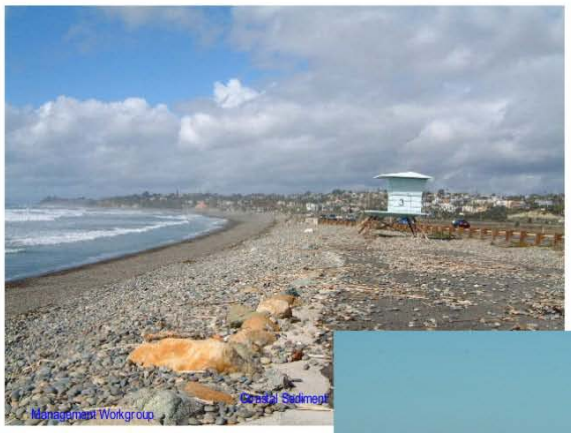
DRAFT

REVIEW OF SEDIMENT MANAGEMENT IMPACTS AND ISSUES RELEVANT TO PROTECTION OF CALIFORNIA COASTAL BIOTA

VOLUME 2: USER'S GUIDE AND RESOURCE PROTECTION GUIDELINES



Prepared in Support of the:

CALIFORNIA SEDIMENT MANAGEMENT MASTER PLAN

Coastal Sediment Management Workgroup

Prepared for:

California Coastal Sediment Management Workgroup
Monterey Bay National Marine Sanctuary

National Marine Sanctuaries
Monterey Bay

In coordination with:

U. S. Army Corps of Engineers

Prepared by:

Science Applications International Corporation

SAIC
From Science to Solutions

Under Contract to:

Beach Erosion Authority for Clean Oceans and Nourishment

B.E.A.C.O.N.

DISCLAIMER:

CSMW is making this document available in its draft form to enable interested parties to view the study results. CSMW is currently pursuing peer review of this document, which will be finalized after such review. Until such time, CSMW makes no warranties, expressed or implied, regarding the data contained herein.

REVIEW OF SEDIMENT MANAGEMENT IMPACTS AND ISSUES RELEVANT TO PROTECTION OF CALIFORNIA COASTAL BIOTA

Volume 2
USER'S GUIDE AND
RESOURCE PROTECTION GUIDELINES

Prepared In Support Of:

CALIFORNIA SEDIMENT MANAGEMENT MASTER PLAN

Prepared For:

California Coastal Sediment Management Workgroup
And
National Oceanic and Atmospheric Administration
Monterey Bay National Marine Sanctuary

In Coordination With:
U.S. Army Corps of Engineers, Los Angeles District

Under Contract To:
Beach Erosion Authority for Clean Oceans and Nourishment

Prepared by:

Science Applications International Corporation
Contact:
Karen Green

2012

This Page Intentionally Blank

TABLE OF CONTENTS

LIST OF FIGURES ix
LIST OF TABLES x

ACRONYMS A-1
1.0 INTRODUCTION 1-1
1.1 Background 1-2
1.2 User Guide Organization and Uses 1-5

2.0 RELEVANT BACKGROUND INFORMATION 2-1
2.1 Overview of Coastal Zone Terminology and Biological Habitats 2-1
2.2 Overview of Sediment Management Locations 2-7
2.3 Overview of Types of Sediment Management Activities and Methods 2-11
2.3.1 Pre-Construction Phase 2-11
2.3.2 Construction Phase 2-11
2.3.3 Post-Construction Phase 2-14
2.3.4 Mitigation and Monitoring 2-15
2.4 Overview of Coastal Environmental Conditions Relevant to Sediment Management Activities 2-15
2.4.1 Natural Sediment Supply and Sinks 2-16
2.4.2 Currents, Tides, and Waves 2-16
2.4.3 Upwelling and Downwelling 2-22
2.4.4 Climate Oscillation Patterns 2-22
2.4.5 Water Quality 2-25
2.5 Overview of CEQA/NEPA Impact Assessment Considerations 2-30
2.5.1 CEQA/NEPA Document 2-30
2.5.2 Types of Impacts 2-31
2.5.3 Significance Criteria 2-33
2.5.4 Threatened or Endangered Species Consultations 2-34
2.5.5 Essential Fish Habitat Consultations 2-35
2.6 Overview of Applicable Laws and Regulations 2-36
2.6.1 Federal Environmental Regulations 2-39
2.6.2 State Environmental Regulations 2-44
2.6.3 Water Quality Standards 2-46
2.7 Overview of Potential Biological Impacts Associated with Sediment Management Activities 2-50
2.7.1 Equipment and Disturbance 2-50
2.7.2 Burial and Disturbance 2-55
2.7.3 Sediment Reworking and Sand Transport 2-57
2.7.4 Sediment and Water Quality 2-59
2.7.5 Turbidity 2-61

2.7.6 Environmental Effects of Turbidity and Sedimentation 2-78
2.8 Mitigation and Monitoring Considerations.....2-89
2.8.1 Ecosystem and Species Monitoring Considerations.....2-91
2.8.2 Types of Monitoring and Management Questions 2-93

3.0 RESOURCE PROTECTION GUIDELINES..... 3-1
3.1 Guideline Organization and Format 3-1
3.2 Cross-Reference Summaries of Sediment Managemnt Activities, Impacts, and Potential Mitigation Measures..... 3-4
3.2.1 Impact Considerations 3-4
3.2.2 Mitigation Considerations..... 3-5
3.2.3 List of Resource Protection Guidelines 3-7
3.3 Resource Protection Guidelines for Habitats and Resources Where Sediment Management Occurs 3-8
3.3.1 Sandy Beach Habitat 3-9
Sand Compatibility Guideline 3-17
Beach Water Quality Guideline 3-21
Beach Invertebrate Recovery Guideline.....3-27
Beach Wrack Guideline.....3-29
Clam Bed Guideline 3-31
Grunion Habitat Assessment Guideline.....3-33
Grunion Spawning Guideline.....3-35
California Least Tern Guideline.....3-38
Western Snowy Plover Guideline.....3-41
California Brown Pelican Guideline.....3-44
Migratory Bird Guideline.....3-46
3.3.2 Sandy Subtidal Habitat.....3-48
Nearshore Water Quality Guideline.....3-54
Subtidal Invertebrate Recovery Guideline 3-59
Marine Mammal Guideline 3-62
3.3.3 Embayment Habitats.....3-66
Embayment Water Quality Guideline 3-75
Aquatic Invasive Species Guideline 3-81
Dungeness Crab Guideline 3-83
Green Sturgeon Guideline 3-85
Pacific Herring Guideline.....3-89
Salmonid Guideline.....3-91
Clapper Rail Guideline 3-93
3.4 Resource Protection Guidelines for Sensitive Habitats in the Vicinity of Sediment Management Activities.....3-95
3.4.1 Coastal Dune or Strand Habitat 3-96
Coastal Dune or Strand Vegetation Guideline.....3-101
3.4.2 Hard Substrate Habitats.....3-103
Hard-Bottom Habitat Assessment Guideline 3-113
Rocky Intertidal HAPC Guideline 3-116
Rocky Subtidal HAPC Guideline 3-119

Kelp Forest HAPC Guideline 3-121
Surfgrass HAPC Guideline 3-125
3.4.3 Eelgrass Meadow 3-128
Eelgrass HAPC Guideline 3-133

4.0 PREPARERS AND PARTICIPANTS 4-1

5.0 LITERATURE CITED 5-1

APPENDIX A – IMPACT AND MITIGATION SUMMARY TABLES

LIST OF FIGURES

2.1-1 Cross-reference between coastal terminology and biological habitat boundaries 2-2
2.2-2 Locations of potential future sediment management activities in northern California 2-8
2.2-3 Locations of potential future sediment management activities in central California 2-9
2.2-4 Locations of potential future sediment management activities in southern California 2-10
2.4-1 Sediment sources, movement, and sediment sinks in the coastal zone 2-16
2.4-2 Diagram of the beach shorezone and associated coastal features 2-17
2.4-3 Example of seasonal difference in summer and winter beach profiles 2-17
2.4-4 Littoral cells and estimated erosion rates offshore California 2-18
2.4-5 Example of seasonal beach change on Leucadia Beach prior to sand nourishment and condition of beach after nourishment 2-19
2.4-6 Natural suspended sediment concentrations in coastal habitats 2-26
2.7-1 Comparison of representative TSS concentrations and turbidity plume lengths during sand placement relevant to ambient conditions 2-63
2.7-2 Representative water clarity, turbidity, and TSS measurements during beach sand placement 2-64
2.7-3 Representative water clarity, turbidity, and TSS measurements during nearshore placement 2-67
2.7-4 Maximum total suspended sediment concentrations measured around commonly used mechanical and hydraulic dredges 2-70
2.7-5 Comparison of TSS concentrations (mg/L) within 1,000 ft (305 m) of bucket, cutterhead, and hopper dredges with and without overflow 2-74
2.7-6 Representative water clarity, turbidity, and TSS measurements during harbor dredging 2-75

2.7-7 Representative water clarity and turbidity measurements during offshore borrow site dredging 2-76
2.7-8 Dredge plume suspended sediment concentrations relative to ambient conditions 2-77
2.7-9 Total suspended solids effects data for species relevant to California beach nourishment, offshore borrow site, or maintenance dredging projects 2-84
3.3-1 Flow chart to sandy beach habitat resource protection guidelines 3-16
3.3-2 Flow chart to sandy subtidal habitat resource protection guidelines 3-53
3.3-3 Flow chart to embayment habitat resource protection guidelines 3-74

LIST OF TABLES

1.1-1 Biological Impacts Analysis Volume 1 goals and objectives 1-3
1.1-2 List of useful information sources relevant to sediment management projects and California resources 1-4
1.1-3 Cross- reference of section in the Volume 2 User's Guide with more detailed discussions in Volume 1 BIA reference document 1-6
2.1-1 Cross-reference between coastal habitats, shorezone terminology, and locations relative to beach depth of closure 2-5
2.1.2 Regulatory status and associated habitats for special-interest species and general biological resource categories 2-6
2.4.1 Sea-level rise projections using 2000 as the baseline condition 2-24
2.4-2 Total suspended solids concentrations during storms, high waves, or river runoff in bays and the nearshore zone 2-27
2.6-1 Agencies involved with review and/or approval of sediment management projects 2-38
2.6-2 Condensed summary of Ocean Plan water quality objectives 2-47
2.6-3 Ocean Plan effluent limitations 2-48
2.6-3 Bacteria water-contact and shellfish harvesting standards 2-48
2.6-5 Numeric water quality objectives for enclosed bays and estuaries 2-49
2.7-1 Construction noise levels 2-53
2.7-2 Noise disturbance and injury guidelines 2-53
2.7-3 Reported suspended sediment concentrations and plume lengths during beach nourishment 2-62
2.7-4 Locations of suspended sediment during dredging 2-69
2.7-5 General characteristics of suspended sediment concentrations (mg/L) within 1,000 ft (305 m) of commonly used dredge types 2-73
2.7-6 Summary of laboratory effects data in relation to exposure concentrations and durations associated with dredging 2-82
2.7-7 Summary statistics for total suspended sediments (mg/L) effects concentrations for fish and invertebrates 2-82

2.7-8 List of marine and estuarine species with available suspended sediment dose-response data, which were considered most relevant to beach nourishment related activities 2-83
2.7-9 Reported responses to sedimentation for representative aquatic plant, fish, and invertebrate species that occur in California 2-88
3.1-1 Topics addressed in habitat descriptions or resource protection guidelines 3-3
3.2-1 Cross-reference summary of sediment management impact considerations by type of activity for coastal habitats and resources 3-4
3.2-2 Types of mitigation measures with demonstrated and/or likely effectiveness to protect biological resources during sediment management activities 3-6
3.2-3 List of guidelines and habitats to which they may apply 3-7
3.3-1 Impact factors and resource disturbance issues - habitats where sediment management occurs 3-8
3.3-2 Generalized comparison of beach substrate type and seasonal habitat uses..... 3-11
3.4-1 Impact factors and resource disturbance issues - sensitive habitats 3-95

This Page Intentionally Blank

ACDP	Acoustic-Doppler Current Profiler
AIS	Aquatic invasive species
ASBS	Areas of Special Biological Significance
BA	Biological Assessment
BCDC	Bay Conservation and Development Commission
BECA	Beach Erosion Concern Area
BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BIA	Volume 1, Biological Impacts Analysis
BMPs	Best Management Practices
BO	Biological Opinion
Caltrans	California Department of Transportation
CANOD	California Aquatic Non-native Organism Database
CCA	California Coastal Act
CCC	California Coastal Commission
CD	Consistency Determination
CDP	Coastal Development Permit
CDFG	California Department of Fish and Game
CDHS	California Department of Health Services
CEQ	Council of Environmental Quality
CEQA	California Environmental Quality Act
CERES	California Environmental Resources Evaluation System
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CGS	California Geological Survey
cm	Centimeter
CMANC	California Marine Affairs and Navigation Conference
CMLR	California Marine Life Refuge
CNPS	California Native Plant Society
CNRA	California Natural Resources Agency
CRSMP	Coastal Regional Sediment Management Plan
CSLC	California State Lands Commission
CSMW	California Coastal Sediment Management Workgroup
cy	Cubic yards
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
dB	Decibel
dBA	A-weighted decibel
DBW	Department of Boating and Waterways
DO	Dissolved oxygen
DPR	Department of Parks and Recreation
DPS	Distinct Population Segment
EA	Ecological Assessment

EFH	Essential Fish Habitat
EHW	Extreme high water spring tide
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELW	Extreme low waters spring tide
ENSO	El Niño Southern Oscillation
ESA	Endangered Species Act
ESHA	Environmentally Sensitive Habitat Area
ESU	Evolutionary Significant Units
FE	Federal endangered species
FGC	Fish and Game Code
FMP	Fishery Management Plan
FONSI	Findings of No Significant Impacts
FP	Fully protected species
FT	Federal threatened species
ft_H	Feet
ft/sec	Feet per second
FWCA	Fish and Wildlife Coordination Act
HAPC	Habitat area of particular concern
H_{sat}	Hours of irradiance-saturated photosynthesis
HTL	High tide line
in	Inch
ITM	Inland Testing Manual
JTU	Jackson turbidity unit
kg/m^3	Kilogram per cubic meter
km	Kilometer
LEDPA	Least environmentally damaging practicable alternative
LiDAR	Light Detection and Ranging
LTMS	Long Term Management Strategy (San Francisco Bay)
m	Meter
MBNMS	Monterey Bay National Marine Sanctuary
MBTA	Migratory Bird Treaty Act
mg	Milligram
mg/L	Milligrams/liter
MHW	Mean high water
MHHW	Mean higher high water
ml	Milliliter
MLW	Mean low water
MLLW	Mean lower low water
MLPA	Marine Life Protection Act
mm	Millimeter
MMPA	Marine Mammal Protection Act

MMRP	Mitigation, Monitoring, and Reporting Program
MMS	Minerals Management Service
MND	Mitigated Negative Declaration
MOA	Memorandum of agreement
MOU	Memorandum of understanding
MP	Marine Preserve
MPA	Marine Protected Area
MPN	Most probable number
MPRSA	Marine Protection, Research, and Sanctuaries Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean sea level
ND	Negative Declaration
NEPA	National Environmental Policy Act
NFMP	Nearshore Fishery Management Plan
NGO	Non-governmental organization
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometer turbidity unit
ONMS	Office of National Marine Sanctuaries
OPC	Ocean Protection Council
OSPR	Office of Spill Prevention and Response
PAR	Photosynthetically active radiation (or photosynthetically available radiation)
PDO	Pacific decadal oscillation
ppm	Parts per million
ppt	Parts per thousand
PSU	Practical salinity unit
REC-1	Water contact recreation
REC-2	Non-water contact recreation
RHA	Rivers and Harbors Act
RGP	Regional general permit
rms	Root mean square
RPM	Reasonable and prudent measure
RSM	Regional sediment management
RWQCB	Regional Water Quality Control Board
SABS	Suspended and bedded sediments
SANDAG	San Diego Association of Governments
SAP	Sampling and Analysis Plan
SAR	Sensitive Aquatic Resource Survey
SAS	Special aquatic site

SAV	Submerged aquatic vegetation
SCC	State Coastal Conservancy
SMCA	State Marine Conservation Area
SCOUP	Sand Compatibility and Opportunistic Use Program
SCUBA	Self-contained underwater breathing apparatus
SE	State endangered species
SEL	Sound exposure level
SER	State Ecological Reserves
ST	State threatened species
SMCA	State Managed Conservation Area
SMP	Sediment Management Master Plan
SPCC	Spill Prevention Control and Countermeasure plan
SSC	State species of concern
SWQPA	State Water Quality Protection Area
SWRCB	State Water Resources Control Board
TOC	Total organic carbon
TSS	Total suspended solids
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USDN	United States Department of the Navy
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WDR	Waste Discharge Requirement
WQCA	Porter-Cologne Water Quality Control Act

1.0 INTRODUCTION

Section Topics

1.0 Introduction
1.1 Background
1.2 User Guide Organization and Uses

The California Resources Agency and U.S. Army Corps of Engineers (USACE) formed the California Coastal Sediment Management Workgroup (CSMW) to facilitate regional approaches for protecting, enhancing, and restoring California's coastal beaches and watersheds. The CSMW mission is accomplished through federal, state, and local cooperative efforts with participation by the Department of Boating and Waterways (DBW), Department of Parks and Recreation (DPR), California Coastal Commission (CCC), CalCoast, Minerals Management Service (MMS), State Coastal Conservancy (SCC), California State Lands Commission (CSLC), and U.S. Geological Survey (USGS).

Photo credit: Karen Green

The foundation of the CSMW's efforts is the development of the *California Sediment Management Master Plan (SMP)*. Goals of the SMP are to reduce shoreline erosion and storm damages, restore sediment supply to the coast, and in doing so, optimize the use of varied sources of sediment. Integral activities include better coordination of coastal sediment management issues such as dredging, sediment flow through watersheds, and application of beach nourishment to areas of coastal erosion.

Coastal Sediment Management Workgroup

Mission

Conserve, restore, and protect California's coastal resources by developing and facilitating regional approaches to managing sediment imbalances.

Goals

- *Reduce* shoreline erosion and coastal storm damages;
- *Restore* and protect beaches and coastal habitat by restoring natural sediment supply from rivers, impoundments and other sources to the coast; and
- *Optimize* the use of sediment from ports, harbors, and other opportunistic sources.

A key element of the SMP mission is to conserve, restore, and protect California's coastal resources. The CSMW conducted an initial assessment of issues and concerns associated with development of the SMP and identified a need to better understand the actual effects of sediment management activities on coastal biota, particularly related to beach nourishment and protection. In response to this need, the CSMW commissioned preparation of the following document: *Review of Sediment Management Impacts and Issues Relevant to Protection of California Coastal Biota, Volume 1: Biological Impacts Analysis* (SAIC 2011).

This Volume 2 is a companion to the Volume 1 Biological Impacts Analysis (BIA) document. Volume 2 provides an abbreviated user's guide to the comprehensive review document, and includes resource protection guidelines for sediment management projects. The guidelines consider all the various activities associated with obtaining, delivery, and placement of sand at the beach, which includes both the dry upper beach and tidal-subtidal profile. Seven workshops were conducted throughout the State in 2010 to facilitate the development of the resource protection guidelines. The habitats and species featured in the guidelines were selected based on input received from resource and regulatory agencies and coastal managers that participated in coordination relative to both Volumes 1 and 2.

1.1 Background

Beach nourishment is widely used around the world to reduce coastal erosion and increase shoreline protection. The NRC (1995) summarized that this method provides a "soft" solution to shoreline protection that may be favored because of less disruption to natural coastal processes than hard structures such as seawalls, breakwaters, or rock groins. However, there also are opponents who argue that such efforts provide only temporary benefits, and managed retreat from the coast may be a better long-term solution.

The CSMW recognizes that a variety of solutions may be appropriate to address the range of sediment management needs associated with the diverse coastline of California. Accordingly, The SMP is being implemented through a series of coastal regional sediment management plans (CRSMPs), which are being prepared by appropriate regional entities with oversight and assistance from CSMW. At the time of this writing, three CRSMPs had been completed and seven were in progress or planned (*http://www.dbw.ca.gov/csmw/crsmp.aspx*).

Several activities provide opportunities of source materials for beach nourishment, including beneficial reuse of sands dredged during routine maintenance of ports and harbors, inlet areas of bays and estuaries, or maintenance of river flood control channels or basins. Sands excavated during coastal development projects (opportunistic sand sources) or mined from offshore sand deposits (borrow sites) represent other potential sources. Sediment testing guidance developed by the U.S. Environmental Protection Agency (USEPA) and USACE require sediments used for beach nourishment to be free of hazardous contaminants and compatible with biological and recreational beneficial uses.

Beach Nourishment

Involves the addition of sand to extend a beach and the nearshore shallows seaward. NRC 1995

Photo credit: Karen Green

Workshops were held to support development of resource protection guidelines

Beach nourishment and related sediment management activities involve use of construction equipment that impacts sediment, water, and biological resources. The coastal habitats in which these activities take place may support coastal fisheries, migratory and resident wildlife, and endangered or threatened species.

The CSMW identified a disparity in permit requirements regulating coastal sediment management projects in California, some of which was believed to be attributable to incomplete knowledge of coastal ecosystems and understanding of impacts.

The CSMW identified that a more complete understanding and better scientific data are needed to support environmentally sound decision-making by policy-makers, the regulatory community, and project proponents with respect to coastal sediment management. In particular, the CSMW was interested in a review of California coastal biological resources and potential impacts associated with sediment management to address several questions, as follows.

- *What are the positive and negative effects of beach nourishment on species and/or ecosystems?*
- *Are documented concerns based on scientific data, uncertainty-based conservatism, or other information?*
- *What are the types of species, threatened and/or endangered species, and sensitive habitats/ecosystems that are potentially impacted by sediment management activities?*
- *What is the appropriate level and type of pre- and post-project sampling needed to evaluate the project for significant changes?*
- *What are the ways biological resources may be impacted by sediment management activities?*
- *What mitigation measures have been implemented and has the effectiveness of any of these mitigation measures ever been demonstrated?*
- *What are the areas where the information needed to make science-based decisions is sparse or unknown?*
- *How can potential impacts from sediment management activities to coastal biota and ecosystems be minimized in order to reduce concerns of the regulatory community and streamline permitting of sediment management activities?*

Several goals and objectives guided the preparation of the Volume 1 BIA document to address the above questions (Table 1.1-1). The focus was to provide a document to meet multiple information needs and uses by the anticipated variety of users of the document. Hundreds of documents, including published literature, beach nourishment and dredging permits, monitoring reports, and other "gray" literature were reviewed. Substantial information also was obtained and reviewed from resource and regulatory agencies and other sources (Table 1.1-2).

Table 1.1-1. Biological Impacts Analysis Volume 1 goals and objectives.

Study Goals

- Serve as a reference document for future beach nourishment and related sediment management projects,
- Provide an educational tool for regulators, project proponents, and interested public,
- Provide a mechanism for dialog among stakeholders on potential impacts of sediment management activities on California's natural resources.

Study Objectives

- Organize relevant information for ease of reference.
- Accurately explain the basis of concern to biological resources from sediment management activities.
- Provide a balanced critical evaluation of concerns based on review of relevant available information.
- Identify information gaps that limit current understanding of impacts.
- Provide science-based recommendations to address critical information gaps.
- Provide recommendations for appropriate ways to protect California's resources during sediment management activities, based on a current understanding of potential impacts.
- Provide recommendations to streamline permitting.

The Volume 1 BIA provides background descriptions of sediment management practices, coastal processes, coastal habitats, and associated biological resources. Integrated technical summaries review impacts to coastal habitats and species associated with equipment use (e.g., dredging, excavation, sand spreading, vessels, vehicles), sand burial and post-construction sand movement or sedimentation, and changes to water quality. The discussions distinguish between direct, indirect, and cumulative impact concerns.

In addition, issues associated with preparation of impact assessments, such as significance thresholds, mitigation measures, and monitoring are reviewed.

Recommendations are provided to address critical data gaps and to assist planning decisions with respect to environmental design, mitigation, monitoring, and permitting of sediment management projects. Furthermore, recommendations are made regarding development of tools, processes, or guidelines to facilitate evaluation of project performance and more effective management of ecosystem and cumulative impacts on a regional basis.

The Volume 1 BIA also includes educational information and data summaries. A detailed glossary summarizes scientific and technical terms relevant to sediment management.

Technical appendices review historical permit requirements relevant to protection of biological resources, results of monitoring beach nourishment projects in California and elsewhere in the world, and representative significance criteria and mitigation measures applied to California sediment management projects.

Photo credit: Karen Green

Table 1.1-2.

List of useful information sources relevant to sediment management or California resources.

CSMW

- *http://dbw.ca.gov/csmw/sedimentmasterplan.htm*

Selected California State and Municipal Websites

- *http://www.beacon.ca.gov/*
- *http://www.calcoast.org*
- *http://ceres.ca.gov*
- *http://www.coastal.ca.gov/*
- *http://coastalchange.ucsd.edu/*
- *http://www.dfg.ca.gov/marine/*
- *http://www.opc.ca.gov/*
- *http://www.sandag.org/*
- *http://www.swrcb.ca.gov/*

Selected Other State Websites

- *http://www.dep.state.fl.us/beaches/programs/bcherosn.htm*
- *http://www.dnr.state.md.us*
- *http://dcm2.enr.state.nc.us/sitemap.htm*
- *http://wdfw.wa.gov/hab/ahg/dredge.htm*

Selected Federal Websites

- *http://www.spl.usace.army.mil/*
- *http://www.spk.usace.army.mil/*
- *http://www.spn.usace.army.mil/ltms*
- *http://el.erdc.usace.army.mil/dots/doer*
- *http://www.boemre.gov/sandandgravel/*
- *http://www.usgs.gov/state/coastal_offshore.asp*

Selected International Websites

- *http://www.cefas.co.uk/home.aspx*
- *http://www.eurosion.org/shoreline/index.html*
- *http://www.mwg.utvinternet.com/iss_mag_extract.html*
- *http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/index.shtml*
- *http://www.ukmarinesac.org.uk/publications.htm*

1.2 User Guide Organization and Uses

This guide is organized in five sections. After this introductory section, Section 2 provides relevant background information on sediment management locations and activities, environmental considerations and potential impacts, and applicable regulations. Section 3 presents the resource protection guidelines, where users will gain greater understanding of biological impact issues and considerations to lessen impact concerns during project implementation. Acknowledgements and references are given in Sections 4 and 5, respectively. Table 1.1-3 provides a cross reference to technical background information discussed in greater detail in the Volume 1 BIA document.

A total of 27 guidelines are included in this volume. Guidelines consider both sand placement (at beach or nearshore receiver sites) and obtaining or delivery of source sands (dredging, pipelines, trucks). The guidelines cover all project phases: pre-construction, construction, and post-construction.

A standard format is used that reviews regulatory status, definition or functions of the resource, sediment management issues, relevant impact activities, guideline objectives, resource protection considerations, effectiveness considerations, seasonal considerations, monitoring considerations, and references.

The resource protection considerations (e.g., environmental or mitigation measures) include measures that may or may not apply depending on project-specific activities or site-specific environmental considerations. Monitoring considerations consider seasonal timing as well as information to support impact or minimization effectiveness evaluations. *The guidelines are considerations, they are not regulatory requirements.*

User's Guide Organization

Section 1 – Introduction
Provides the background for preparation of both Volumes 1 and 2.

Section 2 – Relevant Background Information
Provides overviews of relevant technical information regarding sediment management activities, impact issues, coastal processes, and regulations.

Section 3 – Resource Protection Guidelines
- 3.1 - Habitats Where Sediment Management May Occur
- 3.2 - Sensitive Habitats

Section 4 –Acknowledgements
Lists document preparer, reviewers, and Workshop Participants.

Section 5 – Literature Citations.

User's Guide Topics

Covered
- Beach nourishment
- Beneficial reuse of maintenance materials
- Opportunistic sand placement
- Types of biological impacts associated with sediment management projects
- Factors that influence impact significance
- Laws and Regulations
- Resource Protection Guidelines

Not Covered
- Contaminated sediment issues
- Managing erosion, runoff, and fine sediment accumulation in embayments
- Port and harbor development
- Other coastal development

The guidelines consider the potential use of a broad range of sediment sources. Because sands used for beach nourishment must be physically suitable and clean, the guidelines do not address resource protection issues associated with dredging or disposal of contaminated coastal sediments, maintenance activities in embayments involving removal of sedimentation from watershed runoff, or marine construction projects. However, many of the guidelines may be applicable to those types of projects because of similar resource protection considerations or concerns. In those cases, additional protective measures may be required to address project-specific environmental issues.

Table 1.1-3. Cross-reference of sections in the Volume 2 User's Guide with more detailed discussions in the Volume 1 BIA reference document.

TOPIC	VOLUME 2 USER GUIDE	VOLUME 1 BIA
INTRODUCTION	Section 1	Section 1
Study Purpose	1.1	1.1
Study Questions	1.1	1.2
Goals and Objectives	1.1	1.3
Use of Guide	1.2	NA
Methodology		1.4
Report Organization	1.2	1.5
BACKGROUND	Section 2	Various
Coastal Zone Terminology and Biological Habitats	2.1	3.1
Sediment Management Locations	2.2	2.1
Sediment Management Activities and Methods	2.3	2.2
Coastal Environmental Conditions	2.4	2.3
CEQA/NEPA Assessment Considerations	2.5	6
Applicable Laws and Regulations	2.6	5
Water Quality Standards	2.6	2.4, 5.5
Potential Impacts	2.7	5
Mitigation and Monitoring	2.8	7
RESOURCE PROTECTION GUIDELINES		
Habitats	Section 3	Section 3
Organization, Format	3.1	3.1
Impact and Mitigation Considerations	3.2	3
Habitat Functions and Values	3.3, 3,4	3.2
Habitats and Impacts	3.3, 3.4	3.3
Sandy Beach	3.3.1	3.3.2
Sandy Subtidal	3.3.2	3.3.3
Shallow-Inlet Embayment	3.3.3	3.3.9
Deepwater Inlet Embayment	3.3.3	3.3.10
Coastal Dune and/or Strand	3.4.1	3.3.1
Rocky Intertidal	3.4.2	3.3.4
Rocky Subtidal	3.4.2	3.3.5
Kelp Forest and/or Bed	3.4.2	3.3.6
Surfgrass Bed	3.4.2	3.3.7
Eelgrass Meadow	3.4.3	3.3.8
Species	Section 3	Section 4
Overview of Species and Impact Concerns		4.1
Invertebrates		4.2
Sandy Beach Invertebrates	3.3.1	4.2.6
Pismo Clam	3.3.1	4.2.4
Sandy Subtidal Invertebrates	3.3.2	4.2.7
Dungeness Crab	3.3.3	4.2.3
Rocky Intertidal Invertebrates	3.4.2	4.2.8
Rocky Subtidal Invertebrates	3.4.2	4.2.9
Abalone	3.4.2	4.2.1
California Spiny Lobster	3.4.2.	4.2.2
Sea Urchins	3.4.2	4.2.5

Table 1.1-3 (Continued)

TOPIC	VOLUME 2 USER GUIDE	VOLUME 1 BIA
Fish		4.3
California Grunion	3.3.1	4.3.1
Green Sturgeon	3.3.3	4.3.2
Pacific Herring	3.3.3	4.3.3
Salmonids	3.3.3	4.3.4
Bottom-Dwelling Fish	3.3.2	4.3.5
Nearshore Water Column Fish	3.3.2	4.3.6
Tidepool Fish	3.4.2	4.3.7
Subtidal Reef Fish	3.4.2	4.3.8
Birds		4.4
California Brown Pelican	3.3.1	4.4.1
California Least Tern	3.3.1	4.4.2
Clapper Rail	3.3.3	4.4.3
Western Snowy Plover	3.3.1	4.4.4
Gulls, Skimmers, and Terns	3.3.1	4.4.5
Shorebirds	3.3.1	4.4.6
Wading Birds	3.3.3	4.4.7
Waterfowl and Seabirds	3.3.1	4.4.8
Marine Mammals		4.5
Sea Otters	3.3.2	4.5.1
Pinnipeds	3.3.2	4.5.2
Cetaceans	3.3.2	4.5.3
BENEFICIAL AND ADVERSE IMPACTS		Section 5
Beneficial Effects	2.7	5.1
Adverse Impact Issues and Concerns	2.7	5.2
Equipment and Disturbance Impacts	2.7.1	5.3
Burial and Disturbance Impacts	2.7.2	5.4
Sediment Reworking and Sand Transport	2.7.3	5.4
Sediment and Water Quality	2.7.4	5.5
IMPACT SIGNIFICANCE THRESHOLDS AND MITIGATION MEASURES		Section 6
CEQA/NEPA and Thresholds of Significance	2.5	6.1
Overview of Mitigation Measures	2.8, 3.2	6.2
Pre-Construction Phase Mitigation Measures	3.2, 3.3, 3.4	6.3
Construction Phase Mitigation Measures	3.2, 3.3, 3.4	6.4
Post-Construction Mitigation Measures	3.2, 3.3, 3.4	6.5
Summary of Mitigation Measures	3.2, Appendix A	6.6
RESOURCE MANAGEMENT AND MONITORING APPROACHES	2.8, 3.2, 3.3, 3.4	Section 7
RECOMMENDATIONS		Section 8
PREPARERS AND CONTRIBUTORS	4.0	Section 9
LITERATURE CITED	5.0	Section 9
REVIEWED PERMITS		Appendix A
ANNOTATED SUMMARIES OF REPORTED IMPACTS		Appendix B
WATER QUALITY TECHICAL SUPPORT INFORMATION		Appendix C
SIGNIFICANCE CRITERIA AND MITIGATION MEASURES		Appendix D

This Page Intentionally Blank

2.0 RELEVANT BACKGROUND INFORMATION

This section provides an overview of beach nourishment related activities, environmental conditions, potential impacts, and regulatory requirements and considerations associated with sediment management activities in the coastal zone.

Section 2.1 provides an overview of coastal zone terminology and biological habitats addressed in this document. Locations where coastal sediment management projects occur are shown in Section 2.2. Different activities (e.g., dredging, placement, beach construction) associated with beach nourishment projects are described in Section 2.3. Section 2.4 provides an overview of coastal processes and environmental conditions that naturally influence habitats and supported biological resources. Environmental documentation and impact assessment considerations are reviewed in Section 2.5. Applicable laws and regulations are described in Section 2.6. Impacts to biological resources and waters from sediment management activities are described in Section 2.7. Types of measures and monitoring used to protect biological resources and waters during implementation of sediment management projects are reviewed in Section 2.8.

Section Topics - Overviews

2.1 Costal Zone Terminology and Biological Habitats
2.2 Sediment Management Locations
2.3 Types of Sediment Management Activities and Methods
2.4 Coastal Environmental Conditions
2.5 CEQA/NEPA Impact Assessment Considerations
2.6 Applicable Laws and Regulations
2.7 Potential Biological Impacts
2.8 Mitigation and Monitoring Considerations

Photo credit: SANDAG

SECTION 2

2. 1 Overview of Coastal Zone Terminology and Biological Habitats

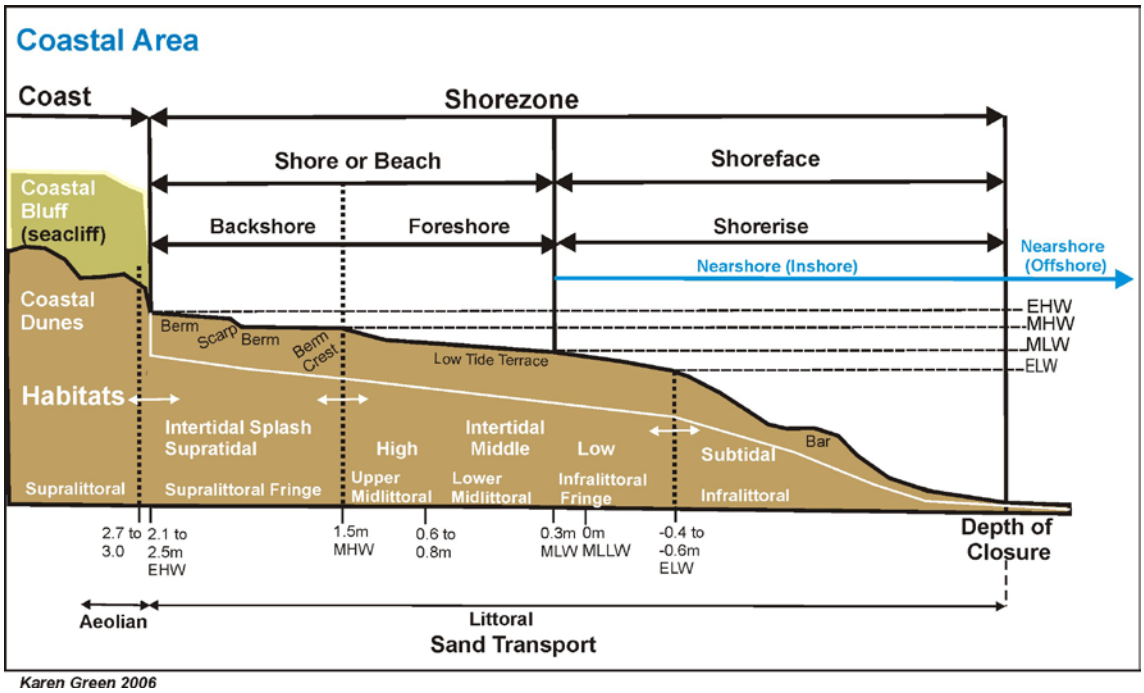
Coastal zone terminology defines the shorezone (or littoral zone) as comprising two primary areas: (1) the beach (or shore), and (2) the shoreface (or shorerise) extending seaward from the shore to the beach closure depth (Figure 2.1-1). The *depth of closure* refers to the depth beyond which the natural seasonal onshore and offshore movement of sand is not significant. The depth of closure varies along the coastline and varies over time depending on wave climate (Swartz 2005).

Regulatory Note

USEPA and USACE permit beneficial reuse of suitable dredge material for beach nourishment if discharge occurs within the littoral zone defined by the beach *depth of closure*.

The shorezone includes three zones (Figure 2.2-1). The beach that most people are familiar with includes the lower part of the beach, which is wetted by the waves (foreshore) and a dry backshore, which is the area above the normal reach of tides but may be breached during storm tides. Generally, beachgoers lay their towels on the dry backshore or high tide zone, when dry. The landward extent of the beach is where there is marked change in material or physiographic form such as a seacliff, line of permanent vegetation on dunes, seawall or other artificial boundary. The seaward extent of the beach, which is termed the shoreface (or shorerise) includes the downward slope of the beach beyond the waves to the depth of closure. The nearshore area within the beach closure depth is the inshore zone and the area further seaward is referred to as offshore. Sand moves within the entire shorezone (also termed littoral zone).

The shorezone boundaries are defined by tide elevations. The mean high water (MHW) line is the backshore/foreshore boundary. The MHW line is the jurisdictional limit for Section 10 of the Rivers and Harbors Act. The mean low water line is the boundary between the foreshore and nearshore shoreface. The extreme high water (EHW) line is the landward boundary of the backshore. The high tide line (HTL) is the tidal waters' landward jurisdictional limit of the authority of the Corps of Engineers under the Clean Water Act. The HTL encompasses spring high tides and other high tides that occur with periodic frequency, but does not include storm surges.



Karen Green 2006

Coastal shorezone terminology - Shepard 1963, Voight 1998, NOAA 2001a, USACE 2002
Biological habitats - CCC 1987, Thompson et al. 1993, Hill et al. 1998, Shaffer 2002

Definitions: EHW = extreme high water spring tide, ELW = extreme low water spring tide, MHW = mean high water, MLW = mean low water, MLLW = mean lower low water.

Note: Tide elevations were based on reference to CCC (1987), Thompson et al. (1993), and review of 2006 extreme high and low tides for several recording stations along the coast of California from Crescent City to Point Loma (*http://tbone.biol.sc.edu/tide/sites_uswest.html*). *1 meter (m) = 3.281 ft*
Note: Tide elevations may vary depending on wave exposure (protected, exposed coasts) and type of tide (spring, neap tides).

Figure 2.1-1. Cross-reference between coastal terminology and biological habitat boundaries.

The mean HTL is used by the CSLC to distinguish the boundary between private property and state-owned lands. The location of the mean HTL naturally varies, seasonally and between years, due to the natural on- and offshore movement of sand. The variation may be large or it may be small depending on wave exposure and whether or not the beach is backed by a hard structure (e.g., seacliff, seawall). It is influenced by beach nourishment, which widens the beach. There are legal ramifications to where the line is designated. Therefore, a mean HTL survey is required prior to implementation of projects on a beach.

Regulatory Note

Prior to implementation of coastal projects on a beach, a *mean high tide line survey* must be conducted and submitted to the California State Lands Commission to verify ownership and interests by the state.

Biological resource development varies along the beach in characteristic zones, which are referred to as the supratidal (splash zone), intertidal (area wetted across the tide range from high to low), and subtidal (Figure 2.1-1). The upper limit of the splash zone may extend slightly landward of the backshore definition based on extreme high water; for example, wave splash on dune, rock, or coastal bluffs. The lower limit of intertidal habitat is defined as extreme low water, which is seaward of the foreshore definition. The lower intertidal habitat includes the area exposed on the lowest (minus) tides. The elevations on the beach corresponding to these zones vary depending on wave exposure (protected, exposed coasts) and type of tide (spring, neap tides).

The shore and inshore zones within the depth of closure may be sandy, rocky, or mixed with both sand and rock habitats. Vegetated habitats may occur on rock (e.g., surfgrass, kelp forest) or sand (eelgrass meadows). Biological resources substantially differ between sandy, rocky, and vegetated habitats.

Sandy beaches support a variety of biological resources, some easily seen and others beneath the sand. The sand is primary habitat for invertebrates (small animals without backbones such as, clams, sand crabs, and worms). The invertebrates provide forage for bottom-dwelling fish under high tides, and for shorebirds under low tides. Beaches also are important resting areas for shorebirds and gulls, and in certain areas nesting also may occur. Beaches are spawning habitat for the California grunion, a small fish that swims onto beaches to lay eggs during the highest tides in spring and summer. Seals and sea lions (pinnipeds) may haul out on sandy beaches. Sandy beaches are used for sunbathing, wading, surfing, and swimming, and may support recreational clamming and fishing.

Sandy beach

Dunes *Photo credits: Karen Green*

The area adjacent to the backshore may have coastal strand vegetation or dunes. Dunes provide shoreline protection from winter storms and contribute sand to the coastal zone. Vegetation stabilizes the dunes, which may support a variety of insects, birds, and other wildlife. Native dune species have been substantially impacted by human development and native vegetation is considered rare in California. Many dunes are dominated by invasive species such as European beach grass or iceplant, which reduce ecological diversity of the habitat.

Several large dune complexes are part of the California State Parks system, and support a variety of recreational uses.

In certain protected areas of the coast, seagrass beds of eelgrass may occur; which provides vertical structure above the sandy bottom. Eelgrass is an important nursery habitat for nearshore fishes and invertebrates.

Rocky habitats generally support a greater diversity of biological resources than sandy beaches. The most productive reef habitats are characterized by a complex variety of rock heights, crevices, and rugosity, all of which provide important living space or shelter for invertebrates, reef fish, and marine plants. Pinnipeds may haul out on rocks and birds may forage in tidepools.

Seagrass beds of surfgrass occur on rocky shores from the intertidal to shallow nearshore in certain areas of the coast. Surfgrass beds are important nursery habitats for lobster and marine fish.

Intertidal tidepools are popular places to visit to view marine life at the beach. Nearshore rocky reefs, including kelp beds, are popular destinations of commercial and recreational fishermen and divers. Collectively, hard bottom species (e.g., kelp, lobster, rock crab, sea urchins, octopus, sea cucumber, sheephead) account for the highest value of commercial landings in California (CDFG 2001).

Kelp forests may be associated with rocky habitats offshore. Kelp are the most productive of all the nearshore marine habitats off California, supporting hundreds of species of invertebrates, fish, and marine plants (algae, kelp, and seaweeds). They also are important foraging areas for seabirds and marine mammals.

Coastal embayments are valuable ecosystems and important commercial or recreational areas. Estuaries include a variety of wetland and upland habitats (e.g., open water, mudflats, eelgrass meadows, marshes) and support thousands of species of plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. Estuaries are important nurseries for marine fish, nesting and foraging areas for resident and migratory birds, and critical habitats for several endangered or threatened species. Embayments may support a variety of recreational (e.g., bird watching, hiking, boating, fishing) and mariculture uses (e.g., shellfish beds).

Eelgrass meadow *Photo credit: Rick Ware*

Surfgrass, low tide *Photo credit: Karen Green*

Vegetated nearshore reef, San Diego
Photo credit: San Diego Nearshore Program http://nearshore.ucsd.edu/

Batiquitos Lagoon, San Diego
Photo credit: Karen Green

Table 2.1-2. Regulatory status and associated habitats for special-interest species and general biological resource categories in the coastal zone.

Species or Resource Category	Regulatory Status	Associated Habitat
Invertebrates		
Abalone	Black, White Abalone [FE] Green, Pink, Pinto [Federal SSC]	Rocky Intertidal-Subtidal
California Spiny Lobster	Managed fishery species	Rocky Subtidal, Surfgrass, Kelp Forest,
Dungeness Crab	Managed fishery species	Eelgrass, Embayment, Beach, Sandy Subtidal
Pismo Clam	Managed fishery species	Beach, Sandy Subtidal
Sea Urchins	Managed fishery species	Kelp Forest, Rocky Intertidal-Subtidal
Sandy Beach	EFH prey items	Beach
Sandy Subtidal	EFH prey items	Sandy Subtidal
Rocky Intertidal	EFH prey items	Rocky Intertidal
Rocky Subtidal	EFH prey items	Rocky Subtidal
Fishes		
California Grunion	Managed fishery species	Beach, Neritic
Green Sturgeon	Southern DPS [FT], Northern DPS [Federal SSC]	Embayment, Neritic, River, Sandy Subtidal
Pacific Herring	Managed fishery species	Eelgrass, Embayment, Neritic,
Salmonids	Chinook, Coho, Steelhead [designated runs as FE, SE, FT, ST]	Eelgrass, Embayment, Neritic, River
Bottom-Dwelling Fish	Groundfish FMP and/or State NFMP: Flatfishes, Ratfish, Skates	Eelgrass, Embayment, Sandy Subtidal
Water Column Fish	Coastal Pelagics FMP: Northern Anchovy, Mackerels, Pacific Sardine	Embayment, Neritic
Subtidal Reef Fish	Groundfish FMP and/or State NFMP: Cabezon, CA Scorpionfish, CA Sheephead, Kelp and Rock Greenling, Lingcod, Rockfish, Treefish	Kelp Forest, Rocky Subtidal
Tidepool Fish	State NFMP: Monkeyface Prickleback	Rocky Intertidal
Birds		
California Brown Pelican	[State FP]	Beach, Embayment, Neritic
California Least Tern	[FE, SE]	Beach, Dune, Embayment, Neritic
Clapper Rail	California, Light-footed [FE, SE]	Embayment
Western Snowy Plover	FT, State SSC	Beach, Dune, Embayment
Gulls	Migratory birds	Beach, Dune, Embayment, Neritic, Rocky Intertidal,
Skimmers, Other Terns	Migratory birds [some SSC]	Beach, Dune, Embayment, Neritic
Shorebirds	Migratory birds	Beach, Dune, Embayment
Wading Birds	Migratory birds [some SSC]	Embayment, Rocky Intertidal
Waterfowl	Migratory birds [some SSC]	Embayment, Neritic, Rocky Intertidal
Marine Mammals		
Sea Otter	[FT, State FP]	Embayment, Kelp Forests, Neritic,
Seals and Sea Lions	Guadalupe fur seal [FT, ST], Northern elephant seal (State FP), Stellar sea lion [FT]	Beach, Embayment, Neritic, Kelp Forest, Rocky and Rocky Subtidal
Whales, Dolphins, Porpoises	Blue, Fin, Humpback Pacific Right, Sei, Sperm whales [FE], Gray whale (Federal FP)	Kelp Forest, Neritic
Vegetation		
Kelp Forest	EFH-HAPC	Rocky Subtidal
Surfgrass	EFH-HAPC	Rocky Intertidal-Subtidal
Eelgrass	EFH-HAPC, SAS	Embayment, Sandy Subtidal

EFH = Essential Fish Habitat, FE = Federal endangered, FP = fully protected, FT = Federal threatened, SE = State endangered, SSC = species of concern, ST = State threatened. FMP = Fishery Management Plan, NFMP = Nearshore FMP

Notes: Not all FMP species are listed, refer to FMPs for full list of species. Neritic = coastal open water.

2.2 Overview of Sediment Management Locations

Sediment management is routinely conducted in embayments to maintain navigable channels. Shallow-inlet embayments (e.g., small estuaries, lagoons, sloughs) also may require periodic removal of excess sedimentation to maintain adequate tidal exchange. Additionally, sediment dredging or excavation is required in some rivers (e.g., debris basins, flow channels) to maintain flood control channel capacity.

Sands removed during maintenance activities may be placed on a nearby beach or in the nearshore within the beach closure depth. This is an example of "*beneficial reuse*", which is defined as the use of dredged materials in productive ways. Other activities also may provide source materials for beach nourishment, including coastal wetlands restoration, coastal development projects, or dredging from offshore sand deposits (e.g., borrow sites). In areas of coastal erosion, there may be shoreline protection projects that include beach nourishment as an element.

The importance of beach nourishment to counteract coastal erosion and provide shoreline protection was recognized with the passage of Assembly Bill 64 (Public Beach Restoration Act) in 1999, which included grants to support beach nourishment projects and coastal studies. One of the funded projects was the California Beach Restoration Study, which identified candidate locations for beach nourishment projects (DBW and SCC 2002). Higgins et al. (2004) of the California Geological Survey (CGS) identified erosion "hot spots" in the state. Recently, the CSMW (2010) updated the list of beach erosion areas of concern (BECAs) in California.

California has more than 400 beaches stretching along more than 500 miles of Pacific Ocean and San Francisco Bay coastline (NRDC 2010). Locations of historical and potential future coastal sediment management activities involving beach nourishment are shown on Figures 2.2-2 through 2.2-4. Beach or nearshore placement sites associated with embayment maintenance projects, erosion hot spots, or BECAs are identified. Additional sites may be identified in future CSMW regional sediment management plans. The figures demonstrate that most sediment management activities involving beach nourishment are localized and do not occur along the entire coastline of California.

Most sediment management activities in northern California have been associated with maintenance dredging at Crescent City Harbor, Humboldt Bay, Noyo Harbor, Bodega Bay, San Francisco Bay, and Pillar Point Harbor (Figure 2.2-2). Several erosion hot spots have been identified with a need for beach nourishment in and near San Francisco Bay.

Most central California sediment management activities are associated with maintenance dredging at Santa Cruz Harbor, Moss Landing Harbor, Morro Bay, and Port San Luis (Figure 2.2-3). Maintenance activities in San Lorenzo River are periodically required. Identified BECAs include southern Monterey Bay beaches, Cayucos Beach, and Price Street Pocket Beach.

The greatest variety of sediment management activities have been identified for southern California (Figure 2.2-4). These include maintenance dredging at several ports and harbors, maintenance activities in lagoons and sloughs, and regional as well as opportunistic beach nourishment projects at several locations. Over 30 BECAs have been identified with identified beach nourishment needs in southern California. Some BECAs already receive periodic nourishment from embayment maintenance, regional, or opportunistic sediment management programs.

Coastal ports, harbors, and marinas have been constructed in portions of larger bays or along natural indentations of the coastline of California. These areas have a relatively deep water connection to the ocean and provide protected habitats due to headlands, structural breakwaters, or distance from the open ocean. Commercial shipping, U.S. Navy homeport facilities, commercial fishing landings, and recreational boating and fishing occur in ports and harbors.

Ports of Long Beach and Los Angeles
Photo permission: Ralph Appy

The coastal habitats addressed in this document are listed in Table 2.1-1, which includes their locations relative to shorezone terminology and beach depth of closure.

Table 2.1-1. Cross-reference between coastal habitats, shorezone terminology, and locations relative to beach depth of closure.

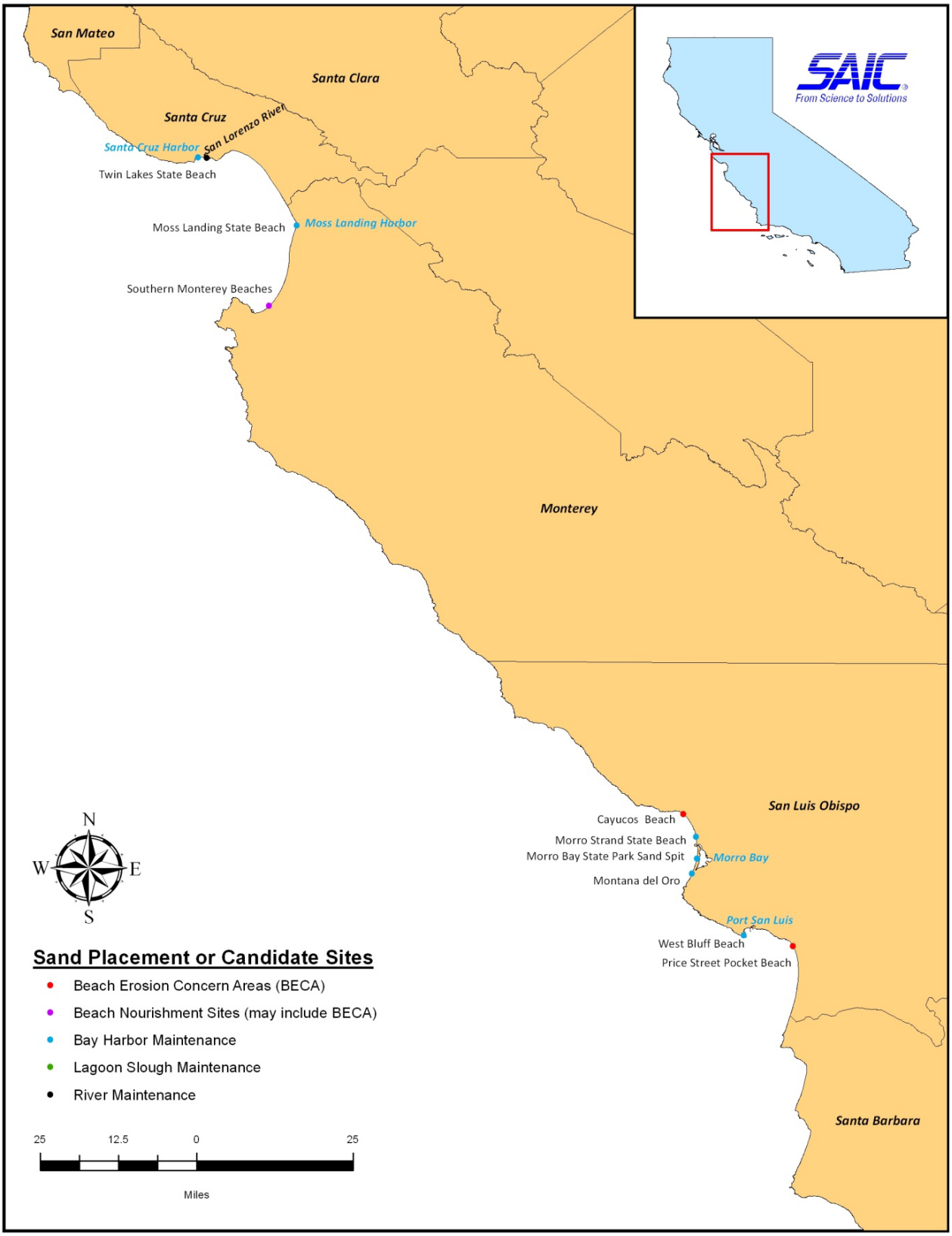
Habitat	Location Relative to Coastal Shorezone Terminology	Location Relative to Beach Depth of Closure
Coastal Dune/Strand	Coast	Landward
	Shore (Incipient Foredune)	Within
Sandy Beach	Beach or Shore (backshore, foreshore)	Within
Sandy Subtidal	Nearshore (Inshore), Shoreface, Shorerise	Within
	Nearshore (Offshore)	Seaward
Rocky Intertidal	Shore	Within
Rocky Subtidal	Nearshore (Inshore), Shoreface, Shorerise	Within
	Nearshore (Offshore)	Seaward
Kelp Forest or Bed	Nearshore (Inshore), Shoreface, Shorerise	Within (protected locations)
	Nearshore (Offshore)	Seaward (primary location)
Surfgrass	Nearshore (Inshore), Shoreface, Shorerise	Within (primary location)
	Nearshore (Offshore)	Seaward (protected locations)
Eelgrass	Nearshore (Inshore), Shoreface, Shorerise	Within (protected locations)
	Nearshore (Offshore)	Seaward (protected locations)
	Bays and Estuaries	Landward
Embayment (bays, estuaries)	Coast	Landward

Each of the coastal habitat types occur in northern, central, and southern California. However, the occurrence of these habitats vary regionally. Generally, sandy beaches dominate the shore in southern California and rocky shores are more prevalent in central and northern California (Ambrose et al. 1989). In contrast, rocky subtidal habitat supporting kelp forests is more prevalent in southern California. Dunes are most developed in central and northern California. Seagrass beds occur throughout the state. There are more embayments in southern California.

Sediment management activities have the potential impact a variety of plants and wildlife associated with the above-listed habitats. Several species groups and individual species were selected in coordination with resource and regulatory agencies as being of special interest relative to California beach nourishment and related sediment management activities (Table 2.1-2). The species groups refer to general wildlife categories associated with different substrates (sandy, rocky, vegetation), water depths (intertidal, subtidal), or location in a water body (bottom-dwelling, water-column). Selected special-interest species include threatened or endangered species, fully protected species, or managed fishery species.

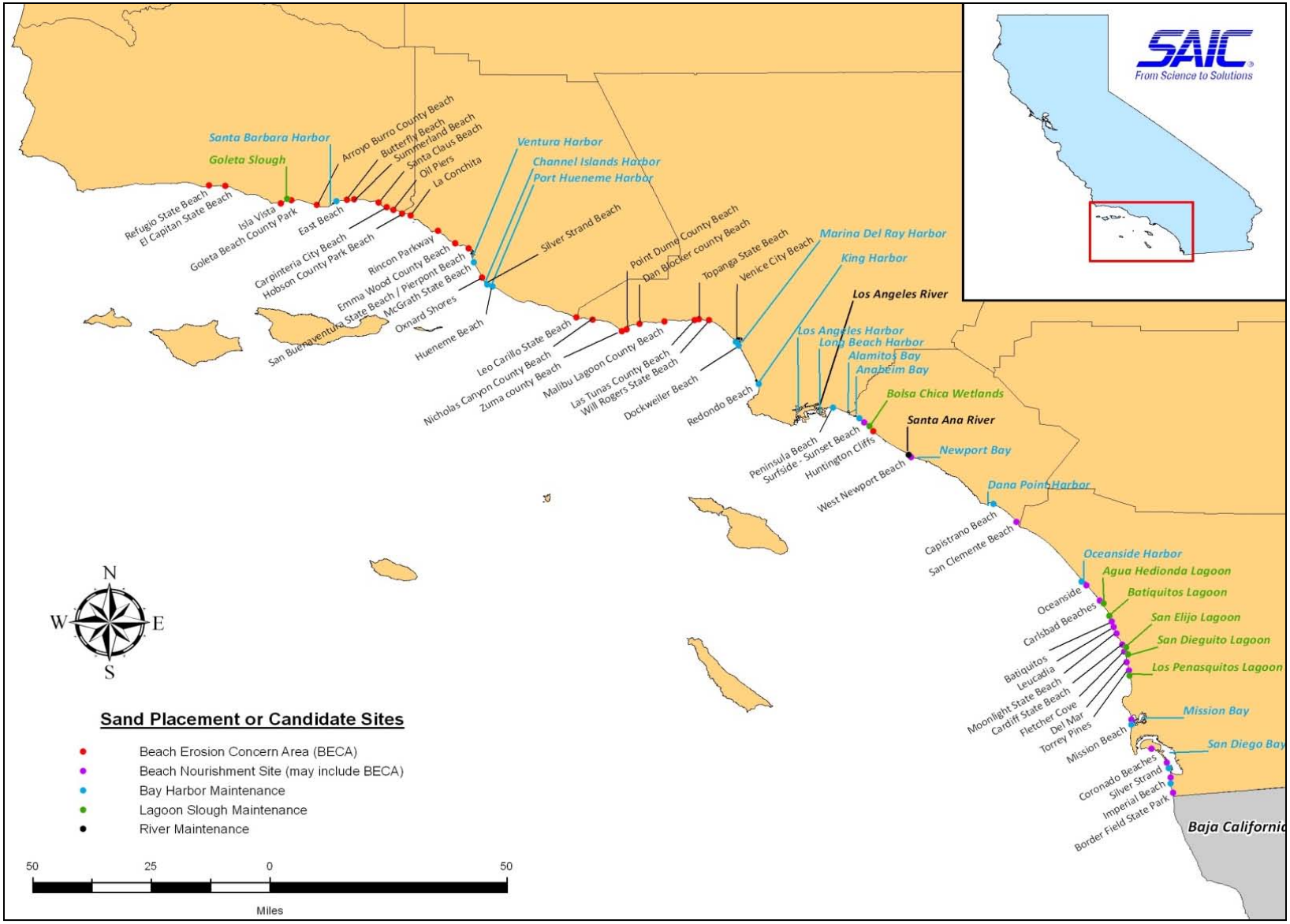
Notes: Maintenance sites may or may not be BECAs. A standard legend is used, not all types of sites may apply in this map.

Figure 2.2-2. Locations of potential future sediment management activities in northern California.



Notes: Maintenance sites may or may not be BECAs. A standard legend is used, not all types of sites may apply in this map.

Figure 2.2-3. Locations of potential future sediment management activities in central California.



Notes: Maintenance sites may or may not be BECAs. A standard legend is used, not all types of sites may apply in this map.

Figure 2.2-4. Locations of potential future sediment management activities in southern California.

2.3 Overview of Types of Sediment Management Activities and Methods

Implementation of sediment management projects includes pre-construction, construction, and post-construction phases. Activities and methods associated with each phase and their relevance to protection of biological resources are briefly described below.

2.3.1 Pre-Construction Phase

The foundation for protection of biological resources is set during the pre-construction phase. It is during this phase that environmental constraints are identified, potential impacts are evaluated, environmental consequences are considered, and mitigation measures to avoid and minimize adverse impacts are recommended. Activities undertaken during the pre-construction phase generally include: definition of the project and alternatives, preparation of environmental documentation consistent with the California Environmental Quality Act and National Environmental Policy Act (CEQA, NEPA), technical studies needed to support project design or CEQA/NEPA analyses, and application and obtaining of permits.

Pre-Construction Activities

- ✓ Define Project and Alternatives
- ✓ Prepare CEQA and/or NEPA Documentation
- ✓ Obtain permits and conditions
  - Regulatory Agencies (CCC, RWQCB, CSLC, SWRCB, USACE, USEPA)
  - Resource Agencies (CDFG, NMFS, USFWS)
  - Local Jurisdictions
- ✓ Initiate monitoring, as needed

Several federal, state, and local agencies are involved with the permitting or approval process for sediment management activities (Section 2.6). Permits or authorizations specify terms and conditions associated with project implementation. Special conditions may be included to address sensitive habitat or species concerns.

Monitoring may be necessary to establish baseline conditions if post-construction monitoring will be required to verify that no significant impacts occur from the proposed action. This would need to be determined in coordination with the resource and regulatory permitting agencies for the project.

2.3.2 Construction Phase

The construction phase involves all activities associated with implementation of sediment management projects. Some activities may be undertaken just prior to construction to finalize project planning and logistics; however, most activities occur during project implementation. Construction activities may include dredging, excavation, obtaining sand from other sources, and delivery of sediments to the receiver site. Construction activities also may involve spreading sands and grading of beach fills with earth moving equipment.

Opportunistic sand delivery, Encinitas
Photo credit: Kathy Weldon

Monitoring often is required to document compliance with permit conditions. Generally, water quality monitoring is conducted. Other monitoring may be required if sensitive species or habitats are in the vicinity. Activities associated with construction phase are briefly reviewed below. Monitoring is reviewed in more detail in Section 2.8.

Sand Sources and Delivery of Materials for Beach Nourishment

The method for delivery of sand to the receiver site (beach or nearshore) generally depends on the source of the material. For example, dredged sands may be conveyed by hopper dredge vessels, barge scow, or pipelines. Sands excavated from tidal inlets may be moved to the receiver site using bulldozers. Sands obtained from upland sources are delivered by truck.

Several sources of materials are used for beach nourishment or beneficial reuse projects in California (DBW and SCC 2002), as follows:

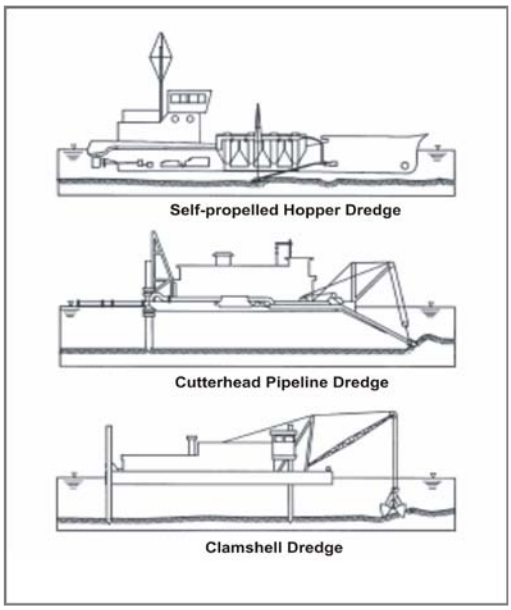
Sand bypassing pipeline at Oceanside
Photo credit: Karen Green

- Sand backpassing (transfer of sand from downcoast to an upcoast sediment-starved beach).
- Sand bypassing (transfer of accumulated sand upcoast of a barrier such as a jetty to the downcoast side).
- Littoral System bypassing (maintenance dredging of littoral sands)
    - Bays and Harbors (entrance basins, navigational channels).
    - Lagoons and Sloughs (entrance inlets, outer basins, sand bars).
    - Rivers (flood control debris or detention basins, dam reservoir basins, or flood control construction projects).
- Offshore sands (offshore dredging of nearshore sand deposits).
- Upland (excavation from coastal development projects).

Dredging

Sands dredged from coastal water bodies in California generally use a bucket dredge, cutterhead pipeline dredge, or trailing-suction hopper dredge, Both the cutterhead and hopper dredges hydraulically pump sands from the bottom. The bucket dredge takes "bites" of the sediment from the bottom.

A hopper dredge may be used for work in rougher sea conditions or where there is greater distance between the dredge and discharge location (NRC 1995). Hopper dredges pump the sand-water slurry into bins on the vessel. The hopper dredge operation occurs in two separate phases consisting of: (1) dredging and filling the hopper barge, and (2) transit of the hopper to the receiver site and offloading of the materials. Hopper vessels may either directly release sediments from the bins to nearshore locations or hydraulically pump sediments via a pipeline to the beach.



Source: USEPA and USACE 2004

The dredge and discharge operations are continuous with a cutterhead-suction dredge. Typically, a cutterhead-hydraulic pipeline method is used in calm waters where the receiver site is located close enough for efficient hydraulic pumping of the dredged sand-water slurry through a pipeline with or without booster pumps.

The bucket dredges, such as the clamshell dredge, is used in confined areas such as around piers, docks, etc. and/or where the disposal area is too far for feasible use of a cutterhead dredge. Sediments are placed in a dump scow and transported by support vessels to the discharge location.

Sediment Placement

Construction activities vary depending on where the sands are placed. Several locations across the beach profile, ranging from the backbeach to nearshore zone, have been used for beach nourishment (DBW and SCC 2002). *Placement must be within the beach depth of closure to quality as beach nourishment.* Different placement methods are briefly described below.

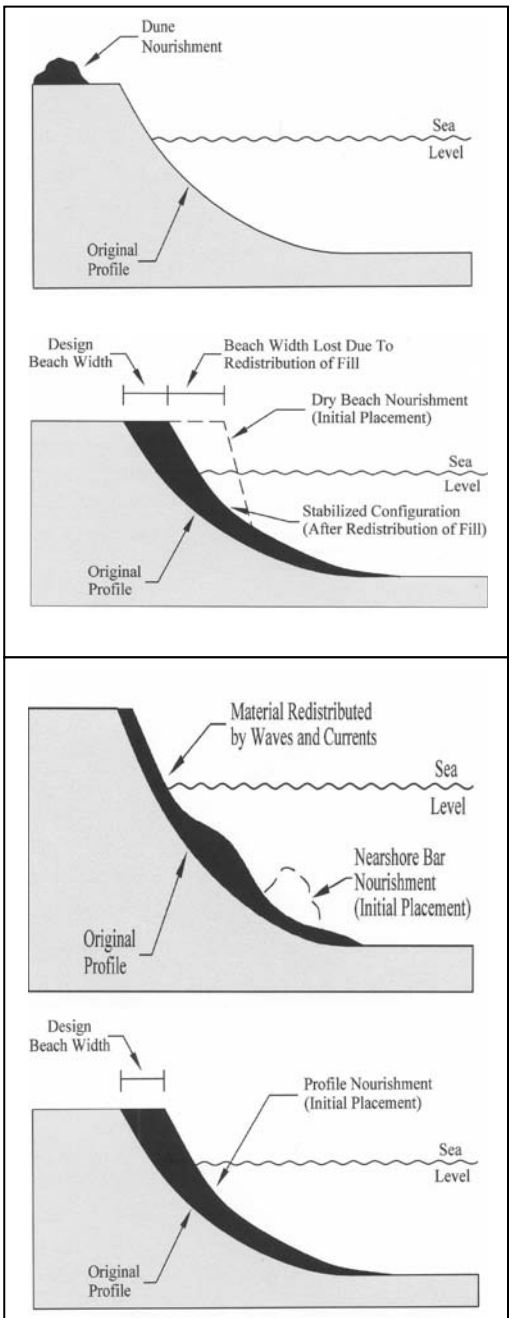
Dune placement involves use of earth moving equipment to place sand high above the waterline for shore protection and to serve as a stockpile that gradually winnows and contributes sands to the beach.

Dry Beach placement is the most commonly used method for beach nourishment in California. It may involve hydraulic pipeline delivery of the sand-water slurry from a hopper or cutterhead dredge to the receiver beach. Trucks may be used to deliver sand from upland sources to the beach. Trucked sand may be placed on the backshore or foreshore.

Nearshore placement involves discharge of sands seaward of the surf zone. Redistribution of sand to the intertidal portion of the beach will vary according to wave and climatic conditions. Nearshore placement is the second most commonly used placement method for projects in California.

Profile placement involves a combination of nearshore and dry beach placement along the entire beach profile. This placement attempts to build a stable beach so there is less change in beach width associated with sand redistribution. This method is considered the most difficult of the placement methods (DBW and SCC 2002).

Sand spreading may or may not occur after sand placement. Generally, hydraulically pumped sands must be spread with earth moving equipment because



Source: DBW and SCC 2002

sands are discharged at the end of a stationary pipe. (Booster pumps may be necessary to move the slurry along extended pipeline sections.) Sands discharged above the high tide line also are spread with earth moving equipment.

Sands placed in piles on the foreshore or in the surf zone do not require spreading because wave action reworks and redistributes the sands.

Structures may or may not be associated with beach nourishment projects. Termed as "hybrid" projects by the NRC (1995), projects may include a combination of beach nourishment and structures such as seawalls, revetments, groins, detached breakwaters, or submerged sills. Submerged sand retention devices in conjunction with beach nourishment are being considered in some areas of southern California to prolong the duration of beach nourishment benefits (Everts and Eldon 2000, Moffatt & Nichol 2002, EIC 2010). The USACE is conducting a design study for an offshore submerged structure for beach erosion control at Oil Piers, Ventura County (ASR Ltd. 2004).

Bulldozer spreading hydraulically pumped sand
Photo credit: Karen Green

Truck-placed sand piles on foreshore, Encinitas
Photo credit: Kathy Weldon

2.3.3 Post-Construction Phase

After sand placement, sediment is transported up- or downcoast and on- or offshore according to natural coastal processes (currents, waves). Sands are redistributed in the littoral zone throughout the shore and shorerise portions of the beach profile. Sands placed on the dry beach may form a scarp (steep profile) as a result of wave action until an equilibrium profile is reached. Scarps also may naturally form from wave action, particularly during the winter storm season.

Beach scarp after winter storm, Oceanside
Photo credit: Karen Green

Maintenance

Sediment management activities often are a maintenance action. Periodic dredging and excavation are undertaken to maintain navigable channels, tidal exchange in lagoons, or flood control channel capacity. A number of factors may influence maintenance frequency including sedimentation rates, sediment characteristics, shoreline characteristics, local bathymetry, proximity to man-made structures, oceanographic conditions, and weather. The time interval between activities (maintenance cycles) may vary from one to several years depending on climate and site-specific environmental and physical conditions.

Benefits from beach nourishment erode over time as a result of sand transport. Unless there is identified funding, beach nourishment generally is not considered a maintenance activity. In

contrast, shoreline protection projects that include beach nourishment typically specify renourishment intervals to maintain project benefits.

Frequency of disturbance is an important consideration when evaluating the potential for impacts to biological resources. Biological resources need time to recover from disturbance. The amount of time for recovery generally is influenced by the nature and scale of impact, timing of the impact, as well as environmental conditions during the recovery phase.

Beach Grooming

Beach grooming is undertaken by municipalities at some beaches in California to remove trash and debris to enhance public recreation. This maintenance activity is unrelated to sediment management. Biological resource development or use patterns may differ at beaches that are groomed compared to those that are not (Dugan et al. 2003, Dugan and Hubbard 2010). Therefore, beach grooming is an important aspect of existing conditions and evaluations of potential impacts from sediment management activities.

Beach grooming, Coronado *Photo credit: Karen Green*

The Ecologically Sensitive Beach Management Working Group, consisting of scientists, resource agency personnel, and other beach professionals, was established in 2003 to discuss and develop best management practices (BMPs) to protect grunion spawning at managed beaches The group is now a nonprofit educational organization, the Beach Ecology Coalition.

2.3.4 Mitigation and Monitoring

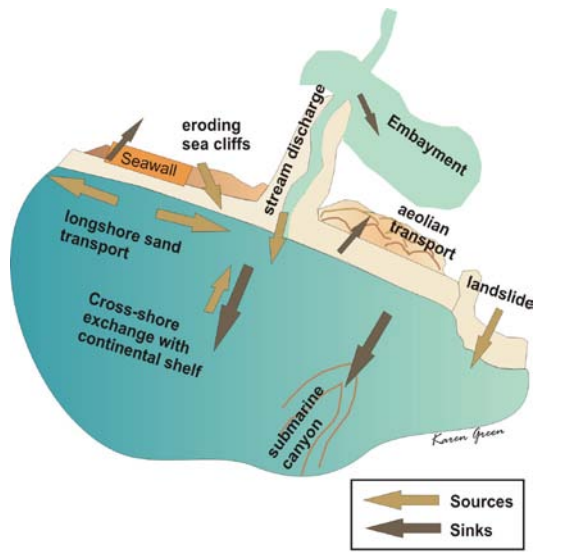
Mitigation and monitoring may occur throughout all project phases (pre-construction to post-construction) of sediment management projects. Mitigation measures include actions taken during project design or construction to avoid or minimize environmental impacts. Post-project mitigation may include monitoring or additional actions to protect resource values of sensitive habitats. If monitoring determines that the project resulted in significant impacts to sensitive resources, remediation or compensatory mitigation may be required. In that case, mitigation would be necessary to rectify or to compensate impacts by replacing (in-kind mitigation) or providing substitute (out-of-kind mitigation) resources. Mitigation and monitoring is discussed in greater detail in Section 2.8.

2.4 Overview of Coastal Environmental Conditions Relevant to Sediment Management Activities

Oceanographic conditions and coastal processes are key factors influencing local differences in physical, chemical, and biological characteristics of the marine environment. These factors influence circulation and mixing of waters and transport of sediments. They also influence distribution and abundance of aquatic organisms. Environmental conditions that are particularly relevant when evaluating the potential for impacts to biological resources from sediment management activities are presented in the following subsections.

2.4.1 Natural Sediment Supply and Sinks

Sediment input, movement, and trapping within the coastal zone is a dynamic process (Figure 2.4-1). Sediments washed from the land during winter storms are conveyed to the ocean by creeks, rivers and streams, which transport 70 to 90 percent (%) of the natural sand supply to California beaches (DBW and SCC 2002). Erosion of coastal bluffs and cliffs (including landslides) provide an important secondary source of sediment to the coast.



Modified from: Komar 1996

Figure 2.4-1. Sediment sources, movement, and sediment sinks in the coastal zone.

The relative contribution of sediment supply from river and stream discharges versus bluff erosion varies along the 1,100-mile (mi) (1,760 kilometer, km) coastline of California depending on local conditions (CCC 1987). Heavier rainfall contributes to a greater number of perennial flows, and sand supply, in northern California than in southern California, where most streams flow only part of the year.

