 Coast Guard Beach, Yakutat, AK
Debbie Caron, Yakutat High School

SITE 10 Cannon Beach, Yakutat, AK
Debbie Caron, Yakutat High School

SITE 11 Sandy Beach, Sitka, AK
Jennifer Williams and Bonnie Brewer, Sitka National Historical Park; Gabriella Crowley, Community Schools

SITE 12 Totem Beach, Sitka, AK
Bonnie Brewer, Sitka National Historical Park; Gabriella Crowley, Community Schools

Hawaiian Islands (main)

Region Nine

Volunteer NMDMP Survey Directors who participated in this study

SITE 1 Kahuku Point Area, Oahu
Captain Terry Rice, Captain Paula Carroll, Wayne Garcia and David Getchell, U.S. 14th Coast Guard District Office; Christine Woolaway

SITE 2 Malaekahana Beach, Laie, Oahu
Marlu Oliphant-West, Save the Sea Turtles, Inc.

SITE 3 Kahana Beach, Oahu
Barbara Kelly and Michael McMahon, Youth for Environmental Services

SITE 4 Chun's Reef, Northshore, Oahu
Marlu Oliphant-West, Save the Sea Turtles, Inc.

SITE 5 Waimanalo/Kaiona Beach, Oahu
Lisa Ferentinos, Surfrider Foundation

SITE 6 Makua Beach, Oahu
Katy Kok and Nancy Evans, Nani O'Wai'anae; Fred and Karen Dodge, Malama Makua

SITE 7 Mokuleia Beach Park, Oahu
Verta Betancourt, Camp Mokuleia

SITE 8 Kalaeloa CDD (Barber's Point), Oahu
Mike and Kay Tokunaga, Pearl Harbor Kiwanis; Rebecca Hommon, CIV NAVREGHAWAII Counsel; Christine Woolaway

SITE 15 Baldwin Beach, Maui
Alan Hastings, Jr., Sierra Club

SITE 16 Waihe'e Beach Park, Maui
Jan Roberson, Maui Surfriders

SITE 18 Oneola (Big Beach, S. Makena), Maui
Marilyn Chapman, Maui Disposal Company, Inc.

SITE 21 PMRF North, Kauai
John Burger, Pacific Missile Range Facility

SITE 22 Kinikini Ditch, Kauai
John Burger, Pacific Missile Range Facility

 © 2007 OCEAN CONSERVANCY

OCEAN CONSERVANCY

INTRODUCTION

What Is Marine Debris?

Marine debris – which many researchers define as any man-made object that enters the marine environment due to numerous processes, including careless handling or disposal, intentional or unintentional release of materials or as a result of natural disasters and storms – is one of the most pervasive, yet potentially solvable, pollution problems plaguing the world's oceans and waterways (Coe & Rogers, 1997). The ubiquitous presence of marine debris, coupled with its physical, ecological, cultural and socio-economic complexities, poses one of the most severe threats to the sustainability of the world's natural resources.

Marine debris is more than an unsightly inconvenience for beach-bound vacationers or pleasure boaters. It also affects the inhabitants and economies of coastal and waterside communities worldwide. Over the past 40 years, organic materials (once the most common forms of litter) have yielded to synthetic elements as the most abundant material comprising solid waste. Durable and slow to degrade, plastic and synthetic materials – including those used to make beverage bottles, packing straps, tarps, fishing line and gear – can all become marine debris with staying power.

In addition, many of these items are highly buoyant, allowing them to be carried in currents for thousands of miles, endangering sensitive marine ecosystems and wildlife along the way. Cigarette filters and cigar tips, fishing line, rope and gear, baby diapers and nappies, six-pack rings, beverage bottles and cans, disposable syringes, batteries and tires – the litany of debris is as varied as the products available in the global marketplace, but it all shares a common origin. At a critical decision point, someone, somewhere, mishandled it – thoughtlessly or deliberately, while either on land or on the water.

OCEAN CONSERVANCY

Top: Marine debris, Kahuku Point Area, Oahu, Hawaii (Region 9, Site 1). Below: Frigate Bird, Northwest Hawaiian Islands (Region 9).

According to the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution, land-based sources can account for up to 80 percent of the world's marine pollution (GESAMP, 1991). Much of the debris reaches the ocean after people engaged in recreational beach-going activities have discarded it; debris is also blown into the water, or carried by creeks, rivers, storm drains, sewers and landfills to ocean areas. Other marine debris comes from activities on the water, including vessels (from small powerboats and sailboats to fishing vessels and large transport ships carrying people and commercial goods), offshore drilling rigs and platforms, fishing piers and marinas.

While there are laws regulating the dumping of trash at sea and on shore, the global nature of marine debris, the inability to confine debris within territorial boundaries and the complexity of identifying debris sources have made effective laws difficult to develop and even harder to enforce.

Why Is Marine Debris a Problem?

Marine debris that collects along beautiful shorelines and waterways detracts from the aesthetic beauty and enjoyment of those beaches and negatively affects tourism. Debris can also be a human health and safety hazard. Discarded fishing line, rope and plastic bags can wrap around and damage boat propellers, or get sucked into boat engines. Medical wastes and drug paraphernalia lying on beaches can carry diseases, and broken glass and other sharp objects pose obvious dangers for barefooted beachgoers.

Marine debris can also cause habitat destruction by affecting water quality and causing physical damage to sensitive ecosystems. Coral reefs, seagrass beds and their bottom-dwelling species are very susceptible to the impacts of marine debris.

Marine debris can also be lethal for marine wildlife. Many species accidentally ingest trash, mistaking it for food. Abandoned fishing nets and gear, discarded fishing line and other forms of debris can entangle marine wildlife – including sea turtles, manatees, sea birds and fish – maiming or even killing them.

OCEAN CONSERVANCY

 © 2007 OCEAN CONSERVANCY

Where Does Marine Debris Come From?

Since trash and debris can travel long distances before being deposited on shorelines or settling on the ocean bottom or riverbed, determining the origin of marine debris is no easy task. Researchers traditionally classify marine debris sources as either land- or ocean/waterway-based, depending on how the debris enters the water. Other factors, such as ocean current patterns, climate and tides and proximity to urban centers, industrial and recreational areas, shipping lanes and fishing grounds, influence the types and amount of debris that are found on the open ocean or collected along beaches and waterways or underwater.

Land-based debris blows, washes or is discharged into the water from land areas. Multiple sources and activities contribute to land-based debris, including beachgoers, fishermen, materials manufacturers/processors/transporters, shore-based solid waste disposal and waste processing facilities, sewage treatment and combined sewer overflows, inappropriate or illegal dumping and public littering.

Of these, people's mishandling of waste materials – the packaging from convenience items, food wrappings, beverage containers and a host of other materials – creates the foundation for the marine debris problem. In addition, both legal and illegal waste handling practices contribute to marine debris. These include the inadvertent release of debris from coastal landfills and garbage from water transports, recreational beach and roadside litter and the illegal dumping of domestic and industrial garbage into coastal and marine waters.

OCEAN CONSERVANCY

Public wastewater treatment facilities are prohibited from discharging plastics and other materials into the marine environment. Under normal "dry weather" conditions, most wastes are screened out. However, materials can bypass treatment systems and enter waterways when rain levels exceed treatment facilities' handling capacity.

People also generate marine debris while at sea. Ocean/waterway-based contributors include fishing vessels, merchant, military and research vessels, recreational boats, yachts, cruise ships and offshore petroleum platforms and associated supply vessels. Debris can end up in the water through accidental loss or system failure, poor waste management practices or illegal disposal and indiscriminant littering.

Commercial and subsistence fishermen can create marine debris when they discard trash overboard, fail to retrieve fouled fishing gear or accidentally lose gear. Debris associated with fishing activities includes nets and ropes, salt treatment bags (used for separating shellfish catch), bait boxes and bags, fish baskets or totes, fish and lobster tags and gillnet or trawl floats. This debris can also pose a threat to suspecting wildlife through entanglement and/or ingestion.

Pleasure boaters, yachtsmen and fishermen may also discard trash overboard. Such debris may consist of food wrappers, beverage containers, grocery and trash bags, monofilament fishing line and other related fishing gear and oil lube bottles and other boat engine and cleaning or maintenance containers. Large vessels with extensive crews typically carry supplies for several months, and therefore produce solid wastes on a daily basis. However, any of these materials can become debris if not properly disposed of or stowed. The maritime and waste management industries have researched ways to better handle and store wastes aboard ships for long voyages and developed technologies for zero discharge practices for most wastes produced on these ships (Sheavly, 2005).

Undersea exploration and resource extraction of oil and gas also contribute to the marine debris problem. Daily oil/gas platform operations can create large amounts of trash. Discarded or lost hard hats, plastic sheeting and tarps, computer equipment and supplies, survey materials and personal and galley wastes can become marine debris when platform and supply vessel crews do not handle waste properly (Sheavly, 2005).

Why Does Marine Debris Need to be Monitored?

A national marine debris monitoring program can provide a better understanding of the debris problem and serve as an ongoing assessment component to aid debris management strategies. Monitoring can help clarify the marine debris problem (e.g., types, sources, distribution). Marine debris data and research can help formulate management solutions, which must in turn be implemented by management agencies with support from the private sector. Ongoing monitoring activities can then be used to assess the effectiveness of management strategies, legislation and other activities designed to control this pollution problem (Coe & Rodgers, 1997 and Sheavly, 2005).

Successful management of the marine debris problem requires a comprehensive understanding of the issue, including identifying the dominant forms of marine debris, their abundance and potential sources, and ultimately, the human behaviors and activities producing the debris. International treaties and conventions, national, regional and local legislation and regulations and governmental and private sector compliance and enforcement will also help form the foundation for effective and successful marine pollution prevention policies and initiatives (Sheavly, 2005).

Years of beach cleanups and research have shown that the amount and types of debris that accumulate on shorelines is primarily dependent upon geographic location, oceanographic and meteorologic systems and proximity to land-based and ocean-based sources (Cole *et al,* 1990; Manski *et al,* 1991; Ribic *et al,* 1992; Corbin & Singh, 1993; Faris & Hart, 1995; Coe & Rogers, 1997; Debrot *et al,* 1999; De Mora, 2004; and UNEP, 2006).

Conducting effective documentation and monitoring activities to assess the types and amounts of marine debris – combined with coordinated public education programs and effective waste management strategies – can lead to the global reduction and abatement of the marine debris problem.

Federal Mandate for Monitoring Marine Debris

The U.S. Environmental Protection Agency (EPA) Office of Water monitors and manages land-based pollution found on the nation's beaches and waterways. Acknowledging the need for public education and involvement in solving the marine debris problem, Congress passed the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 (Public Law 100-220, Title II). In addition, Section 2204 of the MMPRCA authorized the EPA Administrator, the National Oceanic and Atmospheric Administration (NOAA) Administrator and the U.S. Coast Guard (USCG) to conduct programs to encourage the formation of volunteer groups to assist in the monitoring, reporting, cleanup, and prevention of ocean and shoreline pollution.

Congress authorized EPA to produce a report to assess the effectiveness of legislation and other methods of controlling marine debris. At the time, the most geographically extensive set of marine debris data was being collected during annual beach cleanup efforts coordinated by Ocean Conservancy through the International Coastal Cleanup (ICC). The ICC is implemented by volunteer coordinators across the United States and in over 100 countries. Information from this volunteer effort helped form the foundation for EPA's research on the status of marine debris in the United States.

EPA funded Ocean Conservancy to conduct pilot testing of a scientifically valid methodology for monitoring marine debris (Escardó-Boomsma *et al.,* 1995). The field testing involved local groups in monitoring and removing marine debris from New Jersey and Maryland beaches. Information from these pilot studies and work done in collaboration with the Marine Debris Monitoring Workgroup (formed in 1989 by EPA and comprised of federal agencies, scientists and other groups that were working on marine debris monitoring), resulted in the development and implementation of the **National Marine Debris Monitoring Program (NMDMP)**, which was conducted by Ocean Conservancy.

This report chronicles the development and field-testing of the marine debris monitoring protocol, implementation and completion of the national study and the study's final analysis and results.

 © 2007 OCEAN CONSERVANCY

PROJECT BACKGROUND

On December 31, 1987, the United States ratified Annex V of the International Convention for the Prevention of Pollution from Ships (also known as MARPOL 73/78). Annex V prohibits the at-sea disposal of plastic wastes and regulates the distance from shore that ships may dump all other solid waste materials. The Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 (Public Law 100-220, Title II) implements the legislation for Annex V and extends the dumping regulations to vessels in all navigable waterways of the United States. Annex V became effective in the United States on December 31, 1988.

Recognizing the need for public education and involvement in solving the marine debris problem, Section 2204 of the MMPRCA authorized the EPA Administrator, the NOAA Administrator and the U.S. Coast Guard (USCG) to conduct public education programs in the marine environment. Section 2204 also authorizes the EPA Administrator, along with the Secretary of Commerce and the USCG, to conduct a program encouraging the formation of volunteer groups to assist in the monitoring, reporting, cleanup and prevention of ocean and shoreline pollution. A review of relevant U.S. marine debris legislation is found in Appendix A.

In 1990, Congress authorized EPA to assess the effectiveness of marine debris legislation and other methods to control debris. The EPA funded Ocean Conservancy (formerly the Center for Marine Conservation) in the marine debris effort because the organization maintained the most geographically comprehensive and continuous set of marine debris data. The marine debris data derived through the International Coastal Cleanup (ICC) provided a means to assess and review the nature and characteristics of marine debris pollution prior to the development of the National Marine Debris Monitoring Program. The information gathered during the annual ICC events, though useful and informative, is not a scientific means of collecting marine debris data.

The National Marine Debris Monitoring Program (NMDMP) was developed to create a standardized and statistically valid method of monitoring marine debris. As a result, a Marine Debris Monitoring (MDM) Workgroup – comprised of representatives from NOAA, the National Park Service (NPS), Ocean Conservancy, USCG, the Marine Mammal Commission and selected scientists – developed a protocol and monitoring methodology that was reviewed by all federal agencies that monitor marine debris. Congress funded the development of demonstration programs to utilize volunteers in monitoring and removing marine debris along selected beaches. As part of the program, Ocean Conservancy, in conjunction with the EPA, began to test a statistically valid methodology for determining trends in marine debris. Beach sites were selected in Maryland, New Jersey, and the Gulf of Mexico (Alabama and Texas), and volunteers were recruited and trained in the program protocol. The protocol development is described briefly in the following sections; details are in Escardó-Boomsma *et al.* (1995).

Workgroups Addressing Marine Debris

In 1989, EPA and other federal agencies established a working group to monitor the status and trends of marine debris as directed under section 2204 of the MPPRCA. MPPRCA authorized EPA, NOAA and USCG to conduct a program to encourage the formation of volunteer "Citizen Pollution Patrols" to assist in the monitoring, reporting, cleanup and prevention of ocean and shoreline pollution.

As part of this effort, EPA funded the Ocean Conservancy to conduct marine debris monitoring pilot studies involving local volunteer groups in New Jersey, Maryland and in the Gulf of Mexico (Alabama and Texas). The EPA also established the MDM Workgroup made up of members from the EPA, NOAA, NPS and selected scientists, to develop a nationwide methodology for monitoring marine debris. A listing of members of the MDM Workgroup is presented in Appendix B for review.

The objective of the MDM Workgroup was to define a common goal of all the interested federal agencies and other groups that could be translated into a scientifically acceptable standard design to monitor marine debris changes over time. The Workgroup agreed on a working hypothesis that asserted that marine debris on shorelines would be reduced by a combination of education and compliance to debris-dumping laws. The Workgroup utilized available marine debris information and data to conduct statistical analyses and develop a new marine debris survey methodology. The Workgroup addressed such issues as survey area and types of shorelines to be considered, location and size of survey units, type of debris items, sample size (number of survey units) and survey frequency, procedure, equipment and logistics.

The MDM Workgroup also selected a survey design that could detect a specified percentage change in beach debris, while keeping the methods within acceptable statistical, logistical and financial limits. The design was based on the available marine debris research conducted by members of the Workgroup and other researchers. Marine debris research showed that shorelines accumulate varying amounts and types of marine debris dependent on their geographical location, oceanographic and meteorological conditions and proximity to land-based or ocean-based sources. As a result, the Workgroup identified the geographic "boundaries" of the different types of marine debris and designated nine regions in the United States. The regional designations were primarily based on prevailing current patterns, relevant marine debris information and logistics.

Through an extensive review process, the MDM Workgroup selected 31 common debris items for monitoring based on current debris research studies (see Appendix C). These specific items would provide the information needed to measure the changes and trends in the amount of debris washing ashore by time and region. The list included items that could indicate land-based and ocean-based debris sources and items of particular concern due to biological or other potential impacts.

 © 2007 OCEAN CONSERVANCY

Pilot Study Protocol

The preliminary design for NMDMP was based on a power analysis, fiscal constraints and sampling logistics and included the following guidelines:

- Use of national indicator items for the marine debris pilot study as outlined by Escardó-Boomsma *et al.* (1995);
- Detect a 30% decline in indicator items over five years (if it occurs), with a power of 0.84 and a Type I error rate of 0.10 with a monthly survey frequency;
- Approximately 88,000 miles of U.S. coastal shorelines were divided into nine regions based on the types of marine debris found in those areas, the prevailing currents and logistical considerations of access to the area;
- Twenty 500-meter sites per region would be identified and surveyed, with these sites meeting specific criteria (e.g., substratum, slope) advocated by other marine debris studies and then selected by a geographically stratified random selection process;
- Approximately 30 indicator items would be surveyed every 28 ±3 days, on the same day in the same region (for regional comparisons);
- The monitoring would be conducted by trained and certified volunteer surveyors, who would be guided and checked by survey director, who in turn would be supervised by project staff; and
- The monitoring program would adhere to the scientific protocol established for this study and would conduct quality assurance procedures (QAP) to ensure quality on all levels of the program.

Pilot Program Reviews for the Development of the Marine Debris Monitoring Protocol

EPA initially funded Ocean Conservancy to develop demonstration programs to utilize volunteers in monitoring and removing marine debris along selected beaches. As part of the program, Ocean Conservancy began to test a statistically valid methodology for determining trends in marine debris. Beach sites were selected along the East Coast (Maryland, New Jersey), and the Gulf of Mexico (Alabama and Texas) and volunteers were recruited and trained in conducting the monitoring protocol.

EAST COAST

In June of 1991, Ocean Conservancy, with funding from EPA, initiated marine debris monitoring pilot studies in New Jersey and Maryland. However, the Maryland survey site was washed away by a severe winter storm during the first year. As a result, the initial pilot study was only performed on the New Jersey site.

The purpose of the pilot study was to evaluate the practicality of the MDM Workgroup's preliminary marine debris survey protocol. Volunteers at each monitoring site were required to conduct marine debris surveys every 28 days (± 3 days). The objectives of this pilot study were to (1) determine the composition of debris in relation to indicator and non-indicator items for one beach (Island Beach Park) and (2) see how indicator and non-indicator items changed over time. Data were collected over an eight-year period.

The New Jersey pilot program (May 1991 - May 1999) yielded a wealth of marine debris information and provided insights into the practicalities of conducting a long-term national study. The New Jersey study data also exhibited seasonal variability. The lowest amount of debris occurred in the summer. The other seasons showed about twice as much debris, comparatively. An average of 766 items was found on the study beach over the eight-year period. Debris abundance varied greatly, from a low of 29 items to a high of 3,198 items per 500 meters; the coefficient of variation was 0.78, indicating high variability in the data. An average of 212 indicator items (about 30% of the debris in the survey) and 554 non-indicator items were found per survey. Most indicator items were land-based (60.1%) or general-source debris (30.4%); only 9.4% were ocean-based debris. Most of the non-indicator items were small, such as plastic pieces, tobacco-related items and local items like drug-related paraphernalia; none of which would be good candidates for a national survey (Ribic, 2001b).

GULF OF MEXICO

Additional efforts were conducted to expand the testing of the statistical sampling design in other coastal areas. Volunteers implemented activities for more than 20 months in Beaumont, Texas at Sea Rim State Park until a series of storms hit the Gulf Coast area and washed out the monitoring site and widened the beach area to twice its normal size. Due to the irreparable damage to this site and adjoining areas, the Sea Rim State Park pilot site was aborted. In addition, volunteers were monitoring a site at the South Padre Island State Park to help test the draft protocol. Monitoring teams at this site had to contend with a high volume of debris accumulation, which required assistance to haul away the massive amounts of debris collected during each survey period. Monitoring efforts were also established at the Bon Secour National Wildlife Refuge in Alabama.

A review of the data being collected from monthly surveys evaluated gaps in the data set for the two regions, determined amounts and variability between sites and within regions and analyzed the data for trends (Ribic, 2001a).

The New Jersey Pilot Study and the other subsequent pilot studies conducted along the Gulf of Mexico presented the opportunity to test and refine the study protocol and statistical design. The results of the pilot studies yielded the base information necessary to determine the number of required monitoring sites, the frequency of the surveys, the required duration of the national study, and the strength of the planned statistical analysis. The pilot studies also provided insights into the practicality of conducting a long-term national debris study utilizing a volunteer workforce. The resulting methodology led to the development of NMDMP.

Statistical Review of the Pilot National Marine Debris Monitoring Protocol

A statistical review was conducted to assess the status and progress of NMDMP. The following is a summary of the report's findings:

Task 1 – Evaluated data gaps for sites in the Gulf of Mexico (named Regions 4 and 5 in the NMDMP study). This report identified two problems: data indicated that volunteers were missing the 28-day survey target interval and volunteers regularly missed surveys due to holidays. Task 1 also revealed that there appeared to be no change in the amount of indicator items over time for Region 4, with Region 5 exhibiting a significant increase in land-based debris items. (Ribic, 2001a).

