

San Diego Bay Integrated Natural Resources Management Plan

Public Draft—September 1999







Reference: U.S. Department of the Navy, Southwest Division (USDoN, SWDIV). 1999. San Diego Bay Integrated Natural Resources Management Plan, and San Diego Unified Port District Public Draft. September 1999. San Diego, CA. Prepared by Tierra Data Systems, Escondido, CA.

Key words/phrases: Natural Resources Management; NAVORDCENPACDIV; OPNAVINST 5090.1B; Natural Resources Plan; Wildlife Management Plan; Ecosystem Management Plan; Coastal Resources.

San Diego Bay Integrated Natural Resources Management Plan

This Plan was prepared during 1997-1999 under the direction and advice of the following:

Technical Oversight Committee (TOC)

US Navy, Southwest Division Jerry R. Boggs, Ph.D., Chair

US Navy, Commander Naval Base Margaret Lenz US Navy, Commander Naval Base Steve Barnhill Eileen Maher Port of San Diego Port of San Diego Melissa Mailander Stacey Baczkowski Ogden Environmental, Advisor to Port of San Diego California Coastal Commission Diana Lilly California Regional Water Quality Control Board Peter Michael California Department of Fish and Game Bill Tippets California Department of Fish and Game Marilyn Fluharty Friends of South Bay Wildlife James Peugh National Marine Fisheries Service Robert Hoffman San Diego Association of Governments (SANDAG) Michael McLaughlin The Environmental Trust Don Hunsaker, Ph.D. **US Army Corps of Engineers** David Zoutendyk US Fish and Wildlife Service, Ecological Services Martin Kenney US Fish and Wildlife Service, Refuges Brian Collins Zoological Society of San Diego Jeff Opdycke

Science Advisory and Review Team

Consultant Elizabeth Copper
CSU Northridge Larry Allen, Ph.D.
Scripps Institution of Oceanography Lisa Levin, Ph.D.
Scripps Institution of Oceanography Tom Hayward, Ph.D.
Scripps Institution of Oceanography Peter Franks, Ph.D.

Naval Installations Oversight Committee (NIOC)

US Navy, Southwest Division Jerry R. Boggs, Ph.D., Chair

US Navy, Commander Naval Base

US Navy, Southwest Division

US Navy, Southwest Division

US Navy, Southwest Division

Waval Air Station North Island

Naval Command Center Operations Specialist

Margaret Lenz

Daston Bordenave

Mevin McKeagh

Dan Larson

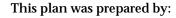
Naval Command Center Operations Specialist

Don Lydy

Naval Station 32nd Street Mary Ann Flanagan National Park Service, Cabrillo National Monument Carol Knipper

US Coast Guard Maritime Safety

LT M.T. Cunningham



Project Manager Tierra Data Systems Elizabeth M. Kellogg 10110 W. Lilac Rd. Escondido, CA 92026 (760) 749-2247 fax (760) 751-9707 Planner-In-Charge Sommarstrom and Assoc. Sari Sommarstrom, Ph.D. P.O. Box 719 Etna, CA 96027 (530) 467-5783 Marine Biologist Richard Ford, Ph.D. Department of Biology S.D.S.U. 5500 Campanile Drive San Diego, CA 92182 Research, GIS, and Editing Cynthia Booth Danielle Booth Sherman Jones James L. Kellogg Peter McDonald Keri Salmon Scott Snover Layout and Design Catherine Lush 208 O'Keefe Street Menlo Park, CA 94025 (650) 327-9201 fax (650) 327-9224

Wildlife Illustration Peter Else 403 South 8th Street Laramie, WY 82070 (307) 755-1837

Cover and Executive Summary photos and illustrations © US Navy Southwest Division, Tom Upton and Peter Else.

This plan was prepared for the US Department of the Navy, Southwest Division, Naval Facilities Engineering Command, 1220 Pacific Highway, San Diego, CA 92132. Contract No. N68711-95-D-7605/0006.

San Diego Bay Integrated Natural Resources Management Plan Approving Officials: Commander, Naval Bases San Diego Date Chair, Board of Port Commissioners San Diego Unified Port District Field Supervisor Carlsbad Field Office U.S. Fish and Wildlife Service Regional Director Date