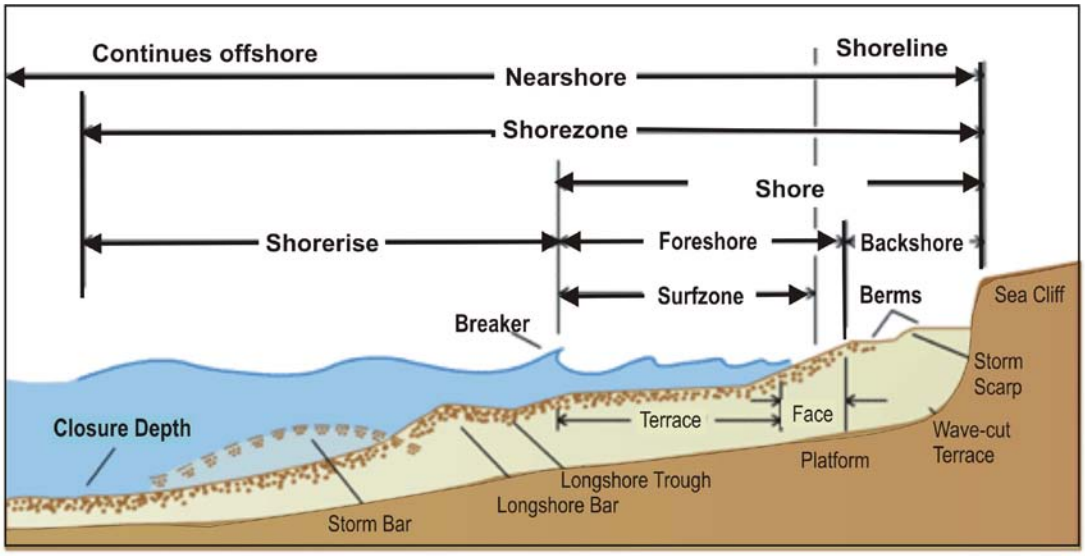
Human construction and development have substantially reduced natural sediment loads to the coastal zone (e.g., dams, flood control channelization, urban development, and increased water diversion and draw down to meet agricultural and urban demands). Approximately 10% of the coast had been armored (e.g., seawalls) to protect lowlands, dunes, and eroding sea cliffs in the 1980s (CCC 1987), and that percentage has increased since then. It has been estimated that damming of rivers alone has reduced half the natural sand supply to beaches between Santa Barbara and Mexico.

Sediment often becomes trapped within embayments, resulting in sedimentation and the need for sediment management (e.g., maintenance dredging, excavation). Littoral sands may become trapped in entrance channels and basins. Watershed runoff may result in sedimentation in back bay areas where stream discharges enter embayments.

Coastal dunes represent another type of sediment sink. Strong winds may blow beach sands landward with drifts accumulating around objects (e.g., beach wrack, driftwood). Dune formation is a slow process, and sands are subject to wind (aeolian) transport until stabilized by plants.

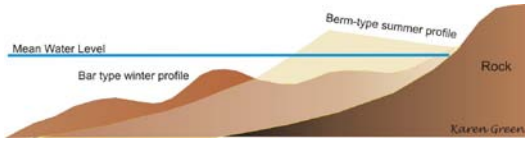
2.4.2 Currents, Tides, and Waves

Sediments move both along and across the coastal shelf. A specific transport area exists within the beach closure depth, termed the littoral zone, within which sediments associated with the beach habitat move. The littoral zone is bounded by the backshore and nearshore closure depth of the beach (Figure 2.4-2). The closure depth is variable along the coast depending on local bathymetry and other physical characteristics.



Source: Inman and Masters (eds), UCSD 2003. http://coastalchange.ucsd.edu, accessed September 2005. Reproduced with permission

Figure 2.4-2. Diagram of the beach shorezone and associated coastal features.



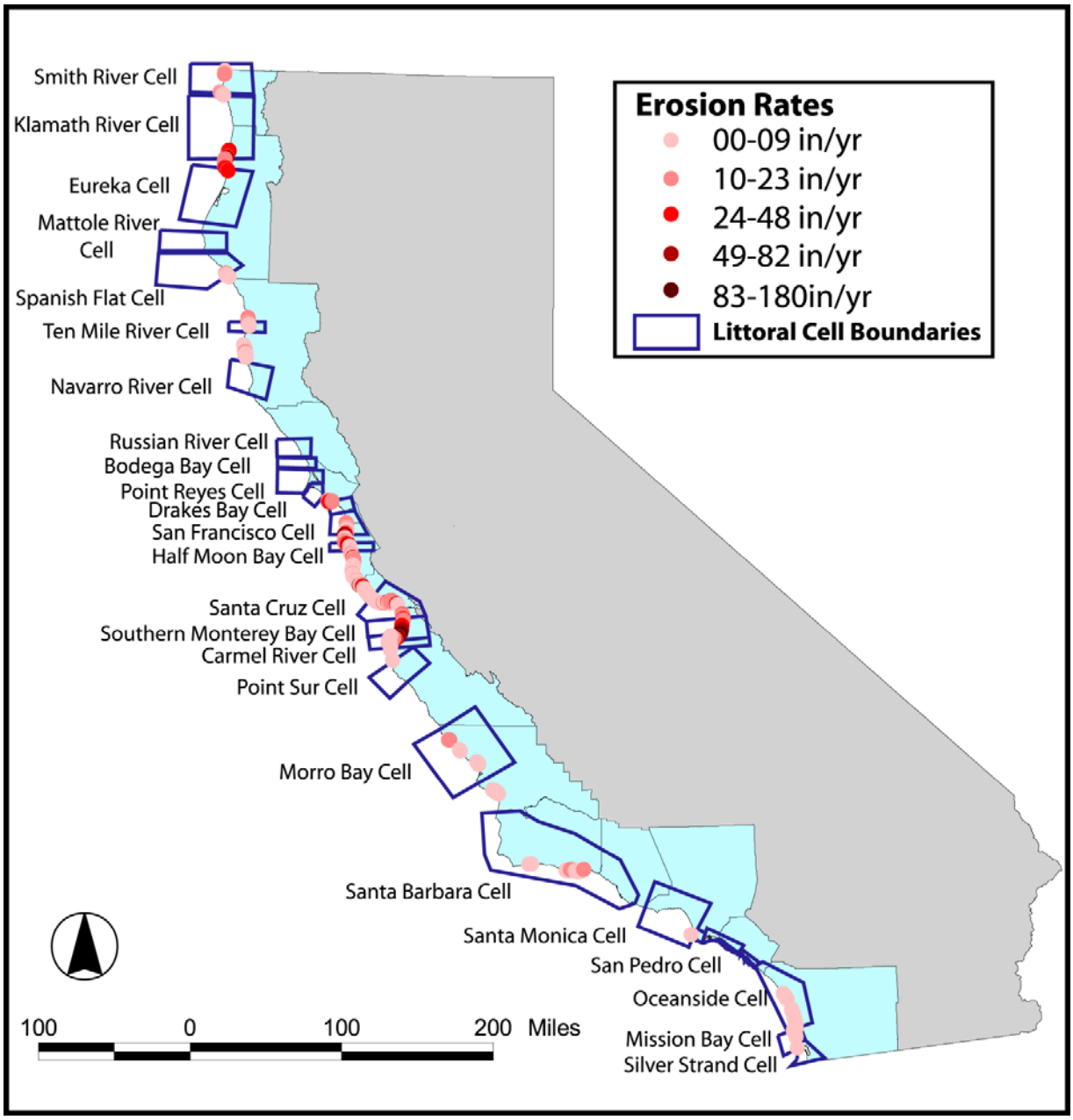
Modified from: Komar 1998

Figure 2.4-3. Example of seasonal difference in summer and winter beach profiles.

Seasonal variations in wave climate result in changes in sand volume on beaches with generally less sand (erosion) during winter and more sand (accretion) during summer (Shepard and Inman 1951). The sand may form a berm-like profile in summer from sand accumulation within the relatively narrow exposed beach (Figure 2.4-3). When sand moves offshore during the winter season, it may accumulate in one or more bars in the nearshore. The position of the bars may shift farther seaward during substantial storms (refer to Figure 2.4-2). When sand supply within a littoral cell is at a deficit (i.e., more sediment lost to sinks than supplied from sources), sand may be seasonally stripped to an underlying rocky platform (Figure 2.4-5).

All coasts are divided into natural sand transport compartments, termed littoral cells, which encompass a complete sedimentation cycle including sources, sinks, and transport paths associated with the beach (Figure 2.4-4). Rocky headlands or submarine canyons represent natural boundaries of littoral cells, with submarine canyons acting as sediment sinks. Large storms and waves may extend the transport zone seaward beyond the normal closure depth.

The dynamic nature of sediment movement is important to consider when evaluating potential impacts to biological resources from sediment management activities. Nearshore aquatic habitats and species naturally experience sedimentation and sand movement associated with cross-shelf transport, longshore sand movement, and episodic storm runoff. However, the degree of exposure to these effects vary by location, depth, wave exposure, and weather.



Sources: Habel and Armstrong 1977 in DBW and SCC 2002.
Reproduced with permission from DBW

Figure 2.4-4. Littoral cells and estimated erosion rates offshore California.

May 1999 – seasonal sand eroded condition prior to nourishment

July 1999 – seasonal sand accretion condition prior to nourishment

June 2002, view south toward beach in above photographs after nourishment
(sand appearance was representative of location shown in first two photographs)

Photo credit: Karen Green

Figure 2.4-5. Example of seasonal beach change on Leucadia Beach prior to sand nourishment and condition of beach after nourishment.

The oceanographic circulation of waters offshore California is closely tied to the California Current, which carries cold and relatively less saline water in a equatorward (southward) direction from the Gulf of Alaska along the California coast and turns shoreward near the U.S.-Mexico Border (Hickey 1993). The California current flows at relatively shallow depths.

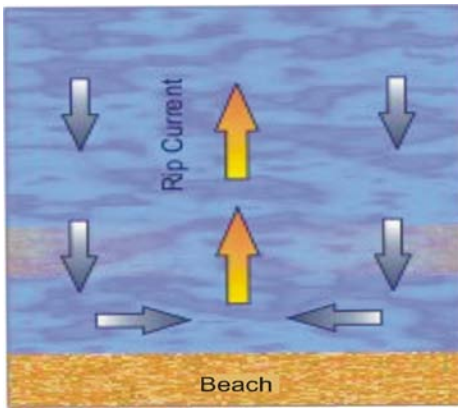
In southern California, a portion of the California Current turns poleward (northward), which is termed the Southern California Countercurrent. Eddies and gyres may form where the California current and Southern California Countercurrent meet. The Southern California Eddy may seasonally form between the mainland and southern Channel Islands in summer and fall when equatorward winds relax and the California Current slows. The Santa Barbara gyre is a relatively closed counterclockwise circulation between the Santa Barbara coast and northern Channel Islands.

Below the coastal surface flows is the northward flowing California Undercurrent, which has relatively higher temperature and salinity (Hickey 1993). North of Point Conception, the flow extends throughout the water column during late fall and winter, representing a reversal of the California Current and surfacing of the California Undercurrent (also referred to as the Davidson Current). Surface currents are complex between Point Sur and San Francisco; jets or squirts of upwelled colder water may extend offshore, and counterclockwise (cyclonic) or clockwise (anti-cyclonic) eddies may form (Broenkow 1996).

Tides off California are a mixed, semidiurnal type with two unequal high tides and two unequal low tides. Tides are the primary sediment transport force inside enclosed bays and estuaries (Inman and Masters 2003). Longshore transport of sand within the littoral zone is important to the inlet dynamics of shallow-inlet embayments. Sand inflow may reduce tidal prism (volume of water exchange with tides) and result in sand accumulation (shoaling) that may result in inlet closure. In deepwater-inlet embayments, littoral sands may become trapped in entrance and outer harbor areas.

Tidal currents also are important to transport of finer sediments offshore. Waves and the nearshore currents they generate are the predominant factors affecting nearshore sand transport and deposition (Nittrouer and Wright 1994). Waves break at an angle to the beach and generate a longshore current that flows parallel to shore either up or downcoast based on the propagation direction of the breaking wave.

The water in the longshore current returns seaward as a cross-shelf *rip current*, with the spacing between rip currents generally two to eight times the width of the surf zone (Inman and Masters 2003). Rip currents are a common occurrence, but are episodic in nature, varying with tide stage and wave conditions. Headlands, breakwaters, and other obstructions may alter the direction of longshore currents and spacing of rip currents. Obstructions (e.g., groins) also may accelerate erosion of downdrift beaches.



Rip Current through break in sand bar
Public domain, www.ripcurrents.noaa.gov

Rip currents facilitate movement of suspended sediments offshore. Currents are typically 1-2 feet per second (ft/sec), although they may range up to 8 ft/sec (NOAA 2005a). Rip currents can be very narrow or extend several hundred feet in width. They may end just beyond the breaker zone or extend several hundred feet offshore. Waters in rip currents often are turbid as a result of the sandy sediment being suspended in the water, giving waters a discolored "dirty" appearance.

Rip current, Encinitas, California
Photo Credit: Kathy Weldon

Turbidity in rip current
Photo credit: Nick Steers, Life Guard Captain, http://www.ripcurrents.noaa.gov

Movement and settling rates of sediment depends on particle size and water depth. Waves and currents sort sediment as it moves offshore. Consequently, coarser sands tend to remain closer to shore and finer sediments generally occur offshore. The wave climate is influenced by storm swells, which may originate from different locations, as follows:

- extratropical storms during northern hemisphere winters (north or northwest swell),
- tropical storm swells and cyclones off the Mexican coast during northern hemisphere summers (southeast swell), and
- southern hemisphere swells generated by large South Pacific storms during southern hemisphere winters (south-southwest swell).

Winds generate waves and when combined with storm swells can produce high wave conditions, which may result in substantial sand reworking and transport in the littoral zone. Wave energy in southern California is partially sheltered (shadowed) by offshore islands, shallow banks, or coastal submarine canyons depending on the direction of wave propagation. Wave energy is not shadowed along the central and northern California coasts, which also have more rugged and rocky coastlines.

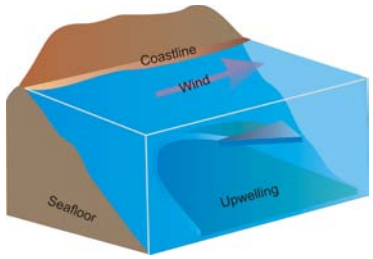
Wave heights tend to be higher during winter and spring due to storms from the North Pacific. Substantial wave heights also may be associated with El Niño Southern Oscillation (ENSO) events. Waves in California generally range from 3 to 10 ft (1 to 3 m) although heights > 19 ft (6 m) have been recorded during extreme storm conditions (Seymour et al. 1989, USACE 1991). Extreme wave heights also have the potential to occur with tsunamis, which originate from a large displacement of water (e.g., earthquake, volcanic eruptions, landslides, etc.).

Winter wave beach retreat, Oceanside
Photo credit, Karen Green

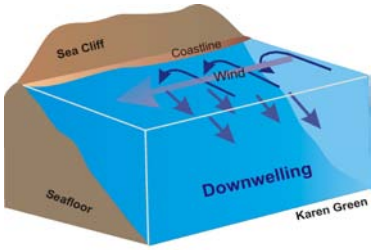
2.4.3 Upwelling and Downwelling

Winds that blow parallel to the coast from the north (equatorward surface currents) push nearshore waters offshore (coriolis effect in northern hemisphere deflects water to the right),and nutrient-rich water rises from depth to replace the displaced water (Hickey 1993). Upwelling is critical to primary production and has widespread influence on ocean productivity. Although coastal upwelling regions account for only one percent of the ocean surface, they contribute roughly 50 percent of the world's fisheries landings. (NOAA 2005b).

Downwelling is the opposite phenomenon, occurring when winds from the south push offshore waters towards the shore, and the relatively warm surface water piles up and sinks downward and away from the coast. Storm generated downwelling also may influence sand transport, and is considered a source of sediment to the inner shelf off northern California (Cacchione and Drake 1990 cited in Nittrouer and Wright 1994).



Strong winds from the north may produce upwelling.



Strong winds from south or onshore may produce downwelling.

Modified from http://oceanexplorer.noaa.gov

2.4.4 Climate Oscillation Patterns

ENSO events are global-scale climatic variations with a dominant period of 5 to 7 years (Hickey 1993). They are characterized by a decrease in atmospheric pressure in the eastern tropical Pacific Ocean, a decrease in the easterly trade winds, and an increase in sea level on the west coast of North and South America (Chelton et al. 1982). El Niño conditions may cause higher than average wave heights. The severe storms associated with the 1982-1983 and 1997-1998 ENSO events contributed to denuded beach conditions in southern and central California (Inman and Masters 2003). Following El Niño conditions, there may be a period of cold-water conditions, termed La Niña.

El Niño and La Niña events may be thought of as lying on top of a large- scale climate pattern termed the Pacific Decadal Oscillation (PDO). The PDO, which sometimes is described as a long-lived El Niño like climate pattern, occurs on the order of every 20 to 30 years (Mantua et al. 1997). Generally, the PDO is referenced as "warm" or "cool" phases corresponding to temperature of surface waters.

Useful References on ENSO and PDO Climate Patterns

- *www.elnino.noaa.gov*
- *jisao.washington.edu/pdo*
- *www.jpl.nasa.gov/science/el-nino.html*
- *http://darwin.bio.uci.edu/~sustain/ENSO.html*

These climate patterns are relevant with respect to understanding existing marine ecosystem conditions at the time a sediment management project may be scheduled. El Niño events may result in substantial effects on marine resources due to depressed upwelling, nutrient limitation, higher temperatures, greater wave energy, and influx of southern species farther up the coast than is typical (Chelton et al. 1982, Broenkow 1996). Major changes in Pacific marine ecosystems have been correlated with phase changes in the PDO with warm phases characterized by lower productivity and cool phases having the opposite trends.

A longer-term issue of significance is climate change and the challenges that presents to coastal management. Emissions of carbon dioxide (CO_2) since the Industrial Revolution have resulted in higher atmospheric, ocean, and terrestrial CO_2 levels. It has been estimated that the world's oceans have served as a sink for up to 30% of all anthropogenic CO_2 produced since the Industrial Revolution, and that level will change in the future.

Useful Climate Change Links

- *www.climatechange.ca.gov/*
- *http://cal-adapt.org/*
- *www.coastal.ca.gov/climate/climatechange.html*
- *www.bcdc.ca.gov/*
- *www.scc.ca.gov/*
- *http://resources.ca.gov/copc/*
- *www.resources.ca.gov/*
- *www.ipcc.ch/*
- *www.pewclimate.org/*
- *www.ucsusa.org/*
- *www.coastalstates.org/*
- *www.climatescience.gov/Library/*

Coastal habitats and resources will experience changes in weather patterns, increased intensity of storms (wave heights, storm surges), higher temperatures, sea level rise, altered water chemistry (decreased pH levels, termed: ocean acidification), and increased shoreline erosion. Models have predicted sea level rise of 1 to more than 6 ft and pH decreases of 0.2 to 0.4 units by the end of the century (Rahmstorf 2007, PPIC 2008).

Sea level rise, higher temperatures, ocean acidification, and the synergistic impacts of other stressors have the potential for widespread changes to marine ecosystems. The following is a list of potential impacts to marine/estuarine habitats and resources (Kennedy et al. 2002, Bjork et al. 2008, CINMS 2008, CCC 2008; Fabry et al. 2008, Feely et al. 2008, 2010; Crim 2010, Hale et al. 2011, NABCI 2010):

- Reduction or loss of dunes and beaches;
- Greater inundation of wetlands, including reduction or loss of habitats and fragmentation of migration corridors;
- Ocean acidification impairment of calcification rates for species (particularly early life stages) with carbonate shells, tests, or skeletons (e.g., abalone, calcareous algae, clams, corals, coccolithophorids, echinoderms, foraminifera, lobsters, mussels, oysters, pteropods, sea urchins);
- Reduction in giant kelp forests;
- Reduction in native species and proliferation of exotic, invasive species.
- Ecosystem shifts, including changes in species' geographic distributions, and alteration of marine biodiversity and community structure.
- Impacts to oceanic and coastal bird populations.

There is uncertainty about the pace or magnitude of changes, and several models and scenarios have been developed to inform decision-making relative to climate change adaptation and mitigation (reduction) strategies. California has enacted a wide range of legislation addressing climate change and the Governor also has issued executive orders directing state agencies to address climate change (*www.climatechange.ca.gov/*). The California Ocean Protection Council recently adopted a resolution to provide guidance on sea level rise projections to be used by state agencies (OPC 2011) (Table 2.4-1).

Table 2.4-1. Sea-level rise projections using 2000 as the baseline condition.

Year		Average of Models	Range of Models
2030		7 in (18 cm)	5-8 in (13-21 cm)
2050		14 in (36 cm)	10-17 in (26-43 cm)
2070	Low	23 in (59 cm)	17-27 in (43-70 cm)
	Medium	24 in (62 cm)	18-29 in (46-74 cm)
	High	27 in (69 cm)	20-32 in (51-81 cm)
2100	Low	40 in (101 cm)	31-50 in (78-128 cm)
	Medium	47 in (121 cm)	37-60 in (95-152 cm)
	High	55 in (140 cm)	43-69 in (110-176 cm)

Notes: Estimates based on Vermeer and Rahmstorf (2009)
For dates after 2050, three different values are based on low, medium, and high greenhouse gas emission scenarios. These values are based on the Intergovernmental Panel on Climate Change emission scenarios as follows: B1 for the low projections, A2 for the medium projections and A1Fi for the high projections. For future reference, check the OPC website at *www.opc.ca.gov* for updates.

State and local agencies are working to develop approaches to mitigate (reduce) and adapt to climate change effects on the coastal zone (CCC 2008, CNRA 2009), including Local Coastal Program updates (e.g., City of Solana Beach 2009), climate action plans (City of Encinitas 2011), or development of adaptation policies (e.g., BCDC 2009, Ocean and Coastal Policy Center Santa Barbara 2009).

Coastal regional sediment management, including beach nourishment, is likely to feature in climate and sea level rise adaptation strategies. To date, CSMW and their various regional partners have completed three Coastal RSM Plans (Monterey Bay, San Diego, Santa Barbara) and six others are in preparation or planned (Eureka, Los Angele County, Orange County, San Francisco Bay, San Francisco Littoral Cell, Santa Cruz Littoral Cell).

Several different types of methods may be considered in adaptation strategies (CCC 2008, BCDC 2009), such as:

- Beach and dune nourishment,
- Captive breeding programs and relocation programs,
- Create buffer zones for marsh migration,
- Land acquisition (e.g., accommodate inland migration of wetland habitats),
- Prioritize wetland restoration,
- Living shorelines (e.g., stabilization with seagrasses, marsh, or riparian vegetation, oyster beds, reefs, riprap, breakwater),
- Produce habitat and species status projections under different [climate change] scenarios,
- Managed retreat, and
- Rolling easements.

California Climate Adaptation Strategy, Ocean and Coastal Guiding Principles (CNRA 2009)

- California must protect public health and safety and critical infrastructure;
- California must protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well being depend;
- California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources;
- New development and communities must be planned and designed for long-term sustainability in the face of climate change;
- California must look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time; and
- California must begin now to adapt to the impacts of climate change. We can no longer act as if nothing is changing.

2.4.5 Water Quality

Waters naturally vary in quality depending on a variety of environmental conditions and anthropogenic influence. Existing water quality conditions are an important consideration when evaluating the potential for dredging or discharge activities to impact biological resources.

Along the open coast, water quality may be influenced by plankton blooms, rip currents, high waves and river discharges during storms, or man-made discharges (e.g., waste-water outfalls, non-point source storm water runoff, oil spills). Microbial water quality sampling (for total coliforms, fecal coliforms (or *E. coli*), and enterococci) is routinely conducted at beaches throughout California, although the frequency of sampling was reduced in certain parts of the state in 2009 due to budget cuts (NRDC 2010). Beaches are posted with an advisory to protect the public by the California Department of Health Services if state water standards for recreational use are exceeded. Most exceedances occur in winter months associated with stormwater runoff; although certain beaches may have poor water quality year-round.

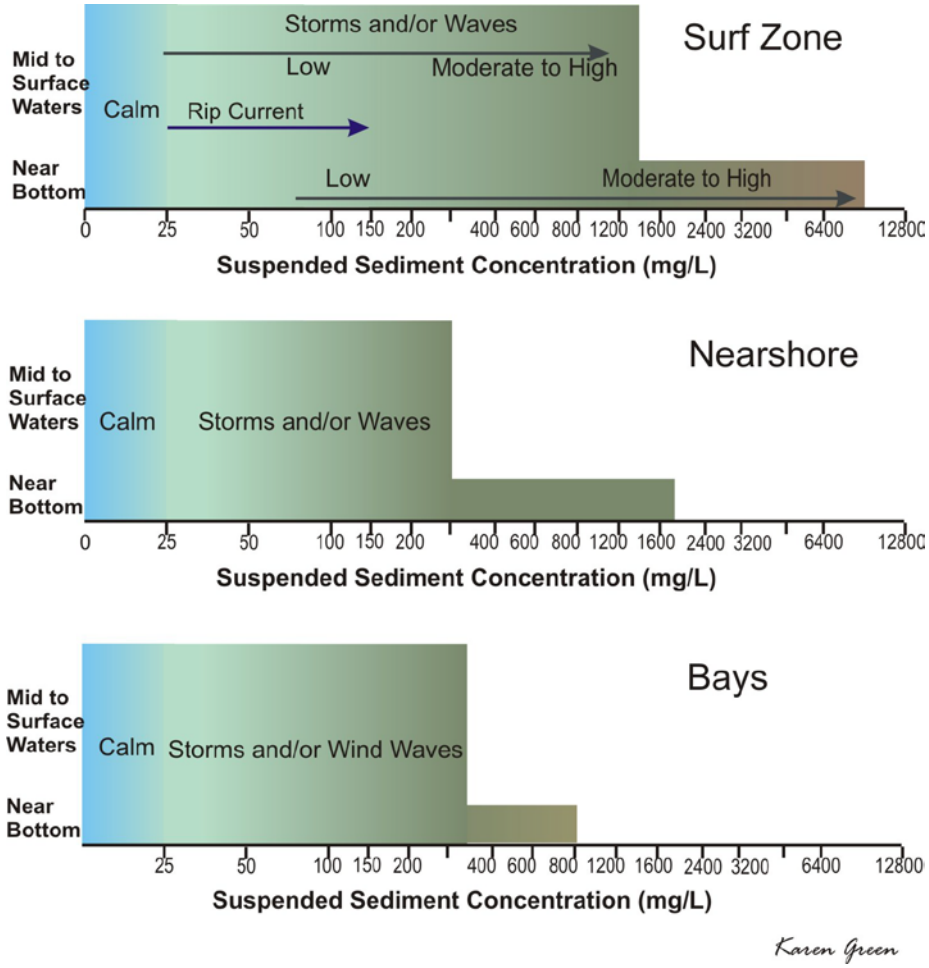
Because beach nourishment uses "clean" sandy material and the receiving environment is well mixed, there are few water quality concerns associated with beach or nearshore placement. Generally, the primary concern is elevated suspended sediment concentrations, which may discolor the water, reduce water clarity, and adversely affect marine organisms.

Similarly, turbidity (cloudiness of water) is a primary water quality consideration during dredging. However, additional considerations may apply to borrow sites depending on excavation depths and proximity to man-made discharges. Oxygen depletion (anoxia) of bottom waters from an accumulation of fine particulates and organics has been reported for some borrow sites that were dredged as deep pits (NRC 1995).

Several additional considerations may apply depending on location and environmental conditions. Water quality in coastal embayments is influenced by tidal circulation and exchange, and lower quality may occur in areas where water exchange is reduced. Stormwater runoff, vessel traffic and docking, and dredging or discharges also may be influential. In addition, sediment quality may vary with respect to organic matter, nutrient concentrations, and contaminant loadings associated with watershed inputs or industrial activities (past or present), all of which have the potential to affect water quality when sediments are disturbed.

Turbidity naturally varies in coastal waters, and understanding that variability helps place into context potential impacts during dredging or discharge. Suspended sediment concentrations in a water body may range from low levels during calm weather to relatively high levels during turbid conditions associated with storms or high wave activity.

Along the coast, ambient calm weather suspended-sediment concentrations generally range between 2 and 26 mg/L in the water column (Table 2.4-2, Figure 2.4-6). Suspended-sediment concentrations ranging from 25 to approximately 150 mg/L have been measured in rip currents (Smith and Largier 1995, Warrick 2010). Higher concentrations may occur during storms or high wave conditions.



Note: Maximum values based on available literature, actual values may range higher. Sources: see Table 2.4-2

Figure 2.4-6. Natural suspended-sediment concentrations in coastal habitats.

Suspended sediment concentrations in the surf zone vary with height above the bottom, wave height, and sea condition. Concentrations are higher near the bottom and decrease with height above the bottom. Generally, near-surface concentrations rarely exceed 1,000 mg/L (Clark et al. 2009). Schiff et al. (2011) measured suspended sediment concentrations in the surf zone at reference sites and Areas of Special Biological Significance (ASBS) in southern California before and after several storms in 2010. The overall mean concentration was 16.5 mg/L before the storms and the post-storm concentrations in the ASBSs ranged up to 460 mg/L.

Watts (1954) investigated suspended sediment concentrations in the surf zone at Pacific Beach, California along a water depth profile ranging from 1 to 13 ft (0.9 to 4 m) during rough sea conditions between January and May. Measurements were taken at heights above the bottom ranging from < 1 to 4 ft (<0.3 to 1.2 m). Concentrations ranged between 26 and 7,910 mg/L. During periods with small waves (<3 ft, <0.9 m), average concentrations ranged from 288 to 510 mg/L within 1 ft (0.3 m) of the bottom, and 89 to 321 mg/L at elevations 2 to 4 ft (0.6-1.2 m) off the bottom. During periods with 3 to 6 ft (0.9-1.8 m) waves, average concentrations ranged from 850 to 3,470 mg/L within 1 ft (0.3 m) of the bottom, and 375 to 1,360 mg/L at elevations of 2 to 4 ft (0.6-1.2 m) off the bottom.

Table 2.4-2. Total suspended solids concentrations during storms, high waves, or river runoff in bays and the nearshore zone.

Location	Ambient (mg/L)	Storm or High Waves (mg/L)	Comments	Reference
Surf Zone to Nearshore				
Oregon, San Marine Beach		600-2,900	Surf zone, dissipative beach (1 to 6 in above bottom in 1 to 2 ft of water); waves 6.5 to 8 ft	Ogston and Sternberg 1995
Northern California	35	110 (peak hourly 1,000)	Surf zone (1-3 ft above the bottom)	Ogston and Sternberg 1999
	2-12		Nearshore, sea state <4	Pacific Affiliates, Inc. 2006, 2007
Central California Santa Cruz	40-50	470 (average mean)-1,690 (maximum mean)	Nearshore (40 ft water depth, 7 inches above bottom; 2 storms)	Storlazzi and Jaffe 2002
Southern California	16.5	60-460	Surf zone; ambient 85th percentile, storm data at ASBSs	Schiff et al. 2011
		26-1,570 (288-510 average)	Surf zone (<1 ft above bottom); 1-3 ft waves	Watts 1954 (Sampling conducted January-May)
		244-7,910 (850-3,470 average)	Surf zone (< 1 ft above bottom); 3-6 ft waves	
		89-521 (89-321 average)	Surf zone (2-4 ft above bottom; 1-3 ft waves)	
		182-1,840 (375-1,360 average)	Surf zone (2-4 ft above bottom; 3-6 ft waves)	
	<10-<25		Surf zone	Sherman et al. 1998, Warrick 2010
		>200-300	Nearshore, Santa Barbara Channel	Warrick et al. 2004a (Sampling after El Niño storms)
		45-80	Nearshore	Warrick et al. 2007
	2-6		Nearshore	USACE 2004 data
	25-150		Rip current	Warrick 2010
New Jersey	<10-<20	120->150	Swash	Wilber et al. 2006 (Storm data after hurricanes)
	<10-<20	<50->150	Surfzone	
	<10-<20	<50	Nearshore	
Offshore River Mouths				
Eel River, CA		1,000 to 2,000 (bottom); >10,000 (bottom)	Storm outflow; major flood discharge	Wright et al. 1999; Ogston et al. 2000
Russian River, CA		56 to 100	Storm outflow	Sherwood et al. 1994
Santa Clara and Ventura Rivers, CA		60 to 100	Storm outflow	Mertes et al. 1998, Warrick et al. 2004a
Bays				
San Francisco Bay, CA	6-22	58-350; (600-800)	Storm conditions; (null or entrapment zone)	O'Connor 1991, Schoellhamer 1996[1], LFR 2004
Ventura Harbor, CA	29-46		Pre-dredge ambient	USACE 2004 data
Los Angeles, CA	18-19			Anchor Environmental 2003
Dana Point Harbor, CA	18-26			USACE 2000 data
Oceanside Harbor, CA	<20			USACE 1998 data
San Diego Bay, CA	4-12			USACE 2004 data
Indian River Bay, DEL		570		Huntington and Miller 1989[1]
Chesapeake Bay, MD,VA		600		Brownlee et al. 1988[1]

[1]cited in Wilber et al. 2001.

Concentrations also may vary with beach type. For example, suspended sediment concentrations of 600 to 2,900 mg/L (near-bottom) were reported in the surf zone at a dissipative beach in Oregon during wave heights ranging from 6.5 to 8 ft (2-2.5 m) (Ogston and Sternberg 1995). Similarly, Concentrations of 1,000 to 2,000 mg/L at elevations of 6 to 11 in (15 to 27 cm) above the bottom have been measured offshore the Eel river during storm conditions (Wright et al. 1999).

Waves and winds also influence suspended sediment concentrations of nearshore waters on the inner shelf. Storlazzi and Jaffe (2002) deployed a bottom-mounted instrument array at a water depth of 40 ft (12 m) off Santa Cruz in central California that measured waves, currents, suspended-sediment concentration, temperature, salinity, and seabed-level changes for 800 hours between May and June 1998. Two storms with deep-water waves of more than 10 ft (3 m) occurred during the deployment. Suspended sediment concentration was estimated using an optical backscatter sensor at a height of 7 inches (0.18 m) above the bottom. Ambient near-bottom suspended sediment concentrations were 40 to 50 mg/L prior to sediment suspension events, which were associated with wave groups or large waves. Maximum instantaneous burst concentrations, lasting 1 to a few seconds, ranged up to 20,000 mg/L. However, the mean concentration across a sediment suspension event (i.e., ambient, increase, peak value, decrease, ambient) was much lower. The mean concentration over all sediment suspension events was 340 mg/L. During the higher wave events, the overall mean concentration was 470 mg/L and the maximum mean concentration was 1,690 mg/L.

Ogston and Sternberg (1999) conducted a year-long study of the inner shelf off Northern California and reported suspended sediment concentrations at elevations of 1 to 3 ft (30 and 100 cm) above the bottom. Mean concentrations were 35 mg/L during ambient conditions and 110 mg/L during sediment suspension events; peak hourly concentrations exceeded 1,000 mg/L. Suspended sediment events associated with significant wave heights, tidal currents, and river discharges generally had durations ranging from 1 to 8 days.

Concentrations ranging from 56 to 100 mg/L have been measured offshore the Russian, Santa Clara, and Ventura Rivers in California (Mertes et al. 1998, Sherwood et al. 1994, Nezlin and DiGiacomo 2005, Warrick et al. 2004a). Much higher concentrations may occur close to shore. As material is introduced into coastal waters from rivers, it is influenced by density differences between fresh and saline water, suspended sediment concentration, and processes that affect particle flocculation. Because freshwater is less dense than seawater, river water will typically enter the ocean as a buoyant plume (hypopcynal), which may be quite turbid (Wright and Nittrouer, 1995; Farnsworth and Warrick 2007). These buoyant plumes have been observed to extend tens of kilometers from the California shoreline; however, little of the discharged sediment resides in the buoyant plume due to rapid settling (Warrick et al. 2004b). Studies of sediment dispersal from the Santa Clara River (satellite observation and ship-based sampling) suggest that approximately 90% of the fine sediment settled from the buoyant plume within (1 km) of the river mouth during storm discharge (Warrick et al. 2004b).

Hypopyncnal – density of river outflow plume is less than that of the receiving sea water. In this case, the sediment will form a spreading plume at the sea surface and will gradually settle to the sea-bed.

Homopyncnal – plume density is equal to that of the receiving sea-water, in which case the plume will mix vertically with the sea-water and drop its load in a mouth bar.

Hyperpyncnal - plume density is greater than that of the receiving sea-water. In this case the plume will sink to the sea floor and may form a turbidity current.

When very high concentrations of sediment are discharged to the ocean, turbidity plumes may sink and form hyperpycnal (near-bottom) plumes of high-density benthic suspensions (fluid mud). Generally, hyperpycnal plumes form when river discharge enters the ocean with suspended concentrations in excess of 36 kg/m^3 (36,000 mg/L) and sink due to buoyancy considerations, or at concentrations of 1-5 kg/m^3 (1,000-5,000 mg/L) if there is convective instability (Parsons et al. 2001, Mulder et al. 2003). Concentrations >10,000 mg/L have been measured in hyperpyncnal plumes offshore the Eel River (Ogston et al. 2000, Warrick and Milliman 2003). The Santa Clara and Salinas Rivers also discharge very high suspended sediment concentrations (Farnsworth and Warrick 2007).

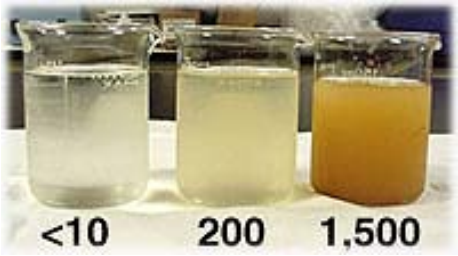
Sediment delivery from coastal watersheds to the marine environment is episodic. Sediment delivery is extremely episodic in southern California with approximately 90% of the annual fine-sediment load delivered over approximately 4 days per year (Farnsworth and Warrick 2007). More sediment is discharged to the ocean from central and northern California rivers over slightly longer periods, but is still episodic. ENSO and PDO events strongly influence sediment discharge, which greater discharge during cool phases in northern California and greater discharges during the warm phases in central and southern California (Farnsworth and Warrick 2007).

Alongshore turbidity plume during sand discharge, City of Encinitas

Photo credit: Moffatt & Nichol

Studies indicate that movement of turbidity plumes is primarily alongshore than across-shore, except in areas of rip currents (Sherman et al. 1998, AMEC 2002, Warrick et al. 2004b). Winds may strongly influence plume transport over temporal scales of days. Once settled, sediment deposits may be transported offshore over successive storm events or more energetic waves during winter (Farnsworth and Warrick 2007).

Calm weather concentrations in California bays and harbors generally are less than 30 mg/L. Winter concentrations in San Francisco Bay generally are ≤200 mg/L (LFR 2004), but may range up to 350 mg/L in surface waters and 600-800 mg/L in the near-bottom turbidity entrapment zone (Table 2.4-2). Elevated values of 570 to 600 mg/L have been reported for certain East coast bays.



mg/L

Photo credit: USGS

Water clarity and color change with increased TSS concentration. Waters may appear relatively clear with a TSS concentration less than 30 mg/l. Water discoloration and cloudiness increases with greater TSS concentrations. Concentrations near 1,000 mg/L are relatively brown.

2.5 Overview of CEQA/NEPA Impact Assessment Considerations

Activities involving dredging or placement of sediment in waters of the U.S. require preparation of a CEQA and/or NEPA environmental document. Important considerations include the appropriate type of document to be prepared, analysis of impacts, and consistency with applicable laws and regulations. The following subsections provide overview summaries relevant to assessment of biological resources, including applicable laws and regulations. Additional information is reviewed in Volume 1 BIA Sections 2.4, 2.6, and Section 6 (SAIC 2011).

2.5.1 CEQA/NEPA Document

CEQA and NEPA Guidelines

- *http://ceres.ca.gov/ceqa/*
- *http://www.whitehouse.gov/administration/eop/ceq/initatives/nepa*

Projects requiring state or local government approval, financing, or participation by the state must comply with CEQA. Projects undertaken by federal agencies must comply with the NEPA. The CEQA and NEPA statutes specify document requirements and the process to be followed for preparation of these environmental documents. Guidelines are available on the world-wide web. Several agencies may be involved in the regulatory review, concurrence, or permitting process for sediment management projects (refer to Table 2.3-1). Coordination also may occur with additional agencies or non-governmental organizations (NGOs) to minimize conflicts with other land and water uses (e.g., California Department of Parks and Recreation, National Marine Sanctuaries, local commercial fishing organizations, local aquaculture or mariculture enterprises, Surfrider Foundation). The environmental process requires public notification, meetings, and specific time periods for public review and comment.

Different environmental documents are required under CEQA and NEPA, although joint documents may be prepared when there is shared project responsibility between federal and local (state, municipal) agencies.

- CEQA documents may either be a negative declaration (ND), mitigated negative declaration (MND) or environmental impact report (EIR). An ND is appropriate when the project has no significant impacts under CEQA. An MND is appropriate for projects that have potentially significant impacts, which can be mitigated to be less than significant. An EIR is required for projects with a potentially significant effect that cannot be mitigated to be less than significant. EIRs also may be appropriate even if significant impacts can be mitigated to less than significant when the project is controversial or is under substantial public scrutiny.
- NEPA documents may include an environmental assessment (EA) followed by a finding of no significant impact (FONSI) or a more comprehensive environmental impact statement (EIS) may be required. An EA and FONSI are prepared for most regulatory actions. An EIS normally is required for authorization and construction of major projects, proposed changes to projects that substantially increase project size or add additional purposes, or for projects that would result in major changes in operation or maintenance (USACE 1988).

Various technical studies may be conducted to support design or assessment of project alternatives. A biology technical study may or may not be required depending on the nature of the project and proximity to sensitive resources. The contents of a technical study also may differ depending on whether it is conducted in support of CEQA and/or NEPA. Generally, a biology technical study would include a description of existing habitat conditions and resources at the project location and adjacent habitats within the area subject to potential effects of the action. Potential occurrence of endangered and threatened species, critical habitat, or other sensitive species would be addressed. Results of recent surveys of the project area would be referenced. Potential impacts of proposed project alternatives would be evaluated, including assessment of potential effects to essential fish habitat and/or adjacent sensitive habitats. In addition, recommendations may be made for mitigation (avoid or minimize impacts) and monitoring, as applicable.

Biology Technical Study

- Existing habitat conditions and biological resources
- Potential occurrence of endangered and threatened species, critical habitat, and other sensitive species
- Impact analysis, EFH assessment
- Mitigation and monitoring recommendations (may or may not be required)

Other data or evaluations relevant to the assessment of biological impacts may include results of sediment testing, water quality analysis, noise analysis, and coastal processes (e.g., currents, sand transport, tides, waves). Coastal process modeling may be performed to better understand potential sand transport movement of placed sediments, particularly if hard-substrate or vegetated habitats are in the vicinity (e.g., SANDAG and USDN 2000, SANDAG and USACE 2011).

2.5.2 Types of Impacts

Generally, biological impact concerns relate to degree of change from existing conditions and environmental consequence of change. Biological impacts of particular concern include those that result in loss or degradation of sensitive habitats, habitats of particular concern (HAPC), loss or degradation of spawning or nursery areas for important fishery species, reduced or degraded function of native habitats, and injury or disturbance of sensitive wildlife. Direct, indirect, or cumulative impacts particularly relevant to sediment management projects are described below.

Direct Impacts

Direct effects are "caused by the action and occur at the same time and place" (40 CFR Sec. 1508). The following direct impact concerns have been reported for sediment management activities (Naqvi and Pullen 1982, Mauer et al. 1986, LaSalle et al. 1991, Nelson 1993, NRC 1995, Lindeman and Snyder 1998, Reine and Clarke 1998, Wilber and Clarke 2001, Greene 2002, Germano and Cary 2005):

- Equipment damage to sensitive habitats or injury to species.
- Sand placement burial of sensitive habitats or benthic organisms.
- Dredge removal of sensitive habitats or benthic organisms.
- Dredge entrainment and mortality of benthic invertebrates and fish.

Indirect Impacts

Indirect effects are "caused by the action and are later in time or farther removed in distance, and may include ..... related effects on water and other natural systems, including ecosystems" (40 CFR Sec. 1508). Indirect consequences of direct impacts to benthic organisms are reduction in forage for wildlife, the duration of which relate to benthic recovery rates. The area associated with indirect impacts may include the direct project footprint, as relevant to benthic community recovery. Indirect impacts also may occur over the range of distances associated with noise, lights, turbidity, sedimentation and sand transport. The following types of indirect impact concerns have been reported for sediment management activities (Naqvi and Pullen 1982, LaSalle et al. 1991, NRC 1995, Clarke and Wilber 2000, Wilber and Clarke 2001, Greene 2002, Colby and Hoss 2004, Germano and Cary 2005, Peterson and Bishop 2005, Speybroeck et al. 2006):

- Reduced invertebrate forage prey to secondary consumers (birds, fish, marine mammals).
- Avoidance or attraction of mobile wildlife due to noise, lights, increased human activity, equipment, or turbidity.
- Sublethal and/or lethal turbidity (suspended sediment) effects on aquatic plants and animals.
- Sublethal and/or lethal sedimentation effects on aquatic plants, hard bottom habitats, and demersal early life stages of fish and invertebrates.
- Delayed recovery or altered community due to changed physical conditions.

In the case of post-construction sand transport, the indirect impact may result in a "press disturbance", which is one that continues to affect a biological system for some relatively long period of time after disturbance, as contrasted with a "pulse disturbance", which is a discrete event (Peterson and Bishop 2005).

Cumulative Impacts

Cumulative effects as the "impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions ..." (40 CFR 1508.7). The area of potential effect may occur in the project area over time or be regional in scope. Cumulative impacts may arise from additive or interactive processes in the following ways (CEQ 1997, USDOI/MMS 1999 cited in Greene 2002):

- Time crowding effects – repeated effects from an action in the same area.
- Space crowding effects – high density of different impacts in the same area.
- Additive effects – multiple sources that all add to an overall impact.
- Compounding effects – multiple sources that interact to yield impact greater than additive effects of individual source impacts.
- Nibbling – combination of effects taking place slowly, incrementally or decrementally.
- Time lags – delayed effects.
- Cross boundary effects – occur away from the source.
- Fragmentation – impact results in change of landscape pattern.
- Triggers and thresholds – fundamental change in system behavior or structure.
- Indirect (secondary) effects – project facilitates other projects and their impacts.

Cumulative impact analysis is the most challenging, and likely of greater importance in the long-term. Peterson and Bishop (2005) stated that a more rigorous analysis of cumulative impacts is of critical concern for beach nourishment given its expanding scope due to sea level rise and the consequences of multiple escalating stressors in the coastal zone. They emphasized that this analysis is "the essence of ecosystem-based management for coastal resources, an overarching recommendation of the U.S. Commission on Ocean Policy."

Scheduling of projects or renourishment cycles is an important consideration of cumulative impact analyses, not only with respect to other projects, but also with consideration of climate oscillation patterns that have the potential to depress productivity (e.g., El Niño periods). Frequency of disturbance also is an important consideration, particularly where maintenance or opportunistic sand projects are conducted.

2.5.3 Significance Criteria

Section 15065(a) of the CEQA Guidelines states that a project may have a significant effect if:

(1) The project has the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, or substantially reduce the number or restrict the range of an endangered, rare or threatened species.

(2) The project has the potential to achieve short-term environmental goals to the disadvantage of long-term environmental goals.

(3) The project has possible environmental effects that are individually limited but cumulatively considerable. "Cumulatively considerable" means that the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.

CEQ regulations (40 CFR Section 1508.27) specify that significance requires consideration of both context and intensity of the action. Context refers to analysis of several different contexts, as appropriate, such as the affected region, locality, and site-specific area including both short- and long-term effects. Intensity refers to the severity of impact, which includes consideration of beneficial and adverse impacts, unique characteristics or resources, degree to which the action may adversely affect an endangered or threatened species or its habitat, degree to which the effects are uncertain and/or likely to be controversial, whether it is anticipated that the action may contribute to a cumulatively significant impact on the environment, or threatens a violation of environmental protection laws. Significance thresholds for non-covered native species generally address direct effects to populations and loss and/or degradation of habitats.

Useful Online References for Thresholds of Significance in California

State website
http://www.ceres.ca.gov/planning/ceqa/thresholds.html

Counties with Adopted Thresholds of Significance

San Diego - *http://www.sandiego.gov/development-services/news/pdf/sdtceqa.pdf*

Ventura - *http://www.ventura.org/planning/pdf/ordinanes_regs/Initial_Study_Assessment_Guidelines2_06. pdf*

Santa Barbara - *http://www.sbcountyplanning.org/*

For example, the County of Santa Barbara (2006) uses the following guidance criteria to assess whether disturbance to habitat or species may be significant:

a. Substantially reduce or eliminate species diversity or abundance.
b. Substantially reduce or eliminate quantity or quality of nesting areas.
c. Substantially limit reproductive capacity through losses of individuals or habitat.
d. Substantially fragment, eliminate, or otherwise disrupt foraging areas and/or access to food sources.
e. Substantially limit or fragment range and movement (geographic distribution or animals and/or seed dispersal routes).
f. Substantially interfere with natural processes, such as fire or flooding, upon which the habitat depends.

An issue of importance is the time period over which the impact occurs. For example, impact determinations based on a period of one year may be sufficient for short-term construction-related effects, but may be insufficient to account for press disturbances associated with post-construction sand transport. Time scales for beach profile equilibration and alongshore spreading occur over different time scales depending on project length and volume, grain size, and wave environment, but generally range from few to several years (NRC 1995). Recovery rates after dredging or beach nourishment may range from months to several years depending on initial environmental conditions, frequency of disturbance, nature and scale of impact disturbance, project schedule, and oceanographic conditions during the recovery period (SAIC 2011, Section 5.2.3.6).

2.5.4 Threatened or Endangered Species Consultations

Impact assessments generally include separate evaluations for species covered under the federal Endangered Species Act (ESA) and California Endangered Species Act (CESA). Criteria for evaluating federal-listed or state-listed species include the potential to affect individuals, their habitat, or populations. The USFWS and NMFS share responsibilities for administering the ESA.

Useful Online References Regarding Federal and State Endangered Species Consultation

http://www.fws.gov/endangered/consultations/s7hndbk/s7hndbk.htm
http://www.CDFG.ca.gov/hcpb/ceqacesa/cesa/cesa.shtml

Section 9 prohibits taking of species federally listed as threatened or endangered (take is defined as to harm, harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct, and includes habitat modification or degradation that could potentially kill or injure wildlife by impairing essential behavioral patterns, including breeding, feeding, or sheltering). A take incidental to otherwise lawful activities may be authorized under the ESA Section 7 when there is federal involvement or under Section 10 when there is no federal involvement in the project.

Federal agency actions with the potential to adversely affect federal-listed species or designated critical habitat require federal resource agency coordination or consultation (e.g., NMFS, USFWS) pursuant to Section 7 of the ESA. Candidate or proposed species for listing are

addressed by resource agencies during conferencing and considered when making natural resource decisions (USFWS and NMFS 1998).

Non-federal projects that would result in take of listed species or critical habitat must obtain an Incidental Take Permit from USFWS or NOAA-Fisheries for authorization of the take. Section 10(a)(1)(B) permits generally include conditions that focus on efforts to minimize and mitigate the anticipated take.

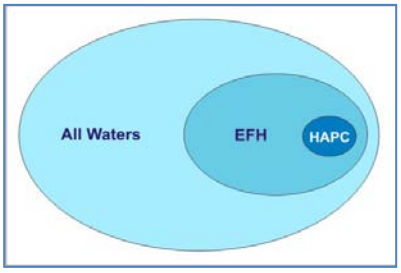
Similarly, the CESA requires that state lead agencies coordinate or consult with CDFG to ensure that state agency actions are not likely to jeopardize the continued existence of any species that is state listed as endangered, threatened, or rare. The CDFG also may make a Consistency Determination of whether conditions specified in a federal incidental take statement pursuant to a Section 7 consultation or a non-federal Section 10(a)(1)(B) incidental take permit are consistent with the CESA (Fish and Game Code Section 2080.1). Federal and state resource agencies both recommend informal early coordination to avoid potential impacts to rare, endangered, or threatened species. Advantages of early consultation include appropriate mitigation planning to offset impacts to listed species and their essential habitats and a streamlined consultation process (USFWS and NMFS 1998).

2.5.5 Essential Fish Habitat Consultations

Essential Fish Habitat (EFH) is managed under the Magnuson-Stephens Fishery Conservation and Management Act (refer to Section 2.6.1). This act protects waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. Federal agencies and permit applicants must consult with NMFS on actions that may adversely affect EFH, which is identified and described for managed species in Fishery Management Plans (FMPs). FMPs for Federal waters off the coasts of California, Oregon, and Washington address Pacific coast groundfish, Pacific coast salmon, coastal pelagic species and highly migratory species(*http://www.pcouncil.org/*).

EFH provisions provide a means to indentify Habitat Areas of Particular Concern (HAPCs) [50 CFR 600.815(a)(8)] within FMPs. HAPCs are areas within EFH that are ecologically important, sensitive to disturbance, or rare. Several HAPCs are designated for Pacific groundfish; the following are particularly relevant to sediment management activities:

- Estuaries
- Kelp Canopy
- Rocky Reefs
- Seagrass (Eelgrass, Surfgrass)



Redrawn from NPFMC and NMFS 2010

Designated HAPC are not given additional regulatory protection; however, federal projects with potential adverse impacts to HAPC will be more carefully scrutinized during consultation (NMFS 2009).

NMFS (2004) EFH guidance provides the following definitions of effects:

- Adverse effect means any impact that reduces quality and/or quantity of EFH, including direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH.

Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810(a)).

- Substantial adverse effects are defined as effects that may pose a relatively serious threat to EFH and typically could not be alleviated through minor modifications to a proposed action; e.g., major harbor development with significant dredging and filling, channel realignments, or shoreline stabilization near EFH.

NMFS (2004) guidance notes that it is difficult to conceive of situations involving active construction in EFH without crossing the "may adversely affect" threshold. However, NMFS (2004) stated that incorporation of avoidance and minimization measures into the proposed action may eliminate or lessen the need for additional conservation measures. Types of appropriate avoidance and minimization measures may include careful alternatives analysis, design stipulations, BMPs, time-of-year restrictions, avoidance of submerged aquatic vegetation and shellfish beds, and/or monitoring.

2.6 Overview of Applicable Laws and Regulations

Several federal, state, and local agencies are involved with the permitting or approval process associated with sediment management activities (Table 2.6-1). The USACE has regulatory responsibility associated with sediment management and related construction activities under three different authorities depending on the location and nature of the activity: Section 10 of the Rivers and Harbors Act (RHA), Section 404 of the Clean Water Act, and Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA).

The USACE issues permits for all work (dredging and placement of structures) which affects the course, location, condition or capacity of navigable waters (under of RHA Section 10); for discharges of dredged or fill material in waters of the U.S. (CWA Section 404); and for transportation of dredged material for the purpose of disposal into ocean waters (MPRSA Section 103). The USACE conducts Civil Works projects involving dredging and discharges under the same regulatory criteria as other projects, but does not issue itself permits.

The "*navigable waters*" of RHA jurisdiction include the territorial sea (within 3 nautical miles of the coast) as well as all waters subject to the ebb and flow of the tide that have been historically used, are currently used, or are susceptible to use to transport interstate or foreign commerce (33 CFR 329.4).

Types of Permit Applications

- ✓ USACE
  - CWA Section 404 permit
  - RHA Section 10 permit
  - MPRSA Section 103 permit
- ✓ RWQCB
  - CWA Section 401 water quality certification
- ✓ CCC
  - CDP or CD
- ✓ CDFG
  - Streambed alteration agreement (if river, lake, stream)
- ✓ CSLC
  - Lease
- ✓ BCDC (if within San Francisco Bay)
  - Major or Region-wide permit
- ✓ USFWS and/or NMFS
  - Section 10 incidental take permit

The "waters of the U.S." under Section 404 include the territorial sea, tidal-waters, adjacent wetlands, and certain non-tidal waters and wetlands (33 CFR 328). Thus, the CWA jurisdiction covers Section 10 waters plus their tributaries, adjacent wetlands and isolated waters with the potential to affect interstate or foreign commerce. The USACE generally processes both permits concurrently for projects with overlap of CWA and RHA jurisdictions.

The USACE issues Section 103 permits for the transportation of dredged material for disposal in the ocean (beyond the territorial sea). An overlap of CWA and MPRSA jurisdictions exist for discharges in the territorial sea. The MPRSA applies if the purpose is disposal. The CWA applies if the purpose is fill (e.g., beach nourishment) (33 CFR 336.0, 40 CFR 230.2).

Example Activities Associated with Different Department of Army Permits

RHA Section 10 – Navigable Waters
- Dredging and excavation.
- Construction (e.g., artificial reefs, piers, cable/pipeline crossings, wharves).

CWA Section 404 – Waters of the U.S.
- Discharge of dredge materials or fill.
- Construction involving fill (e.g., breakwaters, groins, revetments).

MPRSA Section 103 – Ocean and Territorial Sea
- Disposal of dredged material at designated ocean disposal sites.
- Disposal into territorial sea, if necessary.

Note: Examples do not reflect all potential activities; permit requirements should be verified with the USACE.

The USEPA in coordination with the USACE, developed the Section 404(b)(1) evaluation guidelines (40 CFR part 230) and testing manuals to evaluate permits under the CWA and MPRSA, and reviews and provides concurrence on testing of dredged materials and discharge permits. In addition, The USEPA designates and manages ocean dredge material disposal sites and issues permits for the ocean discharge of wastes under Section 102 of the MPRSA.

The USEPA develops environmental criteria in conjunction with USACE by which dredged material discharges are evaluated under the CWA or MPRSA, and reviews and provides concurrence on testing of dredged materials and discharge permits. In addition, The USEPA designates and manages ocean dredge material disposal sites and issues permits for the discharge of wastes in the ocean under Section 102 of the MPRSA.

Federal resource agencies (NMFS, USFWS) are responsible for regulatory coordination under the Fish and Wildlife Coordination Act, including review of CEQA/NEPA documentation, essential fish habitat assessment, and preparation of a biological opinion regarding actions that may affect federal-listed endangered or threatened species or their critical habitat, as applicable. The CDFG conducts similar reviews and will either concur with the federal BO or issue a separate BO for state-listed endangered or threatened species. The CDFG also would regulate sediment management activities that would include dredging or excavation within any stream, river, or lake and placement of materials at the beach.

Other state agencies with regulatory authority include the State Water Resources Control Board (SWRCB) and associated regional water quality control boards (RWQCBs), California Coastal Commission (CCC), and California State Lands Commission (CSLC). The Bay Conservation and Development (BCDC) regulates dredge and fill permits within San Francisco Bay. Counties and cities review proposed sediment management activities for consistency with local plans and policies, and regulate local permits required to place dredged material or fill at beaches.

Table 2.6-1. Agencies involved with review and/or approval of sediment management projects.

Agency	Role
U.S. Army Corps of Engineers (USACE)	Regulatory authority for 404 (Clean Water Act, CWA) and Section 10 (Rivers and Harbors Act, RHA) permits for state or local projects involving discharge or fill in waters of the U.S.; regulatory authority for all discharges of dredged materials in the ocean under Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA or "Ocean Dumping Act"); sponsor for federal navigation, flood control, or ecosystem restoration projects; feasibility studies and NEPA documentation for federal projects.
U.S. Coast Guard (USCG)	Responsible for several missions, including marine safety, navigation, and marine environmental protection. Review and coordination relative to dredging or discharge projects, including but not limited to vessel routes, anchor plans, communication, and publication of a Notice to Mariners of proposed activities.
U.S. Environmental Protection Agency (USEPA)	Review of permits for dredged material or fill into the ocean or waters of the U.S. under Section 404 of the CWA or Section 103 of MPRSA. Lead responsibility for establishing the environmental guidelines/criteria that must be met to receive Section 404 or Section 103 permits. Regulatory authority under Section 102 of the MPRSA.
U.S. Fish and Wildlife Service (USFWS)	Regulatory coordination (Fish and Wildlife Coordination Act); review of CEQA/NEPA documentation, preparation of federal biological opinion (BO) regarding actions that may affect federal-listed endangered or threatened species or their critical habitat; sponsor for federal restoration projects; regulatory authority for Incidental Take permits
National Oceanic and Atmospheric Administration (NOAA) - National Marine Fisheries Service (NMFS)	Administers the Coastal Zone Management Program, which requires coastal states to have enforceable policies to protect ocean and coastal resources, including policies that affect sediment management. Regulatory coordination (Fish and Wildlife Coordination Act); review of CEQA/NEPA documentation; preparation of federal BO for endangered or threatened species; essential fish habitat assessment review; regulatory authority for Incidental Take permits.
State Water Resources Control Board (SWRCB) and regional offices (RWQCB)	Regulatory authority (Porter-Cologne Water Quality Control Act) for Section 401 (CWA) water quality certification that discharge in waters of the U.S. will not violate water quality standards established for the water body affected by the project; review of CEQA/NEPA documentation and obtained permits.
California Coastal Commission (CCC)	Regulatory authority for Coastal Development Permits (CDP) for state or local projects; Consistency Determinations (CD) for federal projects; review of CEQA/NEPA documentation and other obtained permits.
California Department of Fish and Game (CDFG)	Regulatory authority for Streambed Alteration Agreements and Incidental Take permits; CEQA/NEPA review; concurrence with federal BO or issuance of separate BO for state-listed endangered or threatened species.
California State Lands Commission (CSLC)	Statutory authority to approve uses of state lands under its jurisdiction and oversight responsibility for tide and submerged lands legislatively granted in trust to local jurisdictions (Public Resources Code § 6301); may sponsor state projects.
Office of National Marine Sanctuaries (ONMS)	Reviews and/or approves activities within designated marine sanctuaries.
Bay Conservation and Development Commission (BCDC)	Regulatory authority under the McAteer-Petris Act for permits pertinent to dredge or fill in San Francisco Bay.
Local County	Regulatory authority for county permits; review for consistency with county policies and ordinances; may sponsor local projects; may be CEQA lead for local projects.
Local City	Regulatory authority for local permits; review for consistency with Local Coastal Plan, policies, and ordinances; local project sponsor; may be CEQA lead for local projects.

Notes: Additional information on environmental laws is provided in Section 2.6.
For more information on the regulatory process, see the Beach Restoration Regulatory Guide (EIC 2006).

Sediment management activities involving use of dredges, support vessels, and discharge pipelines in waters also require coordination with the U.S. Coast Guard, who has responsibilities relative to marine safety, navigation, and environmental protection.

Compliance with other laws, including NEPA, Coastal Zone Management Act (CZMA), ESA, and Section 401 of the CWA, are considered as part of USACE's processing of permit applications. Federal and state environmental regulations relevant to sediment management activities are briefly reviewed below. These regulations form the basis for biological impact evaluations pursuant to the CEQA and NEPA and/or permitting of sediment management projects. Regulations that apply to other environmental (e.g., air quality) or cultural resources are not discussed in this document.

2.6.1 Federal Environmental Regulations

Clean Water Act , as amended 1972 (CWA)

The CWA (33 U.S. Code [U.S.C.] §1251 *et seq.*) was established to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Specific sections concern different aspects of protecting waters and water quality. Section 401 of the CWA provides the SWRCB and RWQCBs with the regulatory authority to waive, certify, or deny projects that result in discharges to surface waters of the State. Section 401 applies to dredging and disposal activities, and requires certification by the RWQCB or equivalent that the permitted project complies with State Water Quality Standards, and would not cause concentrations of chemicals in the water column to exceed these standards. Section 401 of the CWA requires a water quality certification for issuance of a 404 permit (33 U.S.C. 1344).

The RWQCB or SWRCB is required to submit Waste Discharge Requirements (WDRs) for a 401 Certification, unless waived pursuant to CWA section 13269. To waive or certify a project, these agencies must find that the proposed discharge will comply with state water quality standards (*http://www.waterboards.ca.gov/plans_policies/*). Water quality standards address the following three factors:

- *Beneficial Uses* - water for drinking, agriculture, navigation, recreation, and fish and wildlife habitat;
- *Objectives* - numeric and narrative limits on water characteristics or bans on substances, which affect water quality; and
- *Anti-Degradation Policy* - requires that existing high-quality waters be protected and maintained.

The USACE issues 404 permits for the dredging and disposal of materials within the *waters of the U.S.* The lateral limits of jurisdiction may be divided into three categories: territorial seas, tidal waters, and non-tidal waters (see 33 CFR 328.4). Waters of the United States, as defined in 33 CFR Part 328 (USACE), 40 CFR 230.3 (USEPA), include the following:

1. All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
2. All interstate waters including interstate wetlands;
3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows,

playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:

(i) Which are or could be used by interstate or foreign travelers for recreational or other purposes; or

(ii) (From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or

(iii) Which are used or could be used for industrial purposes by industries in interstate commerce;

4. All impoundments of waters otherwise defined as waters of the United States under this definition;
5. Tributaries of waters identified in paragraphs 1-4 of this section;
6. The territorial sea;
7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs 1-6 of this section.

(Dredging without aquatic or wetland disposal does not require a 404 permit or evaluation.)

The geographic extent of waters of the United States is landward to the ordinary high water mark in non-tidal systems, to the high tide line in tidal systems, and to the landward extent of wetlands that may lie up slope of the ordinary high water mark or high tide line. Territorial seas are defined as waters extending from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three miles.

Section 404(b)(1) guidelines require that discharge activities should have no unacceptable adverse impacts. A permit application must include an evaluation of the impacts on the affected resources, including, but not limited to: physical and chemical characteristics of the aquatic ecosystem, biological characteristics of the aquatic ecosystem, specific designated sites, where applicable, and human use characteristics. The 404(b)(1) Guidelines specify the use of available information (e.g., prior evaluations, chemical and biological tests, scientific research, and experience) to make preliminary determinations concerning the suitability of dredge or fill materials and need for testing. The Guidelines employ a "reason to believe" process to determine whether testing is necessary (USACE 2006, Regional Guidance Letter 06-02). Where there is reason to believe that contaminants are not present in the discharge material, no testing is required (40 CFR 230.60(a)). The reason to believe that no testing is required is based on the type of material to be dredged and/or its potential to be contaminated. For example, dredged material is most likely to be free of contaminants if the material is composed primarily of sand, gravel, or other inert material and is found in areas of high current or wave energy (40 CFR 230.60(a)). Testing of dredged material, if required, follows the *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.*, also known as the "Inland Testing Manual (ITM)" (*http://www.epa.gov/waterscience/itm/total.pdf*). The USACE is authorized only to issue a Section 404 permit for the least environmentally damaging practicable alternative (LEDPA). The USACE prepares 404(b)(1) evaluations for federal projects, including evaluation of alternatives and identification of the LEDPA, but does not issue a permit to itself.

Coastal Zone Management Act of 1972, as amended (CZMA)

The CZMA (16 U.S.C §1451 *et seq.*), administered by NOAA's Office of Ocean and Coastal Resource Management, provides for management of the nation's coastal resources and balances economic development with environmental conservation. This Act requires activities to be consistent with the enforceable policies of the approved state coastal program to the maximum extent practicable.

Fish and Wildlife Coordination Act of 1934, as amended (FWCA)

The FWCA (16 U.S.C 661 *et seq.*) requires any federal agency proposing any action that may affect wildlife to first consult with the USFWS and/or NMFS. The FWCA establishes a consultation requirement for federal departments and agencies that undertake any action that proposes to modify any stream or other body of water for any purpose, including navigation and drainage [16 U.S.C. 662(a)].

Federal Endangered Species Act of 1973, as amended (ESA)

The ESA (16 U.S.C. §1531 *et seq.*) protects endangered and threatened species by prohibiting federal actions that would jeopardize the continued existence of such species or result in the destruction or adverse modification of designated critical habitat of such species. Under Section 7(a)(2) of the ESA, federal agencies must consult with federal resource agencies (USFWS and NMFS) and may prepare a Biological Assessment (BA) if a project may affect listed species and/or may modify designated critical habitat. The USFWS and/or NMFS will prepare a Biological Opinion (BO) in response to a BA on how the action would affect endangered or threatened species, essential fish habitat or critical habitat of federally managed species. Under most circumstances, the ESA prohibits take, which is defined as harming (includes killing) or harassing a listed species. In some cases, an action may adversely affect a species, but not jeopardize its continued existence. In that case, an incidental take statement is included in the BO for the proposed Federal project. The statement includes the amount or extent of anticipated take due to the Federal action, reasonable and prudent measures to minimize the take, and terms and conditions that must be observed when implementing those measures. As part of the development of federal biological opinions, reviews are conducted pursuant to the Marine Mammal Protection Act and Magnuson-Stevens Fishery Conservation and Management Act.

Informal consultation may be substituted for projects where those potential impacts are minor; in that case neither a BA nor a BO is prepared. Informal consultation is accomplished via telephone, email, or letter concluding with USFWS proposing reasonable and prudent measures that it believes would avoid jeopardizing the continued existence of the species or adversely modifying its designated critical habitat. No consultation is required where the lead federal agency determines that the project will not affect listed species or adversely modify designated critical habitat.

For non-federal projects with the potential to affect federal endangered or threatened species, applicants must apply to the USFWS and/or NMFS for an Incidental Take permit pursuant to Section 10(a)(1)(B) of the ESA. The applicant is required to develop a conservation plan, often referred to as a habitat conservation plan, as part of that permit process. The purpose of the conservation planning process associated with the permit is to ensure there is adequate minimizing and mitigating of the effects of the authorized incidental take. The purpose of the incidental take permit is to authorize the incidental take of listed species, not to authorize the activities that result in take.

Magnuson-Stevens Fishery Conservation and Management Act of 1996, as amended (MSFCMA)

The MSFCMA (16 U.S.C. §1801 *et seq.*) sets forth a number of mandates for the National Marine Fishery Service (NMFS), regional fishery management councils, and federal action agencies to identify and protect important marine and anadromous (migrating) fish habitat, with the goal of maintaining sustainable fisheries. Fisheries management councils, with assistance from NMFS, are required to delineate Essential Fish Habitat (EFH) in Fishery Management Plans or FMP amendments for all managed species. EFH is defined as those "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The MSFCMA requires federal agencies to consult with the NMFS on actions that may adversely affect EFH. The NMFS encourages streamlining the consultation process using review procedures under NEPA, FWCA, CWA, and/or ESA provided that those documents meet regulatory requirements for EFH assessments. EFH assessments must include (1) a description of the proposed action, (2) an analysis of effects, including cumulative effects, (3) the federal agency's views regarding the effects of the action on EFH, and (4) proposed mitigation, if applicable. NMFS will then prepare EFH Conservation Recommendations, if appropriate, to avoid, minimize, or otherwise offset adverse effects of the action on EFH.

Marine Mammal Protection Act of 1972, as amended (MMPA)

The MMPA (16 U.S.C. §1361 *et seq.*) restricts the taking, possession, transportation, selling, offering for sale, and importing of marine mammals and establishes a marine mammal commission to regulate such protection. Take means to harass, hunt, capture, collect, or kill any marine mammal, including attempts to do so. NMFS and the USFWS administer the MMPA. Section 7 of the ESA requires a federal authorizing or action agency to consult with NMFS on any actions that might affect endangered or threatened marine mammals. If the agency or NMFS determines an action would result in take of a listed species, formal consultation is required, and would require an incidental take statement to authorize the take. Non-federal actions which would result in incidental take of a listed species would require authorization under Section 10 of the ESA.

Marine, Protection, Research, and Sanctuaries Act of 1972, as amended (MPRSA)

The MPRSA, also known as the Ocean Dumping Act, is divided into three parts: Title 1 – Ocean Dumping, Title 2 – Comprehensive Research on Ocean Dumping, and Title 3 – Marine Sanctuaries. Title 1 and 2 provisions are administered by USEPA and USACE (33 U.S.C. §1401 *et seq.*), and Title 3 provisions are administered by NOAA (16 U.S.C. §1431 *et seq.*).

Title 1 establishes the permit program for the disposal of dredged and non-dredged materials, mandates determination of impacts and alternative disposal methods, and provides for enforcement of permit conditions. Section 102 of the MPRSA requires the USEPA, in consultation with the USACE, to develop environmental criteria which must be met before any proposed ocean disposal activity is allowed to proceed. Section 102 also gives the USEPA authority to designate ocean disposal sites within and beyond the territorial sea, and directs the USACE to use such USEPA-designated sites to the maximum extent feasible (MPRSA Section 102 (c) and Section 103(b)).

The USACE issues permits for the transportation and disposal of dredged materials in ocean waters under Section 103 of the Act, subject to USEPA concurrence and use of USEPA dumping criteria (40 C.F.R. 227-228). Section 103 also authorizes the USACE to select ocean disposal sites for project-specific use if one is needed by the Corps to carry out its dredging

responsibilities and if the use of a site designated by the USEPA is not feasible. Site selection is subject to compliance with USEPA's site designation criteria and subject to USEPA concurrence (MPRSA Section 103(b)).

The National Contaminated Sediment Assessment and Management Act of 1992 (33 U.S.C. 1271) established a National Contaminated Sediment Assessment and Management program, and amended certain sections of the MPRSA, particularly with respect to assessment of aquatic sediment quality, development of contaminant guidelines and control measures, and time periods to review and concur with proposed permits.

Sediment management activities associated with discharge of dredged materials or fill for beach nourishment generally are not regulated under MPRSA. However, the regulations include provision for dredged material that is composed predominantly of sand, gravel, or shell with compatible particle sizes to be used for beach nourishment without further testing (40 CFR 227.13). Through agreement between the USEPA and USACE, discharges of dredged material or fill in territorial waters for beach nourishment are regulated under the CWA.

It is possible that materials believed only to be suitable for ocean disposal are determined after additional evaluation to be suitable for beach nourishment. In that case, sediments may have been evaluated according to the *Evaluation of Dredged Material Proposed for Ocean Disposal*, commonly referred to as the "Green Book" (*http://www.epa.gov/owow/oceans/gbook/index.html*). Sediments determined to be suitable based on Green Book evaluation also would satisfy suitability criteria under the Inland Testing Manual.

Activities in sanctuary areas may be authorized only if the Secretary of Commerce certifies that the activities are consistent with Title III of the Act and can be carried out within in the regulations for the sanctuary (see National Marine Sanctuaries Act).

Migratory Bird Treaty Act of 1918, as amended (MBTA)

The MBTA (16 U.S.C. §703 *et seq.*) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. The Act restricts the killing, taking, collecting, selling, or purchasing of native bird species or their parts, nests, or eggs.

National Environmental Policy Act of 1969, as amended (NEPA)

The NEPA (42 U.S.C. §4321 *et seq.*) requires federal agencies to consider environmental consequences and project alternatives before a decision is made to implement a federal project. The law requires the government to consider the consequences of major federal actions on human and natural aspects of the environment in order to minimize, where possible, adverse impacts. Equally important, NEPA established a process of environmental review and public notification for federal planning and decision-making. The CEQ was established under NEPA, and in 1978 issued *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* (40 Code of Federal Regulations [C.F.R.] §§ 1500-1508). Resulting documents under NEPA include environmental assessments (EAs) or environmental impact statements (EISs).

National Marine Sanctuaries Act of 1972, as amended (NMSA)

The NMSA (16 U.S.C., Chapter 32, §1431 et seq.) authorizes the Secretary of Commerce to designate and protect areas of the marine environment with special national significance due to

their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or esthetic qualities as national marine sanctuaries. Office of National Marine Sanctuaries (ONMS) regulations are codified at 15 CFR Part 922. ONMS regulations prohibit specific kinds of activities, describe and define the boundaries of the designated national marine sanctuaries, and set up a system of permits to allow the conduct of certain types of activities (that would otherwise not be allowed), such as dredge material disposal. Each sanctuary has its own set of regulations within 15 CFR Part 922; Subparts F through R each contain the Sanctuary-specific regulations for all thirteen sanctuaries (in order of designation) *http://sanctuaries.noaa.gov/protect/regulations/.*

Rivers and Harbors Act of 1899 (RHA)

Section 10 of the RHA (33 U.S.C. §403) prohibits the unauthorized obstruction or alteration of navigable waters, and authorizes the USACE to regulate all activities that affect the course, capacity, or coordination of navigable waters. This includes the territorial seas and navigable waters as defined in 33 CFR Part 329 as: those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. As such, the RHA regulates dredging, excavation, and construction in navigable waters. The USACE may process a Section 10 permit simultaneously with a 404 permit if the applicant were going to dredge and discharge, or discharge and place a structure with the same project. However the USACE does not issue Section 10 permits to itself.

2.6.2 State Environmental Regulations

California Coastal Act of 1976, as amended (CCA)

The California Coastal Act (Public Resources Code [P.R.C]. §30000 *et seq.*) constitute the statutory standards applied to planning and regulatory decisions made by the CCC and by local governments, pursuant to implementation of the CZMA. Non-federal development activities within the coastal zone generally require a coastal development permit. The federal CZMA gives state coastal management agencies regulatory control (federal consistency review authority) over all federal activities if the activity affects coastal resources. P.R.C. §§ 30230-30236 include several policies to protect biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes, including consideration of effects associated with dredge and fill projects. The coastal zone established by the Coastal Act does not include San Francisco Bay, where development is regulated by the BCDC (see McAteer-Petris Act).