Task 2 – Evaluated differences between indicator and non-indicator items for an eight-year data set from New Jersey. Ribic's report concluded that indicator items did not change over the time period regardless of source, but non-indicator items exhibited an increase up to 1998 followed by a subsequent decrease. It was concluded that non-indicator items would not be useful in a national study. (Ribic, 2001b).

Task 3 – A power analysis using data from Regions 4 and 5 was conducted to determine the number of beaches to be used for NMDMP. The original design called for the establishment of 20 monitoring sites per nine coastal regions (180 sites total) along the U.S. coast. Task 3 was designed to identify the statistical minimum number of monitoring sites needed to perform regional marine debris trend analysis over the course of five years. Upon subsequent review of the parametric power analysis for NMDMP data collected to date, it was determined that 12 sites in Region 4 and Region 5 would be sufficient to detect a 30% change or more with a power of 0.84 and a Type I error of 0.10 from the original NMDMP statistical protocol (Ribic 2001c).

EPA and Ocean Conservancy subsequently assumed that the variability in Regions 4 and 5 represented what was seen nationwide and decided that NMDMP would be considered implemented on a national basis when a minimum of 12 marine debris monitoring sites (with at least one site in each of the Regions 1 through 7) was reporting quality data. Region 8 (Alaska) and Region 9 (Hawaii) were not included due to the unique nature of the logistics for conducting surveys in these two regions and would be analyzed separately.

 © 2007 OCEAN CONSERVANCY

OCEAN CONSERVANCY

METHODOLOGY

Study Objectives

EPA developed NMDMP to standardize marine debris data collection in the United States using a scientifically valid protocol to determine marine debris status and trends. The program divided the country into nine regions based on several criteria, including: the types of marine debris found in those areas; prevailing currents; and logistical considerations of access and other parameters. The program initially identified and randomly selected up to 20 beach sites within each region, which were monitored by trained teams of volunteers. The purpose of this study was to answer the following questions:

- Is the amount of debris on our coastlines changing over a five-year period?
- What are the major sources of the debris?

Survey Regions

Studies have shown that shorelines accumulate varying amounts and types of marine debris dependent on their geographical location, oceanographic and meteorological conditions and proximity to land-based or ocean-based sources (Cole *et al,* 1990; Manski *et al,* 1991; Ribic *et al,* 1992; Corbin & Singh, 1993; Faris & Hart, 1995; Coe & Rogers, 1997; Debrot *et al,* 1999; De Mora, 2004; and UNEP, 2006). The MDM Workgroup identified the geographic "boundaries" of the different types of marine debris as described in current research and used this information to designate nine regions in the United States. The regional designations were primarily based on prevailing current patterns, marine debris information and logistics.

Top: volunteers at Barber's Point, Oahu, Hawaii (Region 9, Site 8).

NMDMP Survey Regions

Region 1 U.S./Canada border to Provincetown, MA

Region 2 South of Cape Cod, MA to Beaufort, NC

Region 3 Morehead City, NC to Port Everglades, FL

Region 4 Port Everglades, FL, Puerto Rico, U.S. Virgin Islands to Gulf Shores, AL

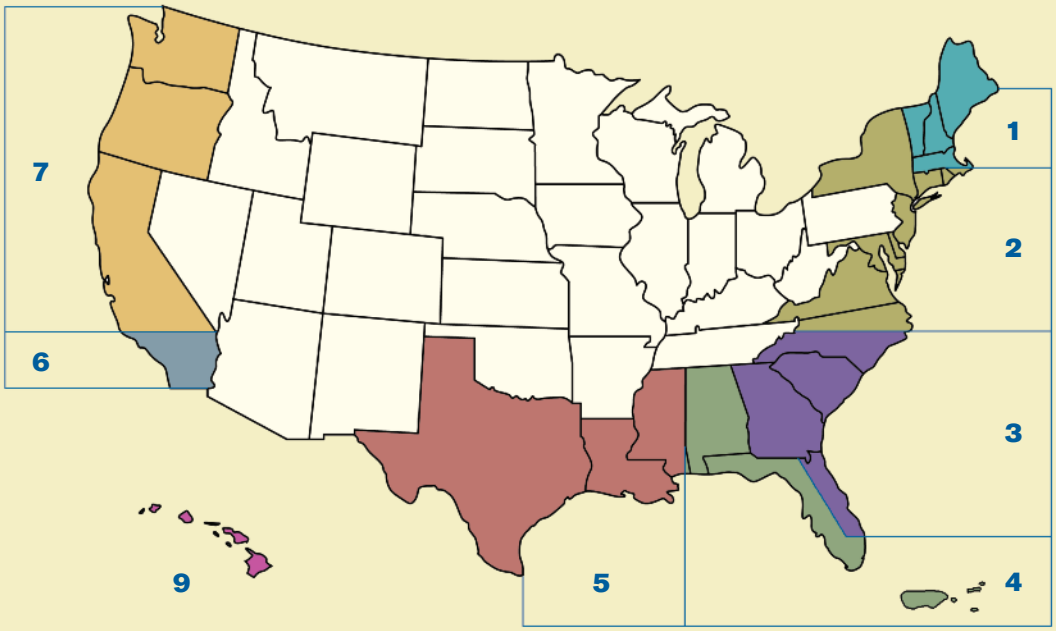
Region 5 Dauphin Island, AL to U.S./Mexico border

Region 6 U.S./Mexico border to Point Conception, CA

Region 7 North of Point Conception, CA to U.S./Canada border

Region 8 Alaska (southern coast and Aleutian Islands)

Region 9 Hawaiian Islands (main)



Survey Site Selection Criteria

Within each of the nine study regions, 20 marine debris monitoring sites were initially identified for the study. All designated marine debris monitoring sites were randomly selected from a comprehensive list of potential beach locations that met the following NMDMP study criteria:

- Length of at least 500 meters (≈0.31 miles)
- Low to moderate slope (15-45°)
- Composed of sand to small gravel
- Clear, direct access to the sea (not blocked by breakwaters or jetties)
- Accessible to volunteers year round
- Site would not impact any endangered or protected species such as sea turtles, sea/shorebirds, marine mammals or sensitive beach vegetation

A description of the regions and monitoring site specific information, including GPS coordinates and start dates for the 47 sites used in the initial analysis of this study is provided in Appendix D.

 © 2007 OCEAN CONSERVANCY

Survey Site Preparation

OCEAN CONSERVANCY

Each survey site was measured and marked to assure length accuracy and repeatability of successive surveys. A surveyor's measuring wheel was used for accurate site measurement. Semi-permanent markers were placed at the beginning and ending points of the 500-meter study site (see photo). In the event that it was not permissible or possible to mark a study site, a natural or man-made landmark such as a large rock, or building was accurately noted. In addition to establishing visual boundary markers for each site, global positioning system (GPS) coordinates (latitude and longitude) were also recorded for use in possible GIS mapping of the study sites and database manipulation.

Photographs of each selected survey site were taken, noting unique features and landmarks that would identify the site's location, along with securing a detailed map of each location.

Volunteers conducted initial beach cleanups at each of the survey sites to clean the beach of all debris that had accumulated over an unknown time period. This cleanup provided a "clean slate" in preparation of the subsequent debris survey and beach cleanup to be conducted 28 days later. Volunteer groups also used this initial cleanup as continued training for proper debris identification and as a practice run for future surveys.

Data Collection and Processing

INDICATOR ITEMS

National indicator items were developed for this study based on previous research and Ocean Conservancy pilot studies (Ribic, 1989 and Escardó-Boomsma *et al.,* 1995).

Ocean-based Source Indicator Items: gloves, plastic sheets (≥1 meter), light bulbs/tubes, oil/gas containers (>1 quart), pipe-thread protectors, nets (≥5 meshes), traps/pots, fishing line, light sticks, rope (≥1 meter), salt bags, fish baskets, cruise line logo items, floats/buoys.

Land-based Source Indicator Items: syringes, condoms, metal beverage cans, motor oil containers (1-quart), balloons, six-pack rings, straws, tampon applicators, cotton swabs.

General-source Indicator Items: plastic bags (<1 meter), plastic bags (≥1 meter), strapping bands (open), strapping bands (closed), plastic beverage bottles, plastic food bottles, plastic bleach/cleaner bottles, other plastic bottles. These items represent debris that originates at unspecified ocean- or land-based sources.

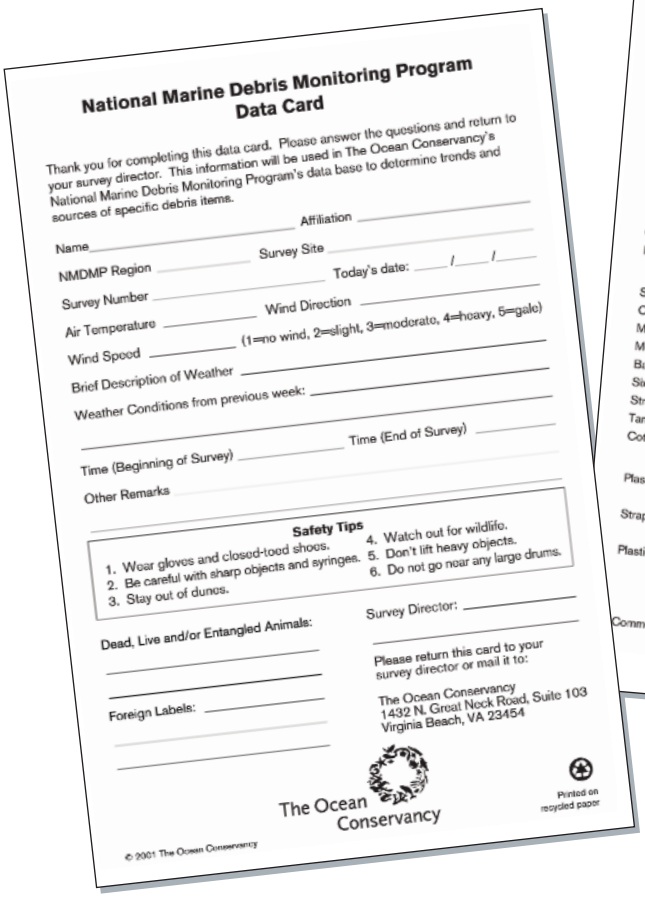
A standardized data card was developed for this study for recording monitoring information and related environmental data. One volunteer was designated as the "data recorder" while the other volunteers picked up the debris and reported what they found to the recorder. Tally marks were used on the data card to keep a count of the debris numbers during the survey and the final debris totals were recorded in the total boxes provided for each item. Comments, observations or unusual items were recorded at the bottom of the card.

The Data Card Required the Following Information:

- Volunteer name, the name of their group or organization and the date of the survey.
- The survey director provided the region and survey site numbers.
- An estimate of the air temperature and direction of wind at the site on the day of the survey was recorded, along with a brief description of the day's weather and the weather conditions from the previous week. Volunteers were encouraged to watch local forecasts or read a local paper for weather information.
- The survey beginning and ending times.
- Notes were taken of any animals found entangled in debris or any debris with labels of a foreign nature.
- Volunteers counted and recorded information on the 31 marine debris items listed on the data card. Volunteers were trained on the identification of the 31 indicator items being monitored in this study using photographs and actual samples of the various debris forms.

NOTE: All debris was physically removed from the study area even if it was not listed on the card

Upon completion of each survey, the NMDMP card was returned to the survey director. The survey director reviewed the card and returned it to Ocean Conservancy for processing and inputting into the NMDMP database.



National Marine Debris Monitoring Program Data Card

Thank you for completing this data card. Please answer the questions and return to your survey director. This information will be used in The Ocean Conservancy's National Marine Debris Monitoring Program's data base to determine trends and sources of specific debris items.

Name _____ Affiliation _____

NMDMP Region _____ Survey Site _____

Survey Number _____ Today's date: ___/___/___

Air Temperature _____ Wind Direction _____

Wind Speed _____ (1=no wind, 2=slight, 3=moderate, 4=heavy, 5=gale)

Brief Description of Weather _____

Weather Conditions from previous week: _____

Time (Beginning of Survey) _____ Time (End of Survey) _____

Other Remarks _____

Safety Tips

1. Wear gloves and closed-toed shoes.
2. Be careful with sharp objects and syringes.
3. Stay out of dunes.
4. Watch out for wildlife.
5. Don't lift heavy objects.
6. Do not go near any large drums.

Dead, Live and/or Entangled Animals: _____

Foreign Labels: _____

Survey Director: _____

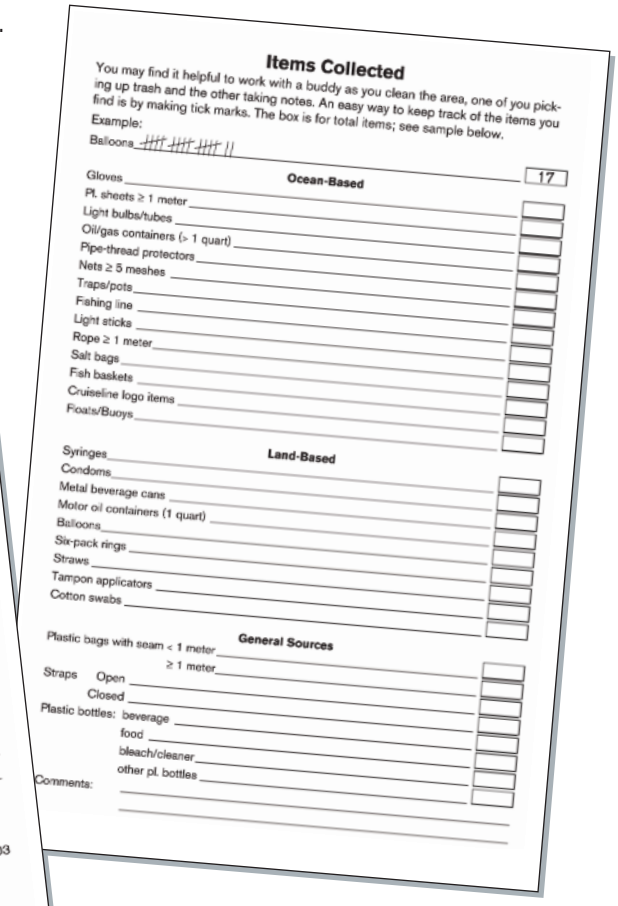
Please return this card to your survey director or mail it to:

The Ocean Conservancy
1432 N. Great Neck Road, Suite 103
Virginia Beach, VA 23454

The Ocean Conservancy

Printed on recycled paper

© 2001 The Ocean Conservancy



Items Collected

You may find it helpful to work with a buddy as you clean the area, one of you picking up trash and the other taking notes. An easy way to keep track of the items you find is by making tick marks. The box is for total items; see sample below.

Example:

Balloons 𝍸 𝍸 𝍸 || 17

Ocean-Based

Gloves
Pl. sheets ≥ 1 meter
Light bulbs/tubes
Oil/gas containers (> 1 quart)
Pipe-thread protectors
Nets ≥ 5 meshes
Traps/pots
Fishing line
Light sticks
Rope ≥ 1 meter
Salt bags
Fish baskets
Cruiseline logo items
Floats/Buoys

Land-Based

Syringes
Condoms
Metal beverage cans
Motor oil containers (1 quart)
Balloons
Six-pack rings
Straws
Tampon applicators
Cotton swabs

General Sources

Plastic bags with seam < 1 meter
≥ 1 meter
Straps Open
Closed
Plastic bottles: beverage
food
bleach/cleaner
other pl. bottles

Comments:

NMDMP volunteers in Florida demonstrate an organized walking pattern (Method 1).

OCEAN CONSERVANCY

CONDUCTING THE SURVEY

Surveys were conducted on 28-day intervals. Volunteers had up to three days before to three days after the scheduled survey date to complete the survey and beach cleanup. The time to conduct each survey may vary from site to site, but on average each survey took one to two hours to complete.

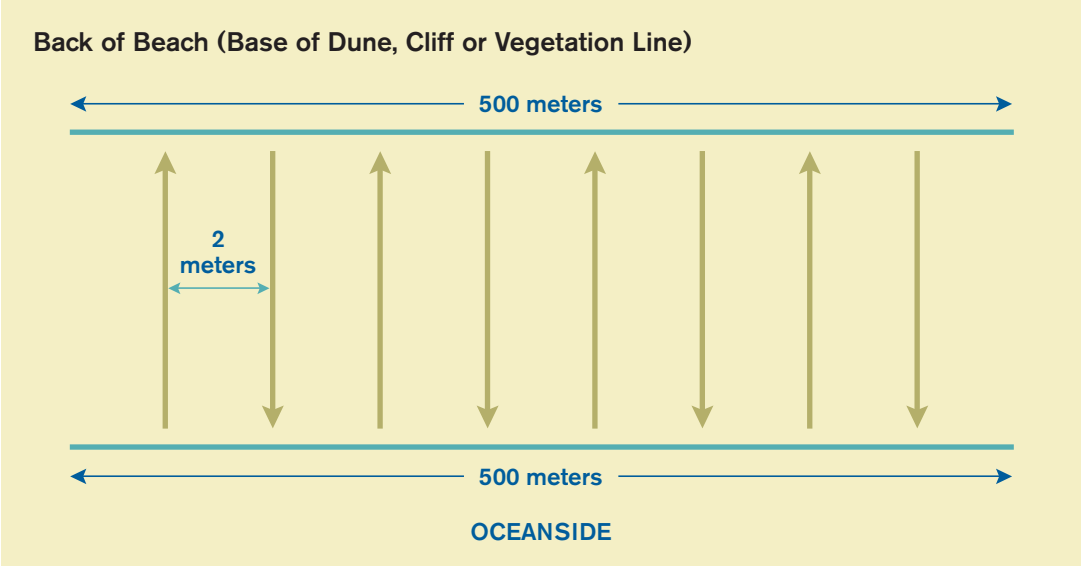
Depending on the size of the monitoring team, volunteers could choose one of the following walking patterns for each survey. This helped ensure that the entire 500-meter study site was covered and the data was consistent from survey to survey.

NMDMP SURVEY WALKING PATTERNS

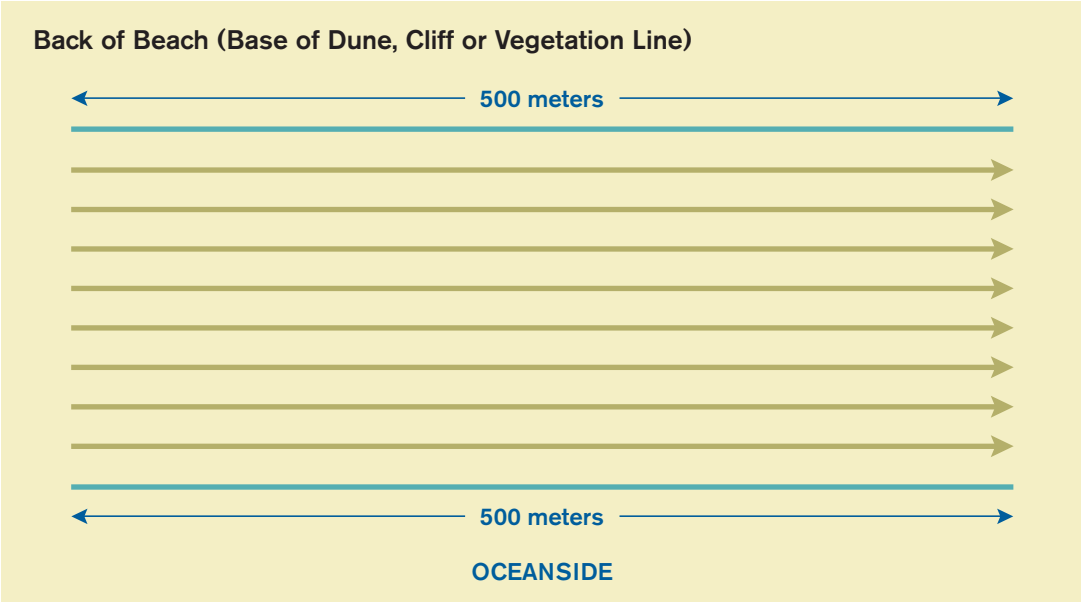
Method 1

Volunteers sweep up and back from the water's edge to the back of the beach along the 500-meter study site (see diagram below). Volunteers or sweeps should be spaced about every two meters (approximately six feet). This method was determined to work the best for small groups of volunteers (two to five people).

METHOD 1 WALKING PATTERN



METHOD 2 WALKING PATTERN



Method 2

Volunteers line up, spaced about every two meters (approximately six feet), from the back of the beach to the water's edge and sweep along the length of the 500-meter study site. This method was determined to work best with larger numbers of volunteers (> 5 people).

QUALITY ASSURANCE PROCEDURES

As with any scientific study, quality assurance (QA) procedures were developed and implemented for this study to ensure that all data collected was reproducible and comparable. Members of the NMDMP staff traveled to each monitoring site to provide basic training for volunteer groups in an effort to assure that volunteers understood the program's protocol. Volunteers were present at the establishment of each monitoring site where the boundaries of the 500-meter stretch of beach were measured and marked. GPS coordinates were recorded for each monitoring site so that a site could be re-established if markings were disturbed by storm or other activity. This process assured that the volunteers knew exactly where to begin and end their debris surveys/cleanups each month.

Volunteers were trained on the accepted walking patterns used for the program to assure that all debris was located and documented within the study area. A thorough review of the data card and debris indicator items was conducted, allowing volunteers the opportunity to ask questions regarding the data collection and recording process. At the conclusion of the training session, volunteers and the local survey director had been afforded a proper understanding of the survey protocol, techniques and program requirements. Each survey director was also instructed to contact the NMDMP staff with any questions regarding the completion of the debris surveys or program protocol.