Region V
California Department of Fish and Game

v

~~~~~~~~~~~~~~~~~

# **Table of Contents**

# **Executive Summary**

# Part I: Introduction

| 1.0 Welcome to the Plan                                | 1-1  |
|--------------------------------------------------------|------|
| 1.1 The Plan: Why, What, and Where                     | 1-1  |
| 1.1.1 The Plan's Goal                                  | 1-2  |
| 1.1.2 Plan Origin                                      | 1-2  |
| 1.1.3 Purpose                                          | 1-5  |
| 1.1.4 Planning Zones                                   | 1-6  |
| 1.1.5 Roles of Plan Collaborators                      | 1-6  |
| 1.1.6 Missions of US Navy and Port                     | 1-14 |
| 1.1.7 Relationship to Other Regional Plans             | 1-14 |
| 1.1.8 Relationship to Local Plans                      | 1-15 |
| 1.2 San Diego Bay: An Important and Sensitive Resource | 1-16 |
| 1.2.1 Values                                           | 1-16 |
| 1.2.2 Key Management Issues                            | 1-17 |
| 1.3 Ecosystem Management Framework                     | 1-18 |
| 1.3.1 Defining Ecosystem Management                    | 1-18 |
| 1.4 Strategic Design of Plan                           | 1-19 |
| 1.4.1 Audience                                         | 1-19 |
| 1.4.2 Intent of Use                                    | 1-20 |
| 1.4.3 Organization                                     | 1-20 |
| 1.4.4 Implementation                                   | 1-21 |
| 1.4.5 Updating                                         | 1-22 |

# Part II: State of the Bay

| 2.0 State of the Bay—Ecosystem Resources       | 2-1  |
|------------------------------------------------|------|
| 2.1 Ecoregional Setting                        | 2-2  |
| 2.2 Physical Conditions                        | 2-2  |
| 2.2.1 Climate and Hydrography                  | 2-2  |
| 2.2.2 Sediment                                 | 2-4  |
| 2.2.3 Water                                    | 2-11 |
| 2.2.3.1 Turbidity                              | 2-11 |
| 2.2.3.2 Circulation, Temperature, and Salinity | 2-11 |
| 2.2.3.3 Residence Time of Water                | 2-12 |
| 2.2.3.4 Hydrodynamic Regions of the Bay        | 2-15 |
| 2.3 Water and Sediment Quality                 | 2-15 |
| 2.3.1 Historical Conditions                    | 2-15 |
| 2.3.2 Current Conditions                       | 2-18 |
| 2.3.2.1 Contaminants                           | 2-18 |
| 2.3.2.2 Coliform Contamination                 | 2-21 |
| 2.3.2.3 Other Water Quality Conditions         | 2-21 |

|     | 2.3.3 Regional Comparisons                                                               | 2-22         |
|-----|------------------------------------------------------------------------------------------|--------------|
|     | 2.3.4 Ecological Effects                                                                 | 2-22         |
| 2.4 | Bay Habitats                                                                             | 2-24         |
|     | 2.4.1 Deep Subtidal (>-20 ft/-6 m MLLW)                                                  | 2-28         |
|     | 2.4.2 Moderately Deep Subtidal (-12 to -20 ft (-4 to -6 m) MLLW)                         | 2-29         |
|     | 2.4.3 Shallow Subtidal (-2.2 to -12 ft [-0.7 to -4 m] MLLW)                              | 2-30         |
|     | 2.4.3.1 Unvegetated Shallow Soft-Bottom                                                  | 2-31         |
|     | 2.4.3.2 Vegetated Shallow Subtidal                                                       | 2-33         |
|     | 2.4.4 Intertidal (+7.8 to -2.2 ft [+2.4 to -0.7 m] MLLW)                                 | 2-35         |
|     | 2.4.4.1 Intertidal Flats                                                                 | 2-36         |
|     | 2.4.4.2 Salt Marsh                                                                       | 2-39         |
|     | 2.4.4.3 Artificial Hard Substrate                                                        | 2-46         |
|     | 2.4.5 Salt Works                                                                         | 2-51         |
|     | 2.4.6 Upland Transitions                                                                 | 2-52         |
|     | 2.4.6.1 Beaches and Dunes                                                                | 2-52         |
|     | 2.4.6.2 Coastal Created Lands and Disturbed Uplands                                      | 2-55         |
|     | 2.4.6.3 Freshwater Wetlands and Riparian                                                 | 2-56         |
|     | 2.4.6.4 River Mouths                                                                     | 2-57         |
| 2.5 | Species Assemblages                                                                      | 2-58         |
|     | 2.5.1 Plankton                                                                           | 2-58         |
|     | 2.5.1.1 Phytoplankton                                                                    | 2-59         |
|     | 2.5.1.2 Zooplankton                                                                      | 2-60         |
|     | 2.5.1.3 Ichthyoplankton                                                                  | 2-61         |
|     | 2.5.2 Algae                                                                              | 2-64         |
|     | 2.5.2.1 Macroalgae                                                                       | 2-64         |
|     | 2.5.3 Invertebrates                                                                      | 2-66         |
|     | 2.5.3.1 Invertebrates of Soft Bottom, Unconsolidated Sediment                            | 2-67         |
|     | 2.5.3.2 Invertebrates of Eelgrass Beds                                                   | 2-71         |
|     | 2.5.3.3 Invertebrates of Man-made Habitats                                               | 2-72         |
|     | 2.5.3.4 Assessment of Invertebrates as Indicators of Pollution or Habitat                |              |
|     | Disturbance                                                                              | 2-73         |
|     | 2.5.4 Fishes                                                                             | 2-75         |
|     | 2.5.4.1 Description                                                                      | 2-75         |
|     | 2.5.4.2 Species Composition Baywide                                                      | 2-78         |
|     | 2.5.4.3 Rankings Based on Ecological Index                                               | 2-78         |
|     | 2.5.4.4 Comparison of Total Abundance and Biomass                                        |              |
|     | Among Bay Regions and Habitats                                                           | 2-79         |
|     | 2.5.4.5 Comparisons of Abundance by Region                                               | 2-79         |
|     | 2.5.4.6 Seasonal Changes in Abundance and Biomass                                        | 2-81         |
|     | 2.5.4.7 Patterns of Biodiversity and Species Assemblages                                 | ۵ 01         |
|     | in Four Regions of the Bay                                                               | 2-82         |
|     | 2.5.4.8 Functional Groups of Fishes                                                      | 2-83         |
|     | 2.5.4.9 Species Caught by Commercial or Recreational Fishing                             | 2-92         |
|     | 2.5.4.10 Warm Water Species in San Diego Bay During El Niño Conditions                   |              |
|     | 2.5.4.11 Correlation of Fish Abundance With Environmental Factors                        | 2-93         |
|     |                                                                                          |              |
|     | 2.5.4.12 Possible Sensitive Habitats or Nursery Area for Fish in San Diego B 2.5.5 Birds | 2-94<br>2-94 |
|     | 2.5.6 Marine Mammals                                                                     |              |
|     | 2.5.6.1 Mammals of Interest                                                              | 2-109        |
|     |                                                                                          | 2-110        |
|     | 2.5.6.2 Historical Changes in the Bay                                                    | 2-110        |