California Endangered Species Act of 1970, as amended (CESA)

The CESA (Fish and Game Code [F.G.C.] §2050 *et seq.*) generally parallels the main provisions of the federal ESA and is administered by the CDFG. Unlike the ESA, CESA also applies the take prohibitions to species petioned for listing (state candidates). The state legislature encourages cooperative and simultaneous findings between state and federal agencies. Participation by CDFG in federal consultation and adoption of a federal BO is authorized by FGC §2095. If the federal BO is found to be inconsistent with CESA, the CDFG will issue its own BO per F.G.C §2090. CESA allows for take incidental to otherwise lawful development projects. F.G.C. §2080.1 requires an applicant who has obtained a federal incidental take statement pursuant to a federal Section 7 consultation or a federal Section 10(a) incidental take permit to submit the federal document to the CDFG Director for a Consistency Determination as to whether the federal document is "consistent" with CESA. If the CDFG determines that the federal statement/permit is not consistent with CESA, the applicant must apply for a state

Incidental Take Permit pursuant to F.G.C. §2081. A Section 2081(b) Incidental Take Permit also would be required if other species covered under CESA were not addressed in the federal incidental take statement or permit.

California Environmental Quality Act of 1970, as amended (CEQA)

The CEQA (P.R.C. §21000 *et seq*.) requires that state and local agencies consider environmental consequences and project alternatives before a decision is made to implement a project requiring state or local government approval, financing, or participation by the state. In addition, CEQA requires the identification of ways to avoid or reduce environmental degradation or prevent environmental damage by requiring implementation of feasible alternatives or mitigation measures. Resulting documents under CEQA include negative declarations (NDs), mitigated negative declaration (MND), or environmental impact reports (EIRs).

Marine Life Protection Act of 1999, as amended (MLPA)

The MLPA (F.G.C. §§2850-2863) requires California to reevaluate all existing marine protected areas (MPAs) and potentially design new MPAs that together function as a statewide network to improve protection of marine life and habitats, marine ecosystems, and marine natural heritage. MPAs are developed on a regional basis with MLPA and MPA specific goals in mind, and are to be evaluated over time to assess their effectiveness for meeting these goals. Specific geographic areas are designated as MPAs, including intertidal and subtidal habitats and associated flora and fauna. MPA classifications include marine life reserves, state marine parks, and state marine conservation areas. The level of marine resource protection varies among MPAs, ranging from no take to allowable commercial and recreational fishing. Sediment management activities (e.g., beach nourishment, dredging) or other sediment uses (e.g., beach grooming) may or may not be among the allowable activities depending on the MPA.

McAteer-Petris Act of 1965, as amended

The McAteer-Petris Act (P.R.C. §66600 *et seq.*) created the San Francisco Bay Conservation and Development Commission (BCDC) to prepare a plan to protect the Bay and shoreline and provide for appropriate development and public access. The McAteer-Petris Act directs the BCDC to issue or deny permit applications for placing fill and extracting materials, including dredged material, or changing the use of any land, water, or structure within its jurisdiction, which includes the Bay, shoreline band, saltponds, managed wetlands, and certain waterways. Such permits are issued or denied in accordance with the provisions of the McAteer-Petris Act and Suisun Marsh Preservation Act, and the policies of the *San Francisco Bay Plan* and the *Suisun Marsh Protection Plan*. The BCDC issues four types of permits: major permits, administrative permits, emergency permits, and region-wide permits. BCDC permits are in addition to permits required under federal and other state laws. Under the federal CZMA, federal agencies are required to carry out their activities and programs in a manner consistent with BCDC's coastal management program. To implement this provision, federal agencies make "consistency determinations" on their proposed activities, and applicants for federal permits or other authorizations make "consistency certifications." The BCDC reviews the consistency determinations or certifications and makes a decision to either concur or object to them consistent with the provisions of the CZMA and Department of Commerce regulations.

Porter-Cologne Water Quality Control Act of 1969, as amended (Porter Cologne Act)

This Porter-Cologne Act (California Water Code §13000 *et seq*.) provides the framework for the regulation of waste discharges to both surface and ground waters of the state. It further provides for the adoption of water quality control plans and the implementation of these plans by

adopting waste discharge requirements for individual dischargers or classes of dischargers. The Act mandates activities that may affect waters of the state shall be regulated to attain the highest quality. Section § 13142.5 includes the following additional considerations with respect to water quality as it relates to the coastal marine environment are that: (a) wastewater discharges shall be treated to protect present and future beneficial uses, and, where feasible, to restore past beneficial uses of the receiving waters. Highest priority shall be given to improving or eliminating discharges that adversely affect any of the following: (1) wetlands, estuaries, and other biologically sensitive sites, (2) areas important for water contact sports, (3) areas that produce shellfish for human consumption, and (4) ocean areas subject to massive waste discharge.

Streambed Alteration Agreement

The Legislature enacted F.G.C. §§ 1600-1616 to protect and conserve fish and wildlife resources of this state. Section 1602 requires an entity to notify CDFG of any proposed activity that may substantially modify a river, stream, or lake. If DFG determines that the activity may substantially adversely affect fish and wildlife resources, a Lake or Streambed Alteration Agreement will be required that includes reasonable conditions necessary to protect those resources. A Streambed Alteration Agreement also would be required if there would be a substantial change or use of any material from the bed, channel, or bank within such water bodies. The disposal or deposit of debris or waste into any river, stream, or lake also is regulated. Sediment management activities involving dredging or excavation of sediments from rivers, streams, lake, or estuary with placement at the beach would require a Streambed Alteration Agreement.

2.6.3 Water Quality Standards

The principal state law on water resources is the Porter-Cologne Water Quality Control Act (WQCA) (California Water Code §§ 13000-13999.10). The WQCA gives the SWRCB and nine RWQCBs responsibility for protecting the waters within their regions. The RWQCBs also implement provisions of the CWA that regulate point (industrial) and nonpoint (storm water) sources of pollution. The WQCA directs local RWQCBs to establish beneficial uses for water bodies in California, and controls to ensure that these beneficial uses are not degraded. Under the authority of California law, the SWRCB has promulgated the Water Quality Control Plan, Ocean Waters of California (Ocean Plan), which contains numerical criteria for protection of beneficial uses.

The RWQCBs maintain Water Quality Control Plans (Basin Plans) for each major hydrologic basin in California. The Basin Plans list the water bodies in each region and describe the applicable water quality objectives. Water quality objectives are specified for ocean waters and other waters, which may be divided into categories such as enclosed bays and estuaries, inland surface waters, groundwater, and other specific water bodies depending on regional board. Water quality objectives for ocean waters are relevant to offshore borrow site dredging and beach or nearshore discharges. Objectives for bays and estuaries are pertinent to maintenance dredging of ports and harbors and smaller embayments. Water quality objectives associated with inland surface waters and groundwater are not applicable to beach nourishment associated activities and are not discussed further.

Water Quality Objectives for Ocean Waters

Water quality criteria (i.e., water quality objectives) are qualitative or quantitative estimates of the concentration of a water constituent which, when not exceeded, will ensure water quality is protective of beneficial uses (Table 2.6-2). Sediment management projects must comply with water quality objectives that protect both public and biological resource beneficial uses. By definition, water quality objectives must protect the most sensitive of the beneficial uses which have been designated for a water body.

Table 2.6-2. Condensed summary of Ocean Plan water quality objectives.

- Bacterial Characteristics – See Table 2.6-4
- Shellfish Harvesting Standards – see Table 2.6-4
- Physical Characteristics
  1. *No visible floating particulates, grease and oil.*
  2. *No aesthetically undesirable discoloration.*
  3. *Natural light not significantly reduced outside the initial dilution zone.*
  4. *Deposition rate and characteristics of sediments do not degrade biota (indigenous benthic communities).*
- Chemical Characteristics
  1. *Dissolved oxygen not reduced by more than 10%.*
  2. *pH not changed by more than 0.2 units.*
  3. *Dissolved sulfides not significantly increased.*
  4. *Sediment contaminants shall not degrade biota.*
  5. *Sediment organic materials shall not degrade biota.*
  6. *Nutrients shall not cause objectionable aquatic growths or degrade biota.*
- Biological Characteristics
  1. *Marine life (vertebrates, invertebrates, plants) shall not be degraded.*
  2. *The natural taste, odor, and color of marine life used for human consumption shall not be altered.*
  3. *Organic materials in marine life used for human consumption shall not bioaccumulate to harmful levels.*
- Radioactivity
  1. *Discharge shall not degrade marine life.*

Note: Significant is defined as a difference in the means of two distributions of sampling results at the 95 percent confidence level.
Source: SWRCB 2009; Refer to: http://www.swrcb.ca.gov/CWA401/index.html

The Ocean Plan also includes effluent limitations for certain constituents, including turbidity and suspended solids (Table 2.6.3). Effluent limitations sometimes have been applied to dredge barge supernatant or decant waters prior to discharge (SAIC 2011, Appendix C.1

Table 2.6-3. Ocean Plan effluent limitations.

Parameter	Monthly(30-day Average)	Weekly (7-day Average)	Maximum
Grease and Oil (mg/L)	25	40	75
Suspended Solids	See Notes+		
Settleable Solids (Ml/L)	1.0	1.5	3.0
Turbidity NTU	75	100	225
pH Units	Within limit of 6.0 to 9.0 at all times		

Notes:

Effluent limitations apply only to publicly owned treatment works and industrial discharges for which Effluent Limitations Guidelines have not been established pursuant to Sections 301, 302, 304, or 306 of the Federal Clean Water Act.

+ Suspended Solids: Dischargers shall, as a 30-day average, remove 75% of suspended solids from the influent stream before discharging wastewaters to the ocean, except that the effluent limitation to be met shall not be lower than 60 mg/l. Regional Boards may recommend that the SWRCB, with the concurrence of the Environmental Protection Agency, adjust the lower effluent concentration limit. If the lower effluent concentration limit is adjusted, the discharger shall remove 75% of suspended solids from the influent stream at any time the influent concentration exceeds four times such adjusted effluent limit.

Source: SWRCB 2009

Compliance objectives for bacteria pertain to water contact recreation and areas of shellfish harvesting (Table 2.6-4). Compliance criteria where shellfish are harvested are more stringent.

Table 2.6-4. Bacteria water-contact and shellfish harvesting standards.

Parameter	30-day Geometric Mean (MPN/100 ml)	Single Sample Maximum (MPN/100 ml)	Shellfish Median (per 100 ml)
Total Coliform	1,000	10,000 or 1,000 if fecal > 10% of total coliform	70 with not more than 10 percent of samples > 230
Fecal Coliform	200	400	
Enterococcus	35	104	

Notes: MPN = most probable number of bacteria colonies per 100 milliliters
MPN standards also apply to measurements based on colony forming units (CFU)
Source: SWRCB 2009

The Ocean Plan identifies Areas of Special Biological Significance (ASBS) that are areas designated by the SWRCB as requiring protection of species or biological communities to the extent that alteration of natural water quality is undesirable (SWRCB 2009). All ASBSs are also classified as a subset of State Water Quality Protection Areas (SWQPAs).

Water Quality Objectives for Enclosed Bays and Estuaries

Water quality objectives for enclosed bays and estuaries include a combination of visual observations, numerical criteria, restriction against significant changes from natural (ambient) conditions, and non-degradation criteria. All RWQCBs have visual observation water quality objectives for floatables, oil and grease, color (discoloration), suspended and settleable solids, suspended sediments, and biostimulatory growths (algae).

In addition, observation-based objectives concern taste and odor of fish and shellfish used for human consumption. These water quality objectives specify they not cause nuisance or adversely affect beneficial uses. Several numerical objectives have been established for enclosed bays and estuaries, with some variability among regional boards (Table 2.6-5).

Generally, turbidity values must be within 10 to 20 percent of ambient measurements depending on background concentration. Some RWQCBs specify that turbidity measurements not exceed

10 Nephelometer Turbidity Units (NTU) or 10 Jackson Turbidity Units (JTU) above ambient values when turbidity is naturally high. Some RWQCBs have additional requirements based on water clarity.

Dissolved oxygen concentrations must be above 5 mg/L and must range between 5 and 9 mg/L depending on beneficial uses and the RWQCB. In addition, objectives for annual or median dissolved concentrations are specified by some RWQCBs. Criteria for pH range between 6.5 and 9 with an allowable deviation from ambient of 0.2 to 0.5 pH units depending on the RWQCB. All RWQCBs follow guidance in the Thermal Plan for temperature, which specifies that water quality objectives for bays and estuaries should not exceed 4°F, and inland surface waters with WARM or COLD beneficial use designations should not exceed 5°F.

Table 2.6-5. Numeric water quality objectives for enclosed bays and estuaries.

Parameter	North Coast	San Francisco Bay	Central Coast	Los Angeles	Santa Ana	San Diego
Turbidity where ambient is 0 to 50 NTU	≤ 20% above ambient	Not specified	≤ 20% above ambient	≤ 20% above ambient	≤ 20% above ambient	≤ 20% above ambient
Turbidity where ambient is 50 to 100 NTU	same	≤ 10% above ambient	Not > 10 JTU	≤ 10% above ambient	Not > 10 NTU	Not > 10 NTU
Turbidity where ambient is > 100 NTU	same	≤ 10% above ambient	≤ 10% above ambient	≤ 10% above ambient	≤ 10% above ambient	≤ 10% above ambient
pH	≥ 6.5 or ≤ 8.5, ≤ 0.2 units from ambient MAR	≥ 6.5 or ≤ 8.5, ≤ 0.5 units from ambient	≥ 7 or ≤ 8.5, ≤ 0.2 units from ambient MAR	≥ 6.5 or ≤ 8.5, ≤ 0.2 units from ambient	≥ 7 or ≤ 8.6, ≤ 0.2 units from ambient	≥ 7 or ≤ 9, ≤ 0.2 units from ambient
Dissolved oxygen (mg/L)	≥ 7-9 SPWN ≥ 6 COLD, ≥ 5 WARM, MAR	≥ 7 COLD, ≥ 5 WARM, 3-month median 80% saturation	≥ 7 COLD, MAR, SPWN, ≥ 5 WARM, median values ≥ 85% saturation	≥ 5 MAR, WARM, ≥ 6 COLD, mean ≥ 6 LA-LB Harbors	No adverse effect to beneficial uses	≥ 6 COLD, ≥ 5 WARM or MAR, mean ≥ 7
Temperature*	≤ 5°F above ambient WARM; ≤ 4°F bays, estuaries	≤ 5°F above ambient WARM, COLD; ≤ 4°F bays, estuaries	≤ 5°F above ambient WARM, COLD; ≤ 4°F bays, estuaries	≤ 5°F above ambient WARM, COLD; ≤ 4°F bays, estuaries	≤ 4°F bays, estuaries	≤ 5°F above ambient COLD; ≤ 4°F bays, estuaries

*Note: COLD = cold freshwater habitat, WARM = warm freshwater habitat, MAR = marine habitat, SPWN = Fish spawning beneficial use.
Sources: LARWQCB 1994, NCRWQCB 2005, SARWQCB 1995, SDRWQCB 1994, SFBRWQCB 2004, CCRWQCB and SWRCB 1994.

Bacteria numerical criteria for enclosed bays and estuaries cover water contact recreation (REC-1), non-contact water recreation (REC-2), and/or shellfish harvesting (SHELL) beneficial uses. Basin Plans should be consulted for objectives specific to water bodies within each region.

Several numerical chemical (ammonia, toxic pollutants) and radioactivity objectives also apply to enclosed bays and estuaries. Because sediments removed from bays and estuaries that qualify for beneficial reuse must be tested and determined to be "clean" and free from substantial contamination, numerical criteria for contaminants are not discussed further.

2.7 Overview of Potential Biological Impacts Associated with Sediment Management Activities

Sediment management activities may affect biological resources directly, indirectly, or cumulatively. Impacts have the potential to be beneficial, adverse, or significant depending on the nature and location of the activity, duration and magnitude of impact effects, characteristics of existing habitats, and species present. Generally, The extent and persistence of adverse impacts depend upon the relative level of impact above that occurring naturally.

Types of Impacts from Sediment Management Activities

Direct

- Equipment (anchors, pipelines, vehicles) damage to habitats, injury of species.
- Discharge burial of habitat and invertebrates.
- Dredge removal of habitat and invertebrates.
- Dredge entrainment of invertebrates and fish.

Indirect

- Invertebrate forage reduction.
- Disturbance or interference (noise, lights, equipment) of wildlife movement or migration.
- Turbidity effects (reduced photosynthesis, feeding, growth, or mortality).
- Sedimentation effects (reduced photosynthesis, recruitment, nutrient stimulation, or mortality).
- Enhanced sandy beach habitat and supported resources

Direct impacts occur within project footprints during construction and may include burial, crushing, entrainment, or removal of sand habitat and associated animals during beach nourishment and associated activities. Indirect impacts may occur during or after construction. Indirect construction impacts may include turbidity and sedimentation from dredging or placement of sands, operation of equipment (noise, lighting), or reduction of the invertebrate forage prey for other animals. Indirect impacts after construction may result from the migration of sediments from the project site. Generally, direct impacts are easier to quantify than indirect impacts, but are not necessarily the most serious or long-lasting impacts (Greene 2002). Cumulative impacts are of increasing concern due to multiple and increasing uses in the coastal zone, including beach nourishment (Peterson and Bishop 2005).

The different types of direct and indirect impacts associated with sediment management activities are briefly described below. Detailed review of types of impacts and vulnerabilities of habitats and species to sediment management activities are presented in the Volume 1 BIA Sections 3, 4, and 5.

2.7.1 Equipment and Disturbance

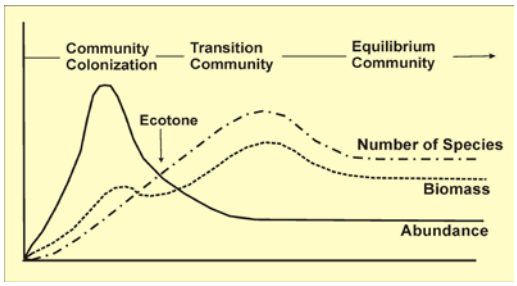
Equipment used during sediment management activities may include dredges, vessels (support boats), earth moving equipment (cranes, bulldozers, backhoes, graders), vehicles, pipelines, and lighting. Dredging or excavation will remove invertebrates along with the sediment. Equipment generated noise, human activity, or construction lighting may disturb, temporarily displace, or interfere with wildlife (e.g., Courtenay et al. 1972, Worden et al. 2002, Worden and Smith 2004). Therefore, proximity to sensitive wildlife areas (e.g., nesting sites, major roosting sites, haul outs or rookeries) is a key consideration of impact assessments.

Dredging or Excavation

Dredging or excavation will remove sediment and benthic (bottom-dwelling) organisms. The dredged or cut depression will infill from slumping of adjacent sediment and sedimentation over

time, the duration of which will be influenced by the initial cut depth and sedimentation rate in the water body. Generally, complete mortality is assumed for organisms removed by the dredge, although some small percentage may survive (NRC 1995, Greene 2002).

Recovery begins almost immediately with settlement of planktonic larvae and immigration from adjacent areas. Recovery generally follows a similar pattern of succession, including colonization and enhanced abundance of opportunistic species (peak of opportunists), followed by a transitional community composed of opportunists and some longer-lived species, and then recovery of an equilibrium community (Pearson and Rosenberg 1978, Newell et al. 1998). As the number of species increases, the abundance of the initial colonizers decreases (termed ecotone), marking the beginning of the transitional community. The equilibrium community may include larger, long-lived and slow growing species.



Generalized recovery of benthic invertebrate community after substantial disturbance or loss

Modified from Pearson and Rosenberg 1978 and Newell et al. 1998

Dredge or excavation recovery rates of invertebrates in embayments will depend on existing conditions. For example, recovery rates may range from less than 1 year for frequently disturbed areas (e.g., maintenance channels, inlet channels) that lack equilibrium communities, to several years for less disturbed locations (McCauley et al. 1977, Oliver et al. 1977, Newell et al. 1998, Merkel & Associates 2010).

Opening the inlet at San Dieguito Lagoon

Photo credit: Southern California Edison (Abigail Smigel)

Reports of recovery rates of the benthic invertebrate community after offshore dredging generally range from 2 to 4 years, although longer timeframes may be necessary for recovery of longer-lived species (Newell et al. 1998, Burlas et al. 2001, Dalfsen and Essink 2001). Recovery may take many years, if at all, if there is a substantial change in hydrodynamics or substrate. This has been reported for borrow sites where dredging resulted in deep pits, which accumulated silts and resulted in low dissolved oxygen concentrations, and for offshore mining sites with a high intensity of dredging use (Naqvi and Pullen 1982; Barry Vittor & Associates cited in Byrnes et al. 2004; Boyd 2004, 2005).

Entrainment

Hydraulic dredging (cutterhead, hopper dredge) may entrain bottom-associated invertebrates, fish, or their larval stages due to the strong suction produced at the dragarms or cutterhead. Entrainment rates generally are higher if the dragarms or cutterhead are not in direct contact with the bottom. Mortality rates may range from 5 to 100% depending on dredge, species, and organism size (Reine and Clarke 1998, Nightingale and Simenstad 2001). Bucket dredges have the lowest entrainment rates.

Dredge entrainment has been cited as a concern for early life stages of sturgeon, outmigrating salmonid smolts, and Dungeness crab, among others (Reine and Clarke 1998). Generally,

entrainment rates of fish and shellfish in embayments are low (< 1 fish, crab, or shrimp per cubic yard of dredged material). The majority of entrained fishes have been bottom-associated (demersal); however, a few pelagic species also have been collected. Higher rates have the potential to occur in narrow channel areas where species may be unable to avoid the dredge or in areas when certain species may concentrate (e.g., spawning areas) (LaSalle et al. 1991).

Noise

The type of sediment management activity will define the types of equipment and noise levels during construction. Depending on method of beach nourishment, equipment may be limited to trucks or may involve use of earth moving equipment and diesel engines to operate hydraulic pumps associated with pipeline delivery of source sediments. Dredges, barges, and support vessels may be used to obtain source sediments dredged from offshore borrow sites or from within embayments during maintenance or restoration projects.

Sound is a pressure wave that is transmitted in air or water. The pressure level is a logarithmic measure of the root mean square (rms) pressure (force/area) of a particular noise relative to a reference noise source, usually measured in decibels (dB). Values on land generally are reported according to the A-weighted decibel scale (dBA), which corrects sound pressure level in air to relative frequency of the human ear; that is, a de-emphasis on low and high frequency sounds inaudible to humans. The standard reference sound pressure at 3.3 ft (1 m) is 20 micropascals (re 20 $\mu Pa_{rms)}$ in air and 1 micropascal (re 1 μPa) in water. Values underwater are not weighted and are reported as dB (re 1 μPa_{rms}).

Noise levels from dredging equipment, earthmoving equipment, cranes, and dredges are within ranges that may disturb wildlife, but would not be expected to result in injury (Tables 2.7-1 and 2.7-2).

Noise levels of earth moving and handling equipment (e.g., backhoes, bulldozers, compressors, cranes, front loaders, generators, graders, pumps, trucks) may range from 68 dBA to more than 100 dBA at 50 ft (15 m). Combined noise levels during beach nourishment have been estimated as 85 to 90 dBA (SANDAG and USDN 2000). Reported noise levels of dredges range from 76 to 88 dBA at 50 ft (15 m).

Creating public access berm over hydraulic pipeline
Photo credit: Karen Green

The intensity, periodicity, and spectra of emitted sounds differ greatly among dredge types (Clarke et al. 2003). Bucket dredges produce a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying (Dickerson et al. 2001).

Hopper dredge sounds also consist of a suite of sounds, including the relatively continuous engine and propeller noise similar to that of similarly-sized commercial vessels, sounds at the dredge site of dragheads moving in contact with the substrate, and additional sounds at the discharge site of sediment release. In contrast, cutterhead dredges generate relatively continuous sounds associated with the contact of the cutterhead at the dredge site, engine noise, and discharge of sediment at the end of the pipe.

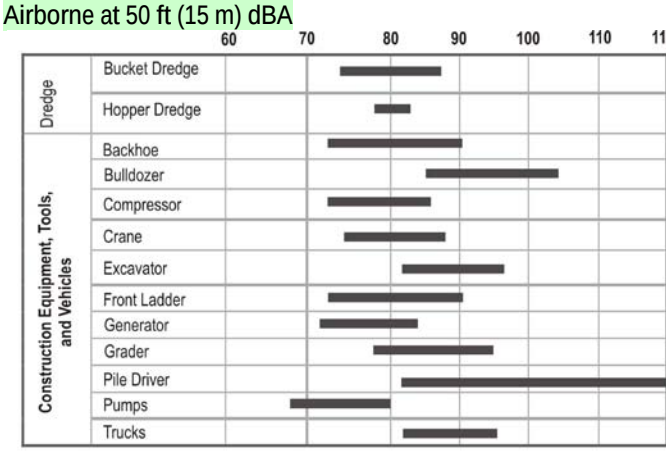
Sound levels will decrease with increasing distance from the source. Noise attenuation is affected by sound absorbing elements within the path of the sound (e.g., terrain, structures, and vegetation on land; suspended matter in water). On land, sound decreases by 3 (line source – e.g., traffic) to 6 (point source – e.g., single moving vehicle, stationary equipment) dBA for each doubling of distance (WSDOT 2006). Absorptive ground results in an additional noise reduction of 1.5 dB per doubling of distance (e.g., 4.5 to 7.5 dBA). Water and sand are considered reflective (hard surfaces) rather than absorptive surface (WSDOT 2006). Based on these considerations, a standard attenuation rate of 6 dBA per doubling of distance generally would apply to airborne noise from equipment used during sediment management projects.

In water, sound transmission loss is somewhere between 3 and 6 dB per doubling of distance, with approximately 4.5 dB per doubling of distance in nearshore waters (Vagle 2003 cited in WSDOT 2006).

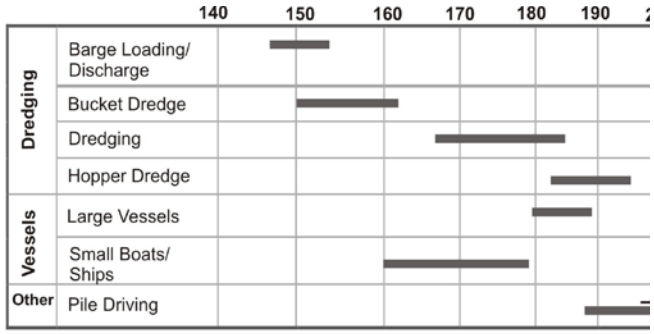
NMFS (Federal Register 2005) uses noise guidelines to estimate when harassment to marine mammals may occur. Current practice (e.g., NMFS 2011a) is that that cetaceans and pinnipeds exposed to impulse sounds of 180 and 190 dB_{rms} or above, respectively, are considered Level A (i.e., injurious) harassment. Behavioral harassment (Level B) is considered to occur when marine mammals are exposed to sounds at or above 160 dB_{rms} for impulse sounds (e.g., impact pile driving) and 120 dB_{rms} for continuous noise. Dredging is considered a continuous noise. For airborne noise, seal and sea lion disturbance guidelines are 100 dB (unweighted) in general, and 90 dB

Table 2.7-1. Construction noise levels.

Airborne at 50 ft (15 m) dBA



Underwater at 3 **ft (1 m) dB (1 µPa rms)**



Note: Sound level decreases by 3-6 dB per doubling of distance from source.

Sources: USEPA 1971, Chambers Group 1992, Dickerson et al. 2001, OSPAR Commission 2009, SAIC 2011

Table 2.7-2 Noise disturbance and injury guidelines.

Animal	Airborne dB (20 µPa rms)	Underwater dB (1 µPa rms)	
		Disturbance	Injury
Cetaceans[1]		120_c, 160_i	180
Harbor seal[1]	90	120_c, 160_i	190
Other pinnipeds[1]	100	120_c, 160_i	190
Fish (All Fish)[2]		150	206
Fish ≥ 2 grams[2]		150	187
Fish < 2 grams[2]		150	183
Birds (Marbled Murrelet)[3]	>20 dB above ambient or ≥ 90 dB	150	180
Sensitive bird nesting areas[4]	>60 dBA or greater than ambient		

Notes: rms = root mean square. Continuous noise ($_c$), Impact noise ($_i$).
The standard reference sound pressure at 3 ft (1 m) is 20 micropascals (µPa) in air and 1 µPa underwater.
Sources: [1]NMFS 2011, [2]ICF Jones and Stokes and Illingworth and Rodkin 2009, [3]USFWS 2006a, [4]City of San Diego 2007.

(unweighted) for harbor seals.

Noise guidelines also have been specified for certain federal- or state-listed endangered or threatened bird species. For example, harassment may occur when construction activities result in a 20-25 dB increase in sound levels above ambient conditions, sound levels are ≥ 90 dB, or visual proximity of activities is close to active nest sites (within 132 ft, 40 m) (USFWS 2006a). An average sound level of 60 dBA over 24 hours or exceeding ambient if above 60 dB are used as significance thresholds for sensitive birds, including snowy plover, during their breeding season in San Diego (City of San Diego 2007).

Regulatory noise thresholds have not been adopted for fish; however, interim guidance used for pile driving projects specify 150 dB_{rms} as a behavior effects threshold, between 183 and 187 dB cumulative sound exposure level (SEL) for injury depending on fish size, or 206 dB_{peak} as a peak exposure threshold injury level for all fish (Table 2.7-2).

Generally, available information indicates that sounds produced during sediment management activities are below levels known to result in injury or mortality, but may disturb fish, birds, or marine mammals depending on proximity.

Artificial Lighting

Artificial lighting may be of concern during outmigration of salmonids, grunion spawning, or near seabird nest sites. Visual predators such as large fishes, birds, and marine mammals, have been observed to concentrate foraging on schooling fishes around lighted vessels, presumably because the light illuminates their prey (DFG 2003). Juvenile chum salmon and larger predators (e.g., hake, dogfish, sculpin, large Chinook and Coho salmon) have been observed to congregate beneath night security lights, with attraction of juveniles potentially delaying outmigration (Nightengale and Simenstad 2002). Keitt et al. (2004) hypothesized that artificial lighting at nesting colonies could affect seabirds in two ways: (1) increased predation on young, and/or (2) altered behavior resulting in decreased foraging efficiency and ability to feed chicks.

Pipelines, Vehicles, Vessels

An important impact consideration is whether pipeline, vehicle, or vessel routes used to access project sites would cross over or be in close proximity to sensitive habitats. Coastal strand and dune vegetation is highly vulnerable to damage from equipment, vehicles or trampling. Vehicle access routes may be an additional concern during the grunion season, if habitat is suitable for spawning.

Placement of opportunistic sands outside the grunion season, Encinitas, CA
Photo credit: Kathy Weldon

Vessel routes to and from dredge or discharge sites may be of concern if canopy forming kelp beds are present. Vessel propellers have the potential to damage or dislodge kelp plants. Vessel propellers also have the potential to increase turbidity within eelgrass beds. If pipelines are used to convey dredge materials from a hopper dredge to the beach, anchoring locations and pipeline routes require careful planning if reefs are in the vicinity (AMEC 2002).

Collisions with marine mammals are considered a relatively low, but potential hazard. There is at least one reported fatality of a whale calf from collision with a hopper dredge (Laist et al.

2001). In the majority of cases, collisions with seals, sea lions, sea otters, or whales have been from fast moving vessels (Laist et al. 2001, Caretta et al. 2004, Harvey 2004). Where steps are needed to reduce collision risks (e.g., during migration, near haul outs, or foraging areas), advanced planning to avoid or minimize travel distances or to reduce vessel speeds have been recommended.

Accidental Leaks or Spills

A final consideration is the potential for accidental leaks or spills from operation of equipment. It is possible for leaks/spills of dredged materials to occur from pipelines (if joints are improperly sealed or damaged) or collisions with hopper dredges or dredge scows (or barges). Hopper dredges or scows/barges may transport several thousand cubic yards of sediment. Production rates of cutterhead dredges are on the order of hundreds of cubic yards per hour (USACE 1983). Leaks or spills of contaminants have the potential to occur from dredges, support vessels, or vehicles. A catastrophic collision with a cutterhead or hopper dredge would have the potential to release thousands of gallons of fuel. Typically, accidental discharges are controlled with BMPs and spill prevention plans. The potential for collisions generally is minimized by use of a U.S. Coast Guard Local Notice to Mariners that specifies dredge vessel activity areas and schedule.

2.7.2 Burial and Disturbance

Sand placement will temporarily alter the appearance of the habitat within the receiver site. Beach placement generally results in a wider beach, steeper profile, and a distinct scarp or berm at the shoreface until the beach fill adjusts from wave action (NRC 1995). Discharge of sands in the nearshore portion of the beach profile will result in an elevated mound, which will erode and move within the beach profile according to seasonal erosion and accretion cycles.

The primary direct impact to biological resources during beach nourishment projects is burial, crushing, and smothering of invertebrates within the receiver site footprint (NRC 1985, Greene 2002). Mortality of invertebrates living in the sands is generally assumed to be complete when burial exceeds 3 feet (0.9 m); survival of shallower overburdens depends on species and sediment characteristics. Larger, motile animals may be able to escape sand placement impacts.

Goleta Beach Nourishment Demonstration
Photo credit: Moffatt & Nichol Engineers

Sand placement has the potential to bury California grunion eggs, if present. Sands placed above the typical high water line have the potential to bury coastal strand plants living on supratidal beach, if present. Potential impacts to coastal strand/dune plants or grunion eggs may be avoided or minimized. Impacts to invertebrates are unavoidable; but the duration or severity of impact may vary depending on project- and site-specific considerations, which are reviewed below.

Invertebrate communities at sandy beach receiver sites represent important prey items for birds and fish that forage along the foreshore depending on tidal stage. Invertebrates at nearshore placement sites also are prey for fish. Recovery of the invertebrate community from direct burial effects may range from months to years depending on the habitat and affected biological

resources. Recovery rates may be influenced by existing conditions, compatibility between source and native sediments, project schedule, and frequency of disturbance.

Reported recovery rates of sandy beach communities vary from a few months to > 1 year (e.g., Parr et al. 1978, Jutte et al. 1999, Burlas et al. 2001, Versar 2004, SAIC 2011). Beaches with invertebrate communities dominated by relatively few, small-sized species that are short-lived (e.g., sand crabs, amphipods, isopods, bean clams, worms), such as occurs on beaches that are seasonally erosive, appear to recover relatively quickly after substantial disturbance. Re-establishment of the community largely results from larval recruitment, but also may be influenced by immigration from shallow nearshore and adjacent beaches or survival of some benthic species. Project schedule has the potential to influence recovery rates because beach invertebrate community development is strongly tied to a seasonal recruitment period (spring-early summer peak). Projects completed before the onset of the peak recruitment period may have quicker recovery rates than a project implemented during or after the peak recruitment period (e.g., recovery influenced more by the following season recruitment period).

Recovery would be expected to take longer for relatively more diverse communities or those that also include slow growing and long-lived species that may reach larger size, such as Pismo clams or northern razor clams. Generally, several years would be required to reestablish reproductive age structure of such populations. For example, Pismo clams are long-lived (over 20 years) and are several years old before sexually mature. While the occurrence of juvenile Pismo clams on a beach is not uncommon because they settle from the plankton, developed Pismo clam beds consisting of different age classes only establish in certain areas where physical conditions are suitable. Generally, Pismo clams may occur at relatively flat beaches that have a persistent sand base across seasons (Shaw and Hassler 1989, Masters 2006).

The reduction in invertebrates at the beach nourishment site may have secondary indirect impacts on the forage base for mobile animals (e.g., fish, shorebirds) until there is recovery of the invertebrate community. This may be more or less of an issue depending on the existing beach condition (seasonally erosive or persistent), project timing (e.g., related to recovery rates), or use patterns by sensitive species (e.g., threatened snowy plover).

Recovery rates have the potential to be influenced by the compatibility of source sediments to the receiver site. Slower recovery rates, altered species composition or abundance, or altered biological use patterns have been reported when placed sediments included clay balls (Reilly and Bellis 1983), high shell content (Petersen et al. 2002), or substantially coarser sand (McLachlan 1996).

Generalized Invertebrate Community Recovery After Beach Nourishment

Factor	Faster	Slower
Beach Type	Reflective Intermediate	Intermediate Dissipative
Location	Beach	Nearshore
Disturbance	Frequent	Infrequent
Age Structure	Short-lived Species	Includes long-lived species
Sediment	Compatible coarser or	Substantially Finer
Timing[1]	Winter	Summer

[1]Recovery periods for projects conducted in spring may be relatively fast if prior to the onset of peak recruitment

Beach nourishment has the potential to enhance sandy beach habitat for invertebrates, fish, and birds where sandy beach habitat is seasonally erosive. Monitoring after the 2001 San Diego Regional Beach Sand Project documented there was an increase in the persistence of sandy

beach habitat across seasons, which resulted in increased invertebrate diversity earlier in the season, increased bird use across tide conditions, and enhanced habitat for grunion spawning (e.g., increased beach width, reduction in cobble) compared to erosive conditions prior to the project (SAIC 2006).

Recovery of the benthic community at nearshore placement sites may range from several months to > 1 year (Oliver et al. 1977, Burlas et al. 2001). Species diversity increases seaward because physical controlling factors are relatively less harsh than on the beach, although they are still harsher compared to deeper nearshore waters. Inshore sands are dominated by species adapted to living in or on unstable sediment. Species may include a variety of small crustaceans (amphipods, cumaceans, isopods, ostracods) and worms, as well as larger and longer-lived burrowing anemones, clams, moon snails, sand dollars, sea pansies, sea pens, or sea stars (Parr et al. 1978, Morris et al. 1980, Thompson et al. 1993). Similar to beach habitat, substantial recovery of species composition and abundance may occur in less than 1 year; however, a longer time period would be needed to reestablish populations of longer-lived species (e.g., Pismo clams), if present.

2.7.3 Sediment Reworking and Sand Transport

Sand placed at a receiver site will winnow and eventually erode from natural physical processes. Sands placed on the intertidal or nearshore portions of a beach will be mobilized and reworked by waves and transported by currents. Sand transport from the receiver site will result in an increase in sand level along the beach profile (onshore-nearshore) and indirect sedimentation of adjacent nearshore and downcurrent beaches. Mobile invertebrates living within beach and nearshore sands are adapted to seasonal changes in sand level; therefore, they would not be expected to be substantially affected by sand movement after placement.

In erosive areas, the indirect addition of sand has the potential to improve habitat conditions for invertebrates, grunion, and shorebirds (SAIC 2006). For example, monitoring after the 2001 San Diego Regional Beach Sand Project documented positive influences at two non-receiver sites, each located approximately 1,000 ft (300 m) downcoast of receiver sites. However, improved habitat conditions for biological resources were more variable at these non-receiver sites across seasons and/or years compared to those at receiver sites, presumably due to differences in sand level increase and persistence.

Surfside Beach, Encinitas, with cobble, prior to upcoast beach nourishment

Photo credit: Kathy Weldon

Surfside Beach, two years after beach nourishment (1,500 ft upcoast)

Photo credit: Karen Green

Nearshore placement has the potential to supplement the beach profile and renourish the beach; whereby, sands are added to the littoral system and fines (silt/clays) move offshore. Experiments conducted at the Department of Army Waterways Experiment Station found that wave action is a significant contributor to (1) the amount of material available for transport, and (2) the direction of transport (Smith and Gailiani 2005). They summarized that sand placement in the relatively narrow, calm-weather surf zone may not be an option due to shallow water depth, but placement in the wider surf zone associated with storms may be

feasible. In that case, storm events would be the predominant transport mechanism for the placed material.

Monitoring conducted after nearshore placement offshore Ocean Beach, San Francisco indicated movement of discharged sediment towards shore, primarily after storms; however, effects were localized (Barnard et al. 2009). The authors recommended that future placements should be in water depths no greater than 16 ft (5 m) to drive a positive shoreline response at that location.

Sand transport may be of concern if receiver sites are near sensitive habitats (e.g., reefs, seagrass beds, kelp forests). Mechanisms of sand transport that may adversely affect rocky habitats include burial, scour/abrasion by moving sand, or increased exposure to resuspension and fine-layer deposition (Airoldi 2003). Within the littoral zone, sand moves on- and offshore on a seasonal basis and contributes to natural variability in resource development of intertidal and nearshore reefs (Littler et al. 1983, Ambrose et al. 1989, Murray and Bray 1993, Airoldi 2003). Severe storms with high waves also may redistribute sand and contribute to this variability. Marine species differ in their tolerances or adaptations to sand influence. Therefore, reefs subject to frequent sand disturbance generally support annual and/or sand-tolerant species. In contrast, reefs subject to less sand disturbance generally support a greater variety of species. Differences in resource development of intertidal and nearshore reefs associated with natural variability in sand inundation or scour are reviewed in greater detail in Section 3.4.2.

Key concerns of project-related sand movement in the vicinity of hard-bottom or vegetated habitats include the potential to degrade or result in loss essential fish habitat. Changes in sand level also would be of concern if it resulted in burial, increased scour, or substantial "sanding-in" of crevices or lower ledges that function as sheltering locations for fish or lobster.

There are examples of sand transport from beach nourishment resulting in burial or increased scour of sensitive reef habitats in other areas of the U.S. (e.g., Lindeman and Snyder 1999, Goreau 2001, Coastal Planning & Engineering 2004a, b). There also are examples of beach nourishment projects being conducted in the vicinity of reefs or vegetated habitats (surfgrass, kelp beds) without reported significant impacts (e.g., Chambers Group 2004, Coastal Planning & Engineering 2004c, AMEC 2005). Factors that may influence these differences in impact level likely include some combination of project size (sand volume), proximity to sensitive habitats, reef characteristics, and environmental conditions. Site-specific reef characteristics that may be particularly influential include reef heights above average seasonal sand levels, orientation relative to the shore, occurrence of breaks in the reef that may function as on-offshore sand transport channels, and overall size of the reef feature.

Storm sedimentation of surfgrass

Storm sand scour *Photo credits: Karen Green*

Sand transport also may be a concern if receiver sites are located near the entrance (ocean inlet) of embayments. Accelerated sand accumulation in entrance channels has the potential to

influence the volume or frequency associated with normal maintenance projects in either shallow- or deepwater-inlet embayments. In the case of shallow-inlet embayments, an additional concern is the potential for substantial sand accumulation to reduce tidal prism or cause inlet closure. Adverse impacts to biological resources may result if sedimentation increased the frequency of maintenance dredging or excavation or resulted in a reduction in water quality associated with reduced tidal exchange.

Potential impacts associated with indirect sedimentation are challenging to assess because of the complexity of interaction between placed sediments (physical characteristics), project sediment volume, and environmental conditions during and after construction (e.g., currents, waves, bathymetry, barriers). Models and tools have been developed to increase understanding and prediction of beach erosion and shoreline change for sandy habitats (e.g., GENESIS, NEMOS, SBEACH) (*http://chl.erdc.usace.army.mil/software*). Model limitations in predicting sand level changes in areas with rocky outcrops or seagrass beds, which may modify sand accumulation or movement have been reviewed (e.g., Thieler et al. 2000). Establishing and monitoring elevation changes along beach profiles may be used to increase understanding of sediment movement after beach nourishment. Beach profile data are essential for verification of impact assumptions, model calibration or verification, or tracking of project performance. However, post-project verification of model assumptions has been rarely funded in California.

2.7.4 Sediment and Water Quality

Sediment management activities involving dredging or discharge of sediments in waters of the U.S. are required to have the sediments evaluated prior to such activities to provide factual data upon which determinations by the USACE, in consultation with the USEPA, are made regarding permitted disposal or beneficial use options (e.g., beach nourishment). USEPA and USACE (2004) specify guidelines for acceptability of dredge material for beneficial use as beach nourishment, as follows: it should closely match the sediment composition of the eroding beach and be low in fine sediments, organic material, and pollutants.

Beneficial Reuse of Dredged Material

- Closely match sediment composition of receiver site
- Low silt/clay and organic content
- Free of substantial contamination

A tiered approach to analysis is used to evaluate sediments for dredging or discharge consistent with guidelines in the Inland Testing Manual (ITM) (USEPA and USACE 1998) or Ocean Testing Manual (Green Book) (USEPA and USACE 1991). Generally, sediments used for beach nourishment are tested with the ITM. Testing is performed at the lowest tier at which a suitability determination can be made.

Sediment Testing

Tier 1 – Evaluation of existing data, distance from known contaminant sources

Tier 2 – Chemistry screening and models

Tier 3 – Biological toxicity testing and bioaccumulation analyses

Tier 4 – Site or region specific analysis

Source: Steevens 2008

Tier 1 analysis evaluates the physical characteristics of source sediments (dredge or opportunistic) and the likelihood for contamination based on physical characteristics, previous and still appropriate chemical testing of sediments from the same vicinity, and/or whether the location of dredge/discharge materials is far removed from contaminant sources or from pre-industrial age deposits not exposed to modern pollution (40 CFR Sec. 230.60(a), U.S. Code of Federal

Regulations 2003). *Tier 2* chemical analysis is conducted if additional information is necessary to evaluate chemical contaminant levels within sediments. *Tier 3* is rarely needed for beach nourishment activities, but can be used if sediment chemistry alone is insufficient to make a determination. Sediments requiring Tier 4 would not be suitable for beach nourishment.

Turbidity is the primary change to water quality during dredging, excavation, or discharge of sediment. This results in an increase in suspended sediment particles in the water column, which increases cloudiness (turbidity), decreases water clarity, and reduces light transmission through water. The fate of suspended sediment is to settle to the bottom, becoming bedded sediment (also termed sedimentation). The term "SABS" is used to identify the dual processes of suspended and bedded sediment. Suspended sediment concentrations, turbidity plume characteristics, and biological effects of SABS are described in greater detail in the following subsections.

> SABS are defined as organic and inorganic particles that are suspended in, are carried by, or accumulate in waterbodies. SABS are natural parts of aquatic systems and are not considered harmful until they are out of balance, that is, excessive or deficient.
>
> *USEPA 2006*

Other water quality concerns may include contaminant release, oxygen depletion, release of nutrients, or release of bacteria depending on the environmental conditions at the dredge location. Typically, sediments that would result in substantial changes in water chemistry or bacteriology during dredging or discharge would not be suitable for beneficial reuse for beach nourishment.

Potential Dredge-Discharge Water Quality Concerns

Effects	Potential Impacts
Suspended solids	Altered behavior; abrasion; impaired respiration, feeding, and excretory functions; retarded egg development; reduced larval growth; reduced photosynthesis; mortality; protection from predation.
Dissolved oxygen depletion	Increased stress, reduced efficiency of oxygen uptake, impaired respiration, mortality.
Contaminant release	Uptake and bioaccumulation in aquatic organisms, toxicity.
Nutrient release (nitrogen, phosphorus)	Biostimulation of algae, harmful algal blooms.
Bacteria release	Water-contact human health risks

Open water discharge of dredged sediments would not be expected to cause significant dissolved oxygen (DO) depletion in the water column (Houston et al. 1989, Lee and Jones 1999).

Aquatic pipeline discharge of sediment slurry from cutterhead operations has the potential to result in an anoxic turbid plume at the bottom that may range several hundred feet from the discharge location (Lee and Jones 1999). This impact may occur with slurry discharge of muddy sediments and formation of a low-density fluid mud mound overlying the existing sediment (USACE 1983). Similar effects have not been reported with dredging of sands.

DO reductions may occur in the immediate area of dredging, although at varying levels. Generally, DO reduction is a function of the amount of suspended sediment placed into the water column, the oxygen demand of the sediment, and duration of resuspension (LaSalle et al. 1991). Reductions in DO may occur in the immediate area of the dredge; however, this is not usually the case unless dredging muddy sediment.

The potential for nutrient-release from dredged sediments to contribute to harmful algal blooms may be a concern in some embayments. Generally, dredged sediment-associated nutrients will rarely have an adverse effect on eutrophication-related water quality at the disposal site because the events are short-lived, dilution is relatively rapid, and nutrient release generally is small (Jones and Lee 1981). Discharge of dredged sediments has the potential to increase total and fecal coliform and other bacteria concentrations in waters if the dredged sediment is contaminated with waste (Grimes 1980). Testing of bacteria levels in waters at the discharge site may be required if there is the potential for contamination.

Sandy sediments with a low organic matter content tend to not accumulate contaminants unless a contamination source is nearby (USACE 1983). Nutrient release or DO depletion also has a low potential with sandy sediments with low organic content.

2.7.5 Turbidity

Turbidity associated with suspended sediment will occur with beach or nearshore placement. Turbidity also will be generated during dredging. Turbidity plume characteristics, suspended sediment concentrations, and water clarity measurements during beach placement, nearshore placement, and dredging are reviewed in the following subsections.

Turbidity – Beach Sand Placement

Turbidity during opportunistic sand project, Encinitas
Photo credit: Kathy Weldon

Turbidity plumes will be generated with upper beach or swash placement. Placing sands at the backshore (dune placement) will not generate turbidity under average tide conditions; however, dune placement may be subject to wave run-up and turbidity generation during extreme high water associated with storm or high wave conditions.

Beach sand placement will result in suspended sediment or turbidity plumes. Plume characteristics may depend on a number of factors, such as equipment used, location of placement, sediment characteristics, environmental conditions, and use of operational or engineered controls during placement. The equipment used for sand delivery may result in continuous or discrete periods over which turbidity is generated. Cutterhead dredging and pipeline discharge are a continuous operation; therefore, turbidity is generated throughout the time of active pumping operations.

Hopper dredge operations involve two discrete periods associated with dredging and discharge. The cycle time between these activities may range from one to several hours depending on the distance between the dredge and discharge site. Therefore, turbidity plumes may occur as pulses that will tend to dissipate at the receiver site during the cycle time between loads.

Truck placement also involves one discrete period associated with sand discharge at the beach. Whether turbidity is generated in pulses or nearly continuously will depend on the cycle time between loads, which will depend on the number of trucks used and total truck trips per day. It also will depend on the location where the discharge occurs on the beach and tide condition. For example, sands placed in piles on the dry backshore will generate pulses of turbidity when exposed to tidal action. Turbidity may be nearly continuous if sands are pushed directly into the swash zone using earth moving equipment.

Whether hydraulically pumped or mechanically placed, waves or swell will rework placed sediment, sorting sands from silts/clays. The heavier sands typically settle quickly and remain in the littoral zone. Silts/clays have slower settling times and stay in suspension longer. Therefore, the silt/clay content of placed sediments may greatly influence turbidity plume characteristics. Generally, silt/clays remain in suspension in the turbulent surf zone and settle outside the breaker zone.

Monitoring indicates that turbidity plume dimensions may substantially vary during beach nourishment projects (Table 2.7-3, Figure 2.7-1). Plume lengths of approximately 100 ft (30 m) to more than 2 mi (3.2 km) have been measured. Plume widths may be confined to the surf zone (e.g., a few hundred feet of shore) or may extend more than 1,500 ft (457 m) offshore. Rip currents may facilitate transport of fines offshore (Section 2.4.2).

TSS concentrations during beach nourishment (Table 2.7-3) may be similar or higher than concentrations during storm or high wave conditions. Generally, concentrations ≥1,000 mg/L are rare in the surf zone (Section 2.4.5), unless directly above the bottom during high waves (Table 2.4-2). Reports of higher concentrations during beach nourishment were associated with projects that included unconfined hydraulic discharge (Reilly and Bellis 1983), sediments with higher silt/clay content (e.g., Reilly and Bellis 1983, Warrick 2010), or use of a bulldozer to push sediments into the swash zone (Sherman et al. 1998).

Table 2.7-3. Reported suspended sediment concentrations and plume lengths during beach nourishment.

Equipment and Method	Sand: Silt/Clay Ratio	Total Suspended Solids (mg/L)		Turbidity Plume (ft)		Reference
		Maximum	Ambient	Length	Width	
Hydraulic pipeline unconfined discharge (North Carolina)	Sands with clay balls	1,700-4,700	86-96	NA	NA	Reilly and Bellis 1983
Hydraulic pipeline - pumped high on beach (New Jersey)	≤ 90:10	176->600	12-<20, except storms (81-425)	300-1,312	Confined to swash	Wilber et al. 2006
Hydraulic pipeline pumped high on beach (San Diego, CA)	≥90:10	NA	NA	700-2,500	100-800	SAIC 2011 (Aqua Hedionda data)
Hydraulic pipeline diked discharge (San Diego, CA)	>80:20	NA	NA	100-984	66-164, (except 984 one time)	AMEC 2002
Truck/front loader – sand spread on upper beach (San Diego, CA)	83:17	NA	NA	1,320-2 mi	600-1,700	City of Encinitas, 2009 monitoring maps
Bulldozer – sand pushed into swash (San Diego, CA)	82:18	1,606	17-26	>2 mi	984	Sherman et al. 1998
Truck – sand placed in piles on foreshore (San Diego, CA)	60:40	955 – 4,398	6-14, except rip currents (25-150)	3,000 <6,000	1,000-1,500	Warrick 2010*

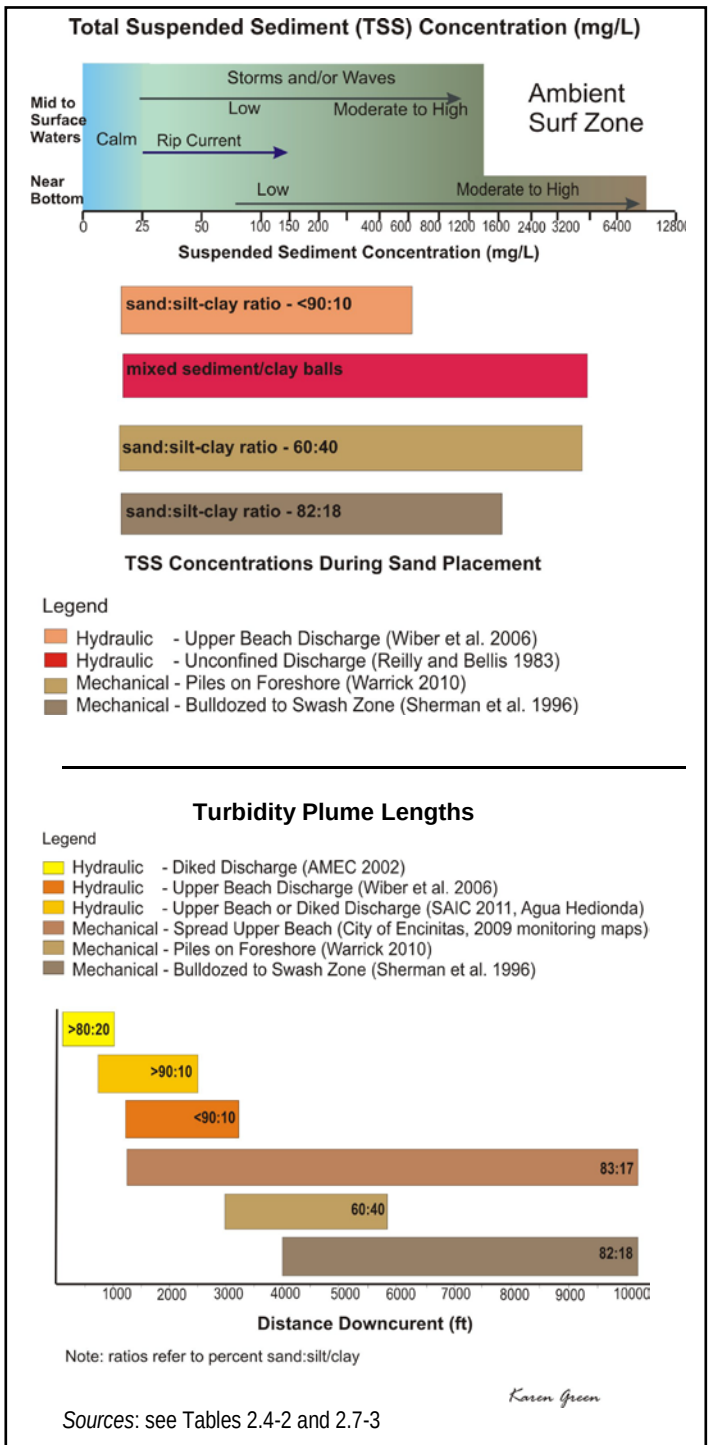
Notes: TSS = total suspended solids. NA = not applicable, not measured. Measurements of plume width for Weldon are approximate based on map interpretation. *Measurements for Warrick 2010 are approximate based on review of preliminary findings maps.

Turbidity plume dimensions also may be greater if the introduction of sediment to the surf zone is rapid, such as occurs with unconfined hydraulic discharge or pushing sediment directly into the swash zone (e.g., Reilly and Bellis 1983 or Sherman et al. 1998 on Figure 2.7-1, Table 2.7-3).

Control measures that slow the introduction of sediment to the surf zone may be effective for reducing turbidity plume length and concentration. During hydraulic discharge, different methods may be used to reduce turbidity plumes. For example, temporary sand dikes may be constructed to promote sand settlement so that the water returning to the sea (return water) has a low sediment content and plumes are reduced (e.g., AMEC 2002 on Figure 2.7-1, Table 2.7-3). Material may be pumped high on the beach to accomplish the same objective of promoting sand settlement and reducing turbidity plumes (e.g., Wilber et al. 2006 on Figure 2.7-1, Table 2.7-3).

Existing beach conditions are important to consider if deciding to hydraulically pump sand slurries either behind temporary sand dikes or on the upper beach. Sufficient beach width is necessary to either build the dikes or slow the movement of the slurry. If the beach is narrow, turbidity may be substantially higher until sufficient sand can be pumped to the beach to increase the effectiveness of control measures.

When trucks are used to deliver sands, placement of sand in piles on the foreshore also may be effective for slowing the introduction of sediment to waters. Turbidity plumes lengths generally were smaller, despite the silt/clay content being substantially greater (40%), with the Tijuana Fate and Transport Study (Warrick 2010 on Figure 2.7-1, Table 2.7-3) than a project



Sources: see Tables 2.4-2 and 2.7-3

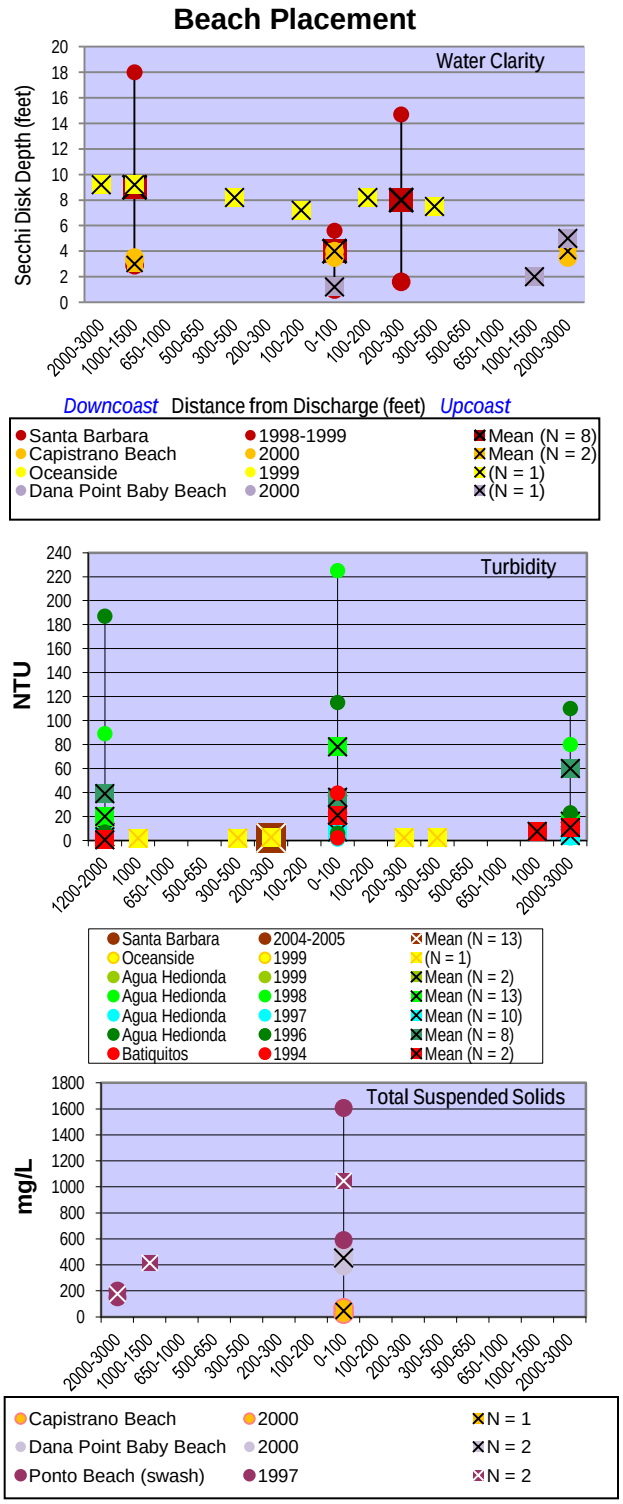
Figure 2.7-1. Comparison of representative TSS concentrations and turbidity plume lengths during sand placement relative to ambient conditions.

that used a bulldozer to push sands with a lower silt/clay content (18%) directly into the swash zone (Sherman et al. 1998 on Figure 2.7-1, Table 2.7-3).

Substantial variability in turbidity plume lengths, ranging from <0.25 to 2 mi (0.4 to 3.2 km), was observed during an opportunistic sand project that varied in the placement location on the beach relative to tide stage (City of Encinitas 2009 on Figure 2.7-1, Table 2.7-3). Field notes suggest that greater plume lengths occurred when material was deposited in the swash zone at the beginning of the project or when placement occurred during high tides. Smaller plumes appeared to occur when sand was placed on the upper beach during low tides.

There has been a lack of consistency in monitoring requirements of beach sand projects in California (Figure 2.7-2; refer to SAIC 2011 Appendix C). Inconsistencies include the type of measurements collected (e.g., water clarity, turbidity, TSS, turbidity plume), distances from the discharge location where measurements are recorded, and location where the measurements are taken (e.g., outside the breaker zone, surf zone, water depth). In addition, the effectiveness of measures used to control turbidity during project implementation generally have been poorly documented. Despite some of these limitations, monitoring data collected during eleven representative California beach projects indicate the following trends:

- Mean water clarity (Secchi disk) values may or may not be > 20% greater offshore the discharge than ambient values. Values near or below 3 ft (1 m) were measured within 1,500 ft (457 m) for 2 projects. Slight or localized reductions were noted for another 2 projects.
- Mean turbidity values (nephelometer NTU units) may or may not be



Notes: Circles depict range, square box with centered "x" depict mean value. The distance scale up- and downcoast is the same for all figures.

Figure 2.7-2. Representative water clarity, turbidity, and TSS measurements during beach sand placement.

substantially elevated beyond the surf zone during sand placement. When plumes extend offshore the breaker zone, values may or may not range ≥ 20% higher than ambient and plume dimensions may vary. Ambient levels were measured within 300 to 3,000 ft (91 to 914 m) for 7 projects. One project measured similar to higher elevated turbidity within 1,500 ft (450 m) downcoast and 3,000 ft (914 m) upcoast as offshore the discharge location suggesting ambient levels were elevated during project implementation.

- Limited TSS data have been collected during California beach nourishment projects. Monitoring of the Ponto Beach project was conducted in the surf zone; concentrations of 590-1,606 mg/L were measured directly offshore the discharge and elevated concentrations of approximately 100 mg/L were detected 1.9 miles (3.1 km) downcurrent. Sediments (82:18 sand to silt/clay ratio) were pushed directly into the swash zone, and the authors noted that a large-scale rip current contributed to plume expansion (Sherman et al. 1998). Elevated concentrations were not detected outside the breaker zone with the Capistrano Beach project. A mean concentration of 452 mg/L was measured 500 ft (150 m) offshore a beach receiver site in a protected area of Dana Point Harbor.

The duration of turbidity-related effects, during beach sand placement projects, appear to be temporary and of short duration. Plumes were not visible within hours of completion of the Ponto Beach project (Sherman et al. 1998). In addition, plumes were not visible during off days between periods of sand placement during an opportunistic sand project in Encinitas (City of Encinitas 2009, monitoring data for Pacific Station project).

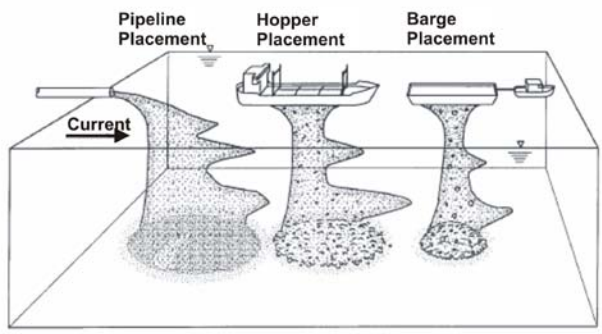
The reviewed literature and monitoring information suggests the following resource protection considerations relevant to sand placement:

- Plumes may be confined largely to the surf zone or extend more than 1,500 ft (457 m) offshore. Suspended sediment plume concentrations and dimensions are likely influenced by sediment characteristics, placement method, and environmental conditions (e.g., rip currents, tide stage, wave climate).
- Suspended sediment concentrations in the surf zone generally exceed ambient conditions by > 20% within distances that may range from 100 ft (30 m) to more than 2 mi (3.2 km) from the discharge location, presumably due to swift currents. Concentrations may exceed 1,000 mg/L offshore the discharge location, but appear to decrease exponentially with increasing distance from the source.
- Concentrations outside the surf zone may or may not exceed ambient conditions by >20%. Plume dimensions and concentrations may be variable outside the breaker zone. If plumes extend offshore, elevated turbidity and reduced water clarity may be localized within 300 to 1,500 ft (91 to 457 m) of the discharge with ambient conditions measured within 3,000 ft (914 m) of sand placement. The large range of distances over which ambient values were reached was due more to inconsistent sampling design than measured values. For example, measurements away from the discharge sometimes were taken only at far-field distances of 1,000 to 3,000 ft (305 to 914 m) away.
- Suspended sediment concentrations during sand placement appear to be comparable to concentrations during moderate to high waves or storms. Concentrations in the swash zone adjacent to the discharge have the potential to be very high.
- Plumes and suspended sediment concentrations may be reduced by slowing the rate of introduction of sediment to the swash zone.

- Turbidity plumes rapidly dissipate after cessation of placement operations.
- Permit compliance monitoring requirements have lacked consistency.

Turbidity – Nearshore Placement

Dredged material may be placed at nearshore sites using hydraulic pipeline placement of fluidized sediment, hopper dredge discharge of sediment, or release of mechanically dredged material from a dump scow or barge.



Source: USACE and USEPA 2004

Example open water placement methods

Nearshore or profile placement results in turbidity and sedimentation when sediment is released through the water column and also from the resuspension of sediment when the discharge plume hits the bottom. The discharge plume dimensions depend on a variety of factors, including the released sediment volume, sediment characteristics (e.g., percent silt/clay, bulk density), method of discharge (e.g., mechanical, hydraulic), discharge rate, discharge location (e.g., above, at, or below water), water depth, and environmental conditions (LaSalle et al. 1991)

Discharge characteristics vary depending on source material (Williams 1998), as follows:

- Hydraulically dredged material is fluidized, which significantly reduces bulk densities, and is more susceptible to dispersion during descent through the water column.
- Mechanically dredged sediment tends to maintain bulk densities, which contributes to a more cohesive mound feature at the placement location.
- Coarse-grained material (sands) loses coherence during descent through the water column, but is more conducive to mound formation than fluidized sediments.

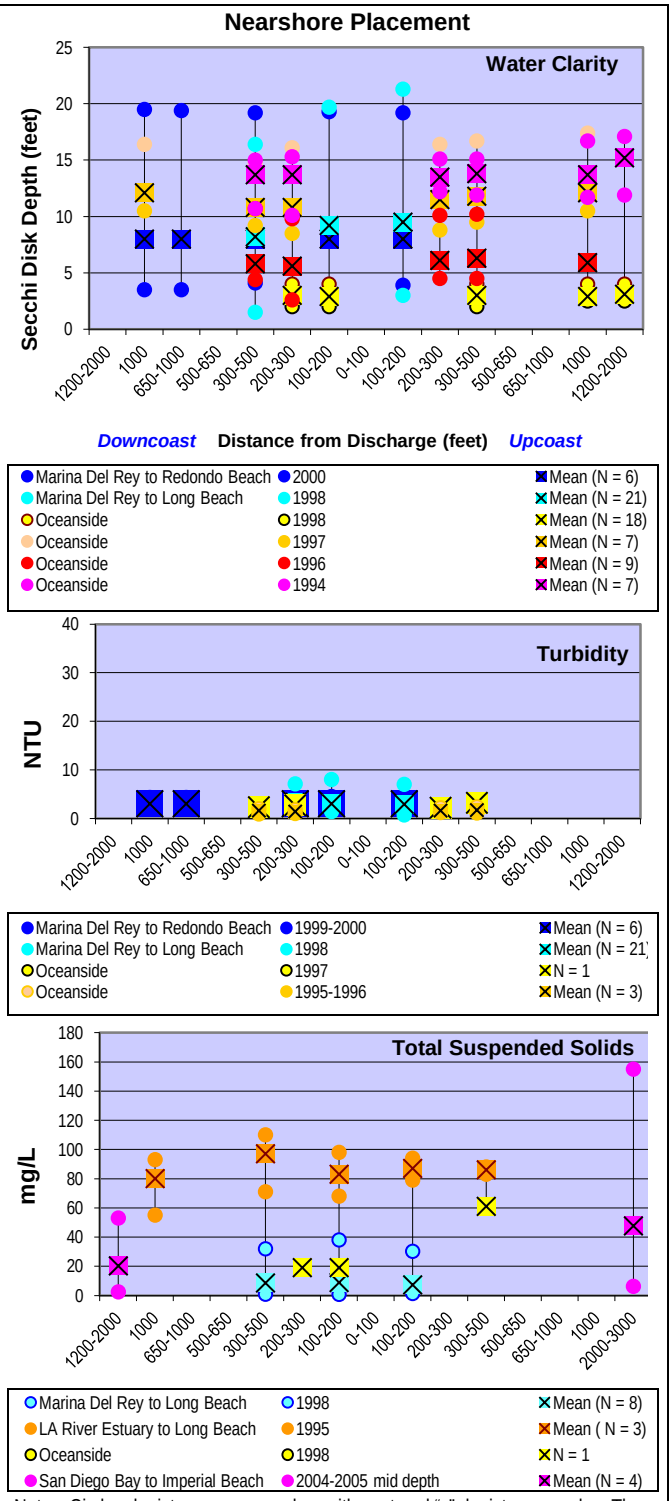
Discharge characteristics also vary with equipment (USACE 1993, USACE and USEPA 2004):

- Hydraulic pipelines discharge a fluidized sediment slurry. Open-water discharge creates a vertical gradient of fine suspended solids, forming a turbidity layer above the fluidized sediment layer. Ambient water is entrained by the discharge momentum.
- Continuous discharge of fluidized sediment (e.g., cutterhead operation) may produce TSS concentrations that exceed 10,000 mg/L in a fluid mud layer at the bottom, while the overlying plume would have lower concentrations. The mound may require one to several years to consolidate depending on sediment characteristics. Discharge of sandy material generally would result in less suspended sediment concentrations and/or durations than silty sands.

- Hopper dredges are designed with bottom doors or with a split-hull, and the entire load is emptied in a matter of minutes. The fluidized dredged material entrains ambient water as it falls through the water column as a well-defined jet. Most material rests at the impact site, but some may spread in a bottom surge until the momentum is dissipated. Discharge and settlement of sandy material is very rapid.
- Dump scows with bottom doors empty the contents within seconds, essentially as an instantaneous discharge, and only a small amount of the material remains suspended.

Monitoring data collected during nine California nearshore placement projects (Figure 2.7-3) indicate the following:

- Generally, monitoring has occurred within 500 to 3,000 ft (150 to 914 m) of the discharge. Measurement distances from discharge are not standard.
- Mean water clarity was not substantially reduced within 1,000 ft (305 m) of the discharge during seven projects, suggesting rapid plume settlement and little resuspension to the surface.
- Mean water clarity values exceeded 5 ft (1.5 m) for most projects. Lower water clarity was uniformly observed at both near and far-field stations for one project, suggesting ambient turbidity was relatively high.
- Turbidity values were not substantially elevated in the vicinity of discharge with four projects, suggesting rapid plume settlement.
- Elevated near-surface TSS concentrations (mean values < 100 mg/L, maximum value < 200 mg/L), were detected within distances ranging from 500 ft (150 m) to 3,000 ft



Notes: Circles depict range, square box with centered "x" depict mean value. The distance scale up- and downcoast is the same for all figures.

Figure 2.7-3. Representative water clarity, turbidity, and TSS measurements during nearshore placement.

(914 m) of the discharge. Low concentrations near the discharge for two projects indicate samples were collected after plume settlement. TSS concentrations at mid-depth were elevated up to 3,000 ft (914) away for one project; lack of near-field data limit interpretation of project effects.

- Near-bottom TSS concentrations or turbidity were not measured, but would be expected to range higher.
- The maximum length of the turbidity plumes were not measured with the sampling designs.
- Measured TSS in near-surface or mid-water samples were within the range observed during mild to moderate storms (mean < 100 mg/L, range < 200 mg/L) (Figure 2.7-4).

Monitoring has demonstrated variable performance with respect to nearshore placement contributing to shoreline increase. The receiving environment and water depth relative to the beach depth of closure appears to be influential. Monitoring conducted after nearshore placement of approximately 190,000 cy off the Silver Strand, San Diego in 1988 demonstrated that the crest elevation of the offshore bar was raised from -15 ft to -10 ft (-4.6 to -3 m) during the placement operations and that the sand from the artificial bar migrated landward (Juhnke et al. 1990). The authors reported that an incidental benefit of the project was enhanced surfing conditions, based on good press on the subject printed in local newspapers.

Monitoring conducted after annual placement for three years of 230,000 to 300,000 cy of sediment off Ocean Beach, San Francisco has shown limited onshore movement of sediment to a target area of coastal erosion (Barnard et al. 2009). Some sediment moved onshore during 2006-2007 large waves, but approximately half was still present at the discharge site after storms. Sediment was placed between approximately 29 and 46 ft (9 and 14 m). The authors concluded that dredge material must be placed in water depths no greater than 16 ft (5 m) to derive a positive shoreline response. However, the site increased wave dissipation with only a negligible effect on nearshore morphology.

The reviewed information suggests the following resource protection considerations during nearshore placement:

- Discharged sediment rapidly descends and near-surface plumes may be weakly developed. Lower water clarity was observed within 1,000 to 1,500 ft (305-450 m) for two projects, but the sampling design did not measure the extent of the plume or deviation relative to ambient conditions.
- Suspended sediment concentrations may exceed ambient conditions by more than 20% near the surface, but values may be relatively low (≤ 200 mg/L).
- Suspended sediment concentrations may range higher in the lower water column, but were not adequately measured in the reviewed projects.
- Suspended sediment concentrations during nearshore placement may be comparable to those measured at similar depths during low to moderate waves or storms.
- Turbidity plumes would be expected to rapidly dissipate after cessation of placement operations based on observations suggesting rapid plume settling rates.
- Permit compliance monitoring requirements have lacked consistency.
- The onshore migration of placed sediment depends on discharge depth and exposure to wave action.

Turbidity - Dredging

Suspended sediment concentrations vary depending on dredge equipment, operations, sediment characteristics, distance from the dredge, and hydrology. Turbidity is generated at the bottom from the dredging activity, and also may occur in the water column or at the surface depending on the equipment used (Table 2.7-4).

Suspended sediment plumes dissipate with time and distance from the dredging operation due to a combination of particle settling, mixing, and dilution processes. The duration and extent of turbidity relates to the settling rate of the resuspended material, water depth, turbulence of the water, current speed, and type of dredge equipment. Generally, silts-clays remain in suspension longer than sands.

Table 2.7-4. Locations of suspended sediment during dredging.

Dredge Type	Operation	On Bottom	Lifting Through Water	Loading	Movement
Conventional Bucket	Cycle (descent, lift)	Bucket impact	Yes	Yes, If overflow	Yes, If overflow from barge or scow
Enclosed Bucket	Cycle (descent, lift)	Bucket impact	No	Yes, If overflow	Yes, If overflow from barge or scow
Cutterhead	Continuous	Cutter	No	No	No
Hopper dredge	Cycle (dredge, discharge)	Dragarms	No	Yes, if overflow	Dredging and during loaded transit to discharge location

Source: modified from OMOE 1994

Conventional, open bucket dredges generate turbidity throughout the water column, at the bottom from the impact of the dredge, during lifting through the water column, and from spillage overflow at the surface. Offloading the sediment into transport barges or scows also may generate turbidity. Barges or scows will be partially filled with residual water at the beginning of the filling cycle; therefore, residual water may be displaced as the scow is filled (Palermo and Randall 1990). If filling is continued past the point at which the scow is full, the overflow is spilled over the sides. Enclosed buckets reduce release of sediments and suspended sediments during the dredging operation, and have particular application in areas with contamination or high environmental concern. Enclosed buckets generally are smaller, have longer cycle time, and cost more to operate. In areas without contamination concerns, conventional buckets are typically used.