Quality assurance procedures did not end at the conclusion of the volunteer training session. It was the responsibility of each monitoring site survey director to follow QA procedures during subsequent volunteer training and data collection activities. Throughout the course of each year of the study, survey directors were instructed to randomly select four surveys on which to conduct a QA procedure. The QA procedure required the survey director to follow behind volunteers, taking note of any debris items that were overlooked. Collected debris was also re-inspected and a new data card was completed with "QA" labeled on top. Both the original data card and the QA data card were returned to Ocean Conservancy for a calculation of percent error by project staff.

Assessment of the QA data card included a mathematical comparison of collected materials conducted by the survey director. The items surveyed were recounted and recorded on a second data card. A comparison was made between what was tallied by the survey volunteer to the survey director's count (see sample on next page).

 © 2007 OCEAN CONSERVANCY

Quality assurance for data processing continued within Ocean Conservancy by the project staff. Data cards submitted by volunteers were reviewed for errors, questions or problems. Survey interval dates and missing surveys were noted and tracked. These gaps in data were brought to the attention of volunteer groups in an effort to keep them on schedule and maintain a high level of performance. The NMDMP database was routinely updated as the monthly surveys were completed and the data cards were received. Regular backups of the database were also performed. Actual data cards were processed by staff, manually filed and physically stored offsite for the duration of the study.

OCEAN CONSERVANCY

DATA PROCESSING

Ocean Conservancy program staff maintained all data collection and data entry processes. Survey directors submitted data cards through the postal service to Ocean Conservancy. Upon receipt, the cards were reviewed prior to data entry in Microsoft Access. Data was manually entered into structured forms built around a relational database. The application stored all data related to NMDMP, including survey data, region and site information and the volunteer roster. The application was configured to provide access to survey data for ad-hoc and periodic reporting.

To ensure data integrity, periodic reviews of the data were performed to verify accuracy of the data entry process. The verification process consisted of manually checking the survey data cards against the data stored in the application. Back-up copies of the application and data were created regularly in order to prevent loss of data and to recover data quickly in the case of file corruption or application failure.

Percent Error Calculation – Sample QA Card Analysis

Surveyor Card	# of Items	QA Data Card	# of Items	Error Pts.
Plastic bags	4	Plastic bags	6	2
Plastic sheeting	3	Plastic sheeting	2	1
Rope	1	Rope	1	0
Metal can	1	Metal can	1	0
		Balloon	1	1
TOTAL	**9**		**11**	**4**

Based on the comparisons in tallied data, this site survey card would be rejected.
Divide the number of error points (4) by the total QA points (11): 4/11 x 100% = 36%.

In this study, an error rate of 20% was the maximum accepted for quality data. It should be noted that in most cases the QA data card showed less than 20% error, which was computed by project staff during the actual data entry process.

NOTE: All QA data cards were processed prior to establishing the final data set for analysis of this study.

Top: Survey Director, Milagros Justiniano Rodriguez, Mayagüez, Puerto Rico (Region 4, Site 15).

Statistical Procedures and Analyses

The sampling protocol was designed to detect a 30% change in debris at an alpha level of 0.10 (Escardó-Boomsma, *et al.,* 1995). This protocol assumed sites were monitored every 28 days, with a ± 3-day window, for a five-year period. The sample size per region and sampling frequency per site were not met in all regions, primarily due to the extreme efforts required for volunteer groups to maintain long-term monitoring activities and restricted access to monitoring sites due to severe storm activity or changes in national security. Prior to analyzing the dataset for changes in debris over time, the program tested the assumption that time between surveys affected the amount of debris encountered.

IMPACT OF GAPS IN SURVEY DATA

In order to maximize the data used in the analysis, program staff evaluated whether to use the data collected outside of the ±3 day window in the protocol. There were two concerns with varying time periods between surveys. The first was that surveys done in a shorter period may not collect as much debris as those done during the standard period. The second was that surveys done in a longer period may have either too much debris (more time to accumulate on the beach) or too little (more of a chance to be washed out into the water).

Staff compared data from individual sites, which had valid and off-target surveys, using a Mann-Whitney test, which controlled for any site variation that may have influenced results. In all cases, there was no evidence that the total counts were significantly different for valid and off-target surveys ($p>0.10$ for all tests). Therefore, the analysis used all surveys for an individual site in the final data analysis.

SITE AND REGION SELECTION CRITERIA FOR STATISTICAL ANALYSIS

While time between surveys did not affect the amount of debris encountered, sites must have conducted surveys throughout the entire five-year period in order to be used in the linear regression model (beginning on page 32). As such, only sites that conducted at least 32 surveys spanning the entire study period of 65 surveys were used to assess changes in amount of debris. The five-year period between September 2001 and September 2006 was selected for analysis because that time period provided the greatest number of sites that had conducted surveys throughout the entire time period. In total, 47 sites around the United States met the criteria of 32 to 65 valid surveys during the five-year study period.

In order to conduct regional analyses based on the site selection criteria, neighboring regions were combined. Regions 5 and 6 had only three survey sites active during this five-year period and could not be individually analyzed for changes in marine debris. Data from Region 5 were combined with Region 4 to assess changes in marine debris for the entire Gulf Coast region. Regions 6 and 7 had eight active sites and were combined for analysis to examine changes in indicator items for the U.S. west coast. Region 8 did not have a sufficient number of surveys conducted during the study period and therefore data could not be statistically analyzed. A summary presentation of the total data collected in Region 8 during the study is presented in Appendix H.

Region 9 was separated from the national data along with the island-based survey sites in Region 4 to establish a "continental U.S." data set and to provide a continental view of the debris patterns. Other research has indicated that insular patterns of debris accumulation and deposition may be affected by a leeward and windward monitoring site locations and relative ocean currents and weather patterns (Cole *et al,* 1990; Manski *et al,* 1991; Ribic *et al,* 1992; Corbin & Singh, 1993; Faris & Hart, 1995; Haynes, 1997; Coe & Rogers, 1997; Debrot *et al,* 1999; Velander & Mocogni, 1999; Convey, *et al.,* 2002; Otley & Ingham, 2003; De Mora, 2004; UNEP, 2006 and Morishige, *et al.,* 2007).

 © 2007 OCEAN CONSERVANCY

OCEAN CONSERVANCY

DATA AND RESULTS

Change in Debris Items Over Time

To investigate change in total indicator items over the five-year study period, a linear regression model was fit to total debris items over time at each study site (*i.e.,* slope of the series). Previous analyses showed that there was a strong seasonal effect in abundance of marine debris (Ribic, 1998) therefore a seasonal variable was added into the regression model to adjust for any seasonal effects. Data were log transformed to meet the assumption of normality and down weight extreme observations (Draper & Smith, 1981). In sites where zero items were collected during at least one survey, slopes were calculated using log (debris items + 1) transformed data.

The slope from the regression model for each site was used to compare changes in indicator items over time at the national and regional levels using a Wilcoxon signed-rank test comparing deviation of the slopes from zero at alpha = 0.10. Regression models were constructed for totals of ocean-based, land-based and general debris items, again using slopes from each site to test for deviation from zero at both the national and regional level using the Wilcoxon signed-rank test at alpha = 0.10.

Descriptive statistics were calculated for national, regional and site level data, including the mean number of debris items and standard error (see Appendices E – F). Bias adjusted coefficient of variation was calculated for each survey site (Sokal & Braumann, 1980). The coefficient of variation allows for comparison of variation across sites, with values close to one having high variation over time and values closer to zero with less variation over time. For changes in debris over time, the average percent change each year was calculated based on: (mean debris items in $year_{i+1}$ – mean debris items in $year_i$)/mean in $year_i$).

National Analysis

Over the five-year study period, an average of 95.4 ± 28.6 standard error (SE) indicator items were collected during each survey (Table 1). Over the five-year period, there was no significant change in total amount of debris monitored in this study (Table 2, Fig 1a). Variability in number of debris items was very high throughout the study period, as noted by the coefficient of variation (CV) of 2.05 (Table 1).

Land-based debris items made up the majority of debris collected, comprising 48.8% of all items, followed by general source items at 33.4% and ocean-based items comprising 17.7% (Table 1). While there were no significant changes in either land-based or ocean-based indicator items (Table 2, Figure 1b), the amount of general source items significantly increased over the five-year period ($p = 0.028$) with an average annual increase of 5.4% (Table 1). During the first year, an average of 28.3 ± 6.3 (SE) general source items were collected, while during the fifth year, an average of 33.1 ± 9.5 (SE) general source items were collected.

The total number of debris items documented during the NMDMP study was 238,103 (Table 3). The dominant land-based indicator items collected during this national study were straws (65,384; 27.5%), balloons (18,509; 7.8%) and metal beverage cans (17,705; 7.4%). See Table 3. Dominant general source indicator items surveyed were plastic beverage bottles (30,858; 13.0%) and small plastic bags, < 1 meter (21,477; 9.0%). The leading ocean-based source debris items were pieces of rope > 1 meter (13,023; 5.5%), clumps of fishing line (8,032; 3.4%) and floats and buoys (3,488; 1.5%). See Table 3.

FIGURE 1A

National total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

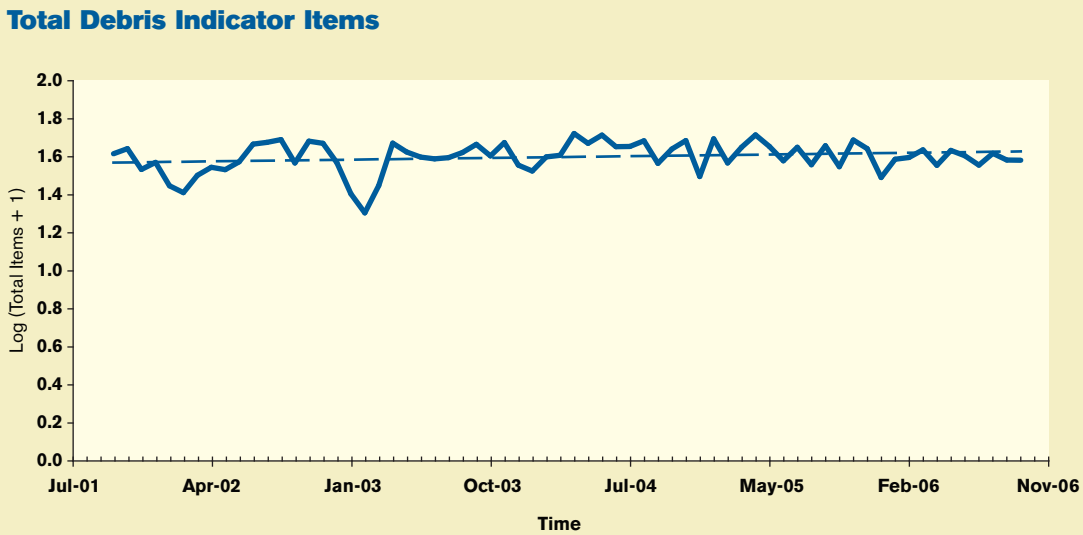
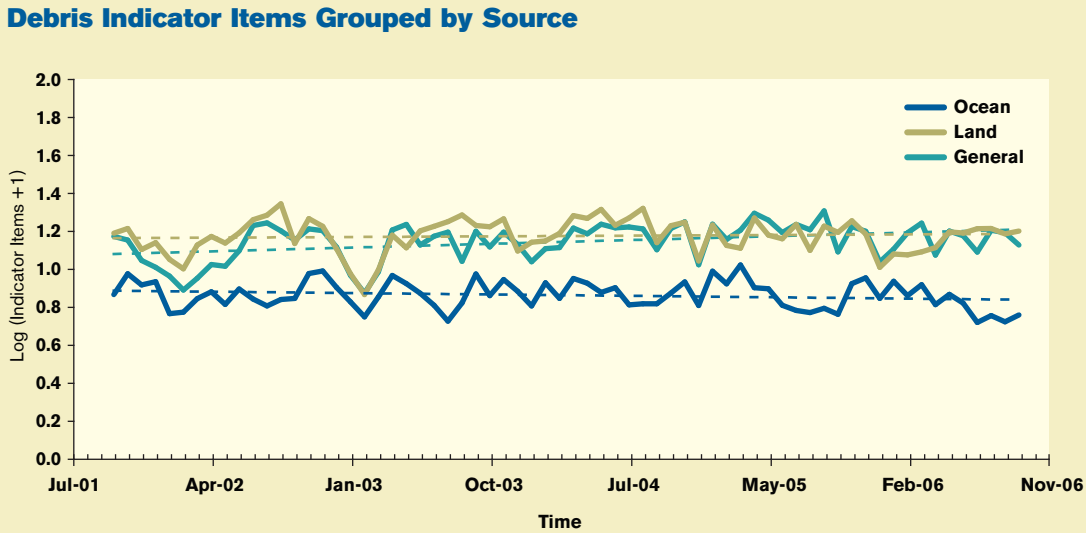


FIGURE 1B

National debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.



 © 2007 OCEAN CONSERVANCY

Continental United States Analysis

In the continental United States, an average of 86.2 ± 32.1 (SE) indicator items were collected per survey (Table 1). Total debris items increased over the five-year study period ($p = 0.013$; Table 2, Figure 2a) with an average annual increase of 8.2%. On average, 67.5 ± 18.7 (SE) indicator items were collected during surveys within the continental U.S. during the first year and 91.8 ± 14.6 (SE) during the fifth year.

Land-based debris comprised the majority of indicator items (51.6%; Table 1), which did not vary over time (Table 2). Ocean-based debris also did not change significantly over time (Table 2) and comprised 14.2% of all indicator items (Table 1). General source debris items comprised 34.2% of all debris, and increased over time ($p = 0.003$; Table 2, Figure 2b). The abundance of general source items increased by an average of 9.8% a year during this study (Table 1). In the first year of the study, 23.1 ± 6 (SE) general source items were collected during each survey while 32.3 ± 10.8 items were collected in year five.

The total number of debris items documented in the continental U.S. during the NMDMP study was 196,387 (Table 4). The dominant indicator items collected during the study were land-based and general source debris items. The leading land-based debris items were straws (55,578; 28.3%), balloons (17,841; 9.1%) and metal beverage cans (13,842; 7.0%). See Table 4. The dominant general-source debris items were plastic beverage bottles (27,001; 13.7%) and small plastic bags, < 1 meter (17,798; 9.1%). Dominant ocean-based debris items were pieces of rope >1 meter (9,853; 5.0%) and fishing line (4,309; 2.2%). See Table 4.

FIGURE 2A

Continental U.S. total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

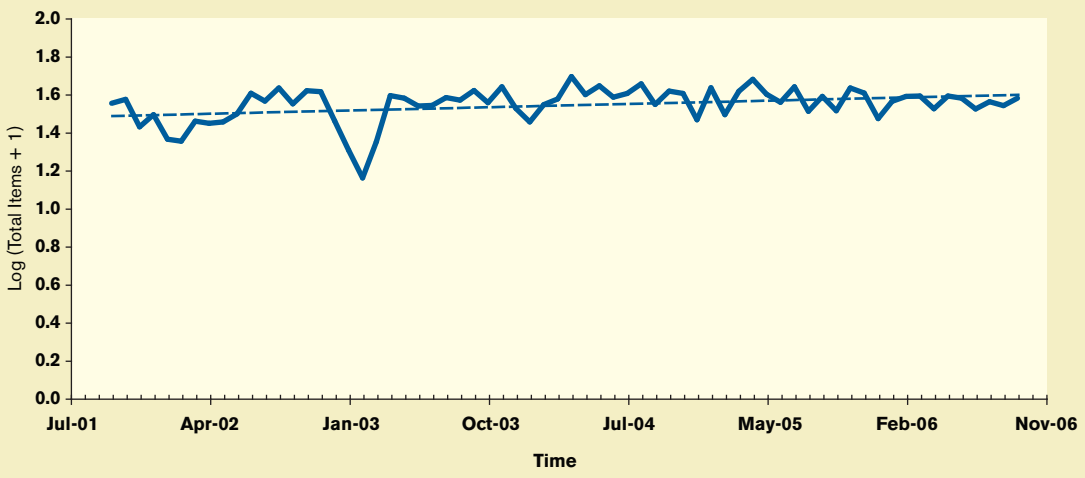
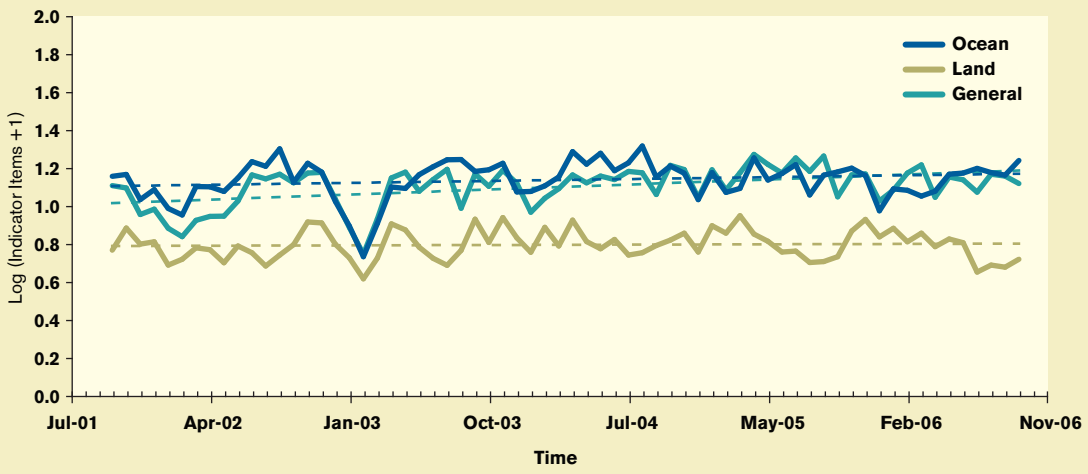


FIGURE 2B

Continental debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.



Regional Analysis

In Region 1, 54.8 ± 14.9 (SE) indicator items were collected during each survey over the five-year period (Table 1). The total number of items found per survey increased significantly over time (Table 2, Figure 3a); total debris increased 13.7% annually during the five-year study period (Table 1). In the first year of the study, 35.3 ± 7.4 items were collected while 48.9 ± 13.8 (SE) items were collected during the fifth year.

Ocean-based debris items comprised the majority of debris, making up 42.0% of debris surveyed (Table 1, Figure 3b). General source items followed, comprising 30.2% and land-based debris with 27.7% (Table 1). Ocean-based items significantly increased during the study period in Region 1 (Table 2, Figure 3b), increasing an average of 20.1% each year (Table 1). In the first year of the study, 14.2 ± 3.1 (SE) items were collected while 19.2 ± 2.8 (SE) items were collected during the fifth year.

The total number of debris items documented in Region 1 during the NMDMP study was 19,911 (Table 5). The dominant indicator item collected in Region 1 was rope > 1 meter (3,978; 20.0%), an ocean-based indicator debris item. The leading general-source debris items were small plastic bags, < 1 meter (2,039; 10.2%) and plastic beverage bottles (1,673; 8.4%). See Table 5. Metal beverage cans (1,944; 9.8%); balloons (1,765; 8.8%) and straws (1,562; 7.8%) were the dominant land-based indicator items (Table 5).

REGION 1 Atlantic Coast: U.S./Canada Border to Provincetown, Massachusetts

Total Debris Indicator Items

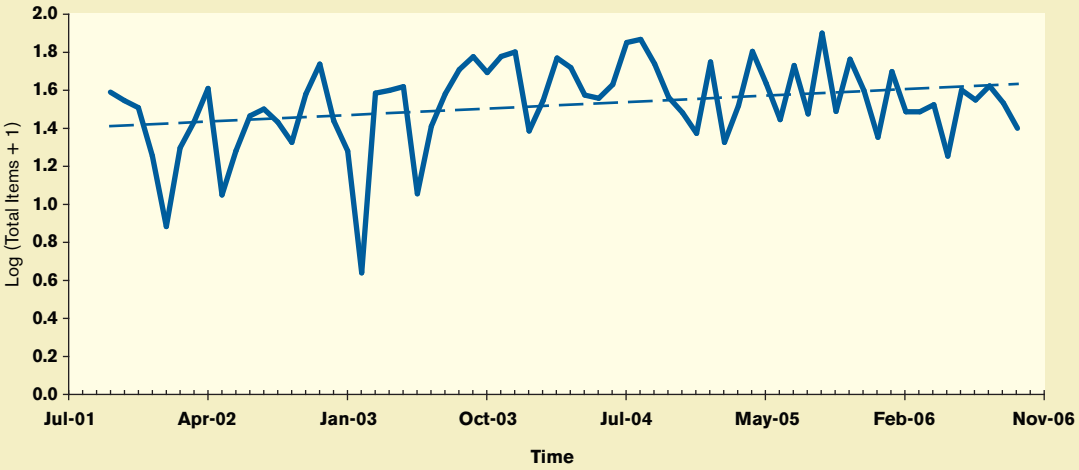


FIGURE 3A

Region 1 total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Debris Indicator Items Grouped by Source

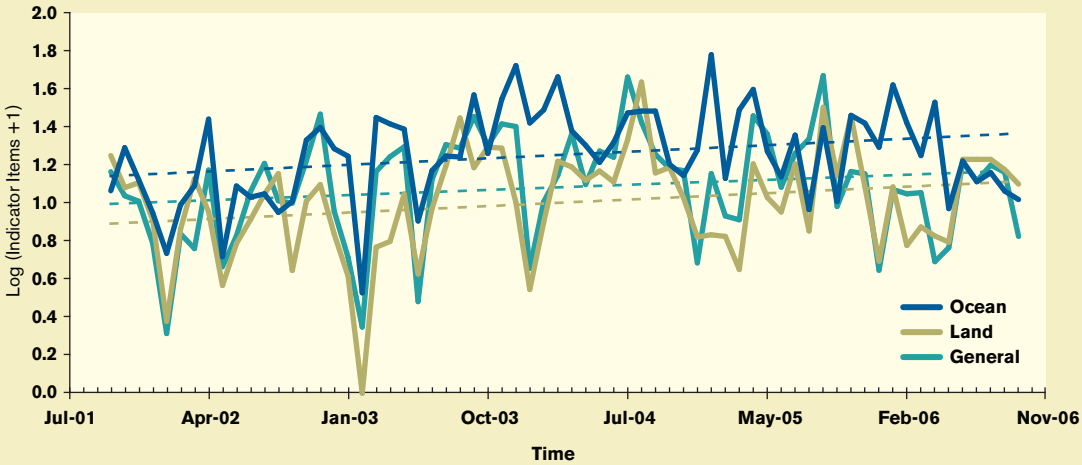


FIGURE 3B

Region 1 debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

 © 2007 OCEAN CONSERVANCY

On average, 178.8 ± 134.4 items were collected per survey in Region 2 (Table 1). Despite the high variability in Region 2 (CV = 2.31, Table 1), there was a significant increase in the number of indicator items over time (Table 2, Figure 4a). On average, total debris items increased 22.5% annually (Table 1). In the first year of the study, 133.3 ± 52.4 (SE) items were collected while 201.7 ± 57.5 (SE) items were collected during the fifth year.