|     | 2.5.6.3 Ecological Roles in the Bay                                                      | 2-111        |
|     | 2.5.6.4 Species Accounts                                                                 | 2-111        |
|     | 2.5.7 Exotic Marine and Coastal Species                                                  | 2-113        |
|     | 2.5.7.1 History and Background                                                           | 2-114        |
|     | 2.5.7.2 Species of Interest                                                              | 2-115        |
|     | 2.5.7.3 Sources of Marine and Coastal Exotics                                            | 2-119        |
|     | 2.5.7.4 Ecological and Economic Impacts                                                  | 2-119        |
|     | 2.5.7.5 Potential Invasions of Exotics to San Diego Bay                                  | 2-121        |

| 2.6 Sensitive Species                                                      | 2-122        |
|----------------------------------------------------------------------------|--------------|
| 2.6.1 Federally Listed Species                                             | 2-123        |
| 2.6.1.1 Green Sea Turtle—Chelonia mydas                                    | 2-123        |
| 2.6.1.2 California least tern—Sterna antilarium browni                     | 2-125        |
| 2.6.1.3 Light-footed clapper rail—Rallus longirostris levipes              | 2-130        |
| 2.6.1.4 California brown pelican—Pelecanus occidentalis                    | 2-131        |
| 2.6.1.5 Western snowy plover—Charadrius alexandrinus nivosus               | 2-131        |
| 2.6.1.6 Sand dune tiger beetle—Cicindela latesignata latesignata           | 2-132        |
| 2.6.1.7 Salt marsh bird's beak—Cordylanthus maritimus maritimus            | 2-132        |
| 2.6.2 State Listed Species and Species of Concern                          | 2-133        |
| 2.7 The Ecosystem as a Functional Whole                                    | 2-134        |
| 2.7.1 Ecosystem Attributes                                                 | 2-134        |
| 2.7.2 Physical Structure                                                   | 2-135        |
| 2.7.3 Community Organization                                               | 2-135        |
| 2.7.3.1 Nutrient Cycling                                                   | 2-137        |
| 2.7.3.2 Primary Production                                                 | 2-137        |
| 2.7.3.3 Energy Transfer Through Food Webs                                  | 2-139        |
| 2.7.3.4 Biodiversity                                                       | 2-141        |
| 2.7.4 Disturbance Regimes and Time Scales of Change                        | 2-141        |
| 2.8 State of Ecosystem Health: Information Needs Assessment                | 2-142        |
| 2.8.1 What We Need to Know to Describe Bay Ecosystem Health                | 2-143        |
| 2.8.2 What We Currently Understand About Bay Ecosystem Health              | 2-145        |
| 3.0 State of the Bay—Human Use                                             | 3-1          |
| 3.1 Ecological History of Human Use                                        | 3-3          |
| 3.1.1 Summary of Human Use and Change                                      | 3-3          |
| 3.2 The Bay Region's Human Setting                                         | 3-3          |
| 3.2.1 Area and Population                                                  | 3-7<br>3-7   |
| 3.2.2 Land Use and Ownership                                               | 3-7          |
| 3.2.2.1 Bay Water and Tidelands                                            | 3-8          |
| 3.3 Current Patterns of Use                                                | 3-0<br>3-11  |
|                                                                            |              |
| 3.3.1 Navy Plans and Uses 3.3.2 Port Plans and Uses                        | 3-11<br>3-17 |
| 3.3.3 Local Plans                                                          |              |
| 3.3.4 Recreation and Tourism Uses                                          | 3-19<br>3-19 |
| 3.3.5 Navigation                                                           |              |
| 3.3.6 Fisheries                                                            | 3-20<br>3-20 |
|                                                                            | 3-20<br>3-32 |
| 3.4 Future Patterns and Plans at the Bay                                   |              |
| 3.4.1 Navy                                                                 | 3-32         |
| 3.4.2 Port                                                                 | 3-33         |
| 3.4.3 City Plans                                                           | 3-34         |
| 3.5 Economics of Use                                                       | 3-37<br>3-37 |
| 3.5.1 Navy                                                                 |              |
| 3.5.2 Port                                                                 | 3-38         |
| 3.5.3 Fisheries                                                            | 3-38         |
| 3.5.4 Recreation and Tourism                                               | 3-38         |
| 3.5.5 Other Uses                                                           | 3-39         |
| 3.6 Overview of Government Regulation of Bay Activities 3.6.1 Introduction | 3-39         |
|                                                                            | 3-39         |
| 3.6.2 Federal Agencies and Laws                                            | 3-40         |
| 3.6.3 State Agencies and Laws                                              | 3-43         |
| 3.6.4 Local Agencies and Laws                                              | 3-47         |
| 3.6.5 Project Mitigation Under NEPA and CEQA                               | 3-48         |

# Part III: Management Strategies

| 4.0 Ecosystem Management Strategies                                  | 4-1   |
|----------------------------------------------------------------------|-------|
| 4.1 San Diego Bay's Natural Resource Values and Ecosystem Management | 4-2   |
| 4.2 Habitat Protection and Management                                | 4-2   |
| 4.2.1 Strategy by Habitat                                            | 4-2   |
| 4.2.1.1 Deep Subtidal                                                | 4-2   |
| 4.2.1.2 Moderately Deep Subtidal                                     | 4-6   |
| 4.2.1.3 Unvegetated Shallow Subtidal                                 | 4-7   |
| 4.2.1.4 Vegetated Shallow Subtidal                                   | 4-11  |
| 4.2.1.5 Intertidal Mudflats and Sand Flats                           | 4-14  |
| 4.2.1.6 Salt Marsh                                                   | 4-20  |
| 4.2.1.7 Shoreline and Marine Structures                              | 4-25  |
| 4.2.1.8 Salt Works                                                   | 4-31  |
| 4.2.1.9 Upland Transition                                            | 4-34  |
| 4.2.1.10 River Mouths and Floodplains                                | 4-36  |
| 4.2.2 Mitigation and Enhancement                                     | 4-38  |
| 4.2.3 Protected Sites                                                | 4-52  |
| 4.3 Species Population Protection and Management                     | 4-62  |
| 4.3.1 Exotic Species                                                 | 4-62  |
| 4.3.2 Plankton                                                       | 4-72  |
| 4.3.2.1 Benthic Algae                                                | 4-74  |
| 4.3.2.2 Invertebrates                                                | 4-75  |
| 4.3.3 Fishes                                                         | 4-77  |
| 4.3.3.1 Harvest Management                                           | 4-79  |
| 4.3.3.2 Artificial Propagation                                       | 4-85  |
| 4.3.4 Birds                                                          | 4-89  |
| 4.3.5 Marine Mammals                                                 | 4-96  |
| 4.3.6 Sensitive Species Special Protections                          | 4-100 |
| 4.3.6.1 Green Sea Turtle                                             | 4-100 |
| 4.3.6.2 California Least Tern                                        | 4-105 |
| 4.3.6.3 Light-footed Clapper Rail                                    | 4-108 |
| 4.3.6.4 Western Snowy Plover                                         | 4-109 |