Bucket dredge and scow

Photo credit: USACE, New England District

Cutterhead dredge *Photo credit: Karen Green*

The cutterhead dredge is the most commonly used dredge in the United States and includes a variety of pipeline sizes, ranging from 6 to 44 inches (Herbich and Brahme 1991). The pipeline slurry typically has a solids content of 10 to 20% by weight (Barnard

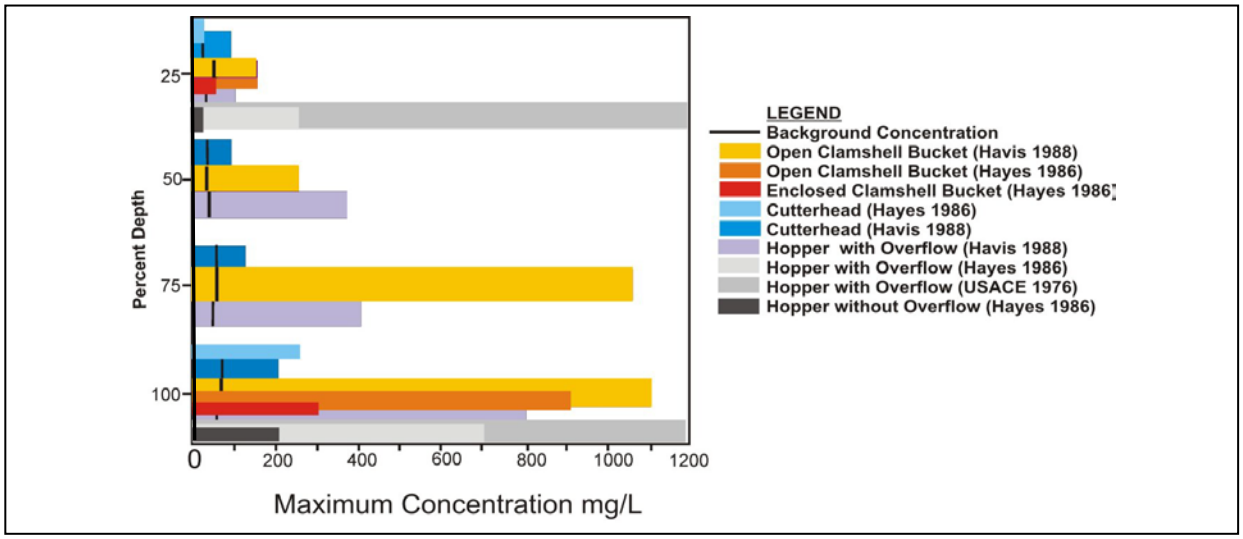
1978). Most of the turbidity is generated in the immediate vicinity of the cutter as it swings back and forth in front of the dredge platform, and decreases exponentially towards the surface. Operational conditions greatly influence suspended sediment concentrations. Turbidity may substantially increase as the thickness of the cut, swing rate, or cutter rotation increase (Huston and Huston 1976, Barnard 1978, Collins 1995).

Hopper dredge with pipeline to shore

Photo credit: SANDAG

Hopper dredges generate turbidity at the bottom associated with the movement of the dragarms on the bottom on either side of the vessel. In addition, turbidity may be generated at the surface if the hopper bins are filled to and past the point where residual waters are displaced and allowed to overflow through weirs on each side of the vessel. Overflow is conducted to increase the sediment load, which may be referred to as *economic loading*. When the sediments are composed of sands or heavier material, the settling process within the hopper is generally efficient and the hopper can be nearly filled with settled solids before significant quantities of sand are contained in the overflow (Palermo and Randall 1990). However, overflow tubidity from dredging silty sands may be excessive (LaSalle et al. 1991).

Generally, suspended sediments are highest near the bottom and decrease towards the surface, unless there is overflow or spillage at the surface. Sediment re-suspension is lowest with a cutterhead dredge, enclosed bucket dredge, or hopper dredge operated without overflow (Figure 2.7-5). Open bucket dredges with surface spillage may generate turbidity levels comparable to overflowing hopper dredges depending on sediment characteristics (e.g., silt/clay content). Although not shown on Figure 2.7-4, the turbidity plume disturbance from a backhoe dredge is considered to be comparable to that from a clamshell bucket dredge (OMOE 1994).



Sources: Redrawn from Havis 1988, and with additional data from USACE 1976 and Hayes 1986

Figure 2.7-4. Maximum total suspended sediment concentrations measured around commonly used mechanical and hydraulic dredges.

The amount of SABS generated at the dredge site is related to the sediment characteristics (e.g., solids concentration, percent silt/clay content, organic content), type of dredge equipment, operational conditions of the dredge equipment (e.g., thickness of cuts, overflow or spillage, skill of operator), and environmental conditions (e.g., water depth, currents). Turbidity plumes may vary depending on equipment, substrate characteristics, currents, and factors that influence water circulation (e.g., tide stage, currents, wind waves, water depth, distance from the embayment inlet).

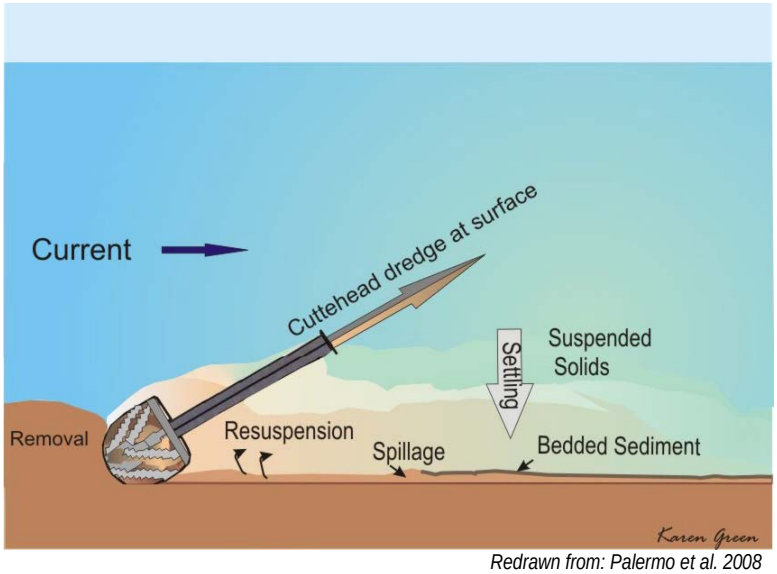
General Dredge Plume Characteristics

Mixing zone	< 100 ft (<30 m)
Near-field zone	≤ 300 ft (≤100 m)
Far-field zone	>300 ft (>100 m)

Source: Bridges et al. 2008

Transport of resuspended sediments may be conceptualized within 3 zones: (1) the initial mixing zone, where the dredging operation dominates the process and suspended sediment concentrations are expected to be relatively uniform; (2) the near field zone, which is dominated by dispersion and rapid settling velocities and gradual changes in total suspended sediments with distance and depth; and (3) the far field zone, where the total load in the plume is slowly varying and where advective diffusion, flocculation, and settling are of the same order of magnitude (Bridges et al. 2008). Sometimes the mixing zone is included in the near-field definition (e.g., Hayes and Je 2000).

The dredge influenced mixing zone is not definitive, but generally ends 33 to 66 ft (10 to 20 m) from the dredging operation (Hayes and Je 2000). The near-field zone typically is within 300 ft (100 m) of the dredging operation (Bridges et al. 2008). Turbidity plumes disperse and suspended sediment concentrations decrease with increasing distance. Plume lengths are influenced by sediment grain size and currents. Transport also may depend on use of controls (e.g., silt curtains) (Palermo et al. 2008).



Redrawn from: Palermo et al. 2008

Notes:

Bedded Sediment:	Thin layer deposit from settlement of suspended sediment
Resuspension:	Sediment put into suspension
Spillage:	Material left after dredging

Illustration of turbidity generated by a cutterhead dredge

Resuspension factors vary depending on sediment, equipment, and environmental conditions. Palermo et al. (2008) reviewed resuspension factors that have been reported from monitoring of navigational maintenance operations as well as derived predictive estimates. The authors summarized that there is no such thing as a typical resuspension factor, and pointed out that the DREDGE model developed for the USACE (Hayes and Je 2000) allows users to select from several predicted resuspension factors or an estimate from site-specific empirical observations. These are combined with information about site conditions to simulate the size and extent of the suspended sediment plume under steady state conditions. The USACE PTM (Particle Tracking Model) addresses unsteady flow regimes (McDonald et al. 2006).

Characteristic Resuspension Factors Relative to Percent Fine (Silt/Clay) Content of Sediment

- 0.02 to 3.93 % for cutterhead dredges, with mean values of 0.5 to 1%, and a conservative characteristic factor of 0.5%;
- 0.2 to 1% for open clamshell buckets, 0.3 to 2% for watertight clamshells, 0.3 to 2% for other bucket dredges, and overall mean values of 1 to 1.5%, and conservative characteristic factors of 1% for open or watertight bucket dredges without overflow and 0.5% for environmental buckets without overflow;
- 8.6-10.9% for bucket dredges with barge overflow; and
- 0.6 to 5% for excavators.

Source: Palermo et al. 2008

Literature reported suspended sediment concentrations during dredging are summarized in Table 2.7-5 and Figure 2.7-5. Most of the data are from maintenance dredge projects conducted in U.S. embayments, including San Francisco Bay, which primarily involved removal of silty sediments.

No suspended sediment concentration data were available for California offshore dredging projects. Therefore, potentially relevant data from other sources were reviewed. The primary source of information was from offshore dredging during marine aggregate mining (sands-gravels) in the United Kingdom (UK). With those operations, hopper dredges typically are used with overflow and sediment screening (to remove unwanted sediment sizes) (Newell et al. 1998, MMS 2004). Offshore dredging with sediment screening is not comparable to borrow site dredging in California; therefore, only data sources for marine mining that excluded sediment screening were included in Table 2.7-5 and Figure 2.7-5.

Hopper dredge discharging sands for beach nourishment, San Diego County

Photo permission: SANDAG

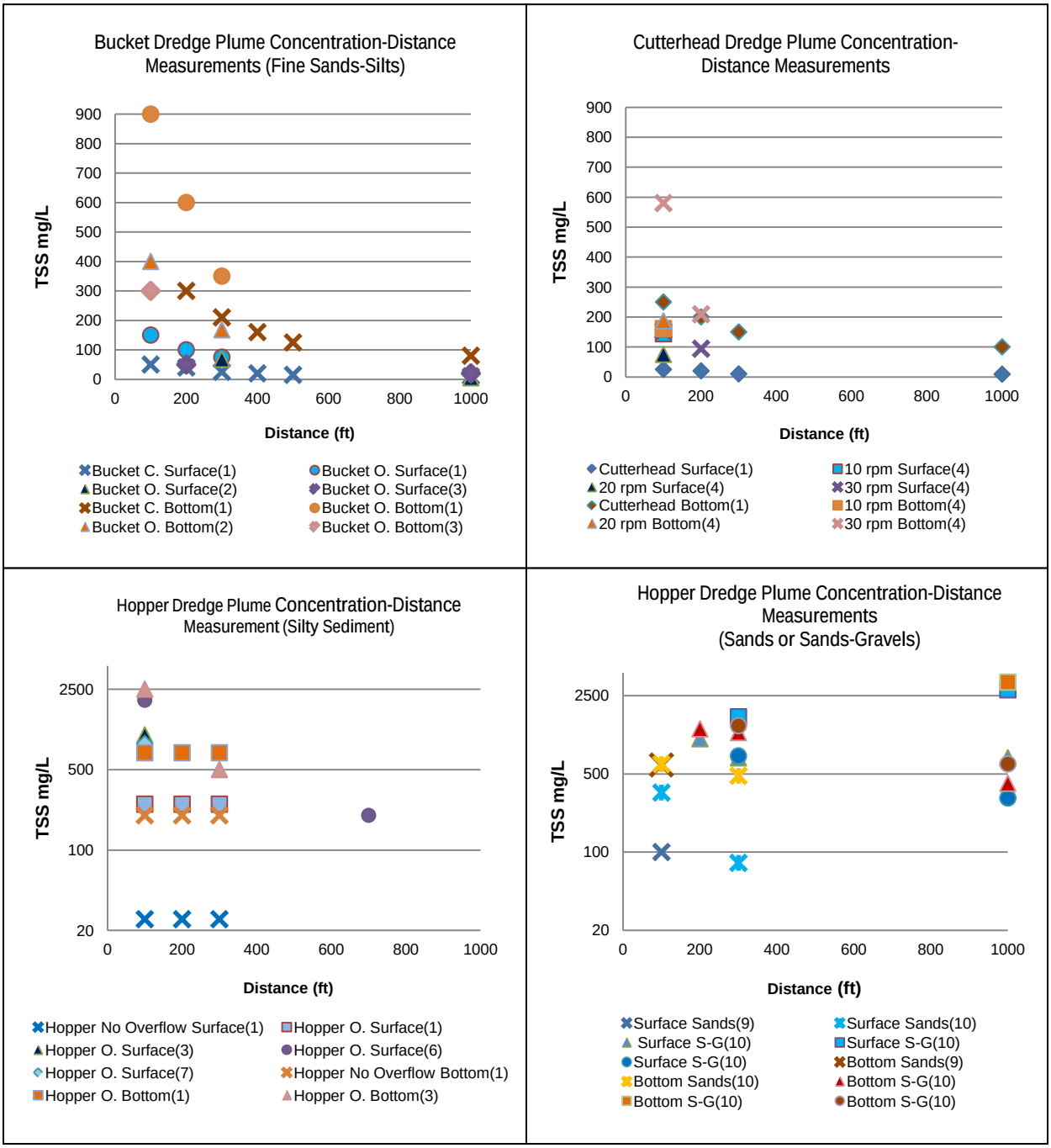
Suspended sediment concentrations during mining of sands-gravels in the UK were relatively similar to hopper dredges with overflow when dredging silty sediments in embayments; however, plume lengths for sands-gravels generally were much shorter (Table 2.7-5). For example, most TSS concentrations ranged from <500 to 1,300 mg/L within 300 to 400 ft (100-122 m) of the vessel when dredging sands or sands and gravels, which are similar to ranges summarized in Figure 2.7-4. Most turbidity plume lengths were ≤1,600 ft (480 m) from the dredge, with most sands settling within 820 ft (250 m) (Hitchcock and Bell 2004). This is similar to the plume lengths, 650 to 2,000 ft (200 to 600 m), summarized by MMS (2004) for offshore sand dredging.

Table 2.7-5. General characteristics of suspended sediment concentrations (mg/L) within 1,000 ft (305 m) of commonly used dredge types.

Dredge Type	Sediment Type	Location	Within 100 ft		Within 200 ft		Within 300-400 ft		Within 1000 ft		End of Plume (ft)
			S	B	S	B	S	B	S	B	
Bucket Dredges											
Enclosed Clamshell[1]	Silts	St. Johns River, FL	50	300	40	210	25	100			600 (S) >800 (B)
Open Clamshell[1]			150	900	100	600	75	350			
Open Bucket[2]	Fine sand-silts	Thames River, CT		400			68	168	5		<1,000 (S), 1,640 (B)
Open bucket[3]	Not reported	San Francisco, CA			50	300			20		1,000 (S), 1,500 (B)
Bucket[4]		Generalized	0-700	≤1,100							330-2,000 (S), ≤3,300 (B)
Cutterhead Dredge											
Cutterhead[1]	Not reported	Savannah River, GA	25	250	20	200	10	150	<10	100	<100 mg/L at bottom within 1,640
10 rpm[4]	Sandy clay – med. clay	Corpus Christi, TX	26-144	52-161							
20 rpm[4]			22-75	37-187							
30 rpm[4]			106-154	208-580	94	209					
Cutterhead[5]		Generalized	0-150	≤500							0-330 (S), ≤1,640 (B)
Hopper Dredge											
No overflow[4]		Generalized	0-100	≤500							0-2,300 (S), ≤ 4,000 (B)
No overflow[1]	Silty-clay	Grays Harbor, WA	25	200	25	200	25	200			3,600
With overflow[1]	Silty-clay		250	700	250	700	250	700			4,000 (S), 8,500 (B)
With overflow[3]	Silty-clay	San Francisco, CA	>1,000	2,500				500			2,200 (B)
With overflow[7]	Not reported	Chesapeake Bay, MD-VA	2,000		<200		100		50		>3,300 (S)
With overflow[8]	Not reported	Chesapeake Bay, MD-VA	840	7,200							17,000 (S)
With overflow[8]	Sands	United Kingdom (UK)	100	<600				<500			<300 (S), <1,000 (B)
With overflow [10]	Sands	UK	340	611			80	480			1,640
With overflow [10]	Sands-Gravel	UK (NAB)			1,030	1,260 (5,517 mid)	695-1,615	1,170	696-2,820	411-3,301	>3,300
With overflow [10]	Sands-Gravel	UK (Owers)					723	1,171-1,346	304	613	1,640

Notes: S = near surface, B = near bottom

Sources: [1]Hayes 1986 (concentrations adjusted for background), [2] Bohlen and Tramontano 1977 cited in LaSalle et al. 1991, [3]USACE 1976 cited in O'Connor 1991, [4]Huston and Huston 1976, [5]LaSalle et al. 1991, [6]Hayes et al. 1984 cited in Hayes 1986, [7]Barnard 1978 cited in Herbich and Brahme 1991, [8]Nichols et al. 1990, [9]Hitchcock and Drucker 1996 cited in Newell et al. 1998, [10]Hitchcock and Bell 2004.

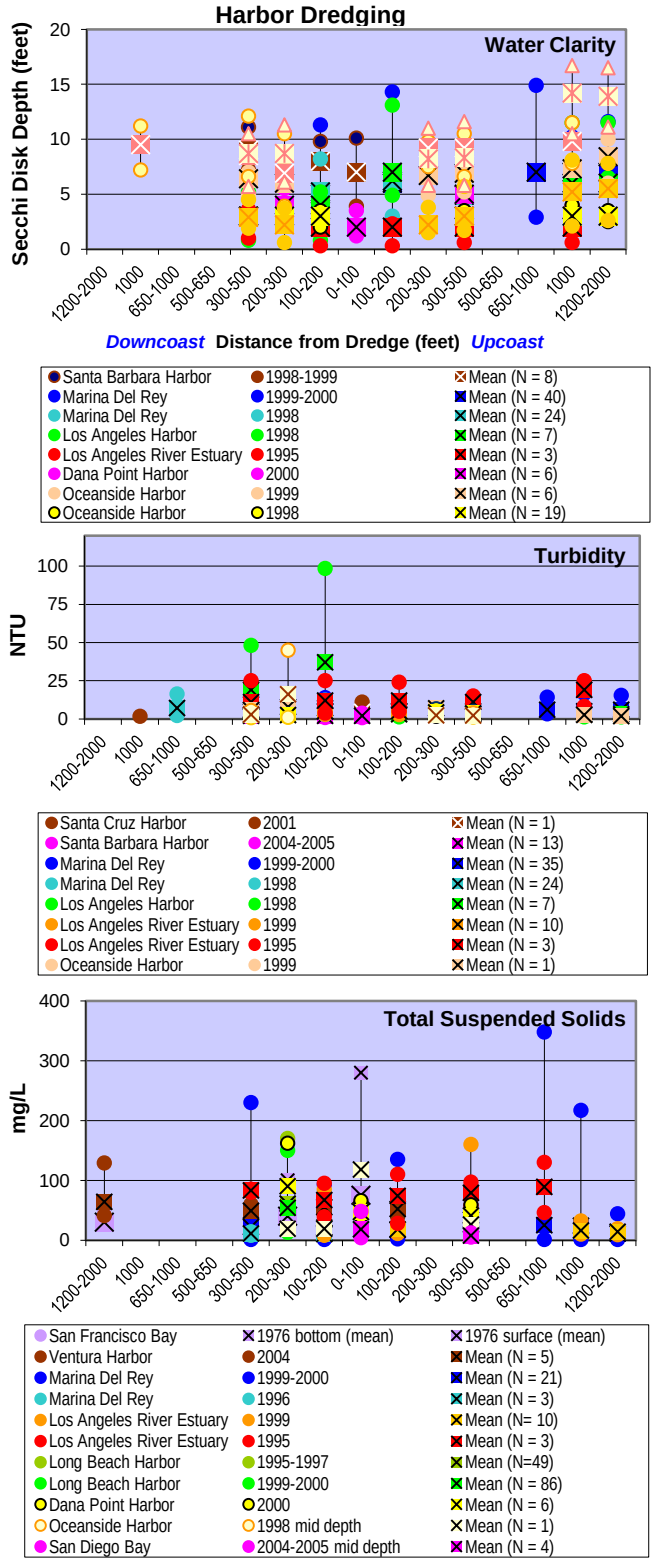


Notes:
Near-surface and near-bottom values from same dredge have the same symbol, but the color differs (near-surface = blue, green, near-bottom =browns).
The letter "C" or "O" after bucket dredge refers to closed or open, respectively. The letter "O" after hopper dredge refers to overflow, S-G = sands-gravel. Surface or Bottom refers to location where TSS was measured (i.e., near surface or near bottom). The numbers after the dredge descriptions in the legends refer to the data sources, which are listed in Table 2.7-5.

Figure 2.7-5. Comparison of TSS concentrations (mg/L) within 1,000 ft (305 m) of bucket, cutterhead, and hopper dredges with and without overflow.

Monitoring data collected during 17 California maintenance dredging projects (Figure 2.7-6) indicate the following:

- Monitoring occurred within the near-field zone and at one or more "control" locations, which were located 1,000 to 2,000 ft (305 to 610 m) from the dredge. Sometimes control stations were not measured.
- Reductions in water clarity were localized. Generally, Secchi depth values of 3 ft (0.9 m) or less were localized within 500 ft (150 m) of the dredge. In some cases, uniformly low water clarity was observed at both near- and far-field stations, suggesting ambient turbidity was relatively high.
- Elevated turbidity NTU values were localized, primarily within 200 to 500 ft (91 to 150 m) of the dredge for several projects.
- Near-surface TSS concentrations were elevated within 1,000 to 1,500 ft (305 to 457 m) of the dredge for several projects. Values ranged up to 350 mg/L, but mean far-field concentrations generally were <100 mg/L at distances > 300 ft (91 m) from the dredge for all 11 projects.
- Mean concentrations >100 to 280 mg/L, were measured at mid-depth and near the bottom, respectively, within 100 ft (30 m) of the dredge for two projects. However, measurements generally were lacking for these depths.



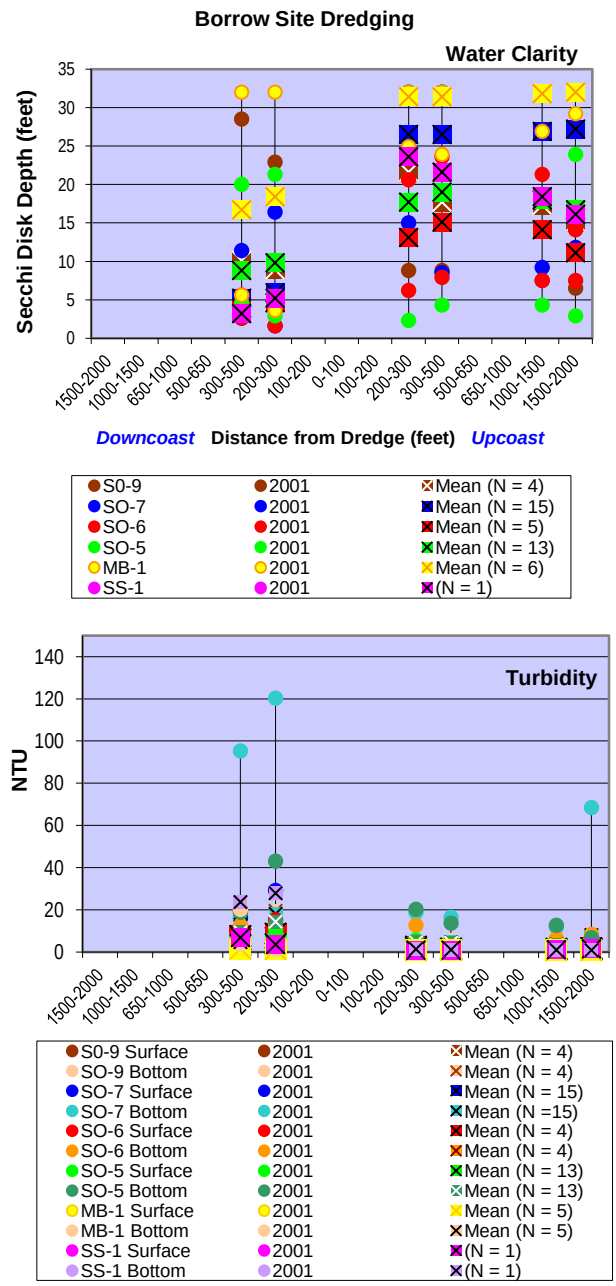
Notes: Circles depict range, square box with centered "x" depict mean value. The distance scale up- and downcoast is the same for all figures.

Figure 2.7-6. Representative water clarity, turbidity, and TSS measurements during harbor dredging.

Monitoring data collected during hopper dredging of 6 offshore borrow sites in San Diego, California (Figure 2.7-7) indicate the following:

- Water clarity was significantly reduced by more than 20% of ambient within 500 ft (150 m) downcurrent of the dredge at all borrow sites. In most cases, mean water clarity values were > 5 ft (1.5 m). Mean water clarity values of approximately 3 ft (0.9 m) were noted for one site (SS-1). This site was abandoned during implementation of the San Diego Regional Beach Sand Project due to unacceptable silt content of sediment.
- Mean turbidity values near the bottom were 20% higher than ambient within 500 ft (150 m) downcurrent for all borrow sites. Mean turbidity values near the surface also were 20% higher than ambient for most borrow sites within this distance.
- Generally, mean turbidity values were less than 40 NTU, which is within the range observed during storm conditions. Turbidity values ranged to over 100 NTU for one project.
- Turbid conditions generally dissipated with 5 to 10 minutes after the hopper dredge moved from the borrow area (AMEC 2002).

The reviewed TSS data from literature reports and monitoring data collected during California monitoring projects indicates that suspended sediment concentrations generally are within the range that may be observed during storms or high waves (Figure 2.7-8). However, maximum reported concentrations for hopper dredges with overflow and open bucket operations have the potential to be at the higher end of reported storm conditions.

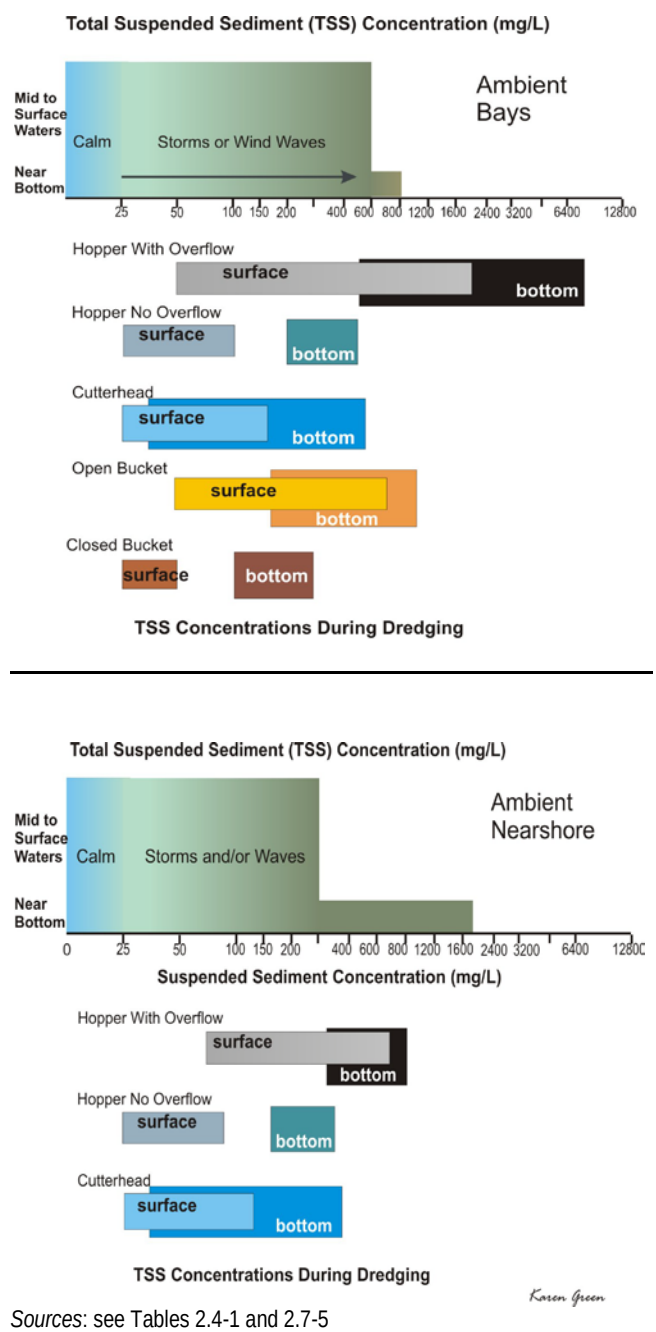


Notes: Circles depict range, square box with centered "x" depict mean value. The distance scale up- and downcoast is the same for all figures.

Figure 2.7-7. Representative water clarity and turbidity measurements during offshore borrow site dredging.

The reviewed dredging information suggests the following resource protection considerations during embayment and offshore borrow site dredging:

- Reductions in water quality generally are localized to within 200 to 1,000 ft (61-305 m) of the dredge depending on equipment, operations (e.g., overflow or spillage), and sediment characteristics.
- Reduced water clarity, elevated turbidity and elevated suspended sediment concentrations may exceed ambient conditions by more than 20%. Concentrations may substantially vary within 1,000 ft (305 m) of the dredge. But deviations appear to be greatest within 500 ft (150 m) of the dredge.
- Suspended sediment concentrations generally are low near the surface unless there is overflow or spillage. Measured concentrations within 300 ft (91m) of the dredge (e.g., <500 mg/L without overflow) may be comparable to concentrations observed during low to high wave or storm conditions.
- Higher suspended sediment concentrations occur at mid-depth and near the bottom, although monitoring programs in California often lack measurements for these depths. Concentrations may be several grams/L near the dredge, but generally decrease to <1,000 mg/L within 300 to 500 ft (91 to 150 m) of the dredge, unless there is substantial overflow. Such concentrations are comparable to near-bottom values observed during moderate to high waves or severe storms.
- Turbidity plumes associated with dredging rapidly dissipate after cessation of operations. Settling rates may be on the order of minutes when dredging sands.
- Permit compliance monitoring requirements in California have lacked consistency.



Sources: see Tables 2.4-1 and 2.7-5

Figure 2.7-8 Dredge plume suspended sediment concentrations relative to ambient conditions.

2.7.6 Environmental Effects of Turbidity and Sedimentation

SABS generally are a stress disturbance for aquatic vegetation and animals (LaSalle et al. 1991, Wilber and Clarke 2001, Berry et al. 2003, EPA 2006). Effects of suspended sediments (or turbidity) on habitats and species are reviewed in Volume 1 (SAIC 2011, Section 5.5.4 and Appendix C.3). SABS may result in several types of effects:

- *Behavioral – attraction or avoidance responses to turbid waters, interference with migration, altered predator-prey interactions, impaired recognition of reproductive cues, impaired detection of prey;*
- *Physical – abrasion of gills or soft-tissue, clogging of filtration or respiratory structures;*
- *Physiological – impaired photosynthesis, altered feeding rates or success, reduced growth, delayed egg development or hatching, reduced respiration;*
- *Sedimentation – silt filling the interstitial spaces between larger sediment particles and reducing oxygen exchange, shift in sediment properties and benthic communities, smothering of benthic eggs or larvae, interference with attachment of early life stages on clean surfaces of hard substrates; or*
- *Mortality.*

Suspended sediments may interfere with behavior, feeding, respiration, or movement of invertebrates and fish. Reduced water clarity also has the potential to interfere with foraging of birds and marine mammals. However, some species are attracted to turbid waters to escape predation, forage on suspended organic particulates, or in the case of predators to forage on prey attracted to the turbid waters (De Robertis et al. 2003).

Marine and estuarine organisms vary in their tolerance of elevated suspended sediment concentrations, and those tolerances also may vary by life stage. Generally, pelagic species (living in the water column) are more sensitive than bottom-associated species, filter- or suspension-feeders are more sensitive than deposit-feeders, and early life stages (eggs, larvae) are more sensitive than adults (LaSalle et al. 1991, Clarke and Wilber 2000, Wilber and Clarke 2001, Berry et al. 2003). Generally, species in the littoral zone have various adaptations or tolerances to turbidity and shifting sands.

Relevant Organism Life History, Attributes, Behaviors, or Responses to Suspended Sediment

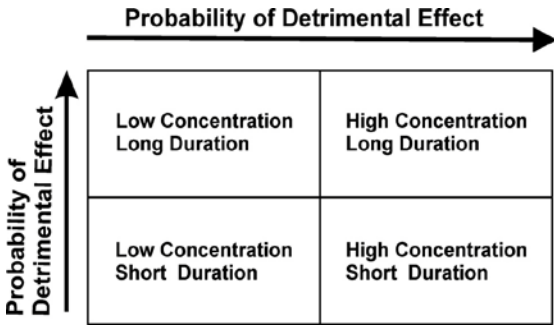
- Species may be tolerant or sensitive.
- Species may be attracted to escape predation, forage on particulates, or prey on attracted species.
- Early life stages generally are more sensitive than adults.
- Pelagic species generally are more sensitive than bottom-associated species.
- Benthic and epibenthic organisms generally are more tolerant.
- Visual predators may avoid turbid waters.
- Reduced feeding, growth, respiration, or photosynthesis under moderate concentrations may occur.
- Mortality under high suspended sediment concentrations or long exposures may occur.
- Altered communities may occur with chronic exposure to suspended sediment.
- Species that migrate between shallow and deep water in fall may have reduced exposure to natural episodes of high turbidity.

Animals and plants have various adaptations or tolerances to SABS that may be associated with behavior, life history, physical attributes, or physiology. Mobility is an important factor relative to vulnerability to impact.

Several species (e.g., lobster, California halibut, northern anchovy, Pacific sardine, white croaker, white seabass) undergo seasonal on- and offshore movements with higher inshore abundance during summer-early fall than during winter (Engle 1979, Love 1997, Allen et al. 2006). The reason for this movement pattern may vary (e.g., reproductive, environmental conditions, following food resources, die-back of vegetation); however, the seasonal fall-winter offshore distribution naturally minimizes the exposure of many species to greater suspended sediment concentrations during winter storms or higher wave conditions.

Sessile organisms or species with high site fidelity (e.g., associated with reef or vegetated habitats) may experience relatively greater durations of exposure or higher concentrations of suspended sediment than mobile animals. In nearshore habitats, many animals have adaptations that lessen potential for adverse impacts. Depending on concentration and exposure duration, shellfish (e.g., clams, mussels) may retract siphons and close their shell. Plants may draw upon stored carbohydrate reserves if light levels are too low to support photosynthesis.

Effects of suspended sediments depend on concentration and exposure duration. High concentrations may produce effects at short or long durations. Low concentrations generally do not produce adverse effects unless there is prolonged exposure.



Source: Clarke and Wilber 2000

Marine and estuarine organisms may be exposed to variable levels of turbidity associated with resuspension of sediments by waves, rip currents, winds, or storm runoff. Natural inputs of sediment to coastal waters and elevated turbidity are episodic in nature. Generally, winter storms are primary sources of natural episodes.

Natural exposure durations to relatively high suspended sediment concentrations may be on the order of hours or days during storms. Chronic SABS may be associated with natural landslide areas, non-point source discharges, or point-source discharges. In areas with chronic exposure to SABS (e.g., landslide areas, continuous discharges), altered communities may occur with reduced diversity of plants and invertebrates (Pondella et al. 1996).

Existing Suspended Sediment Conditions

Naturally Variable - Episodic

- Higher in surf zone, rip currents, high waves, storms, near river outlets
- Lower outside breaker zone, low tides, or small waves

Chronic – Localized Areas

- Higher in areas of landslide activity, point-source discharges, some watershed segments

Exposure to suspended sediments associated with dredging or discharge are on the order of minutes to days, with most exposures occurring within 1 to 5 days. Wilber and Clarke (2001) reviewed that likely exposure durations to suspended sediment plumes during dredging would be less than minutes to hours (< 1 day) for mobile, pelagic species and 1 to 4 days for sessile

benthic organisms depending on equipment. They considered 3.5 days a reasonable estimate to use for impact assessments to benthic organisms, and considered it unlikely that durations of exposure of benthic species would exceed 5 days in most situations. They noted that actual exposure durations may be intermittent, such as with use of a hopper dredge (i.e., dredging is discontinued during transit to and from a placement site) or in areas subject to ebb and flow of tides.

Similarly, Germano and Cary (2005) considered exposure durations to thin-layer sedimentation from dredging to be on the order of 1-5 days, but noted that disposal operations could potentially last longer with episodic plumes of density currents depositing fresh layers of sediment. They suggested that impact assessments to benthic organisms should consider exposure durations of 3-5 days. The timeframe for assimilation of bedded sediments into some level of equilibrium was judged to be on the order of weeks with the actual rate dependant on physical (hydrodynamics) and biological (animal bioturbation) reworking rates at the site. Effects to benthic habitats and species from thin-layer sedimentation area poorly understood.

During beach nourishment projects, sand placement may span days, weeks, or months depending on method of sand delivery (hydraulic, mechanical) and project volume. Placement may occur along a stretch of beach or may be focused in a relatively small area. Effects may be acute or chronic depending on project duration and implementation method. In addition, exposure duration would relate to construction schedule (e.g., day-time versus 24-hour schedules). Continuous operations may occur with use of a cutterhead dredge. Intermittent exposures would apply with use of a hopper dredge, trucks to deliver sands, or restriction of placement to day light hours.

Hydrodynamics will influence exposure duration and concentration (e.g., circulation, currents, tides, wave energy). In areas with restricted circulation, effects thresholds may be lower than may otherwise occur where there is good tidal exchange of waters. For example, Sabol et al. (2005) documented an adverse impact to eelgrass growing in a semi-enclosed basin adjacent to where channel maintenance dredging occurred. In that case, currents and reduced tidal exchange may have contributed to elevated turbidity that together with other existing conditions cumulatively reduced light availability, although a cause and effect relationship was not clearly established.

Resources or Locations of Particular Concern Relative to SABS

- HAPC reefs and vegetated habitats (kelp forests, surfgrass beds, eelgrass meadows),
- Spawning grounds,
- Migration routes of sensitive species where effects may concentrate (e.g., narrow channels),
- Foraging areas near nest sites or rookeries of sensitive species during the breeding season, and
- Locations with restricted circulation if sensitive resources have the potential to occur.

Proximity of dredging or placement activities to hard-bottom or vegetated habitats where associated animals may be sessile or display high site fidelity also are of particular concern relative to effects of SABS. Proximity also may be of concern for locations where species may concentrate during sensitive use periods (e.g., spawning grounds) or effects on sensitive migrating species may be concentrated (e.g., narrow channels). Additional locations of concern may include foraging areas in proximity to nesting sites or rookeries of protected species (e.g., least tern, marine mammals).

Protection of water quality and aquatic life from effects of turbidity during beach nourishment or dredging projects in California have been based on narrative (e.g., water discoloration, degradation of benthic communities) and numerical criteria (i.e., relative difference in turbidity compared with ambient conditions) (See Section 2.6.4).

The USEPA reviewed current regulatory criteria for SABS throughout the U.S. and biological effects of SABS and made several key summary points relevant to resource protection considerations (Berry et al. 2003):

Many states have set standards for SABS, but there is little consistency among them and differences do not appear be due to regional variation.

- *Generalizations are difficult because biological response to both increased suspended sediment and increased bedded sediment varies with species and sediment characteristics.*
- *After additional research it may be possible to develop national scientifically-defensible SABS criteria using the traditional "toxicological" dose-response approach. These criteria will presumably have to incorporate some habitat-specificity in order to be widely applicable.*
- *Some habitats that have not been well studied (in terms of their sensitivity to SABS) deserve more study, especially those habitats with moderate and variable amounts of SABS.*

Available biological effects data for suspended and bedded sediments are reviewed in greater detail below to support resource protection guideline considerations.

Fish exposed to elevated suspended sediment *Photo credit: Justin Meager*

<u>Suspended Sediment Effects Data</u>

Several reviews have considered results of laboratory experiments testing dose-response of invertebrates and fish to suspended sediment. Substantial information is available regarding effects of SABS on salmonids or habitat suitability of streams for their early life stages. Response to suspended sediment has been tested for several estuarine, marine, and freshwater species. However, laboratory effects data for coastal marine species are limited as are data for species that occur in California estuarine and marine habitats. These limitations support a cautious approach with respect to resource protection guideline considerations.

LaSalle et al. (1991) reviewed available laboratory response data for freshwater and estuarine species compared to values typically associated with dredging, and summarized that 500 mg/L would be a "safe" level. Nightengale and Simenstad (2001) recommended 200 mg/L as a "safe" level to minimize the potential for sublethal effects on juvenile salmonid foraging.

Clarke and Wilber (2000) conducted a comprehensive review of available laboratory effects data testing dose-response of invertebrates and fish to suspended sediment. They concluded that generic assessments based on responses across broad taxonomic lines, or extrapolations from responses at inappropriate concentrations or exposure durations [relevant to dredging] should be viewed with extreme caution.

Wilber and Clarke (2001) organized laboratory effects data into categories by type of species (e.g., estuarine and non-salmonid fish, salmonid and freshwater fish, bivalves, crustaceans) and life stage (eggs/larvae, juveniles and adults). They eliminated laboratory test results based on artificial substrates if results using natural sediment were available. Graphs were presented of suspended sediment concentrations associated with sublethal and lethal effects compared to TSS concentrations and durations associated with dredging, which they defined as <1,000 mg/L for 1 day for pelagic species and up to 3.5 days for benthic species or life stages (Table 2.7-6).

Table 2.7-6. Summary of laboratory effects data in relation to exposure concentrations and durations associated with dredging.

Taxa	Exposure Duration	Reported Effects at Concentrations ≤1,000 mg/L
Freshwater and salmonid fish eggs/larvae	3.5 days	Sublethal, 26-75% mortality (>20-1,000 mg/L)
Nonsalmonid and estuarine fish eggs/larvae	3.5 days	0-1 day - no effect, sublethal; >1-3.5 days - sublethal, 26-75% mortality (>100-1,000 mg/L)
Nonsalmonid and estuarine fish	1 day	Sublethal, 10% mortality (>100 to 1,000 mg/L)
Salmonid and freshwater fish juveniles	1 day	Behavior, Sublethal
Salmonid and freshwater fish adults	1 day	Behavior, Sublethal, 10-25% mortality (>200 mg/L)
Estuarine bivalve larvae	3.5 days	Sublethal, 26-75% mortality (≥800-1,000 mg/L)
Estuarine and marine bivalve adults	3.5 days	No effect, sublethal
Estuarine and marine crustaceans juveniles/adults	1 day	No effect

Notes: dose-response concentrations were compared to a range of concentrations < 1,000 mg/L, which were considered by the authors to depict "the most probable dosage associated with most dredging operations."
Source: Summarized from graphs presented in Wilber and Clarke 2001

Anchor Environmental (2003) considered data reviewed by Wilber and Clarke along with additional studies and computed 5th, 10th and 50th percentile response statistics for acute (3 days or less) and chronic (≥ 4 days) lethal and sublethal responses (Table 2.7-7). High standard deviations underscore the wide range of reported effects levels. Sublethal effects included reduced feeding, delayed egg hatching, reduced growth, etc. The 10th percentile was compared with suspended sediment concentrations measured during dredging in Los Angeles Harbor. The authors selected the 10th percentile because it was considered "*a reasonably conservative value given the uncertainties of the data set and the variety of organisms tested*." This was reasonable given that the summary statistics were based on a mix of laboratory results for freshwater and estuarine fish, estuarine invertebrates, larvae to adult life stages, tests using artificial or natural sediments, and chronic exposure durations ranging from 4 to more than 30 days. In addition, data included multiple lethal concentrations for the same species, including high concentrations that produced similar responses as lower concentrations.

Table 2.7-7. Summary statistics for total suspended sediments (mg/L) effects concentrations for fish and invertebrates.

Endpoint	5th percentile	10th percentile	50th percentile	N	Standard Deviation
Acute Lethal	500	760	7,000	67	69,262
Acute Sublethal	76	100	560	50	2,935
Chronic Lethal	50	142	2,150	59	28,725
Chronic Sublethal	22	45	500	68	3,402

Notes: Acute = 1-3 days, Chronic = 4-days; N = sample size, standard deviation around mean.
Source: Anchor Environmental, 2003

Laboratory effects data for California estuarine and marine species, and dose-response data for nearshore species, in particular, are limited. TSS effects data that were considered potentially relevant to California sand placement projects are listed in Table 2.7-8. Figure 2.7-9 summarizes the effects data according to acute (1-3 days) or chronic (≥ 4 days) exposure durations for lethal and sublethal endpoints (e.g. reduced feeding, growth, delayed hatching, etc.). Generally, response concentrations are lower with longer rather than shorter exposure durations, and lower concentrations are associated with sublethal responses. Sublethal response concentrations are highly variable, which is not unexpected given the range of reported endpoints.

Table 2.7-8. List of marine and estuarine species with available suspended sediment dose-response data, which were considered most relevant to beach nourishment related activities.

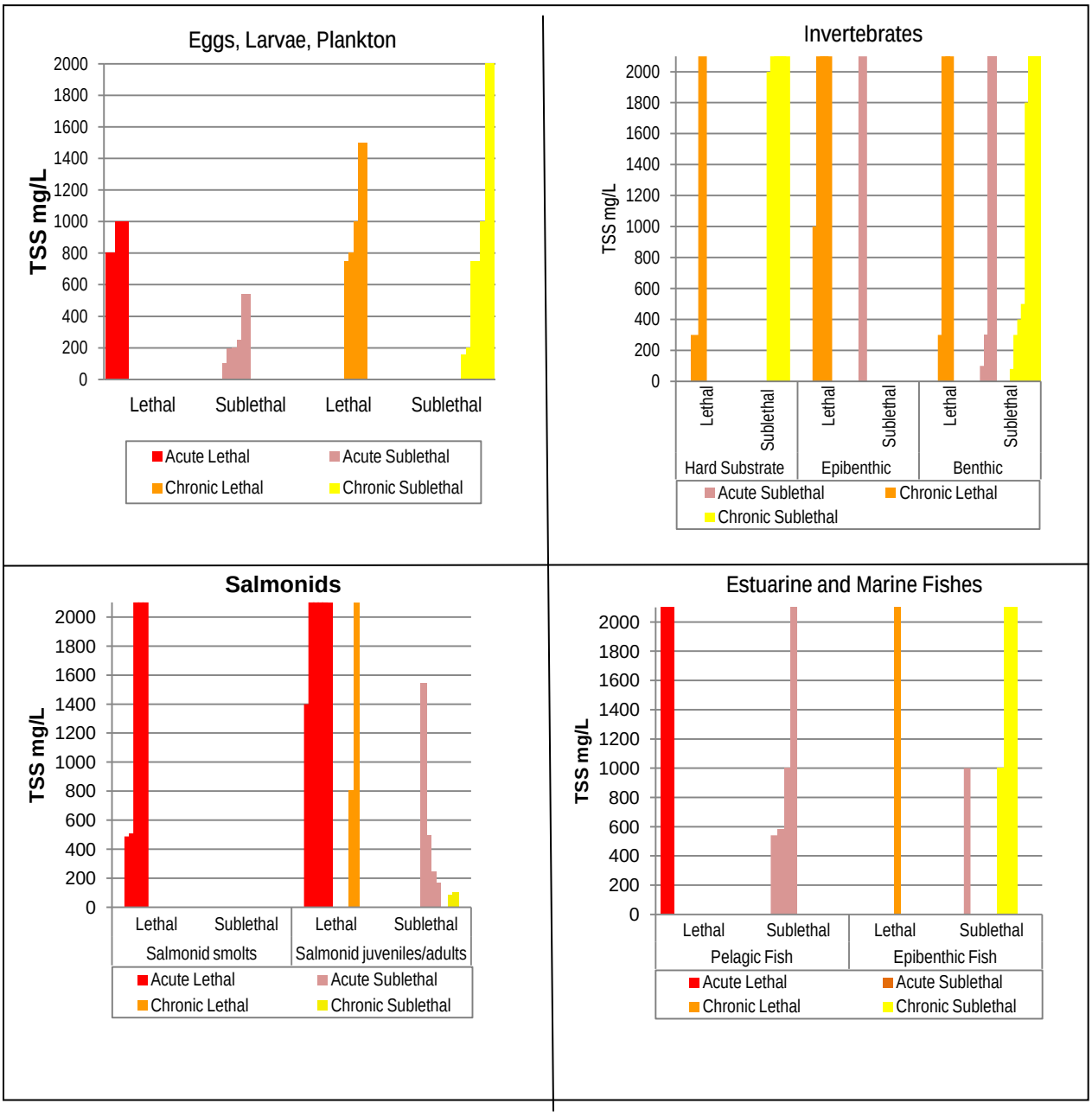
	Eggs/Larvae/ Plankton	Invertebrates	Salmonids	Estuarine and Marine Fishes
Pelagic (water-column)	Copepod (*Acartia tonsa*), Pacific herring (*Clupea pallasi*) [l]			Atlantic silverside (*Menidia menidia*) Bay anchovy (*Anchoa mitchilli*)
Epibenthic (associated with sediment surface)	Pacific herring ([e] Pacific (Japanese) oyster (*Crassostrea gigas*) [l]	Black-tailed shrimp (*Crangon nigricauda*) Grass shrimp (*Palaemon macrodactylus*) Mysid (*Mysidopsis bahia*)	Chinook (*Onchorhynchus tshawytscha*) [a, j, s] Chum (*O. keta*) [j] Coho (*O. kisutch*) [j, s] Steelhead (*O. mykiss*) [a, j]	Atlantic croaker (*Micropogonias undulatus*) Shiner perch (*Cymatogaster aggregata*)
Benthic (bottom-dwelling)	Flounder (*Paralichthys spp.*) [l] Northern quahog (*Mercenaria mercenaria*) [e, l]	Cockles (*Austrovenus stutchburyi*) Dungeness crab (*Cancer magister*) [j] Heart urchin (*Echinocardium*) Wedge clam (*Macomona*) Northern quahog Scallop (*Pectin novaezelandiae*) Surf clam (*Spisula*) Worm (*Boccardia*) Worm (*Phragmatopoma lapidosa*)		
Attached to Hard Substrate		Bay mussel (*Mytilus edulis*) CA mussel (*Mytilus californianus*) Tunicate (Ascidea)		

Notes:

Font colors distinguish California species (blue) from other potentially relevant species (black). Freshwater species or estuarine species associated with silty habitats were not included.

a = adult, e = egg, j = juvenile, l = larvae, s = smolt

Sources: see Figure 2.7-9.



Notes: The scale for TSS was fixed at 2,100 mg/L to facilitate identification of lower concentration levels; concentrations above 2,000 mg/L may range substantially higher. Each bar represents a referenced data source; data tables are in BIA Volume 1, Appendix C.3).

Acute = 1-3 days, Chronic = ≥ 4 days.

Sources: Sherk et al. 1974, 1975; Cardwell et al. 1976; Noggle 1978; Peddicord and McFarland 1978; Stober et al. 1981; Redding and Shreck 1982; Robinson et al. 1984; Main and Nelson 1988; Turner and Miller 1991; Colby and Hoss 2004; NIWA 2004, 2008; Griffen et al. 2009.

Figure 2.7-9. Total suspended solids effects data for species relevant to California beach nourishment, offshore borrow site, or maintenance dredging projects.

Figure 2.7-9 summarizes total suspended sediment effects data for the species listed in Table 2.7-8. Representative suspended sediment effects are summarized below. Review of additional studies and data summary tables are provided in SAIC (2011, Appendix C.3).

- Early life stages (eggs, larvae) and plankton (including copepods, eggs, and larvae) may have relatively low effects concentrations. For example, acute lethal effects concentrations of 800 -1,000 mg/L were found for Pacific oyster larvae and relatively low acute sublethal concentrations have been measured for copepods (>100 mg/L), flounder larvae (200 mg/L), and Pacific herring eggs (250 mg/L) (Sherk et al. 1975, Cardwell et al. 1976, Colby and Hoss 2004, Griffen et al. 2009). However, some early life stages are relatively more tolerant. For example, northern quahog larvae survived exposure to 1,000 mg/L for 12 days, but had a 35% reduction in egg development after exposure to 4,000 mg/L (Davis 1960).
- Migrating salmonid smolts (juveniles that migrate to the ocean) died after exposure to concentrations near 500 mg/L for 4 days (Stober et al. 1981). Juvenile Chinook salmon died from exposure to 1,400 mg/L for 3 days (Newcomb and Jensen 1996); whereas, Coho salmon juveniles experienced gill damage after exposure to 1,547 mg/L for 4 days (Noggle 1978). Adult steelhead exhibited stress when exposed to 500 mg/L for 3 hours (Redding and Schreck 1982). Several reviews indicate that adult salmonids are generally tolerant of high suspended sediment concentrations (Wilber and Clarke 2001).
- Marine-estuarine fish vary in tolerance to suspended sediment. The Atlantic silverside is relatively sensitive with up to 10% mortality at 500 mg/L and 50% mortality at 2,500 mg/L (Sherk et al. 1974). The Atlantic croaker, bay anchovy, and shiner surfperch are relatively more tolerant with 10% mortality experienced at 1,000 mg/L (Sherk et al. 1974, 1975). The 50% mortality concentration (LC_{50}) for bay anchovy is 4,700 mg/L (Sherk et al. 1975).
- Epibenthic shrimp are relatively tolerant. Black-tailed shrimp exposed to 4,300 mg/L for 3 days exhibited 5% mortality (Peddicord and McFarland 1978). Black-tailed and grass shrimp had a LC_{50} after exposure to much higher concentrations (50,000 mg/L) for 8 days. Mysid shrimp died after exposure to 1,000 mg/L for 28 days (Nimmo et al. 1982).
- Attached species common to docks and piers (e.g., bay mussels, tunicates) may tolerate high concentrations (>10,000 mg/L) for several weeks (Peddicord and McFarland 1978).
- Attached species on the open coast, such as California mussels, tolerated exposure to 15,500 mg/L for several weeks. The attached reef-building tube worm on the east coast (*Phragmatopoma lapidosa*) tolerated 2,000 to 6,000 mg/L for 4 days without adverse effects (Main and Nelson 1988). However, mortality may result if sediment settles on the colony. For example, the California species (*P. californica*) died after exposure to direct sedimentation for 5 days (Taylor and Littler 1982).
- Benthic clams may experience sublethal effects from exposure to high suspended sediment concentrations for periods of less than 1 week, but mortality or increased vulnerability to predation occurs after prolonged exposure to high concentrations. For example, suspension-feeding wedge clams tolerated short-term exposure to 300 mg/L, but died after 14 days (NIWA 2004). Cockles were adversely affected by prolonged exposure to 400 mg/L (NIWA 2001). Feeding in scallops and northern quahog was adversely affected at concentrations >100 mg/L (Turner and Miller 1991, NIWA 2004). The surf clam tolerated concentrations as high as 1,000 mg/L over 3-day experiments, and was able to acclimate to suspended sediment concentrations up to 500 mg/L over a

21-day experiment, but was unable to acclimate to 1,000 mg/L over that same period (Robinson et al. 1984). Reduced growth was noted when wedge clams (*Donax variabilis*) was exposed to turbidity (96 NTU) for two weeks (Peterson et al. 2002).

- The deposit feeding heart urchin was adversely affected after 3 days to suspended sediment concentrations above 80 mg/L, and was vulnerable to increased predation after exposure to 300 mg/L for more than a week (NIWA 2004).
- Dungeness crabs appear to be relatively tolerant. Juvenile Dungeness crab developed abnormalities after exposure to 1,800 to 4,000 mg/L for 25 days; adult crabs experienced 50% mortality at 35,000 mg/L after 21 days (Peddicord and McFarland 1978).
- The small, deposit-feeding tube worm, *Boccardia*, was substantially affected by exposure to 750 mg/L after 9 days (NIWA 2004). In contrast, the relatively large, free-living Neanthes succinea had a LC_{50} of 48,000 mg/L after 8 days (McFarland and Peddicord 1980).

Sedimentation

SABS generated during dredging generally result in relatively thin-layer deposits. Sedimentation depths may range from a couple of inches to thin veneers (several cm to a few millimeters) depending on distance from the source and hydrodynamic conditions (Newell et al. 1998, Wilber et al. 2005). Characteristics of the resuspended and settled sediment (bedded sediment) will be similar or different from undisturbed sediment depending on the process by which they were created (Palermo et al. 2008). For example, dislodged sediment not picked up by the dredge may have similar characteristics as the undisturbed sediment. In contrast, thin-layer deposits, which are generated as resuspended sediment settles from plumes, have a relatively low dry bulk density. The time for assimilation of bedded sediments into some level of equilibrium has been estimated to be on the order of weeks.

Germano and Cary (2005) summarized that the spatial extent of sedimentation from dredging could range from 656 to 3,281 ft (200 to 1000 m) away from the source, but strongest effects would occur within 984 ft (300 m). They also considered it likely that dredges would move past an area of sedimentation in 1-5 days, but suggested that assessment of impacts should consider 3-5 days. They considered this scale a similar approximation to the duration of storm-induced disturbance. Longer temporal scales may be relevant to placement. Germano and Cary (2005) noted that disposal operations would potentially result in longer-term sedimentation with the potential for episodic plumes or density currents depositing fresh layers of sediment. They suggested that the scale might approach a chronic, recurring frequency during one or more seasons.

Sedimentation also will occur from beach nourishment or nearshore discharge. Beach nourishment results in winnowing of the fine sediment fraction, which typically settles outside the breaker zone. Hydrodynamics influence silt dispersal or accumulation in the nearshore.

Parr et al. (1978) reported short-term (less than 2 months) enhancement of nearshore invertebrates from increased silt (organics) offshore a 1 million cubic yard (mcy) beach nourishment project in Imperial Beach, California. The silt/clay content of the source sediment for that project was relatively low, ranging from 5 to 15%. Enhanced silt levels at nearshore stations did not persist after winter storms.

Limited fine-sediment effects also were documented for small pilot projects using less-than-optimum sands. For example, monitoring after two separate placements of approximately 3,000 to 6,000 cy of silty sand (60-69% silt/clay) in the surf zone at Santa Cruz demonstrated offshore transport of fines, but there were no significant changes in mean grain-size on beaches or in the nearshore (Watt and Greene 2001, Sea Engineering 2006).

In contrast, Rakocinski et al. (1996) reported that nearshore sediments offshore a beach placement site had increased silt/clay content after a several million cy beach nourishment project in the Gulf of Mexico offshore Florida. Although the silt/clay content of the source materials was <4%; the silt/clay deposited in the nearshore where it persisted for more than two years. Contributing factors likely included a very large project volume and low wave energy. There was a substantial decline in species at that location that persisted over the study duration. This result may be a relevant consideration for sediment management projects if conducted in protected or low wave areas.

Field and laboratory studies indicate a number of species are sensitive to effects of sedimentation (Table 2.7-9). Light sedimentary deposits on hard-bottom habitat have the potential to inhibit recruitment of early life stages of giant kelp and other algae (Devinny and Volse 1978, Airoldi 2003, Germano and Cary 2005). Laboratory studies demonstrate that sediment overburdens of less than 1 mm may prevent spore attachment or gametophyte survival of giant kelp. Reduction of canopy-forming kelp beds have been reported in areas affected by turbidity and sedimentation from landslides (Konar and Roberts 1996, Pondella et al. 1996, Bence et al. 1989). Early life stages of demersal (bottom-associated) fish and invertebrates are sensitive to sedimentation. Pacific herring have adhesive, demersal eggs that attach to clean substrate (Ogle 2005). Oyster larvae also require a clean substrate for attachment (Germano and Cary 2005).

Some invertebrate species are capable of surviving relatively thick overburdens, while other species have much lower tolerances. These differences are relevant to impact considerations associated with beach or nearshore placement. Placed sand depths may range from > 3 ft to inches (> 1 m to several centimeters) across a beach sand receiver site fill (NRC 1995). Experiments demonstrate that adult Dungeness crabs easily survived burial by 3 in (8 cm) of sand, but survival began to decline with burial by 4-5 in (10-13 cm), and <10% survived burial by 6-9 in (16 to 22 cm) of sand (Vavrinec et al. 2007). Shallow and deep burrowing clams with siphons may escape overburdens ranging between 4 and 20 in (10 and 50 cm); whereas, relatively sedentary bivalves may be unable to escape < 1 in (2.5 cm) (Kranz 1972 cited in Maurer et al. 1986).

Sediment compatibility may influence burrowing ability. Reduced vertical migration rates and increased mortality have been associated with overburdens having silt/clay contents ranging from 17 to 99 percent depending on species (Turk and Risk 1981). Maurer et al. (1986) concluded based on experiments testing overburdens with sand, mixed sediment, and silty sediment that vertical migration may contribute to invertebrate recolonization when deposits are similar to native sediments, but did not expect this to be a viable mechanism when placed sediments were dissimilar (e.g., substantially siltier) or in areas where deposits exceeded 2.9 ft (0.9 m) of overburden. Germano and Cary (2005) reviewed that overburden stress, which combines burial thickness and porosity, is important to mobile organisms attempting to escape deposition events.

Table 2.7-9. Reported responses to sedimentation for representative aquatic plant, fish, and invertebrate species that occur in California.

Taxa	Thickness	Duration	Response	Habitat	Reference
Kelp spores	0.45 mm (0.02 in)		Unable to attach	Hard substrate	Devinny and Volse 1978
Eelgrass (*Zostera marina*)	10 cm (4 in)		Shift in sediment, covered leaf blades and loss	Embayment	Blois et al. 1961
Eelgrass	10 cm (4 in)		Loss of short-blade plants	Embayment	Onuf and Quammen 1983
Eelgrass	2-15 cm (1-6 in)		Survived when ≥ 5 cm (2 in) of blade length exposed	Embayment	Harrison 1990
Surfgrass (*Phyllospadix*)	8 cm (3 in)		Healthy	Hard subsrate	Phillips 1979
Surfgrass	12 cm (5 in)		Reduced carbohydrate storage	Hard substrate	Plechner 1996
Surfgrass	25 cm (10 in)		Reduced density	Hard substrate	Craig et al. 2008
Surfgrass seedlings	5-25 cm (2-10 in)	Prolonged	Loss	Hard substrate	Reed and Hollbrook 2003
Brown algae (*Zonaria farlowii)*	Burial	6 months	Loss, regrowth from basal remnants	Hard substrate	Dahl 1971**
Green algae (Codium setchelli)	2-5 cm (0.8-2 in)	4-5 weeks	Reduced biomass	Hard substrate	Trowbridge 1996**
Red algae (*Neorhodemela larix)*	2-20 cm (0.8-7.9 in)	3 months	Holdfast and basal crusts survived, epiphytes did not	Hard substrate	D'Antonio1986**, Trowbridge 1996**
Red algae (*Ahnfeltiopsis linearis*)	2-5 cm (0.8-2 in)	4-5 weeks	No effect	Hard substrate	Trowbridge 1996**
Colonization of hard surbstrate	7 mm (0.3 in)	2-3 mo	Reduced plant and animal cover, increase opportunists (Ulva, Enteromorpha)	Hard substrate	Thomsen and McGlatery 2005
Pacific herring eggs	>0 mm		Lethal; require clean surface	Hard substrate (vegetation)	Ogle 2005
Sea anemone (*Anthopleura elegantissima*)	Burial	Several months	Survived	Hard substrate	Sebens 1980, Taylor and Littler 1982
Dungeness crab	8-21 cm (3-9 in)		No effect (8 cm), <10% survival 16-21 cm	Sand	Vavrinec et al. 2007
Reef building worm (*Phragmatopoma californica*)	Sedimentation	5 days	Lethal; note – (*P. lapidosa*) tolerated 18 cm (7 in) for 1-3 days, then died	Hard substrate	Taylor and Litttler 1982
Oyster larvae attachment	>1 mm (0.04 in)		Adverse	Hard substrate	Germano and Cary 2005
Oyster larvae post-attachment	3-5 mm, 0.1-0.2 in)		Negative, if deposition greater than burrowing rate	Hard substrate	Germano and Cary 2005
Clam (*Protothaca staminea*)	10 cm (4 in)		Lethal	Estuarine sand flat	Peterson 1985*
Clam (*Chione undatella*)	10 cm (4 in)		Lethal	Estuarine sand flat	Peterson 1985
Clam (*Macoma*)	25 cm (10 in)		No effect	Sand	Hinchley et al. 2006 ***
Amphipod (*Leptocheirus*)	5 cm (2 in)		50% mortality	Sand	
Worm (*Streblospio*)	2.5 cm (< 1 in)		50% mortality	Sand	

Notes: Other sources cited in: *Archambault et al. 2004, **Airoldi 2003, ***Germano and Cary 2005

2.8 Mitigation and Monitoring Considerations

Mitigation and monitoring typically are associated with coastal sediment management projects. Mitigation is defined in the CEQA Guidelines (§ 15370) and NEPA Guidelines (40 § C.F.R. 1508.20), as including one or more of the following measures:

- Avoiding the impact altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the impacted environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environments.

Generally, mitigation measures are considered in sequence with avoidance considered first and compensation last (CCC 1995). Compensatory mitigation only is undertaken to replace lost habitat. In order to receive permits authorized by the USACE, the proposed action must comply with *The Compensatory Mitigation for Losses of Aquatic Resources Final Rule* adopted on April 10, 2008 (Federal Register 2008). The Compensatory Mitigation Rule establishes a hierarchy for mitigation, as follows: (1) mitigation banks, (2) in-lieu fee programs, and (3) permittee-responsible mitigation projects. In addition, there is an emphasis on the use of a watershed approach to increase success and improve the health of resources in mitigated areas.

MMRPs Basics

What is Purpose?

- Ensure compliance with mitigation measures during project implementation.

How are Measures Enforced?

- Permit conditions, Memorandum of Understanding or Agreement (MOU, MOA), or other agreements.

When Must Alternatives or Mitigation Measures be Adopted?

- When the CEQA document is prepared.

When Must a Lead Agency Adopt a MMRP?

- When a lead agency adopts a mitigated negative declaration (MND), or
- When a lead agency approves findings upon completion of a certified EIR.

Source: *//ceres.ca.gov/ceqa/flowchart/la_mmrp.html*

Monitoring is an important aspect of implementation of many mitigation measures. It also may be used to document the effectiveness of mitigation or to improve future decisions by providing information on project performance or lessons learned. Mitigation measures and monitoring may occur throughout all project phases ranging from pre-construction to post-construction. Types of mitigation and monitoring associated with sediment management projects in California are reviewed in Volume 1 BIA Sections 6 and 7, respectively (SAIC 2011).

A Mitigation, Monitoring, and Reporting Program (MMRP) is required for CEQA documents that include mitigation measures to reduce impacts below a level of significance. The MMRP generally is the basis for monitoring requirements specified in project permits. Monitoring requirements also may be specified for projects that qualify for implementation under a regional general permit such as RGP 67, which requires turbidity monitoring for all projects and preparation of an MMRP for sensitive aquatic resources, as appropriate (USACE 2006).

MMRPs for sediment management projects typically include measures to avoid or minimize impacts during construction. Measures also may be included for the pre-construction or post-construction phases depending on resource issues of concern.

Pre-Construction phase mitigation measures generally focus on project design, buffer distance between impact source and sensitive resources, sediment compatibility, or refinement of construction plans to avoid or minimize potential impacts. Pre-construction surveys may be required to verify locations of sensitive habitats or habitat suitability for sensitive biological resources to ensure appropriate impact avoidance and minimization measures are implemented during construction. For example, pre-construction surveys may be required to finalize vessel routes if EFH-HAPC are in the vicinity. Pre-construction surveys also may be used to provide up-dated information on occurrence of sensitive resources or habitat suitability to support a managed fishery resource (e.g., grunion spawning).

Construction phase mitigation measures may include discharge location controls, buffers, prohibition zones, schedule restrictions (environmental windows), equipment operational controls, BMPs, or monitoring. Construction monitoring generally is required to ensure compliance with permit conditions. The RWQCB may require monitoring of water quality to meet waste discharge requirements specified as a condition of the 401 water quality certification. Biological monitoring may be required by resource agencies to verify absence of sensitive species from the project area during construction, halt or redirect construction if sensitive resources enter the project area, ensure construction does not significantly impact sensitive resources, or to confirm construction remains within designated work areas.

Post-Construction mitigation measures may include impact verification monitoring. Mitigation measures may specify how impacts would be rectified or compensated in the event there is a failure in project performance and a significant impact occurs. Post-construction monitoring typically concerns sensitive habitat areas. Post-construction monitoring may be conducted to document recovery rates of dredge or fill sites. Post-construction monitoring also may be conducted to document physical project performance over time (e.g., beach width, sand movement).

CEQ (2011) reviewed that federal agencies have not been consistent in following through on mitigation or monitoring commitments, and in 2011 released final guidance on those topics (*http://ceq.hss.doe.gov/current_developments/docs/FRN_Published_Mitigation_Monitoring21Jan2011_76FR3843.pdf*). The guidance clarifies that agencies should adhere to mitigation commitments, monitor how they are implemented, and monitor the effectiveness of the mitigation. The guidance affirms that:

- agencies should commit to mitigation in decision documents when they have based environmental analysis upon such mitigation (by including appropriate conditions on grants, permits, or other agency approvals, and making funding or approvals for implementing the proposed action contingent on implementation of the mitigation commitments);
- agencies should monitor the implementation and effectiveness of mitigation commitments;
- agencies should make information on mitigation monitoring available to the public, preferably through agency web sites; and
- agencies should remedy ineffective mitigation when there is federal action remaining to be taken.

MMRPs and permit conditions vary among sediment management projects. MMRPs may range from construction monitoring to meet 401 Water Quality Certification requirements to more comprehensive programs with monitoring during all project phases. The degree of monitoring typically relates to level of impact concern. Fewer monitoring requirements generally are required for projects conducted in areas lacking sensitive resources, at times of year when sensitive resources are avoided, or when there is agency concurrence that prior monitoring demonstrated that a similar level of activity did not result in significant impacts. With respect to the latter consideration, it is important to note that potential effects of SABS are highly dependent on the nature of sediment characteristics, project volume, and environmental conditions during and after project implementation. Project areas with sensitive habitats warrant special consideration and more detailed evaluation of potential effects. Monitoring associated with project-specific environmental conditions may or may not be applicable under different environmental conditions. Modeling can be useful to frame potential impact risks; however, results of simulations may remain speculative unless monitoring is conducted to verify model performance (biological impact assumptions, modeling assumptions).

2.8.1 Ecosystem and Species Monitoring Considerations

During the past three decades there has been a shift in environmental protection policy away from species management toward consideration of the entire ecosystem (Fulton et al. 2003). For example, the ecosystem rather than species management approach is specifically identified as an action in *Protecting Our Ocean: California's Action Strategy* (California Resources Agency and California Environmental Protection Agency 2004). That document states:

> *"A major aspect of ecosystem management is to move beyond case-by-case or species-by-species approaches to management that focuses instead on ecosystem protection needs - often at a regional scale."*

The primary advantage of the ecosystem management approach is the focus on protection of functions and values for all native resources, not just those of special interest due to endangerment status or commercial interest. In that sense, the ecosystem-based approach is more proactive in protection of ecosystem health than species-based management that reacts to individual population trends.

Examples of environmental regulations and policies considered reflective of the ecosystem-based management approach include:

- Porter-Cologne Water Quality Control Act and Clean Water Act 401 water quality certification requirements to comply with state and federal water quality objectives.
- Magnuson-Stevens Fishery Conservation and Management Act requirements to protect Essential Fish Habitat.
- California State Wetlands Conservation Policy to ensure no overall net loss and a long-term net gain in wetlands acreage.
- Southern California Eelgrass Mitigation Policy to ensure no overall loss of eelgrass habitat.
- Marine Mammal Protection Act, which was the first legislation that called for a need for an ecosystem-based approach to resource management.

- Migratory Bird Treaty Act, which protects most breeding birds in the U.S.
- Marine Life Protection Act, which provides CDFG with authority to develop a Marine Life Protection Program, including a Master Plan for a network of Marine Protected Areas for California.

An advantage of ecosystem-based monitoring is that physical habitat boundaries are relatively easy to document. However, evaluation of impacts other than loss (i.e., functions and quality) requires a more complex monitoring approach because many attributes of the ecosystem may need to be measured to determine whether it is functioning properly.

Monitoring to verify significance of impacts to sensitive habitats generally requires before-after assessments at impact and unaffected reference areas to distinguish project-related impacts from natural environmental variability. Ecosystem-based monitoring can be expensive and challenging due the number of monitoring variables. This is particularly so for aquatic environments where sampling may require use of boats, divers, sophisticated sampling equipment, or laboratory analyses of collected samples. Therefore, a primary disadvantage of ecosystem-based monitoring is that it will likely cost more than single-species monitoring.

One strategy to minimize monitoring costs is to assess indicators or indicator species. For example, rocky HAPC habitats in southern California have been assessed by monitoring indicators such as surfgrass, giant kelp, sea palm, feather boa kelp, and sea fans (US Navy 1997; MEC 2000a; AMEC 2005; SAIC 2007, 2011).

The species-based management approach generally is focused on protection of sensitive, commercially important, or other special interest species. Examples of environmental regulations and policies considered reflective of the species-based management approach include:

- Federal Endangered Species Act, which protects federal-listed endangered and threatened species and candidate and proposed species for listing.
- California Endangered Species Act, which protects state-listed endangered and threatened species and candidate and proposed species for listing.
- Fishery Management Plans (e.g., Groundfish Management Plan, Nearshore Fishery Management Plan).

Management examples using a species-based approach include incidental take permits, time area closures, gear restrictions, environmental work windows (i.e., schedule allowances or restrictions) and/or other species-based limitations. Monitoring under the species-based management approach consists of direct assessment of individuals or critical habitat of a particular species. An advantage of the species-based approach is that it is relatively straightforward and cost-efficient to monitor individual species. A disadvantage is that information may provide limited understanding of broader environmental impacts.

2.8.2 Types of Monitoring and Management Questions

The NRC (1995) defined monitoring for beach nourishment projects, as:

> *"The systematic collection of physical, environmental, and economic time-series data or a combination of these data in order to make decisions regarding the need for or operation of the project or to evaluate the project's performance."*

The types of monitoring were distinguished, as follows:

- *Physical monitoring* - to quantify the physical processes that comprise sources, sinks, and sand volume changes in the project area. This may include previous history of the site, beach profiles, waves, currents, water levels, structures, sediment characteristics, and photographic documentation.
- *Environmental monitoring* - to document a project's effects on biota, to determine whether any short- or long-term changes have occurred, and to ensure protection of sensitive resources.
- *Economic monitoring* – to evaluate the economic impacts of a project to determine whether a project's economic justification was valid (e.g., were economic benefits realized, where construction costs correct, were hidden costs incurred).

Therefore, monitoring addresses two primary purposes:

- *Operational* – to determine the need for remedial action (e.g., construction compliance, maintenance, repairs, renourishment).
- *Performance* – to develop information and procedures for design verification and to document lessons learned that may be applied to future projects.

Several types of management questions are relevant to biological resource protection and monitoring. These may cover a range of project performance and impact concerns, application of lessons learned from monitoring to future projects, and appropriate management of multiple uses to avoid cumulative impacts.

Ewing (1997) developed procedural guidance for monitoring shoreline protection and beach nourishment projects that is considered broadly applicable to environmental monitoring programs for sediment management projects. The guidance identifies that an effective monitoring program "*is a way to answer questions about project effectiveness and to identify project strengths and weaknesses"* and includes the following major components:

- Objectives – *Why* the monitoring is being proposed.
- Features to be monitored – *What* will be monitored.
- Monitoring methods – *Who* will perform the monitoring, *Where* will monitoring occur, and *How* will monitoring be conducted.
- Monitoring schedule – *When* will monitoring be conducted.
- Monitoring reports – *So What* documentation of program elements, analyses of results, conclusions, and/or recommendations with respect to maintenance and/or performance criteria, if appropriate.

Monitoring objectives associated with the different project phases are reviewed below.

Pre-construction Phase Monitoring

Pre-construction phase monitoring generally is undertaken to address one or more of the following objectives:

- *Determine substrate characteristics* - to determine compatibility for beach nourishment or disposal options and to predict turbidity plumes.
- *Characterize existing conditions* - to support project design and environmental review.
- *Identify biological constraints* – to identify resource concerns that may require implementation of mitigation measures during or after construction.
- *Establish baseline conditions* - to support post-project verification of impacts or to assess project performance.

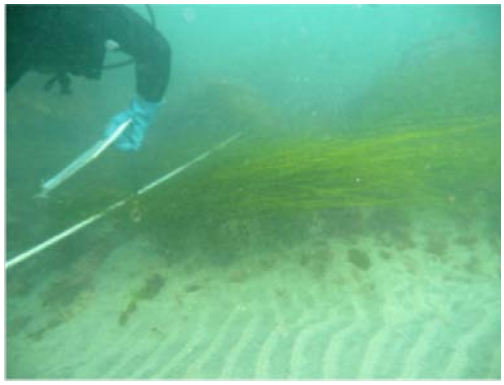
Construction Phase Monitoring

Construction phase monitoring generally is undertaken to address one or more of the following objectives:

- Document water quality compliance and determine need for additional operational controls.
- Monitor sensitive species occurrence and determine need for additional protective measures.
- Verify habitat buffers and determine need for additional protective measures.

A primary consideration of construction monitoring is proximity to sensitive resources. For a project conducted in an area without sensitive biological resources, the only construction monitoring that may be required is water quality to ensure compliance with the water quality objectives. For example, small, opportunistic beach nourishment projects that qualify under RGP 67 (USACE 2006) may only require turbidity monitoring if scheduled outside the grunion spawning season and no sensitive habitats or species are in the vicinity.