Land-based items were the most abundant, comprising an average of 63% of debris collected in Region 2 (Table 1, Figure 4b). General source items comprised 30.2% with only 6.9% of debris from ocean-based items (Table 1). There was no significant change in ocean-based debris items, but land-based and general source items significantly increased over the five-year period (Table 2). Land-based items increased 24.2% annually while general source items increased 25.2% annually (Table 1, Figure 4b). In the first year of the study, 80.3 ± 34.0 (SE) land-based items were collected while 123.2 ± 38.5 (SE) land-based items were collected during the fifth year. In the first year of the study, 42.2 ± 17.2 (SE) general source items were collected while 65.0 ± 18.0 (SE) general source items were collected during the fifth year.

The total number of debris items documented in Region 2 was 104,211 (Table 6). The dominant ocean-based indicator items collected were rope > 1 meter (2,578; 2.5%) and fishing line (1,738; 1.7%). See Table 6.

REGION 2 South of Cape Cod, Massachusetts to Beaufort, North Carolina

FIGURE 4A

Region 2 total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Total Debris Indicator Items

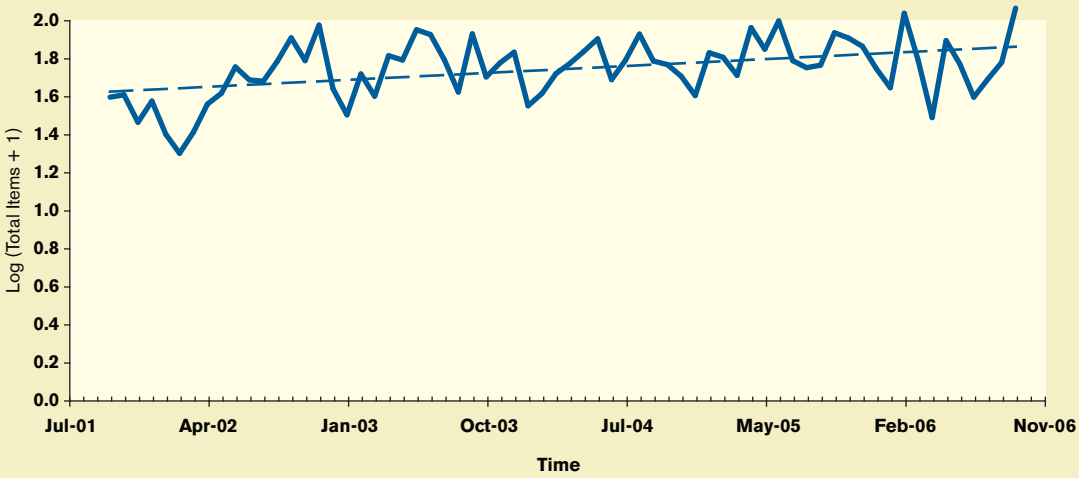
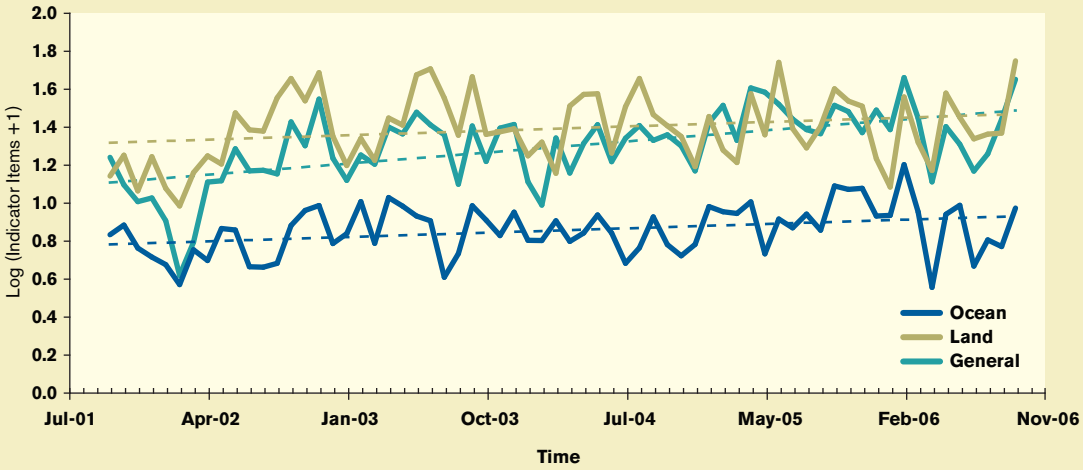


FIGURE 4B

Region 2 debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Debris Indicator Items Grouped by Source



Regional Analysis

The leading general-source debris items in Region 2 were plastic beverage bottles (14,382; 13.8%) and small plastic bags, < 1 meter (8,076; 7.7%). The largest amounts of land-based indicator items were straws (41,015; 39.4%), balloons (8,050; 7.7%) and cotton swabs (6,177; 5.9%). See Table 6.

The Gateway National Recreation Area site had larger amounts of debris per survey compared to the other sites in the region (Appendix E). Specifically, this was due to the large amount of straws, a land-based indicator item, found at this site. When this site was removed from analysis, there was still a significant increase in total indicators ($p = 0.011$) and for land-based items ($p = 0.098$). Without this site, the percentage of specific items in relation to the total did change. Specifically, the two top land-based indicator items switched places, with balloons being 23.4% of the total and straws being 10.4%. It should be noted that removal of this site from analysis did not change the results of the national or continental U.S. trend results presented previously.

Over 600 Volunteers in 21 Coastal States, Islands and Territories

From 1996 to 2007, Ocean Conservancy worked with more than 600 dedicated volunteers in 21 U.S. coastal states, islands and territories to collect data and calculate results for NMDMP. Below are just a few of the many volunteers who helped make this project a success.

1.

2.

3.

4.

5.

6.

PHOTOS: OCEAN CONSERVANCY

1. *Holmes Beach, Florida (Region 4, Site 8)*
2. *Bradley Beach, New Jersey (Region 2, Site 21)*
3. *Clatsop County Beach, Oregon (Region 7, Site 21)*
4. *Sea Rim State Park, Texas (Region 5, Site 11)*
5. *Carmel River State Beach, California (Region 7, Site 18)*
6. *Huntington Beach State Park, South Carolina (Region 3, Site 3)*

 © 2007 OCEAN CONSERVANCY

An average of 57.5 ± 21.6 (SE) indicator items were collected during an individual survey in Region 3 (Table 1) with no change in total number of indicator items detected (Table 2, Figure 5a). Variability in total items was moderate, with a CV of 0.87 (Table 1).

Both land-based and general source items were collected in similar amounts, 41.2% and 44.3% respectively (Table 1), and did not vary over time (Table 2, Figure 5b). Ocean-based debris items comprised an average of 14.3% (Table 1) and decreased significantly over time (Table 2, Fig 5b). Ocean-based debris decreased an average of 4.4% a year during the study period (Table 1). During the first year, 13.3 ± 5.1 (SE) ocean-based debris items were collected during a survey while 6.0 ± 1.1 (SE) ocean-based debris items were collected during the fifth year.

The total number of debris items documented in Region 3 was 18,680 (Table 7). The dominant land-based indicator items collected in Region 3 included straws (3,414; 18.3%), balloons (2,210; 11.8%) and metal beverage cans (1,484; 7.9%). See Table 7. Dominant general-source debris items were plastic beverage bottles (3,207; 17.2%) and small plastic bags, < 1 meter (2,547; 13.6%). The leading indicator debris items associated with ocean-based sources were light sticks (585; 3.1%), rope > 1 meter (548; 2.9%) and fishing line (420; 2.2%). See Table 7.

REGION 3 Morehead City, North Carolina to Port Everglades, Florida

FIGURE 5A

Region 3 total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Total Debris Indicator Items

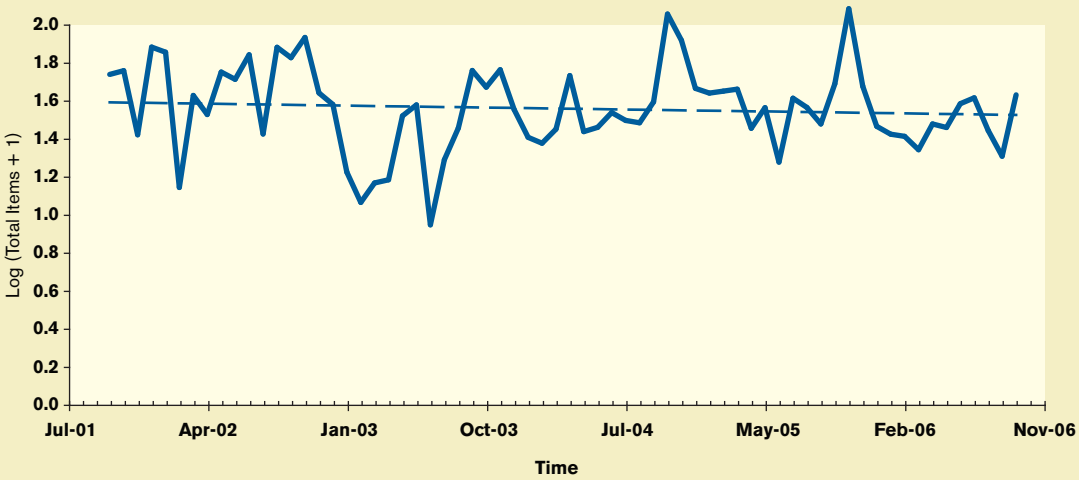
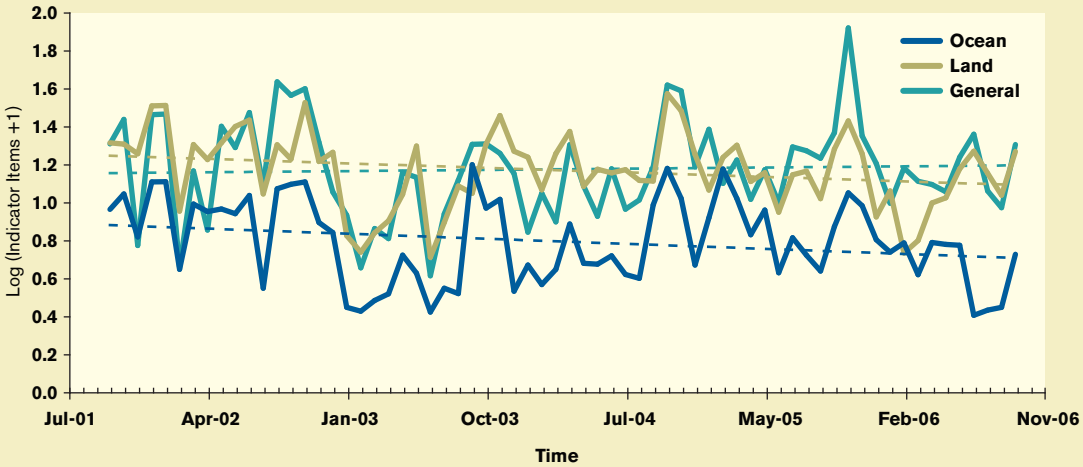


FIGURE 5B

Region 3 debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Debris Indicator Items Grouped by Source



Regional Analysis

Within the Gulf Coast region, an average of 102 ± 42.8 (SE) indicator items were collected per survey over the five year period (Table 1) with no significant change in the number of items over time (Table 2, Figure 6a).

The majority of collected debris came from land-based sources, comprising 48.3% of debris collected (Table 1); land-based debris did not change over time (Table 2). General source items increased over time (Table 2) at an average of 8.8% a year (Table 1, Figure 6b). In the first year of the study, 6.4 ± 2.3 (SE) general source items were found while 21.2 ± 5.6 (SE) general items were collected during the fifth year. Ocean-based debris made up the smallest amount of indicator items at 15.9% (Table 1) and, as seen with the land-based items, did not change significantly over time (Table 2, Figure 6b).

The total number of debris items documented during the NMDMP study in Regions 4 and 5 was 39,169 (Table 8). The dominant land-based source indicator items collected in the Gulf Coast regions were straws (9,514; 24.3%) and metal beverage cans (5,065; 12.9%). General-source debris items such as plastic beverage bottles (5,592; 14.3%) and small plastic bags, < 1 meter (2,792; 7.1%) also exhibited high numbers (Table 8). The leading indicator debris items associated with ocean-based sources were rope > 1 meter (2,170; 5.5%) and fishing line (1,089; 2.8%).

REGIONS 4 & 5 Port Everglades, Florida to U.S./Mexico Border, Including U.S. Territories of Puerto Rico and the U.S. Virgin Islands (Gulf Coast)

Total Debris Indicator Items

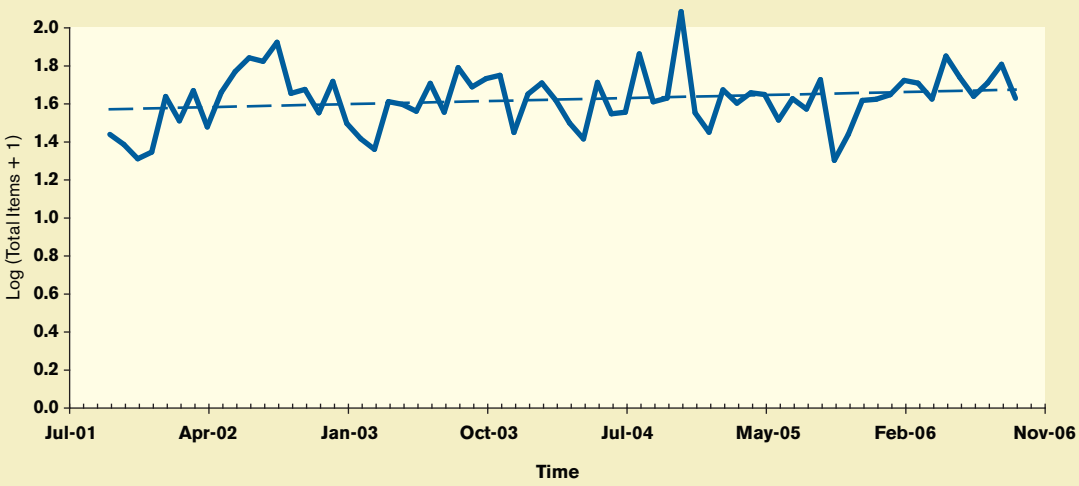


FIGURE 6A

Regions 4 and 5 total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Debris Indicator Items Grouped by Source

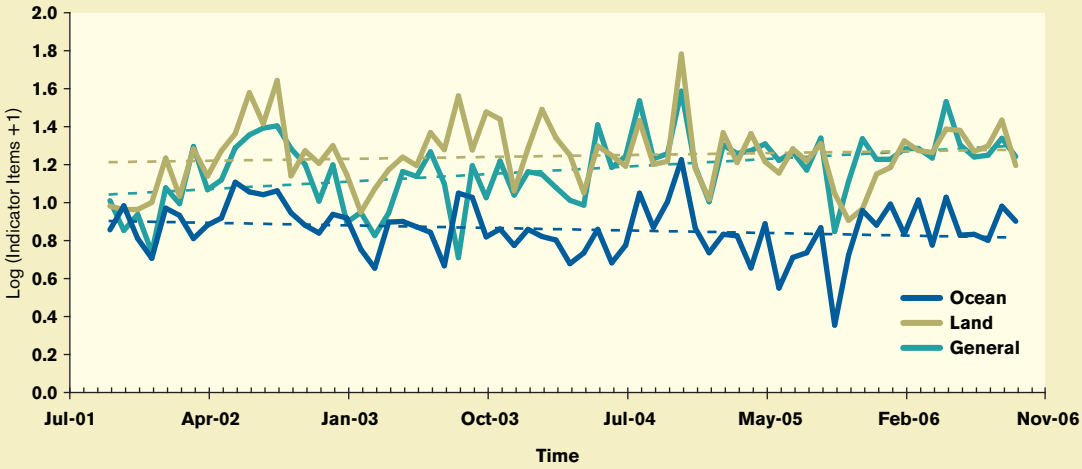


FIGURE 6B

Regions 4 and 5 debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

 © 2007 OCEAN CONSERVANCY

Along the U.S. West Coast, 46.6 ± 14.7 (SE) indicator items were found on average during surveys (Table 1) with no change in total number of debris items over time (Table 2, Figure 7a).

Land-based debris comprised the majority of the indicator items with an average of 54.2%, followed by general source items at 34.4% (Table 1). Ocean-based items made up the smallest number of indicator items, comprising only 11.3%. There was no change in any debris source group over time along the U.S. West Coast (Table 2, Figure 7b).

The total number of debris items documented during the NMDMP study in Regions 6 and 7 was 25,961 (Table 9). The dominant land-based indicator items collected in the West Coast regions were straws (7,562; 29.1%), balloons (3,605; 13.9%) and metal beverage cans (1,912; 7.4%). General-source debris items such as plastic beverage bottles (3,090; 11.9%) and small plastic bags, <1 meter (2,877; 11.1%) also exhibited high numbers. The leading indicator debris items associated with ocean-based sources were rope > 1 meter (842; 3.2%), floats/buoys (574; 2.2%) and fishing line (404; 1.6%). See Table 9.

REGIONS 6 & 7 U.S./Mexico Border to U.S./Canada Border (West Coast of the Continental U.S.)

FIGURE 7A

Regions 6 and 7 total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Total Debris Indicator Items

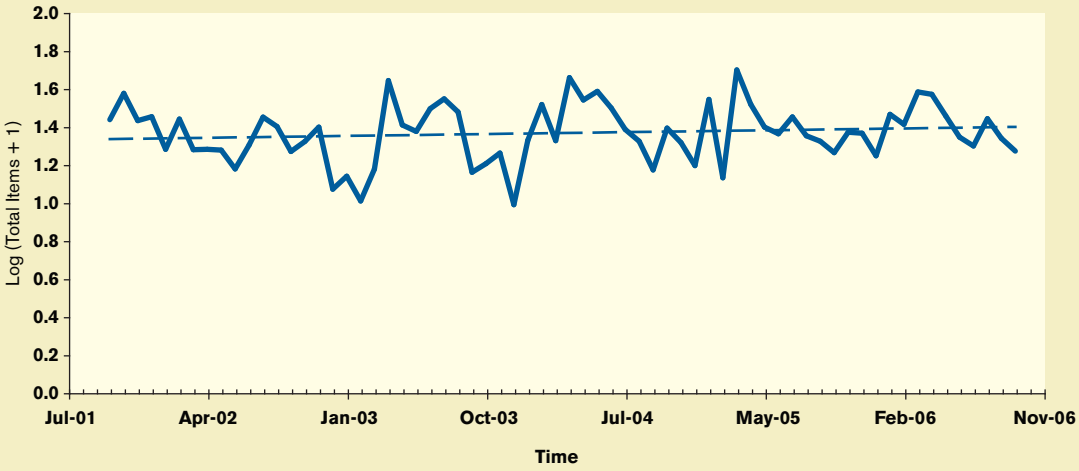
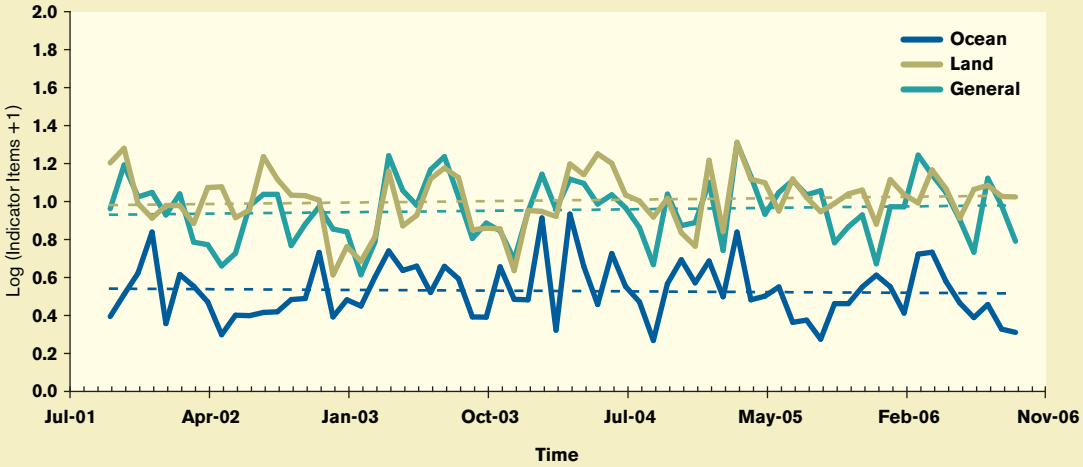


FIGURE 7B

Regions 6 and 7 debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Debris Indicator Items Grouped by Source



Regional Analysis

In the Hawaiian Islands, the average number of indicator items was 127.6 ± 63.8 (SE) over the five-year period (Table 1). The total number of indicator items decreased significantly over the five-year period (Table 2, Figure 8a); the decrease averaged 18.4% annually. During the first year, an average of 191.2 ± 82.5 (SE) items were collected per survey, while 76.0 ± 18.0 (SE) were collected per site in the final year.