| 4.3.6.5 Salt Marsh Bird's Beak                                       | 4-110 |
| 4.4 Ecosystem Approach                                               | 4-112 |
| 5.0 Compatible Use Strategies                                        | 5-1   |
| 5.1 Within Bay Project Strategies                                    | 5-2   |
| 5.1.1 Dredge and Fill Projects                                       | 5-2   |
| 5.1.2 Ship and Boat Maintenance and Operations                       | 5-17  |
| 5.1.3 Shoreline Construction                                         | 5-26  |
| 5.1.4 Water Surface Use and Shoreline Disturbances                   | 5-34  |
| 5.2 Watershed Management Strategies                                  | 5-42  |
| 5.2.1 The Watershed Management Approach                              | 5-42  |
| 5.2.2 Stormwater Management                                          | 5-45  |
| 5.2.3 Freshwater Inflow Management                                   | 5-52  |
| 5.3 Cleanup of Bay Use Impacts                                       | 5-55  |
| 5.3.1 Remediation of Contaminated Bay Sediments                      | 5-55  |
| 5.3.2 Oil Spill or Hazardous Substance Prevention and CleanUp        | 5-62  |
| 5.4 Cumulative Effects                                               | 5-66  |
| 5.5 Environmental Education                                          | 5-69  |
| 6.0 Monitoring and Research                                          | 6-1   |
| 6.1 Concepts and Models for Monitoring and Research                  | 6-2   |
| 6.1.1 Tenets for Design of a Monitoring and Research Program         | 6-2   |
| 6.1.2 Key Management Questions                                       | 6-3   |
| 6.2 Program Elements                                                 | 6-4   |

| <ul> <li>6.2.1 Long-term Monitoring for the Bay's Ecological Condition and Trend</li> <li>6.2.2 Project Monitoring</li> <li>6.2.3 Research to Support Management Needs</li> <li>6.3 Data Integration, Access, and Reporting</li> </ul> | 6-5<br>6-16<br>6-19<br>6-23                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 7.0 Implementation Strategies                                                                                                                                                                                                          | 7-1                                        |
| 7.1 Achieving Success                                                                                                                                                                                                                  | 7-1                                        |
| 7.2 Components of Implementation                                                                                                                                                                                                       | 7-3                                        |
| 7.2.1 Institutional Resources                                                                                                                                                                                                          | 7-3                                        |
| 7.2.1.1 Existing Organizations                                                                                                                                                                                                         | 7-3                                        |
| 7.2.1.2 Potential New Institutions                                                                                                                                                                                                     | 7-4                                        |
| 7.2.1.3 Mechanisms                                                                                                                                                                                                                     | 7-4                                        |
| 7.2.2 Funding Resources                                                                                                                                                                                                                | 7-6                                        |
| 7.2.2.1 Existing Sources                                                                                                                                                                                                               | 7-7                                        |
| 7.2.2.2 Potential New Sources                                                                                                                                                                                                          | 7-11                                       |
| 7.2.2.3 Volunteer Contributions                                                                                                                                                                                                        | 7-11<br>7-12                               |
| 7.2.3 Priority Setting                                                                                                                                                                                                                 | 7-12<br>7-12                               |
| 7.2.3.1 Criteria for Ranking Priority Strategies 7.2.3.2 Determining Priority Strategies                                                                                                                                               | 7-12<br>7-12                               |
| 7.2.3.3 Scheduling Priorities                                                                                                                                                                                                          | 7-12<br>7-12                               |
| 7.3 Categories of Implementation                                                                                                                                                                                                       | 7-13                                       |
| 7.3.1 Strategies by Implementation Category                                                                                                                                                                                            | 7-13                                       |
| 7.4 TOC Priorities for Year One [still in draft]                                                                                                                                                                                       | 7-14                                       |
| 8.1 Chapter 1 8.2 Chapter 2 8.3 Chapter 3 8.4 Chapter 4 8.5 Chapter 5 8.6 Chapter 6                                                                                                                                                    | 8-1<br>8-2<br>8-16<br>8-18<br>8-26<br>8-33 |
| A Acronyme                                                                                                                                                                                                                             | A-1                                        |
| A. Acronyms                                                                                                                                                                                                                            |                                            |
| B. Glossary                                                                                                                                                                                                                            | B-1                                        |
| C. Oversize Maps                                                                                                                                                                                                                       | C-1                                        |
| D. Comprehensive Species List of San Diego Bay                                                                                                                                                                                         | D-1                                        |