Beach Survey



Nearshore dive transect surveys

Box Core Sampler

Photo credits: Karen Green and Danny Heilprin

If sensitive habitats are nearby, monitoring may be used to ensure sensitive habitats are avoided, turbidity is controlled to avoid excessive SABS in sensitive habitat areas, or adequate buffers are maintained. If sensitive species have the potential to occur in the project area, protective measures may be needed to address noise, artificial lighting, turbidity effects in foraging areas, or human activity disturbance distances. In some cases, environmental monitors may be required to ensure that project activities do not harm sensitive species.

A variety of methods have been used to monitor and/or document suspended sediment plumes associated with dredging and/or discharge operations, and are briefly reviewed below (selected methods are reviewed in the box insert).

- Visual observations.
- Water clarity (using a Secchi disk);
- TSS or suspended sediment concentraiton (based on laboratory analysis of water samples);
- Turbidity (using a nephelometer, Nephelometric Turbidity Units [NTU]);
- Light transmittance or turbidity (using a transmissometer);
- Optical Backscatter Sensor (OBS);
- Acoustic monitoring (e.g., acoustic backscatter sensor [ABS], acoustic-Doppler current profiler [ADCP]); and
- PAR (using light sensors).

Visual observations of turbidity plumes may be required with some permits (e.g., Beach Nourishment RGP 67). Visual estimates of plume dimensions may be effective for field decisions of whether dimensions (relative to permit specifications) would require additional controls or adjustments to operations to comply with permit conditions. Plume monitoring also may be useful for identifying whether or not the direction or dimensions of the plume have the potential

Plume Measurements and Relevance

- Visual Observations

  Advantages: Enables permit compliance verification of water appearance and plume characteristics.

  Limitations: Not relevant to biological effects unless correlated with TSS or PAR.

- Water Clarity (Secchi Depth)

  Advantages: Real-time data for permit compliance verification; relevant to water clarity for visual predators (e.g., fish, birds), correlated with light attenuation.

  Limitations: Estimate of light attenuation less reliable in turbid waters. Sensitive to sun angle, observer.

- Total Suspended Solids (TSS, mg/L) or Suspended Sediment Concentration (mg/L)

  Advantages: Direct measure of suspended sediment in water; relevant to biological effects data.

  Limitations: Requires laboratory analysis; does not provide real-time data for permit compliance verification.

- Turbidity (Nephelometer, NTU)

  Advantages: Real-time data for permit compliance verification; estimates of SSC/TSS.

  Limitations: Not relevant to biological effects data unless site-specific correlations are established with TSS.

- Percent Light Transmittance (Transmissometer)

  Advantages: Real-time data for permit compliance verification; estimates of light or SSC/TSS..

  Limitations: Does not measure light necessary for photosynthesis. Less reliable with high turbidity.

- Optical Backscatter Sensors (OBS)

  Advantages – Real-time data for permit compliance verification; estimates SSC/TSS.

  *Limitations – SCC/TSS n*ot accurate unless calibrated with field conditions.

- Acoustic Sensors(ABS, ADCP)

  Advantages: Enables profiles and tracking of plume; nd estimates SSC/TSS.

  Limitations: Post-processing of data. Not accurate unless calibrated with field conditions.

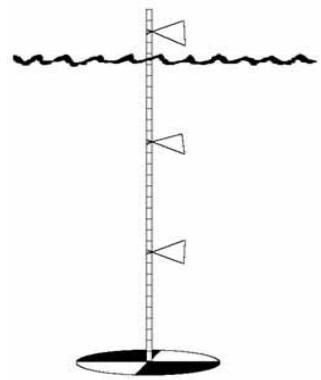
- Photosynthetically Active Radiation (Light Sensors)

  Advantages: Biologically relevant measurement.

  Limitations: Multiple sensors or lengthy deployments may be necessary to assess potential biological effects.

to impact sensitive habitat areas.

However, surface plumes may not fully represent the area of influence of subsurface plumes and deposition (particularly with dredging or nearshore placement projects). Additionally, visual plume mapping is qualitative and may be affected by weather, sun angle, time of day, or difficult in areas of high ambient turbidity. Although the human eye may distinguish water color differences; turbidity plume monitoring generally involves present-absent decisions and does not distinguish relative differences in the intensity of turbidity as a function of distance from the activity. While plume monitoring is useful for identifying whether the direction of the plume is towards a sensitive habitat area, the potential for biological effects would require additional information (e.g., TSS concentration, PAR, water clarity).

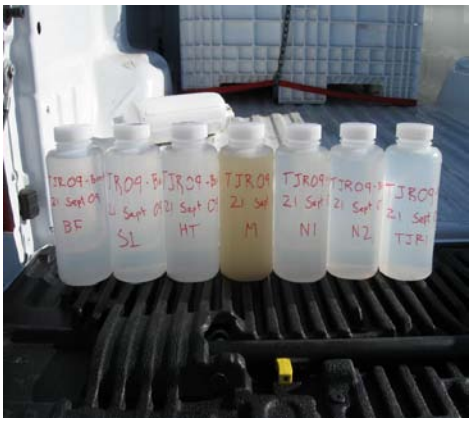


Secchi Disk

source: http://water.epa.gov/type/rsl/monitoring/

Water clarity (or transparency) may be measured using a Secchi disk, which is lowered from the side of a boat and the water depth at which it is no longer clearly visible is recorded. The method is inexpensive, fairly reliable, and has relevance to visual predators (e.g., fish, birds) or aesthetic quality of waters (Davies-Colley and Smith 2001). However, Secchi depth is sensitive to suspended particulates, and is not considered a reliable predictor of light attenuation in turbid waters (Devlin et al. 2008, Kirk 2011).

TSS or SSC provide actual measures of the inorganic and organic particle loading in water. Therefore, it is relevant to comparison with dose-response laboratory experiments of effects of suspended sediments. TSS is the recommended parameter for evaluation of sediment resuspension due to dredging operations (Palermo et al. 2008). While TSS measurements have been reported for some California dredging or discharge projects, this parameter is less often included in permit specifications than NTU or Secchi depth measurements (SAIC 2011). Palermo et al. (2008) reviewed that field measurements of turbidity (NTU) are commonly used to support real-time feedback during construction to support decisions of whether resupension levels would require implementing control measures or changes in dredging operations. In contrast, TSS measurements require collection of water samples that are analyzed in the laboratory; thus, the delay to obtain lab results does not support real-time decision-making regarding turbidity plume management.



Water samples collected for TSS analysis

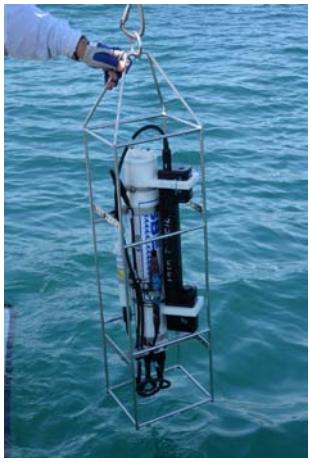
Photo credit: Warrick 2010

Gray et al. (2000) reviewed that measurements of SSC, which are based on analysis of entire sample, are more accurate than TSS, which is based on subsample analysis. They noted that the deviation between the methods is more pronounced with sandy sediments due to difficulty of obtaining accurate subsamples with the TSS method due to rapid settling of sand particles.

Turbidity measures the optical property (cloudiness) of water. It is easily measured in the field with a relatively inexpensive nephelometer; therefore, it is routinely used during dredging or discharge projects.

However, nephelometers do not distinguish between type of particles (e.g., plankton, sediment), sediment characteristics greatly influence readings, and there is no standard conversion between NTUs and TSS (Puckette 1998, Davies-Colley and Smith 2001). Site-specific calibration is necessary to establish accurate NTU and TSS relationships (Thackston and Palermo 2000, Gray and Gartner 2009).

Light transmission through water is reduced (attenuation) by particulates in the water column. A transmissometer is an optical sensor used to measure the percentage of light transmitted through the water column, with 100% for clear water and 0% when no light is transmitted. Data also may be reported in terms of a beam attenuation coefficient, which is related to SSC. Transmissometers provide measurements that support field verification of permit compliance based on relative percent change between ambient and plume waters. However, transmissometers may become saturated (less reliable) when suspended sediment concentrations exceed 150-500 mg/L (Puckette 1998, Gray and Gartner 2009); transmissometers also do not measure light necessary for photosynthesis.

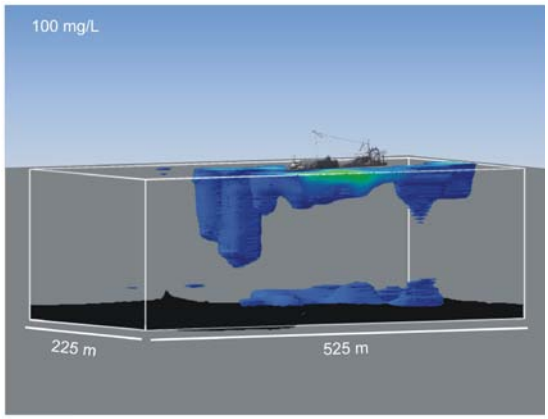


CTD Instrument, transmissometer, OBS, and water sampler

Photo credit: Warrick 2010

An OBS also is an optical sensor, but measures the quantity of light scattered off suspended particles and reflected back to the sensor. Calibration coefficients are used to estimate suspended sediment concentration. OBS readings are influenced by grain size and are non-linear with concentration; therefore, calibration with representative water samples collected at the time of sampling generally is recommended.

Acoustic monitoring sometimes is used to identify and track suspended sediment plumes associated with sediment management activities. For example, ADCP instruments have been used for plume tracking in San Francisco Bay and Boston Harbor (e.g., MEC and USACE-ERDC 2004, Batelle 2009). An advantage of ADCPs is the ability to deploy and obtain profiles of the water column while the vessel is underway, enabling real-time plume tracking. Acoustic data from ACDPs and ACBs are sensitive to grain size distribution and other environmental factors (e.g., water density, plankton concentration); therefore, the relationship between backscatter intensity to suspended sediment concentration is variable. When combined with analysis of water samples for TSS, site-specific correlations may be made between plume signatures and TSS concentration (Puckette 1998, Thackston and Palermo 2000, Gartner 2004). Post-processing of data is required to estimate SSC; the data processing is labor intensive and more expensive when compared optical methods (Gray and Gartner 2009).



Source: MEC and U.S. Army ERDC 2004

Illustration of 100 mg/L TSS concentration, acoustic monitoring of turbidity plume from clamshell dredging operations.

Various sensors may be used to measure photosynthetically available radiation (PAR) to provide a direct measure of light wavelengths that are used by plants for photosynthesis. The maximum depth at which significant photosynthesis can occur (the euphotic depth) generally is defined as the point at which PAR is reduced to 1% of its surface value (also termed compensation depth). Aquatic plants (or life stages) vary in their light requirements, and critical thresholds may vary geographically. Measurements of PAR are considered more biologically relevant during dredging than NTU in areas with sensitive marine habitats (Sofonia and Unsworth 2009). Site-specific baseline information is necessary to understand natural background conditions and potential effects of light attenuation due to dredging.

Post-Construction Phase Monitoring

Post-construction monitoring generally is performed in combination with pre-construction baseline monitoring to verify the significance of project effects. Elements selected for monitoring should have a clear nexus to expected effects and uncertainty associated with the significance of effects (CCC 1995). For example, sand transport effects on sensitive habitats (e.g., reefs, seagrass beds, kelp forests).

Environmental Performance Questions

- What are changes in beach width, sand level, and slope over time at the receiver site. How does that compare with distance downcurrent?
- Did the project result in persistent non-compliant water quality? If so, how long and what measures were used to increase effectiveness of compliance?
- Did beach nourishment result in an increase in shoaling and dredge frequency of downcurrent inlets and/or entrance channels of embayments (bays, creeks, lagoons, rivers, sloughs)? If so, how does that relate to sediment volume and proximity of beach nourishment to inlet.
- Did unacceptable environmental impacts occur? How can they be avoided in the future?
    - Did sensitive habitat degradation or loss occur?
    - Did any sensitive species or critical habitat experience unacceptable environmental impacts?
    - Did commercial fishing activities or catches in the project vicinity substantially change?
    - Did the project require compensatory mitigation to replace loss of sensitive habitat? Was mitigation judged successful by resource agencies? Was mitigation cost-effective?
- How frequent would renourishment be necessary to maintain sediment management objectives (e.g., maintenance dredging), shoreline protection, or public beneficial uses? Does that frequency have the potential to result in cumulative impacts?
- How frequent should the same borrow site be used? When should alternate borrow sites be sought?
- Would dune restoration be effective for reducing renourishment schedules?
- When should structures be included as part of a project to increase the time between periodic renourishments?
- Did renourishment result in exceedance of impact thresholds for sensitive habitats? How should future renourishment procedures or volumes be modified to avoid significant impacts and mitigation?

Acknowledgement: Inspired by NRC 1995

3.0 RESOURCE PROTECTION GUIDELINES

The resource protection guidelines were developed based on information reviewed in the Volume 1 BIA document (Section 6, Mitigation Measures), other relevant documents, and a stakeholder outreach process. Seven workshops were conducted throughout the state in 2010 with a variety of stakeholders to solicit their input and participation in the development process for the guidelines. During the workshops, mitigation measures reviewed in Volume 1 were discussed to receive additional input on potential applicability or effectiveness over a broad range of project experiences, and to identify additional input relevant to guideline development. Workshop participants included resource and regulatory agencies, port managers, municipalities, non-governmental organizations, and other interested stakeholders (Section 4).

Section 3.1 provides an overview of the types of guidelines included in this document and describes the format used for the guidelines. Section 3.2 and Appendix A provide cross-reference tables that summarize sediment management activities, relevant habitats and resources, impact considerations, and types of mitigation measures for the habitats and species reviewed in Volume 1. Resource protection guidelines for the primary habitats where sediment management activities occur (sandy beach, sandy subtidal, embayments) are provided in Section 3.3. Section 3.4 describes guidelines for sensitive habitats that may be adjacent or in close proximity to locations where sediment management activities may occur.

3.1 Guideline Organization and Format

Guidelines address resource protection considerations relevant to sand compatibility of source materials to receiver sites, water quality, equipment operation, sedimentation, and post-construction sand transport. Guidelines consider all project phases: pre-construction, construction, and post-construction.

Section Topics:

3.1 Guideline Organization and Format

3.2 Cross-Reference Summaries of Sediment Management Activities, Impacts, and Potential Mitigation Measures

3.3 Resource Protection Guidelines for Sediment Management Habitats

3.4 Resource Protection Guidelines for Sensitive Habitats

Storm erosion, Oceanside

Marbled godwits, Ocean Beach

Photo Credits: Karen Green

SECTION 3

Several types of sediment management activities may occur in the following coastal habitats in California:

- Sandy Beach – sand placement activity - sand sources may include dredged or excavated maintenance materials from embayments, dredged materials from offshore borrow sites, or excavated materials from opportunistic inland sources.
- Sandy Subtidal – nearshore placement activity – sand sources may include dredged maintenance materials from embayments. Offshore borrow sites – dredging activity – sand dredged to provide source for beach nourishment.
- Embayments (Bays, Estuaries) – maintenance dredging or excavation activities – sand may be beneficially reused (beach or nearshore placement). Sand sources also may include maintenance of flood control channels or basins. Relevant to this document is beneficial reuse of suitable material at beach or nearshore receiver sites. (Note: beneficial reuse of maintenance dredged materials also may occur in embayments, but is not specifically addressed in this document.)

Direct impacts to invertebrates living within the sands will occur during removal (dredging, excavation) or sand placement activities within the three above-listed habitat types. Indirect impacts may occur to adjacent invertebrates (mobile or sedentary), fish, or birds.

Sensitive habitats or species have the potential to be impacted if present in the vicinity where sediment management activities occur. There may be the potential for direct impacts if work requires access through or over a sensitive habitat. Indirect impacts have the potential to occur at distances within a few hundred feet to over one (1) mile from effects such as noise, turbidity, sedimentation, or sand transport. Sensitive habitats that may occur in proximity to sediment management activities include:

- Coastal Dune or Strand,
- Rocky Reefs (Intertidal, Subtidal),
- Kelp Forest, or
- Seagrass Beds (Surfgrass, Eelgrass).

Sensitive habitats also include Areas of Special Biological Significance (ASBS), EFH Habitats of Particular Concern (HAPC), Marine Protected Areas (MPA), Special Aquatic Sites (SAS), and submerged aquatic vegetation (SAV). Other considerations are unique areas of resource concentration such as spawning grounds, migratory routes, nesting sites, nursery areas, or shellfish beds.

Several sensitive species, fishery species, or other high interest species associated with one or more of the above habitats are addressed in this document. Sensitive species include endangered or threatened species and their critical habitat, as applicable. All habitats and species considered in this document were selected in coordination with resource and regulatory agencies. More detailed descriptions of the habitats and species, including review of potential impacts and mitigation measures are provided in BIA Volume 1.

The primary organization of the guidelines is based on habitats. Soft-sediment habitats (beach, sandy subtidal, embayment) are described first, followed by sensitive hard-substrate and vegetated habitats. Each habitat section provides an overview of issues and considerations relevant to protection of supported resources. The habitat descriptions follow a standard format

that includes pertinent background information regarding the habitat, types of sediment management activities that may occur, resources and impacts of concern, lists of relevant resource protection considerations, and other guideline considerations (e.g., potentially occurring adjacent sensitive habitats or resources).

Standard formats are used for all habitat descriptions and resource protection guidelines according to several topics (Table 3.1-1). Explanations of the topics follow below.

Table 3.1-1. Topics addressed in habitat descriptions or resource protection guidelines.

Habitat Description	Resource Protection Guideline
Habitat Name	Guideline Name
Regulatory Consideration	Regulatory Status (if applicable)
Habitat Definition	Definition or Function
Sediment Management Issues	Sediment Management Issues
Relevant Background Considerations	Relevant Impact Activity and Issue Summary
• Functions and Resources of Concern	• Impacts of Concern, Species of Concern
• Sediment Management Activities and Impact Considerations	• Relevant Sediment Management Activities
• Other Activities or Issues	• Other Activities or Issues of Concern
• Recovery Considerations	Guideline Objectives
• Impact Mitigation Considerations	Resource Protection Considerations
• Monitoring Considerations	Effectiveness Considerations
Guideline Considerations	Seasonal Considerations
• List of Resource Protection Guidelines	Monitoring Considerations
• Other Potential Relevant Guidelines	
Cross-Reference Table to Volume 1 BIA Document	Cross-Reference to Volume 1, Other References

The habitat descriptions or resource protection guidelines address the following topics:

- Regulatory Status - designations that may apply to habitats or species (e.g., ASBS, Critical Habitat, CESA, ESA, EFH, HAPC, MPA, SAS, SAV).
- Definition – description of habitat or resource.
- Functions and Resources of Concern – ecological functions, types of supported uses (e.g., primary living, foraging, reproduction), and list of resources or species of particular concern.
- Sediment Management Issues – reasons sediment management is conducted and issues related to potential impacts or resource protection.
- Relevant Sediment Management Activities and Impact Considerations – types of applicable activities (e.g., beach nourishment, dredging). Types of potential impact factors (e.g., burial, disturbance, entrainment, noise, lights, sedimentation, turbidity) or concerns (e.g., habitat alteration, degradation, injury, loss) .
- Other Activities or Issues of Concern – other activities or uses with the potential to affect habitat quality, supported resources, or implementation of sediment management projects (e.g., beach grooming, fishing, high public use, other discharges).
- Recovery Considerations – range of reported recovery rates or influential factors associated with recovery from disturbance.
- Impact Mitigation Considerations – potential mitigation measures likely to be effective.

- Monitoring Considerations – issues relevant to monitoring resource or methods.
- Guideline Objectives – impact concerns addressed by the guideline.
- Resource Protection Considerations – list of potential mitigation measures associated with guideline implementation.
- Effectiveness Considerations – factors associated with the relative effectiveness of resource protection considerations.
- Seasonal Considerations – time of year that may influence the effectiveness or applicability of the guideline.
- References – relevant sections of the Volume 1 BIA or other key references.

3.2 Cross-Reference Summaries of Sediment Management Activities, Impacts, and Potential Mitigation Measures

3.2.1 Impact Considerations

Table 3.2-1 summarizes direct and indirect impact considerations associated with different types of sediment management activities by coastal habitats and types of resources. Impacts may include direct damage from equipment (dredges, earth-moving equipment, pipelines, vehicles, vessels, anchoring), or from sand burial or removal. Indirect impacts may result from equipment operation (noise, lights, activity disturbance), reduction in forage prey from sand burial or removal, changes to water quality, sedimentation, or beneficial effects of sand placement. Appendix A.1 includes summary tables of types of impact considerations.

Table 3.2.1. Cross-reference summary of sediment management impact considerations by type of activity for coastal habitats and resources.

Resource	Beach Nourishment (Place Sediment)				Dredging (Remove Sediment)	
	Dune	Beach	Nearshore	Profile	Offshore	Embayment
Coastal Habitats						
Coastal Dune or Strand	D, I	D, I	I	I		I
Sandy Beach	I	D, I	I	D, I		D, I
Sandy Subtidal	I	I	D, I	D, I	D, I	D, I
Rocky Intertidal		D, I	I	D, I		I
Rocky Subtidal		I	D, I	D, I	D, I	I
Kelp Forest		I	D, I	D, I	D, I	I
Surfgrass		D, I	D, I	D, I		
Eelgrass		I	D, I	D, I		D, I
Embayment		I	I	I		D, I
Types of Resources						
Invertebrates	D, I	D, I	D, I	D, I	D, I	D, I
Fish		D, I	D, I	D, I	D, I	D, I
Birds	D, I	D, I	I	I	I	I
Mammals	I	I	I	I	I	I
Vegetation	D, I	D, I	I	I	D, I	D, I

D = potential for direct impact, I = potential for indirect impact.

3.2.2 Mitigation Considerations

Several types of mitigation measures may apply depending on activity (beach nourishment, dredging) and project phase. Appropriate measures would depend on project- and site-specific considerations. Primary considerations include project location, size, proximity to sensitive resources, or schedule. General categories of mitigation measures applicable to coastal habitats and species are summarized in Table 3.2-2. More detailed lists are In Appendix A.2. The different types of mitigation measures that have been applied to sediment management projects are reviewed in Section 6 of the Volume I BIA document (SAIC 2011, Section 6).

Pre-construction measures may address design, implementation considerations, or pre-project data collection, as follows:

- Project design may address locations, project size, or methods to avoid or minimize impacts to sensitive resources or natural habitat hydrodynamics.
- Buffer distances may be used to minimize impacts to sensitive resources.
- Sediment compatibility may be relevant to project design (e.g., placement location, methods) and may be an important consideration relative to impacts and recovery. Implementation strategies may address frequency of or distance between sediment management activities to minimize cumulative impacts. Environmental coordination may include preparation of plans (e.g., hazardous materials management plan), agency coordination or notifications, or contractor environmental training.
- Monitoring may include preparation of a MMRP, surveys to finalize construction plans, or surveys to establish baseline conditions for long-term monitoring, if required.

Construction phase measures may include location controls, schedule restrictions, construction methods or BMPs, or monitoring, such as:

- Location controls, where construction activities or access may be restricted (e.g., no work zones) or confined (e.g., outside the swash zone) to minimize impacts.
- Schedule or seasonal considerations (environmental windows) to avoid or minimize impacts to endangered, threatened, commercially important, or other high-interest species.
- Construction equipment, methods, operation controls, engineered controls, or BMPs to minimize impacts.
- Monitoring to verify compliance with permit conditions.

Post-construction phase measures generally include impact verification monitoring or mitigation, such as:

- Monitoring to comply with permit requirements to verify no significant impacts occur to sensitive habitats.
- Remedial or compensatory mitigation if monitoring identifies a significant impact.

Some locations already have memorandums of agreement or understanding (MOAs, MOUs) with resource and regulatory agencies that include measures to minimize impacts associated with sediment management. A notable example is San Francisco Bay, where dredging and disposal activities require a permit from BCDC. The BCDC coordinates the implementation of the Long Term Management Strategy (LTMS), which is a collaborative partnership involving the

regulatory agencies, resource agencies and stakeholders working together to maximize beneficial reuse of dredged material (*www.bcdc.ca.gov/*).

Table 3.2-2. Types of mitigation measures with demonstrated and/or likely effectiveness to protect biological resources during sediment management activities.

Resource	Pre-Construction						Construction Phase					Post Project	
	Sediment Compatibility	Project Design	Implementation Strategy	Buffers	Coordination	Monitoring	Location Controls	Environmental Windows	Operational Controls	Construction Methods, BMPs	Construction Monitoring	Impact Verification Monitoring	Compensatory Mitigation
Coastal Dune and/or Strand	X	X	X	X	X	X	X		X		X	X	X
Sandy Beach	X	X	X			X		X	X	X		X	
Sandy Subtidal	X	X	X			X			X	X		X	
Rocky Intertidal		X	X	X	X	X	X		X	X	X	X	X
Rocky Subtidal		X	X	X	X	X	X		X	X	X	X	X
Kelp Forest and/or Bed		X	X	X	X	X	X		X	X	X	X	X
Surfgrass Bed		X	X	X	X	X	X		X	X	X	X	X
Eelgrass Meadow		X	X	X	X	X	X	X	X	X	X	X	X
Embayment		X	X	X		X			X	X	X	X	X
Abalone		X	X	X					X				
California Lobster		X	X	X					X			X	
Dungeness Crab	X		X	X				X	X				
Pismo Clam	X	X	X	X	X	X	X		X			X	
Sea Urchins			X	X					X				
Beach Invertebrates	X		X			X		X	X	X		X	
Subtidal Sand Invertebrates	X		X			X			X	X		X	
Intertidal Rock Invertebrates		X	X	X		X			X			X	X
Subtidal Reef Invertebrates		X	X	X		X			X			X	X
California Grunion	X	X	X	X	X	X	X	X	X	X	X		
Green Sturgeon	X	X	X	X	X		X		X	X			
Pacific Herring			X	X			X	X	X	X			
Salmonids			X	X	X			X	X				
Demersal Fish	X		X						X				
Pelagic Fish			X						X	X			
Intertidal, Subtidal Reef Fish		X	X	X					X	X			
CA Brown Pelican			X	X	X				X	X			
CA Least Tern			X	X	X			X	X	X	X		
Clapper Rail		X	X	X	X		X	X	X	X	X		
Western Snowy Plover	X	X	X	X	X		X	X	X	X	X		
Gulls, Skimmers, Terns	X		X	X					X				
Shorebirds	X	X	X						X				
Wading Birds, Waterfowl			X						X				
Sea Otters		X	X	X	X		X	X	X		X		
Seals and Sea Lions		X	X	X	X		X		X		X		
Cetaceans			X	X	X		X		X		X		

Note: The listed habitats and species were selected in coordination with resource and regulatory agencies.

Species may or may not be relevant depending on geographic location.

3.2.3 List of Resource Protection Guidelines

Table 3.2-3 lists the guidelines included in this document according to the habitats to which they may apply. To avoid redundancy among habitat sections, guidelines are only described once. The document section number indicates where the guideline is described. Other habitats where the guideline may apply are noted (letter "x"). Potential adjacent sensitive habitats that may require consideration also are noted (letter "p").

Table 3.2-3. List of guidelines and habitats to which they may apply.

Guideline	Sediment Management Locations			Potential Adjacent Habitats			
	Sandy Beach	Nearshore/ Offshore	Bay, Estuary	Dune, Strand	Rocky Reef	Kelp Bed	Seagrass Bed
Physical-Chemical							
Sand Compatibility	3.3.1	x	x	x			
Water Quality - Beach	3.3.1				x		x
Water Quality – Nearshore		3.3.2			x	x	x
Water Quality - Embayment			3.3.3			x	x
Habitat or Vegetation							
Beach Wrack	3.3.1			x			
Dune or Strand Vegetation	p		p	3.4.1			
Invasive Species*			3.3.3	x			
Kelp Forest HAPC	p	p	p		p	3.4.2	p
Rocky Habitat Assessment	p	p			3.4.2	p	p
Rocky Intertidal HAPC	p		p		3.4.2		p
Rocky Subtidal HAPC	p	p	p		3.4.2	p	p
Seagrass - Surfgrass HAPC	p	p	p		p	p	3.4.2
Seagrass - Eelgrass HAPC	p	x	x				3.4.3
Invertebrates							
Clam Beds	3.3.1	x	x				
Dungeness Crab	x	x	3.3.3				x
Intertidal Invertebrate Recovery	3.3.1		x				
Subtidal Invertebrate Recovery		3.3.2	x				
Fish							
Green Sturgeon		x	3.3.3				
Grunion Habitat Assessment	3.3.1						
Grunion Spawning	3.3.1	x	x				
Pacific Herring			3.3.3				x
Salmonids			3.3.3				x
Birds							
Clapper Rail	p		3.3.3				
Least Tern	3.3.1	x	x	x			
Migratory Birds	3.3.1	x	x	x			x
Snowy Plover	3.3.1		x	x			
Marine Mammals							
Sea Otters		3.3.2	x		x	x	
Seal or Sea Lions	x	3.3.2	x		x	x	
Whales, Dolphins, Porpoises		3.3.2	x			x	

Notes: The report section where the guideline is described is shown by number. The letter "x" denotes other habitats where the guideline may apply. The letter "p" identifies potential adjacent habitat.

*Invasive species are listed under the habitat and vegetation heading because of the potential for these species to substantially alter or degrade habitat.

3.3 Resource Protection Guidelines for Habitats Where Sediment Management Occurs

Table 3.3-1 lists impact factors and resources that may be disturbed by sediment management activities in sandy beach, nearshore, or embayment habitats. These factors were considered as part of the development process for the resource protection guidelines.

Table 3.3-1. Impact factors and resource disturbance issues - habitats where sediment management occurs.

Impact Factors and Resource Disturbance	User's Guide Section		
	3.3.1 Sandy Beach	3.3.2 Sandy Nearshore	3.3.3 Embayment
Activity	*Placement*	*Offshore Dredge, Placement*	*Dredge, Excavation*
Impact Factors			
Burial (Sand Placement)	X	X	
Dredge-Excavate (Sand Removal)		X	X
Entrainment		X	X
Hazardous Leaks or Spills	X	X	X
Hydrodynamics/Morphodynamics	X	X	X
Lights	X	X	X
Mono Buoy (offloading)		X	
Noise	X	X	X
Pipelines	X	X	X
Sand Compatibility	X	X	
Sand Transport After Placement	X	X	
Turbidity-Sedimentation	X	X	X
Vehicles	X		
Vessels (anchors, propellers)		X	X
Water Quality	X	X	X
Resource Disturbance*			
Beach Wrack	bury, remove		
Benthic Invertebrates	Bury, damage	bury, damage, remove	Damage, remove
Birds	attract, disturb, forage reduction	attract, disturb, forage interference	attract, disturb, forage interference
Fishes	forage reduction, spawning interference	attract, disturb, forage reduction, migration or spawning interference	attract, disturb, forage reduction, migration or spawning interference
Marine Mammals	disturb	forage reduction, behavior or migration interference, collision	forage reduction, behavior or migration interference, collision
Hard-Substrate Habitats or Vegetation (if nearby)	damage, turbidity, sedimentation	damage, turbidity, sedimentation	damage, turbidity, sedimentation

* Invertebrate populations and bird use may be enhanced at erosive beaches after beach nourishment.

3.3.1 Sandy Beach Habitat

Photo credit: Karen Green

Regulatory Considerations: The State's sovereign lands extend seaward of the mean high tide (MHT) line. Sandy beach up to the mean higher high water level (MHHW) is EFH. Some sandy shores have special regulatory status as critical habitat for threatened western snowy plover.

Habitat Definition: The beach includes the dry backshore and intertidal foreshore, which generally extends between the approximate MHHW and mean lower low water (MLLW) elevations.

Sandy beach habitat occurs along the coast and is directly influenced by waves and littoral sand transport, including seasonal cycles of sand accretion and erosion. Sandy tidal flats or shorelines in embayments may support some of the same or similar species as found along the coast (e.g., birds, worms, crustaceans, clams). However, physical processes are not as dynamic. Embayments are discussed in Section 3.3.3.

Sediment Management Issues: Coastal sandy beaches protect shorelines and support numerous ecological functions. A variety of human activities (e.g., urbanization, dams, harbors, breakwaters, groins, seawalls) have resulted in less sand delivery to the coastline from natural sources (river discharges, bluff erosion) or impede the movement of sand along the coastline. Several locations in California have been identified as Beach Erosion Concern Areas (BECAs) (CSMW 2010).

Beach nourishment has the potential to improve shoreline protection and enhance sandy beach habitat when placed at BECAs. Supported resources differ among beaches. Generally, seasonally erosive locations support fewer resources than persistent sandy beaches (SAIC 2006). Beach nourishment has been shown to enhance habitat functions for biological resources in areas with erosive beach conditions. Types of species relevant to California that may benefit include sandy beach invertebrates, California grunion, birds, and dune vegetation. Functions that may be supported include primary habitat for dune vegetation or invertebrates; spawning habitat for grunion; and foraging, resting, and/or nesting habitat for birds (NRC 1995, SAIC 2006, SAIC 2011).

Sandy beach habitat is harsh and subject to substantial disturbance by waves on a daily basis and sand erosion-accretion cycles on a seasonal basis. Sand that is placed on the beach adjusts over time due to these processes. Sand placement disturbance directly impacts the invertebrate animals that live within the sand and indirectly the higher-order animals that feed on the invertebrates. Disturbance impacts may be short-term when beach nourishment occurs at erosive beaches. However, there is potential for long-term adverse effects if sand is placed at beaches supporting unique features such as clam beds or diverse communities with multi-age class populations. Sand placement also may result in long-term effects if there is a substantial change to substrate characteristics between source and native substrates.

Proximity to sensitive or unique resources is an important consideration for beach nourishment projects. Adjacent sensitive habitats may include coastal dune or strand landward of the beach backshore, rocky intertidal up- or downcoast, rocky subtidal and/or kelp forests in the adjacent

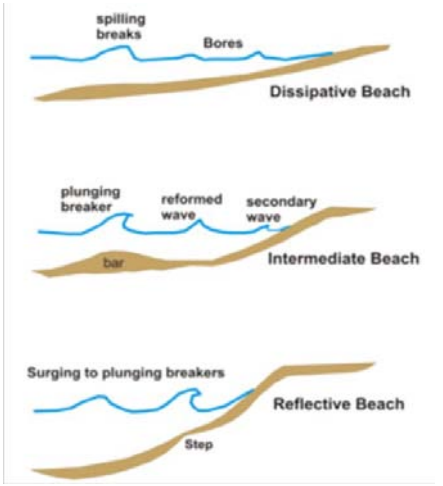
nearshore, and/or seagrass habitats. Embayments may be located upcoast, downcoast, or landward.

Overview of Relevant Background Considerations:

Functions and Resources of Concern

The intertidal zone of sandy beaches is habitat for a variety of invertebrates (e.g., worms, sand crabs, isopods, amphipods, clams), which provide forage for fish when tides are high and for birds when tides are low. California grunion use sandy beach as spawning habitat. Sandy beaches may provide important foraging and resting habitats for a variety of shorebirds and seabirds. Threatened snowy plover or endangered least terns may nest at beaches. Threatened snowy plover also may forage or overwinter at beaches. Beach wrack is an important foraging location for snowy plovers. Seals and sea lions may haul out (rest) on beaches; breeding rookeries may occur at secluded beaches on the mainland, but most occur on the Channel Islands. The backshore may support coastal strand vegetation or transition to dune habitat (Section 3.4.1).

Beaches display considerable variability based on a combination of physical variables, including slope, width, and grain size characteristics. The interactions between tidal regime, wave climate, and sediment type produce a range of beach morphodynamic types spanning a continuum from wide and flat (dissipative) beaches to narrow and steep (reflective) beaches (Short and Hesp 1982, Defeo and McLachlan 2005).



After: Komar 1998
Drawn by K. Green

Supported resources vary depending on beach type. Generally, dissipative beaches with gentle slopes and limited sand mobility support relatively high invertebrate diversity. In contrast, reflective beaches with steep slopes and coarse sand support fewer biological resources. A variety of beach states fall in between these two extremes. A bar-trough morphology and rip current circulation generally characterize intermediate beaches (Short and Hesp 1982).

Unstable Cobble
Supports Little Marine Life

Close up view of beach cobble

Photo credit: Karen Green

Biological resources at a beach vary depending on substrate conditions and season. The percentage of rock cover may influence species composition and relative use patterns of invertebrates, birds, and habitat suitability for grunion spawning (Table 3.3-2). At some beaches, the amount of rock cover is influenced by the natural seasonal erosion and accretion cycles of sand movement on- and offshore. For example, invertebrate community development may fluctuate from moderately developed after seasonal sand accretion to limited (few species) after seasonal sand erosion if the sand layer thins and bedrock or cobbles become dominant (Brown and McLachlan 2002, SAIC 2006). Substantial winter erosion can limit habitat suitability for grunion spawning until sufficient sand has seasonally

accreted to the beach; seasonal erosion also may limit foraging and resting habitat for shorebirds and seabirds (SAIC 2006).

Table 3.3-2. Generalized comparison of beach substrate type and seasonal habitat uses.

Consideration	Substrate Type			
	Persistent Sand	Seasonally Mixed Sand and Cobble	Mixed Sand and Rock	Unstable Cobble
Summer Season	Sand	Cobble (generally less)	Sand and Rock (exposed rock may be less)	Cobble
Winter Season	Sand	Cobble (generally greater)	Sand and Exposed Rock (exposed rock may be greater)	Cobble
Habitat Uses				
Invertebrate Development	Relatively high	May vary with relative change in cobble cover	May affect species composition	Limited
Grunion Habitat Suitability	Generally Yes (beach width may vary)	May vary across season with relative change in cobble cover	May vary depending on rock cover	No
Shorebird Foraging/Resting	Yes	May vary with relative change in cobble cover	May affect species composition	Limited

Notes: unstable cobble is subject to tumbling by waves. In contrast, relatively wide beaches with mixed rock, cobble, or boulders may support diverse rocky intertidal habitat.

The endangered least tern and/or threatened snowy plover may nest on the beach backshore. Least terns may forage in the nearshore; therefore, beach water quality during beach nourishment activities may be an issue of concern. Snowy plovers may forage above or below the high-tide line, particularly on invertebrates associated with beach wrack.

Resources of Concern

- Endangered Least tern
- Threatened Snowy plover
- Beach invertebrates
- Beach wrack
- Clam beds
- Grunion
- Seals or Sea lions
- Shorebirds and Gulls
- Water quality

Managed fisheries species such as California grunion use sandy beaches as spawning habitat part of the year, depending on habitat suitability. Other fisheries species such as Pismo clam, Pacific razor clam, or common littleneck clam may form clam beds in the lower intertidal to subtidal depths at certain beaches.

Shorebirds, gulls, and neashore fishes feed on beach invertebrates; therefore, recovery of invertebrates after sand placement is an issue of concern. Beaches also are important resting areas for shorebirds and gulls. Birds may flush and move away from vehicles, people, and dogs, particularly when there is direct approach, loud noise, or fast movement (e.g., running dogs, joggers, children at play) (Bennett and Zuelke 1999, Lafferty 2001a, Tarr et al. 2010).

Public beach use patterns are an important, but often overlooked consideration, when evaluating the potential impacts of invertebrate recovery on secondary consumers. Bird abundance, foraging, and resting may be negatively affected at beaches with high public use, particularly when dogs are off-leash (Bennett and Zuelke 1999). Beach maintenance activities

such as beach grooming may remove beach wrack, which is an important food source for certain invertebrates that are in turn eaten by shorebirds, including the threatened snowy plover. Removal could affect the behavior of this species. Gulls are opportunistic scavengers and forage on animals cast ashore with beach wrack, invertebrates exposed in the swash zone, or food left by humans. Access to garbage provides an important food subsidy for gulls and may influence their distribution and population growth (Weiser and Powell 2010). Consequently, overall bird use and types of bird species at a beach may vary depending on site-specific conditions as well as seasonal variations related to bird migration.

Beach access, Monterey
Photo credit: Karen Green

Generally, indirect effects of invertebrate recovery rate impacts may be of greater concern at beaches with relatively lower public use and greater shorebird occurrence than beaches with high public use or dominance by gulls. This same consideration does not apply to invertebrate recovery rate considerations relative to essential fish habitat for fish. Under high tide conditions, sandy beach invertebrates provide forage for fish that live or feed at the bottom.

Sediment Management Activities and Impact Considerations

Types of sediment management activities and potential impacts to sandy beach resources include:

- Beach nourishment
  - Beach placement – equipment, burial, sedimentation, turbidity
  - Dune placement – sedimentation
  - Nearshore placement – sedimentation, turbidity
  - Profile placement – equipment, burial, sedimentation, turbidity
- Dredging or Excavation
  - Maintenance (harbors, lagoons, rivers) – not applicable
  - Offshore borrow site – not applicable

Sediment management activities involving beach nourishment are designed to result in local increases in sandy beach habitat. Consequently, documented impact concerns do not relate to habitat loss, but rather the environmental consequences of disturbing the habitat and associated biological resources. Documented concerns include temporary loss of invertebrates, which in turn may affect foraging patterns of nearshore fish and birds; disturbance of birds or marine mammals that may use beach habitats or adjacent areas for breeding, nesting, or resting; and potential disturbance of sensitive bird or plant species (Naqvi and Pullen 1982, Hurme and Pullen 1988, NRC 1995, Greene 2002).

Other Activities or Issues

Beach resources have the potential to be impacted by beach grooming, beach scraping, or non-point source discharges. Bird use has the potential to be affected by public use, particularly when accompanied by off-leash dogs.

Recovery Considerations

Shorebirds feeding on bean clams two years after beach nourishment at Cardiff-by-the-Sea
Photo credit: Karen Green

Invertebrate recovery after beach nourishment begins almost immediately with recruitment of larvae from the plankton or migration of animals from adjacent beach or subtidal waters. However, recovery rates after disturbance may depend on a number of factors, including type of beach, time of year, substrate characteristics, or frequency of disturbance.

Recovery rates generally are relatively rapid (< 1 year) for beach types subject to substantial natural sand movement or changes in sand/cobble-rock cover on a seasonal basis. In contrast, recovery may take more than 1 year for persistent sandy beaches with more diverse invertebrate communities. Several years would be required to re-establish multi-age classes of long-lived species, such as occurs in clam beds.

Invertebrates exhibit seasonal patterns in resource development on beaches; generally, being most productive in spring-summer and less so in fall-winter. Invertebrates may migrate between the beach and nearshore during seasonal sand accretion and erosion cycles. In addition, invertebrates naturally recruit to beaches in spring-early summer. Because of this seasonality, project timing may affect beach nourishment impact duration and recovery rates. For example, projects conducted during fall-winter may substantially recover by the following spring-summer (e.g., a few months); whereas, projects conducted in summer may not recover until the following season (e.g., 1 year).

If there are multiple projects at the same location during the same year or on an annual basis, there is the potential for recovery to be affected by the cumulative effects of frequent disturbance. Frequent disturbance has the potential to degrade habitat functions. However, existing conditions prior to disturbance is an important consideration relative to potential cumulative effects (e.g., erosive or persistent sand beach conditions).

Mitigation Considerations

Primary mitigation considerations include avoidance and minimization of impacts to sensitive habitats and resources. This may be accomplished by schedule, distance buffers, operational controls, or monitoring.

Another important impact issue is the temporary reduction in the invertebrate forage base for fishes and birds. Recovery rates may be promoted by use of measures that minimize changes in substrate characteristics between source sands and receiver beach, minimize turbidity interference with recruitment, or minimize the frequency or spatial scale of disturbance.

Monitoring Considerations

Water quality monitoring during construction generally is a permit requirement associated with a 401 water quality certification or specified waste discharge requirements. Construction monitoring also may be required for listed sensitive species (e.g., snowy plover, least tern) or managed fishery species (e.g., grunion), if present.

A characterization survey of the sandy beach project area is recommended during the pre-construction environmental review phase to provide current information on the existing conditions within the receiver site. Monitoring considerations associated with sandy beach resources are included in the resource protection guidelines in this report section.

A sensitive aquatic resource survey also may be necessary if such resources occur in the vicinity and have the potential to be impacted by the project. Monitoring considerations for potential adjacent sensitive habitats are included in the guidelines presented in Section 3.4.

Cross-Reference Table to Relevant Sections of the Volume 1 BIA Document

Topic	Volume 1	
	Section	**Subsection**
Resource Description and Sediment Management Issues		
Sandy Beach	3	3.3.2
Sandy Beach Invertebrates	4	4.2.6
Grunion	4	4.3.1
Least Tern	4	4.4.2
Snowy Plover	4	4.4.3
Gulls and Terns	4	4.4.4
Shorebirds	4	4.4.5
Seals and Sea Lions (Pinnipeds)	4	4.5.2
Impact Issues		
Equipment – Sandy beach invertebrates	5	5.3.3.2, 5.3.4.1
Equipment- Birds, marine mammals	5	5.3.4.3, 5.3.5.4
Burial or Sedimentation – Invertebrates, fish or birds (forage)	5	5.4.4.1, 5.4.3.2, 5.4.4.3
Turbidity – Invertebrates, fishes, birds, marine mammals	5	5.5.4.3 through 5.5.4.6
Mitigation Measure Considerations		
Sediment compatibility and quality	6	6.3.1.2
Avoid sensitive habitats or species	6	6.3.2.1, 6.4.1.3, 6.4.1.4
Minimize frequency of disturbance	6	6.3.3.1
Multiple small rather than one large receiver site	6	6.3.3.2
Avoid steep scarps or slopes	6	6.3.2.4
Buffers to minimize impacts to sensitive habitats or species	6	6.3.5, 6.3.6
Schedule (e.g., environmental windows) – fish, birds	6	6.4.2.2, 6.4.2.3, 6.4.2.4
Construction operational controls, methods, BMPs – Turbidity	6	6.4.1.4, 6.4.4.2
Minimize noise levels in sensitive wildlife areas	6	6.4.4.5
Minimize artificial lighting in sensitive wildlife areas	6	6.4.4.6
Prepare hazardous materials plan, minimize leaks or spills	6	6.3.7.1, 6.4.4.4
Monitoring Considerations		
Physical		
Sediment compatibility inspections	6	6.4.5.1
Inlet monitoring and response	6	6.3.7.2
Water quality	6, 7	6.4.5.2, 7.4.2, 7.4.3
Biological		
Pre-construction habitat characterization	6	6.3.8.2
Sensitive habitat (e.g., snowy plover critical habitat)	7	7.3.2.2
Grunion habitat assessment, spawning	6, 7	6.4.5.4, 7.4.5.1
Least tern	6, 7	6.4.5.5, 7.4.5.2
Snowy plover	6, 7	6.4.5.5, 7.4.5.3
Marine mammals	6, 7	6.4.5.6, 7.4.5.4

Guideline Considerations:

List of Relevant Resource Protection Guidelines

The following guidelines may be relevant to Sandy Beach habitat depending on site-specific conditions:

Resource Protection Guidelines	User's Guide	
	This Section	Other Sections
Physical-Chemical		
Sand Compatibility	X	
Beach Water Quality	X	
Biological		
Beach Invertebrates	X	
Beach Wrack	X	
Clam Beds	X	
Dungeness Crab		3.3.3
Grunion Habitat Assessment	X	
Grunion Spawning	X	
Least Tern	X	
Snowy Plover	X	
Migratory Birds	X	
Marine Mammals		3.3.2

The guidelines for sandy beach invertebrates and beach wrack are relevant to resource protection of migratory birds (gulls and shorebirds) (see Section 3.3.3 for additional measures that may be applicable to migratory birds). Guidelines for beach water quality and sandy beach invertebrates are relevant to resource protection for nearshore fish.

Figure 3.3-1 provides a decision flow chart to relevant guidelines. Project duration and distance from sensitive resources are included in some of the decision questions. The project duration question specifies five days because RGP 67 specifies that implementation must be halted or modified if turbidity exceeds compliance criteria for five consecutive days. In addition, available laboratory studies of environmental effects associated with suspended sediments or sedimentation generally have tested for acute effects over time periods ranging from 24-96 hours (1 to 4 days) and chronic effects over time periods ranging from 8 to 25 days.

A distance within 1 mi (1.6 km) is referenced relative to occurrence of sensitive vegetated or hard bottom habitats or least tern nest sites. Impacts are not presumed within that distance, but rather that distance is suggested for evaluating potential environmental constraints. This is because turbidity and sedimentation effects in open coast energetic environments may occur within that distance (Section 2.7).

Other Potential Relevant Guidelines

The following sensitive habitats have the potential to occur adjacent, landward, or seaward of sandy beach habitat depending on site-specific conditions:

- Embayment habitat (Section 3.3.3),
- Dune or coastal strand habitat (Section 3.4.1),
- Rocky intertidal or subtidal habitats (Sections 3.4.2), or
- Seagrass habitats (Section 3.4.2 Surfgrass, 3.4.3 Eelgrass).
-

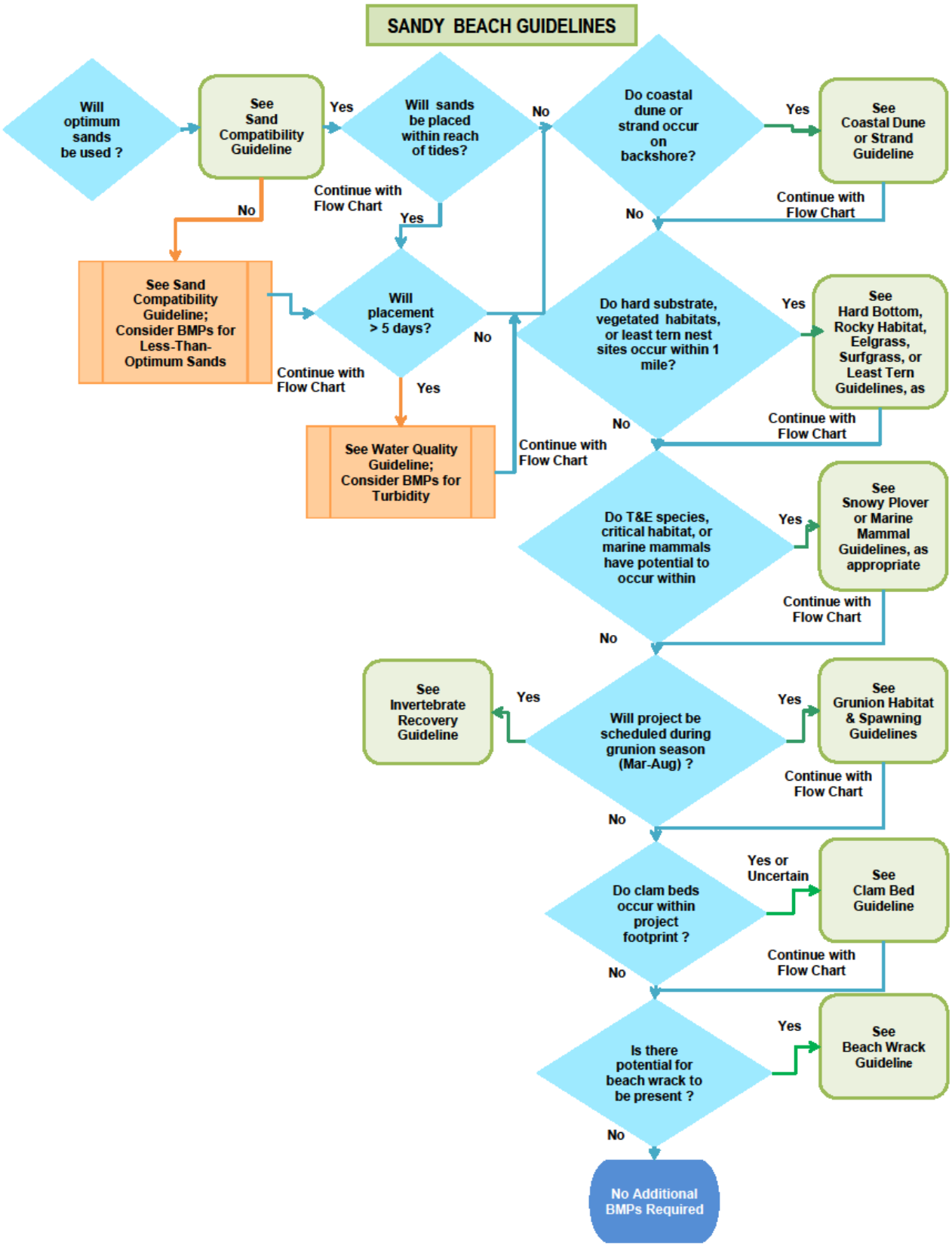


Figure 3.3-1. Flow chart to sandy beach habitat resource protection guidelines.

Sand Compatibility Guideline

Sand dollar test on sand
Photo credit: Karen Green

Definition: Compatible sands are physically and ecologically compatible for beneficial reuse as beach nourishment material.

Functions: Sand is the foundation of sandy beach and subtidal habitats and their associated ecological functions.

Sediment Management Issues: Physical and chemical characteristics of source material compared to receiver site conditions are used to define sand compatibility for beach nourishment. Sediment evaluation or testing is required consistent with the Inland Testing Manual prior to any sediment management activity involving dredging or discharge of materials within waters of the U.S. (USEPA and USACE 1998). USEPA and USACE (2004) guidelines for acceptability of dredge material for beneficial reuse specify that materials closely match the sediment composition of the eroding beach and be low in fine sediments, organic material, and pollutants. Generally, sands with less than 20% fines (silt/clay) or within 10% of the finest beach sample, and that are free of substantial contamination, may be permitted for beach nourishment in California (Higgins et al. 2004).

The Regional General Permit (RPG 67), used by the USACE (Los Angeles District, Regulatory Division) for beach nourishment, specifies that material must be at least 80% sand and have no more than 10% sand difference from the receiving beach (USACE 2006). For example, if the receiver beach has 5% fines, fill materials cannot exceed 15% fines. The permit further specifies that if materials deviate from this general practice, additional site-specific testing would likely be required, to be determined on a case-by-case basis, to ensure compliance with the 404(b)(1) guidelines. Placement of non-traditional materials (e.g., upland sand sources) may be authorized in the surf zone, subject to other applicable restrictions (location, timing).

Additional guidelines developed for the Sand Compatibility and Opportunistic Use Program (SCOUP) Plan (Moffatt & Nichol 2006) are referenced in the RGP 67. The SCOUP Plan distinguishes optimum from less-than-optimum sand sources based on silt/clay content of sediments, and also defines other considerations relative to sediment compatibility related to color, compaction, debris, location, particle shape, and particle size, as follows:

- Color - must reasonably match color of receiver site after natural color changes occur. Material not initially matching the receiver site's color must be placed in the surf zone;
- Compaction - must not form a hardpan crust if placed above reach of tides and waves;
- Debris content - must be free of trash and debris;
- Location - Optimum sands (< 15% fines) are appropriate for placement on the dry beach. Less-than-optimum sands (15-45% fines) may be placed in the surf zone or nearshore, dependant on [site specific] conditions and fines content;
- Particle shape - must not be substantially angular or jagged shaped (e.g., should not constitute greater than 10% of beach fill volume);
- Particle size (not larger than cobbles, and cobbles should constitute a very small portion of the fill.

Reviews indicate that material significantly coarser, finer, or with greater shell content than native beach sediments have the potential to adversely impact to invertebrates, fish, or

shorebirds (NRC 1995, Greene 2002, Rice and Peterson 2005). Therefore, sediment compatibility between sand sources and receiver sites is a relevant resource protection consideration for California. However, there is limited understanding of thresholds of deviation that may produce adverse effects or the influence of environmental factors (e.g., physical conditions and hydrodynamics) on impact significance. Several factors should be considered when evaluating source sand compatibility with selected receiver sites, including existing conditions, wave exposure and energy, and time of year. Sand placement at erosive beaches has the potential to enhance or restore sandy beach communities. Silt/clays may quickly disperse from sands at exposed beaches with higher wave energy. Impacts may be lessened by scheduling placement outside higher productivity timeframes.

Pilot projects using less-than-optimum sands in California have been implemented off Santa Cruz and Imperial Beach. Monitoring of those projects demonstrated that the high-energy coastal processes at those locations were effective at reworking small to moderate volume discharges of less-than-optimum sands. Sands deposited in the littoral zone and the fines settled farther offshore, essentially mimicking the fate of storm discharges.

- The Santa Cruz Port District conducted two demonstration projects (2001 and 2005) involving placement of approximately 3,000 to 6,600 cy of silty sand (31-40% sand, 60-69% silt/clay) into the surf-zone or nearshore off Twin Lake Beach. Monitoring of sediment samples demonstrated that fine sediments were transported offshore by local waves and currents and did not cause any significant changes in mean grain-size or silt/clay on beaches or shallow nearshore (Watt and Greene 2001, Sea Engineering 2006).

- The 2008-2009 Tijuana Estuary Fate and Transport study involved two separate placements (10,000 cy, 35,000 cy) of sands with 40% fines in the surf zone. Preliminary analysis of monitoring results demonstrated that fine sediments were completely reworked in beach sediments within 4 weeks of discharge (Warrick 2010). Monitoring results for biological resources were not available at the time of this writing.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Alteration of invertebrate communities • Turbidity interference with invertebrate recruitment and recovery, least tern foraging, or wildlife behavior • Compaction or sedimentation of snowy plover critical habitat or grunion spawning habitat
Other Activities or Issues of Concern • Proximity to sensitive habitats. • Compatibility with dune, if present	**Resources of Concern** • Invertebrates, grunion, demersal fish, least tern, snowy plover, shorebirds

Guideline Objectives:

- Maintain native sediment characteristics of beaches.
- Minimize alteration of invertebrate prey species for nearshore fishes and shorebirds.
- Promote recovery of invertebrate populations after beach nourishment disturbance.

Resource Protection Considerations

- Evaluate or test physical/chemical source sediments according to the Inland Testing Manual to verify "clean" and suitable for beach nourishment, or categorically excluded from testing according to 40 Code of Federal Regulations (CFR) 230.60(a) and (d).
- Restrict cobble or coarse shell hash content of source materials to no more than 10% combined. Avoid placement of rock larger than cobble size.
- Use rounded sand particles, minimize inclusion of angular or jagged particles to no more than 10%.
- Inspect sediment during construction to verify compliance of source materials with permit requirements and to ensure materials are free of debris or foreign materials.
- *Use Compatible Sands for Beneficial Reuse* – At least 80% sand with no more than a 10% difference in sand content between source and discharge sites.
  - Placement of compatible sands may include dry beach, surf zone, nearshore, or profile locations.
  - Standard monitoring requirements should apply based on project- and site-specific considerations (e.g., water quality, applicable sensitive aquatic resources).
- If permitted for use of *Non-Traditional Materials (including Less-Than-Optimum Sands; >15-45% fines)*, minimize impacts to biological resources using one or more of the following measures:
  - Avoid discharge in protected areas with low wave energy.
  - Place material in the active portion of the beach profile (e.g., surf zone, nearshore between the breaker zone and depth of closure), or within an actively flowing stream channel (near ocean outlet) to ensure rapid reworking of fill material. If conducting surf zone placement, test to ensure material does not create hard pan. Restrict from placement on dry beach.
  - Schedule during fall-winter (September 16-February 29) to mimic natural processes, and to avoid peak recruitment periods for beach invertebrates, spawning runs of grunion, or nesting season of least terns, as applicable.
  - Avoid placement not less than 1 week after substantial storm or high waves to minimize potential for cumulative impacts from prolonged turbidity.
  - Monitor water quality during construction and adjust or modify operations to ensure compliance with RWQCB permit requirements, as appropriate.*
  - Avoid placement in critical habitat of western snowy plover.
  - Initial placements should be small (e.g., ≤10,000 cy). Use adaptive management process to determine appropriate volume or sediment compatibility limitations based on site-specific conditions and monitoring.
  - Compare sediment grain size distribution and total organic carbon (TOC) before and after (e.g., 90 days) construction and submit to regulatory and resource agencies. Prior to implementation of future projects using non-traditional materials, coordinate with agencies to review results and potential project modifications (e.g., adaptive management), as appropriate.

*Refer to: Beach and Nearshore Water Quality Guidelines

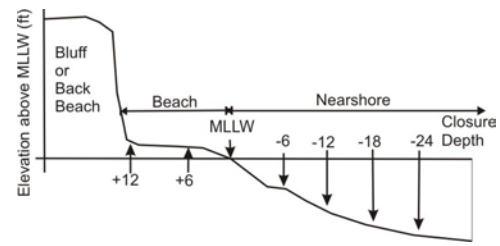
Effectiveness Considerations: Routine inspections of sediment characteristics during construction should be effective for ensuring that source materials comply with permit requirements as well as allowing early identification and remedy of delivery of inappropriate materials.

Minimizing changes in sediment characteristics between source and receiver site sediments generally is recommended for protecting sandy beach resources. This is a precautionary recommendation based on lessons learned from projects conducted elsewhere in the U.S. or abroad with reports of adverse effects when source and native sediments substantially differed. Most beach nourishment projects conducted in California have used sediments with <20% fines. A few relatively small pilot projects (3,000 to 35,000 cy) have used less-than-optimum sands with substantially greater percentages of fines (40-60%). Available monitoring of those projects indicate that surf zone hydrodynamics were effective at transporting fines offshore and reworking sediments.

Seasonal Considerations: Spring-Summer is the peak productivity period for beaches and nearshore waters. Summer also is the high use period for beach recreational use, which increases potential safety considerations associated with sand placement. Turbidity levels naturally range higher during the winter season due to storms and larger waves. Therefore, scheduling projects using less-than-optimum sands in late fall-winter would more closely mimic natural processes, minimize impacts, and lessen conflicts with public use of beaches.

Monitoring Considerations:

Sediment compatibility inspections during construction should include visual observations of sediment characteristics with particular attention given to presence of cobble/rock, coarse shell hash, silt/clay, foreign materials, or debris.



Source: Modified from Moffatt & Nichol 2006

Example of elevation locations for sediment sampling along a beach profile.

Sediment testing requirements for source materials are specified in the Inland Testing Manual (USEPA and USACE 1998). The SCOUP Plan recommends that sediment samples be collected at the receiver site at several locations (i.e., every 6 ft of elevation change) along onshore-offshore profiles, with at least two profiles surveyed for every ½ mile of affected beach (Moffatt & Nichol 2006). Sample results may be used to define a representative *profile composite,* grain size envelope, to "bracket" the range of grain sizes that occur. Stauble (2005) recommends computing separate intertidal and profile composites; generally, long-term beach fill performance is more favorable when matched to the intertidal composite. If less-than-optimum sands are used, pre- and post-construction sediment testing is recommended to verify that the silt/clay content is not significantly increased.

Limited information is available regarding impact thresholds for biological resources if source sediments are substantially coarser or finer than existing sediment conditions. It is possible that such thresholds may differ depending on type of beach, supported resources, and environmental conditions. Monitoring considerations are given in the Beach and Nearshore Water Quality Guidelines (Sections 3.3.1, 3.3.2), Beach Invertebrate Recovery Guideline (this Section 3.3.1), and sensitive HAPC habitats (Section 3.4).

Volume 1 References: SAIC (2011) – Section 5 (5.2.3.2, 5.5.3.5), Section 6 (6.4.5.1), and Section 7 (7.4.1).

Beach Water Quality Guideline

Sand bypass, Oceanside, San Diego
Photo credit: Karen Green

Definition: The surf zone and inner nearshore zone adjacent to the surf break zone.

Functions: Essential to marine life, foraging habitat for seabirds.

Sediment Management Issues: The SWRCB (implemented by regional offices RWQCB) is the regulatory authority for Clean Water Act (CWA) Section 401 Water Quality Certifications and/or Waste Discharge Requirements (WDRs) for dredge/fill projects, which must be obtained as part of the permitting process to implement a beach sand placement project. Monitoring requirements are specified in the certification and/or WDR, and may be project-specific (SAIC 2011, Appendix C).

Regulation of ocean water quality is based on several characteristics, including bacteria, physical, chemical, and biological objectives. Monitoring requirements generally include visual observations to verify water quality objectives for the following parameters, which may not be detected at levels that cause a nuisance or adversely affect beneficial uses:

- Discoloration.
- Floating particulates, trash, debris, solids, foam, scum.
- Objectionable aquatic growths.
- Odors (not detected and/or no aesthetic nuisance).
- Oil, grease, waxes, petroleum substances, visible films, coatings on objects.

Bacteria monitoring may be required to verify compliance that sediment disturbing activities do not result in adverse impacts to recreational beneficial uses of waters. Permit conditions have varied with respect to this monitoring requirement, presumably based on considerations such as receiver site proximity to stream discharges, source of sediment, and public use patterns, etc. Because bacteria sampling is a recreational use consideration, it is not discussed further in this biological resource protection guideline.

Sediments used for beach nourishment must be determined by the USACE, in coordination with USEPA, to be free of substantial contamination based on results of a sediment suitability evaluation or testing consistent with the Inland Testing Manual. Therefore, contaminants are not monitored during beach nourishment projects.

Suspended sediment is a primary water quality issue of concern to marine-associated biota during beach sand placement projects. Marine biota living within the littoral zone are adapted to episodic increases in suspended sediments, such as occurs with rip currents, high waves, or storms. Suspended sediments may result in adverse effects to feeding, respiration, spawning, photosynthesis, or movement of marine species, and under very high concentrations or prolonged exposures may be lethal. Reduced water clarity associated with suspended sediment also may interfere with foraging of seabirds.

Turbidity monitoring generally is required during dredging or discharge as an indicator of suspended sediment. Turbidity monitoring specifications in 401 certifications or WDRs may vary. Compliance criteria may be tailored by the RWQCBs. The Ocean Plan defines effluent limitations for turbidity (NTU) and specifies that natural light (light transmissivity, or total

irradiance) not be significantly reduced outside the zone of initial dilution (i.e., statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level).

Under the RGP 67, compliance is based on turbidity plumes not exceeding 0.5 mi (0.8 km) downcoast or offshore. Monitoring specifications include daily reports of plume mapping and photographs. Exceedance of the compliance criteria after two consecutive days requires notification of resource and regulatory agencies and modifying or halting the discharge. Furthermore, if plumes are out of compliance on the third day, water clarity testing (light transmission at mid-depth) is required at four locations (near discharge site, and 0.5 mi offshore, 0.5 mi downcoast, and 0.5 mi upcoast) until no project-related turbidity is detectable (i.e., offshore and downcoast readings return to ambient). If measured values downcoast or offshore are out of compliance for five (5) consecutive days, the discharge must be halted or modified.

Monitoring data indicate that turbidity plumes or measurements may deviate from compliance criteria. Although turbidity plumes may extend up to 2 mi (3.2 km) from the discharge location, concentrations rapidly decrease with distance when sandy sediments comprise the discharge or fill. Suspended sediment concentrations of approximately 1,000 to >4,000 mg/L may occur in the surf zone at the discharge location during placement activities, particularly if the discharge or fill are rapidly introduced to the swash zone (e.g., unconfined hydraulic discharge, bulldozer pushes sands into swash) or silt/clay content exceeds 20%. Concentrations decrease with increasing distance, both alongshore and offshore. Suspended sediment concentrations during beach sand placement generally are within the range observed during moderate to high waves or storms. However, very high concentrations, while within the range that may naturally occur near the sediment bottom, may be rare for overlying waters.

Laboratory experiments suggest that many marine species tolerate relatively high suspended sediment concentrations over relatively short periods of time (e.g., hours to a few days) (Section 2.7.6). However, tolerance or threshold levels for adverse effects decrease with prolonged exposure. Early life stages generally have the lowest thresholds for impacts.

Most natural episodes of high suspended sediment concentrations occur during winter storms or high waves. Marine resources exhibit seasonal differences in distribution, abundance, reproduction, and productivity. Therefore, project timing may be an important consideration relative to the nature of potential impacts associated with changes to water quality during sediment management projects and resource protection considerations.

Based on these considerations, suspended sediment effects may be of greater concern during spring-summer invertebrate recruitment, or in proximity to sensitive habitats (ASBS, HAPC, MPA, SAS), endangered least tern breeding colonies, or other suspended-sediment sources with potential for cumulative effects (e.g., streams, other discharges).

Turbidity plumes during beach sand placement may vary depending on equipment and methods of placement. Suspended sediment concentrations may vary from nearly continuous with use of a cutterhead dredge to pulsed discharges with periods of recovery between discharges (e.g., hopper dredge discharge, truck placement). Suspended sediment concentrations generally are lower when materials are placed behind temporary sand dikes or higher on the beach, both of which may promote settlement of sand on the beach during hydraulic pumping operations (Section 2.7.5). Concentrations also may be lower when sand is placed in piles on the foreshore and waves rework the material. Sand spreading in the swash zone results in higher concentrations and should be minimized to the extent practical.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Debris, leaks or spills • Suspended sediment, turbidity, water clarity
Other Activities or Issues of Concern	**Resources of Concern**
• Proximity to other discharges	• ASBS, HAPC, MPA, SAS • Forage base, Clam beds, grunion, least terns

Guideline Objectives:

- Avoid degradation of sensitive marine habitats during sediment management activities.
- Minimize adverse effects of suspended sediment and turbidity.

Resource Protection Considerations

- Evaluate or test sediments according to the Inland Testing Manual to ensure that source sands for placement are free of substantial contamination or organic content.*
- Conduct inspections of sediment during sand placement to verify compliance with permit requirements and that materials are free of unintended debris or materials.*
- Prepare a Spill Prevention Control and Countermeasures Plan (SPCC) prior to initiating placement operations that specifies fueling, equipment maintenance procedures to prevent spills and leaks, and best management practices (BMPs) to contain and clean-up hazardous materials in the event of a spill.
- Clean or repair equipment (other than emergency repairs) at least 500 ft (152 m) from the high tide line.
- Locate staging areas outside the reach of tides or waves.
- Avoid driving vehicles or spreading sand in the swash zone to extent practical.
- Schedule project outside the spring-summer peak invertebrate recruitment period, if feasible, which also coincides with the grunion season, if suitable grunion habitat is present.**
- Monitor water quality during placement to verify compliance with RWQCB 401 water quality certification and/or WDR requirements.
  - Document visual observations relevant to water quality objectives (e.g., discoloration, floating particulates, debris/trash, solid waste, odors, petroleum substances or films, tide stage, current direction and speed, weather).Conduct turbidity plume mapping during discharge operations (daily first week, once/week thereafter). A qualified observer will map plume from one or more high vantage points (e.g., lifeguard tower, bluff). Document the following:
    - Date, time, wave height, swell direction, tide stage, weather.
    - Plume dimensions – length up- and downcurrent, and whether plume extends beyond waves.
    - Rip currents that may contribute to turbidity outside the breaker zone.
    - Representative photographs – document plume appearance near and away from the discharge.
    - Verify plume dimensions do not exceed 0.5 mi (0.8 km) downcurrent, upcurrent, or offshore.
    - Note plume incursions into sensitive habitat areas (ASBS, HAPC, MPA, SAS), if nearby.
    - Note if plume is outside wave zone within 1 mi (1.6 km) of least tern breeding colonies.

Continued Next Page

Resource Protection Considerations (Continued)

- Note any corrective actions and the effectiveness of measures used to meet compliance requirements. Take all reasonable steps to correct operations resulting in non-compliance, including implementation of one or more of the following BMPs or operational control measures, as applicable or necessary, according to following placement methods:

  Hydraulic Discharge

  - Pump behind temporary sand dikes to promote settlement of sands and slow the introduction of suspended sediments to receiving waters. May need to pump sand to beach to construct dikes.
  - Pump high on the beach to promote settlement of sands and slow the introduction of suspended sediments to receiving waters if temporary dikes have not yet been constructed or are not practical.
  - Adjust operational controls (e.g., slow placement rate, cycle time), as necessary.

  Sand Placement by Trucks or Other Earth Moving Equipment

  - Place sands on foreshore in discrete piles. Piles should be open to wave action on all sides and not form long continuous, wide, or tall walls of sand. If material is not dispersed within one tide cycle, pile dimensions should be adjusted to ensure reworking on next high tide. Do not spread sand in swash.
  - Adjust operational controls (e.g., sand pile dimensions, rate of pile placement), as necessary.
- Notify the RWQCB and USACE by e-mail, if turbidity plumes are out-of-compliance for two consecutive days, and comply with any measures identified by the permitting agencies, in consultation with other responsible agencies, as appropriate, to mitigate project-related turbidity, including modifying or halting discharge.
- If out of compliance turbidity persists the third day, conduct additional monitoring as may be necessary to determine the nature and impact of non-compliance:
  - If Project duration < 1 week and plume does not extend into sensitive habitat – continue to map turbidity plume and modify discharge to achieve compliance.
  - If Project duration is > 1 week, plume extends into sensitive habitat (ASBS, HAPC, MPA, or SAS), or within 1 mi (1.6 km) of least tern breeding– conduct additional monitoring.
- Sampling, analysis, quality assurance, reporting, and photo-documentation should be in accordance with the Surface Water Ambient Program (SWAMP) requirements, as applicable.

Effectiveness Considerations: Preparation of appropriate plans for addressing hazards, inspections, and equipment operation restrictions, are effective for avoiding and minimizing contaminant concerns and issues.

Reducing turbidity during beach nourishment projects may be accomplished at the design phase by limiting the percentage of fines in the beach fill material (see Sand Compatibility Guideline). Data evaluation suggests that turbidity may be minimized during construction by use of structural measures (temporary dikes), placement methods (e.g., piles, upper beach discharge), or operational controls (adjust sediment-water slurry, cycle times) (Section 2.7.5). However, comparative data are limited on the relative effectiveness of these different types of measures. Therefore, it is recommended that monitoring reports include description of methods

and corrective actions to control turbidity so that information may be collected to help address that data gap.

Unconfined hydraulic discharge

Hydraulic discharge behind dike

Photo credit: SANDAG

Seasonal Considerations: Turbidity naturally ranges higher during winter storms or high wave conditions. Therefore, the difference between project-related turbidity and ambient conditions may be less during winter than in summer. Generally, elevated suspended sediment is of greater concern during spring-summer when biological productivity is higher, invertebrate larvae recruit from plankton to beaches, grunion may spawn on beaches, and breeding populations of sensitive birds species may be in the vicinity (e.g., California least tern, snowy plover).

Monitoring Considerations: Monitoring generally is required to comply with RWQCB 401 water quality certifications and/or WDRs. Monitoring may include visual inspections or observations, water quality measurements, and/or water samples. The Munsell color system is recommended to help standardize color descriptions and distinction between sediment-derived color shifts from those of plankton blooms (*http://oceandatacenter.ucsc.edu/PhytoBlog/color%20system.html*).

Turbidity plumes dimensions are useful for determining the extent of project influence on water quality. Visual estimates of upcoast and downcoast plume lengths may be effective for field decisions of whether additional control measures (e.g., lengthening of temporary dikes, decreasing sand pile dimension, adjustments to slurry, increased cycle times) may be needed to comply with permit limits. Visual plume mapping can be affected by weather, sun angle, or may be difficult in areas of high ambient turbidity, all of which may reduce monitoring effectiveness. Use of polarized sunglasses is recommended to cut down on glare from the water. While it is easier to see turbidity plumes and rip currents from a high vantage point, care should be exercised if viewing from a bluff top; sandstone bluffs are erodible and may be unstable.

Additional monitoring may assist biological resource protection if placement operations have the potential to result in prolonged turbidity, relatively large plumes, or operations are scheduled during the relatively more sensitive spring-summer productivity period. This may be particularly relevant if plumes have the potential to affect sensitive habitats (e.g., ASBS, HAPC, MPA, SAS) or resources (e.g., endangered least tern foraging areas).

A nephelometer instrument (NTU values) may be used to provide field measurements of turbidity. NTU measurements are helpful for assessing the effectiveness of measures used to adjust BMPs or operational controls to minimize turbidity plumes. Measurements recorded along a distance gradient from the receiver site generally are more informative for assessing the effectiveness of field adjustments to meet compliance criteria than measurements limited to inside and outside the plume. Use of standard distances to collect data would improve consistency among projects and the ability to evaluate the effectiveness of control measures.

Light transmission and/or TSS measurements provide values with greater biological relevance than turbidity values. However, they are more time consuming or expensive to measure (e.g., require boat, instrument, or laboratory analysis). Additional monitoring may be relevant if prolonged turbidity would affect sensitive habitats or foraging areas of sensitive species.

Volume 1 References: SAIC 2011 – Section 5 (5.5.2), Section 6 (6.4.1.4, 6.4.3.3, 6.4.4.2, 6.4.4.4, 6.4.5.2), and Section 7 (7.4.2, 7.4.3).

Beach Invertebrate Recovery Guideline

Photo credit: Karen Green

Definition: Animals without backbones that live within or on sandy beaches between low and high tides. Terrestrial insects also may be associated with beach wrack. Common invertebrates include clams, sand crabs, other crustaceans, and worms.

Functions: Prey for birds and fish, and recycle nutrients.

Sediment Management Issues: Sandy beach invertebrates are essential prey items for shorebirds and fish, which feed at different times depending on tide stage. Sandy beach invertebrate communities differ in development depending on beach type and substrate. Beach nourishment activities bury or crush invertebrates within the fill site, but may result in habitat enhancement at or adjacent to the fill site associated with the influx of sand. Generally, invertebrate recovery is relatively rapid to beaches, but may take longer depending on project schedule, frequency of disturbance, or compatibility of source materials. Recovery also may be delayed if disturbance impacts clam beds or highly diverse communities supporting multi-age class populations.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Equipment, burial, turbidity
Other Activities or Issues of Concern	**Species of Concern**
• Beach grooming • Beach scraping	• Clams, crustaceans (e.g., amphipods, isopods, sand crabs), worms

Guideline Objectives:

- Promote recovery of invertebrates.
- Minimize degradation of prey species for nearshore fishes and shorebirds.