Ocean-based debris comprised the majority of debris (42.8%) over the five-year period (Table 1). Ocean-based items decreased significantly over the study period (Table 2, Figure 8b), with an annual decrease of 23.8%. During the first year, 89 ± 49.3 ocean-based items were collected during a survey while 24.5 ± 4.8 ocean-based items were collected during the last year. Land-based items made up 22.4% of the items (Table 1). Land-based items decreased significantly over the study period (Table 2, Figure 8b), with an annual decrease of 11.1%. During the first year, 36.6 ± 4.9 land-based items were collected during surveys while 16.5 ± 1.8 land-based items were collected during the fifth year. General source items did not change significantly over the study period (Table 2).

The total number of debris items documented in Region 9 was 30,171 (Table 10). The dominant indicator items collected in the Hawaiian Islands were ocean-based indicator items, specifically fishing line (3,573; 11.8%), rope > 1 meter (2,907; 9.6%) and nets > 5 meshes (1,735; 5.8%). Dominant land-based indicator items were metal beverage cans (3,628; 12.0%) and straws (2,317; 7.7%). General-source debris items that exhibited higher numbers were small plastic bags, < 1 meter (3,146; 10.4%) and plastic beverage bottles (2,914; 9.7%). See Table 10.

REGION 9 Hawaiian Islands (main)

FIGURE 8A

Region 9 total debris indicator items collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Total Debris Indicator Items

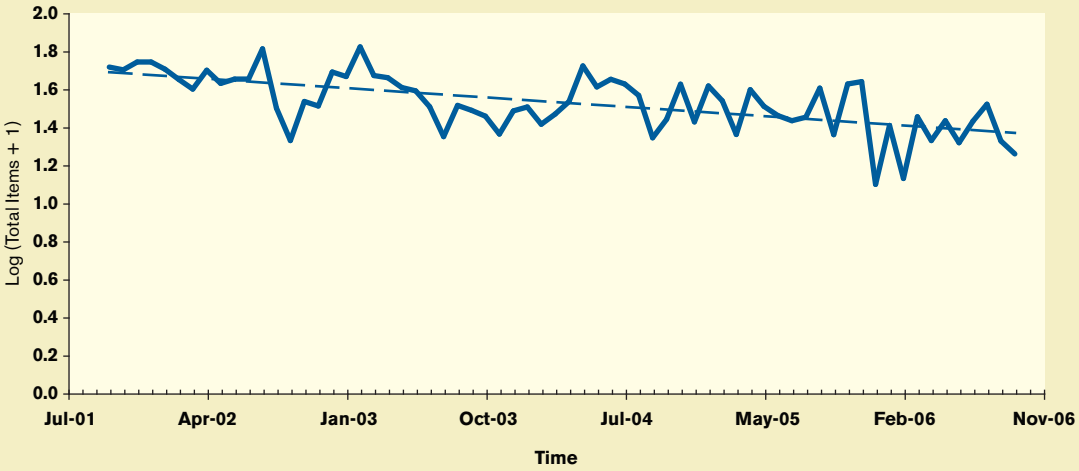
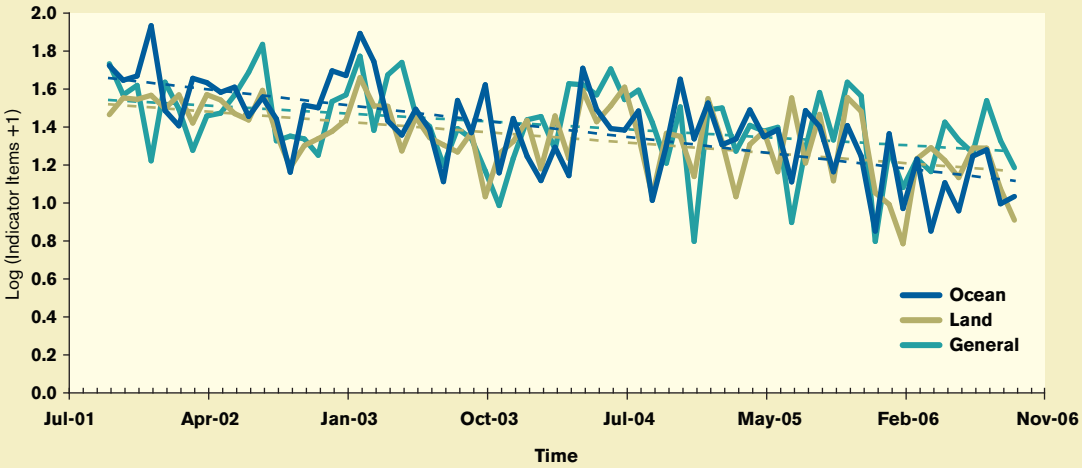


FIGURE 8B

Region 9 debris indicator items grouped by source collected per 500 meters of beach from September 2001 to September 2006. Dashed line represents linear regression model with the seasonal component excluded for simplicity.

Debris Indicator Items Grouped by Source



 © 2007 OCEAN CONSERVANCY

OCEAN CONSERVANCY

DISCUSSION

The National Marine Debris Monitoring Program (NMDMP) was an experiment designed to standardize marine debris data collection in the United States using a scientifically valid protocol to determine marine debris status and trends. The program divided the United States into nine regions based on several criteria, including: the types of marine debris found in those areas; prevailing currents; and logistical considerations of access and other parameters. The program identified and randomly selected up to 20 beach sites within each region, which were monitored by trained teams of volunteers.

USE OF VOLUNTEERS

The use of volunteers for a research study of this magnitude was an experiment in and of itself. Could a "volunteer" group of novice field researchers be successful? The answer is yes, but with some stipulations. NMDMP volunteers came with varied backgrounds, including retired corporate executives, technicians, educators, local conservation organizers, middle and high school science classes, college students, U.S. Naval and Coast Guard offices and other members from the private sector. NMDMP proved that such diverse groups could be effective field researchers if they were properly trained and had the local support needed to keep the monitoring teams on schedule. Many of these volunteers could be compared to fledgling graduate students involved in field studies for the first time. If they can do it, so can the volunteers!

Successfully managing these volunteer monitoring teams was dependent upon effective and frequent communications, site visits for training and various other incentives including financial and local programmatic support. Since NMDMP was implemented

Top: Volunteers in St. Croix, USVI.

incrementally from 1996 until the fall of 2001, some sites were actually monitored over a period of more than 10 years by the end of the study. This represented a significant time investment by the groups that signed onto this program. It also resulted in necessary replacement efforts for teams that had to quit because of other organizational interests and obligations. In the future, it is essential that a monitoring program of this nature be realistic as to expectations of labor and length of time needed to conduct this type of study.

For this program, Ocean Conservancy maintained a staff ranging in size from two to four personnel and required that these staff travel as needed to facilitate site implementation and volunteer training. As the monitoring activities progressed, follow-up visits were scheduled to coincide with re-training efforts and other activities. Long-term monitoring efforts would be further enhanced in future studies if local, one-to-one support was available for the volunteer groups/leaders. If future monitoring efforts are to be implemented, it is also suggested that local partnerships be developed with state or municipal agency staff to facilitate the monitoring and integrate these efforts into their overall volunteer programming.

For the most part, the volunteers participating in this effort did not receive monetary support to cover transportation expenses related to their efforts. Some support was provided to school groups that rented buses or groups that needed ferry transport to reach offshore barrier island sites. The volunteers, their organizations and/or businesses donated the overall financial resources used to conduct the monthly surveys. Future research efforts should consider offering a monetary stipend to offset some of the monitoring teams' transportation costs and other expenses.

Ocean Conservancy provided a few incentives including website recognition and various clothing items (hats, T-shirts, sweat shirts and rain ponchos) to recognize volunteers' affiliation with the program. Some organizations also received plaques and other mementos acknowledging their five-year involvement. While the very nature of a volunteer is not to expect anything in return for his/her efforts, people do like to know that their efforts are meaningful and appreciated. This program could not have succeeded without the dedication and support of these volunteers.

MONITORING PROTOCOL & RESEARCH DESIGN

The MDM Workgroup and Ocean Conservancy project team originally designed and implemented a monitoring protocol for assessing the amount and source of select marine debris along U.S. beaches. The timeframe for the monitoring study was determined to be a period of five years with surveys conducted every 28 ±3 days (13 surveys/year) in order to achieve the specified percent change in the debris (30%, with a power of 0.84 and a Type 1 error rate of 0.10).

The results of this study have provided some insight into the nature of marine debris as well as the methodology used for its assessment. The U.S. coastline was divided into nine regions based on prevailing ocean currents and logistical considerations of access. The areas of Alaska and Hawaii were designated their own regions due to their location and distance from the continental United States. The random selection of 500 meter-long monitoring sites in each of the nine regions was employed as part of a standard research design to provide an unbiased data source for changes in debris composition patterns over time. The length of the monitoring site (500 m ≈ 0.31 miles) was established to provide an adequate area for debris assessment along a stretch of beach and the ability of the volunteers to manage the overall distance covered during the monitoring exercise with multiple passes being conducted to assess the entire monitoring site.

MONITORING SITE PERFORMANCE

Twenty sites were initially prescribed for each of the nine regions. The selection of a monitoring site was based on meeting the requirements of beach type (sandy or small gravel composition), a moderate to low slope of (15-45°), receive no other routine cleaning, not be protected offshore by jetties and breakwaters, be accessible for monthly monitoring and have at least 500 meters of accessible length. The project team identified and set up the required number of monitoring sites for the study, but was not able to maintain activity at all sites for all regions for the duration of the study. The random site

 © 2007 OCEAN CONSERVANCY

selection process resulted in several of the monitoring sites being located on state and federal park or refuge lands as well as federal military installations. Access to some of these sites became problematic following the events of September 11, 2001 when public access was inhibited or even retracted in multiple Regions (specifically Regions 1, 2, 3, 6 and 7).

Difficulties arose in Alaska (Region 8) and Hawaii (Region 9) when groups initially committed to the monitoring program, but did not follow through due in some part to cultural issues and year-round access. Future efforts in Alaska would require a significant endorsement of the local tribal communities for a study to be effectively conducted. Hawaii would also require special attention due to cultural concerns on the various islands. Hurricanes and other powerful storms took their toll on monitoring sites in Regions 3, 4 and 5. Several established monitoring sites were destroyed by weather events and access to other beach areas were significantly impaired following many storm events. Access issues in Region 5 and the sheer volume of debris collected were the primary deterrents in this region.

Another significant factor influencing the maintenance of monitoring site activity was the volunteer groups selected to participate in the study. In Regions 5, 6, 8 and 9 difficulties arose when several volunteer groups were unable to conduct their surveys with proper frequency. Program staff implemented numerous efforts to engage more effective volunteer groups for the study. In most cases, volunteer efforts would start very strong, but would wane after several months.

A baseline of data has been developed in this study using the randomly selected sites meeting specific criteria. It may be appropriate to revisit the design to take advantage of advances in selecting sites in a spatially balanced manner or to consider stratification of sites such as by known sources of debris producing activities – outfall pipes, river mouths, recreational beaches, shipping/marina operations and other locales. Being able to connect specific activities to specific forms of debris would greatly enhance the development of programs for reduction and prevention of debris. Alternately, collection of variables such as distance to known debris-producing activities could be used in later analyses.

MONITORING FREQUENCY

The original protocol developed for NMDMP required that monitoring surveys be conducted every 28 ±3 days. Missing a scheduled survey, for whatever reason, posed an analysis problem related to assessing the change in debris totals over time. When the data was first analyzed – selecting only the sites that had met this criterion – 27 sites qualified for analysis. Questions arose as to whether there was a statistical difference in the total amount of debris at a site that was not cleaned every 28 days. Did longer periods between surveys result in larger debris counts, or did shorter times between surveys result in smaller debris counts? At the time the study was designed (early 1990s), analysis techniques able to deal with the problem of missing data were limited. Subsequently, advances in statistical techniques such as Bayesian analysis have since been made and have the potential to allow direct evaluation of the time between surveys in a modeling framework beyond what was done in this report.

Other monitoring research and analysis of the debris patterns in this study indicates that there is a seasonal effect in debris accumulation and there was evidence of seasonal patterns within the regional analyses. Tidal cycles could also have an effect. The monitoring protocol required that surveys be conducted at the low tide stage to expose the largest amount of beach area. We suggest that future monitoring efforts at the regional level investigate seasonal patterns for debris deposition. In more temperate and warmer areas where the seasonal changes are less dramatic than experienced in the North Atlantic and Pacific Northwest, less frequent sampling activities may provide an adequate amount of data for analysis. In more tropical areas, seasonal sampling based on wet and dry seasons may provide adequate information. It should also be noted that expecting volunteer monitors to sustain frequent sampling efforts over an extended period (several years) might not be practical.

DEBRIS COMPOSITION AND SOURCES

The national statistics from this study revealed that overall there was no significant change in the total amount of debris during the five years of this study but when the data was analyzed by source, there was an increase in general source items. General source items are primarily composed of plastic materials and increased use of these products in general over the past 10 years are reflected in debris items surveyed on the beaches.

There were differences in the trends seen for both the continental U.S. and Hawaii. This difference in debris accumulation may be due in part to the effects of weather patterns and oceanographic current patterns on islands. Marine debris research for the Hawaiian Islands has indicated that climatological influences such as El Niño may affect the amount of debris deposited on island beaches (Morishige, *et al.,* 2007). Further investigation of this phenomenon is suggested.

Undoubtedly, the seasonality exhibited in marine debris deposition patterns is due to weather influences and other factors. Storm activities promote the most variability in the presence of debris due to surging waves and wind gusts. Wind and waves can result in the deposition of debris up onto the beach as well as removing it and carrying it back into the retreating waters. Further research should be done on individual debris items to study their patterns of accumulation based on weather, land-use activities and other factors.

The most abundant debris item overall was straws, but that varied among regions. In particular, Region 2 had the greatest number of straws collected during the study. Further review of the data revealed that a single site, Gateway National Recreation Area in Region 2, was the source of the elevated number. This site is located near Sandy Hook, New Jersey in the Gateway National Recreation Area – Sandy Hook National Park. The park operates concession stands for visitors where they sell beverages and distribute straws. In addition, a local restaurant also near the monitoring site sells drinks and gives customers access to straws. These activities help account for the elevated numbers. During the course of this study a team of student volunteers from the Marine Academy of Science and Technology (MAST) conducted a campaign using the data they collected in NMDMP to encourage the park staff to ban the use of the straws. The park rangers decided to work with the students and implemented a program to reduce the use of straws in 2003. Their preliminary analysis of the straw data showed a seasonal pattern for the appearance of straws – summer was a high use period compared to winter – but did not show a definitive reduction in the number of straws tabulated overall. The students of MAST are continuing this monitoring effort as part of the curriculum.

 © 2007 OCEAN CONSERVANCY

CONCLUSION

The National Marine Debris Monitoring Program was an experiment designed to standardize marine debris data collection in the United States using a scientifically valid protocol to determine marine debris status and trends. A volunteer workforce was used to implement this study. The purpose of this study was to answer the following research questions:

- Is the amount of debris on our coastlines changing over a five-year period?
- What are the major sources of the debris?

OCEAN CONSERVANCY

Based on the results from this study, during the five-year period of September 2001 and September 2006, there was no significant change in total amount of debris monitored along the coasts of the United States. An average of 95.4 ± 22.6 (SE) indicator items was removed during each survey. Variability in number of debris items was large throughout the study period, with a coefficient of variation of 2.05.

The major sources of debris in the United States during this study indicated that land-based debris items made up the majority of debris surveyed nationally, comprising 48.8% of all collected items, followed by general source items at 33.4% and ocean-based items at 17.7%. The most abundant debris forms were straws, balloons and metal beverage cans. The sources of these indicator items are characterized as land-based and general source. The amount of general source items surveyed significantly increased over the five-year period, increasing annually by 5.4%.

Regional analysis of the data revealed high variability among regions and among sites of an individual region, influenced by seasonal parameters and other activities. Total indicator debris in Regions 1 and 2 increased over the study period. The only region to display a significant decrease in debris was Region 9 (Hawaii). This decrease may have been influenced by the effects of El Niño weather patterns.

Monitoring marine debris is an important component in dealing with this pervasive pollution problem. The information obtained from monitoring programs provides a roadmap for addressing the sources of the debris. Monitoring can also be used to measure the success of the programs developed to abate marine debris.

NMDMP volunteers successfully implemented this program and produced the first national baseline of data that can be used in the United States to build a program for marine debris prevention and reduction. The protocol used in this study has established a sound foundation for development of future monitoring efforts. Marine debris monitoring is not a "one size fits all" exercise. The diversity in the types and amounts of debris is as varied as the many sources producing it. Only through changes in human behavior and informed choices in products and packaging, can this pollution issue be effectively addressed and dealt with worldwide. NMDMP – and its results and lessons learned – is one step forward in the fight against marine debris.

LITERATURE CITED

Coe, James M. & Rodgers, Donald B., Eds. 1997. Marine Debris: Sources, Impacts and Solutions. Springer-Verlag: New York. 432 pp.

Cole, C. Andrew, John P. Kumer, David A. Manski, and Daniel V. Richards (eds.). 1990. *Annual Report of National Park Marine Debris Monitoring Program: 1989 Marine Debris Survey.* Tech. Report NPS/NRWV/NRTR-90/04.

Conover, W.J. 1999. Practical Nonparametric Statistics. Third Edition. Wiley and Sons, New York.

Convey, R., D. K. A. Barnes and A. Morton. 2002. Debris accumulation on oceanic island shores of the Scotia Arc, Antarctica. Polar Biol. 25: pp. 612-617.

Corbin, C. J. and J.G. Singh. 1993. *Marine Debris Contamination of Beaches in St. Lucia and Dominica.* Marine Pollution Bulletin. Vol. 26, No. 6, pp. 325-328.

Debrot, Adolphe O., Aubrey B. Tiel, and John E. Bradshaw. 1999. *Beach Debris in Curaçao.* Marine Pollution Bulletin. Vol. 38, No. 9, pp. 795-801.

De Mora, Stephen. 2004. Report to UNEP: Review of Marine Pollution Monitoring and Assessment in UNEP's Regional Seas Programmes. International Atomic Energy Agency, Marine Environment Laboratory, Monaco. 37 pp. http://www.unep.org/regionalseas/Publications/RSP_Review_UNEP_Final_Report.pdf.

Draper, N. R. and H. Smith. 1981. Applied Regression. Second Edition. Wiley, New York.

Escardó-Boomsma, J., K. O'Hara, and C.A. Ribic. 1995. National Marine Debris Monitoring Program, Volumes 1-2. Final report, U.S. EPA Office of Water, Washington, DC. 130 pp.

Farris, Jeannie and Kathy Hart. 1995. Seas of Debris: A Summary of the Third International Conference on Marine Debris Proceedings – May 1994, Miami, FL. N.C. Sea Grant Program/NMFS/NOAA. UNC-SC-95-01. 54 pp.

GESAMP (Group of Experts on the Scientific Aspects of Marine Pollution). 1991 The State of the Marine Environment. London: Blackwell Scientific Publications. 146 pp.

Haynes, D. 1997. *Marine debris on continental islands and sand cays in the far northern section of the Great Barrier Reef Marine Park, Austria.* Marine Pollution Bulletin, Vol. 34, No. 4, pp. 276-279.

Manski, D.A., W.P. Gregg, C.A. Cole, and D.V. Richards. 1991. Annual Report of the national park marine debris monitoring program, 1990 marine debris surveys. USDI NPS Technical Report NPS/NRWV/NRTR-91.

Morishige, C., M. Donohue, E. Flint, C. Swenson, and C. Woolaway. 2007. *Factors affecting marine debris deposition at French Frigate Shoals, Northwestern Hawaiian Islands Marine National Monument,* 1990-2006. Marine Pollution Bulletin, Vol. 54 (8), pp.1162-1169.

National Academy of Sciences. 1975. *Marine Litter.* In: *Assessing Potential Ocean Pollutants.* A report on the study of assessing potential ocean pollutants to the Ocean Affairs Board, Commission of the Natural Resources, National Research Council, National Academy of Sciences. Washington, DC. 465 pp.

Otley, H. and R. Ingham. 2003. *Marine debris surveys at Volunteer Beach., Falkland Islands, during the summer of 2001/02.* Marine Pollution Bulletin, Vol. 46, pp. 1534-1539.

Ribic, Christine A., Trevor R. Dixon, and Ivan Vining. 1992. *Marine Debris Survey Manual.* NOAA Technical Report NMFS 108. 92 pp.

Ribic, C.A. 1998. Use of indicator items to monitor marine debris on a New Jersey Beach from 1991 to 1996. *Marine Pollution Bulletin* 36: pp. 887-891.