| D.1 References                                                                                                                                                                                                                         | D-27                                       |
| E. Species and Their Habitats                                                                                                                                                                                                          | E-1                                        |
| E.1 References                                                                                                                                                                                                                         | E-32                                       |
|                                                                                                                                                                                                                                        | 202                                        |
| F. Narratives on Sensitive Species Not Listed Under Foderal or State Endangered Species Acts                                                                                                                                           | F-1                                        |
| Species Not Listed Under Federal or State Endangered Species Acts                                                                                                                                                                      |                                            |
| G. Ecological History of San Diego Bay                                                                                                                                                                                                 | G-1                                        |
|                                                                                                                                                                                                                                        |                                            |

H-24

| H. Draft Policies for Protection of Intertidal Flats and Unvegetated Shallows      | , васк-     |
|------------------------------------------------------------------------------------|-------------|
| ground Paper on Habitat Values of Unvegetated Shallows, and Current Soutl          | hern Cal-   |
| fornia Eelgrass Mitigation Policy                                                  | H-1         |
| H.1 Proposed Policy to Protect Southern California Intertidal Flat Habitat of Bays | s and Estu- |
| aries (Modeled After Existing Eelgrass Mitigation Policy)                          | H-3         |
| H.2 Proposed Policy to Protect Unvegetated Shallows of Southern California Bay     | s and Estu- |
| aries (Modeled After Existing Southern California Eelgrass Mitigation Policy)      | H-10        |
| H.3 Background Paper on Soft-Bottom Shallow Subtidal Functions, Values, and R      | esponse to  |
| Disturbance: A Basis of Policy Development                                         | H-15        |
| H.4 Southern California Eelgrass Mitigation Policy (Adopted July 31, 1991)         | H-21        |

**H.5 References** 

# **List of Figures**

| 1-1.  | Roles of Plan Collaborators.                                                                                                                                        | 1-13  |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1-2.  | Relationship of Planning Terms and Strategy, from Broad to Specific.                                                                                                | 1-21  |
| 2-1.  | Percent Total Copper Loading to San Diego Bay.                                                                                                                      | 2-19  |
| 2-2.  | Percent Total PAH Loading to San Diego Bay.                                                                                                                         | 2-19  |
| 2-3.  | Habitat Definitions Used in this Plan in Relation to Tidal Elevation.                                                                                               | 2-27  |
| 2-4.  | Eelgrass Bed.                                                                                                                                                       | 2-34  |
| 2-5.  | Intertidal Area Exposed Annually in San Diego Bay (1999).                                                                                                           | 2-36  |
| 2-6.  | Intertidal Flat Community.                                                                                                                                          | 2-37  |
| 2-7.  | Intertidal Salt Marsh—Subtidal Interface.                                                                                                                           | 2-40  |
| 2-8.  | Vegetation Patterns in Salt Marsh and Upland Transition Habitats.                                                                                                   | 2-43  |
| 2-9.  | Artificial Shoreline Environment.                                                                                                                                   | 2-46  |
| 2-10. | Typical Diversity and Abundance of Life in Riprap Compared to a Tide Pool.                                                                                          | 2-50  |
| 2-11. | The Beach Environment.                                                                                                                                              | 2-53  |
| 2-12. | Abundance of Fishes in San Diego Bay by Station, 1994–1997.*                                                                                                        | 2-80  |
| 2-13. | Biomass of Fishes in San Diego Bay by Station, 1994–1997.                                                                                                           | 2-80  |
| 2-14. | Comparison of Fish Density in Vegetated and Nonvegetated Samples. *Statistically significant differences.                                                           | 2-80  |
| 2-15. | Fish Density without SS Vegetated vs. Nonvegetated Sites. *Statistically significant differences.                                                                   | 2-80  |
| 2-16. | Abundance of Fishes in San Diego Bay by Sampling Period.                                                                                                            | 2-81  |
| 2-17. | Biomass of Fishes in San Diego Bay by Sampling Period.                                                                                                              | 2-81  |
| 2-18. | Patterns of abundance (left) and biomass (right) of the 10 most common fishes sampled from the northern and southern halves of San Diego Bay (based on Allen 1997). | 2-83  |
| 2-23. | Comparison of Fish Biomass Density in Vegetated and Nonvegetated Samples.*<br>Statistically significant differences.                                                | 2-89  |
| 2-24. | Foraging Habitat Partitioning by Birds of San Diego Bay. Dabbling Ducks Forage in Brackish Water, Unrelated to Tidal Elevation.                                     | 2-97  |
| 2-25. | First Records of Marine Non-native Species in San Diego Bay.                                                                                                        | 2-114 |
| 2-26. | Population Trend in the California Least Tern.                                                                                                                      | 2-129 |
| 2-27. | Mean Annual Fledging Success for Least Tern Nesting Sites in San Diego Bay and Vicinity.*                                                                           | 2-129 |
| 2-28. | Mean Number of California Least Tern Nests in San Diego Bay and Vicinity, 1994–1997.                                                                                | 2-129 |
| 2-29. | Factors Affecting Abundance and Diversity of Birds in San Diego Bay.                                                                                                | 2-136 |
| 2-30. | Simplified San Diego Bay Food Web.                                                                                                                                  | 2-138 |