Resource Protection Considerations

- Avoid sand placement at productive, gently sloping (dissipative) beaches.
- Avoid repetitive sand placement at the same location during the same year.
- Conduct sediment inspections during sand placement to ensure compatibility with permit requirements.
- Minimize impacts with implementation of one or more of the following measures:
  - Minimize shell, rock, very coarse sands, or silt/clay content of source materials used for beach nourishment.
  - Schedule sand placement outside the peak (spring-summer) invertebrate recruitment period, if possible.
  - Use temporary dikes, swales, or operational BMPs to minimize turbidity during sand placement.
  - Incorporate refuge areas with use of multiple small sites instead of one large site (e.g., leave gaps between receiver site locations).

Effectiveness Considerations: Minimizing differences between source sediments and existing sands should lessen the potential to alter invertebrate communities. However, several factors should be considered when evaluating source sand compatibility with selected receiver sites. Sand placement at erosive beaches has the potential to enhance or restore sandy beach communities. Generally, the proportion of very coarse or very fine sediment in sand source materials should be minimized. Shell hash or very coarse sediment may interfere with shorebird foraging or reduce the moisture holding properties of sediment, which may be detrimental to grunion egg incubation. High silt/clay content may result in excessive turbidity or reduce oxygen content of sediment, which may be detrimental to invertebrates or grunion egg incubation. Recovery may be promoted by minimizing frequency of disturbance or conducting activities outside the spring-summer peak recruitment period. (However, it should be noted that use of less-than-optimum source sands [e.g., coarser, finer] may be beneficial in certain situations.)

Seasonal Considerations: Recovery may be promoted by lessening interference with natural seasonal recruitment, which primarily occurs in spring and summer.

Monitoring Considerations: Sampling design considerations (number of stations, replicates) for sandy beach monitoring should be determined based on site conditions and study objectives. Habitat characterizations require less effort than documentation of recovery.

Habitat characterizations may include description of physical conditions such as substrate (e.g., sand, cobble ratios), slope, sand depth if over a rock bench or cobble, and grain size characteristics. Biological resource descriptions may include collection of sediment samples for analysis of invertebrates and visual observations of wildlife (e.g., shorebirds, gulls, seals or sea lions). Notes should be made of adjacent habitats, particularly sensitive coastal strand, rocky intertidal, or subtidal habitats, including occurrence of surfgrass.

Sand crab

Photo credit: Peter Bryant

Sandy beach invertebrates exhibit tidal zonation and sampling designs should include collection of samples across the beach from low to high tide. This may be accomplished by sampling at uniform intervals across the beach or within upper, middle, and lower intertidal zones (Parr et al. 1978, Straughan 1982, Dugan et al. 2000, 2003; SAIC 2006). Because conditions may vary along the length of a beach, measurements and samples should be collected at more than one location. Establishing transects (oriented in on- to offshore direction) at different locations along the beach enables easy co-location of physical and biological sample collection.

Beach Invertebrates have been sampled using hand-held cores, box samples, or standard shovel samples (Parr et al. 1978, Straughan 1982, McLachlan et al. 1984, Nelson 1993, Dugan et al. 2000, Schoeman et al. 2000, Dugan et al. 2003, SAIC 2006). If cores are used, Straughan (1982) recommended that they should have a minimum diameter of 3 in (7.6 cm) and depth of 8 in (20 cm). Collected samples are sieved in the wave wash to separate animals from sediment; use of a 1 mm sieve provides the greatest consistency with historical data from California (Straughan 1982, Dugan et al. 2000, Dugan et al. 2003, SAIC 2006). Certain upper intertidal invertebrates (e.g., beach hoppers) or terrestrial insects (e.g., kelp flies) may require specialized techniques to capture, but the occurrence may be noted. Effective detection of clam beds requires additional sampling techniques (see Clam Bed Guideline).

Volume 1 References: SAIC 2011 – Section 4 (4.2.6), Section 5 (5.2, 5.3.3.2, 5.3.4.1, 5.4.3.2, 5.4.4.1, 5.5.4.3), Section 6 (6.3.1, 6.3.3), and Section 7 (7.5.1).

Beach Wrack Guideline

Photo credit: Karen Green

Definition: Beach wrack includes dislodged marine vegetation (e.g., algae, kelp, seagrasses) or debris that is cast ashore.

Ecological Functions:
Nutrient recycling, dune formation, and wildlife forage.

Sediment Management Issues: Beach wrack is an ecologically important resource. Beach wrack supports numerous small invertebrates like beach hoppers, beetles, isopods, kelp flies, and other insects (Beeler 2009). Once stranded, seaweed is soon visited by kelp flies. Kelp flies may be a nuisance when there are substantial piles of kelp, but they are not interested in "bugging" beach goers. They do not feed on picnic food or lay eggs on trash. *Kelp flies are specialized to live on kelp.* When disturbed, the flies take to the air, but stay low to the sand and quickly resettle onto the seaweed. The flies feed on kelp wrack, deposit eggs on the wrack, and the larvae feed on the rotting seaweed. The fly larvae, together with the beach hoppers, are responsible for the breakdown of the kelp wrack. Many of the wrack-associated invertebrates live nowhere else. A variety of gulls and shorebirds feed on the animals associated with beach wrack.

Kelp fly and beach hopper
Photo credit: Peter Bryant

Beach wrack may occur year round, but generally is more common during winter when larger waves or storms may dislodge plants. The invertebrates associated with beach wrack may be an important part of the diet of threatened snowy plovers, particularly those that overwinter at beaches. Beach wrack as well as drift wood catch and hold beach sand, which may lead to formation of hummocks that contribute to development of dunes, if present.

California State Parks ban the collection of kelp or driftwood to protect snowy plovers and their habitat (State Parks 2002). However, beach wrack may be perceived as a nuisance or safety issue at beaches with high public use. Beach grooming that removes wrack reduces the diversity and abundance of the invertebrate forage base, which in turn may reduce the variety and abundance of birds found at a beach (Dugan et al. 2003). Cities may restrict or limit wrack removal (e.g., CCC 2006 a, b), but policies are not standard (NOAA 2008).

Beach nourishment has the potential to result in a temporary reduction in beach wrack, particularly if hydraulic discharge and sand spreading are conducted. Nourishment involving placement of sand piles in the surf zone does not involve sand spreading. Generally, beach nourishment would not have a long-term effect on beach wrack occurrence at a beach. However, there would be the potential for beach nourishment to indirectly influence beach wrack if grooming practices were initiated as a result of the additional sand.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Equipment, vehicles
Other Activities or Issues of Concern	**Resources of Concern**
• Beach grooming	• Western Snowy Plover

Guideline Objectives:

- Minimize impact of removal of beach wrack to beach ecology.
- Promote recovery of invertebrate forage base after beach nourishment.
- Protect forage for shorebirds, including threatened snowy plover.
- Minimize impact to nutrient recycling of beach habitat.

Resource Protection Considerations

- Do not bury or remove beach wrack unless part of an authorized activity (beach nourishment, maintenance).
- If authorized, implement one or more of the following measures, as appropriate:
  - Coordinate with USFWS if snowy plovers or their critical habitat are present and burial or removal of beach wrack is anticipated.
  - Minimize burial of beach wrack during beach nourishment.
    - If conducting hydraulic discharge and beach wrack is present, remove a portion to the back beach or adjacent beach where it may be left undisturbed.
    - If placing sand by truck, avoid burial of beach wrack to maximum extent practical.
  - Minimize removal of wrack during beach maintenance unless public health or safety hazard.*
    - Avoid removal of localized or isolated piles of wrack that do not pose a hazard.
    - Leave wrack line ungroomed during grunion season. Mark the wrack line after the semilunar highest high tide line and avoid use of any mechanized maintenance equipment seaward of that line for the following two week period. Re-establish the line with each semi-lunar high tide for the duration of the grunion season (March 1-August 31).
    - If removal of large piles of wrack are necessary, remove to dry back beach above high tide zone and cover with sand to enhance shoreline protection and retain nutrients. Work landward of the wrack line when feasible and minimize operation of vehicles seaward of the wrack line.

*Beach maintenance activities are independent of beach nourishment, but were included in the guideline based on requests by stakeholder participants in the guideline development workshops

Effectiveness Considerations: Retaining beach wrack helps protect beach ecology. Kelp wrack naturally dries and decomposes; therefore, management generally is unnecessary unless a substantial volume is present. Removal of excessive wrack to a dry beach area where it cannot be reached by tides or other water and covering the piles with sand should be effective for reducing the volume of organic matter (D. Simmons, 2011 personal communication). Coordination of management protocols with resource agencies should be effective for minimizing unintended wildlife impacts.

Environmental beach grooming at Mission Beach, California

(Groomed area on backshore and un-groomed foreshore with kelp)

Photo credit: Karen Martin

***Seasonal Considerations*:** Beach wrack may be greater after winter storms or high wave conditions.

Monitoring Considerations: Implementation does not require monitoring. Periodic inspections would be sufficient to verify compliance with guideline.

Volume 1 References: SAIC 2011 – Section 3 (3.3.2) and Section 6 (6.4.4.6).

Clam Bed Guideline

Gull with Pismo Clam
Photo credit: Karen Straus

Definition: An underwater or intertidal area in which clams are established in large numbers**.** A clam bed is further distinguished as a persistent feature characterized by the presence of multi-age classes of clams.

Status: State managed fishery species.

Functions: Prey for birds, fish, and other wildlife.

Sediment Management Issues: Juvenile clams are not uncommon at beaches due to recruitment from the plankton. However, clam beds, which may occur in the lower intertidal to subtidal depths, only occur at certain beaches where environmental conditions support their development. Generally, Pismo clam (*Tivela stultorum*) beds in central and southern California or Pacific razor clam (*Siliqua patula*) beds in northern California are associated with gentle sloped beaches with persistent sand across seasons. The common littleneck clam (*Protothaca staminea)* concentrates in localized areas on the open coast with coarse sands mixed with cobble, fine gravel, or shell. Clam beds are subject to recreational fishing pressure and clam species are managed with daily bag limits and in some areas additional restrictions (CDFG 2009). Sea otters also favor clams and have resulted in substantial predation pressure on clam beds in certain areas of the coasts.

Clam beds may be relatively persistent features. Pismo clams may live more than 50 years (Leet et al. 1992). Pacific razor clams may live 5 to 10 years. Because of the multi-age structure of clam beds, recovery after major disturbance could take several years.

Beach nourishment has the potential to directly impact clam beds, if present, by burial (beach, nearshore, profile placement) or damage from earth moving equipment or vehicles. Indirect impacts may result from turbidity or sedimentation. Clam beds generally only establish on persistent sand beaches that maintain a sandy low-tide terrace through the storm season. Clams feed on small planktonic organisms and detritus through their siphons. Turbidity may interfere with feeding or result in death if exposed to prolonged durations of elevated suspended sediment. In an experiment, surf clam (*Spisula solidissima*) was able acclimate to suspended sediment concentrations up to 500 mg/L with some interference of feeding, but was unable to acclimate to concentrations exceeding 1,000 mg/L (Robinson et al. 1984). Razor clams have been reported to die from suffocation after exposure to high concentrations of silt (Lassuy and Simons 1989). A large littleneck clam bed at a cobble beach at San Onofre in southern California required 5 years to recover after heavy creek runoff resulted in sanding-in of the cobble habitat (CDFG 2001). Generally, clams are competent burrowers that change position in the sand in response to changes in sand levels or disturbance. Therefore, the primary impacts of concern to clam beds from beach nourishment activities include burial or substantial turbidity.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Burial • Sedimentation, Turbidity
Other Activities or Issues of Concern	Resources of Concern
	• Pismo clam, Pacific razor clam, common littleneck clam

Guideline Objectives:

- Avoid direct impacts to clam beds.
- Minimize turbidity in clam beds.
- Minimize degradation of prey species for nearshore fishes and shorebirds.

Pismo clam

Photo credit: Shane Anderson

Resource Protection Considerations

- Avoid direct burial of adult clams of legal harvest size.
- Contact CDFG to obtain current information on local populations and surveys in the project area.
- Conduct a pre-construction assessment of the proposed fill site to verify presence or absence of clam beds.
- Minimize impacts with implementation of one or more of the following measures if a clam bed is present or suspected in low intertidal or shallow subtidal:
  - Avoid surf- or swash zone discharge.
  - Narrow the beach fill to avoid placement in the 0 MLLW to minus tide zone.
  - Place sand on upper beach to slow the rate of sand movement seaward.
  - Slow the rate at which beach width is built towards the lower intertidal.
  - Use temporary dikes or operational controls to minimize turbidity.

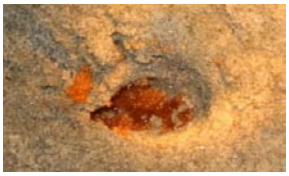
Effectiveness Considerations: Clam beds may occur in lower intertidal to subtidal depths. Avoiding discharge of sand in the lower intertidal, swash zone, or surf zone minimizes the potential to directly impact adult clams, if present. Avoidance of impacts to legal-sized adults would protect reproduction and lessen the potential for local population impacts. During the 1995 Surfside-Sunset Beach Nourishment Project, the USACE (1995) specified that beach material would be placed on the upper portion of beach and allowed to slowly migrate seaward to minimize impacts to Pismo clams. Pismo clams, Pacific razor clams, and common littleneck clams are capable burrowers. Therefore, slowing the seaward movement of sand may be effective by allowing time for adult clams to adjust position to changing sand levels.

Seasonal Considerations: Clam beds are perennial. Generally, peak spawning occurs in late spring through summer, although the timing may vary depending on a variety of factors.

Monitoring Considerations: The DFG uses transects to conduct beach surveys for Pismo clams, which involve digging trenches with clam forks (or potato forks) from the low intertidal to the mid-tide zone at several locations per beach site. Transects also may be used for underwater surveys by qualified biologists, who look for visible signs of clam occurrence (e.g., siphons, shells), with species verified by collection.

Volume 1 References: SAIC 2011 – Section 4 (4.2.4), Section 5 (5.5.4.3), and Section 6 (6.3.8.2, 6.4.1.4).

Grunion Habitat Assessment Guideline



Grunion eggs
Photo credit: Holly Williams

Definition: Grunion spawning habitat occurs on sandy beaches, but spawning also may occur on tidal sand flats in certain bays (e.g., Mission Bay, Newport Bay, San Diego Bay, San Francisco Bay).

Sediment Management Issues: Grunion spawn in sand on beaches or tidal flats at night during semi-lunar spring high tides between March and August, although some spawning may occur in February or September. Beach construction has the potential to interfere with spawning or damage eggs. Although grunion is not a protected species, its spawning habitat is limited to sandy beaches and resource agencies generally require avoidance or minimization of potential impacts to spawning or spawning habitat during their predicted spawning season.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Burial or destruction of spawned eggs • Sediment compatibility for egg incubation • Turbidity interference with spawning
Other Activities or Issues of Concern	**Resources of Concern**
• Egg damage (beach grooming, vehicles)	• California grunion

Guideline Objectives:

- Identify potential grunion habitat.
- Minimize impacts to grunion spawning.

Resource Protection Considerations

- Assume sandy beach is suitable for spawning unless assessed by a qualified biologist.
- Coordinate with CDFG and NMFS prior to and after habitat assessments if construction is scheduled during the predicted spawning season.*
- A qualified biologist will conduct the initial habitat assessment no more than 2 weeks prior to a predicted grunion run within 30 days of construction. The assessment will be based on multiple factors, including:
  - *Beach slope*. Steep slopes may impede spawning or contribute to grunion stranding if following waves would be insufficient to carry them back to sea after spawning.
  - *Beach width*. Grunion will not spawn where beaches are too narrow and waves completely cover the foreshore during average high tides.
  - *Impediments (e.g., sea cliff, riprap, seawall)*. Grunion will not spawn where they cannot emerge from tides, but may spawn seaward of impediments as the tide drops if beach width is suitable.
  - *Percent hard substrate cover*. Grunion will not spawn where there is complete cover by rock. However, grunion may spawn in sand at beaches with mixed sand and cobble.
  - *Sand characteristics*. Shallow sand depths (< 5 in, 13 cm) over hard substrate may be insufficient for females to deposit eggs. Grunion will not spawn in coarse pebbles or cobble.
  - *Scarps*. Steep scarps may form during winter and impede spawning during the grunion season. However, grunion may spawn adjacent to a scarp or sand berm if able to emerge during falling tides.

Resource Protection Considerations (Continued)

- Habitat assessments may be scheduled on the same day in advance of monitoring a predicted grunion run provided that no construction is scheduled seaward of the highest semi-lunar spring tide line for the following two week period if spawning is observed.
- Habitat assessments are to be repeated prior to each predicted grunion run during construction if the initial assessment is negative. Repeat assessments are unnecessary once habitat is assessed as being suitable for spawning. However, suitable habitats will be monitored for spawning runs every two weeks during construction.*
- Submit habitat assessment results and proposed grunion protective measures to resource and regulatory agencies for concurrence prior to construction.

*Refer to: Grunion Spawning Guideline.

Effectiveness Considerations: The assumption that habitat is suitable unless assessed otherwise is protective. Assessment of habitat suitability by a qualified biologist should be effective when based on multiple criteria. Repeat assessments should be effective for ensuring that findings are up-to-date as beach conditions change over the season.

Seasonal Considerations: Spawning runs are predicted by the CDFG between March 1-August 31. The spawning season varies and start-end times of the season should be verified with appropriate resource and regulatory agencies.

Monitoring Considerations: Grunion runs may occur at approximately two-week intervals during the spawning season. During this period, habitat suitability may naturally improve as sand accretes to beaches between spring and summer. Grunion habitat suitability surveys should be conducted by a qualified biologist.

Sand depth measurements and substrate characteristics may be visually assessed in the upper intertidal zone between the spring and neap high tide levels, which will vary over time depending on beach slope and width. Assessments should be conducted shoreward of the highest neap tide or daytime lower high spring tide. Assessments should be referenced according tide type (spring, neap), stage (higher high, high), and time of day.

Volume 1 References: SAIC 2011 – Section 4 (4.3.1), and Section 6 (6.4.2.3, 6.6.2.2)

Other References:
Beach Ecology Coalition 2011.
Predicted runs available at *www.dfg.ca.gov/mrd/gruschd.html.*

Rip rap may limit suitability

Dense cobble limits suitability

Narrow beach may limits suitability

Wide sandy beach suitable

Grunion Spawning Guideline

Leuresthes tenuis

Photo credit: Karen Straus

Status: State managed fishery species.

Functions: Prey for birds, fish (including federally managed species), and other wildlife.

Sediment Management Issues: California Grunion spawn in sand on beaches or tidal flats at night during semi-lunar spring high tides generally between March and August, although some spawning may occur in February or September. There is potential to interfere with spawning or damage incubating eggs if mechanized equipment is used on the beach during the spawning season.

There also is the potential to interfere with spawning during discharge operations. Grunion may concentrate in the nearshore during the day prior to night-time spawning runs (K. Martin, 2011 personal communication). Grunion forage on small, particulate matter. Studies have shown attraction or avoidance of turbidity plumes by planktivorous fish (such as grunion) that feed on small planktonic organisms or particulates depending on turbidity concentration and duration (Wilber and Clarke 2001, DeRobertis et al. 2003).

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Burial or destruction of spawned eggs • Sediment compatibility • Turbidity, sedimentation
Other Activities or Issues of Concern • Beach grooming • Beach driving	**Resources of Concern** • California grunion

Guideline Objectives:

- Avoid or minimize impacts to grunion spawning.
- Protect buried eggs until hatching.

Resource Protection Considerations

- Schedule construction outside the spawning season if suitable habitat is present.
- Avoid driving or operation of mechanized equipment seaward of the semi-lunar spring tides during the grunion season if suitable spawning habitat is present. (Note that the semi-lunar spring tide area will be the egg incubation areas with dry sand in between spawning runs). *
- If construction cannot be scheduled outside the spawning season, coordinate with CDFG and NMFS at least 30 days prior to the proposed discharge. The project proponent will need to provide a detailed justification why construction must occur during the grunion season. The justification should outline the planning steps that were taken to avoid and/or minimize construction during the grunion spawning season and specify the economic, environmental, and/or logistical constraints that preclude operating outside the spawning season. If permitted, implement one or more of the following protective measures, as appropriate to project, site conditions, and direction of the resource agencies:
  - Use source sands for beach nourishment with low percentages of fines (silt-clay) or very coarse sands if suitable spawning habitat is present.*

Resource Protection Considerations (Continued)

- Direct construction lights away from the surf zone.
- If sufficient space is available on the supratidal beach terrace, restrict construction shoreward of the highest semi-lunar spring tide line.
- Use a diked, single-point discharge if suitable spawning habitat is present.*
  - Construct temporary sand dikes (one perpendicular and one parallel to the ocean) shoreward of the highest semi-lunar spring tide along the length of construction.
  - If the fill site is long, dikes may be built in sections with movement of construction along a beach, provided that the new section is in place prior to discharge.
  - Temporary dikes are to be maintained until construction is over and monitoring has confirmed no spawning or the grunion season has ended, at which time the dike may be knocked down and contoured into the finished beach slope.
  - Any maintenance of a temporary dike shall be from the shoreward side.
- A qualified biologist will monitor all predicted grunion runs within two weeks prior to and throughout the construction period if suitable spawning habitat is present.*
  - Monitor the entire length of the beach fill or the anticipated length of construction over the following two-week period as well as an adjacent buffer distance (e.g., 100 ft, 30 m). The buffer distance may be project-specific.
  - If a grunion run is observed, categorize it according to the Walker scale, flag and GPS spawning locations.
  - If a dike is present, inspect to verify that spawning occurs seaward of the dike.
  - If the dike is breached and fish spawn behind the dike, redirect construction shoreward, and count and return stranded fish to the sea. Any dike repair will be shoreward of the highest tide line and at least 15 ft from spawning locations.
  - If spawning is observed and no dike is present, implement one or more of the following measures with concurrence of CDFG and NMFS:
    - If Walker scale is 0 or 1, no additional measures are necessary.
    - If Walker scale is 2 and spawning is localized, establish a dike or buffer area to ensure construction activities or sand transport do not bury or disturb eggs.
    - If Walker scale is $\geq$ 2 with multiple spawning areas, restrict construction shoreward of the highest semi-lunar spring tide line until eggs hatch (about 2 weeks) or halt construction if impact avoidance is not feasible. If during subsequent grunion spawning events a Walker scale $\geq$ 2 occurs, the same restrictions described in this section would apply.

*Refer to: Grunion Spawning Habitat Assessment Guideline

Effectiveness Considerations: Use of a diked, single-point discharge minimizes the area of potential impact and decreases turbidity. Construction shoreward of the highest semi-lunar spring tide protects incubating eggs, if present. Limited information is available regarding sand compatibility thresholds for egg incubation. Concerns are that coarse sand may retain insufficient moisture to protect eggs or silt-clays may fill air spaces between sand grains and smother eggs. Use of the Walker scale may increase consistency of monitoring programs.

Seasonal Considerations: Spawning runs are predicted by the CDFG between March 1-August 31. The spawning season varies and start-end times of the season should be verified with appropriate resource and regulatory agencies.

Monitoring Considerations: Monitoring only is necessary if construction is scheduled during the grunion season and suitable spawning habitat is present. Monitoring should be conducted by qualified biologists for a total of four nights starting with the new or full moon of the predicted grunion run. Monitor for 2 hours each night starting at the onset of the high tide for a total of 8 hours over a four-night predicted run. During monitoring of a grunion run, monitor the wave wash area of the entire project area or the entire length of anticipated construction over the following two week period, including an adjacent buffer area (e.g., 100 ft). Use of flashlights should be limited. Assess grunion runs according to the Walker scale (Martin et al. 2001). If a run is≥ 2 on the Walker scale, additional coordination and protective measures would be necessary.

Volume 1 References: SAIC 2011 – Section 4 (4.3.1), Section 5 (5.3.4.2), Section 6 (6.4.2.3, 6.6.2.2), and Section 7 (7.3.2.5).

Other References

Beach Ecology Coalition 2011.
Predicted runs available at *www.dfg.ca.gov/mrd/gruschd.html.*

California Least Tern Guideline

Sterna antillarum browni

Photo Credit: Kathy Keane

Status: Federal, State Endangered

Critical Habitat: No

Sediment Management Issues: The least tern is a seasonal migrant that nests on sandy substrates in coastal areas. Least terns normally are found along the coast from the greater San Francisco Bay area south to San Diego County. They are rare records as far north as Del Norte County; however, the northernmost nesting sites are in San Francisco Bay (Keane 2001). Least terns breed on sparsely vegetated sandy beaches, salt-flats, or anthropogenically created lands (e.g., estuarine artificial islands, harbor fill) in colonies of up to several hundred nesting pairs. Sandy beaches close to estuaries and coastal embayments historically have served as nesting sites for least terns, and in recent years islands have been constructed from beneficial reuse of dredged materials in many bays, harbors, and lagoons that have been successfully used by least terns for nesting (Marschalek 2010).

Least terns are colonial nesters, which affords some protection to eggs and chicks. Both predation and non-predation disturbance (e.g., abandonment, flooding, and human damage) are primary sources of mortality to birds (Marschalek 2010). Most nest sites in California are fenced to minimize human disturbance and predation (USFWS 2006b).

Least terns forage on fish in the upper water column. They may forage in bays, estuaries, harbors, marsh channels, nearshore ocean waters, and in freshwater ponds or lakes near the coast (Collins et al. 1979, Keane 2001, KBC 2011). Least terns prefer to forage close to nesting sites, but are opportunistic. Coastal breeding birds may forage within 2 mi (3.2 km) of breeding colonies (Collins et al. 1979). Atwood and Minsky (1983) studied foraging patterns of least terns at three major breeding colonies in southern California and found that approximately 75% of the terns foraged within the ocean and approximately 90-95% of the ocean feeding was within 1 mi (1.6 km) of shore in waters less than 60 ft deep (Atwood and Minsky 1983). Although foraging has been documented farther away, birds foraging > 2.5 mi (4 km) from nesting sites were suspected of being non-breeders (Massey and Atwood 1980).

Dredging or discharge activities have the potential to impact least terns. There is the potential to disturb birds or reproductive success if construction it is too close to nest sites. Artificial lighting may increase foraging abilities of western gulls or other predators on nesting colonies, resulting in increased levels of predation (CDFG 2003). Turbidity is a potential concern if it were to interfere with foraging or substantially increase the time adults are away from chicks or eggs to acquire food. Environmental windows have been specified for sediment management projects to protect terns during the breeding season (e.g., USACE 1999, USACE et al. 2001). However; there is limited and contradictory evidence in the literature regarding impacts of increased turbidity on least tern foraging success (KBC 2011, H. T. Harvey & Associates 2012).

If least terns or their foraging habitat have the potential to be impacted from construction, consultation with the USFWS is required. Under the RGP 67 permit, beach sand placement activities are not authorized within 3,000 ft (0.9 km) of a colony during the breeding season. Projects authorized during the breeding season may require mitigation measures to ensure adverse impacts to the species are avoided (e.g., SANDAG and USDN 2000).

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging, beach nourishment	• Turbidity, equipment, activity disturbance
Other Activities or Issues of Concern	**Resources of Concern**
• Human disturbance, predation	• Least tern

Guideline Objectives:

- Avoid impacts to least tern breeding or nesting success.
- Minimize impacts to least tern foraging habitat.

Resource Protection Considerations

- ➢ Conduct activity consistent with previously established MOA work windows and measures, if applicable.
- ➢ Avoid dredging or beach nourishment during the breeding season if colony is within 1 mi (1.6 km).
- ➢ Consult with USFWS if project must be scheduled within breeding season and nest sites are within 1 mi (1.6 km). If permitted, implement one or more of the following measures, as coordinated with USFWS based on specific project and site conditions, as appropriate:
  - Use BMPs, operational, and engineered controls to reduce turbidity during sand placement, nearshore placement, or dredging and monitor water quality.*
  - Establish vehicle routes to avoid disturbance near nest sites.
  - Use buffer distance or noise suppressors to maintain ambient or≤ 60 dBA noise levels at nesting sites during the nesting season. Buffer distances to nest sites should be based on project and site-specific conditions or 500 ft (152 m) from dredging and not less than 500 ft (152 m) from discharges.
  - Shield night-time lighting away from nest sites, as applicable.
  - Conduct construction monitoring by a qualified biologist, as necessary.

*See Beach, Nearshore, and Embayment Water Quality Guidelines.

Effectiveness Considerations: Scheduling construction outside the nesting season is effective for avoiding impacts to least tern populations. Distance also should be an effective measure for avoiding or minimizing potential effects.

Photo credit: Kathy Keane

The RGP 67 specified avoidance of sand placement activities within 3,000 ft (914 m) of least tern nesting sites. That distance took into account both the potential effects of noise and activity disturbance as well as turbidity interference with foraging. Review of data from several beach nourishment and dredging projects indicates that this distance may be protective, and lesser distances also may be depending on characteristics of discharged or dredged sands.

Although turbidity has the potential to extend more than a 1 mi (1.6 km) from sand placement sites, most is confined inshore of the wave break zone unless carried offshore by rip currents. A threshold based on size of turbidity plume and water clarity of > 3 ft (1 m) (measured by Secchi disk) was

specified by the USFWS (2001) to protect foraging habitat of least terns during implementation of the San Diego Regional Beach Sand Project when construction was within 1 mi (1.6 km) of breeding colonies. That project used temporary sand dikes to promote sand settlement and reduction of turbidity in return waters. Construction monitoring indicated that plume dimensions only rarely were below the plume distance compliance criteria, and water clarity in the vicinity of borrow site dredging mostly exceeded 5 ft (1.5 m) (AMEC 2002). Generally, monitoring data for more than 15 reviewed projects indicate that water clarity values are greater than 3 ft (1 m) within 500 ft (150 m) of sand placement, nearshore placement, or dredging unless ambient turbidity also is relatively high (Section 2.7.5). Therefore, it is recommended that buffer distances between beach nourishment and least tern nesting not be less than 500 ft (152 m), and consider project-specific construction methods, sediment characteristics, and hydrodynamics of receiver site.

KBC (2011) reviewed that limited information is available upon which to base scientifically-based buffer distances. However, 300 ft (91 m) was suggested to minimize effects of noise and activity disturbance during dredging and disposal operations based on monitoring showing that a 200-ft buffer was effective with dredging conducted during the Upper Newport Bay Ecosystem Restoration Project. Buffer distances ranging from 300 to 500 ft have been recommended to minimize disturbance to nest sites from human activities (Valente and Fischer 2011). Construction noise would be expected to attenuate to ≤60 dB or ambient within distances of 300 to 1,600 ft (91 to 487 m) depending on project activities, equipment used, and site specific factors, which may influence noise attenuation (Section 2.7.1). Therefore, it is suggested that a buffer distance between dredging activities and least tern nesting sites be established based on project and site-specific conditions or not less than 500 ft (152 m).

Seasonal Considerations: The breeding season of least terns varies geographically, and different environmental window restricted periods for construction may be specified. The San Francisco District specifies environmental restricted periods of March 16 to August 1 or June 1 to September 15, depending on location. The Los Angeles District restricted periods may range from April 1 to September 30 or April 15 to September 15. Applicable work windows should be verified with appropriate resource and regulatory agencies.

Monitoring Considerations: Monitoring of turbidity plumes is useful for evaluating the potential for sediment management activities to affect foraging areas of least terns. If turbidity plumes during beach nourishment substantially extend beyond the breaker zone in the vicinity of least tern breeding colonies, the discharge should be modified to reduce the plumes, and additional monitoring may be warranted. Similarly, additional monitoring may be warranted during dredging if least tern breeding colonies are in the vicinity. Because least terns are visual predators of fish near the surface, water clarity (Secchi disk depth) or light transmission would provide relevant water quality measurements for this species. Projects with the potential for substantial or prolonged turbidity in the vicinity of active nest sites should consider adding a biological monitor to monitor effects to foraging or nesting, as appropriate.

Least terns are surveyed annually as part of the CDFG Nongame Wildlife Program (e.g., Marschalek 2010). Available data provides information on breeding locations and population status in different areas of the state.

Volume 1 References: SAIC 2011 – Section 4 (4.4.2), Section 5 (5.3.5.3, 5.5.4.5), and Section 6 (6.3.6.2, 6.4.2.4, 6.4.4.5, 6.4.5.5, 6.6.2.3).

Western Snowy Plover Guideline

Chardrius alexandrinus nivosus

Photo Credit: Callie Bowdish

Status: Federal Threatened, California Species of Special Concern

Critical Habitat: Yes

Sediment Management Issues: Snowy plovers are year-round residents that may be present at certain beaches, dunes, or estuaries. The coastal population of western snowy plover breeds from southern Washington to southern Baja California; it breeds along the entire California coast (Miller et al. 1999). Most breeding occurs from southern San Francisco Bay south.

Critical Habitat for western snowy plovers has been designated and includes nesting and wintering areas (USFWS 2005). Critical Habitat includes beaches in northern, central and southern California. Critical habitat was recently revised and expanded (USFWS 2012). Wintering snowy plovers may be found on many of the beaches used for nesting, but also on beaches not used for nesting.

Snowy plovers nest on sparsely vegetated beaches backed by dunes, sand spits, beaches at creek and river mouths, dredge spoils, flats of salt evaporation ponds, river bars, bluff-backed beaches, and salt pans in lagoons and estuaries. Nests are depressions in the substrate lined with bits of debris or shells. Human use of nesting beaches has been the greatest factor in the decline of the western snowy plover (Bruce et al. 1994).

Plovers feed on invertebrates and insects, including those associated with beach wrack. In beach areas snowy plovers probe for crustaceans and worms in the low-tide zone, search for insects and other small invertebrates among debris (especially drift kelp) along the high-tide line, or probe the sand under low foredune vegetation (Lafferty 2000).

Snowy plovers tend to rely on their cryptic coloration for protection. Snowy plovers are very hard to notice unless they move. In addition, snowy plovers shelter or lay eggs in sand depressions. For these reasons, snowy plovers, including their eggs and chicks, are vulnerable to equipment or vehicle impacts, if present. Beach nourishment activities have the potential to affect snowy plovers if construction occurs within or near critical habitat, foraging areas, nesting sites, or overwintering areas. Beach nourishment is identified in the recovery plan for the species as a strategy for enhancing habitat for the species (USFWS 2007).

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Dredging	• Equipment, vehicles • Alteration of critical habitat
Other Activities or Issues of Concern	**Resources of Concern**
• Beach grooming	• Snowy plover • Invertebrate forage

Guideline Objectives:

- Avoid impacts to snowy plover breeding or nesting success.
- Avoid direct impacts to adults, chicks, or eggs.
- Minimize impacts to snowy plover critical habitat, unless enhancement.

Resource Protection Considerations

- Consult with USFWS if the project has potential to impact critical habitat, occurs near nesting sites, or is within area used for foraging or overwintering.
- If permitted, implement one or more of the following measures as coordinated with USFWS based on specific project and site conditions, as appropriate:
  - Schedule outside the breeding season.
  - Avoid conducting activities within 1,500 ft (457 m) of areas where prior nesting has been reported during the breeding season (RGP 67).
  - Use buffer distance or noise suppressors to maintain ambient or ≤ 60 dBA noise levels at nesting sites during the nesting season. Buffer distances to nest sites should be based on project and site-specific conditions or not less than 500 ft (152 m).
  - Should plovers start nesting on the beach adjacent to the project area, establish a 500-ft (152 m) buffer between active nests and construction activities, and establish the buffer with construction fencing on every side except the ocean side.
  - Restrict pipeline placement or removal to outside the breeding season.
  - Minimize impacts to critical habitat by using compatible sands and minimizing percentage of fine sediment (silt/clay).*
  - Design beach receiver site with gentle slope (at least 10:1, horizontal: vertical).
  - Establish vehicle routes and operate at slow speeds (<15 mph) if plovers are present.
  - Shield night-time lighting away from nest sites, as applicable.
  - Maintain distance of 100 ft (30 m) from wintering snowy plovers to extent practical.
  - Minimize burial or removal of beach wrack.**
  - Minimize disturbance with use of surf-zone or single point discharge.
  - Conduct construction monitoring by a qualified biologist, as necessary.

* Refer to Sand Compatibility Guideline**Refer to Beach Wrack Guideline

Photo Credit: Callie Bowdish

Effectiveness Considerations: Scheduling construction outside the breeding season may be effective for minimizing impacts to snowy plover populations. Measures that avoid or minimize the potential to disturb nest sites also should be effective. The RGP 67 specified avoiding sand placement within 1,500 ft (457 m) of nest sites during the breeding season. That distance should be effective as a buffer distance, and lesser distances also may be. Construction noise would be expected to attenuate to ≤60 dB or ambient within distances of 300 to 1,600 ft (91 to 487 m) depending on project activities and selected equipment (Section 2.7.1). Buffer distances of 500 to 600 ft (152-183 m) between nesting areas and construction or sand placement projects have been recommended (SFBBO 2011, Trulio et al. 2011, SANDAG and USACE 2011).

A minimum distance of 100 ft (30 m) has been recommended to buffer snowy plover from human activities during winter (Lafferty 2001b). In the recently revised critical habitat designation, the USFWS (2012) summarized that disturbance appears to be a relative feature

that varies between sites, likely associated with other uses; consequently, one level of disturbance at a particular site may not be detrimental at another site.

Depending on proximity of snowy plovers and season, monitoring during construction should be considered to ensure effectiveness of protective measures.

Seasonal Considerations: Snowy plover is a resident shorebird that may occur year-round at certain beaches or seasonally move between the coast and nesting sites, which may be located in a nearby estuary. Snowy plover may overwinter at certain beaches (USFWS 2007) where environmental conditions are suitable. Use may vary with proximity to nest sites during the breeding season or beach conditions during winter (e.g., if erosive, may be inadequate for overwintering). The start-end time of nesting varies, and time periods specified in permits to minimize effects during the nesting season are not standard, ranging from March 1-September 15 to May 1-September 30. Applicable environmental constraint periods should be verified with appropriate resource and regulatory agencies.

Monitoring Considerations: Monitoring may be required if the project location is within critical habitat and snowy plover are present, the project site is near nesting locations, or the site or adjacent areas support overwintering populations. Monitoring may be needed to verify compliance with permit conditions and to ensure that corrective action is taken, as needed, to ensure that snowy plovers are not harmed during construction. Surveys may be used to determine species occurrence and whether additional protective measures may be required during construction.

Snowy plover are surveyed during summer and winter by the USFWS (unpublished data). These surveys provide information on breeding locations and population status in different areas of the state.

Volume 1 References: SAIC 2011 – Section 4 (4.4.4), Section 5 (5.3.4.3), and Section 6 (6.4.2.4, 6.4.4.4, 6.4.4.5, 6.4.5.5, 6.6.2, 6.6.2.3).

California Brown Pelican
Pelecanus occidentalis californicus

Photo credit: Karen Green

Status: The California brown pelican was delisted as a federal endangered species in 2009 due to recovery. It also was delisted as endangered by the state, but remains a Fully Protected species (FGC 355 11(b)(2).

Sediment Management Issues:

Brown pelicans generally forage within six mi (9.6 km) of shore along the mainland or coasts of southern California offshore islands. Pelicans primarily feed on small surface-schooling fishes, particularly northern anchovy and sardines (Jaques et al. 1996). Brown pelicans are plunge divers and must come ashore regularly to dry and restore their plumage. Roost site selection is based on proximity to prey resources, isolation from potential predators and human disturbance, and microclimate features that aid in thermoregulation. In northern and central California, primary roosting habitat consists of offshore rocks and natural substrates in estuaries; whereas, artificial structures (e.g., breakwaters, jetties, etc.) are mainly used in southern California (Jaques and Strong 2000).

In California, brown pelicans breed on Anacapa and Santa Barbara Islands off the coast of southern California (Burkett et al. 2007). The breeding season extends from summer to autumn.

Sediment management activities have the potential to disturb pelicans at communal roosting sites, if nearby. Brown pelicans may react to disturbance by shifting position, flushing, or flying away. There also is the potential for turbidity from sediment management activities to interfere with brown pelican foraging, although this may be limited given their large foraging range.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Activities	Impacts of Concern
• Beach nourishment • Dredging	• Disturbance of communal roosts • Turbidity
Other Activities of Concern	**Resources of Concern**
	• Brown pelican

Guideline Objectives:

- Minimize disturbance at communal roosting locations.
- Minimize interference with foraging activities.

Resource Protection Guidelines

- Use measures to reduce turbidity during sediment management activities.
- Avoid sediment management activities within 300 ft (91 m) of communal roost sites one hour before sunset to sunrise, if pelicans are present.
- If construction activities are necessary at distances < 300 ft (100 m) of communal roost sites. Implement one or more of the following measures to minimize impacts:
  - Conduct engine start-up more than 300 ft (91 m) from communal roost.
  - Avoid sudden approach and use slow speed at distances <300 ft (91 m) from communal roost.
  - Avoid direct lighting of communal roost.
  - Increase buffer distance to avoid flushing birds from roost, as necessary.

Effectiveness Considerations: Collazo et al. (1995) reviewed that available information suggests human disturbance should be limited within 328 to 1,968 ft (100 to 600 m) of roosting or nesting sites, and points out that thresholds appear to vary depending on disturbance levels routinely experienced by the birds. In San Francisco Bay, the long-term management strategy for the placement of dredged materials requires consultation for sediment management activities if within 300 ft (91 m) of large, communal pelican roost sites between July and September when pelicans are most abundant in the area (USACE et al. 2001). The USFWS required that brown pelican behavior be monitored during dredging within 270 ft (80 m) of an important roosting site on the Marina Del Rey Breakwater. Punctuated events such as dredge start-up after periods of inactivity, illuminating the breakwater by the dredge after long periods of inactivity, and a tugboat passing between the dredge and the breakwater to retrieve the haul barge caused disturbance to the colony including movements of occasionally large numbers of birds (Varanus 1999). These impacts resulted in pelicans shifting positions or flushing and returning to the breakwater after several minutes. Pelicans otherwise did not appear to be disturbed by more continuous dredging operations.

Seasonal Considerations: Dredging is restricted within 300 ft (91 m) of large communal roosts between July 1 and September 30 in San Francisco Bay and San Pablo Bay (*http://el.erdc.usace.army.mil/tessp*).

Monitoring considerations: Generally, monitoring is not necessary unless there would be the potential for construction activities to significantly disturb brown pelicans at a communal roost site.

Volume 1 References: SAIC 2011 – Section 4 (4.4.1), Section 5 (5.3.4.3), and Section 6 (6.3.6.2, 6.4.2.4, 6.4.4.5, 6.6.2.3).

Migratory Bird Guideline

Marbled Godwits
Photo Credit: Andrew Lissner

Status: Nesting birds and particularly raptor nests are protected by Fish and Game Code of California Sections 3503, 3503.5, 3511, 3513 and 3800. Most birds are also regulated under the Federal Migratory Bird Treaty Act (MBTA).

Sediment Management Issues: The Pacific Flyway is a major north-south route of travel for migratory birds in California, extending from Alaska to Patagonia. Every year, migratory birds travel some or all of this distance both in spring and in fall, termed: spring migration or fall migration. The birds migrate to breeding grounds or travel to overwintering sites. Along the Pacific Flyway, there are many locations where birds gather. Several hundred species of birds migrate along the coast of California.

Many migratory species breed in California bays and estuaries, including cormorants, gulls, black skimmers, terns, shorebirds, and waterfowl. Gulls, black skimmers, and terns may nest on islands in bays, some created from beneficial reuse of dredged materials. Brandt's and double-crested cormorants may nest on breakwaters. California bays and estuaries also are important stopover locations for migratory birds. Beaches also are important foraging, resting, or overwintering areas for migratory gulls and shorebirds.

The majority of shorebird use of California beaches occurs during migration and overwintering periods. The lowest numbers of shorebirds on California beaches are during May and June when shorebirds are on their breeding grounds. The greatest number of shorebirds on California beaches occurs during fall migration (September through November). Many shorebirds overwinter on California beaches from November through February (Hubbard and Dugan 2003). Thus, there is a general pattern of shorebird abundance on beaches that is highest in fall-winter, moderate in summer, and lowest in spring (Lafferty 2001a). The period of greatest competition among shorebirds for prey is in midwinter when there are more shorebirds present and a concomitant decline in their invertebrate prey (Baird 1993). Migratory birds are protected from unauthorized take by the MBTA. This includes direct impacts to birds or chicks, as well as indirect killing of birds by destroying their nests and eggs.

Nesting colonies have the potential to be disturbed by dredging activities, if nearby. Disturbance concerns include reduced foraging, nest abandonment, increased predation of eggs or chicks, and/or reduced feeding. Beach sand placement has the potential to disturb shorebird feeding or resting during construction, and reduce the invertebrate forage base within the receiver site footprint until recovered.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Dredging (Embayment)	• Equipment disturbance • Reduction in forage prey
Other Activities or Issues of Concern	**Resources of Concern**
• Mechanical inlet openings	• Nests, eggs, migratory birds

Guideline Objectives:

- Avoid impacts to migratory birds, including chicks, eggs, and nests.
- Minimize disturbance of migratory birds during the breeding season.

Resource Protection Considerations

- Use discharge BMPs or methods that promote recovery of the invertebrate forage base to minimize secondary indirect impacts to shorebirds.*
- Use dredging or discharge BMPS or methods that reduce turbidity to minimize secondary indirect impacts to fish-eating migratory birds.**
- If sediment management activity is scheduled during the nesting season, approximately February 15 to August 31, and nest sites have the potential to occur within 500 ft (152 m), prepare a site protection plan (SPP) detailing how impacts to migratory nesting birds will be avoided, minimized, or otherwise mitigated.
- Prior to construction, conduct a nest site survey within potential nesting habitat if within the 500-ft of proposed construction; if nests are found, consult with USFWS and CDFG. If permitted use one or more of the following protective measures, as appropriate to project, site conditions, and direction of resource agencies:
  - A qualified biologist (monitor) would be onsite to verify appropriate placement of any pipelines.
  - Schedule placement or removal of pipelines outside the nesting season in occupied breeding territories.
  - Use buffer distance or noise suppressors to maintain ambient or ≤ 60 dBA noise levels at nesting sites during the nesting season.
  - Shield night-time lighting away from nest sites, as applicable.
  - Conduct construction monitoring by a qualified biologist, as necessary.

* See Beach Invertebrate Recovery Guideline; see Embayment and Nearshore Water Quality Guidelines.

.

Effectiveness Considerations: Measures that include distance buffers from nesting locations should be effective for minimizing impacts, provided that noise levels are ambient or ≤ 60 dBA and night-time lighting is not increased. Avoidance of ground disturbing activities (e.g., placing or removing discharge pipelines) also should be effective for minimizing potential impacts during the breeding season. Monitoring may be necessary to ensure the effectiveness of minimization measures if activities occur in proximity to sensitive nesting areas. Operation controls or BMPs that reduce turbidity or promote recovery of the disturbed invertebrate forage base may minimize indirect impacts on foraging of migratory birds.

Seasonal Considerations: The breeding season may vary by species and geographic location and should be based on site-specific conditions.

Monitoring Considerations: Nesting areas of migratory birds are protected and monitoring may be required if there would be the potential for project activities to disturb nesting sites.

Volume 1 References: SAIC 2011 – Section 3 (3.3.9, 3.3.10), Section 4 (4.4.5, 4.4.6, 4.4.7. 4.4.8), and Section 5 (5.3.4.3).

3.3.2 Sandy Subtidal Habitat

Sand Dollars *Photo credit: Danny Heilprin*

Status: Sandy subtidal is EFH.

Habitat Definition: The nearshore sandy subtidal habitat ranges from below the intertidal zone to the edge of the continental shelf-slope interface (Shaffer 2002).

Sediment Management Issues:

Subtidal sands are primary, foraging, and reproductive habitat for a variety of invertebrates and demersal fish. Seabirds may forage on water column fish over sandy habitat. Similarly, marine mammals may forage on water column or benthic fish and invertebrates over sandy habitat. Subtidal sands support commercial and recreational fishery species of invertebrates (e.g., Dungeness crabs, sea cucumbers) and fish (e.g., California halibut, sanddabs) (CDFG 2001).

Sediment management activities involving nearshore dredging or discharge will impact sandy subtidal habitat and disturb the behavior of mobile animals in the vicinity. Habitat recovery rates depend on several factors, such as degree of physical alteration of the substrate, existing conditions, and frequency of disturbance. Generally, benthic populations are less developed inshore due to wave disturbance and may recover more quickly than offshore communities.

Sandy subtidal habitat is widespread inshore. Soft-bottom substrate is widespread offshore; however, sand deposits that are targeted for offshore dredging apparently are localized in occurrence, often relict deposits offshore rivers or streams. There may be the potential for cumulative impacts where discharges or dredging activities are localized and recurrent, or when sediment management activities occur more frequently than recovery rates.

Turbidity during construction and the potential for post-construction sand transport sedimentation towards sensitive resources are important considerations. Adjacent sensitive habitats may include rocky subtidal, kelp forests, or seagrass beds (eelgrass, surfgrass). Endangered least tern may seasonally forage in the area . Grunion may seasonally concentrate in the nearshore during the day prior to spawning.

Overview of Relevant Background Considerations:

Functions and Resources of Concern

Subtidal sands are primary, foraging, and reproductive habitat for a variety of invertebrates and demersal fish. Marine mammals may forage on water column and benthic fish and invertebrates over sandy habitat. Subtidal sands represent important commercial and recreational fishing habitats for marine invertebrates (e.g., Dungeness crabs, sea cucumbers) and fish (e.g., California halibut, sanddabs) (CDFG 2001).

Resources of Concern

- Endangered Least tern
- Sandy subtidal invertebrates
- Clam beds
- Dungeness crab
- Grunion
- Other fish
- Seabirds
- Marine mammals
- Water quality

Sediment Management Activities and Impact Considerations

Types of sediment management activities and potential impact factors to sandy, non-vegetated subtidal habitat include:

- Beach Nourishment
  - Nearshore placement – burial, sedimentation, turbidity
  - Profile placement – burial, sedimentation, turbidity
  - Beach placement – sedimentation, turbidity
  - Dune placement – not applicable
- Dredging or Excavation
  - Maintenance (bays, harbors, lagoons, rivers) – different habitats, but relevant impact issues of equipment, sedimentation, turbidity
  - Offshore borrow site – equipment, sedimentation, turbidity

Subtidal sand habitat, bottom-associated invertebrates and fish, and animals that live and feed in the water column have the potential to be affected by sediment management activities involving beach nourishment (nearshore or profile placement) or dredging. Nearshore sand placement may impact subtidal habitat by sediment burial, anchoring disturbance, sedimentation, and turbidity (Naqvi and Pullen 1982, NRC 1995, Greene 2002). Offshore dredging to obtain sand sources for beach nourishment removes benthic habitat, entrains animals, and results in elevated turbidity (NRC 1995, Greene 2002). These activities have the potential to adversely impact invertebrates and fishes in nearshore and offshore environments.

Grunion may concentrate in the nearshore prior to spawning runs (K. Martin, 2010 personal communication), therefore, discharge operations have the potential to affect the behavior of these fish (avoidance, attraction). Turbidity has the potential to affect foraging behavior of fish-eating seabirds. Marine mammals may be disturbed by noise or turbidity associated with dredging or nearshore discharge operations.

Other Activities or Issues

Proximity of sediment management activities to sensitive habitats or resources are important considerations. The spatial extent of turbidity and sedimentation associated with dredging or discharge will depend on project-specific sediment characteristics (e.g., median grain size, percentage of silt/clay) and water depth of activities. Environmental conditions (currents, waves, winds, etc.) during construction also would be influential.

Proximity to other discharges (e.g., wastewater outfalls) is a relevant consideration to nearshore borrow site dredging or nearshore placmement projects. Resource protection considerations include the potential for sediment disturbing activities to resuspend sediments that may decrease water quality or pose contaminant risks for marine resources or consumers. One of the criteria of Tier 1 testing is distance from known contaminant sources.

Sediment management activities have the potential to conflict with other nearshore land uses (e.g., commercial or recreational fishing, boating, shipping). Nearshore waters are important spawning and rearing habitats for a number of marine invertebrates (e.g., lobster) and fishes (e.g., California halibut). Seasonal movement patterns of fishery populations and local fishing patterns in the vicinity of offshore borrow sites or nearshore receiver sites are potentially important considerations for adequate resource protection. However, site-specific information

often is lacking. Collaboration between scientists and fishermen may be an effective approach for increasing understanding of site-specific fishery use patterns, resource protection issues, and minimizing conflicts.

Minimizing collision risks with other vessels or marine mammals are resource protection considerations. Typically, locations of dredging or discharge activities are reported in local U.S. Coast Guard Notices to Mariners to advise extra caution in areas where these activities take place. This is done to minimize risk of collision, fouling of fishing gear, or other potential conflicts of uses.

Recovery Considerations

Sandy subtidal habitat within the littoral zone is subject to disturbance by waves on a daily basis and sand erosion-accretion cycles on a seasonal basis. Sandy subtidal habitat seaward of the beach depth of closure is disturbed on a less frequent basis, but may be periodically disturbed by large storm waves. Generally, invertebrate diversity increases along a gradient of decreasing disturbance offshore. Disturbance primarily affects the benthic invertebrate animals that live within the sandy substrate and secondarily, bottom-associated (demersal) fish and larger invertebrates that feed on the smaller invertebrates. Recovery rates may be within 1 to 2 years for sandy subtidal invertebrate communities in the littoral zone, which experiences shifting sand levels due to wave activity. Recovery estimates after borrow site dredging generally range from >1 to 3 years; however, longer timeframes may be required if hydrodynamics or substrate conditions are substantially altered. Important considerations with respect to recovery include existing disturbance frequency, species composition, species-abundance relationships, and size distribution (or biomass) of populations (Newell et al. 1998, SAIC 2011). Several years would be required to re-establish multi-age classes of long-lived species, such as occurs in Pismo clam beds. Detailed review of subtidal invertebrate recovery rates are presented in BIA Volume 1 (Sections 4.2.7, 5.2.3.6).

Mitigation Considerations

A key impact issue is occurrence or proximity to listed sensitive species, managed fishery resources, or other sensitive habitats. Impacts may be avoided or minimized by scheduling activities outside sensitive use periods, avoiding clam beds or other important fishery areas, establishing buffer distances to minimize disturbance of sensitive habitats or species, or use of measures to minimize effects of construction noise or lights. An important impact issue is the temporary reduction in invertebrate prey resources for demersal fishes and large invertebrates that feed on the bottom. Recovery rates may be promoted by measures that minimize changes to sediments, hydrodynamics, or frequency of disturbance.

Monitoring Considerations

Sampling design considerations (number of stations, replicates) for sandy subtidal monitoring should be determined based on site conditions and study objectives. Habitat characterizations require less rigorous designs than those addressing recovery of more stable communities. Habitat characterizations should include physical as well as biological conditions. Diving biologists are effective for characterizing surface dwelling biological resources and habitat characteristics in nearshore waters. Invertebrates that live within sediment may be collected and analyzed from sediment cores. Mobile fish and epibenthic invertebrates living on or near the sediment surface may be collected with trawls.

Cross-Reference Table to Relevant Sections of the Volume 1 BIA Document

Topic	Volume 1	
	Section	**Subsection**
Resource Description and Sediment Management Issues		
Sandy Subtidal	3	3.3.3
Dungeness Crab	4	4.2.3
Pismo Clam	4	4.2.4
Sandy Subtidal Invertebrates	4	4.2.7
California Grunion	4	4.3.1
Bottom-Dwelling Fish	4	4.3.4
Water Column Fish	4	4.3.5
California Brown Pelican	4	4.4.1
Least Tern	4	4.4.2
Gulls and Terns	4	4.4.4
Waterfowl and Seabirds	4	4.4.7
Seals and Sea Lions (Pinnipeds)	4	4.5.2
Whales, Dolphins, and Porpoises (Cetaceans)	4	4.5.3
Impact Considerations		
Equipment – Sandy subtidal invertebrates	5	5.3.3.2, 5.3.4.1
Equipment – Fish, marine mammals	5	5.3.2.6, 5.3.4.2, 5.3.5.4
Sedimentation – Subtidal invertebrates		5.4.3.2, 5.4.4.1
Turbidity Impacts – Invertebrates, fishes, birds, marine mammals	5	5.5.4.3, 5.5.4.4, 5.5.4.5, 5.5.4,6
Mitigation Measures		
Sediment compatibility and quality	6	6.3.1
Minimize substrate change		6.3.1.2
Avoid sensitive habitats or species	6	6.3.2.1, 6.4.1.2
Maintain hydrodynamics	6	6.3.2.3
Incorporate refuge areas to promote recovery	6	6.3.3.3
Buffer to minimize impacts to sensitive habitats or species	6	6.3.5, 6.3.6
Limit intentional approaches within 300 ft and slow vessel speed around sensitive marine mammals	6	6.4.1.5
Schedule or seasonal restrictions (environmental windows) – Invertebrates, grunion, birds	6	6.4.2
Construction operational controls, methods, BMPs – Turbidity	6	6.4.3.3
Prepare hazardous materials plan, minimize leaks or spills	6	6.3.7.1, 6.4.4.4
Conduct Coast Guard Notifications	6	6.3.7.4
Monitoring Considerations		
Physical/Chemical		
Sediment compatibility inspections	6	6.4.5.1
Water quality	6	6.4.5.2, 7.4.2, 7.4.3
Biological		
Pre-construction habitat and sensitive resource assessment	6	6.3.8.2
Habitat assessment and potential sensitive species	6	6.4.5.7
Least tern	6	6.4.5.5, 7.4.5.2

Guideline Considerations:

List of Relevant Resource Protection Guidelines

The following guidelines may be relevant to protection of sandy subtidal resources beach nourishment related activities (offshore borrow site dredging, nearshore or profile placement) in Sandy Subtidal habitat depending on site-specific conditions:

Resource Protection Guideline	User's Guide	
	This Section	Other Sections
Physical-Chemical		
Sand Compatibility		3.3.1
Nearshore Water Quality	X	
Biological		
Sandy Subtidal Invertebrate Recovery	X	
Clam Beds		3.3.1
Dungeness Crab		3.3.3
Grunion		3.3.1
Least Tern		3.3.1
Marine Mammals	X	

The guidelines for water quality and California least tern are generally relevant to resource protection for several other fish-eating seabirds (e.g., California brown pelican, other terns) or sea ducks (e.g., grebes), although California brown pelican may forage within the upper 3 to 6 ft of the water column. Cormorants on the other hand, swim to capture fish near the bottom or at mid-depth, although they also may feed on surface fish (Mok et al. 2006). The guidelines for sandy subtidal invertebrate recovery and water quality are generally relevant to resource protection for nearshore fish (bottom-dwelling, water-column).

Figure 3.3-2 provides a decision flow chart to relevant guidelines. The same project duration (> 5 days) and distance (1 mi, 1.6 km) considerations as described for sandy beach habitat were applied to the sandy subtidal habitat flow chart.

Other Potential Relevant Guidelines

The following sensitive habitats have the potential to occur adjacent, landward, or seaward of sandy subtidal habitat depending on site-specific conditions:

- Hard-substrate or vegetated habitats, such as rocky reef, kelp forest, or surfgrass (Sections 3.4.2), or eelgrass (3.4.3).

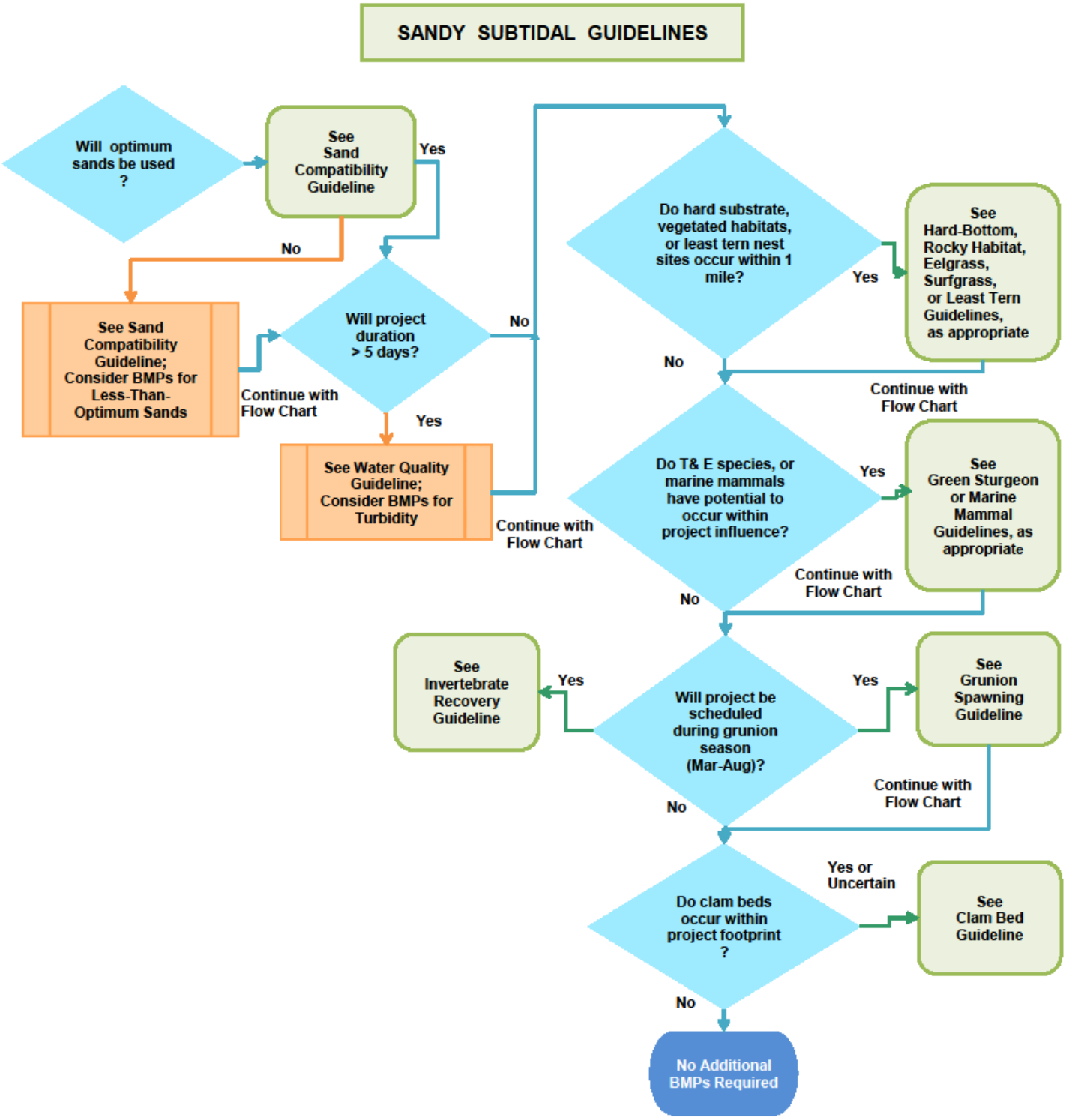


Figure 3.3-2. Flow chart to sandy subtidal habitat resource guidelines.

Nearshore Water Quality Guideline

Turbidity in rip current
Photo credit: Jonathan Warrick:

Definition: The nearshore zone beyond the wave break zone to the beach depth of closure (inshore) and beyond the depth of closure (offshore).

Functions: Essential to marine life, foraging habitat for seabirds and sea ducks.

Sediment Management Issues: The SWRCB (implemented by regional offices RWQCB) is the regulatory authority for Clean Water Act (CWA) Section 401 Water Quality Certifications and/or Waste Discharge Requirements (WDRs) for dredge/fill projects, which must be obtained as part of the permitting process for offshore borrow site dredging or nearshore discharges conducted for beach nourishment. Monitoring requirements are specified in the certification and/or WDR, and may be project-specific (SAIC 2011, Appendix C).

Water quality compliance monitoring during dredging or discharge in ocean waters of the U.S. is based on the Ocean Plan, but also may include modifications by local Regional Water Quality Control Boards (RWQCBs). Monitoring during construction generally includes visual observations to verify water quality objectives for the following parameters, which if detected, may cause a nuisance or adversely affect beneficial uses:

- No visible floating particulates, grease, and oil.
- No aesthetically undesirable discoloration.
- Nutrients shall not cause objectionable aquatic growths or degrade biota.

In addition, several measurements may be required, such as:

- Natural light not significantly reduced outside the initial dilution zone.
- Dissolved oxygen not reduced by more than 10%.
- pH not change by more than 0.2 units.
- Temperature not deviating by more than 4°F (2.2^{o}C).

Sediments used for beach nourishment must be determined by the USACE, in coordination with USEPA, to be free of substantial contamination based on results of a sediment suitability evaluation or testing consistent with the Inland Testing Manual. Therefore, contaminants are not monitored during borrow site dredging or nearshore beach nourishment projects.

Reductions in light levels is of particular concern if activities take place in proximity to vegetated habitats, such as reefs, kelp forests, surfgrass beds, or eelgrass meadows. The Ocean Plan defines that that natural light values (light transmissivity, or total irradiance) not be significantly reduced outside the zone of initial dilution (i.e., difference is defined as a statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level).

Generally, suspended sediment is the primary water quality issue of concern to marine-associated biota during beach nourishment projects. Suspended sediments may result in adverse effects to feeding, respiration, spawning, photosynthesis, or movement of wildlife, and under very high concentrations or prolonged exposures may be lethal. Reduced water clarity associated with suspended sediment also may interfere with foraging of seabirds.

California 401 Certifications for nearshore placement or offshore borrow site dredging have specified monitoring of "turbidity" using one or more of the following methods: light transmittance

(transmissometer), turbidity (nephelometer, NTU), and/or total suspended solids (mg/L) (SAIC 2011). Measurements of Secchi disk depth often have been specified in addition to NTU. Transmissometers measure percent light transmission, which addresses potential natural light reduction, and collected data may be converted to beam attenuation using calibration coefficients to provide a surrogate measure of turbidity. As noted in Section 2.8, TSS provides the only direct measure of suspended sediment concentration; however, water samples must be collected for laboratory testing. For this reason, measurements using one of the above-mentioned methods generally are taken instead or in addition to TSS to support field assessments of permit compliance during construction activities.

The 401 Certification monitoring requirements typically define significance based on comparison of ambient measurements at a station outside the influence of the project "control" with stations located within the plume and at one or more stations outside the zone of initial dilution. Locations of station distances relative to the activity have not been standard. Most of the reviewed 401 Certifications over the last couple of decades have specified significance as turbidity not exceeding ambient by more the 20%. The Ocean Plan also permits a more statistically based determination of significance.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment (nearshore, profile placement) • Dredging (offshore borrow sites)	• Debris, leaks or spills • Suspended sediment, turbidity, water clarity
Other Activities or Issues of Concern	**Resources of Concern**
• Proximity to other discharges	• ASBS, HAPC, MPA, SAS • Clam beds, grunion, least terns

Guideline Objectives:

- Avoid degradation of sensitive marine habitats during sediment management activities.
- Minimize adverse effects of suspended sediment and turbidity during sediment management activities.
- Facilitate standardization of turbidity monitoring requirements for nearshore discharge and offshore dredging.

Resource Protection Considerations

- Evaluate or test sediments according to the appropriate USEPA and USACE testing manual to ensure that source materials for nearshore beach nourishment or dredged sands from borrow sites are free of substantial contamination or organic content.*
- Conduct inspections of sediment during nearshore placement or dredging to verify compliance with permit requirements and to ensure materials are free of unintended debris or materials.*
- Prepare a Spill Prevention Control and Countermeasures Plan (SPCC) prior to initiating nearshore placement or dredge operations that specifies fueling, equipment maintenance procedures to prevent spills and leaks, and best management practices (BMPs) to contain and cleanup hazardous materials in the event of a spill.
- Monitor water quality during nearshore placement or offshore borrow site dredging to verify compliance with RWQCB 401 certification and/or WDR requirements. Modify discharge if water quality exceeds permit limits. Note any corrective actions and the effectiveness of measures used to meet compliance requirements. Include the following information to increase consistency of monitoring:

Resource Protection Considerations (Continued)

- Establish stations at 100 to 250 ft (30 to 76 m) downcurrent and 500 ft (150 m) downcurrent and within plume if visible, and at least 1,000 ft (300 m) upcurrent and outside any visible plume.
- Document visual observations relevant to water quality objectives (e.g., discoloration, floating particulates, debris/trash, solid waste, odors, petroleum substances or films, tide stage, current direction and speed, weather). Photo-document water appearance and measures used to control turbidity, as applicable.
- Measure dissolved oxygen, light transmittance (transmissometer), pH, salinity, temperature, and turbidity (NTU) throughout water column or at surface, mid-water, and near-bottom depths. Verify compliance with Basin Plan-Ocean Plan criteria.
- Note plume incursions into or towards sensitive habitat (ASBS, HAPC, MPA, SAS), if nearby.
- Note if plume exceeds 0.5 mi (0.8 km) from dredging or discharge if least tern breeding colonies are within 1 mi (1.6 km) of project.

➢ Note any corrective actions and the effectiveness of measures used to meet compliance requirements. Take all reasonable steps to correct operations resulting in non-compliance, such as adjusting operation controls or use of BMPs, according to following dredge methods:

Cutterhead Dredge

- Use dredge operation controls (e.g., reduce cutterhead rotation speed, reduce rate of ladder swing and rotating cutterhead, reposition cutterhead in sediment, reduce advance rate), as necessary.

Hopper Dredge

- Use dredge operation controls (e.g., slow cycle time, eliminate overflow), as necessary.
- Avoid overflow if turbidity plume has potential to extend into a ASBS, HAPC, MPA, or SAS.
- Avoid overflow if dredging would occur within 1 mi (1.6 km) of least tern nest sites during breeding season.
- If vessel is so equipped, use a re-circulating system or morning glory spillway to capture turbid water, which otherwise would overflow the vessel, and pump via pipeline to a subsurface discharge either at the draghead or approximately 15 to 20 ft below the surface. In either case, subsurface discharge should be restricted to the borrow site location.

➢ Notify the RWQCB and USACE by e-mail, if turbidity plumes are out-of-compliance for two consecutive days, and comply with any measures identified by the permitting agencies, in consultation with other responsible agencies, as appropriate, to mitigate project-related turbidity, including modifying or halting discharge. Sampling, analysis, quality assurance, reporting, and photo-documentation should be in accordance with the Surface Water Ambient Program (SWAMP) requirements, as applicable.

*Refer to Sand Compatibility Guideline in Section 3.3.1, **Refer to Least Tern Guideline in Section 3.3.1.

Effectiveness Considerations: Tests, inspections, equipment operation restrictions, and preparation of appropriate plans for preventing or minimizing hazards are effective for avoiding and minimizing contaminant concerns and issues. Minimizing turbidity spatial extent and levels by use of operational controls should be effective for protecting biological resources when combined with appropriate monitoring.

The above-noted operational control measures for cutterhead and hopper dredges are based on the reviews by Collins (1995) and Anchor Environmental (2003), and may be more applicable to dredging fine sediments rather than sands. However, measures that minimize turbid overflow from hopper dredges should be effective across a range of sediment types. Maintaining the cutterhead below the sediment surface has been shown to significantly reduce resuspension

compared to partial burial (exposure of blades above the mudline allows more opportunity for wash off) and deep burial (results in sloughing and cave-in along the dredge path) (Collins 1995).

Comparative data are limited regarding relative effectiveness of different types of measures that have been used to minimize turbidity during offshore dredging or nearshore placement. Therefore, the guideline specifies inclusion of description of corrective actions and effectiveness in monitoring reports to help address this data gap.

Seasonal Considerations: Turbidity naturally ranges higher during winter storms or high wave conditions. Therefore, there is a potential for the difference between project-related turbidity and ambient conditions to be less during winter than during summer seasons. Generally, elevated turbidity is of greater concern during spring-summer when nearshore biological productivity generally is greater, grunion may congregate in nearshore in advance of spawning, and endangered California least tern, which forages in nearshore ocean waters, may be present.

Monitoring Considerations: Monitoring generally is required during sediment management projects to comply with RWQCB 401 water quality certifications and/or WDRs. Monitoring may include measurements of light transmission, turbidity water clarity, or some combination of those measurements. The Munsell color system is recommended to facilitate standardized color descriptions. TSS measurements would be useful for assessing the biological relevance of values should out-of-compliance monitoring results persist.

Dredge turbidity plumes have different characteristics in the initial mixing zone, at a near-field distance, and a far-field distance from the dredge. Generally, the transition between near- and far-field occurs at approximately 300 ft (100 m) (Bridges et al. 2008). RWQCB monitoring requirements applied to dredging projects in California are not standard and may differ depending on water body. Distances of 250 ft to 300 ft have been routinely used for comparison of compliance with ambient values during California dredging projects (SAIC 2011, Appendix C.1). Because a distance of 300 ft is near the transition between near- and far-field, a distance of 250 ft is suggested as being more conservative.

A nephelometer instrument (NTU values) may be used to provide field measurements of turbidity. NTU measurements are helpful for assessing the effectiveness of measures used to adjust BMPs or operational controls to minimize turbidity plumes. Measurements recorded along a distance gradient from the receiver site generally are more informative for assessing the effectiveness of field adjustments to meet compliance criteria than measurements limited to inside and outside the plume. Use of standard distances to collect data would improve consistency among projects and the ability to evaluate the effectiveness of control measures.

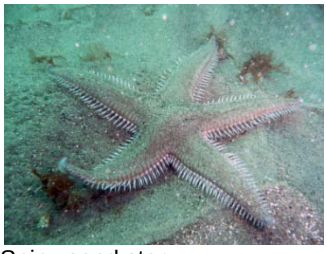
Additional monitoring may assist biological resource protection if placement operations have the potential to result in prolonged turbidity, relatively large plumes, or operations are scheduled during the relatively more sensitive spring-summer productivity period. This may be particularly relevant if plumes have the potential to affect sensitive habitats (e.g., ASBS, HAPC, MPA, SAS) or resources (e.g., endangered least tern foraging areas).

Light transmission and/or TSS measurements provide values with greater biological relevance than turbidity values. However, they are more time consuming or expensive to measure (e.g., require boat, instrument, or laboratory analysis). Additional monitoring may be relevant if prolonged turbidity would affect sensitive habitats or foraging areas of sensitive species.

A nephelometer instrument (NTU values) may be used to provide field measurements of turbidity. NTU measurements are helpful for assessing the effectiveness of measures used to adjust BMPs or operational controls to minimize turbidity plumes. Use of standard distances to collect data would improve consistency among projects and the ability to evaluate the effectiveness of control measures.

Volume 1 References: SAIC 2011 – Section 5 (5.5.2, 5.5.3), Section 6 (6.4.3.3, 6.4.4.4, 6.4.5.2), and Section 7 (7.4.2, 7.4.3).

Subtidal Invertebrate Recovery Guideline


Spiny sand star
Photo Credit: Danny Heilprin

Definition: Animals without backbones that live within or on sandy substrate at water depths below mean lower low water. Common invertebrates include burrowing or tube anemones, crustaceans, sand dollars, sand stars, sea pens, mollusks, and worms.

Functions: Recycle nutrients and prey for fish, diving ducks, and marine mammals.

Sediment Management Issues: Sandy subtidal invertebrates are essential prey items for fish. Diving ducks also feed on subtidal invertebrates in protected habitats. Sandy subtidal invertebrates exhibit zonation with higher densities of mobile crustaceans in shallow littoral depths and an increase in less mobile invertebrates (worms, mollusks) with a decrease in wave disturbance and greater distance offshore. Generally, invertebrate communities are less developed inshore and more developed offshore where disturbance is less.

Disturbance of sandy subtidal invertebrate communities are unavoidable impacts of sediment management activities involving subtidal dredging or discharge. Sediment management activities involving beach nourishment (nearshore, profile placement) would bury or crush invertebrates within the fill site. Dredging of offshore borrow sites remove sediment and invertebrates. Anchoring of work boats or dredges also may remove or damage invertebrates. There are few studies of recovery of benthic communities associated with nearshore dredging or discharges in California. Available studies from California and elsewhere have reported recovery rates of sandy subtidal communities on the order of 1 to 3 years unless there are substantial changes in substrate characteristics, hydrodynamics, or water quality (SAIC 2011). Recovery rates may take several years, if at all, if multi-age populations of long-lived species (e.g., Pismo clam beds) are substantially disturbed.

An important issue relevant to resource protection of nearshore sandy subtidal communities is to promote the recovery of the invertebrate forage base after disturbance. Another important issue is to avoid and minimize disturbance of spawning grounds or populations of important fisheries species.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Dredging	• Equipment, burial, turbidity
Other Activities or Issues of Concern	Species of Concern
• Commercial or recreational fishing	• Dungeness crab, Pismo clam • FMP or NFMP Groundfish

Guideline Objectives:

- Promote recovery of invertebrates.
- Minimize degradation of prey species for nearshore fishes and marine mammals.

Resource Protection Considerations

- Avoid sand placement on clam beds or areas of concentration of fishery species (e.g., breeding concentrations of Dungeness crabs).*
- Avoid repetitive sand placement at the same location during the same year.
- Avoid creation of deep holes (> 10 ft) during borrow site dredging.
- Maximize invertebrate recovery rates using one or more of the following measures:
  - Closely match source sediment characteristics with those at nearshore placement site.**
  - Schedule sand placement outside the peak (spring-summer) invertebrate recruitment period, if possible.
  - Incorporate refuge areas into project design (e.g., leave undisturbed patches within dredge or placement areas).
- Coordinate with local fishing organizations to obtain information on productive fishing areas, and seasonal considerations relative to fishing locations. Incorporate measures to avoid and minimize impacts to those areas.
- Conduct U.S. Coast Guard notification to minimize hazards and interference with other uses, including fishing.