Ribic, C. A. 2001a. *Trends in Indicator and Non-indicator Items of Debris on a New Jersey Beach, 1991-1999.* Report for Task 1 of USGS BRD Project "Evaluation of the USEPA National Marine Debris Monitoring Program. pp 1-35.

Ribic, C. A. 2001b. *Trends in Indicator and Non-indicator Items of Debris on a New Jersey Beach, 1991-1999.* Report for Task 2 of USGS BRD Project "Evaluation of the USEPA National Marine Debris Monitoring Program. pp 36-53.

Ribic, C. A. 2001c. *Trends in Indicator and Non-indicator Items of Debris on a New Jersey Beach, 1991-1999.* Report for Task 3 of USGS BRD Project "Evaluation of the USEPA National Marine Debris Monitoring Program. pp. 54-79.

Sheavly, S. B. 2005. *Marine Debris – an Overview of a Critical Issue for Our Oceans.* Paper Presented at the "Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans & the Law of the Sea." June 6-10, 2005. New York, NY. 7 pp. http://www.un.org/Depts/los/consultative_process/consultative_process.htm

Sokal, R.R. and C.A. Braumann. 1980. Significance tests for coefficients of variation and variability profiles. *Systematic Zoology.* 29: pp. 50-66.

United Nations Environment Programme (UNEP). 2006. *Marine Litter in the Wider Caribbean.* 18 pp. http://www.cep.unep.org/operational-components/amep/marine-litter.pdf.

Velander, Kathy and Marina Mocogni. 1999. *Beach Litter Sampling Strategies: is there a 'Best' Method?* Marine Pollution Bulletin, Vol. 38, No. 12, pp. 1134-1140.

 © 2007 OCEAN CONSERVANCY

TABLE 1.

Average percent change per year and coefficient of variation (CV) were calculated for each Region.

Average Number of Indicator Items (±SE) Collected Along 500 Meters of Beach from September 2001 to September 2006

		Average Number of Indicator Items	Percent of Total	CV	Average Annual Percent Change
United States	Total Items	95.4 ± 28.6		2.05	3.6%
	Ocean-based	16.9 ± 3.5	17.7%	1.42	-9.0%
	Land-based	46.6 ± 19.9	48.8%	2.91	8.8%
	General Items	31.9 ± 7.9	33.4%	1.68	5.4%
Continental United States	Total Items	86.2 ± 32.1		2.37	8.2%
	Ocean-based	12.2 ± 2.2	14.2%	1.14	0.1%
	Land-based	44.5 ± 22.4	51.6%	3.20	10.4%
	General Items	29.5 ± 8.8	34.2%	1.91	9.8%
Region 1 (n=7)	Total Items	54.8 ± 14.9		0.69	13.7%
	Ocean-based	23 ± 6.8	42.0%	0.75	20.1%
	Land-based	15.2 ± 5.7	27.7%	0.95	11.1%
	General Items	16.5 ± 3.7	30.2%	0.57	12.6%
Region 2 (n=10)	Total Items	178.8 ± 134.4		2.31	22.5%
	Ocean-based	12.3 ± 4.8	6.9%	1.21	10.8%
	Land-based	112.6 ± 94.9	63.0%	2.59	24.2%
	General Items	54 ± 35.3	30.2%	2.01	25.2%
Region 3 (n=6)	Total Items	57.5 ± 21.6		0.87	-4.7%
	Ocean-based	8.2 ± 2.3	14.3%	0.66	-4.4%
	Land-based	23.7 ± 7.8	41.2%	0.77	-6.1%
	General Items	25.5 ± 12.2	44.3%	1.11	-1.3%
Region 4 & 5 (n=8)	Total Items	102 ± 42.8		1.14	-2.3%
	Ocean-based	16.2 ± 6.9	15.9%	1.16	-8.8%
	Land-based	49.3 ± 27.7	48.3%	1.53	-4.1%
	General Items	36.5 ± 14.8	35.8%	1.10	8.9%
Region 6 & 7 (n=11)	Total Items	46.6 ± 14.7		0.81	9.2%
	Ocean-based	5.3 ± 1.7	11.3%	0.82	10.5%
	Land-based	25.3 ± 8	54.2%	1.03	7.4%
	General Items	16.1 ± 5.1	34.4%	0.73	13.5%
Region 9 (n=5)	Total Items	127.6 ± 63.8		0.67	-18.4%
	Ocean-based	54.6 ± 27.3	42.8%	0.99	-23.8%
	Land-based	28.5 ± 14.3	22.4%	0.26	-11.1%
	General Items	44.4 ± 22.2	34.8%	0.65	-14.5%

TABLE 2.

Slopes from linear regression models of debris items over time, with a seasonal variable, were used to calculate deviations from zero between September 2001 and September 2006 using the Wilcoxon signed-rank test at alpha = 0.10.

National and Regional Patterns in Changes of Marine Debris Totals Over Time

		Mean Slope	W	p-value
United States	Total (n=47)	0.000020	109	0.253
	Land	-0.000002	8.5	0.929
	Ocean	-0.000028	-84	0.380
	General	0.000060	205.5	0.028
Continental United States (n=41)	Total	0.000050	188.5	0.013
	Land	0.000003	-7	0.929
	Ocean	0.000020	107.5	0.166
	General	0.000090	219.5	0.003
Region 1 (n=7)	Total	0.000110	14	0.016
	Land	0.000090	10	0.109
	Ocean	0.000100	13	0.031
	General	0.000080	6	0.375
Region 2 (n=10)	Total	0.000120	26.5	0.004
	Land	0.000070	17.5	0.084
	Ocean	0.000080	14.5	0.160
	General	0.000190	27.5	0.002
Region 3 (n=6)	Total	-0.000077	-4.5	0.438
	Land	-0.000100	-7.5	0.156
	Ocean	-0.000100	-9.5	0.063
	General	-0.000006	-0.5	1.000
Regions 4 & 5 (n=8)	Total	0.000010	3	0.742
	Land	-0.000025	-2	0.844
	Ocean	-0.000052	-9	0.250
	General	0.000100	15	0.039
Regions 6 & 7 (n=11)	Total	0.000040	4	0.765
	Land	0.000040	4	0.765
	Ocean	-0.000022	-6	0.638
	General	0.000040	6	0.638
Region 9 (n=5)	Total	-0.000200	-7.5	0.063
	Land	-0.000200	-7.5	0.063
	Ocean	-0.000300	-7.5	0.063
	General	-0.000100	-6.5	0.125

Increase

No Change

Decrease

 © 2007 OCEAN CONSERVANCY

TABLE 3.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / NATIONAL

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	1,912	0.8%
Plastic Sheets	1,776	0.7%
Light bulbs/tubes	1,008	0.4%
Oil/gas containers	852	0.4%
Pipe-thread protectors	1,206	0.5%
Nets > 5 meshes	3,247	1.4%
Traps/pots	2,219	0.9%
Fishing Line	8,032	3.4%
Light sticks	1,997	0.8%
Rope > 1 meter	13,023	5.5%
Salt bags	365	0.2%
Fish baskets	563	0.2%
Cruiseline logo items	76	0.0%
Floats/Buoys	3,488	1.5%
Land-based Sources		
Syringes	941	0.4%
Condoms	1,296	0.5%
Metal beverage cans	17,705	7.4%
Motor oil containers	1,368	0.6%
Balloons	18,509	7.8%
Six-pack rings	1,282	0.5%
Straws	65,384	27.5%
Tampon applicators	5,303	2.2%
Cotton swabs	6,325	2.7%
General Sources		
Plastic bags with seam < 1 meter	21,477	9.0%
Plastic bags with seam > 1 meter	3,141	1.3%
Straps: Open	4,946	2.1%
Straps: Closed	725	0.3%
Plastic bottles: beverage	30,858	13.0%
Plastic bottles: food	8,355	3.5%
Plastic bottles: bleach/cleaner	2,639	1.1%
Other plastic bottles	8,078	3.4%
TOTAL ITEMS	**238,103**	**100.0%**

TABLE 4.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / CONTINENTAL U.S.

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	1,826	0.9%
Plastic Sheets	1,576	0.8%
Light bulbs/tubes	574	0.3%
Oil/gas containers	609	0.3%
Pipe-thread protectors	450	0.2%
Nets > 5 meshes	1,481	0.8%
Traps/pots	1,589	0.8%
Fishing Line	4,309	2.2%
Light sticks	1,474	0.8%
Rope > 1 meter	9,853	5.0%
Salt bags	338	0.2%
Fish baskets	226	0.1%
Cruiseline logo items	58	0.0%
Floats/Buoys	2,391	1.2%
Land-based Sources		
Syringes	736	0.4%
Condoms	1,223	0.6%
Metal beverage cans	13,842	7.0%
Motor oil containers	983	0.5%
Balloons	17,841	9.1%
Six-pack rings	978	0.5%
Straws	55,578	28.3%
Tampon applicators	5,107	2.6%
Cotton swabs	6,274	3.2%
General Sources		
Plastic bags with seam < 1 meter	17,798	9.1%
Plastic bags with seam > 1 meter	2,775	1.4%
Straps: Open	3,959	2.0%
Straps: Closed	522	0.3%
Plastic bottles: beverage	27,001	13.7%
Plastic bottles: food	6,491	3.3%
Plastic bottles: bleach/cleaner	1,933	1.0%
Other plastic bottles	6,585	3.4%
TOTAL ITEMS	**196,387**	**100.0%**

 © 2007 OCEAN CONSERVANCY

TABLE 5.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / REGION 1

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	631	3.2%
Plastic Sheets	168	0.8%
Light bulbs/tubes	17	0.1%
Oil/gas containers	67	0.3%
Pipe-thread protectors	17	0.1%
Nets > 5 meshes	791	4.0%
Traps/pots	954	4.8%
Fishing Line	808	4.1%
Light sticks	28	0.1%
Rope > 1 meter	3,978	20.0%
Salt bags	101	0.5%
Fish baskets	94	0.5%
Cruiseline logo items	5	0.0%
Floats/Buoys	583	2.9%
Land-based Sources		
Syringes	14	0.1%
Condoms	98	0.5%
Metal beverage cans	1,944	9.8%
Motor oil containers	68	0.3%
Balloons	1,755	8.8%
Six-pack rings	85	0.4%
Straws	1,562	7.8%
Tampon applicators	148	0.7%
Cotton swabs	14	0.1%
General Sources		
Plastic bags with seam < 1 meter	2,039	10.2%
Plastic bags with seam > 1 meter	350	1.8%
Straps: Open	745	3.7%
Straps: Closed	160	0.8%
Plastic bottles: beverage	1,673	8.4%
Plastic bottles: food	401	2.0%
Plastic bottles: bleach/cleaner	146	0.7%
Other plastic bottles	467	2.3%
TOTAL ITEMS	**19,911**	**100.0%**

TABLE 6.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / REGION 2

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	336	0.3%
Plastic Sheets	320	0.3%
Light bulbs/tubes	110	0.1%
Oil/gas containers	254	0.2%
Pipe-thread protectors	145	0.1%
Nets > 5 meshes	406	0.4%
Traps/pots	218	0.2%
Fishing Line	1,738	1.7%
Light sticks	111	0.1%
Rope > 1 meter	2,578	2.5%
Salt bags	52	0.0%
Fish baskets	56	0.1%
Cruiseline logo items	11	0.0%
Floats/Buoys	653	0.6%
Land-based Sources		
Syringes	511	0.5%
Condoms	954	0.9%
Metal beverage cans	3,672	3.5%
Motor oil containers	474	0.5%
Balloons	8,050	7.7%
Six-pack rings	404	0.4%
Straws	41,015	39.4%
Tampon applicators	4,633	4.4%
Cotton swabs	6,177	5.9%
General Sources		
Plastic bags with seam < 1 meter	8,076	7.7%
Plastic bags with seam > 1 meter	1,567	1.5%
Straps: Open	1,836	1.8%
Straps: Closed	131	0.1%
Plastic bottles: beverage	14,382	13.8%
Plastic bottles: food	2,543	2.4%
Plastic bottles: bleach/cleaner	537	0.5%
Other plastic bottles	2,284	2.2%
TOTAL ITEMS	**104,211**	**100.0%**

 © 2007 OCEAN CONSERVANCY

TABLE 7.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / REGION 3

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	163	0.9%
Plastic Sheets	119	0.6%
Light bulbs/tubes	223	1.2%
Oil/gas containers	93	0.5%
Pipe-thread protectors	24	0.1%
Nets > 5 meshes	31	0.2%
Traps/pots	22	0.1%
Fishing Line	420	2.2%
Light sticks	585	3.1%
Rope > 1 meter	548	2.9%
Salt bags	3	0.0%
Fish baskets	15	0.1%
Cruiseline logo items	4	0.0%
Floats/Buoys	370	2.0%
Land-based Sources		
Syringes	90	0.5%
Condoms	9	0.0%
Metal beverage cans	1,484	7.9%
Motor oil containers	221	1.2%
Balloons	2,210	11.8%
Six-pack rings	72	0.4%
Straws	3,414	18.3%
Tampon applicators	57	0.3%
Cotton swabs	6	0.0%
General Sources		
Plastic bags with seam < 1 meter	2,547	13.6%
Plastic bags with seam > 1 meter	173	0.9%
Straps: Open	481	2.6%
Straps: Closed	94	0.5%
Plastic bottles: beverage	3,207	17.2%
Plastic bottles: food	605	3.2%
Plastic bottles: bleach/cleaner	325	1.7%
Other plastic bottles	1,035	5.5%
TOTAL ITEMS	**18,680**	**100.0%**

TABLE 8.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / REGIONS 4 & 5

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	565	1.4%
Plastic Sheets	819	2.1%
Light bulbs/tubes	159	0.4%
Oil/gas containers	231	0.6%
Pipe-thread protectors	61	0.2%
Nets > 5 meshes	198	0.5%
Traps/pots	162	0.4%
Fishing Line	1,089	2.8%
Light sticks	658	1.7%
Rope > 1 meter	2,170	5.5%
Salt bags	170	0.4%
Fish baskets	17	0.0%
Cruiseline logo items	20	0.1%
Floats/Buoys	228	0.6%
Land-based Sources		
Syringes	196	0.5%
Condoms	94	0.2%
Metal beverage cans	5,065	12.9%
Motor oil containers	291	0.7%
Balloons	2,299	5.9%
Six-pack rings	290	0.7%
Straws	9,514	24.3%
Tampon applicators	119	0.3%
Cotton swabs	14	0.0%
General Sources		
Plastic bags with seam < 1 meter	2,792	7.1%
Plastic bags with seam > 1 meter	529	1.4%
Straps: Open	465	1.2%
Straps: Closed	75	0.2%
Plastic bottles: beverage	5,592	14.3%
Plastic bottles: food	2,177	5.6%
Plastic bottles: bleach/cleaner	877	2.2%
Other plastic bottles	2,233	5.7%
TOTAL ITEMS	**39,169**	**100.0%**

 © 2007 OCEAN CONSERVANCY

TABLE 9.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / REGIONS 6 & 7

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	143	0.6%
Plastic Sheets	169	0.7%
Light bulbs/tubes	110	0.4%
Oil/gas containers	65	0.3%
Pipe-thread protectors	203	0.8%
Nets > 5 meshes	86	0.3%
Traps/pots	234	0.9%
Fishing Line	404	1.6%
Light sticks	205	0.8%
Rope > 1 meter	842	3.2%
Salt bags	19	0.1%
Fish baskets	46	0.2%
Cruiseline logo items	19	0.1%
Floats/Buoys	574	2.2%
Land-based Sources		
Syringes	72	0.3%
Condoms	71	0.3%
Metal beverage cans	1,912	7.4%
Motor oil containers	69	0.3%
Balloons	3,605	13.9%
Six-pack rings	183	0.7%
Straws	7,562	29.1%
Tampon applicators	215	0.8%
Cotton swabs	69	0.3%
General Sources		
Plastic bags with seam < 1 meter	2,877	11.1%
Plastic bags with seam > 1 meter	264	1.0%
Straps: Open	526	2.0%
Straps: Closed	66	0.3%
Plastic bottles: beverage	3,090	11.9%
Plastic bottles: food	973	3.7%
Plastic bottles: bleach/cleaner	274	1.1%
Other plastic bottles	1,014	3.9%
TOTAL ITEMS	**25,961**	**100.0%**

TABLE 10.

The total debris items collected between September 2001 and 2006.

TOTAL DEBRIS COLLECTED / REGION 9

Debris Item	Number of Items Collected	Percent of Total
Ocean-based Sources		
Gloves	74	0.2%
Plastic Sheets	181	0.6%
Light bulbs/tubes	389	1.3%
Oil/gas containers	142	0.5%
Pipe-thread protectors	756	2.5%
Nets > 5 meshes	1,735	5.8%
Traps/pots	629	2.1%
Fishing Line	3,573	11.8%
Light sticks	410	1.4%
Rope > 1 meter	2,907	9.6%
Salt bags	20	0.1%
Fish baskets	335	1.1%
Cruiseline logo items	17	0.1%
Floats/Buoys	1,080	3.6%
Land-based Sources		
Syringes	58	0.2%
Condoms	70	0.2%
Metal beverage cans	3,628	12.0%
Motor oil containers	245	0.8%
Balloons	590	2.0%
Six-pack rings	248	0.8%
Straws	2,317	7.7%
Tampon applicators	131	0.4%
Cotton swabs	45	0.1%
General Sources		
Plastic bags with seam < 1 meter	3,146	10.4%
Plastic bags with seam > 1 meter	258	0.9%
Straps: Open	893	3.0%
Straps: Closed	199	0.7%
Plastic bottles: beverage	2,914	9.7%
Plastic bottles: food	1,656	5.5%
Plastic bottles: bleach/cleaner	480	1.6%
Other plastic bottles	1,045	3.5%
TOTAL ITEMS	**30,171**	**100.0%**

 © 2007 OCEAN CONSERVANCY

APPENDICES

Appendix A

OVERVIEW OF RELATED TREATIES AND LAWS THAT ADDRESS MARINE DEBRIS ISSUES

After many years of irresponsible and unregulated dumping practices, laws now exist to regulate at sea and shore-side dumping. Unfortunately, until recently there had not been a statistically valid method of determining the effectiveness of the existing treaties and laws. The methodology designed for the National Marine Debris Monitoring Program provides the needed assessment capabilities of existing policies for controlling marine debris.

International Marine Pollution Treaty (MARPOL 73/78)

Thirty years ago, ships were a huge source of debris. In 1975, the National Academy of Sciences estimated that ships dumped 14 billion pounds of garbage in the ocean. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), which was established in 1973 and modified in 1978, created international guidelines to prevent ship pollution. MARPOL has six annexes covering oil discharge, hazardous liquid control, hazardous material transport, sewage discharge, plastic and garbage disposal and air pollution. Annex V controls the disposal of plastics and garbage into the oceans from ships. www.imo.org/conventions/contents.asp?doc_id=678&topic_id=258.

MARPOL Annex V

Annex V of MARPOL prohibits ocean dumping of all ship-generated plastics and regulates the dumping of other garbage. Annex V is of particular importance to the maritime community (shippers, oil platforms, fishers, recreational boaters and cruise lines) as it prohibits the disposal of plastic at sea and regulates the disposal of other types of garbage at sea. Under Annex V, garbage includes all kinds of food, domestic and operational waste – excluding fresh fish – generated during the normal operation of the vessel and liable to be disposed of continuously or periodically. This annex also requires ports and terminals to provide garbage reception facilities for boats. As of 31 July 2007, 135 countries have adopted Annex V.

Marine Plastic Pollution Research and Control Act of 1987 (MPPRCA), Public Law 100-220, Title II

On December 31, 1987, Congress passed the Marine Plastic Pollution Research and Control Act (MPPRCA). This federal law implements MARPOL Annex V and extends the dumping regulations to vessels in all navigable U.S. waterways. The law became effective December 31, 1988. Under MPPRCA, it is illegal to throw plastic trash off any vessel in the U.S. Exclusive Economic Zone (EEZ), within 200 miles of the U.S. shoreline. It is also illegal to throw any other garbage overboard while navigating in U.S. waters (including inland waters such as lakes, rivers, bays, sounds and estuaries) or within three miles offshore. The greater the distance from shore, the fewer restrictions apply to non-plastic garbage. However, dumping plastics overboard in any waters is illegal at anytime. MPPRCA applies to foreign vessels in U.S. waters and to U.S. vessels anywhere in the world. The U.S. Coast Guard (USCG) is the MARPOL enforcement agency within the EEZ. The USCG encourages citizens to report MARPOL violations and pursues and prosecutes any case brought to their attention.

Pursuant to Section 2204 of MPPRCA, Congress mandated the EPA to support the need for public education and involvement in solving the marine debris problem. Section 2204 also directs the EPA Administrator to conduct a program to encourage the formation of volunteer groups to assist in the monitoring, reporting, cleanup and prevention of ocean and shoreline pollution. NMDMP methodology has been specifically designed to test the effectiveness of the MPPRCA. http://dnrweb.dnr.state.md.us/download/cleanmarina/10Lawson.pdf.

Appendix A

(Continued)

Clean Water Act

Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. Amended in 1977, the law became commonly known as the Clean Water Act. Its primary objective is to restore and maintain the integrity of the nation's waters. This objective translates into two fundamental national goals: 1) eliminate the discharge of pollutants into the Nation's waters and 2) achieve water quality levels that are fishable and swimmable. www.epa.gov/r5water/cwa.htm.