| 2-31. | This Simplified Food Web Represents Trophic Levels From Producers to a Top Predator, Such as a Harbor Seal.                                                         | 2-140 |
| 3-1.  | Historic Painting of San Diego Bay by John Stobbart.                                                                                                                | 3-4   |
| 3-2.  | Regulatory Jurisdictions for In-water Projects in San Diego Bay (For Tidal Definitions, See Figure 2-3).                                                            | 3-41  |
| 3-3.  | Typical Project Processing Flow Chart.                                                                                                                              | 3-49  |
| 3-4.  | Comparison of CEQA and NEPA Review Processes (From Bass et al. 1999).                                                                                               | 3-51  |
| 5-1.  | Contaminated Sediment Remedial Actions Flowchart (After Barker 1990).                                                                                               | 5-59  |
| 6-1.  | Monitoring and Research Program Elements to Support Management Decisions.                                                                                           | 6-4   |
| 6-2.  | Sample State of San Diego Bay Annual Report.                                                                                                                        | 6-25  |

# **List of Tables**

| 1-1.  | Planning Definitions.                                                                                                                                         | 1-21  |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2-1.  | Estimated trends in total fluvial sediment delivery to San Diego Bay (Smith 1976).                                                                            | 2-4   |
| 2-2.  | Comparison of Known Wastes Discharged into San Diego Bay, 1955 and 1966.                                                                                      | 2-17  |
| 2-3.  | San Diego Bay: Comparison of Current and Historic Habitat Acreages.                                                                                           | 2-24  |
| 2-4.  | Genera and Species of Phytoplankton Reported to Occur in San Diego Bay.                                                                                       | 2-59  |
| 2-5.  | Rank Order of Abundance of Zooplankton.                                                                                                                       | 2-62  |
| 2-6.  | South Bay Invertebrate Sampling.                                                                                                                              | 2-69  |
| 2-7.  | Ranking of Top Ten "Ecological Index" Fish Species in San Diego Bay                                                                                           | 2-78  |
| 2-8.  | Total Number of Individuals and Biomass (g) of Fish Species Captured in the North Bay (Station 1), July 1994–April 1997.                                      | 2-84  |
| 2-9.  | Total Number of Individuals and Biomass (g) of Fish Species Taken at the North-Central Bay (Station 2), July 1994–April 1997.                                 | 2-85  |
| 2-10. | Total Number of Individuals and Biomass (g) of Fish Species in the South-Central Bay (Station 3), July 1994–April 1997.                                       | 2-86  |
| 2-11. | Total Number of Individuals and Biomass (g) of fish Species Taken at the South Bay (Station 4), July 1994–April 1997.                                         | 2-87  |
| 2-12. | Species Closely Associated with Eelgrass Beds.                                                                                                                | 2-87  |
| 2-13. | San Diego Bay Fish Taken in Subtidal Eelgrass Bed Habitat.                                                                                                    | 2-88  |
| 2-14. | San Diego Bay Fish Species Taken in Subtidal Unvegetated, Unconsolidated Sediment Habitat.                                                                    | 2-88  |
| 2-15. | San Diego Bay Fish Species Taken in Deep Subtidal Habitats.                                                                                                   | 2-90  |
| 2-16. | Fish Species Associated with Artificial Habitats in San Diego Bay.                                                                                            | 2-91  |
| 2-17. | Indigenous Bay-estuarine Species.                                                                                                                             | 2-91  |
| 2-18. | Fish Species of San Diego Bay Taken by Recreational and Commercial Fishermen.                                                                                 | 2-93  |
| 2-19. | Historic Changes in Bay Bird Populations.                                                                                                                     | 2-96  |
| 2-20. | Comparison of Three Concurrent Surveys of Bay Avifauna Conducted in 1993, and One 1994 Survey of Central Bay.                                                 | 2-98  |
| 2-21. | Cumulative Observations of the Most Abundant Waterfowl.,                                                                                                      | 2-103 |
| 2-22. | Cumulative Observations of the Most Abundant Shorebirds.                                                                                                      | 2-105 |
| 2-23. | Cumulative Observations of the Most Abundant Sea Birds.                                                                                                       | 2-106 |
| 2-24. | Cumulative Observations of Herons and Egrets.                                                                                                                 | 2-107 |
| 2-25. | Nesting/Breeding Areas of Bay Bird Species (and Number of Nests or Pairs Where Reported).                                                                     | 2-109 |
| 2-26. | List of Exotic Marine Animals Found in San Diego Bay, Their Probable Source, Problems, or Effects Caused, and Other Comments.                                 | 2-115 |
| 2-27. | Exotic Coastal Plants at San Diego Bay.                                                                                                                       | 2-118 |
| 2-28. | Sensitive Species, Their Habitats and Risk Factors in San Diego Bay.                                                                                          | 2-122 |
| 2-29. | Colony Sizes, Reproduction, and Fledging Success at Least Tern Nesting Sites in San Diego Bay, Mission Bay, and Tijuana Slough.                               | 2-130 |
| 2-30. | Information Needs for Ecosystem Management of San Diego Bay.                                                                                                  | 2-144 |
| 3-1.  | San Diego Bay Tidelands by Ownership (uncorrected for approximately 1490 acres of land and water transferred from private and state holdings to USFWS, 1999). | 3-8   |
| 3-2.  | Natural Resource Management Plans and Approval Dates for the San Diego Bay Area.                                                                              | 3-12  |
| 3-3.  | US Navy, US Coast Guard, and US Marine Corps Uses of San Diego Bay by Organization.                                                                           | 3-15  |
| 3-4.  | San Diego Bay Port Master Plan Water Use Mapping Definitions, as Seen in Map 3-4.                                                                             | 3-18  |
| 3-5.  | Boat Traffic Patterns.                                                                                                                                        | 3-29  |

| 3-6.  | Boat Traffic Patterns.                                                                                                                                          | 3-30   |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| 3-7.  | Future Navy Plans for In-water Projects.                                                                                                                        | 3-33   |
| 3-8.  | Proposed Capital Improvement Program Projects for Port's Tidelands, 1999–2008, Pertinent to this INRMP                                                          | . 3-37 |
| 3-9.  | Uniform Tourist Tax Collections, FYs 1988-1996, for Cities in San Diego Bay Region.                                                                             | 3-39   |