*See Clam Bed and Dungeness Crab Guidelines (Sections 3.3.1. and 3.3.3, respectively), ** see Sediment Compatibility Guideline (Section 3.3.1).

Effectiveness Considerations: Avoidance or minimization measures that promote invertebrate recovery rates after disturbance lessen the potential for adverse impacts to EFH and other wildlife. The longest reported invertebrate recovery times have been associated with projects that resulted in substantially changed hydrodynamics or substrates (Brynes et al. 2004, Newell et al. 2004) or that experienced high intensity sand mining (Boyd et al. 2004, 2005). Relatively shallow dredging or dredging that resulted in refugia areas (e.g., peaks dredged in ridge-swale topography, undredged areas within larger target dredge area) are thought to promote recovery (e.g., Burlas et al. 2001, Diaz et al. 2004). Therefore, minimizing changes to existing substrate and hydrodynamic conditions, as well as leaving some undredged areas within larger dredge target areas may promote recolonization of invertebrates and recovery of similar communities. Rotating locations of discharge or dredging within larger target areas also may be effective for minimizing the potential for cumulative impacts associated with repetitive disturbance.

Generally, sandy sediments with a content of fines (silt/clay) ≤ 20% have been permitted for beneficial reuse in California (e.g., 80:20 rule). Generally, small increases in silt/clay content of nearshore sands may stimulate productivity. However, substantial increases may depress or alter communities, although this may be more of an issue where wave activity and sediment reworking is low. Limited information is available regarding recovery rates of sandy subtidal invertebrate communities offshore California with placement of sands with > 20% silt/clay.

Seasonal Considerations: Recovery may be promoted by lessening interference with natural seasonal movement patterns. Several invertebrate species migrate to shallow waters in spring-summer and deeper waters in fall-winter (e.g., Dungeness crab, lobster, sand dollars).

Recovery Considerations: Recovery begins almost immediately with recruitment of larvae from the plankton or migration of adults from adjacent undisturbed habitat. However, recovery rates after disturbance may depend on a number of factors, including substrate characteristics, hydrodynamics, time of year, or frequency of disturbance.

Generally, recovery after disturbance of inshore sandy subtidal habitat would be expected to be relatively rapid (e.g., <1-2 years), but may require longer timeframes for less frequently disturbed offshore habitats (SAIC 2011, Sections 4.2.7, 5.2.3.6). Recovery may take many years if there is substantial disturbance of multi-age populations of long-lived species (e.g., clam beds). Recovery also may take many years, if at all, if substantial changes to substrate characteristics or hydrodynamics degrade water quality (e.g., deep holes).

The potential for rates of recovery to be a factor relevant to cumulative impacts should consider natural environmental oceanographic-climate cycles that occur on decadal scales or less (e.g., El Niño events) (SAIC 2011, Sections 3.3.5, 3.3.6). The issue of concern is the potential for slow recovery rates after sediment management disturbance to substantially extend depressed productivity naturally associated with El Niño periods, particularly if during a warm PDO phase. Because El Niño events have a recurrence period of every 5 to 7 years, it is recommended that CEQA/NEPA impact assessments use significance criteria for nearshore habitat recovery that are less than 5 years. Significance criteria that specify recovery within 5- or 10-year timeframes may not adequately account for the potential for cumulative impacts.

Monitoring Considerations: Biologist-divers may observe and collect invertebrate samples if water depths permit efficient surveys. Generally, divers use hand-held cores to collect sediment and invertebrates living within sandy sediments (infauna). Invertebrates living on or above the sediment (epifauna) may be recorded by diver-biologists while swimming transect lines of a specific distance. Transects may be oriented either parallel or perpendicular to bathymetry depending on survey objectives.

In deeper waters, cable-operated samplers (e.g., box core or Van Veen) may be used to collect sediment samples and infauna. Generally, box core or Van Veen samplers are used with a surface area of 0.1 m^2 or the collected data are standardized to that surface area to facilitate comparisons with regional-based data collected off California. Trawls may be used to collect epifaunal invertebrates. Bottom-associated fish and epibenthic invertebrates also may be collected by trawls.

Infauna samples should be processed with 1.0 mm sieves to allow comparability with other available regional data sets; nested 0.5 and 1.0 mm sieves sometimes are used for offshore samples. Specific sampling methods should consider grain size characteristics of sediments and comparability with other available data in the vicinity that may be useful as reference information. Collected animals typically are identified to the lowest practicable taxon and weighed according to taxonomic categories (e.g., crustaceans, echinoderms, mollusks, polychaetes, other minor phyla).

Newell et al. (1998) reviewed that a practical approach for determining "recovery" is that at least 80% of the species diversity and biomass is restored. Therefore, the question of interest with recovery determinations is whether metrics such as species number and/or biomass are similar (e.g., within 80%) or greater than before impact or comparable to control locations.

Volume 1 References: SAIC 2011 – Section 4 (4.2.7), Section 5 (5.2, 5.3.3.2, 5.3.4.1, 5.4.3.2, 5.4.4.1, 5.5.4.3), Section 6 (6.3.1, 6.3.3), and Section 7 (7.5.1)

Marine Mammal Guideline

Sea Otter

Harbor Seals

Gray Whale "spyhopping"

Photo credits: (1) Brad Damitz, (2) Karen Green, (3) Kathy Keane

Status:
All marine mammals are protected under the Marine Mammal Protection Act. Some species have additional status as endangered or threatened species under the CESA and FESA, or have fully protected status under Fish and Game Code 35511 (b)(2). .

Federal Endangered

- Blue whale (*Balaenoptera musculus)*
- Fin whale (*Balaenoptera physalus)*
- Sei whale (*Balaenopera borealis)*
- Humpback whale (*Megaptera novaeangliae)*
- Pacific right whale (*Eubalaena glacialis*)
- Sperm whale (*Physeter macrocephalus*)

Gray whale (*Eschrichtius robustus*) – De-Listed (Recovered)

Federal and State Threatened

- Guadalupe Fur Seal (*Arctocephalus townsendi*)

Federal Threatened, State Fully Protected

- Southern sea otter (*Enhydra lutris nereis)*
- Stellar Sea Lion (*Eumetopias jubatus*)

Sediment Management Issues:

Southern Sea Otter

The southern sea otter ranges from Santa Barbara County to San Mateo County of central and northern California, primarily along mainland rocky shores that support kelp forest communities, although a small translocated colony also occurs at San Nicholas Island (USFWS 2003). They also are known to occur offshore sandy shorelines and in some bays (e.g., Morro Bay) (CDFG 2001, USACE 2001). Kelp beds serve as vital resting, foraging, and nursery sites (NOAA 1992). Sea otters forage on a wide variety of subtidal invertebrates associated with hard-bottom and soft-bottom habitats (e.g., abalone, clams, crabs, mussels, sea urchins). Sea otters also forage dense Pismo clam beds by moving along a "front", progressively removing clams to low levels before moving from one beach to the next (Miller et al. 1975).

Sea otters have the potential to be disturbed by the noise and activity of vessels during sediment management projects, if present. Dredging or nearshore discharge have the potential to temporarily remove forage base. There also is potential risk of collision from dredges or support vessels. Bodkin and Rathbun (1988) observed that abundances of a male group of sea otters in Morro Bay declined after harbor maintenance dredging started. Although they could not establish a cause and effect relationship, they speculated that otters may have left the harbor in response to the substantial increase in human activity associated with the project.

Turbidity and sedimentation also may be important considerations if sediment management activities were to occur in proximity to kelp bed habitats occupied by the species.

Seals and Sea Lions

Seals and sea lions (pinnipeds) that regularly occur along the California coast include harbor seal (*Phoca vitulina*), northern elephant seal (*Mirounga angustirostris*), California sea lion (*Zalophus californianus*), and Steller's sea lion (*Eumetopias jubata*) (Orr and Helm 1989). California sea lions also are common in bays and harbors, and may be seen in estuaries and river mouths. Harbor seals also may occur in bays and estuaries, but generally are less abundant than sea lions. Seals and sea lions are visual feeders, primarily on fish. Some species may eat squid, crustaceans, small sharks or marine mammals (e.g., juvenile harbor seals, sea otters). Sea lions feed during day and night, but do not appear to feed in the vicinity of the haul-out as their foraging trips are long (often >1 day) in duration (Hodder 2005). In contrast, harbor seals may be nocturnal feeders based on observations that they spend more time in the water at night than during the day.

Most seal and sea lion breeding rookeries are on offshore islands; however, rookeries and haul out sites also occur along the mainland. Sea lions commonly are observed hauled out on rocks, breakwaters, docks, buoys, or barges in bays and harbors.

Haul-Outs and Rookeries
GIS-based Map

http://swr.nmfs.noaa.gov/psd/rookeryhaulouts/index.htm

Because pinniped haul-out areas occur along breakwaters, docks, and at certain beaches along the coast, there is the potential to affect pinnipeds during sediment management projects. Pinnipeds either offshore or on land may be disturbed by the noise, light, and activity of sediment management equipment. In general pinnipeds in the water tend to be tolerant of vessels (Richardson et al. 1995). Sea lions rarely react unless a vessel approaches within 328 to 656 ft (100 to 200 m) (Bowles and Stewart 1980). Pinnipeds have the potential to be injured by vessel strikes (Carreta et al. 2004); however, the risk is higher for fast moving vessels and would be relatively low for slow moving dredges or barges.

Generally, pinnipeds are more sensitive to disturbance on land (Richardson et al. 1995). Harbor seals hauled out on shore have been observed to move into the water in response to boats. People walking near or in California sea lion rookeries or haul-out areas have been observed to cause major short-term disturbance. Sea lions hauled out on buoys and docks are relatively tolerant of vessels, but may move into the water if directly approached. Disturbance of pinnipeds on their breeding grounds has the potential to be significant because pups may be killed by a stampede of animals into the water. However, most of the pinniped rookeries in California are in remote areas where sediment management would not occur.

In areas where sediment management activities are likely to occur, the potential to affect pinnipeds at haul-out areas may be influenced by existing conditions. For example, Hodder (2005) thought it unlikely that pinniped haul-outs in areas with high ship traffic (e.g., jetty) would be adversely affected by additional vessel trips associated with periodic dredge operations. Hodder (2005) also considered nearshore dredge discharge unlikely to impact foraging based on the wide foraging range of sea lions and limited potential to affect harbor seals if dredge discharge operations occurred during daylight hours.

Whales, Dolphins, Porpoises (Cetaceans)

Seven species of whales may occur in waters off California: gray whale (*Eschrichtius robustus*), blue whale (*Balaenoptera musculus)*, fin whale (*Balaenoptera physalus),* Sei whale (*Balaenopera borealis),* humpback whale (*Megaptera novaeangliae),* Pacific right whale (*Eubalaena glacialis*), and sperm whale (*Physeter macrocephalus*). With the exception of the gray whale, other whale species primarily occur in offshore waters or are rare in occurrence.

The gray whale, which is now a recovered endangered species, but remains protected under the Marine Mammal Protection Act, migrates along the coast of California from breeding grounds in Baja California to their summer feeding grounds in the Arctic seas. Gray whales generally are observed off the coast of California from mid-December through mid-May, although they may be seen in November or June. A few gray whales may remain all summer or winter along the California coast (Orr and Helm 1989, CDFG 2001).

Dolphins and porpoises that regularly occur along the coast include common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), harbor porpoise (*Phocoena phocoena*), and Dall's porpoise (*Phocoenoides dalli*). The bottlenose dolphin also may be seen in bays and estuaries.

Because they are wide-ranging, cetaceans generally are not a focus of concern for sediment management activities. There is the potential for cetaceans to be disturbed by the noise and lights of offshore equipment and associated vessels. Noise from sediment management activities may be within marine mammal Level B harassment levels for continuous noise, 120 dB_{rms} (re 1 μPa), depending on distance between animal and activities.

Limited information is available on the response of cetaceans to dredges. Observations on whales in Alaska suggest that whales initially will avoid dredging noise but may adapt to it (Richardson et al. 1995). Generally, whales tend to avoid approaching vessels. Most reports of vessel strikes with marine mammals are associated with fast moving vessels, not relatively slow moving dredges or barges. However, Laist et al. (2001) reported one record of a whale fatality from collision with a hopper dredge. Because minimal increase in vessel traffic is associated with sediment management activities (a couple of support boat trips per day), the risk of injury to marine mammals from a vessel strike generally is considered relatively low. Turbidity has the potential to disturb marine mammals, but effects would be expected to be minimal with short exposure durations due to their high mobility.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging • Beach nourishment (nearshore placement)	• Noise and activity harassment, vessel collision • Reduction in subtidal forage or kelp habitat
Other Activities or Issues of Concern	**Resources of Concern**
	• Sea otters, pinnipeds, cetaceans

Guideline Objectives:

- Avoid collision with or injury of marine mammals.
- Avoid or minimize harassment of marine mammals.
- Minimize turbidity or sedimentation of HAPCs (e.g., kelp beds, reefs) or clam beds.

Resource Protection Considerations

- Reduce vessel speed to ≤ 10 knots (≤11.5 miles per hour) if whales are present and maintain a constant speed that is not faster than the whale(s) when paralleling within 300 ft (91 m). Avoid abrupt changes in vessel direction when paralleling whales.
- Avoid intentional vessel approaches within 300 ft (91 m) of whales or sea otters.
- Maintain a distance of 1,000 ft (305 m) of sighted whales whenever possible.
- If a whale is in close proximity and safety permits, reduce speed and shift engines to neutral and do not engage engines until animal clears area.
- If dolphins or porpoise are sighted bow-riding, vessel operators shall attempt to remain parallel to the animal's course.
- Report collisions with marine wildlife to NMFS and DFG pursuant to each agency's reporting procedures.
- Establish and maintain a construction buffer distance of ≥ 500 ft (152 m) from seal or sea lion haul out or rookery areas.
- Avoid disturbance of seals or sea lions on land. If any individual animal is present within 300 ft (91 m), halt or redirect work until animal leaves the beach. If animal is stranded, report to NMFS Stranding Coordinator (562-980-4017).
- Direct lights away from haul outs or rookeries if night-time operations would occur in vicinity.
- Establish vessel routes outside kelp beds to protect foraging habitat of marine mammals.
- Avoid dredge or discharge operations within 500 ft (152 m) of kelp forest or rocky subtidal HAPC habitats to minimize foraging interference of marine mammals.
- Avoid dredge or discharge operations in established clam beds to protect foraging habitat of sea otters, if present.
- Conduct construction monitoring by a qualified biologist, as necessary.

Effectiveness Considerations: Minimizing intentional approaches and speed of vessels is recommended by NOAA-NMFS to avoid harassment of marine mammals. Including buffer distances between construction activities and marine mammal areas of concern (e.g., rookeries, haul outs, areas of sea otter concentration) also may be effective for minimizing the potential for noise or disturbance harassment. Operational controls and BMPs to limit turbidity or sedimentation should be effective for minimizing indirect impacts on marine mammal foraging behavior.

Seasonal Considerations: Marine mammals may be present year-round.

Monitoring Considerations: Use of environmental monitors to ensure avoidance of harassment of marine mammals may be appropriate in certain situations based on proximity of sediment management activities to areas where marine mammals may be of concern. For example, the USACE Los Angeles District recommends monitors during dredging if sea otters are present (*http/el.erdc.usace.army.mil/tessp/info.cfm*).

Volume 1 References: SAIC 2011 – Section 4 (4.5), Section 5 (5.3.2.4, 5.3.2.6), Section 6 (6.6.2.4), and Section 7 (7.4.5.4).

Other References: NMFS-Southwest Office (*http://swr.nmfs.noaa.gov/psd/watching.htm*).

3.3.3 Embayment Habitats

Photo credit: Karen Green

Status: All coastal embayments are EFH-HAPC. Some shallow inlet embayments have additional status as ecological reserves, preserves, and/or wildlife refuges. Embayments also may include one or more special aquatic sites (SAS) as designated under Section 404(b)(1) of the CWA, such as wetlands, mudflats, vegetated shallows, sanctuaries and refuges.

Habitat Definition: Shallow-inlet embayments as defined in this document as shallow inlet estuaries and lagoons. These systems include river mouth estuaries (ocean inlets associated with creeks, rivers, streams), canyon mouth estuaries, coastal dune estuary, and lagoons (Shaffer 2002), and include water bodies identified as esteros and sloughs. Over 75 shallow-inlet embayments occur throughout California.

Deep-water inlet embayments, as defined in this study, include marine bays, large bay-estuaries, ports, harbors, and associated marinas. Over 25 deep-water inlet embayments occur throughout California.

Sediment Management Issues: Sedimentation resulting from trapping of littoral sands in entrance channels or bars or from watershed runoff are maintenance issues for many embayments. Maintenance dredging/excavation may be periodically conducted to maintain navigable waterways or tidal circulation. Dredged materials that are "clean" and sandy provide beneficial reuse opportunity for beach nourishment depending on availability of suitable receiver sites.

Embayments are ecologically important ecosystems that may serve as nursery habitats for marine and estuarine species, include sensitive SAV habitat (eelgrass), provide connection to streams used by anadronomous fish, serve as important stopover and/or nesting areas for migratory birds, and may provide nesting or foraging areas for endangered and threatened species. Conducting sediment management activities in these areas often requires implementation of mitigation measures to avoid or minimize impacts to sensitive resources.

Wetlands enhancement/restoration is not a sediment management activity, per se, although excess sedimentation may be a degradation factor addressed by the project. If removed sediments are suitable, there may be opportunity for beneficial reuse for beach nourishment.

Overview of Relevant Background Considerations:

Functions and Resources of Concern

Useful links to California wetlands information.

- *http://www.wrpinfo.scc.ca.gov/*
- *http://www.ceres.ca.gov/wetlands/inventories/inventories.htm*
- *http://ucjeps.berkeley.edu/wetlands/titlepag.html*

Embayments support a variety of habitats including some combination of open water, channels, mudflats, coastal salt marsh, and salt flats. Creeks and rivers provide long corridors of open water, stream banks, transition from salt to freshwater marsh in areas along their banks, and often include adjacent riparian (freshwater influenced shrubs and trees) habitats. Due to their diversity of habitats, embayments represent sensitive wetland areas and support primary living, foraging,

and reproductive habitat for hundreds of species of invertebrates, fish, birds, and plants (e.g., CCC 1987, Allen 1999, MEC 2000b, Thompson et al. 2000).

Substantial resident populations of invertebrates and fish inhabit embayments; however, there also is considerable transient movement of fish and some invertebrates between the ocean and embayments for spawning and foraging purposes. Anadronomous fish may migrate through embayments on their way to and from the ocean and upstream rivers. Marine mammals, including seals, sea lions, sea otters, dolphins and whales on occasion may be observed in large embayments (MEC 2000b, USACE 2001).

Resources of Concern

- Endangered green sturgeon
- Endangered least tern
- Endangered light-footed clapper rail
- Endangered salmonids
- Threatened snowy plover
- Sandy subtidal invertebrates
- Dungeness crab
- Pacific herring
- Marine mammals
- Invasive species
- Water quality

Wetlands or vegetated habitats may occur adjacent to sediment management areas in embayments. For example, eelgrass meadows commonly occur in many bays and lagoons in California. The vegetated shallows provide important nursery habitat for several commercial/recreation species, including Pacific herring, California halibut, rockfish, and Dungeness crab (CCC 1987, MEC 2000b, CDFG 2001, USACE et al. 2001).

Several endangered or threatened bird species may nest or forage in embayments, including least tern, snowy plover, and light-footed clapper rail. Endangered green sturgeon or salmonids may be present in central and northern California embayments. Protected marine mammals may forage or rest in embayments.

Sediment Management Activities and Impact Considerations

Types of sediment management activities and potential impacts to embayments include:

- Beach nourishment (if nearby, may contribute to sedimentation of embayment entrance channel)
    - Beach placement – sedimentation, turbidity
    - Dune placement – not applicable
    - Nearshore placement – not applicable
    - Profile placement – sedimentation, turbidity

- Dredging/Excavation
    - Maintenance dredging of embayments – equipment, sedimentation, turbidity
    - Maintenance excavation of embayment inlet channel – equipment, sedimentation, turbidity
    - Offshore borrow site dredging – not applicable

Sediment management activities in shallow-inlet embayments may include dredging/excavation to maintain open inlets, tidal circulation, or flood control capacity. Maintenance dredging of deep-water-inlet embayments is conducted to maintain navigable channels and waterways. If suitable, dredged/excavated sediments may provide beneficial reuse as source material for beach nourishment, capping of contaminated sediments, or habitat restoration.

Equipment use associated with beneficial reuse projects may include dredging, pipeline placement, and/or anchoring. Equipment use has the potential to result in the following types of impacts to wildlife.

- Dredge removal of invertebrates with reduction of invertebrate forage base for fish and marine mammals.
- Dredge entrainment of demersal invertebrates or fish. (*Entrainment is defined as: incidental trapping of any life stage within structures that carry water being diverted for anthropogenic use.*)
- Removal and/or disturbance of soft-substrate spawning grounds of fishery species (e.g., Dungeness crab, Pacific herring, salmonids).
- Removal and/or disturbance of SAV habitat.
- Pipeline burial and disruption of benthic invertebrates and/or SAV habitat.
- Activity and/or noise related disturbance displacement of mobile, epifauna invertebrates, fish, birds, and/or marine mammals.
- Light attraction and increased predation on schooling, water-column fish and/or interference with migration of fishery species (Pacific herring, salmonids).

Impact factors during maintenance dredging/excavation primarily concerns turbidity, sedimentation, and disturbance from operation of equipment and activities. Most of these disturbance factors would be expected to be limited to the construction period and consequently would be of short duration. Sedimentation impacts could span months to a year or more depending on thickness of overburden and hydrodynamic considerations.

Beach nourishment has the potential to impact embayments and associated biological resources if sediment transport sedimentation accelerated or increased sand shoaling or resulted in inlet closure (NRC 1995). The degree of vulnerability will depend on a number of factors including, but not limited to: proximity to sediment management activity, volume of placed sands, prevailing current direction, outflow characteristics of water body (including tidal prism as appropriate), and inlet stability. Historical records of inlet closures and/or maintenance dredging requirements generally provide relevant information regarding potential vulnerability to sedimentation effects. Placing beach receiver sites downcurrent from tidal inlets and/or at a sufficient distance that inlet sedimentation is negligible may be the most effective measure to avoid impact concerns. Providing funding to augment dredge maintenance budgets has been required for some California beach nourishment projects. However, determination of whether sedimentation results from beach nourishment or natural processes can be challenging.

Maintenance dredging/excavation of embayments will result in turbidity and sedimentation impacts. The duration of turbidity may be on the order of days to weeks depending on project size and hydrodynamics. Elevated turbidity associated with removal of sandy sediments generally is limited to the construction period and dissipates rapidly after cessation of dredging (e.g., hours) (LaSalle et al. 1991). Potential turbidity impacts may include displacement of motile animals, avoidance by fish-eating birds (e.g., California least tern), disturbance (reduced foraging, respiration) of sedentary animals, or reduced light levels for aquatic plants (e.g., eelgrass, kelp), if present. Thin-layer sedimentation (deposition of suspended sediments) may extend over a broad distance range, but most occurs within 1,000 ft (300 m) of dredge (Germano and Cary (2005). Generally, disturbance is considered comparable to storm-induced sedimentation, ranging on the order of 3-5 days.

Dredging has the potential to entrain early life stages and/or small organisms as a result of near bottom water being withdrawn by suction dredges (LaSalle et al. 1991). Studies examining dredge entrainment effects report that overall entrainment rates are generally low, but mortality rates may range from 56 to 100 percent depending on species and their size (LaSalle et al. 1991, Reine and Clarke 1998). Dredge entrainment may be of concern during seasonal periods when early life stages are more prevalent and when activities occur in more confined areas (e.g., narrow channels, confined basins) where mobile organisms may not be able to avoid the dredge and/or passive organisms concentrate.

The major biological impact of dredging is removal of soft-bottom habitat and benthic invertebrates. This reduces the forage base for bottom-feeding fish and larger invertebrates. Dredging or associated activities (e.g., laying of discharge pipelines) has the potential to disturb or remove vegetated habitat (e.g., eelgrass, wetlands), or impact spawning grounds (e.g., Dungeness crab), if present.

Activities associated with transport and placement of dredged sediments at in-bay aquatic disposal sites, ocean dredged material disposal sites, port development locations, or upland landfills are not addressed in this document since they do not relate to beach nourishment.

Other Activities or Issues

Proximity of sediment management activities to sensitive habitats or resources are important considerations to the assessment of potential impacts from sediment management activities. Bay and estuaries are essential foraging, rearing, or reproductive habitats for several endangered or threatened species. Seasonal use patterns of sensitive species may vary because of the migratory nature of many coastal species. For example, the entrance channels of some embayments support migratory routes of endangered anadromous species, including green sturgeon, Chinook and Coho salmon, and steelhead trout. The migratory, endangered, California least tern seasonally establishes breeding colonies at many embayments in the state. Embayments are important breeding, feeding, and resting areas for many birds that migrate along the Pacific Flyway.

Eelgrass is an important sensitive vegetated habitat that occurs in many embayments. Many species of fish and invertebrates seasonally use eelgrass habitat for spawning or nursery habitat, including endangered salmonids and commercially important species (e.g., California halibut, Dungeness crab, Pacific herring).

Rocky habitats (breakwaters, groins, riprap shore protection) may occur along shorelines of embayments. Although not as productive as nearshore reef or kelp forest habitats, the rocky and hard-bottom associated communities represent essential fish habitat to many marine fish.

Proximity to other discharges (e.g., point or non-point) may affect sediment quality and potential suitability of material for beneficial reuse for beach nourishment. Generally, littoral sands that become trapped in entrance channels of bays and harbors, which are subject to maintenance dredging activities, represent a major sediment source for beneficial reuse as beach nourishment. Sediments from more interior areas of ports and harbors may require additional tiered testing to determine whether the sediment may be suitable for that purpose.

Sediment management activities have the potential to conflict with other vessel or shipping traffic in embayments. Typically, locations of dredging or discharge activities are reported in local U.S. Coast Guard Notices to Mariners to advise extra caution in areas where those

activities take place. This is done to minimize risk of collision, fouling of fishing gear, or other potential conflicts of uses.

Non-native species, including invasive species that displace native species, are of increasing concern in embayments. Introductions primarily have been linked to shipping practices and traffic between ports. However, releases of discarded plants or animals from home aquariums may contribute to localized problems. Surveys for the invasive marine plant, *Caulerpa taxifolia*, is required prior to dredging in many of the embayments in southern California.

Recovery Considerations

Sediment management activities in shallow-inlet embayments may be necessary annually or more frequently to maintain open inlets or flood control capacity. Sediment management in deepwater-inlet embayments may be necessary every year or two to maintain entrance channels due to the trapping of littoral sands. Less frequent maintenance dredging may be required with increasing distance from the inlet and a decrease in shoaling effects. However, watershed inputs of sediment may require periodic dredging or excavation to maintain adequate tidal circulation in areas influenced by stream runoff.

An important impact issue associated with maintenance dredging of sands is the temporary reduction in invertebrate prey resources for demersal fishes and larger invertebrates that feed on the bottom. Recovery rates of benthic invertebrates after dredging depend on existing conditions. Generally, recovery rates are relatively rapid (< 1 year) in areas supporting non-equilibrium populations due to frequent disturbance, such as harbor entrance channels (McCauley et al 1977, Newell et al. 1998). These areas are subject to shifting sediments and sedimentation associated with shoaling as well as the recurring disturbance from dredging or excavation. Generally, invertebrate communities in frequently disturbed areas are less diverse and dominated by short-lived opportunistic species that can quickly colonize after disturbance. Harbor areas dredged less frequently may take 2 to 3 years to recover (Oliver et al. 1977, Merkel & Associates 2010).

Because maintenance dredge depths and frequencies in Ports and Harbors are dictated by needs to maintain navigable waters and funding cycles, resource protection considerations associated with dredge depths and frequency of dredging that were considered for offshore borrow site dredging and nearshore discharges (Sandy Subtidal Invertebrate Recovery Guideline in Section 3.3.2) generally are not applicable to embayments. The approach taken in this section was to include resource protection considerations in the embayment water quality guideline was to include several measures to contribute to the protection of beneficial uses of habitats and general wildlife resources.

The risk of inlet closure due to sand transport from a beach sand receiver site would depend on proximity, prevailing current direction, and project volume. Increased sediment volume without a change to inlet maintenance frequency may disturb habitats and resources, but would not be expected to substantially affect invertebrate recovery after inlet maintenance activities. However, increased sediment volume requiring more frequent maintenance activities has the potential to result in cumulative impacts with prolonged disturbance and recovery rates.

Mitigation Considerations

A key impact issue is occurrence or proximity to listed sensitive species, managed fishery resources, or other sensitive habitats. Environmental work windows (or restricted periods) may be used to avoid or minimize potential impacts to sensitive or high-interest species. Buffers may be used to minimize turbidity or sedimentation effects on eelgrass, spawning areas, or other sensitive habitats. Buffers also may be used to minimize effects of construction noise or lights on sensitive species. Another important consideration is protection of water quality and habitats with use of BMPs and operational control measures.

Monitoring Considerations

Beneficial reuse sources of sand from embayments typically come from maintenance dredging programs. Generally, monitoring is required to demonstrate that the project does not degrade waters in compliance with RWQCB 401 requirements. Additional monitoring may be necessary to ensure protection of sensitive resources, if present during construction. Beach nourishment projects may need to evaluate the potential to increase sedimentation rates in nearby lagoons or embayments associated with post-construction sand transport. Beach profiles may be effective for documenting sand migration after placement.

Cross-Reference Table to Relevant Sections of the Volume 1 BIA Document

Topic	Volume 1 Section	Volume 1 Subsection
Resource Description and Sediment Management Issues		
Shallow-Inlet Embayment	3	3.3.9
Deepwater-Inlet Embayment	3	3.3.10
Eelgrass	3	3.3.8
Dungeness Crab	4	4.2.3
Sandy Subtidal Invertebrates	4	4.2.7
Green Sturgeon	4	4.3.2
Pacific Herring	4	4.3.3
Bottom-Dwelling Fish	4	4.3.5
Water Column Fish	4	4.3.6
Gulls, Skimmers, and Terns	4	4.4.4
Shorebirds	4	4.4.5
Wading Birds	4	4.4.6
Waterfowl and Seabirds	4	4.4.7
Sea Otters	4	4.5.1
Seals and Sea Lions (Pinnipeds)	4	4.5.2
Whales, Dolphins, and Porpoises (Cetaceans)	4	4.5.3
Impact Considerations		
Equipment - Embayment	5	5.3.3.5
Equipment – Dredging	5	5.3.1.2, 5.3.2.2
Equipment- Entrainment	5	5.3.2.3
Sedimentation Impacts – Embayment	5	5.4.3.5
Turbidity Impacts - Species	5	5.5.4
Mitigation Measures		
Avoid sensitive habitats or species	6	6.3.2.1
Schedule or seasonal restrictions (environmental windows)	6	6.4.2.3, 6.4.2.4
Construction operational controls, methods, BMPs – Turbidity	6	6.4.3, 6.4.4
Minimize noise levels in sensitive wildlife areas	6	6.4.4.4
Minimize artificial lighting in sensitive wildlife areas	6	6.4.4.5

Topic	Volume 1 Section	Volume 1 Subsection
Prepare hazardous materials plan, minimize leaks or spills	6	6.3.7.1, 6.4.4.4
Conduct Coast Guard Notifications	6	6.3.7.4
Monitoring Considerations		
Physical/Chemical		
Inlet monitoring and response	6	6.4.5.3
Water quality	7	6.4.5.2, 7.4.2, 7.4.3
Biological		
Pre-construction habitat and sensitive resource assessment	6	6.3.8.2, 7.3.2.2
Caulerpa survey	7	7.3.3
Least tern	7	7.4.5.2

Guideline Considerations:

<u>List of Relevant Resource Protection Guidelines</u>

The following guidelines may be relevant to Embayment habitat depending on site-specific conditions:

Resource Protection Guidelines	User's Guide: This Section	User's Guide: Other Sections
Physical-Chemical		
Embayment Water Quality	X	
Biological		
Aquatic Invasive Species	X	
Sandy intertidal Invertebrates		3.3.1
Sandy Subtidal Invertebrates		3.3.2
Dungeness Crab	X	
Green Sturgeon	X	
Pacific Herring	X	
Salmonids	X	
Least Tern		3.3.1
Capper Rail	X	
Migratory Birds		3.3.1
Snowy Plover		3.3.1
Marine Mammals		3.3.2

Figure 3.3-3 provides a decision flow chart to relevant guidelines. Sediment characteristics, potential impact duration (> 5 days), and distance (1,000 ft, 300 m) from sensitive resources were incorporated as decision considerations in the embayment habitat flow chart.

Similar to beach and nearshore guidelines, available laboratory studies of environmental effects associated with suspended sediments or sedimentation generally have tested for acute effects over time periods ranging from 24-96 hours (1 to 4 days) and chronic effects over time periods ranging from 8 to 25 days. Additionally, exposure durations of sessile organisms to turbidity or sedimentation effects associated with advance rates of dredging are thought to be on the order of days (Wilber and Clarke 2001, Germano and Cary 2005).

A distance within 1,000 ft (305 km) is referenced relative to occurrence of sensitive vegetated or hard-bottom habitats. While turbidity and sedimentation may occur within and beyond that

distance, major influences are within or at about half that distance (Section 2.7.5. This distance also is relevant for evaluating potential environmental constraints to sensitive species from noise and disturbance effects from dredging operations.

Guidelines in this section primarily concern water quality and high interest species associated with embayment habitats. The guideline for water quality is generally relevant to resource protection for invertebrates and fish. Guidelines for Dungeness crab, green sturgeon, Pacific herring, and salmonids are protective of spawning and rearing habitat functions in embayments. The clapper rail guideline, as well as, the migratory bird guideline (Section 3.3.2) is relevant to protection of sensitive bird breeding activities in adjacent wetlands. Other relevant resource protection guidelines may include those for least terns and snowy plovers (Section 3.3.1), which nest and/or forage in embayment habitats, and marine mammals that may forage and rest in these protected habitats (Section 3.3.2).

Other Potential Relevant Guidelines

Eelgrass habitat has the potential to occur adjacent or in proximity to maintenance dredging areas in embayments. In addition, rocky intertidal or subtidal habitat may occur along jetties or rip rap shoreline protection:

- Rocky intertidal or subtidal habitat (Sections 3.4.2)
- Eelgrass habitat (Section 3.4.3)

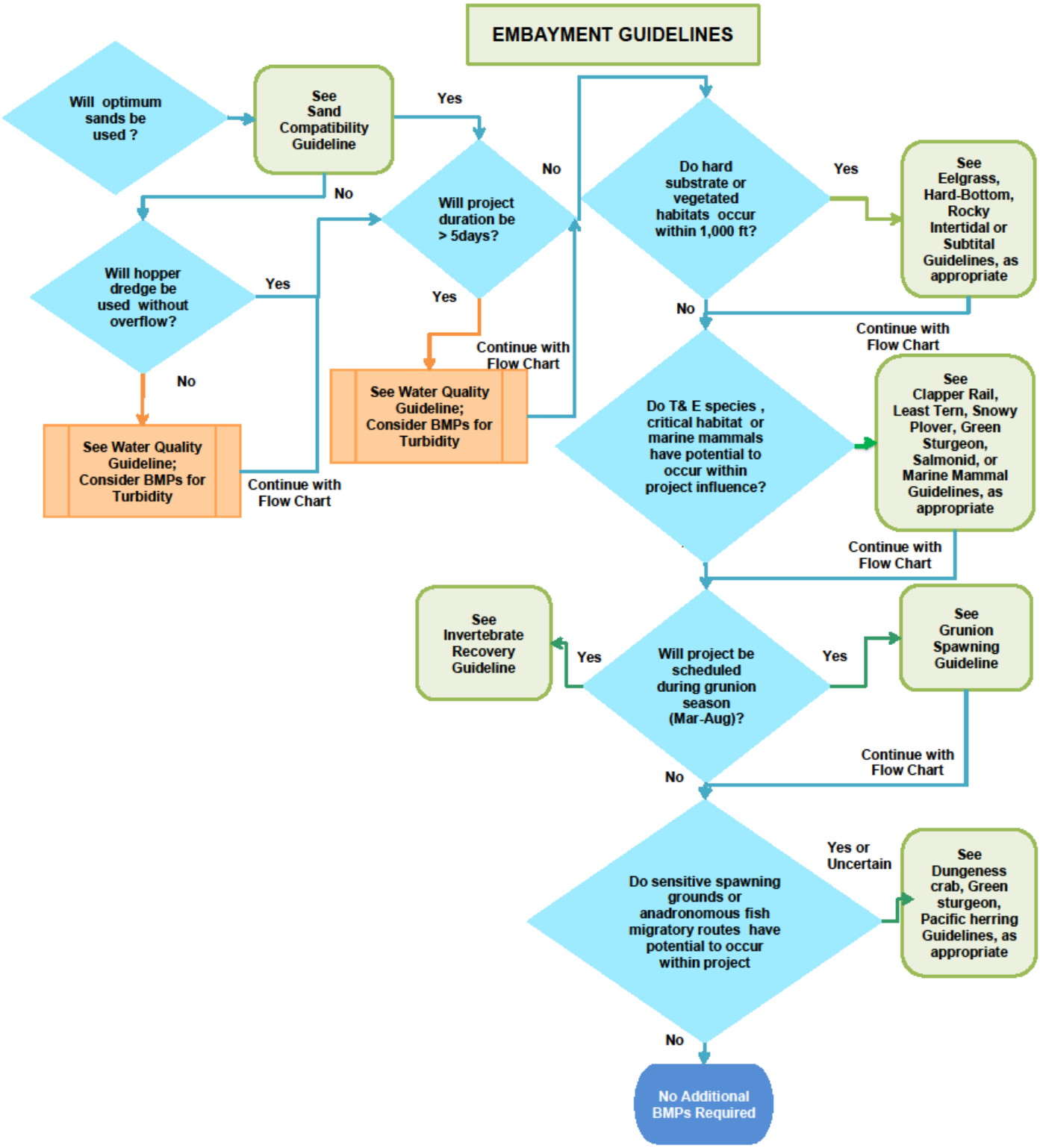


Figure 3.3-3. Flow chart to embayment habitat resource protection guidelines.

Embayment Water Quality Guideline

Lagoon Inlet Photo credit: Karen Green

Definition: Marine and estuarine water physical and chemical characteristics within the enclosed water body.

Functions: Essential to marine and estuarine life, quality of foraging habitat for diving birds, and beneficial uses of the water body.

Sediment Management Issues: The SWRCB (implemented by regional offices RWQCB) is the regulatory authority for Clean Water Act (CWA) Section 401 Water Quality Certification and/or Waste Discharge Requirements (WDRs) for dredge/fill projects, which must be obtained as part of the permitting process to implement a beach sand placement project. Bay and estuary maintenance dredging or restoration projects represent sources of material that may be beneficially reused for beach nourishment. Such dredging requires Section 10 and 404 permits, and 401 Water Quality Certification. Water quality monitoring during dredging is specified in the certification and/or WDR, and may be project-specific (SAIC 2011, Appendix C).

Water quality in enclosed bays, estuaries, lagoons, and inland surface waters are regulated by local RWQCBs and associated Basin Plans. Water quality criteria are qualitative or quantitative estimates of the concentration of a water constituent which, when not exceeded, will ensure water quality sufficient to protect designated beneficial uses.

Prior to dredging, sediments are tested to determine appropriate disposal or beneficial reuse options, with the USACE in consultation with the USEPA, making the ultimate decision regarding suitability of material for beach nourishment. A consideration of suitability is that sediments must be free of substantial contamination. Generally, contaminant release is not an issue for these projects and is not addressed further in this guideline. Bacteria testing usually are not conducted at the dredge site, but may be required at the discharge site if within waters used for water contact recreation.

This guideline addresses water quality monitoring considerations for dredging projects that beneficially reuse dredge material for beach nourishment. Water quality criteria may vary somewhat among RWQCBs (Table 2.6-5). Additionally, monitoring requirements may vary both within and between RWQCBs based on project-specific considerations.

Monitoring generally includes visual observations to verify water quality objectives for the following parameters, which if detected, may cause a nuisance or adversely affect beneficial uses:

- Aesthetically undesirable water discoloration.
- Floating particulates, trash, debris, solids, foam, scum.
- Objectionable aquatic growths.
- Odors.
- Oil, grease, waxes, petroleum substances, visible films, coatings on objects.

Turbidity criteria are based on use of a nephelometer (NTU values), with slight variability among Basin Plans (Table 2.6-5). Generally, compliance criteria are based on comparison of turbidity within the area influenced by dredging activity with that of ambient waters, with different numerical criteria depending on environmental conditions at the time of the activity. Waters

influenced by discharges are not to exceed ambient values by more than 20% when ambient NTU values range from 0 to 50, not more than 10% or 10 NTU when ambient NTU values range from 50 to 100, and less than 10% when ambient turbidity is >100 NTU.

Other monitoring requirements may include standard water quality parameters such as dissolved oxygen, pH, salinity, and temperature. Additionally, water clarity (Secchi disk), light transmittance (transmissometer), or total suspended solids (mg/L) may be specified.

In San Francisco Bay, light levels also may be monitored if dredging occurs within a distance of 1,000 ft (305 m) from eelgrass meadows and dredge sediments have >20% silt/clay, currents will likely result in turbidity in the eelgrass area, and silt curtain BMPs are not feasible to use (see Eelgrass Guideline, Section 3.4.3).

Dredging results in temporary turbidity impacts. The persistence of plumes relates to the sediment grain size and characteristics, currents, tide stage, and circulation patterns. Turbidity associated with dredging or excavation of sandy sediments rapidly dissipates after cessation of the activity (hours at most) (LaSalle et al. 1991). While dredging activities may span several days to weeks, generally mobile organisms have exposures on the order of minutes to hours and sessile organisms have exposures on the order of hours to days because of the advance rate of dredging (Wilber and Clarke 2001). Exceptions may occur in areas where water circulation is reduced.

Marine-estuarine biota are adapted to episodic and varying levels of turbidity. However, highly turbid waters or prolonged turbidity may exceed tolerance levels. Reductions in light levels may reduce photosynthesis, growth, or reproduction of aquatic plants. Although some fish may be attracted to turbid waters to feed on suspended particulates or reduce predation risk, excessive or prolonged turbidity can be detrimental. Turbid waters have the potential to cause adverse effects to feeding, respiration, spawning, or movement of fish or invertebrate species. Turbidity may be lethal under very high concentrations or prolonged exposures (Clark and Wilber 2000, Sabol et al. 2005). Turbidity also may interfere with foraging of visual predators (e.g., fish, fish-eating birds, seals or sea lions).

Reduction of oxygen content of waters or nutrient release may be a concern when dredging sediments from harbors. However, those concerns typically are associated with sediments in depositional areas with a relatively high percentage of fines (silt/clay) and organics. Because sediments used for beneficial reuse must be predominantly sandy and free of substantial organic content (USEPA and USACE 2004), substantial oxygen depletion or biostimulation of harmful algae blooms would not be expected with most projects involving beneficial reuse of sediments for beach nourishment.

Dredging will result in temporary impacts to wildlife associated with noise and disturbance. In addition, dredging will result in entrainment and sediment removal impacts to bottom-associated organisms within the footprint of the dredging activities. This guideline includes resource protection considerations to minimize impacts to general wildlife during dredging. Other guidelines provide resource protection considerations for subtidal invertebrate community recovery or for sensitive habitats and high-interest species.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging • Inlet excavation	• Debris, leaks or spills • Suspended sediment, turbidity, water clarity
Other Activities or Issues of Concern	**Resources of Concern**
• Point and non-point source discharges • Plankton blooms	• ASBS, MPA, SAS, SAV (eelgrass) • threatened & endangered species, protected species, spawning grounds of managed fishery species • Caulerpa

Note: All embayments are HAPC

Guideline Objectives:

- Avoid degradation of waters and embayment habitats during sediment management activities.
- Minimize adverse effects of suspended sediment and turbidity on habitats and resources during sediment management activities.
- Minimize adverse effects of dredging on wildlife beneficial uses of the water body.

Resource Protection Considerations

- Evaluate or test sediments according to appropriate USEPA and USACE testing manual to ensure that sediments used for beneficial reuse are free of substantial contamination or organic content.
- Conduct inspections of sediment during loading (if using barge, scow, hopper dredge, etc.) to verify sediment characteristics meet permit requirements and to ensure materials are free of unintended debris or materials.*
- Prepare a Spill Prevention Control and Countermeasures Plan (SPCC) prior to initiating dredge operations that specifies fueling, equipment maintenance procedures to prevent spills and leaks, and best management practices (BMPs) to contain and clean up hazardous materials in the event of a spill.
- Limit the operation of suction pumps when the dredge cutterhead or dragarms are above the surface to minimize entrainment of invertebrates and fish.
- Avoid use of equipment, pipelines, and construction materials in sensitive habitats.
- Schedule dredging to avoid environmental restricted periods as may locally apply to protect federal- or state-listed endangered or threatened species, to the extent feasible and in accordance with permit conditions.
- Sequence dredge locations so currents or tides transport turbidity away from sensitive habitat areas to the extent practicable.
- Establish buffer distance (300-500 ft, 91-152 m) from federal or state-listed endangered, threatened, or full protected species nesting sites or communal resting areas, to extent practical. The buffer distance may vary depending on species sensitivity to disturbance, equipment to be used, and any relevant site-specific factors that would naturally minimize disturbance.

Continued next page

Resource Protection Considerations (Continued)

- Establish buffer distance of 1,000 ft (305 m) from sensitive habitats or areas (e.g., eelgrass, kelp, spawning ground), if feasible. Buffer distance should consider sediment characteristics and prevailing current direction (e.g., under similar environmental conditions, buffer distance could be less for sandy sediments than silty-sands). If buffer is not feasible, use silt curtains to minimize turbidity impacts to sensitive habitats; and inspect daily to ensure proper operation. Only deploy silt curtains if conditions allow effective operation, such as low current velocities < 2.5/sec (<1.5 knots), stable water levels, winds not excessive, and relatively shallow water depths (< 10-15 ft). Conduct additional monitoring if buffer or silt curtains is not feasible.
- Monitor water quality during dredging to verify compliance with Basin Plan and RWQCB 401 certification and/or WDR requirements. Modify discharge if water quality exceeds permit limits.
  - Establish stations at 100 (30 m) downcurrent, 300 ft (91 m) downcurrent, and 500 ft (152 m) downcurrent , and within plume if visible; and at least 500 ft (150 m) upcurrent and outside any visible plume.
  - Document visual observations relevant to water quality objectives (e.g., discoloration, floating particulates, debris/trash, solid waste, odors, petroleum substances or films, tide stage, current direction and speed, weather). Photo-document water appearance.
  - Measure dissolved oxygen, pH, salinity, temperature, turbidity (NTU) throughout water column or at surface, mid-water, and near-bottom depths, as well as Secchi disk depth. Verify compliance with Basin Plan criteria. If other methods are used to characterize turbidity effects, they should be taken in addition rather than as a replacement to criteria specified in the Basin Plan. Collect mid-depth samples for analysis of TSS (mg/L).
  - Note plume incursions into or towards sensitive habitat (ASBS, MPA, SAS), if nearby.
  - Note if plume exceeds 0.5 mi (0.8 km) from dredging or discharge if least tern breeding colonies are within 1 mi (1.6 km) of project.
- Note any corrective actions and the effectiveness of measures used to meet compliance requirements. Take all reasonable steps to correct operations resulting in non-compliance, such as adjusting operation controls or use of BMPs, according to following dredge methods:

  Cutterhead Dredge

  - Use dredge operation controls (e.g., reduce cutterhead rotation speed, reduce rate of ladder swing and rotating cutterhead, reposition cutterhead in sediment, reduce advance rate of dredge, eliminate bank undercutting), as necessary.

  Hopper Dredge

  - Use dredge operation controls (e.g., eliminate overflow), as necessary.

  Bucket Dredge

  - Use dredge operational controls (e.g., hoist closed buckets slowly to reduce spillage, reduce bucket ascent near and from the water surface, reduce bucket over-penetration, eliminate multiple bites, eliminate bottom stockpiling, use rinse tank to clean bucket at barge between loads, implement waterline pause to allow excess water to drain at surface before raising bucket from water, eliminate overflow of scow or barge).
- Notify the RWQCB and USACE by e-mail, if water quality is out-of-compliance for two consecutive days, and comply with any measures identified by the permitting agencies, in consultation with other responsible agencies, as appropriate, to mitigate project-related effects, including modifying or halting discharge. Conduct additional monitoring, as appropriate.

Resource Protection Considerations (Continued)

- If out of compliance turbidity persists the third day, conduct additional monitoring as may be necessary to determine the nature and impact of non-compliance:
  - If Project duration < 1 week and plume does not extend into sensitive habitat – continue to monitor turbidity plume and modify discharge to achieve compliance.
  - If Project duration is > 1 week, plume extends into sensitive habitat (ASBS, HAPC, MPA, or SAS), or within 1 mi (1.6 km) of least tern breeding – conduct additional monitoring to verify protection of beneficial uses. Modify activity as necessary to ensure sensitive resource protection.
- Sampling, analysis, quality assurance, reporting, and photo-documentation should be in accordance with the Surface Water Ambient Program (SWAMP) requirements, as applicable.

Effectiveness Considerations: Inspections, SPCC plan, monitoring, and implementation of operational or engineered control measures, as necessary, generally are the most effective means available for minimizing impacts to water quality during dredging. Most of the above-noted operational or engineered control measures are based on reviews by LaSalle et al. (1991), Collins (1995), Anchor Environmental (2003), or Palermo et al. (2008). The effectiveness of the operational controls may vary with the skill of the operator (Bridges et al. 2008, Palermo et al. 2008).

An effectiveness consideration with use of a hopper dredge is the incentive to carry economic loads, which maximize the sediment content in the hopper bins. As sediment settles, the cleaner water near the top of the hopper is allowed to flow out a weir(s) on the side of the vessel so that more sediment may be pumped into the hopper. This practice allows more sediment to be transported with each load from the dredge site than would otherwise occur without overflow. The nature of the turbidity plume with overflow largely depends on the grain size characteristics of the dredge material. The method is more beneficial when dredging sands because the settling velocity is high enough for the sands to rapidly settle in the hopper during the short filling time, resulting in cleaner overflow water (Palermo and Randall 1990). The practice is not recommended when dredging sediments with a high silt/clay content because the small particles stay in suspension longer resulting in a highly turbid overflow.

Use of engineered controls such as silt curtains to protect sensitive resources may be effective when site conditions warrant minimal transport of suspended sediment, but may not be effective if there are strong currents (>2.5 ft/sec, > 1.5 knots), changing water levels, strong winds, excessive wave heights (e.g., from ships), or movement of equipment in and out of the curtained area (Palermo et al. 2008). Silt curtain deployment considerations are reviewed in detail by Francinques and Palermo (2005). Silt curtains should be periodically inspected by divers to verify their integrity and effectiveness (Palermo et al. 2008). Palermo et al. (2008) do not recommend silt curtains as a standard BMP, and emphasize that they are highly specialized, temporary use devises and require detailed knowledge of site conditions to evaluate appropriate application to site conditions, if warranted.

Seasonal Considerations: Turbidity naturally ranges higher during winter storms or high wind wave conditions. Therefore, there is a potential for the difference between project-related turbidity and ambient conditions to be less during winter than during summer seasons. Generally, elevated turbidity is of greater concern during spring-summer when biological

productivity generally is greater and the breeding season for a variety of wildlife using embayments may occur.

Monitoring Considerations: Monitoring generally is required during sediment management projects to comply with RWQCB 401 water quality certifications and/or waste discharge requirements (WDRs). Monitoring considerations for documenting compliance for embayment habitats are similar to those described for the Nearshore Water Quality Guideline (Section 3.3.2). Monitoring considerations for eelgrass are described in the Eelgrass Guideline (Section 3.4.3).

Volume 1 References: SAIC 2011 – Section 5 (5.5.2, 5.5.3), Section 6 (6.4.3.3, 6.4.4.1, 6.4.4.4, 6.4.5.2, 6.4.5.3), and Section 7 (7.4.2, 7.4.3).

Aquatic Invasive Species Guideline

Caulerpa taxifolia
Photo credit: Rachael Woodfield

Definition: Non-native species that quickly spread from their point of introduction.

Status: *Caulerpa taxifolia* – Federal noxious weed.

Sediment Management Issues: Non-native species, when invasive, threaten the diversity or abundance of native species through competition for resources, predation, parasitism, interbreeding with native populations, transmitting diseases, or causing physical or chemical changes to the invaded habitat. The DFG established the Invasive Species Program to reduce the negative effects of invasive species on the wildlands and waterways of California. State surveys of California's coastal waters have identified over 300 species of aquatic invasive species (AIS).

Useful Links to California Invasive Species Issues

- *http://www.anstaskforce.gov/default.php*
- *http://www.dfg.ca.gov/invasives/*
- *http://swr.nmfs.noaa.gov/hcd/caulerad.htm*
- *http://www.sccat.net*
- *http://www.invasivespecies.gov/*
- *http://iscc.ca.gov/*
- *http://ice.ucdavis.edu/invasives/home/species*
- *www.exoticsguide.org*

The California Aquatic Invasive Species Management Plan proposes management actions for addressing AIS threats. It focuses on the non-native algae, crabs, clams, fish, plants and other species that continue to invade California's creeks, wetlands, rivers, bays and coastal waters. The DFG – Office of Spill Prevention and Response (OSPR) manages a database that contains the name and location of every known non-native species on the California coast, known as CANOD (California Aquatic Non-native Organism Database).

Many invasive species occur in bays and harbors in California. Most were carried on ship's hulls or carried with ballast, which is used its trim the hull to a proper level in the water when there is little or no cargo aboard. In the past, ships used solid ballast (rocks, sand, or mud that carried various marine plants and animals) (Cohen 2005). Modern cargo ships use large volumes of water as ballast, which carries huge numbers of plankton (including larvae of benthic animals) around the world.

AIS that have been subject to eradication in embayments are described in the California Aquatic Invasive Species Management Plan (CDFG 2008). Rapid response was considered essential to the success of the eradication of *Caulerpa* in San Diego (Merkel & Associates, Inc. 2006) and dwarf eelgrass (*Zostera japonica*) in Humboldt Bay (Schlosser and Eicher 2007).

A single millimeter of Caulerpa may be enough to start an invasion!
www.sccat.net

Currently, the only specific AIS survey recommended prior to sediment management activities is for *Caulerpa*, which is a group of seaweeds that naturally occur in tropical waters, and have been used in salt water aquariums. The two infestations found (and eradicated) in southern California were in small embayments and involved *C. taxifolia*, which was likely introduced by the dumping of aquarium water containing the plant. Because of the potential for very rapid spread of this plant once released, a survey for Caulerpa is recommended prior to a variety of sediment disturbing activities (i.e., dredging, bulkhead repair, pile driving, etc.).

Surveys must be conducted by certified Caulerpa surveyors according to the Caulerpa Control Protocol (*http://swr.nmfs.noaa.gov/hcd /caulerad.htm)*. Surveys are required between Morro Bay and the U.S./Mexico border. Exemptions include offshore islands (except Avalon and Twin Harbors on Catalina Island) and pile driving locations in Long Beach, Harbor, Los Angeles Harbor, and San Diego Bay. Other exemptions may be granted on a case-by-case basis, if warranted.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging • Sand maintenance adjacent to dunes	• Spread of invasive species
Other Activities or Issues of Concern	**Resources of Concern**
• Other AIS species	• *Caulerpa*

Guideline Objective:

- Avoid and minimize the spread of invasive species.

Resource Protection Considerations

- Conduct a *Caulerpa* survey according to the Caulerpa Control Protocol for all dredging and discharge projects under federal or state permits and authorizations issued by the USACE or RWQCBs (Regions 8 and 9), as applicable.
- Coordinate with USACE, in consultation with the CDFG and NMFS, regarding the need to conduct a *Caulerpa* survey at nearshore borrow sites, as appropriate.

Effectiveness Considerations: *Caulerpa* surveys should be effective when conducted by certified surveyors according to the established protocol.

Seasonal Considerations: *Caulerpa* surveys should be conducted during the high growth period, March 1 through October 31, to the extent practical.

Monitoring Considerations: *Caulerpa* survey requirements are specified by protocol: *http://swr.nmfs.noaa.gov/hcd/caulerad.htm.* *Caulerpa* surveys are conducted in certain embayments prior to sediment disturbing activities, and may be a relevant consideration for beneficial use of dredged materials for beach nourishment (e.g., nearshore placement). Because of the low potential for *Caulerpa* to occur, surveys are generally not conducted in the open ocean. However, specific survey requirements should be confirmed with USACE, in consultation with the CDFG and NMFS prior to borrow site dredging.

Volume 1 References: SAIC 2011 – Section 6 (6.4.1.1), and Section 7 (7.3.3).

Other References: See box inset on previous page for links to useful references.

Dungeness Crab Guideline

Cancer magister

Dungeness crabs mating
Photo credit: http://www.noaa.gov

Status: State managed fishery species.

Functions: Dungeness crabs feed on a variety of resources, including other crustaceans (amphipods, isopods), clams, fish, and also prey on each other (CDFG 2001). Many species of fish (e.g., cabezon, flatfish, Pacific herring, rockfish, salmon), larger crabs, octopuses, the threatened sea otter, seals and sea lions prey on Dungeness crabs. Dungeness crabs support commercial and sport fisheries.

Sediment Management Issues: Dungeness crab (*Cancer magister*) ranges from approximately Alaska to Santa Barbara, although it is rare south of Point Conception (CDFG 2001). They may be found on any bottom type, but prefer sandy to sandy-mud substrate, and may be found in intertidal areas to depths of 90 ft (27 m). Adult Dungeness crabs concentrate in shallows to mate, which occurs in the spring from about March through June (Wild and Tasto 1983). Dungness crabs also may use embayments as nursery areas, and have been reported in eelgrass meadows. Humboldt Bay and San Francisco Bay are important nursery areas, but most rearing is believed to occur in nearshore waters (CDFG 2001). Juveniles remain in shallow inshore areas for approximately 1.5 years, generally moving offshore in September the following year after settlement (Wild and Tasto 1983).

The fishing season generally is open in northern California from December 1 through July 15, and in central California from the second Tuesday of November until June 30. However, opening of the season may be adjusted by CDFG based on the condition of crabs. The summer-fall closed period is intended to prevent fishing when the males are soft-shelled.

Maintenance dredging in embayments may have the potential to remove animals, entrain larvae or juveniles, or disturb juveniles with elevated turbidity in nursery grounds, if present. Beneficial reuse of maintenance dredge materials at nearshore placement sites may have the potential to bury mating concentrations of crabs, if present.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging	• Entrainment of larvae or juveniles in rearing habitats • Burial of nearshore mating concentrations • Equipment Damage
Other Activities or Issues of Concern	**Resources of Concern**
• Commercial fishing	• Eelgrass

Guideline Objectives:

- Minimize entrainment impacts in embayments used as nursery habitats.
- Minimize dredging or discharge impacts in commercially important nearshore areas.

Resource Protection Considerations

- Schedule maintenance dredging outside the peak recruitment period (May 1-June 30**) if Dungeness crab larval concentrations have the potential to occur based on water body, channel width, or proximity to known nursery areas (e.g., eelgrass meadow, shallow-water habitat).
- Minimize entrainment using one or more of the following measures, as appropriate:
  - Avoid turning on hydraulic dredge pumps until cutterhead or draghead are near at the bottom and then immediately lower heads into sediment.
  - Avoid undercutting of sediment, operate cutterhead dredge below the sediment surface, and turn hydraulic pumps off after raising head above sediment surface.
  - Avoid raising hopper dredge draghead above the bottom while pumps are on.
  - Use dredge equipment that minimizes entrainment (e.g., bucket dredge, small diameter hydraulic dredge) if in area of species concentration (e.g., nursery areas, narrow channels within migration corridors).
- Minimize dredge turbidity near eelgrass nursery areas (e.g., silt curtains, operational controls, as appropriate).
- Coordinate with commercial fishing organizations to develop and review protective measures if nearshore placement or borrow site dredging would have the potential to impact productive crabbing grounds.

** Peak recruitment periods may vary and should be verified for the location of the action.

Effectiveness Considerations: Minimizing the potential for entrainment or turbidity of larval or juvenile crabs in nursery areas would lessen the potential for impacts at the population level. In areas where larval concentration is known to occur, use of environmental work windows (schedule restriction) may be the only effective resource protection measure. An important Dungeness crab fishery occurs in California. Coordination with commercial fishermen may be effective for minimizing conflicts and increasing protection of the species in areas where nearshore placement or dredging has the potential to impact the species.

Seasonal Considerations: Adult Dungeness crabs concentrate in shallows to mate, which occurs in the spring from about March through June (Wild and Tasto 1983). Larvae settle in nearshore waters between April and June. The USACE, San Francisco District uses an environmental window restricted period of May 1 to June 30 to protect Dungeness crab from entrainment of early juvenile stages in San Francisco Bay/Delta Estuary and San Pablo Bay (*http://el.erdc.usace.army.mil/tessp/)*.

Monitoring Considerations: Few specific surveys for the species have been conducted relative to sediment management activities. Entrainment surveys have been generally are not conducted would not be necessary unless sediment management would have the potential to substantially impact larval recruitment in an embayment or nearshore commercial crabbing area. In that case, entrainment surveys may be considered to estimate potential impacts or pre-if dredging would be scheduled during the peak recruitment period, and the water body was known to be an important nursery area. Pre-construction surveys may be warranted to document and assess adult crab abundance if sediment management activities would have the potential to impact nearshore commercial crabbing areas.

Volume 1 References: SAIC 2011 – Section 4 (4.2.3), Section 5 (5.3.4.1, 5.4.4.1, 5.5.4.3), and Section 6 (6.4.2.2, 6.4.3.2).

Green Sturgeon Guideline

Acipenser medirostris

Photo credit: Dan Gotschall

Status:

Southern Distinct Population Segment (DPS)
Federal Threatened

Northern Distinct Population Segment
Federal Species of Concern

Critical Habitat in California:

- Coastal - Monterey, CA to Oregon border (waters from shoreline to 110 m isobath)
- California Bays and Estuaries: San Francisco Bay, San Pablo Bay, Suisun Bay, Humboldt Bay (including designated creeks and sloughs)
- Bypasses and the Delta: Yolo Bypass, Sutter Bypass, Sacramento-San Joaquin Delta
- Freshwater Rivers: Sacramento River upstream to Keswick Dam, Lower Feather River, Lower Yuba River

Sediment Management Issues: The North American green sturgeon is anadromous, spending its adult life in the ocean and periodically ascending several coastal streams to spawn. Generally, individuals spawn every 2-5 years after reaching maturity at approximately 15 years of age. The green sturgeon feeds on benthic organisms such as shrimps, amphipod and isopod crustaceans, clams, worms, and fishes. The species ranges from Alaska to Mexico. Two distinct population segments (DPS) have been identified: northern DPS that spawn in the Klamath River (California) and Rogue River (Oregon), and southern DPS that spawn in the Sacramento River, below Kenwick Dam. The southern DPS was listed as threatened in 2006, critical habitat was finalized in 2009, and rules establishing take prohibitions were finalized in 2010 (NMFS-NOAA 2009, 2010).

All life stages (juveniles, subadults, adults) of the southern DPS green sturgeon may be found in San Francisco, San Pablo, and Suisun Bays year-round (NMFS-NOAA 2009). From mid-February to late May, adult southern DPS green sturgeon migrate through the San Francisco Bay estuary toward their spawning grounds in the upper Sacramento River, where they spawn in the late spring-early summer. Post-spawn adults hold in the upper Sacramento River and generally migrate downstream through the estuary from November to January. Juvenile green sturgeon rear and feed in fresh and estuarine waters for 1 to 4 years prior to dispersing into marine waters as subadults. Green sturgeon occur in coastal marine waters year-round. They have been collected between 160 to 230 ft (50 to 70 m) (Erickson and Hightower 2007), and potentially range from shallow nearshore to depths of 360 ft (110 m) (NMFS-NOAA 2009).

Sediment management activities involving dredging or discharges in coastal waters, bays, or estuaries from Monterey, CA northward may require consultation with NMFS under ESA section 7. The type of consultation will depend on the level of effect to green sturgeon and its habitat and is determined initially by the Federal action agency (often the Corps of Engineers for dredging projects). This may apply to dredging and discharge projects in bays and estuaries as well as offshore borrow site dredging and nearshore discharges.

Green sturgeon move in and out of estuaries and up and down the coast. Green sturgeon may oversummer in bays and estuaries north of San Francisco (most notably Humboldt Bay) and overwinter off Vancouver Island, British Columbia. Southern and northern DPS populations may overlap in distribution, particularly in Humboldt Bay. The potential for the two DPSs to overlap may be greatest in summer. Therefore, there may be less potential for dredging to impact the southern DPS in estuaries north of San Francisco from late-fall through spring.

Potential dredge-related effects include entrainment, turbidity, sedimentation, underwater noise, habitat changes, and indirect impacts of dredging on benthic forage base from sediment removal, dredge materials discharge, or invasive species introductions from dredge disturbance or changes in shipping patterns (Stanford et al. 2009). General vessel traffic and propeller strikes, including dredge vessels, also was identified as an impact. In addition, adverse effects of contaminated sediments to habitat or from release during dredging were issues of concern.

Dredging activities pose entrainment and injury risks to green sturgeon, which tend to hold position while foraging over the bottom (Clarke and Hoover 2009). Although limited information is available regarding entrainment of green sturgeon, entrainment of juvenile white sturgeon has been reported during dredging operations in the lower Columbia River (Buell 1992 cited in NMFS-NOAA 2010). Turbidity or noise during dredging has the potential to disturb green sturgeon, but this would be expected to result in temporary behavioral effects. White sturgeon have been observed to increase activity, but not disperse, during dredging in the Columbia River (Parsley 2009). Recovery of invertebrate forage prey after dredge-related sediment removal or discharge would be expected to be faster in areas subject to more frequent disturbance (e.g., maintenance dredged channels) than more protected habitats.

Green sturgeon in shallows
Photo credit: Matt Manuel

Movement of fish along the open coast is poorly understood. Tagged subadults and adults indicate that green sturgeon may travel considerable distance during sustained migration (e.g., up to 62 miles, 100 km per day) or reside in aggregation/feeding areas for several days at a time (NMFS-NOAA 2008). Because the southern DPS are only known to spawn in the Sacramento River at this time, potential interference with their spring spawning migration is a primary concern. Migrating green sturgeon swim near the upper water column (Klimley et al. 2009). Therefore, dredging impacts of potential concern include near-surface turbidity or increased vessel activity disturbance in migration corridors through the San Francisco Bay Estuary-Delta.

Generally, relevant sediment management activities associated with beach nourishment (e.g., offshore borrow site dredging, maintenance dredging and beneficial reuse of materials for beach nourishment, nearshore discharges) have the potential to impact migration or foraging of subadult and adult green sturgeon. Turbidity has the potential to affect both foraging or migrating fish. Temporary disturbance and degradation of foraging habitat would occur at both dredging and discharge sites. No impacts to sensitive spawning or nursery habitats would be expected from beach nourishment associated dredging or discharge activities.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Sediment Management Impacts of Concern
• Dredging (maintenance, offshore) • Beach nourishment (nearshore)	• Entrainment, injury • Turbidity, sedimentation • Forage reduction, habitat degradation • Obstructions or interference of migration
Other Activities or Issues of Concern	**Resources of Concern**
• Habitat degradation, obstructions to migration, ship traffic propeller strikes, alteration of prey diversity from invasive species	• Green sturgeon • Benthic invertebrate forage

Guideline Objectives:

- Minimize entrainment.
- Minimize interference with migration.
- Minimize degradation of foraging habitat.
- Minimize turbidity and sedimentation impacts.

Resource Protection Considerations

- Consult with NMFS if project may affect green sturgeon or its critical habitat. Prior to consultation with the Federal action agency, NMFS staff can provide technical assistance to the applicant.
- Minimize entrainment using one or more of the following measures, as appropriate:
  - Avoid turning on hydraulic dredge pumps until cutterhead or draghead are near at the bottom and then immediately lower heads into sediment.
  - Avoid undercutting of sediment, operate cutterhead dredge below the sediment surface, and turn hydraulic pumps off after raising head above sediment surface.
  - Avoid raising hopper dredge draghead above the bottom while pumps are on.
  - Use dredge equipment that minimizes entrainment (e.g., bucket dredge, small diameter hydraulic dredge) if in area of species concentration (e.g., nursery areas, narrow channels within migration corridors).
- Minimize turbidity using one or more of the following measures, as appropriate:
  - Restrict hopper dredge overflow during spring spawning migration if within a migration route.
  - Use operational controls or BMPs to minimize turbidity, as appropriate.*
- Promote recovery of benthic forage base using one or more of the following measures, as appropriate:
  - Avoid substantial changes to hydrodynamics from dredge or fill projects. For example, avoid creation of deep holes with reduced circulation.
  - Minimize changes to surface substrate as a result of dredging (e.g., do not dredge to hardpan; if dredging sand deposit, leave at least 3 ft (1 m) of substrate undredged so that surface is similar to surrounding sediment; if silty sediments are exposed with potential to increase contaminant release, remedy with discharge of clean sand).
  - If dredging a new area (i.e., not a maintenance channel), leave some areas unaffected to promote recovery of the benthic prey base.
- Schedule dredging or discharge activities outside peak periods of upstream migration of adult green sturgeon if within the San Francisco Bay estuary through the lower Sacramento River.

Effectiveness Considerations: Early coordination with NMFS should be effective for identification of appropriate measures to avoid or minimize take based on project- and site-specific conditions. Restricting dredging near river mouths during spring migration should be effective for minimizing impacts to green sturgeon, if present. Use of operational controls and BMPs may be effective for minimizing turbidity or entrainment effects. Turbidity generally would be expected to be relatively localized and of short duration when dredging or discharging sandy sediments typically used for beach nourishment. Measures that promote recovery of the benthic forage base after dredging may help minimize potential effects to foraging habitat quality. Additional restrictions may be necessary during spring migration or in areas where species may concentrate (e.g., constrictions, narrow channels).

Seasonal Considerations: Juvenile green sturgeon are year-round residents in San Francisco, San Pablo, and Suisan Bays; however, adult occurrence may be more limited based on spawning run timing and during the summer foraging period. Bays and estuaries north of San Francisco may be used primarily during summer.

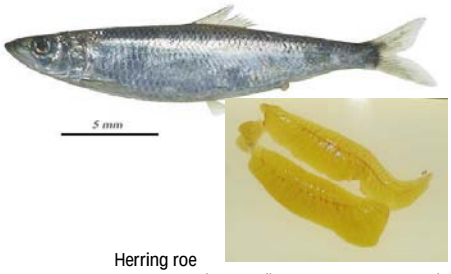
Monitoring Considerations: Several avenues of additional research have been recommended to improve understanding of relative risks from dredging, including evaluation of entrainment rates by different dredge equipment, impacts from vessel traffic, habitat modification from dredging, habitat alteration by invasive species, and fish behavior at dredging sites (Standford et al. 2009). Of these areas of interest, better understanding of seasonal movement patterns and habitat preferences (e.g., deepwater channels versus shallow shoals) may assist resource protection of sediment management activities associated with beach nourishment.

Volume 1 References: SAIC 2011 – Sections 4 (4.3.2), 5 (5.3.4.2, 5.4.4.2, 5.5.4.4), and Section 6 (6.3.2.3, 6.3.3.3, 6.3.6.1, 6.4.3, 6.4.4).

Other References

NMFS 2010, Stanford et al. 2009, *www.sfei.org/cb/greensturgeon/*

Pacific Herring Guideline
Clupea pallasi



Herring roe

Photo credit: Warren E. Savary and Luis A. Solorzano, californiabiota.com

Status: State managed fishery species.

Functions: Pacific herring are visual predators that eat zooplankton including copepods, amphipods, krill and small fishes. Herrings, in turn, are eaten by a variety of predators including larger fishes such as salmon, pinnipeds, and dolphins. Herring eggs are eaten by fishes, by invertebrates such as mollusks and amphipods, and by birds including gulls and diving ducks such as scoters (Lassuy 1989, Love 1996, CDFG 2001).

Sediment Management Issues: Pacific herring enter bays and estuaries to spawn in early winter (may be as early as October) (Watters et al. 2001). Spawning may occur from late October through April; however, most activity takes place December through March and peaks in January–February (Spratt 1981, Love 1996, Watters et al. 2001). Although winter is the primary spawning season, a smaller June-July spawning peak has been reported in Monterey Bay, Moss Landing Harbor, Elkhorn Slough, and Morro Bay (Wang 1986). Reduced salinity may act as a cue for spawning.

Pacific herring broadcast eggs in eelgrass meadows and on rocks, rocky jetties, pilings, other submerged objects, and sandy beaches (Wang 1986). The eggs are sticky and adhere to eelgrass or hard substrate. Eggs are laid in shallow (nearly intertidal) to deeper waters up to a depth of 60 ft (18 m), although depths < 30 ft (9 m) are more common. Eggs hatch after approximately 10 days. Juveniles remain in the bay until summer or early fall when they migrate to the open ocean. Pacific herring undertake daily vertical migrations, moving up into the water column at dusk to feed; during the day they gather near the bottom or in mid-water schools (Lassuy 1989).

There is a commercial fishery for herring roe, which is valuable in Japan (Love 1996). The sac-roe commercial fishery is limited to California's four largest herring spawning areas: San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor (CDFG 2001). Most of the roe fishery includes take of herring just before spawning occurs, which may vary from year to year (Spratt 1981). A smaller fishery involves harvest of roe on seaweed after spawning. There also is a small sport fishery for herring by pier and shore anglers (Barnhart 1988, Love 1996). In San Francisco Bay, CDFG maintain a Herring Hotline from November through March and provide a recorded message on herring schools and their location, spawning events, and the status of the fishery *(http://www.CDFG.ca.gov/mrd/herring/ sf_bay.html).*

Turbidity generated during maintenance dredging has the potential to affect Pacific herring, if present. Turbidity and sedimentation from dredging before or after spawning, both of which could be detrimental, has the potential to reduce the suitability of substrate for egg attachment or cause mortality of laid eggs (LFR 2004, Ogle 2005). It is unknown to what extent dredge turbidity or noise may interfere with behavior of Pacific herring and potential approach to spawning areas. Light-attraction of juvenile Pacific herring may increase their vulnerability to predation (Nightengale and Simenstad 2002). Because of their near-bottom distribution during the day, dredge entrainment poses a risk to Pacific herring, if present.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging	• Entrainment • Noise, Lights • Sedimentation, Turbidity
Other Activities or Issues of Concern	**Resources of Concern**
• Commercial fishing	• Eelgrass

Guideline Objectives:

- Avoid sediment management activities during spawning runs of this managed fishery species.
- Minimize turbidity and sedimentation impacts to spawning areas within 30 days prior to spawning runs, if Pacific herring have the potential to occur.
- Minimize potential dredge entrainment of Pacific herring during outmigration.

Resource Protection Considerations

- Schedule sediment management activities outside peak spawning runs of Pacific herring (San Francisco Bay: December 1-February 28, North Coast: November 1-March 1), if present.
- If dredging is scheduled within 30 days of the onset of the environmental restricted period, minimize turbidity and sedimentation (e.g., silt curtains, operational controls, as appropriate) when dredging near eelgrass meadows or hard substrate spawning sites in areas where Pacific herring are known to spawn.
- Minimize sedimentation and turbidity of eelgrass nursery habitat with buffers, dredge operation controls, or BMPs (e.g., silt curtains).
- Minimize entrainment using one or more of the following measures, as appropriate:
  - Avoid turning on hydraulic dredge pumps until cutterhead or dragarms are near or at the bottom and then immediately lower heads into sediment.
  - Avoid undercutting of sediment, operate cutterhead dredge below the sediment surface, and turn hydraulic pumps off after raising head above sediment surface.
  - Avoid raising hopper dredge dragarms above the bottom while pumps are on.

Effectiveness Considerations: Scheduling sediment management activities to avoid the peak spawning season protects reproduction and lessens the potential for impacts at the population level. Minimizing the potential for entrainment or turbidity impacts on early life stages and juveniles also would lessen the potential for impacts at the population level.

Seasonal Considerations: Potential impacts to Pacific herring from dredging activities is avoided with environmental windows (restricted period), which ranges from November 1 to March 1 along the north coast and from December 1 through February 28 in San Francisco Bay (USACE et al. 2001, *http://el.erdc.usace.army.mil/tessp/windows.cfm*).

Monitoring Considerations: Generally, monitoring for the species is not necessary because of use of a seasonal restriction on dredging activities.

Volume 1 References: SAIC 2011 – Section 4 (4.3.3), Section 5 (5.3.2.3, 5.3.2.6, 5.3.2.7, 5.3.4.2, 5.4.4.2, 5.5.4.4), and Section 6 (6.3.6.1, 6.4.2.3, 6.4.3, 6.6.2.2).

Salmonid Guideline

Chinook Salmon, Coho Salmon, Steelhead
(*Oncorhynchus tshawytscha*), (*O. kisutch*), (*O. mykiss*)

Juvenile salmon
Photo Credit: Danny Heilprin

Status: The NMFS recognizes Evolutionary Significant Units (ESUs) of salmon based on genetic and life history similarities. Regulatory status may vary according to seasonal migration runs.