B.E.A.C.H. Act

The Beaches Environmental Assessment and Coastal Health Act of 2000 (B.E.A.C.H. Act) amends the Clean Water Act to require ocean, bay and Great Lakes states to adopt minimum health-based criteria for water quality, comprehensively test recreational beach waters for pathogens and notify the public when contamination levels make beach water unsafe for swimming, surfing and other activities. Marine debris monitoring efforts provide an indicator for water quality of our beaches and waterways. NMDMP will establish a baseline database to serve as a means to identify regional areas and local sites along the U.S coastline that continue to contend with increasing amounts of marine debris pollution. www.epa.gov/waterscience/beaches/act.html.

Coastal Zone Management Act

Established in 1972, the Coastal Zone Management Act authorizes NOAA to approve and fund state programs that regulate land-based pollution discharges and works to preserve, protect, develop, restore and enhance the United States' coastal zone resources through state coastal management planning. www.legislative.noaa.gov/Legislation/czma.html or www.cr.nps.gov/local law/FHPL_CstlZoneMngmt.pdf.

Marine Protection, Research and Sanctuaries Act (MPRSA)

Established in 1972, the Act gives the USCG and EPA domestic authority to implement the London Convention in regulating the dumping of materials into ocean waters. This legislation distinguishes between ships' normal operational discharges (regulated in MARPOL and implemented domestically through APPS, see both below) and dumping of wastes from vessels (covered by the London Convention and implemented domestically by the Ocean Dumping Act). www.epa.gov/history/topics/mprsa/index.htm.

Act to Prevent Pollution from Ships (APPS)

Mandated in 1983, this act gives the USCG the authority to develop regulations and enforce MARPOL Annex V, including the discharge of garbage and plastics from ships. The act applies to all U.S. flag ships anywhere in the world and to all foreign flag vessels operating in navigable U.S. waters or while at a port or terminal under U.S. jurisdiction. The act also establishes regulations for operational discharges and dumping of wastes from vessels. www.senate.gov/~epw/atppfs.pdf.

Shore Protection Act

The Shore Protection Act of 1994 provides controls on transport vessels to prevent the release of municipal or commercial solid wastes into coastal waters. www.epa.gov/fedrgstr/EPA-GENERAL/1995/December/Day-13/pr-755.html.

Coral Reef Conservation Act

The Coral Reef Conservation Act of 2000 authorizes NOAA to provide assistance to any U.S. state, territory or possession that contains a coral reef ecosystem within its seaward boundaries in removing abandoned fishing gear, marine debris and abandoned vessels from coral reefs. www.coreocean.org/coralreef.html or www.coralreef.noaa.gov/grants.html.

Marine Debris Research, Prevention and Reduction Act

Signed into law in 2006, the Marine Debris Research, Prevention and Reduction Act establishes a program within NOAA to identify, assess, reduce and prevent marine debris and its effects on the marine environment. The Act also directs NOAA to reestablish the Interagency Marine Debris Coordinating Committee, work with the USCG to establish a definition of marine debris, develop a federal marine debris information clearinghouse and work with the international community to address marine debris on a global scale. www.ocean.us/node/524 or www.commerce.senate.gov/pdf/marinedebris_mark.pdf.

 © 2007 OCEAN CONSERVANCY

Appendix B

MARINE DEBRIS MONITORING FEDERAL WORKGROUP MEMBERS

U.S. Environmental Protection Agency
Mr. David Redford
Ms. Kathleen Hurld
Mr. James Ratterree

National Oceanographic and Atmospheric Administration/National Marine Fisheries Service
Mr. James Coe
LCDR John Clary

National Park Service
Ms. Sharon Kliwiniski
Mr. David Manski
Mr. John E. Miller

U.S. Coast Guard
Capt. Michael J. Donohue
Cmdr. Mike Farley
Cmdr. James Borders

Center for Marine Conservation/Ocean Conservancy
Ms. Kathryn O'Hara
Ms. Joan Escardó-Boomsma
Ms. Seba Sheavly

Scientific & Technical Advisors

Dr. Christine Ribic
NMDMP Project Statistician
(NBS, University of Wisconsin-Madison)

Dr. Andrew Cole
(Pennsylvania State University)

Mr. Scott Johnson
(NOAA/AK Fisheries Science Center)

Mr. Anthony F. Amos
(University of Texas-Austin)

Dr. Randall Parkinson
(Florida Institute of Technology)

Mr. David Laist
(Marine Mammal Commission)

Dr. Julio Morell
(University of Puerto Rico)

Mr. Steve Swartz
(NOAA/NMFS)

Appendix C

INDICATOR ITEMS TO BE SURVEYED IN THE NATIONAL MARINE DEBRIS MONITORING PROGRAM

Developed by the Marine Debris Monitoring Federal Workgroup

Probable Source	Indicator Items	
Ocean-based	◆ All gloves ◆ Plastic sheets (≥ 1 meter)*	◆ Light bulbs & light tubes ◆ Oil/gas containers (≥ 1 qt)
Oil/gas platforms	◆ Pipe-thread protectors	
Commercial Fishing	◆ Fishing nets (≥ 5 meshes)* ◆ Traps & pots* ◆ Fishing line* ◆ Floats & buoys*	◆ Light Sticks ◆ Rope (≥ I meter in length)* ◆ Salt bags ◆ Fish baskets*
Cruise ships	◆ Cruiseline logo items (sm. bottles & plastic cups)	
Land-based	◆ Syringes ◆ Condoms ◆ Metal Beverage Cans ◆ Motor Oil Containers (1-qt)	◆ Balloons – Mylar or rubber* ◆ Six-pack rings* ◆ Straws
Urban Combined-sewer Overflows (CSOs)	◆ Tampon applicators ◆ Cotton Swabs	
General	◆ Plastic bags with a seam (< 1 meter & ≥ 1 meter)* ◆ Strapping bands (open & closed)*	
Various Plastic Bottles	◆ Beverage & food ◆ Milk/water ◆ Bleach/cleaner	◆ Oil/lubricant ◆ Personal hygiene ◆ Other

** Indicates a debris form associated with biological impacts.*

Appendix D

DESCRIPTIONS OF REGIONAL AND MONITORING SITES

REGION 1

Region One of the National Marine Debris Monitoring Program extends along the Gulf of Maine from the U.S./Canada border to Provincetown, Massachusetts. The coastline in this region ranges from Maine's rocky shorelines and cobble beaches to Cape Cod's sandy beaches.

SITE 2
Jasper Beach, ME
First Survey: October 1999

GIS Site Information

N Latitude:	44.6290
N Longitude:	-67.3865
S Latitude:	44.6258
S Longitude:	-67.3909

SITE 4
Pemaquid Beach Park, ME
First Survey: February 1999

GIS Site Information

N Latitude:	43.8712
N Longitude:	-69.5246
S Latitude:	43.8689
S Longitude:	-69.5196

SITE 6
Wells Reserve, ME
First Survey: September 1998

GIS Site Information

N Latitude:	43.3312
N Longitude:	-70.5448
S Latitude:	43.3310
S Longitude:	-70.5446

SITE 7
Pirate's Cove Beach, NH
First Survey: July 1999

GIS Site Information

N Latitude:	43.0276
N Longitude:	-70.7287
S Latitude:	43.0221
S Longitude:	-70.7287

SITE 11
Jenness Beach, NH
First Survey: June 2001

GIS Site Information

N Latitude:	42.9893
N Longitude:	-70.7596
S Latitude:	42.9855
S Longitude:	-70.7627

SITE 15
Sears Island, ME
First Survey: April 2000

GIS Site Information

N Latitude:	44.4569
N Longitude:	-68.8823
S Latitude:	44.4445
S Longitude:	-68.8918

SITE 17
Plaice Cove, NH
First Survey: November 1999

GIS Site Information

N Latitude:	42.9508
N Longitude:	-70.7856
S Latitude:	42.9465
S Longitude:	-70.7870

REGION 2

Region Two of the National Marine Debris Monitoring Program extends from Provincetown, Massachusetts south to Beaufort, North Carolina. The coastlines in this region consist mainly of sand and include some of the largest beach resorts on the U.S. East Coast.

SITE 1
Newcomb Hollow Beach, MA
First Survey: June 1998

GIS Site Information

N Latitude:	41.9689
N Longitude:	-69.9989
S Latitude:	41.9647
S Longitude:	-69.9967

SITE 3
Cape Pogue Reservation, MA
First Survey: October 1997

GIS Site Information

N Latitude:	41.3876
N Longitude:	-70.4485
S Latitude:	41.3827
S Longitude:	-70.4494

SITE 5
Crescent Beach, RI
First Survey: October 1997

GIS Site Information

N Latitude:	41.1958
N Longitude:	-71.5642
S Latitude:	41.1908
S Longitude:	-71.5656

SITE 6
Hither Hills State Park, NY
First Survey: December 1997

GIS Site Information

N Latitude:	41.0029
N Longitude:	-72.0225
S Latitude:	41.0031
S Longitude:	-72.0195

SITE 8
Robert Moses State Park, NY
First Survey: November 1997

GIS Site Information

N Latitude:	40.6214
N Longitude:	-73.2961
S Latitude:	40.6213
S Longitude:	-73.2901

 © 2007 OCEAN CONSERVANCY

Appendix D

(Continued)

REGION 2

(Continued)

SITE 10
Gateway National Recreation Area, NJ
First Survey: May 1998

GIS Site Information

N Latitude:	40.4763
N Longitude:	-74.0084
S Latitude:	40.4762
S Longitude:	-74.0144

SITE 14
Delaware Seashore State Park, DE
First Survey: June 1998

GIS Site Information

N Latitude:	38.6434
N Longitude:	-75.0645
S Latitude:	38.6399
S Longitude:	-75.0642

SITE 15
Strathmere, NJ
First Survey: November 1999

GIS Site Information

N Latitude:	39.1903
N Longitude:	-74.6628
S Latitude:	39.1863
S Longitude:	-74.6663

SITE 16
Chincoteague Is. National Wildlife Refuge, VA
First Survey: May 1996

GIS Site Information

N Latitude:	37.8957
N Longitude:	-75.3369
S Latitude:	37.8937
S Longitude:	-75.3383

SITE 17
Back Bay National Wildlife Refuge, VA
First Survey: January 1998

GIS Site Information

N Latitude:	36.6681
N Longitude:	-75.9103
S Latitude:	36.6646
S Longitude:	-75.9073

REGION 3

Region Three of the National Marine Debris Monitoring Program extends from Morehead City, North Carolina to Port Everglades, Florida, including the barrier islands of Georgia and the beaches of the east coast of Florida. These areas are known for their beauty and are very popular vacation destinations.

SITE 1
Shackleford Banks, NC
First Survey: November 1997

GIS Site Information

N Latitude:	34.6788
N Longitude:	-76.6449
S Latitude:	34.6775
S Longitude:	-76.6403

SITE 7
Sapelo Island, GA
First Survey: October 1997

GIS Site Information

N Latitude:	31.3867
N Longitude:	-81.2671
S Latitude:	31.382
S Longitude:	-81.2694

SITE 11
Little Talbot State Park, FL
First Survey: October 1997

GIS Site Information

N Latitude:	30.4689
N Longitude:	-81.4116
S Latitude:	30.4648
S Longitude:	-81.4113

SITE 14
North Peninsula State Recreation Area, FL
First Survey: September 1997

GIS Site Information

N Latitude:	29.4190
N Longitude:	-81.0982
S Latitude:	29.4148
S Longitude:	-81.0965

SITE 15
Canaveral National Seashore, FL
First Survey: November 1997

GIS Site Information

N Latitude:	28.6556
N Longitude:	-80.6319
S Latitude:	28.6489
S Longitude:	-80.6302

SITE 20
Blowing Rocks Preserve, FL
First Survey: November 1997

GIS Site Information

N Latitude:	26.9942
N Longitude:	-80.0879
S Latitude:	26.9895
S Longitude:	-80.0870

Appendix D

(Continued)

REGION 4

Region Four of the National Marine Debris Monitoring Program extends from the northern jetty of Port Everglades, Florida all the way along the coast to Gulf Shores, Alabama. Included are Florida's Keys, Gulf Coast and Pan Handle, as well as the shores of Puerto Rico and the U.S. Virgin Islands. Beaches in this region are known for their pure white, fine-grained sands.

SITE 1
Fort Morgan, AL
First Survey: June 1996

GIS Site Information

N Latitude:	30.2238
N Longitude:	-88.0138
S Latitude:	30.2243
S Longitude:	-88.0073

SITE 8
Holmes Beach, FL
First Survey: July 1996

GIS Site Information

N Latitude:	27.5165
N Longitude:	-82.7272
S Latitude:	27.5132
S Longitude:	-82.7240

SITE 9
Bradenton Beach, FL
First Survey: July 1996

GIS Site Information

N Latitude:	27.4728
N Longitude:	-82.7017
S Latitude:	27.4677
S Longitude:	-82.6998

SITE 10
Sanibel, FL
First Survey: August 1996

GIS Site Information

Latitude:	26.4320
N Longitude:	-82.1163
S Latitude:	26.4303
S Longitude:	-81.1127

SITE 14
Isabella, PR
First Survey: June 1996

GIS Site Information

N Latitude:	18.5147
N Longitude:	-67.0845
S Latitude:	18.5134
S Longitude:	-67.0810

REGION 5

Region Five of the National Marine Debris Monitoring Program extends from Dauphin Island, Alabama to the Texas/Mexico border. Many of the beaches in this region are remote and can only be accessed by four-wheel drive vehicles. Included in this region is Padre Island National Seashore in Texas, the world's longest undeveloped barrier island and an important nesting site for Kemps Ridley, loggerhead, and green sea turtles.

SITE 6
Matagorda Beach, TX
First Survey: February 1998

GIS Site Information

N Latitude:	28.6092
N Longitude:	-95.9442
S Latitude:	28.6108
S Longitude:	-95.9463

SITE 8
Galveston Island State Park, TX
First Survey: January 1998

GIS Site Information

N Latitude:	29.1933
N Longitude:	-94.9149
S Latitude:	29.1837
S Longitude:	-94.9694

SITE 9
San Luis Pass, Galveston Island, TX
First Survey: August 1996

GIS Site Information

N Latitude:	29.1161
N Longitude:	-95.0772
S Latitude:	29.1133
S Longitude:	-95.0814

 © 2007 OCEAN CONSERVANCY

Appendix D

(Continued)

REGION 6

Region Six of the National Marine Debris Monitoring Program extends north from the California/Mexico border to Point Conception just north of Santa Barbara, California. The beaches of southern California are known for their rocky headlands, tidal pools, and series of long sandy beaches backed by steep, eroded cliffs – some of which rise over 100 feet from the beach.

SITE 13
Crystal Cove State Park, CA
First Survey: July 2001

GIS Site Information

N Latitude:	33.5837
N Longitude:	-117.8605
S Latitude:	33.5821
S Longitude:	-117.8562

SITE 14
Capistrano Beach, CA
First Survey: July 1999

GIS Site Information

N Latitude:	33.4526
N Longitude:	-117.6662
S Latitude:	33.4505
S Longitude:	-117.6607

SITE 17
Torrey Pines State Beach, CA
First Survey: March 1999

GIS Site Information

N Latitude:	32.9446
N Longitude:	-117.2638
S Latitude:	32.9398
S Longitude:	-117.2626

REGION 7

Region Seven of the National Marine Debris Monitoring Program extends from north of Point Conception, California to the Washington/Canada border. The beaches of this region range from small pocket beaches contained in hidden coves surrounded by spectacular views of rocky cliffs and headlands, to wide expanses of sandy beach backed by pine forests and mountain ridges.

SITE 8
Bullards Beach State Park, OR
First Survey: January 1999

GIS Site Information

N Latitude:	43.1500
N Longitude:	-124.4143
S Latitude:	43.1463
S Longitude:	-124.4157

SITE 14
Salmon Creek Beach, CA
First Survey: June 1998

GIS Site Information

N Latitude:	38.3400
N Longitude:	-123.0678
S Latitude:	38.3328
S Longitude:	-123.0669

SITE 15
Rodeo Beach, CA
First Survey: February 2000

GIS Site Information

N Latitude:	37.8320
N Longitude:	-122.5397
S Latitude:	37.8291
S Longitude:	-122.5357

SITE 16
Pescadero State Beach, CA
First Survey: October 1998

GIS Site Information

N Latitude:	37.2748
N Longitude:	-122.4096
S Latitude:	37.2696
S Longitude:	-122.4107

SITE 18
Carmel River State Beach, CA
First Survey: July 1999

GIS Site Information

N Latitude:	36.5397
N Longitude:	-121.9318
S Latitude:	36.5365
S Longitude:	-121.9279

SITE 19
Morro Bay City Beach, CA
First Survey: October 1998

GIS Site Information

N Latitude:	35.3812
N Longitude:	-120.8644
S Latitude:	35.3773
S Longitude:	-120.8633

Appendix D

(Continued)

REGION 7

(Continued)

SITE 20
Montana de Oro State Park, CA
First Survey: October 1998

GIS Site Information

N Latitude:	35.3034
N Longitude:	-120.8752
S Latitude:	35.2966
S Longitude:	-120.8783

SITE 22
N. Yachats (mile 196), OR
First Survey: January 2002

GIS Site Information

N Latitude:	44.3436
N Longitude:	-124.0976
S Latitude:	44.3393
S Longitude:	-124.0986

REGION 8

Region Eight did not have a sufficient number of surveys conducted during the study period. Therefore, data could not be statistically analyzed.

REGION 9

Region Nine encompasses the shores of the Hawaiian Islands, which are world-renown for spectacular volcanic scenery and palm tree-lined beaches. Hawaii is composed of 132 islands, reefs, and shoals. Monitoring sites for this study were located on the island of Oahu.

SITE 1
Kahuku Point Area, Oahu
First Survey: January 2000

GIS Site Information

N Latitude:	21.7050
N Longitude:	-157.9639
S Latitude:	21.7023
S Longitude:	-157.9603

SITE 2
Malaekahana Beach, Laie, Oahu
First Survey: September 2000

GIS Site Information

N Latitude:	21.6610
N Longitude:	-157.9271
S Latitude:	21.6565
S Longitude:	-157.9286

SITE 4
Chun's Reef, Northshore, Oahu
First Survey: August 2000

GIS Site Information

N Latitude:	21.6242
N Longitude:	-158.0786
S Latitude:	21.6215
S Longitude:	-158.0825

SITE 6
Makua Beach, Oahu
First Survey: May 2000

GIS Site Information

N Latitude:	21.5358
N Longitude:	-158.2304
S Latitude:	21.5312
S Longitude:	-158.2292

SITE 8
Kalaeloa CDD (Barber's Point)
First Survey: August 2000

GIS Site Information

N Latitude:	21.3010
N Longitude:	-158.0525
S Latitude:	21.3004
S Longitude:	-158.0581

 © 2007 OCEAN CONSERVANCY

Appendix E

DESCRIPTIVE STATISTICS OF INDIVIDUAL SURVEY SITES BETWEEN SEPTEMBER 2001 AND SEPTEMBER 2006

		Total Items Collected During a Survey			
	Surveys	Regression Slope	Average ± SE	CV	Average Annual Percent Change
REGION 1					
Jasper Beach, ME	56	0.000119	45.9 ± 5.8	0.94	11.0%
Pemaquid Beach Park, ME	35	0.000105	59.8 ± 10.7	1.05	115.3%
Sears Island, ME	46	0.000064	13.3 ± 1.3	0.68	10.3%
Wells Reserve, ME	63	0.000043	29.9 ± 3.1	0.81	11.0%
Jenness Beach, NH	64	0.000228	123.7 ± 11.7	0.76	28.4%
Pirate's Cove Beach, NH	66	0.000103	35.9 ± 4.1	0.91	18.9%
Plaice Cove, NH	33	0.000139	74.8 ± 8.8	0.67	35.3%
REGION 2					
Cape Pogue Reservation, MA	60	0.000045	31.5 ± 2.7	0.67	21.2%
Newcomb Hollow Beach, MA	54	0.000153	32.8 ± 2.8	0.63	24.7%
Crescent Beach, RI	56	-0.000009	86.8 ± 5.7	0.49	-0.4%
Hither Hills State Park, NY	54	0.000094	63.1 ± 5.1	0.59	4.7%
Robert Moses State Park, NY	51	0.000184	71.7 ± 7.9	0.78	22.0%
Gateway National Recreation Area, NJ	59	0.000053	1,324.9 ± 102.5	0.59	28.3%
Strathmere, NJ	54	0.000317	64.8 ± 6.8	0.77	29.9%
Back Bay NWR, VA	61	0.000097	40.6 ± 4.4	0.84	23.4%
Chincoteague Is. NWR, VA	48	0.000060	15.8 ± 2	0.88	18.1%
Delaware Seashore State Park, DE	66	0.000157	56.4 ± 5.5	0.79	51.2%
REGION 3					
Shackleford Banks, NC	33	0.000174	55.4 ± 5.6	0.57	42.5%
Blowing Rocks Preserve, FL	63	-0.000020	147.6 ± 11.5	0.61	-4.3%
Canaveral National Seashore, FL	43	-0.000104	30.8 ± 2.1	0.44	-1.0%
Little Talbot State Park, FL	42	-0.000331	25.2 ± 3.8	0.98	-17.5%
North Peninsula State Recreation Area, FL	59	-0.000224	69.3 ± 9.8	1.08	-6.6%
Sapelo Island, GA	64	0.000043	16.9 ± 1.6	0.74	0.7%
REGIONS 4 & 5					
Galveston Is. State Park, TX	41	0.000066	48.9 ± 4	0.52	3.4%
Matagorda Beach, TX	53	-0.000092	234.2 ± 19	0.59	5.1%
San Luis Pass, Galveston Island, TX	62	0.000010	122.8 ± 9.4	0.60	-0.4%
Fort Morgan, AL	56	-0.000024	47.5 ± 5.3	0.83	-2.4%
Bradenton Beach, FL	66	0.000123	9.5 ± 0.7	0.58	17.1%
Holmes Beach, FL	66	0.000061	18.2 ± 1.5	0.68	2.7%
Sanibel, FL	48	0.000137	22.9 ± 1.7	0.51	10.5%
Isabella, PR	37	-0.000173	312 ± 72	1.39	5.0%
REGIONS 6 & 7					
Bullards Beach State Park, OR	64	0.000232	10.4 ± 1.7	1.31	24.4%
N. Yachats (mile 196), OR	61	-0.000104	17.3 ± 2.6	1.16	24.5%
Carmel River State Beach, CA	59	-0.000196	9.2 ± 0.7	0.56	-8.2%
Montana de Oro State Park, CA	58	-0.000269	32.9 ± 4.9	1.13	-6.8%
Morro Bay City Beach, CA	65	0.000176	22.8 ± 4	1.39	38.4%
Pescadero State Beach, CA	63	-0.000045	24 ± 3.1	1.01	-2.1%
Rodeo Beach, CA	53	0.000227	43.4 ± 7.8	1.30	26.5%
Salmon Creek Beach, CA	57	0.000475	59.6 ± 6.5	0.81	47.7%
Capistrano Beach, CA	37	0.000100	114.2 ± 13.3	0.70	64.4%
Crystal Cove State Park, CA	46	0.000113	99.7 ± 8.4	0.56	26.9%
Torrey Pines State Beach, CA	54	-0.000241	79.4 ± 8.1	0.75	11.8%
REGION 9					
Chun's Reef, Northshore, Oahu	51	-0.000108	128.4 ± 12.9	0.71	-2.7%
Kahuku Point Area, Oahu	62	-0.000145	108.4 ± 6.1	0.44	-4.3%
Kalaeloa CDD (Barber's Point), Oahu	64	-0.000374	87.5 ± 7.2	0.66	-23.1%
Makua Beach, Oahu	57	-0.000045	50.8 ± 4.1	0.61	-0.5%
Malaekahana Beach, Laie, Oahu	32	-0.000466	262.6 ± 45.2	0.97	-19.1%