| 3-10. | Federal Agencies with Responsibilities for Natural Resources in San Diego Bay.                                                                                  | 3-42   |
| 3-11. | State Agencies with Responsibilities for Natural Resources in San Diego Bay.                                                                                    | 3-44   |
| 3-12. | Local Agencies with Responsibilities for Natural Resources in San Diego Bay.                                                                                    | 3-47   |
| 3-13. | Examples of Marine Impact Mitigations Described for Recent Bay Projects (Based on EIRs, EISs, and EAs).                                                         | 3-53   |
| 4-1.  | Salt Marsh Mitigation Standards.                                                                                                                                | 4-22   |
| 4-2.  | Attributes That Should be Researched to Determine Their Level of Importance, Practicality, and Cost-effectiveness for Use as a Performance Measure.             | 4-47   |
| 4-3.  | Possible Enhancement Opportunity Areas.                                                                                                                         | 4-49   |
| 4-4.  | In-water Project Preplanning Checklist                                                                                                                          | 4-51   |
| 4-5.  | Marine and Coastal Habitat Areas in San Diego Bay That are Designated for Some Level of Protection from Development [table to be completed to include changes]. | 4-53   |
| 4-6.  | State Marine Protection Area (MPA) Options: Intent, Methods, Examples.                                                                                          | 4-60   |
| 4-7.  | Sport Fishing Limits on Fish and Invertebrate Species of San Diego Bay (CDFG 1997).                                                                             | 4-81   |
| 4-8.  | Recreational Angler Catch Sampling List of Major Species for Inland Marine San Diego County, 1993–1998                                                          | 3.4-82 |
| 4-9.  |                                                                                                                                                                 | 4-115  |
| 5-1.  | Summary of Existing and Potential Dredging Projects and Disposal Methods since 1988.                                                                            | 5-4    |
| 5-2.  | Provisions of the CCA Relevant to Dredge Disposal.                                                                                                              | 5-7    |
| 5-3.  | Biological Effects of Various Dredging Methods Available in San Diego Bay.                                                                                      | 5-12   |
| 5-4.  | Bay Surface Area Occupied by Fixed Structures (Docks, Piers, Wharves) and by Ships and Boats Using these Sites.                                                 | 5-28   |
| 5-5.  | Quantity and Type of Bay Habitat Surface Covered by Docks, Piers, Wharves, and Docked Ships and Boats at Maximum Use.                                           | 5-28   |
| 5-6.  | Projected Net Gain or Loss in Bay Coverage from Navy Wharves, Piers, and Floating Docks.                                                                        | 5-29   |
| 5-7.  | Totals and Averages for Specific Disturbance Types for the Entire South Bay Study Area.                                                                         | 5-40   |
| 5-8.  | Percentage of Birds Sampled Avoiding Survey Boat by Distance Category in Central San Diego Bay.                                                                 | 5-40   |
| 5-9.  | Federal and State Statutes Affecting Management of Contaminated Sediment.                                                                                       | 5-57   |
| 6-1.  | Priority Monitoring Parameters Agreed Upon by the San Diego Bay Interagency Water Quality Panel.                                                                | 6-7    |
| 6-2.  | Examples of the Proposed Use of Ecological Indicators to Learn about San Diego Bay's Condition and Tren                                                         | d 6-9  |
| 6-3.  | Priority Long-term Monitoring Parameters.                                                                                                                       | 6-12   |
| 6-4.  | List of Candidate Target Species for Supporting Long-term Monitoring (and for Project Planning).                                                                | 6-14   |
| 6-5.  | Research (or Pre-research) Interests Identified by TOC (April 21, 1999).                                                                                        | 6-20   |
| 7-1.  | Existing Institutions to Implement the Plan (TOC Members Noted with *).                                                                                         | 7-3    |
| 7-2.  | New Organization Options for Plan Implementation.                                                                                                               | 7-5    |
| 7-3.  | Examples of Formal and Informal Institutional Mechanisms for Implementation.                                                                                    | 7-6    |
| 7-4.  | Available Primary Funding Sources for Plan Implementation.                                                                                                      | 7-7    |
| 7-5.  | Ideas for New Funding Sources for Bay Ecosystem Management.                                                                                                     | 7-11   |
| 7-6.  | General Strategies by Implementation Category [to be completed].                                                                                                | 7-13   |
| E-1.  | Plant Species and Their Habitats.                                                                                                                               | E-3    |
| E-2.  | San Diego Invertebrate Habitats.                                                                                                                                | E-9    |
| E-3.  | San Diego Bay Fishes: Their Habitat and Feeding Strategies.                                                                                                     | E-21   |
| E-4.  | San Diego Bay Birds: Their Diet, Status, and Habitat.                                                                                                           | E-26   |
| G-1.  | Ecological History of San Diego Bay.                                                                                                                            | G-3    |

# **List of Maps**

| 1-1.          | San Diego Bay, the "Conceptual Watershed Influence Zone," in the Southern California Bight.        | 1-7   |
|---------------|----------------------------------------------------------------------------------------------------|-------|
| 1-2.          | San Diego Bay INRMP Footprint and Functional Planning Zone.                                        | 1-9   |
| 1-3.          | San Diego Bay INRMP Functional Planning Footprint and Conceptual Watershed Influence Zone.         | 1-11  |
| 2-1.          | Recent Topography of San Diego Bay Floor.                                                          | 2-5   |
| 2-2.          | Cumulative History of Dredge and Fill Activity in San Diego Bay.                                   | 2-7   |
| 2-3.          | Percent Fine Sediments (Silt and Clay) on the Bay Floor.                                           | 2-9   |
| 2-4.          | Half-life of Water Residing in the Bay with Different Tidal Amplitudes.                            | 2-13  |
| 2-5.          | San Diego Bay Benthic Community Quality Analysis.                                                  | 2-25  |
| 2-6.          | Salt Marsh and Upland Transition Adjacent to San Diego Bay.                                        | 2-41  |
| 2-7.          | Shoreline Structures of San Diego Bay.                                                             | 2-47  |
| 2-8.          | Relative Abundance of Birds Based on Three Surveys Conducted in 1993–1994.                         | 2-99  |
| 2-9.          | Biodiversity of Birds Based on Three Surveys Conducted in 1993-1994.                               | 2-101 |