Appendix F

Data from Individual Sites Separated by Sources: Ocean-based, Land-based, and General-source Debris Items Surveyed Between September 2001 and September 2006

	Number of Items per Survey								
	Average ± SE			CV			Average Percent of Total		
	Ocean Items	Land Items	General Items	Ocean Items	Land Items	General Items	Ocean Items	Land Items	General Items
REGION 1									
Jasper Beach, ME	14.3 ± 1.4	6.4 ± 1.1	25.3 ± 4.3	0.75	1.27	1.25	38.6 ± 2.8	14.8 ± 1.9	46.7 ± 3.0
Pemaquid Beach Park, ME	31.1 ± 5.8	7.7 ± 1.2	20.9 ± 4.4	1.09	0.94	1.24	51.7 ± 3.0	13.6 ± 1.3	34.7 ± 2.7
Sears Island, ME	4.6 ± 0.4	1.8 ± 0.3	7.0 ± 0.9	0.62	1.04	0.89	39.3 ± 3.4	12.6 ± 1.8	48.1 ± 3.2
Wells Reserve, ME	10.1 ± 1.1	10.3 ± 1.4	9.5 ± 1.3	0.84	1.10	1.08	37.9 ± 2.8	31.6 ± 2.3	29.0 ± 2.4
Jenness Beach, NH	52.7 ± 6.0	41.2 ± 3.9	29.8 ± 3.8	0.91	0.75	1.02	40.0 ± 2.4	37.1 ± 2.3	22.9 ± 1.7
Pirate's Cove Beach, NH	16.4 ± 2.2	12.3 ± 1.7	7.2 ± 0.9	1.08	1.12	1.02	49.3 ± 3.1	30.5 ± 2.7	20.2 ± 2.2
Plaice Cove, NH	32.0 ± 4.6	26.6 ± 4.7	16.2 ± 2.4	0.83	1.00	0.83	42.8 ± 3.9	34.5 ± 3.8	22.7 ± 2.3
REGION 2									
Cape Pogue Reservation, MA	5.9 ± 1	18.7 ± 1.7	6.8 ± 0.9	1.25	0.72	1.02	19.1 ± 2.4	60.4 ± 2.7	20.5 ± 2.0
Newcomb Hollow Beach, MA	9.8 ± 1.1	10.4 ± 1.3	12.5 ± 1.6	0.80	0.95	0.95	32.5 ± 2.4	31.2 ± 2.8	36.3 ± 2.7
Crescent Beach, RI	23.3 ± 1.6	37.4 ± 2.9	26.1 ± 2.9	0.51	0.57	0.83	27.9 ± 1.5	41.9 ± 1.7	30.1 ± 1.9
Hither Hills State Park, NY	6.6 ± 0.8	32.9 ± 2.8	23.6 ± 2.9	0.92	0.61	0.89	11.9 ± 1.3	54.3 ± 2.7	33.8 ± 2.3
Robert Moses State Park, NY	14.4 ± 2	35.1 ± 3.5	22.2 ± 3.7	1.01	0.71	1.17	19.6 ± 0.8	50.7 ± 1.6	29.7 ± 1.5
Gateway National Recreation Area, NJ	49.2 ± 4	922 ± 78.1	354 ± 28	0.62	0.65	0.61	4.1 ± 0.3	68.0 ± 1.1	27.9 ± 1.0
Strathmere, NJ	3.6 ± 0.5	20.9 ± 2.4	40.3 ± 4.6	1.08	0.84	0.83	6.6 ± 0.9	34.5 ± 2.5	57.0 ± 2.6
Back Bay NWR, VA	5.4 ± 0.6	15.8 ± 2.1	19.4 ± 2.3	0.84	1.04	0.92	14.6 ± 1.1	38.8 ± 1.9	46.6 ± 1.9
Chincoteague Is. NWR, VA	1.9 ± 0.4	6.8 ± 1.2	7.2 ± 1	1.31	1.19	1.00	12.5 ± 2.3	42.4 ± 3.7	43.1 ± 3.7
Delaware Seashore State Park, DE	2.8 ± 0.5	26.2 ± 3.2	27.4 ± 2.5	1.36	0.98	0.74	4.6 ± 0.5	43.7 ± 1.8	51.7 ± 1.7
REGION 3									
Shackleford Banks, NC	7.7 ± 1.2	25.8 ± 3.1	21.9 ± 3.1	0.92	0.69	0.81	14.4 ± 2.2	44.6 ± 3.0	38.0 ± 3.4
Blowing Rocks Preserve, FL	17.7 ± 2.1	49.5 ± 4.1	79.9 ± 6.6	0.92	0.66	0.65	11.6 ± 0.8	33.4 ± 1.4	53.3 ± 1.7
Canaveral National Seashore, FL	6.1 ± 0.7	13.8 ± 1.1	10.9 ± 1	0.77	0.50	0.59	18.9 ± 1.6	45.7 ± 1.8	35.4 ± 2.2
Little Talbot State Park, FL	4.6 ± 0.7	9.7 ± 1.5	10.9 ± 2.1	1.01	1.00	1.24	20.1 ± 2.2	38.9 ± 3.4	41.0 ± 3.2
N. Peninsula State Recreation Area, FL	9.9 ± 1.5	38.5 ± 6.4	20.9 ± 3.1	1.17	1.27	1.14	16.4 ± 1.9	54.5 ± 2.3	29.1 ± 2.2
Sapelo Island, GA	3.3 ± 0.5	4.9 ± 0.6	8.6 ± 1	1.30	1.02	0.91	17.5 ± 2.2	32.5 ± 2.8	48.5 ± 3.1
REGION 4 & 5									
Galveston Is. State Park, TX	12.7 ± 1.6	16 ± 1.4	20.1 ± 2.3	0.79	0.54	0.71	25.6 ± 2.4	34.7 ± 2.3	39.7 ± 2.7
Matagorda Beach, TX	58 ± 9.3	62.1 ± 4.9	114 ± 11.8	1.16	0.57	0.75	22.2 ± 1.8	29.3 ± 1.9	48.5 ± 2.4
San Luis Pass, Galveston Island, TX	16.9 ± 1.7	55.7 ± 4.9	50.3 ± 5	0.81	0.69	0.78	14.3 ± 1.2	46.5 ± 1.6	39.2 ± 1.7
Fort Morgan, AL	6.5 ± 0.9	17.3 ± 2.2	23.7 ± 2.6	1.01	0.95	0.83	12.7 ± 0.9	35.6 ± 1.6	51.7 ± 1.8
Bradenton Beach, FL	0.7 ± 0.1	6.2 ± 0.5	2.6 ± 0.3	1.10	0.66	0.82	9.2 ± 1.5	64.5 ± 2.3	26.3 ± 2.2
Holmes Beach, FL	2.3 ± 0.3	10.1 ± 0.9	5.9 ± 0.6	0.94	0.69	0.88	13.3 ± 1.3	56.3 ± 2.1	28.9 ± 1.9
Sanibel, FL	12.1 ± 1.2	4.5 ± 0.5	6.3 ± 0.9	0.66	0.81	0.95	53.6 ± 3.2	20.8 ± 2.4	25.6 ± 2.8
Isabella, PR	20.6 ± 4.3	222.1 ± 62.7	69.3 ± 10.2	1.26	1.70	0.89	8.3 ± 1.5	62.9 ± 3.4	28.8 ± 2.7
REGION 6 & 7									
Bullards Beach State Park, OR	2.1 ± 0.5	1.3 ± 0.3	7.1 ± 1.3	1.90	1.60	1.41	19.2 ± 2.9	15.2 ± 2.2	61.0 ± 3.6
N. Yachats (mile 196), OR	6.9 ± 1.3	1.9 ± 0.4	8.5 ± 1.3	1.45	1.80	1.22	36.4 ± 3.0	13.8 ± 2.1	49.8 ± 2.7
Carmel River State Beach, CA	0.7 ± 0.2	4.8 ± 0.5	3.7 ± 0.4	1.80	0.78	0.82	7.2 ± 1.6	49.0 ± 3.2	43.8 ± 3.3
Montana de Oro State Park, CA	6.8 ± 1.2	10.1 ± 1.3	15.9 ± 2.7	1.32	0.99	1.28	18.5 ± 1.8	34.3 ± 2.5	47.2 ± 2.4
Morro Bay City Beach, CA	1.4 ± 0.2	13.9 ± 2.7	7.5 ± 1.3	1.14	1.59	1.38	8.0 ± 1.3	59.0 ± 2.0	32.9 ± 2.0
Pescadero State Beach, CA	2.7 ± 0.6	12.4 ± 1.6	8.8 ± 1.4	1.69	1.02	1.24	9.3 ± 2.0	54.3 ± 3.5	34.7 ± 3.0
Rodeo Beach, CA	2.4 ± 0.7	28.2 ± 5.2	12.8 ± 2.6	1.98	1.33	1.49	5.3 ± 1.2	62.5 ± 3.0	30.3 ± 2.7
Salmon Creek Beach, CA	15.2 ± 2.2	18.3 ± 2.6	26.2 ± 2.6	1.08	1.08	0.73	23.4 ± 2.1	30.2 ± 1.8	46.4 ± 2.0
Capistrano Beach, CA	7.8 ± 1.2	63.2 ± 6.5	43.2 ± 7	0.92	0.62	0.97	7.1 ± 0.8	59.6 ± 2.9	33.3 ± 2.9
Crystal Cove State Park, CA	8 ± 1.3	71.8 ± 6.4	19.9 ± 2.4	1.12	0.60	0.83	8.1 ± 1.2	72.0 ± 2.0	19.8 ± 1.6
Torrey Pines State Beach, CA	4.1 ± 0.6	52.2 ± 5.3	23 ± 3.4	1.09	0.74	1.06	4.7 ± 0.6	68.2 ± 2.2	27.0 ± 2.2
REGION 9									
Chun's Reef, Northshore, Oahu	39.3 ± 9.5	28.6 ± 2.9	60.5 ± 5	1.72	0.73	0.59	23.7 ± 2.3	24.4 ± 1.7	51.9 ± 2.4
Kahuku Point Area, Oahu	53.5 ± 2.9	17.9 ± 1.4	37.1 ± 2.8	0.42	0.62	0.59	51.1 ± 1.6	16.1 ± 1.0	32.8 ± 1.1
Kalaeloa CDD (Barber's Point), Oahu	29.6 ± 2.8	31.8 ± 2.9	26.1 ± 3.4	0.76	0.72	1.03	33.6 ± 2.1	38.3 ± 1.9	28.1 ± 2.0
Makua Beach, Oahu	8.6 ± 0.8	26.8 ± 2.6	15.4 ± 1.8	0.72	0.74	0.89	17.9 ± 1.6	50.7 ± 2.3	29.7 ± 2.2
Malaekahana Beach, Laie, Oahu	42.1 ± 33	37.4 ± 5	83.2 ± 24.9	1.30	0.75	1.68	44.7 ± 4.3	18.3 ± 1.9	33.9 ± 3.9

 © 2007 OCEAN CONSERVANCY

Appendix G

Slopes from Linear Regression Models and Average Annual Percent Change Between September 2001 and September 2006

	Regression Slopes			Average Annual Percent Change		
	Ocean Items	Land Items	General Items	Ocean Items	Land Items	General Items
REGION 1						
Jasper Beach, ME	0.000049	0.000160	0.000081	6.5%	22.8%	19.6%
Pemaquid Beach Park, ME	0.000131	0.000028	0.000025	165.8%	27.9%	115.1%
Sears Island, ME	-0.000007	-0.000043	0.000131	2.0%	15.3%	19.1%
Wells Reserve, ME	0.000216	-0.000008	-0.000080	39.1%	12.2%	-4.0%
Jenness Beach, NH	0.000211	0.000142	0.000442	46.5%	10.0%	50.1%
Pirate's Cove Beach, NH	0.000073	0.000152	-0.000018	54.9%	12.2%	28.8%
Plaice Cove, NH	0.000055	0.000214	-0.000031	61.1%	41.8%	30.7%
REGION 2						
Cape Pogue Reservation, MA	-0.000133	0.000096	0.000271	73.8%	18.2%	61.7%
Newcomb Hollow Beach, MA	0.000164	0.000053	0.000171	46.1%	15.9%	30.2%
Crescent Beach, RI	-0.000027	-0.000004	0.000031	4.7%	-2.0%	0.9%
Hither Hills State Park, NY	0.000290	-0.000154	0.000460	33.1%	-13.8%	29.8%
Robert Moses State Park, NY	0.000255	0.000143	0.000161	31.5%	18.6%	32.5%
Gateway National Recreation Area, NJ	-0.000081	0.000063	0.000027	15.8%	30.2%	30.7%
Strathmere, NJ	0.000236	0.000231	0.000354	64.5%	23.3%	32.1%
Back Bay NWR, VA	-0.000069	0.000081	0.000165	1.2%	29.3%	29.6%
Chincoteague Is. NWR, VA	0.000035	0.000128	0.000082	31.7%	46.1%	12.2%
Delaware Seashore State Park, DE	0.000135	0.000095	0.000193	222.1%	52.8%	44.9%
REGION 3						
Shackleford Banks, NC	0.000060	0.000170	0.000200	144.0%	49.1%	51.0%
Blowing Rocks Preserve, FL	-0.000119	-0.000019	-0.000024	-7.8%	3.3%	-3.8%
Canaveral National Seashore, FL	-0.000269	-0.000181	0.000104	-17.4%	-6.0%	25.0%
Little Talbot State Park, FL	-0.000234	-0.000323	-0.000179	-26.6%	-30.6%	9.0%
North Peninsula State Recreation Area, FL	-0.000088	-0.000299	-0.000230	19.1%	-3.1%	-17.1%
Sapelo Island, GA	-0.000091	-0.000021	0.000093	-8.6%	2.2%	5.8%
REGIONS 4 & 5						
Galveston Is. State Park, TX	-0.000062	0.000050	0.000149	-4.3%	2.7%	15.1%
Matagorda Beach, TX	-0.000323	-0.000124	0.000078	-4.3%	-6.8%	26.6%
San Luis Pass, Galveston Island, TX	-0.000036	-0.000029	0.000106	-7.6%	-2.0%	5.4%
Fort Morgan, AL	-0.000045	0.000104	-0.000071	10.3%	-2.6%	-3.8%
Bradenton Beach, FL	-0.000037	0.000090	0.000185	-0.1%	18.8%	22.9%
Holmes Beach, FL	0.000071	0.000027	0.000082	9.3%	1.2%	6.1%
Sanibel, FL	0.000019	-0.000032	0.000318	17.0%	-2.8%	87.0%
Isabella, PR	-0.000001	-0.000287	-0.000012	17.9%	3.9%	11.2%
REGIONS 6 & 7						
Bullards Beach State Park, OR	-0.000031	0.000140	0.000256	37.2%	79.9%	30.9%
N. Yachats (mile 196), OR	0.000146	-0.000329	-0.000112	63.8%	-46.2%	33.4%
Carmel River State Beach, CA	0.000014	-0.000214	-0.000141	31.4%	11.4%	-13.9%
Montana de Oro State Park, CA	-0.000277	-0.000171	-0.000238	-6.2%	-10.6%	-2.0%
Morro Bay City Beach, CA	0.000024	0.000163	0.000209	23.9%	38.3%	50.1%
Pescadero State Beach, CA	-0.000171	0.000095	-0.000082	-28.0%	10.4%	-10.5%
Rodeo Beach, CA	-0.000081	0.000276	0.000176	25.7%	45.7%	34.1%
Salmon Creek Beach, CA	0.000575	0.000409	0.000435	69.7%	51.0%	39.5%
Capistrano Beach, CA	0.000258	0.000054	0.000217	61.4%	30.1%	226.0%
Crystal Cove State Park, CA	-0.000483	0.000212	0.000013	-1.4%	40.6%	7.5%
Torrey Pines State Beach, CA	-0.000218	-0.000185	-0.000311	119.1%	11.4%	9.2%
REGION 9						
Chun's Reef, Northshore, Oahu	-0.000061	-0.000099	-0.000080	-5.5%	2.6%	1.3%
Kahuku Point Area, Oahu	-0.000099	-0.000282	-0.000163	-2.5%	-11.1%	-3.3%
Kalaeloa CDD (Barber's Point), Oahu	-0.000513	-0.000368	-0.000310	-21.2%	-20.7%	-19.3%
Makua Beach, Oahu	-0.000144	-0.000102	0.000036	-4.4%	1.6%	4.7%
Malaekahana Beach, Laie, Oahu	-0.000637	-0.000181	-0.000205	-32.3%	13.2%	-11.3%

Appendix F

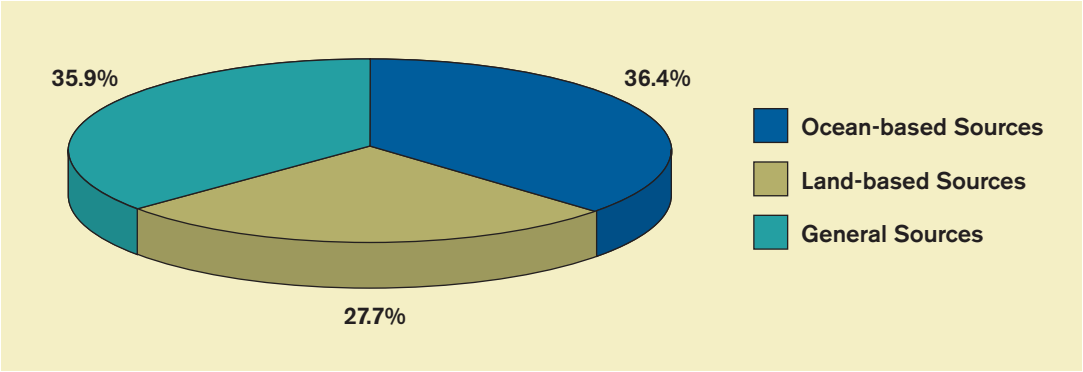
REGION 8

ALASKA: MONITORING DATA TOTALS

Debris Item	Number of Items Collected	Percent of Total
Ocean-Based Sources		
Gloves	565	1.4%
Debris Item	819	2.1%
Light bulbs/tubes	159	0.4%
Oil/gas containers	231	0.6%
Pipe-thread protectors	61	0.2%
Nets > 5 meshes	198	0.5%
Traps/pots	162	0.4%
Fishing Line	1,089	2.8%
Light sticks	658	1.7%
Rope > 1 meter	2,170	5.5%
Salt bags	170	0.4%
Fish baskets	17	0.0%
Cruiseline logo items	20	0.1%
Floats/Buoys	228	0.6%
Land-Based Sources		
Syringes	196	0.5%
Condoms	94	0.2%
Metal beverage cans	5,065	12.9%
Motor oil containers	291	0.7%
Balloons	2,299	5.9%
Six-pack rings	290	0.7%
Straws	9,514	24.3%
Tampon applicators	119	0.3%
Cotton swabs	14	0.0%
General Sources		
Plastic bags with seam < 1 meter	2,792	7.1%
Plastic bags with seam > 1 meter	529	1.4%
Straps: Open	465	1.2%
Straps: Closed	75	0.2%
Plastic bottles: beverage	5,592	14.3%
Plastic bottles: food	2,177	5.6%
Plastic bottles: bleach/cleaner	877	2.2%
Other plastic bottles	2,233	5.7%
TOTAL DEBRIS ITEMS	**39,169**	**100.0%**

REGION 8

ALASKA: PERCENT SOURCE OF INDICATOR DEBRIS ITEMS



 © 2007 OCEAN CONSERVANCY

Ocean Conservancy

1300 19th Street, NW
8th Floor
Washington, DC 20036
www.oceanconservancy.org