| 2-10.         | Least Tern Foraging and Nesting Areas in San Diego Bay.                                            | 2-127 |
| 3-1.          | San Diego Bay Historic Habitat Footprint (1859), with Current Shoreline Overlay.                   | 3-5   |
| 3-2.          | San Diego Bay Regional Land Use.                                                                   | 3-9   |
| 3-3.          | Local Planning Jurisdictions of San Diego Bay Environs.                                            | 3-13  |
| 3-4.          | San Diego Bay Port Jurisdiction Master Plan Water Use Designations.                                | 3-21  |
| 3-5.          | San Diego Bay Marinas, Docks, and Public Recreational Areas.                                       | 3-23  |
| 3-6.          | San Diego Bay Water Navigation Systems and Restricted Areas.                                       | 3-25  |
| 3-7.          | Boat Traffic Patterns on San Diego Bay (Refer to Table 3-6 for Detailed Explanations of this Map). | 3-27  |
| 3-8.          | San Diego Bay US Naval Facilities and Planned Capital Improvements Summary (1997–2002).            | 3-35  |
| 4-1.          | Past Mitigation Projects in San Diego Bay.                                                         | 4-45  |
| 4-2.          | Protected Marine and Coastal Habitat in San Diego Bay—1998.                                        | 4-57  |
| 5-1.          | San Diego Bay Oil Spills Reported to US Coast Guard (1993–1996).                                   | 5-63  |
| C-1.          | Habitats of San Diego Bay.                                                                         | C-3   |
| C-2.          | Mean Numerical Density of All Fish Species January Samples, 1994-1997.                             | C-5   |
| C-3.          | Mean Numerical Density of All Fish Species July Samples, 1994-1997.                                | C-7   |
| C-4.          | Mean Biomass Density of All Fish Species January Samples, 1994-1997.                               | C-9   |
| C-5.          | Mean Biomass Density of All Fish Species July Samples, 1994-1997.                                  | C-11  |
| C- <b>6</b> . | Potential Restoration and Enhancement Projects in San Diego Bay.                                   | C-13  |
|               |                                                                                                    |       |

\_\_\_\_\_\_

# **List of Photos**

| 1-1.         | Aerial Photo of San Diego Bay Region.                                                                            | 1-3   |
|--------------|------------------------------------------------------------------------------------------------------------------|-------|
| 1-2.         | San Diego Bay.                                                                                                   | 1-18  |
| 2-1.         | South Bay Mudflat Adjoining Northernmost Levee of Salt Works.                                                    | 2-1   |
| 2-2.         | Sea Lions Napping on Buoy.                                                                                       | 2-28  |
| 2-3.         | Birds Rafting.                                                                                                   | 2-30  |
| 2-4.         | Ray.                                                                                                             | 2-31  |
| 2-5.         | Eelgrass bed.                                                                                                    | 2-34  |
| 2-6.         | Small Mudflat Adjacent to Delta Beach, Showing Sediment Churned Up At High Tide (1998).                          | 2-38  |
| 2-7.         | Mudflat of South Bay.                                                                                            | 2-39  |
| 2-8.         | Invertebrate in Riprap.                                                                                          | 2-49  |
| 2-9.         | Salt Works.                                                                                                      | 2-51  |
| 2-10.        | Sand Hummocks with Ambrosia Chamissonis.                                                                         | 2-54  |
| 2-11.        | Dune Vegetation in Flower.                                                                                       | 2-55  |
| 2-12.        | Sweetwater Channel.                                                                                              | 2-57  |
| 2-13.        | Wandering Sponge (Tetilla mutabilis) with the Ectoprot Zoobotryon verticillatum and Algae, Including Gracilaria. | 2-71  |
| 2-14.        | Anemones and Tube-forming Polychaete Worms Living on Man-made Surface (Sunken Boat).                             | 2-73  |
| 2-15.        | Killifish.                                                                                                       | 2-75  |
| 2-16.        | Belding's Savannah Sparrow on Pickleweed.                                                                        | 2-134 |
| 3-1.         | San Diego Bay Pier.                                                                                              | 3-1   |
| 3-2.         | Aerial Photos of San Diego Bay 1928.                                                                             | 3-2   |
| 3-3.         | North Island 1936.                                                                                               | 3-4   |
| 3-4.         | US Navy Cruiser and Destroyer.                                                                                   | 3-12  |
| 3-5.         | San Diego Bay.                                                                                                   | 3-17  |
| 3-6.         | Bait for Fishing Available in the Bay.                                                                           | 3-31  |
| 3-7.         | City of San Diego.                                                                                               | 3-33  |
| 4-1.         | Egret at Low Tide.                                                                                               | 4-1   |
| 4-2.         | Bay Traffic.                                                                                                     | 4-3   |
| 4-3.         | "Crater" Produced by a Tube Worm or Bivalve Mollusk.                                                             | 4-8   |
| 4-4.         | Eelgrass Bed.                                                                                                    | 4-12  |
| 4-5.         | Mudflat.                                                                                                         | 4-15  |
| 4-6.         | San Diego Bay Salt Marsh.                                                                                        | 4-21  |
| <b>4</b> -7. | Black skimmers on Salt Works Levee.                                                                              | 4-31  |
| 4-8.         | Planting Eelgrass.                                                                                               | 4-38  |
| 4-9.         | Black-necked Stilt.                                                                                              | 4-42  |
| 4-10.        | Heron Park Sign at NASNI.                                                                                        | 4-52  |
| 4-11.        | Heron.                                                                                                           | 4-89  |
| 4-12.        | Green Sea Turtle.                                                                                                | 4-100 |
| 4-13.        | California Least Tern.                                                                                           | 4-105 |
| 5-1.         | Coronado Bridge Over San Diego Bay.                                                                              | 5-1   |
| 5-2.         | Dredging in San Diego Bay.                                                                                       | 5-3   |
| 5-3.         | Sailing on San Diego Bay.                                                                                        | 5-26  |

### 5-4. Boat Ramp with Riprap. 5-28 5-5. Waterbirds of the Bay. 5-34 5-6. Jet Skier with Navy Carrier. 5-35 5-7. Waterbirds and Boats on San Diego Bay. 5-37 5-67 5-8. Riprap Armoring near Coronado Cays. Arctic Tern. 6-1. 6-1 Shells of San Diego Bay. 7-1 7-1.