[The most protective status is given below, status may vary for other seasonal runs]

Chinook: Winter run – FE, SE, Spring run – FT, ST (location specific) Coho: Central California ESU – SE, FT (location specific) Steelhead: Southern California ESU – FE Northern California, Central California Coast - FT South/central California ESU, Central Valley ESU - FT	*Critical Habitat* : Streams all along the California coast as far south as San Juan creek in southern Orange County. Recovery and/or restoration and management plans are available for Coho salmon and steelhead (*http://www.CDFG.ca.gov/nafwb/pubs.html)*

Functions: Salmonids are eaten by larger fishes, birds and marine and terrestrial mammals. They are fished both commercially and recreationally.

Sediment Management Issues: The seasonal runs of salmonids differ in their timing of migration and spawning. Juveniles also enter the ocean at different times of the year as smolts. Salmonids return to their parent streams to spawn and subsequently die.

A primary concern of sediment management activities is the potential for dredge equipment and turbidity to interfere with migration of salmonids. This may be more of an issue in bays near the outlets of rivers and streams during spawning runs. Dredge entrainment of juveniles and smolts also may be a concern. Juvenile salmonids may be sensitive to elevated suspended sediment concentrations (approximately 500-1,500 mg/L depending on species), which may be of concern if dredging were to occur near nursery habitats (e.g., eelgrass meadows). The potential for sand transport from beach sand placement to contribute to shoaling of nearby river inlets would be of concern if migration was impeded.

Noises from dredges are within ranges that could disturb fish at close range (Hastings and Popper 2005). Nightengale and Simenstad (2002) reviewed several studies that indicate that artificial lighting may attract juvenile salmonids, resulting in delayed outmigration or increased loss from predation; adult migration was less vulnerable to disruption.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Dredging	• Entrainment, Noise, Lights • Sedimentation, Turbidity
Other Activities or Issues of Concern	**Resources of Concern**
• Commercial fishing	• Eelgrass

Guideline Objectives:

- Avoid sediment management activities during salmonid migration, if present.
- Minimize turbidity and sedimentation impacts to eelgrass nursery areas.
- Minimize potential dredge entrainment of salmonids.

Resource Protection Considerations

- Schedule within environmental work windows in areas where adults or smolts migrate.
- Avoid night-time dredging in areas of migration.
- Maintain water quality and minimize sedimentation and turbidity of eelgrass nursery habitat with buffers, dredge operation controls, or engineered controls (e.g., silt curtains), as warranted.*
- Avoid obstructing tributaries used by salmonids during migration.
- Minimize entrainment using one or more of the following measures, as appropriate:
  - Avoid turning on hydraulic dredge pumps until cutterhead or draghead are at the bottom and then immediately lower heads into sediment.
  - Avoid undercutting of sediment, operate cutterhead dredge below the sediment surface, and turn hydraulic pumps off after raising head above sediment surface.
  - Avoid raising hopper dredge dragarms above the bottom while pumps are on.
  - Select dredge equipment that minimizes entrainment (e.g., small hydraulic dredge, bucket dredge), if juvenile salmonids are present.

*Refer to Embayment Water Quality Guideline

Effectiveness Considerations: Scheduling sediment management activities to avoid migration runs is effective for minimizing the potential for impacts at the population level. Minimizing the potential for entrainment of juveniles and using measures to protect eelgrass nursery areas also would lessen the potential for impacts at the population level.

Seasonal Considerations: The timing of migration and spawning runs differ and vary by species and geographic location. Potential impacts to salmonids from dredging activities are avoided or minimized with environmental windows (restricted period), which generally range from September 30 to June 1 for Chinook and Coho salmon. The same restricted period is used for steelhead trout by the USACE Sacramento District, but the period extends to July 31 depending on location for the USACE San Francisco District (USACE et al. 2001).

Monitoring Considerations: Generally, monitoring for the species is not necessary because of use of a seasonal restriction on dredging activities. Juvenile salmonids are sensitive to elevated suspended sediment concentrations; therefore, monitoring of water quality may be protective of the species. The Embayment Water Quality Guideline suggests a TSS threshold of 200 mg/L to protect eelgrass nursery habitat, which may be used by salmonids. That value is consistent with the recommendation of Nightengale and Simenstad (2001), who suggested 200 mg/L as a "safe" level to minimize sublethal effects on juvenile salmonid foraging.

Volume 1 References: SAIC 2011 – Section 4 (4.3.4), Section 5 (5.3.2.3, 5.3.2.6, 5.3.2.7, 5.3.4.2, 5.4.4.2, 5.5.4.4), and Section 6 (6.3.6.1, 6.4.2.3, 6.4.3, 6.6.2.2).

Clapper Rail (*Rallus longirostris*) Guideline

California – (*R. l. obsoletus*)
Light-footed – (*R. l. levipes*)

Photo Credit: Public Domain, http://www.coastal.ca.gov

Status:
California clapper rail: Federal endangered, State endangered
Light-footed clapper rail: Federal, State endangered

Critical Habitat: No

Sediment Management Issues: The California and light-footed clapper rail are resident, hen-sized marsh birds that inhabit marshes dominated by pickleweed (*Salicornia virginica*) and Pacific cordgrass (*Spartina foliosa*). California clapper rail may use the high, middle, and low zones of brackish, transitional, or salt marsh habitats. The light-footed clapper rail also may occur in freshwater marshes containing cattails or tules and rushes. They forage in marsh vegetation in and along creeks and mudflat edges.

The California clapper rail historically occurred in central and northern California. California clapper rails are now restricted almost entirely to the marshes of San Francisco estuary, where the only known breeding populations occur (USFWS 2010). The light-footed clapper rail occurs in southern California, from Santa Barbara County to San Diego County. The breeding season for both species begins in February; nesting ranges from March through May, but may extend until mid-August.

Construction noise and activity associated with beach nourishment or maintenance dredging has potential to disturb breeding success if it is too close to nest sites. California clapper rails disturbed by human activity may abandon home ranges (Overton 2007). Proximity of nest sites to inlets of coastal lagoons may be an issue of concern if sand transport sedimentation after beach nourishment resulted in an increase in the frequency of mechanical inlet openings.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Dredging (Embayment)	• Equipment, noise
Other Activities or Issues of Concern	**Resources of Concern**
• Mechanical inlet openings	• Clapper Rail

Guideline Objectives:

- Avoid impacts to clapper rail breeding or nesting success.
- Minimize disturbance during the breeding season.

Resource Protection Considerations

- Avoid construction within 1,500 ft (457 m) of occupied clapper rail habitat during the breeding season (RGP 67).
- Consult with USFWS if construction is scheduled within breeding season and nest sites are within 1,500 ft (457 m). If permitted, implement one or more of the following measures as coordinated with USFWS based on specific project and site conditions, as appropriate:
    - Restrict pipeline placement or removal in occupied territories to outside the breeding season, as applicable
    - Use buffer distance or noise suppressors to maintain ambient or≤ 60 dBA noise levels at nesting sites during the nesting season. Buffer distances to nest sites should be based on project and site-specific condition.
    - Shield night-time lighting away from nest sites.
    - Conduct construction monitoring by a qualified biologist, as necessary.

Effectiveness Considerations: A buffer distance of 1,500 ft (457 m) may be effective for avoiding or minimizing disturbance associated with noise and human activities, and lesser distances may be as well. For example, buffer distances of 750 ft (229 m) have been specified between nests sites and construction activities (ESA 2008). Construction noise would be expected to attenuate to≤60 dB or ambient within distances of 300 to 1,600 ft (91 to 487 m) depending on project activities and selected equipment (Section 2.7.1). Depending on site use clapper rails, monitoring may be necessary during construction to ensure effectiveness of protective measures. Restricting pipeline placement or removal activities to outside the breeding season in occupied habitat minimizes the potential to disturb reproduction.

Seasonal Considerations: The breeding season for both species extends from late February to the end of August; most eggs are laid between March and May.

Monitoring Considerations: Annual surveys have been conducted of California clapper rails in the San Francisco Estuary as part of the *Spartina* eradication project (*http://www.spartina.org/*). Light-footed clapper rails have been surveyed annually as part of the CDFG Nongame Wildlife Program (e.g., Zembal et al. 2009). Available data sources provide information on population status in different areas of the state.

Volume 1 References: SAIC 2011 – Section 3 (3.3.9) and Section 4 (4.3.3).

3.4 Resource Protection Guidelines for Sensitive Habitats In the Vicinity of Sediment Management Activities

The following types of sensitive habitats are addressed in this section of the document:

- Coastal Dune or Strand,
- Rocky Reef (Intertidal, Subtidal),
- Kelp Forests,
- Surfgrass Beds, and
- Eelgrass Meadows.

Table 3.4-1 lists impact factors and resources that may be disturbed by sediment management activities in sandy beach, sandy nearshore, or embayment habitats. These considerations are addressed with the resource protection guidelines in this section.

Table 3.4-1. Impact factors and resource disturbance issues - sensitive habitats.

Impact Factors and Resource Disturbance	User's Guide Section				
	3.4.1 Dune/Strand	3.4.2 Reef	3.4.2 Kelp Forest	3.4.2 Surfgrass	3.4.3 Eelgrass
Activity	*Sandy Beach Placement*	*Nearshore Placement, Offshore Dredge*	*Beach or Nearshore Placement, Offshore Dredge*	*Beach or Nearshore Placement*	*Beach or Nearsrhore Placement, Embayment Dredge*
Impact Factors					
Burial (Sand Placement)	X	X		X	X
Dredge-Excavate (Sand Removal)	X				X
Entrainment					
Hazardous Leaks or Spills	X	X	X	X	X
Hydrodynamics/Morphodynamics					X
Lights	X	X			X
Mono Buoy (offloading)		X		X	X
Noise	X	X	X		X
Pipelines	X	X		X	X
Sand Compatibility	X				X
Sand Transport After Placement	X	X	X	X	X
Turbidity-Sedimentation		X	X	X	X
Vehicles	X				
Vessels (anchors, propellers)		X	X	X	X
Water Quality		X	X	X	X
Resource Disturbance					
Beach Wrack	bury, remove				
Benthic Invertebrates	damage	damage, degrade, loss	damage, degrade, loss	damage, degrade, loss	damage, degrade, loss
Birds	disturb				disturb
Fishes		disturb	disturb	disturb	disturb
Marine Mammals		disturb	disturb		
Terrestrial Mammals	disturb				
Vegetation	damage	damage, degrade, loss	damage, degrade, loss	damage, degrade, loss	damage, degrade, loss

3.4.1 Coastal Dune or Strand Habitat

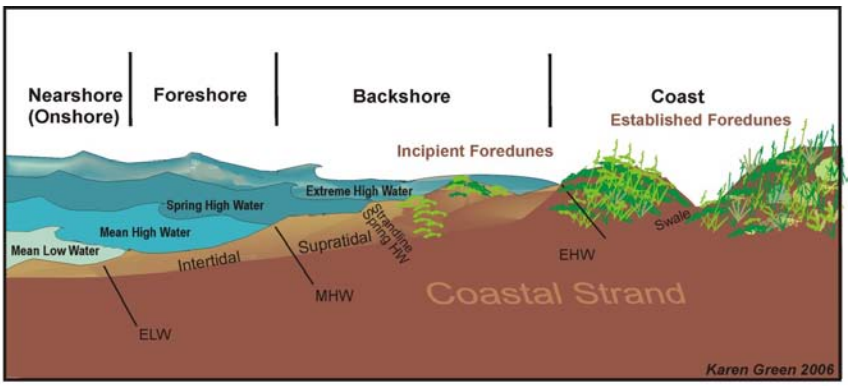
Dunes at Ocean Beach, San Francisco
Photo Credit: Karen Green

Approximately twenty-seven relatively large coastal dune fields occur throughout the state. The largest dunes occur along Monterey Bay and near the Santa Maria River (Guadalupe-Nipomo Dunes complex) in central California. Several large dune areas occur in northern California. Few dune areas occur in southern California; the largest are at Coal Oil Point in Santa Barbara County and at the Tijuana River National Estuarine Research Reserve in San Diego.

Status: Dunes may be designated environmentally sensitive habitat areas (ESHAs). Native dune vegetation is considered rare in California. Plants may include endangered, threatened, or rare species. Sensitive wildlife also may be present.

Habitat Definition: Coastal dunes are formed from the wind blowing sand (aeolian transport) landward from the beach and accumulating in drifts, which become stabilized by vegetation. Dunes may form where there is some relief that can help trap sand, such as washed ashore seeds or vegetation, driftwood, other debris, or growth of rhizomes or plants at the backshore. Dunes usually are in the form of parallel hills or ridges, with the most recently formed foredunes nearest the beach and older established dunes further inland.

The term coastal strand refers to vegetation that grows on the beach backshore or foredune areas. This vegetation is adapted to live in areas strongly affected by wind, waves, and salt spray. Established dunes are distinguished by the growth of scrub or woody plant species, greater height, and more landward position.



Consulted references: Hesp 2002, USACE 2002, CalFlora 2005

Beach-dune system relationships and terminology.

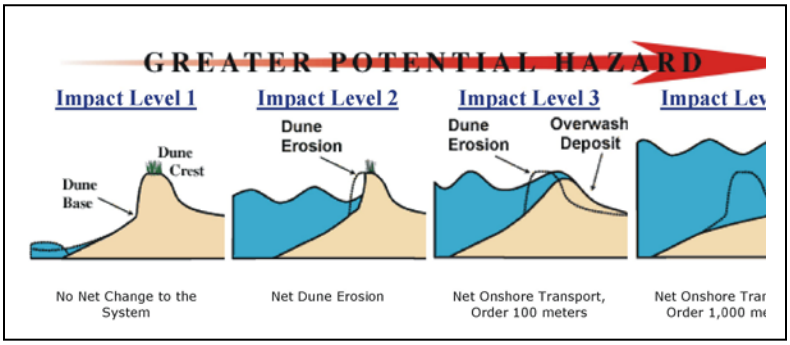
Sediment Management Issues: Coastal dunes trap sand in mounds, which protect shorelines. Vegetation is a key element in dune formation and stabilization. Coastal strand vegetation growing on foredunes or at the back beach provides forage and habitat to a variety of wildlife. Dune or coastal strand is a rare habitat in California and may harbor sensitive species. Coastal strand vegetation is vulnerable to trampling, vehicles, or other equipment impacts. Loss of vegetation may trigger blowouts and dune erosion. Disturbance also may facilitate spread of non-native species, which may degrade dune quality and functions.

Overview of Relevant Background Considerations:

Habitat Functions and Resources of Concern

Dunes serve as a sediment sink and provide sand to beaches from erosion associated with storm wave erosion or blowouts. Sediment storage and exchange are key functions between the beach and foredune system. Dune blowouts are part of the natural dune process, but may be accelerated where vegetation is weakened by trampling or vehicles.

The USGS coastal change hazard scale defines storm wave runup as Impact Level 1 (swash regime) if confined to the beach backshore; Impact Level 2 (collision regime) if runup exceeds and erodes the base of the vegetated dune or unvegetated berm; Impact Level 3 (overwash regime) if runup overtops the dune or berm; and Impact Level 4 (inundation regime) if storm surge overruns beaches and dunes and carries sand up to a kilometer inland.



Public domain credit: http://coastal.er.usgs.gov/hurricanes/mappingchange/scale.html

Several federal- and state-listed endangered or threatened species of plants and wildlife are associated with coastal dune or strand habitat. The coastal beach-dune system supports two sensitive bird species, endangered least tern And threatened snowy plover (Powell 2005). Both species prefer areas with sparse vegetation.

Biological Resources of Concern

- Native dune or strand vegetation
- Endangered California least tern
- Threatened western snowy plover
- Endangered Morro kangaroo rat
- Endangered Pacific pocket mouse
- Endangered blue butterflies
- Species of Concern (e.g., legless lizards, globose dune beetle, tiger beetles, wandering skipper)

Sensitive dune beetles may occur under strand vegetation. Several species of endangered blue butterfly species are endemic to certain dune areas in association with their host plant (buckwheat). The wandering skipper, a federal Species of Concern, is associated with salt grass in coastal strand habitat. The endangered Morro Bay kangaroo rat (*Dipodomus heermanni morroensis*) or Pacific pocket mouse (*Perognathus longimembris pacificus*) may occur in dune or strand habitats in certain areas.

Non-native sea rocket (*Cakile maritima*) and European beach grass (*Ammophila arenaria*) are among the hardiest of the early colonizers of open sands in California (CERES 2006). Pink and yellow sand verbena (*Abronia* spp.) and beach bursage (*Ambrosia chammissonis*) also may occur at more exposed sites. Non-native iceplant, such as Hottentot fig (*Carpobrotus edulis*) and sea fig (*C. chilense*) may form monotypic stands on disturbed foredunes. Non-native species may stabilize dunes; however, blowouts generally are more common when dunes are dominated by non-native European beach grass or iceplant rather than native vegetation.

Dunes may support a variety of wildlife (e.g., birds, deer mice, ground squirrels, pocket gophers, striped skunk, mule deer).

Sediment Management Activities and Impact Considerations

Types of sediment management activities and potential impact factors to coastal dune or strand habitat and associated species include:

- Beach nourishment
    - Beach placement – equipment, turbidity, sedimentation,
    - Dune placement – equipment, burial, sedimentation,
    - Nearshore placement – turbidity, sedimentation, or
    - Profile placement – equipment, turbidity, sedimentation.
- Dredging or Excavation
    - Maintenance (harbors, lagoons, rivers) – not applicable.
    - Offshore borrow site – not applicable.

Beach nourishment has the potential to directly or indirectly impact dune or strand habitat, if present. Direct impacts to vegetation may result if equipment, pipelines, vehicles, or increased foot traffic were to occur. Recovery of native dune vegetation may take several years if at all unless there is restoration. Equipment operation also has the potential to directly or indirectly impact wildlife. The threatened snowy plover is of particular concern because it prefers to rest in depressions in the sand, including those made by vehicles. Disturbance from equipment operation (noise, lights) has the potential to indirectly impact wildlife. Sand placement has the potential to enhance the beach-dune system, by recharging sediment supply (sand transport sedimentation in above lists of potential impacts by types of activities). However, sand retention (e.g., drift fences, vegetation) may be necessary to build or stabilize dunes. Turbidity during sand placement operations would not affect dune habitat and most species. However, there is the potential to impact the foraging behavior of endangered least tern, if present in nearby beach-dune habitat.

Other activities that have the potential to affect dune habitats or quality include beach grooming, removal of driftwood or wrack, or unauthorized vehicle use. Beach grooming may disturb development of incipient dunes or colonization of back beach areas by pioneer vegetation (Dugan and Hubbard 2010). Debris at and above the high tide wrack line (e.g., driftwood, washed ashore kelp, seeds) that traps windblown sand is essential to dune formation. Maintenance practices that remove driftwood or beach wrack have the potential to indirectly impact dune formation or ecological processes. The California State Parks adopted guidelines banning the removal of driftwood or kelp to protect snowy plovers and their habitat (State Parks 2002). Those guidelines also are protective of coastal dune or strand habitat, if present. Dune mining is discouraged because it may disrupt sand transport, remove vegetation, and ultimately result in beach erosion (Magoon and Lent 2005).

Other Activities or Issues

The spread or dominance by invasive species is a primary concern for dune habitats.

Recovery Considerations

Native dune vegetation is sensitive to disturbance. Recovery may take several years if there is substantial loss of plants. Non-native species such as European beach grass, sea fig, or Hottentot fig generally recover more quickly from disturbance. Habitat loss could result in dune destabilization and require the need for restoration

Mitigation Considerations

Because of the sensitivity of dune vegetation to disturbance, establishing and flagging no work zones may be necessary to protect the habitat during adjacent construction activities. Additional measures may be necessary to protect sensitive species, if present.

Monitoring Considerations

Monitoring inspections may be necessary during construction to verify compliance with no work zones. Sand placement along the backshore may not require water quality monitoring if there are no discharges to waters of the U.S. If sensitive species are present (e.g., snowy plover), additional monitoring during construction may be required.

Long-term monitoring of dunes may provide important information on rates of erosion and sea level rise. Techniques such as Light Detection And Ranging (LiDAR) have been suggested for larger-scale monitoring of dune shoreline condition (Dahm et al. 2005). The California Coastal LiDAR Project was funded in 2010 by the California Ocean Protection Council (OPC) and implemented under the supervision of the NOAA (*http://www.opc.ca.gov/2010/11/the-california-shoreline-mapping-project/*). High resolution topographic data (at 11.8 in, 30 cm intervals) were collected from the shoreline to the 33 ft (10 m) elevation contour. In 2009-2010 the USACE conducted a National Coastal Mapping Program survey, which collected LiDAR data from the shoreline to 1,640 ft (0.5 km) onshore (3 ft, 1 m intervals), and bathymetric data from the shoreline to 0.6 mi (1 km) offshore (16.4 ft, 5m intervals) (*http://shoals.sam.usace.army.mil/Mapping.aspx*). Both programs may provide high-resolution elevation and imagery data on a recurring basis.

Guideline Considerations:

List of Relevant Resource Protection Guidelines

The following guidelines may be relevant to the Coastal Dune or Strand habitat depending on site-specific conditions:

Resource Protection Guidelines	User's Guide	
	This Section	Other Sections
Physical-Chemical		
Sand compatibility		3.2.2
Biological		
Coastal dune or strand vegetation	X	
Beach wrack		3.3.1
California least tern		3.3.1
Western snowy plover		3.3.1

Guidelines for the protection of coastal dune or strand vegetation also would be generally applicable to protection of sensitive plant species and general wildlife.

Beach wrack and driftwood may be important to formation of foredunes on the backshore at certain beaches. The guideline for beach wrack is included in Section 3.3-1 because this resource first washes ashore on sandy beach habitat. Sand compatibility is an important consideration and has the potential to affect dune formation (Section 3.3.2).

Other guidelines would be applicable to protection of least terns or snowy plovers, if present. Because those species may be associated with habitats where sediment management may occur (e.g., sandy beach, nearshore embayment), their guidelines are provided in Section 3.3.1.

Other Relevant Guideline Considerations

Incorporation of dune restoration into beach nourishment projects may improve shoreline and resource protection in certain areas (SAIC 2011, Section 6.3.4.1). However, removal of non-native vegetation must be carefully implemented to avoid blow outs.

Generally, beach nourishment activities do not include substantial ground disturbance or vegetation removal in established dune habitats. Therefore, specific guidelines are not provided for sensitive species generally associated with established dune habitats (e.g., endangered blue butterflies, Morro kangaroo rat, Pacific pocket mouse). Projects requiring work in dune habitats may require additional resource protection measures, which would be determined during environmental review or coordination with appropriate resource and regulatory agencies.

Cross-Reference Table to Relevant Sections of the Volume 1 BIA Document

Topic	Volume 1	
	Section	Subsection
Resource Description and Sediment Management Issues		
Coastal dune or strand habitat and vegetation	3	3.3.1
Beach wrack	3	3.3.2
Least tern	4	4.4.2
Snowy plover	4	4.4.3
Impacts		
Equipment - Coastal Dune or Strand	5	5.3.3.1
Equipment- Birds	5	5.3.4.3
Sediment characteristics and compatibility	5	5.2.3.2
Mitigation Measure Considerations		
Sediment compatibility	6	6.3.1.2
Avoid direct impacts to sensitive habitats	6	6.3.2.1
Incorporate dune restoration	6	6.3.4.1
Buffers - Birds	6	6.3.6.2
Avoid equipment use and construction materials in sensitive habitats	6	6.4.1.1
Schedule or Seasonal Restrictions – Birds	6	6.4.2.4
Minimize noise levels in sensitive wildlife areas	6	6.4.4.4
Minimize artificial lighting in sensitive wildlife areas	6	6.4.4.5
Monitor sensitive bird species and modify activities if necessary	6	6.4.5.5
Sensitive species - birds	6	6.6.2.3
Monitoring Considerations		
Sensitive habitat boundaries	7	7.3.2.2
California least tern	7	7.4.5.2
Western Snowy plover	7	7.4.5.3
Impact verification	7	7.5.1

Coastal Dune or Strand Vegetation Guideline

Oxnard Dunes

Photo credit: Stephen Montgomery

Status: Coastal dunes or strand are considered sensitive habitats. Native vegetation may include endangered, threatened, or rare species.

Functions:
Habitat stabilization, primary production, wildlife forage and habitat.

Sediment Management Issues: Coastal vegetation stabilizes shorelines and may provide forage and shelter for a variety of wildlife. Endangered, threatened, or rare species may be present. Native coastal dune or strand vegetation is vulnerable to disturbance impacts and may take years to recover from damage. This may foster colonization or expansion of non-native plants. Non-native species such as European beach grass, sea fig, or Hottentot fig generally recover more quickly from disturbance, which may help stabilize shorelines; however, ecological diversity and functions are reduced where they have expanded to form monotypic stands.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment	• Equipment, vehicles • Spread of invasive species
Other Activities or Issues of Concern • Beach grooming • Trampling	**Species of Concern** • Native dune vegetation • Non-native European beach grass

Guideline Objectives:

- Avoid direct impacts to dune or strand vegetation.
- Minimize disturbance of dune habitat.

Resource Protection Considerations

- Avoid sand placement on coastal strand of dune vegetation.
- Avoid trampling of vegetation.
- Minimize impacts with implementation of one or more of the following measures, as appropriate:
  - Flag and establish authorized work areas and no work zones.
  - Establish vehicle access routes outside vegetated areas.
  - Minimize width (< 50 ft) of vehicle access corridors if must cross dunes.
  - Minimize walking in vegetated areas.
  - Use supports to elevate pipelines above low-growing vegetation.
  - Conduct inspections during construction to verify compliance with work zones and no work zones.
  - Flag and avoid European beach grass, hottentot fig, or ice plant when using mechanized equipment.
- Enhance or restore dune or strand habitat, if damaged.

Effectiveness Considerations: Avoidance of work in vegetated areas is effective for protecting habitat and minimizing the potential to destabilize dunes. Measures to minimize disturbance may be effective if work areas and no work zones are established. Avoidance of European beach grass, hottentot fig, or ice plant when using mechanized equipment on the beach should help prevent plant breakage and inadvertent conveyance to other beach areas where the pieces may re-establish and spread. Enhancement or restoration objectives may differ depending on site-specific factors such as relative dominance of non-native European beach grass or iceplant and ongoing maintenance practices; specific requirements should be determined in coordination with resource and regulatory agencies.

Seasonal Considerations: Vegetation is perennial. However, backshore vegetation may experience seasonal wash out during winter and expansion in spring-summer. Habitat use by sensitive wildlife may vary depending on season.

Monitoring Considerations: Monitoring inspections may be necessary during construction to verify compliance with no work zones. Sand placement along the backshore may not require water quality monitoring if there are no discharges to waters of the U.S. If sensitive species are present (e.g., snowy plover), additional monitoring during construction may be required.

Recovery Considerations: Minor damage to vegetation or minor gaps in dune vegetation may recover within one year (USACE 1998, Dahm et al. 2005). Recovery may take several years, if at all, when there is substantial loss of native vegetation from blowouts, vehicle disturbance, trampling, or higher than normal erosion events (Stephenson 1999, Dahm et al. 2005). Non-native species such as European beach grass, sea fig, or Hottentot fig generally recover more quickly from disturbance. However, substantial disturbance could result in dune destabilization, accelerate sand transport rates, or result in habitat loss requiring the need for restoration.

Natural storm erosion generally would not require intervention or maintenance. If a dune is well vegetated and human disturbance is not extensive, the vegetation will naturally recover (Dahm et al. 2005). However, intervention may be desired in areas where loss of sand from aeolian transport may result in public safety issues or higher maintenance costs of adjacent roads, parking lots, sidewalks, or residential areas (Brooks and Agate 2001, DBW and SCC 2002).

In areas where restoration involves replacement of monotypic stands of exotic species (e.g., European beachgrass, iceplant), a program of gradual replacement with native species is recommended to minimize the likelihood of blowouts, particularly on exposed foredunes (CNPS 1996). Ongoing monitoring and maintenance may be required in areas where public beach use may result in damage to restored areas. Signs and controlled beach access ways have been effective in protecting restored areas (Dahm et al. 2005). Sand fencing may be effective for controlling public access and promoting dune development.

Volume 1 References: SAIC 2011 – Section 3 (3.3.1) and Section 6 (6.3.2.1, 6.4.1.1).

3.4.2 Hard-Substrate Habitats

Starfish and Sea Urchins
Photo credit: Danny Heilprin

Status: Rocky substrate habitats are EFH-HAPC. Rocky habitats may occur in designated Areas of Special Biological Significance (ASBS), State Ecological Reserves (SERs), California Marine Life Refuges (CMLRs), marine sanctuaries, State Marine Conservation Areas (SMCAs), and underwater parks.

Habitat Definition:

Four types of hard-substrate habitats are addressed in this section. The definition of each is presented in the corresponding resource protection guideline.

- Rocky Intertidal HAPC
- Rocky Subtidal HAPC
- Kelp Forest HAPC
- Surfgrass HAPC

Sediment Management Issues:

Rocky substrates may vary in ecological function and sensitivity depending on site-specific substrate, environmental, and disturbance factors. Stable or persistent rocky habitats that extend above the seasonal sand levels may support diverse communities of plants, invertebrates, and fish. Rocky intertidal tidepools also may provide forage for birds when tides are low. Overall diversity also relates to development of vegetation. Intertidal or subtidal rocky areas supporting diverse algae, invertebrate, or fish communities are EFH-HAPCs.

Other rocky habitat HAPCs include surfgrass beds, which range from the minus tide zone to shallow nearshore, and kelp forests, which occur in discrete hard-bottom areas along the coast. The keystone vegetation in these habitats provide structure, attachment sites, and organic matter that contribute to the relatively high productivity of those habitats.

Sand inundation or scour may influence resource development depending on environmental conditions. Unstable hard substrate subject to tumbling by waves (e.g., cobbles, small boulders) or substantial sand scour generally have poorly developed biota, if at all. Low-relief reefs may experience periods of burial, sand scour, or relief above natural, sand level changes in the littoral zone. Field assessment by a qualified biologist may be necessary to distinguish whether rocky substrate is a HAPC.

The amount of exposed hard-substrate is variable due to seasonal on- and offshore sand movement and episodic storms, large waves, or shifts in climatic patterns (e.g., El Niño conditions).

Sediment management activities have the potential to result in equipment, sedimentation, or turbidity impacts to sensitive rocky HAPC, if nearby. Habitat quality has the potential to be degraded or lost depending on the duration or magnitude of impacts. Significant impacts to rocky intertidal, rocky subtidal, surfgrass, or kelp forest HAPCs would require mitigation. Similar impact issues generally do not apply to non-sensitive rocky substrate.

Overview of Relevant Background Considerations

Ecological Functions and Resources of Concern

Rocky Reef Relative Resource Development

Low	**High**
Unstable	Stable
Low-relief	High-relief
Unvegetated	Vegetated

Rocky habitats in the littoral zone are rigorous environments due to hydrodynamic forces of wave shock, ebb and flow of tides, and sand movement. Species assemblages reflect site-specific substrate, environmental, and disturbance factors. Hard-bottom areas with a range of rock sizes, heights, vertical variation (rugosity), heights, and surface textures provide multiple shelter opportunities for motile organisms and surface areas for attachment by sessile organisms. Overall diversity also relates to development of vegetation. Macroalgae provides food, structural complexity, refuge from predation, and spawning/nursery sites for invertebrates and fish (Foster and Schiel 1985, Levin and Hay 2002, Blackmon et al. 2006). Generally, higher relief, vegetated reefs support more diverse communities than low-relief reefs that experience excessive siltation or sand scour (Ambrose et al. 1989).

Rocky Intertidal

Rocky intertidal habitat may provide primary, foraging, and/or reproductive habitat for marine invertebrates, tidepool fish, and plants (algae, surfgrass). Shorebirds (e.g., turnstones), wading birds (e.g., herons, egrets), and gulls may forage within the habitat when exposed by tides. Birds or pinnipeds may rest on exposed rocks. These areas represent productive EFH-HAPCs.

In contrast, unstable intertidal substrates (e.g., cobbles or small boulders) that are frequently overturned by wave action generally support few if any marine life (Sousa 1979, SAIC 2006). Similarly, low-relief rock or sandstone benches subject to seasonal or more frequent sand scour are unstable habitats that may be devoid of life or support only subclimax communities of algae (annual species, crusts, or turf) or few species of animals (Daly and Mathieson 1977, Stewart 1991, SAIC 2011). The proportion of hard substrate at any given time may relate to time of year associated with seasonal on- and offshore sand movement or large waves associated with storms or El Niño conditions.

Vegetated rocky intertidal tidepools (algae, surfgrass)

Sand-scoured rock bench devoid of algae and animals

Photo Credit: Karen Green

Resource development at rocky intertidal habitat also may be affected by human use. Disturbance impacts may result from intensity of uses, including collecting, disregard of fishing limits, overturning of rocks, or trampling. A relevant impact concern if beach nourishment were

to occur in the vicinity of a rocky intertidal habitat with high public use pressure would be the potential for cumulative impacts from combined effects of the different disturbances.

Rocky Subtidal

Similarly, reef height and sand inundation affect resource development inshore within the littoral zone. Generally, higher relief, vegetated reefs support more diverse communities than low-relief reefs that experience excessive siltation or sand scour (Ambrose et al. 1989). Reef animals (e.g., abalone, lobster, sea urchins, sea cucumbers, reef-associated fish) support commercial fisheries and attract considerable recreational sport diving and fishing. Low-relief hard substrate that experiences periods of burial and exposure from natural, sand level change sometimes are referred to as "ephemeral" reefs.

Reef with variety of kelp and algae

Low relief, sand influenced reef with turf algae

Cobble and boulders with no vegetation

Photo credit: Danny Heilprin

In deeper waters outside the littoral zone, sand movement and scour are less influential and productive habitats may occur over a greater range of reef heights. Species diversity relationships to reef heights relate more to living space rather than disturbance factors.

Kelp Forest

Kelp forests with their extensive vertical structure form the most extensive vegetated habitats in the marine environment. Kelp forests support nearly 1,000 species of algae, invertebrates, and fish, and offer forage opportunities for birds and marine mammals, including sea otters, sea lions, and harbor seals (Foster and Schiel 1985). The diversity of a kelp forest community relates to several factors including type and density of the canopy forming species, substrate type and complexity, and spatial extent of the kelp bed. Kelp forests and beds support a greater variety of marine organisms than kelp stands, which consist of a localized group of plants (Foster and Shiel 1985).

Kelp forest

Photo credit: San Diego Nearshore Program
http://nearshore.ucsd.edu/

Giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*) are canopy kelps that are managed commercial species, with harvest regulated within designated and numbered kelp beds (CDFG 2001). The terms kelp forest and kelp bed may be used interchangeably; for example, kelp forests subject to commercial harvest often are referred to as kelp beds (e.g.,

CDFG 2001). The term kelp forest may be used to distinguish dense growths of larger canopy-forming species (giant kelp, bull kelp, and/or elk kelp) from beds of smaller kelp species with limited vertical structure or canopies (e.g., Bushing 2000).

Other kelp species may function as understory plants in kelp forests, including feather boa kelp (*Egregia menziesii*), or bladder chain kelp (*Cystoseira osmundacea*). In shallow waters, understory kelps or some seaweeds (e.g., *Sargassum muticum)* may form moderate –sized canopies.

Kelp and several invertebrates (e.g., red abalone, lobsters, sea urchins, sea cucumbers) support commercial fisheries, and invertebrates and fish are taken by recreational fishermen and sport divers. Recreational and educational diving is prevalent in kelp forests and beds.

Surfgrass

Surfgrass is a type of seagrass. Two species occur off the coast of California, *Phyllospadix. scouleri* with short flowering stems and *P. torreyi* with long flowering stems. Both species range from Vancouver Island to Baja California (Turner and Lucas 1985). Surfgrass grows in rocky habitats from low intertidal to subtidal depths.

Surfgrass is a productive HAPC that ranges from the minus tide zone to depths of approximately 50 ft (15 m), although surfgrass becomes patchy and gradually disappears below 23 ft (7 m). Surfgrass is nursery habitat for the commercially important California spiny lobster (*Panuliris interruptus*) (Engle 1979, Stewart and Meyers 1980, Williams 1995). Surfgrass is grazed on by fish and invertebrates (e.g., mollusks, crabs, and urchins) (Turner and Lucas 1985, Williams 1995). Shorebirds and gulls may feed on associated invertebrates when surfgrass habitat is exposed during minus low tides, and wading birds such as herons and egrets also may forage in this habitat in areas close to coastal lagoons (Green, personal observation). Surfgrass seeds are eaten by a variety of birds, fish, and invertebrates (reviewed in Holbrook et al. 2000). Surfgrass is considered a beach builder, stabilizing beaches by binding sands with its rhizomatous roots (Gibbs 1902). Subtantial removal of rhizomes can lead to habitat loss that can take years to recover. Substantial sedimentation that resulted in loss of surfgrass or its structural function as EFH would be significant.

Rocky intertidal with surfgrass Surfgrass with natural sand inundation

Photo credit: Karen Green

Habitat Functions and Resources of Concern

Several types of resources and species of concern may occur in rocky substrate EFH-HAPCs. Rocky intertidal or subtidal substrates are potential habitat for endangered black abalone (*Haliotis cracherodii*), and endangered white abalone (*H. sorenseni*) may occur subtidally at depths ranging from 60 to 200 ft (18 to 60 m).

Several hundred species of invertebrates, fish, and algae are associated with rocky habitats with or without canopy kelp. Many species also are associated with surfgrass habitat. Several nearshore groundfish species listed in both federal and state FMPs may occur, including various species of rockfish (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus*), California scorpionfish (*Scorpaena guttata*), kelp greenling (*Hexagrammos decagrammus*), and lingcod (*Ophiodon elongatus*). Other state-managed nearshore FMP species that may be associated with rocky habitats include rock greenling (*Hexagrammos lagocephalus*) and in the intertidal, monkeyface prickleback (*Cebidichthys violaceus*). In addition, several invertebrate fishery species are associated with rocky habitats such as California spiny lobster, sea urchins (*Strongylocentrotus franciscanus, S. purpuratus*), brown and red rock crabs (Cancer*.antennarius, C. productus*), and sheep crab (*Loxorhynchus grandis*). The state also manages the commercial harvest of bull kelp and giant kelp, with harvest regulated within designated and numbered kelp beds.

Hard-Bottom Associated Resources of Concern

- Endangered black abalone
- Endangered white abalone
- Federal Groundfish FMP and State Nearshore FMP species –
  - Cabezon
  - California scorpionfish
  - Lingcod
  - Kelp greenling
  - Rockfish
- Other Nearshore FMP species –
  - Calfiornia sheephead
  - monkeyface prickleback
  - Rock greenling
- State-managed invertebrate fishery species
  - California lobster
  - Rock crabs
  - Sea urchins
  - Sheep crab
- State-managed commercial kelp species
  - Bull kelp, giant kelp
- Surfgrass

Other species managed in the Coastal Pelagics FMP may occur in kelp beds, particularly jack mackerel (*Trachurus symmetricus*) (Feder et al. 1974).

Sediment Management Activities and Impact Considerations

Types of sediment management activities and potential impact concerns to rocky habitats include:

- Beach nourishment
  - Beach placement – equipment, burial, sedimentation, turbidity.
  - Dune placement – sedimentation.
  - Nearshore placement – equipment, burial, sedimentation, turbidity.
  - Profile placement – equipment, burial, sedimentation, turbidity.
- Dredging
  - Maintenance dredging of embayments – riprap – sedimentation, turbidity.
  - Offshore dredging of borrow sites – equipment, sedimentation, turbidity.

Generally, sediment management activities would not be permitted in areas with rocky intertidal, subtidal, kelp forest, or surfgrass HAPCs. However, there is the potential for these habitats to be located in the vicinity either up- or downcurrent, inshore or offshore, or along vessel routes between dredge and discharge sites.

Sediment management activities have the potential to result in equipment, sedimentation, or turbidity impacts to sensitive rocky intertidal HAPC, if nearby. Dredge or support vessel anchoring, pipelines, or noise generated from equipment may have the potential to damage or disturb resources in hard-bottom habitats. There may be the potential for burial if rocky habitat was located too close to receiver sites and there was inadvertent discharge or accidental leakage of sand from pipelines. Turbidity has the potential to adversely affect both marine plants and animals associated with hard-bottom habitats. Post-construction sand transport sedimentation may have the potential to reduce exposed rock heights, increase sand scour effects, or reduce living space for marine resources.

Several factors are important considerations relative to the potential to impact hard-bottom habitat in the vicinity of sediment management activities involving dredging or discharges, including:

- Distance between project activities and hard-bottom habitat,
- Project sand volume and duration of activity,
- Prevailing current direction and oceanographic conditions during and after project implementation,
- Physical characteristics of the hard-bottom habitat (e.g., predominant reef heights, spatial extent of hard-bottom area, resource development, natural sand flow dynamics through the hard-bottom area), and
- Occurrence of barriers (e.g., groin, jetty) that may contribute to sand accumulation.

Integration of the above-listed factors is complex and highly dependent on project and site-specific conditions. Key impact issues are whether indirect sedimentation would result in sanding-in or increased scour of productive hard-bottom habitats. However, critical impact thresholds associated with indirect sedimentation are not well understood. Impact verification monitoring may be a permit requirement depending on level of concern or uncertainty associated with potential impacts to rocky habitats.

Sand inundation and scour can substantially modify species assemblages, causing displacement of some mobile species and dominance by opportunistic, sand-tolerant, and/or sand-loving species. This disturbance naturally affects rocky subtidal habitats to varying degrees throughout California on a seasonal basis. Lower relief reefs are more vulnerable to sand disturbance, while higher relief reefs tend to remain above the sand. Impact concerns relate to the potential for indirect sedimentation occurring above natural levels and adversely impacting sensitive rocky subtidal habitat and resources.

- Surfgrass is morphologically adapted to withstand shifting sand movement with long fibrous leaves (1 to 3 ft intertidal, 2 to 6.5 ft subtidal), however, sand accretion along the leaves may affect growth, health, and survival. Experimental studies have demonstrated reduced carbohydrate storage with 5 in (12 cm) of sand burial (Plechner 1996) and a reduction in shoot density when leaves are buried by at least 10 in (25 cm) of sand (Craig et al. 2008).

- Giant kelp may withstand some sedimentation, however, recruitment is adversely affected if hard substrate is covered by sand (Foster and Schiel 1975, Devinny and Volse 1978, North 1986).

Turbidity generally is a short-term impact limited to the construction period. Substantial impact would not be expected with short-term exposures similar to that experienced under natural storm conditions. However, prolonged exposure to turbid waters would be a concern. Relevant studies indicate prolonged turbidity reduces subtidal habitat diversity, with the most pronounced effect on marine plants and to a lesser extent, subtidal invertebrates. Because reef fish generally are site tenacious, there also is concern that they may be relatively more vulnerable to turbidity than more widely ranging pelagic or soft-bottom associated fish.

Critical thresholds of turbidity under field conditions are not well understood.

- Surfgrass has long, buoyant leaves that facilitates photosynthesis under naturally varying light conditions. Light levels < 40% of surface irradiance may limit growth (Williams and McRoy 1982).
- Chronic reduction in near bottom light levels to less than 2% of surface irradiance results in loss of kelp habitat. Juvenile growth may be inhibited at light levels <9-15% of surface irradiance (Dean and Jacobsen 1984).

Recovery Considerations

Recovery rates of hard-bottom communities would depend on existing resource development and nature of impact. Recovery would be expected to be rapid from temporary construction related impacts to unstable cobbles or low-relief substrates characterized by limited resource development (e.g., algal turf, few invertebrates).

In areas with well developed rocky habitats, recovery from indirect impacts (turbidity, sedimentation) would depend on the duration and degree of impact. Recovery could take years if substantial sedimentation resulted in loss of dominant species such as surfgrass, kelp, or resulted in substantial reduction in diversity of invertebrate and algae assemblages.

Mitigation Considerations

Habitats and resources in the littoral zone are generally adapted to sand level changes and episodic or short-term turbidity. However, adverse to significant impacts have the potential to occur with prolonged exposure to turbidity or sand level increases that degraded habitat quality and functions from increased scour or reduction in living space.

Several measures may be used to avoid or minimize potential impacts of sediment management projects on sensitive rocky habitats. An important first step is appropriate evaluation of reef resources and ecological sensitivity.

Buffer distances may be used to minimize effects of sedimentation or turbidity. BMPs and operational controls also may be used to minimize turbidity during construction. A key consideration of beach nourishment projects is to design projects so that sand volumes do not exceed critical thresholds for sensitive habitats that may be nearby. Achieving an appropriate match between project size or location to environmental constraints may require an adaptive management approach with adjustments made based on lessons learned from monitoring.

Loss of sensitive rocky subtidal habitat due to persistent burial would require restoration to avoid significant impact to EFH-HAPC. Reef construction is considered technically and economically feasible with over thirty constructed in southern California by the CDFG since 1958 using a variety of materials (Lewis and McKee 1989). Several reefs have been constructed for mitigation in southern California (e.g., Long Beach Harbor, San Diego Bay, Pendleton reef offshore San Clemente). Kelp restoration has been an element of many of these projects, although with different levels of success. Although restoration of surfgrass beds is technically feasible, it has not been demonstrated to-date beyond an experimental scale.

Monitoring Considerations

A pre-construction sensitive aquatic resource survey may be necessary to finalize temporary pipeline placement and equipment use areas to minimize the potential for adverse impacts to sensitive rocky intertidal or subtidal habitats and associated organisms. A key element of pre-project avoidance and minimization measures is appropriate evaluation of reef resources and ecological sensitivity. Sensitive habitat boundaries relative to the project site should be identified.

Construction monitoring of water quality, including relative turbidity and plumes likely will be required to comply with RWQCB 401 water quality certification or waste discharge requirements.

Monitoring of rocky intertidal or subtidal areas before and after implementation of beach nourishment may be required when there is uncertainty regarding the potential for indirect impacts. Assessment of habitat changes, degradation, or sedimentation requires systematic and repeatable survey methods.

Methods may include some combination of uniform point contact (UPC) sampling along transects, estimating density within swath transects of specified width and length, counts within quadrats, and/or photoplots (Hill et al. 1998, Schuman 2007, *www.marine.gov/sampling-methods.htm, www.piscoweb.org/*). The different methods may be used to estimate percent cover of non-mobile invertebrates and vegetation and abundance of mobile invertebrates and fish. The water column may be divided into near bottom, mid-water, and canopy sections for recording observations of fish. Timed searches sometimes are used to standardize effort with respect to surveys for rare or inconspicuous species. Measurements of beach profiles or sand level changes may provide useful information on sand movement and changes in seasonal sand levels relative to baseline conditions.

Reef monitoring surveys

Photo credit: Danny Heilprin

Several long-term data sets of rocky intertidal and subtidal monitoring data are available for California that may provide useful reference data for studies conducted in association with sediment management projects (*http://www.marine.gov/sampling-methods.htm, http://www.piscoweb.org/data/ catalog/*).

Guideline Considerations:

List of Relevant Resource Protection Guidelines

The following guidelines may be relevant to Rocky Intertidal, Rocky Subtidal, Kelp Forest, or Surfgrass habitat depending on site-specific conditions:

Resource Protection Guideline	User's Guide	
	This Section	Other Sections
Physical-Chemical		
Beach Water Quality		3.3.1
Nearshore Water Quality		3.3.2
Biological		
Rocky Intertidal Habitat Assessment	X	
Rocky Intertidal HAPC (Algae, Invertebrates, and Tidepool Fish)	X	
Rocky Subtidal HAPC (Algae, Invertebrates, Reef Fish) Guideline	X	
Kelp Forest Guideline	X	
Surfgrass Guideline	X	
Marine Mammal Guideline		3.3.1

The guidelines for rocky intertidal HAPC is relevant to resource protection of prey species for birds that may forage in the habitat (e.g., gulls, shorebirds, and wading birds).

Other Potential Relevant Guidelines

Endangered black abalone or white abalone has the potential to occur intertidally, but this and other species of abalone typically are found on subtidal reefs. Resource protection considerations for subtidal rocky reef and kelp forest habitats should be relevant to protection of these species.

Cross-Reference Table to Relevant Sections of the Volume 1 BIA Document

Topic	Volume 1	
	Section	**Subsection**
Resource Description and Sediment Management Issues		
Rocky Intertidal	3	3.3.4
Rocky Subtidal	3	3.3.5
Kelp Forest/Bed	3	3.3.6
Surfgrass	3	3.3.7
Rocky Intertidal Invertebrates	4	4.2.8
Rocky Subtidal Invertebrates	4	4.2.9
Subtidal Reef Fish	4	4.3.6
Tidepool Fish	4	4.3.7
Least Tern	4	4.4.2
Gulls and Terns	4	4.4.4
Shorebirds	4	4.4.5
Wading Birds	4	4.4.6
Waterfowl and Seabirds (Cormorants)	4	4.4.7
Sea Otter	4	4.5.1
Seals and Sea Lions (Pinnipeds)	4	4.5.2
Whales, Dolphins, and Porpoises (Cetaceans)	4	4.5.3
Impacts		
Equipment – Hard Substrate, Kelp Forest	5	5.3.3.3, 5.3.3.4
Equipment – Invertebrates, Fish, Marine Mammals	5	5.3.4.1, 5.3.4.2 5.3.4.4
Sedimentation Impacts – Hard Substrate, Kelp Forest	5	5.4.3.3, 5.4.3.4
Sedimentation Impacts – Invertebrates, Fish	5	5.4.4.1,5.4.4.2
Turbidity Impacts – Kelp Forest	5	5.5.4.2
Turbidity Impacts – Invertebrates, Fish, Birds	5	5.5.4.3, 5.5.4.4, 5.5.4.5
Mitigation Measures		
Avoid direct impacts to sensitive habitats	6	6.3.2.1
Match project size to environmental constraints	6	6.3.2.2
Buffers – minimize turbidity or sedimentation	6	6.3.5.1, 6.3.5.2
Buffers – marine mammals	6	6.3.6.3, 6.4.1.5
Location controls – pipelines, anchoring, vessel operations	6	6.4.1.1, 6.4.1.2
Dredge operation controls – turbidity	6	6.4.3.3
Construction Methods and BMPs - turbidity	6	6.4.4
Minimize noise levels in sensitive wildlife areas	6	6.4.4.4
Minimize artificial lighting in sensitive wildlife areas	6	6.4.4.5
Monitor water quality and modify activities if necessary	6	6.4.5.2
Monitor marine mammals and modify activities if necessary	6	6.4.5.6
Monitor sensitive habitat – verify impact significance	6	6.5.1
Compensatory mitigation – if sensitive habitat loss	6	6.5.2
Monitoring Considerations		
Physical/Chemical		
Turbidity		7.4.3
Sedimentation	7	7.5.2
Biological		
Sensitive habitat and aquatic resource survey	7	7.3.2.1, 7.3.2.2
California least tern	7	7.4.5.2
Marine mammals	7	7.4.5.4
Impact verification	7	7.5.1

Hard-Bottom Habitat Assessment Guideline

Photo credit: John Evans

Definition: Hard-bottom refers to rocky shores, rocky subtidal, or biogenic substrates. Rocky substrate may include cobbles, boulders, rock or sandstone reefs, or man-made structures. Biogenic substrates in California includes sandworm reefs (*Phragmatopoma californica*), *Chaetopterus* worm tube reefs oyster reefs, or purple coral.

Sediment Management Issues: Physical disturbance and substrate characteristics influence resource development of hard substrates. Rocky intertidal habitats that support diverse communities of algae, invertebrates, and fish represent productive EFH-HAPCs. Cobble or boulder beaches may vary in productivity depending on the stability of the habitat (Sousa 1979). Unstable cobble or small boulders subject to tumbling by waves or substantial seasonal sand scour support poorly developed biota, if at all. Whereas, more stable cobble-boulder habitat may support diverse biota.

Shallow subtidal reefs in the littoral zone experience sand level change associated with seasonal on- and offshore movement of sand. Reef heights that extend above the sand level year-round (perennial reefs) typically support greater resource development than low-relief substrate subject to reef-top sand scour or burial for part of the year. Reef areas may include a mix of reef heights that differ in supported resources.

Assessment by a qualified biologist is necessary to characterize hard substrate habitats for the purpose of CEQA/NEPA documentation and permitting associated with sediment management projects. Relevant literature or available survey data may be considered, if recent. Often a sensitive aquatic resource (SAR) survey is required to document or update existing conditions.

For example, the RGP 67 specifies that a SAR survey would be required prior to issuance of that permit for discharges or dredged or upland-derived fill materials for beach nourishment. The SAR survey would be required to identify and delineate habitat types, including eelgrass meadows, high-relief reef and low-relief vegetated reefs (with indicator species including giant kelp, feather boa kelp, large sea fans, sea palms, and surfgrass), immediately adjacent and downcoast of the proposed discharge, with potential to be impacted by the proposed discharge. Those indicators are associated with hard substrates, except eelgrass (see Section 3.4.3).

The RGP 67 is applicable to projects conducted within the boundary of the USACE, Los Angeles District (Los Angeles, Orange, San Diego, Ventura, Santa Barbara, and San Luis Obispo counties). Projects conducted within the San Francisco Corps boundaries may require consideration of additional or other indicator species to delineate sensitive habitats.

While identification and delineation of sensitive hard substrate habitats is important, it is equally important to characterize the habitats in a manner that supports impact assessments based on considerations of turbidity, sedimentation, and cumulative effects. Consequently, information on existing habitat quality, substrate heights, and types of stressors (e.g., discharges, public use) are important to document.

If hard–bottom substrates are identified within the area of potential project influence refer to resource protection guidelines for rocky reef, kelp forest, or surfgrass habitats, as appropriate.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Offshore borrow site dredging Other Activities or Issues of Concern	• Equipment damage, turbidity, sedimentation of HAPC Resources of Concern • Canopy-forming kelp, surfgrass • High-relief and low-relief vegetated reefs supporting diverse communities of algae, invertebrates, and fish.

Guideline Objectives:

- Identify and delineate sensitive hard-bottom substrate in proximity to project area.
- Characterize hard bottom relevant to sand movement considerations.

Resource Protection Considerations

- Assume rocky substrate is HAPC unless assessed otherwise by a qualified biologist.
- A qualified biologist will assess hard substrate habitat based on multiple factors, including but not limited to:
  - Type of substrate. Boulder, cobble, reef [rock, sandstone, biogenic reef (*Phragmatopoma californica)].*
  - Relative percentage of hard substrate by height categories relevant to sand movement (e.g., < 1 ft, 1-2 ft, 2-3 ft, >3 ft).
  - Relative occurrence of hard substrate according to resource development:
    - Hard substrate with no attached biological resources.
    - Substrate supporting few resources (e.g., algal crusts, low growing turfs, no attached animals).
    - Substrate supporting opportunistic species [e.g., feather boa kelp (*Egregia menziesii],* which may occur with hard substrate supporting few or more resources.
    - Substrate with variety of algae, attached animals, mobile invertebrates, and/or fish.
  - Relative occurrence of special interest species (e.g., sparse, common, abundant).
    - Surfgrass.
    - Canopy-forming kelp forest/bed [e.g., giant kelp (*Macrocystis pyrifera*), bull kelp (*Nereocystis luetkeana)].*
    - Intertidal Kelp [e.g., Feather boa kelp*,* giant bladder kelp *(Macrocystis integrifolia)].*
    - Subtidal understory kelp [e.g., bladder chain kelp (*Cystoseira osmundacea),* feather boa kelp, southern sea palm (*Eisenia arborea*), split-blade kelp (*Laminaria setchelii*), winged kelp (*Pterogophora californica)].*
    - Other special interest species [e.g., abalone (*Haliotis* spp.), California spiny lobster (*Panulirus interruptus*), sea fans (*Muricea* spp.), Kellet's whelk (*Kelletia kelletii*), sheep crab (*Loxorhynchus grandis*), warty sea cucumber (*Parasticopus parvimensis*)]. *
  - Mapped delineation of sensitive hard-bottom, surfgrass, or canopy-forming kelp forests/beds. Historical extent of sensitive hard-bottom habitats, as available.
  - Other observed resources (e.g., types of birds, marine mammals).
  - Stressors (e.g., discharges, type and relative intensity of public use).
  - Date, time, tide stage, tide elevation, water depth, underwater visibility during survey, as applicable.
  - Representative photographs.

*Special interest species may vary based on local fishing or other considerations and should be reviewed in advance with resource agencies.

Effectiveness Considerations: The assumption that habitat is a HAPC unless assessed otherwise is protective. Assessment of hard-bottom habitat by a qualified biologist is effective for identifying the sensitivity of the habitat and potential impact significance when based on multiple factors. Natural changes in sand level or other environmental conditions may affect resource development of hard-bottom substrates. Therefore, review of historical information (e.g., kelp bed mapping) is effective for identification of extent of hard-bottom, particularly if canopy kelp is temporarily reduced due to large-scale disturbance (e.g., El Niño, high waves). Habitat conditions are subject to natural variation; therefore, use of up-to-date information will increase the effectiveness of habitat assessments

Seasonal Considerations: Intertidal assessments should be conducted during minus tides so that the full range of intertidal habitat is exposed. The fall-winter season is beneficial for scheduling surveys because the beach sand levels are typically lower than in summer (e.g., enable documentation of erosive beach conditions, as applicable). Conversely, subtidal sand levels in the littoral zone are higher in fall-winter, which permits documentation of height of hard bottom when sand levels may be closer to a seasonal maximum).

Monitoring Considerations: Habitat characterizations should include a narrative description, check list table of observations, maps, and photographs. More detailed survey techniques generally would be necessary to establish pre-construction baseline survey conditions for long-term monitoring programs to verify impact significance (e.g., band transects, point-intercept quadrats, permanent photo-plots).

Volume 1 References: SAIC 2011 – Section 6 (6.3.8.2) and Section 7 (7.3.2.1, 7.3.2.2).

Rocky Intertidal HAPC (Algae, Invertebrates, and Tidepool Fish) Guideline

Photo credit: Karen Green

Status: EFH-HAPC.
Potential to support listed sensitive species or critical habitat (black abalone).

Functions: Rocky intertidal provides habitat for algae, seagrasses, invertebrates, and fish. Algae and seagrass contribute to ecosystem primary production and provide food and physical habitat for a variety of tidepool animals. Vegetation and invertebrates provide food for fish and birds depending on tide stage and exposure.

Sediment Management Issues: Rocky intertidal habitats are rigorous environments due to hydrodynamic forces of wave shock, ebb and flow of tides, and sand movement. Species assemblages reflect site-specific substrate characteristics and disturbance factors. The following guidelines pertain to productive rocky intertidal HAPC habitats supporting a variety of marine plants, invertebrates, and fish.

Sediment management activities have the potential to result in equipment, sedimentation, or turbidity impacts to rocky intertidal habitats, if beach nourishment occurs nearby . Equipment may crush or damage resources. Turbidity has the potential to reduce biological diversity, particularly of marine plants. Sand placement has the potential to fill tidepools, reduce exposed rock heights, increase sand scour effects, or reduce living space for marine resources. Habitat quality has the potential to be degraded or lost depending on the duration or magnitude of impacts. Resource protection measures are necessary to protect sensitive rocky intertidal habitat if nearby sediment management activities.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach Nourishment	• Equipment, Sedimentation, Turbidity
Other Activities or Issues of Concern	**Resources of Concern**
• Non-point Discharges • Intense Public Use	• Surfgrass, Abalone, Monkeyface prickleback • Diverse community of algae, rocky intertidal invertebrates, tidepool fish

Guideline Objectives:

- Avoid construction activities within rocky intertidal HAPC.
- Avoid degradation of rocky intertidal HAPC.
- Minimize turbidity or sedimentation of rocky intertidal HAPC.

Resource Protection Considerations

- Identify and delineate rocky intertidal HAPC habitat within 0.5 mi (0.8 km) of beach sand receiver site boundary. If intertidal HAPC supports surfgrass, see Surfgrass Guideline.
- Assume rocky intertidal habitat is HAPC unless otherwise assessed by qualified biologist and concurrence is obtained from CDFG and NOAA.*
- Use buffer distance (≥ 1,000 ft, 305 m) between receiver site boundary and rocky intertidal HAPC to minimize turbidity or sedimentation impacts, or determine alternate buffer distance based on project-specific grain size characteristics, volume, and site-specific hydrodynamics.
- Delineate rocky intertidal HAPC on construction plans and specifications to ensure avoidance during construction.
  - Avoid sand placement on HAPC reefs.
  - Establish pipelines plans to avoid HAPC reefs.
  - Avoid driving vehicles on exposed HAPC reefs.
- Minimize turbidity and sedimentation with constructed (e.g., temporary dikes) or operational controls (e.g., discharge high on beach, adjustments to operations), as appropriate.**
- Monitor and map turbidity plumes during construction, and determine extent of incursions into rocky intertidal HAPC habitat, as applicable.*
- If project duration will span > 1 week and turbidity plume incursions over rocky intertidal HAPC are documented over at least three consecutive days during the first week of monitoring, adjust discharge, conduct additional water quality monitoring consistent with other sensitive HAPC, if applicable.** If intertidal HAPC supports surfgrass, see Surfgrass Guideline. Additional monitoring would not be required if hard-bottom already is degraded and supports few resources due to seasonal sand scour or burial.
- Modify discharge if water quality guideline thresholds for other sensitive habitats are exceeded.**
- Long-Term Monitoring. If hard-bottom HAPC is within area of potential project influence, pre- and post-construction monitoring by a qualified biologist may be required to verify no significant impacts. This would be determined by resource and regulatory agencies during the permitting phase on a case-by-case basis.

*Refer to Rocky Intertidal Habitat Assessment Guideline, ** Refer to Beach Water Quality Guideline

Effectiveness Considerations: The assumption that rocky intertidal substrate is HAPC unless assessed otherwise is protective. Use of distance buffers between sediment management activities and rocky intertidal habitat may be effective for avoiding or minimizing the potential for turbidity or sedimentation impacts when project size and site-specific environmental conditions are adequately assessed. Modeling may be necessary to support project design considerations when project volumes or proximity pose a risk to sensitive rocky HAPCs. Monitoring may be required to verify project impacts. Remedial or compensatory mitigation may be required to avoid long-term significant impacts.

Seasonal Considerations: Rocky intertidal habitat experiences natural on- and offshore movement of sand on a seasonal basis. Generally, sand levels erode in fall-winter with change in wave climate and storm activity and accrete over late spring-summer. Generally, there is greater productivity and growth of biological resources during late spring-summer.

Monitoring Considerations: A rocky substrate habitat assessment survey may be necessary to identify boundaries, characteristics, and types of HAPCs (including rocky intertidal HAPC) in the vicinity of proposed sediment management projects. Prior to construction, pipeline plans

and vehicle routes should be verified to ensure avoidance of rocky intetidal HAPC. During construction, the primary objective would be to verify permit conditions (e.g., avoidance of rocky intertidal habitat, turbidity plume monitoring). The Beach, Nearshore, and Embayment Water Quality Guidelines suggest additional monitoring of light transmission and/or TSS may be relevant if plumes persist in areas with HAPC habitat. If long-term monitoring is a permit requirement, assessment of habitat changes, degradation, or sedimentation would require systematic and repeatable survey methods.

Volume 1 References: SAIC 2011 – Section 3 (3.3.4), Section 4 (4.2.8, 4.3.7), Section 5 (5.2.3.4, 5.3.3.3, 5.4.3.3, 5.5.4.4), Section 6 (6.3.2, 6.3.5, 6.3.8, 6.4.1.1, 6.4.4.2, 6.4.5.2, 6.5, 6.6.2), and Section 7 (7.5.1).

Rocky Subtidal HAPC (Algae, Invertebrates, Reef Fish) Guideline

Sea Fans *Photo credit: Danny Heilprin*

Status: EFH-HAPC.
Potential to support listed sensitive species (black abalone, white abalone) or critical habitat (black abalone).

Functions: Rocky subtidal provides substrate or shelter for algae and a variety of animals. Algae contribute to ecosystem primary production and provide food and habitat to invertebrates and fish, which may be prey to diving birds and marine mammals.

Sediment Management Issues: Rocky subtidal communities reflect site-specific substrate characteristics and disturbance factors. The following guidelines pertain to productive rocky subtidal HAPC habitats supporting a variety of marine plants, invertebrates, and fish. Sediment management activities have the potential to result in equipment, sedimentation, or turbidity impacts to rocky subtidal habitats, if beach nourishment (beach, nearshore, or profile placement) or offshore borrow site dredging, occurs nearby. Anchors or pipelines have the potential to crush or damage resources. Turbidity has the potential to reduce biological diversity, particularly of marine plants. Sedimentation has the potential to increase sand scour effects, reduce reef heights, or reduce living space for marine resources.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach Nourishment • Dredging	• Equipment damage, Direct burial • Sedimentation, Turbidity
Other Activities or Issues of Concern	**Resources of Concern**
• Non-point Discharges • Commercial & Recreational Fishing	• Surfgrass, Abalone • Diverse community of algae, invertebrates, reef fish

Guideline Objectives:

- Avoid construction activities within rocky subtidal HAPC.
- Avoid degradation of rocky subtidal HAPC.
- Minimize turbidity and sedimentation of rocky subtidal HAPC.

Resource Protection Considerations

- Identify and delineate hard-bottom subtidal HAPC within area of potential project influence. If subtidal HAPC supports sensitive vegetation, see Surfgrass and/or Kelp Forest Guidelines, as appropriate.
- Assume rocky subtidal habitat is HAPC unless assessed otherwise by qualified biologist and concurrence is obtained from CDFG and NOAA.*
- Use buffer distance (≥ 1,000 ft, 305 m) to minimize turbidity or sedimentation impacts or determine alternate buffer distance based on project-specific grain size characteristics and site-specific hydrodynamics.
- Avoid direct damage to subtidal rocky reefs.
  - Avoid sand placement on reefs.
  - Establish anchor and pipelines plans to avoid hard bottom areas.

Resource Protection Considerations (Continued)

- Minimize turbidity with constructed (e.g., temporary dikes) or operational controls (e.g., no dredge overflow, discharge high on beach, adjustments to operations), as appropriate.**
- Monitor and map turbidity plumes during construction, and determine extent of incursions into hard-bottom habitat, as applicable.*
- If project duration will span > 1 week and turbidity plume incursions over subtidal HAPC habitat are documented over at least three consecutive days during the first week of monitoring, additional water quality monitoring may be warranted.** If HAPC supports kelp or surfgrass, see those guidelines. Additional monitoring would not be required if hard-bottom already is degraded and supports few resources due to seasonal sand scour or burial.
- Modify discharge if water quality guideline thresholds for other sensitive habitats.**
- Long-Term Monitoring. If rocky subtidal HAPC is within area of potential project influence, pre- and post-construction monitoring by a qualified biologist may be required to verify no significant impacts. This would be determined by resource and regulatory agencies during the permitting phase on a case-by-case basis.
- If substantial habitat degradation or loss is documented, coordinate with resource agencies and conduct remedial or compensatory mitigation, as applicable.

*Refer to Rocky Intertidal Habitat Assessment Guideline, ** Refer to Beach Water Quality Guideline

Effectiveness Considerations: The assumption that rocky subtidall substrate is HAPC unless assessed otherwise is protective. Use of distance buffers between sediment management activities and rocky subtidal habitat may be effective for avoiding or minimizing the potential for turbidity or sedimentation impacts when project size and site-specific environmental conditions are adequately assessed. Modeling may be necessary to support project design considerations when project volumes or proximity pose a risk to sensitive rocky HAPCs. Monitoring may be required to verify project impacts. Compensatory mitigation could be required if substantial adverse impacts occur to sensitive habitats.

Seasonal Considerations: Rocky subtidal habitat in the littoral zone experiences natural on- and offshore movement of sand on a seasonal basis. Generally, sand levels accrete in fall-winter with change in wave climate and storm activity and erode over late spring-summer. Generally, there is greater productivity of biological resources during late spring-summer.

Monitoring Considerations: A rocky substrate habitat assessment survey may be necessary to identify boundaries, characteristics, and types of HAPCs (including rocky subtidal HAPC) in the vicinity of proposed sediment management projects. Prior to construction, vessel anchor or pipeline plans should be verified to ensure avoidance of rocky subtidal HAPC. During construction, the primary objective would be to verify permit conditions (e.g., avoidance of rocky intertidal habitat, turbidity plume monitoring). The Beach, Nearshore, and Embayment Water Quality Guidelines suggest additional monitoring of light transmission and/or TSS may be relevant if plumes persist in areas with vegetated HAPC habitat. If long-term monitoring is a permit requirement, assessment of habitat changes, degradation, or sedimentation would require systematic and repeatable survey methods.

Volume 1 References: SAIC 2011 – Section 3 (3.3.5), Section 4 (4.2.9, 4.3.6), Section 5 (5.2.3.4, 5.3.3.3, 5.4.3.3, 5.5.4.4), Section 6 (6.3.2, 6.3.5, 6.3.8, 6.4.1.1, 6.4.4.2, 6.4.5.2, 6.5, 6.6.2), and Section 7 (7.5.1).

Kelp Forest HAPC Guideline

***Status**:* EFH-HAPC

Functions: Kelp plants are primary producers of oxygen, serve as attachment sites for a variety of invertebrates, provide shelter with their vertical structure, and contribute organic matter from the breakdown of their leaves. Kelp forests support diverse communities of algae, invertebrates, and fish, and are foraging habitats for seabirds and marine mammals.

Kelp forest offshore San Diego
Photo credit: San Diego Nearshore Programhttp://nearshore.ucsd.edu/

Sediment Management Issues: Giant kelp (*Macrocystis pyrifera*), bull kelp (*Nereocystis luetkeana*), and elk kelp (*Pelagophycus porra*) may exceed 80 ft (25 m) in length and dense growths are commonly referred to as kelp forests due to their substantial vertical structure. Giant kelp and bull kelp are the most common kelp forest species in California and are subject to commercial harvest within designated and numbered kelp beds (CDFG 2001).

Kelp Plant Structure

Kelp plants include a holdfast, which anchors the plant to the bottom, stem-like stipes, and leaf-like blades that extend upward to the water surface. Stipes and blades (termed fronds), are supported in the water column by one or more gas-filled bladders (pnematocysts).

These habitats are dynamic environments characterized by predictable (seasonal) and unpredictable (storm, El Niño, grazing) variability of occurrence. The canopy of kelp forests varies seasonally. In southern California, canopies deteriorate in late summer-fall due to nutrient limitation and higher temperatures (Foster and Schiel 1985). In central California, kelp forest canopies cycle between a maximum in summer and minimum in winter due to storm swells. Consequently, evaluations of the potential to impact these habitats from sediment management activities should take into account the potential for habitat occurrence based on available suitable substrate and historical occurrence rather than just surface canopy.

Detached kelp fronds and stipes may be carried by currents to beaches; kelp wrack is important to beach ecology (refer to Section 3.3.1, Beach Wrack Guideline).

Kelp forests have the potential to be impacted by sediment management activities, if nearby. Vessels moving through a kelp bed may entangle and rip-up fronds or dislodge holdfasts. Kelp and understory plants are sensitive to changing light levels and are limited when light transmission is substantially impaired. Light reduction does not impact adult plants with surface canopies, but can reduce establishment of early life stages and growth of juvenile plants.

Kelp forests are highly vulnerable to sedimentation impacts, which can potentially damage plants from abrasion and scour or preclude recruitment when sediment covers hard substrate. The inshore edge of giant kelp forests is dynamic due to disturbance from water motion (surge stress) and sedimentation, which vary each year with oceanographic conditions. Kelp beds generally occur outside the littoral zone.

Other algae and kelp may occur on rocky substrate within and inshore of kelp forests. A few species may form well developed understory canopies (e.g., feather boa kelp, bladder chain kelp). The inshore species have life strategies (annual plant), live on higher relief rocks, or have adaptations that support persistence despite seasonal changes in sand levels and episodic

turbidity. However, species diversity or occurrence of algae may be substantially reduced in areas of prolonged or chronic turbidity (e.g., landslides, runoff).

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Dredging	• Equipment • Turbidity, Sedimentation
Other Activities or Issues of Concern	**Resources of Concern**
• Point and non-point discharges • Landslide activity	• Bull kelp, Giant kelp • Diverse invertebrates, fish, other algae

Guideline Objectives:

- Avoid damage or loss of kelp HAPC habitat.
- Avoid degradation of kelp HAPC.
- Minimize turbidity or sedimentation of kelp HAPC.

Resource Protection Considerations

- Identify and delineate kelp forest/bed HAPC if within area of potential project influence.
- Use buffer distance (≥ 1,000 ft, 305 m) to minimize turbidity or sedimentation impacts, or determine alternate buffer distance based on project-specific grain size characteristics and site-specific hydrodynamics.
- Avoid direct damage to kelp beds.
  - Avoid sand placement in kelp beds.
  - Prepare anchor and pipelines plans to avoid hard bottom areas with kelp. Verify plans prior to construction.
  - Establish vessel corridor routes to avoid kelp beds.
- Minimize turbidity with operational controls (e.g., no dredge overflow, adjustments to operations), as appropriate.*
- Monitor and map turbidity plumes during construction, and determine extent of incursions into kelp bed habitat, as applicable.*
- If project duration will span > 1 week and turbidity plume incursions into kelp HAPC are documented over at least three consecutive days during the first week of monitoring, additional water quality monitoring may be warranted.*
- Modify discharge if water quality guideline thresholds for vegetated HAPC are exceeded.*
- Long-Term Monitoring. If kelp HAPC is within area of potential project influence, pre- and post-construction monitoring by a qualified biologist may be required to verify no significant impacts. This would be determined by resource and regulatory agencies during the permitting phase on a case-by-case basis.
- If substantial habitat degradation or loss is documented, coordinate with resource agencies and conduct remedial or compensatory mitigation, as applicable.

*Refer to Beach, Nearshore, or Embayment Water Quality Guidelines, as applicable

Effectiveness Considerations: Dredge or discharge projects may require hopper dredge, barge, or support vessel movement in areas where kelp beds may occur or be nearby.

Preparation of anchor and pipeline plans helps ensure adequate pre-planning for avoiding and minimizing impacts during construction. The CDFG maintains a georeferenced digital database on all kelp beds along the California coast (*http://www.dfg.ca.gov/marine/gis/natural resource.asp*). Because kelp beds may exhibit substantial interannual variability in development, examination of several years of mapped data provide a more complete understanding of potential kelp distribution. However, kelp bed conditions during construction may vary from that of available maps. In addition, kelp maps are of surface canopy and the underlying rocky bottom may not be in precise alignment. For these reasons, a pre-construction survey of proposed anchor and pipeline plans is an effective protective measure for ensuring avoidance and minimization of potential damage to this habitat from construction, if in the vicinity.

Use of distance buffers between sediment management activities and kelp habitat may be effective for avoiding or minimizing the potential for turbidity or sedimentation impacts when project size and site-specific environmental conditions are adequately assessed. A distance buffer of > 1,000 ft (> 305 m) may be protective for projects involving dredging or nearshore placement based on review of monitoring data and relevant reports (Sections 2.7.4.2, 2.7.4.3). Smaller distance buffers also may be protective depending on project- and site-specific considerations (e.g., project size, proximity to the sensitive habitat, water depth, sand source characteristics, and environmental conditions).

Determining a suitable buffer distance between kelp habitat and a beach sand placement project may or may not be necessary. In certain locations or years, kelp may expand landward into waters as shallow as 6.5 to 16 ft (2 to 5 m), but depths more typically range from 20 to 65 ft (6 to 20 m) (Aleem 1973, Foster and Schiel 1985, North 1986). Kelp beds often are outside or near the seaward portion of the beach depth of closure, where little sand movement occurs on a seasonal basis, on average. Modeling may be necessary to support assessment of the potential to impact kelp habitat.

Kelp forests are one of the most productive of all marine habitats. Early life stages of kelp require clean attachment surfaces, therefore, turbidity and sedimentation have the potential to adversely impact this habitat and supported resources. The Beach, Nearshore, and Embayment Water Quality Guidelines suggest additional monitoring of light transmission and/or TSS may be relevant if plumes persist in areas with vegetated HAPC habitat.

Long-term monitoring may be required to verify project impacts, if any. If impacts were to result in loss of kelp, remedial or compensatory mitigation may be required to avoid long-term significant impacts. This would need to be determined in coordination with the resource and regulatory permitting agencies for the project. Kelp restoration is feasible and there are proven methods that have been used to create such habitat in California (Foster and Schiel 1985, Ambrose 1986, CDFG 2001).

Seasonal Considerations: Giant Kelp canopies undergo seasonal cycles with less development in late summer-fall in southern California and less development in winter in central California. Bull kelp also deteriorates in late summer-fall. Generally, surface kelp canopy development is less in late summer through winter. Widespread reduction in kelp has been associated with El Niño episodes that included substantially higher temperatures, lower nutrient concentrations, and/or storm episodes with large swells and wave activity (Tegner and Dayton 1987, Parnell et al. 2010). Kelp habitat may be less vulnerable to equipment impacts when canopy development is less, but is vulnerable year-round to turbidity or sedimentation impacts, which may affect kelp recruitment.

Monitoring Considerations: A rocky substrate habitat assessment survey may be necessary to identify boundaries, characteristics, and types of HAPCs (including kelp bed) in the vicinity of proposed sediment management projects. This is generally done to support environmental analysis (CEQA and/or NEPA) of the project.

Because of the seasonal nature of kelp canopy development, a pre-construction survey to verify anchor and pipeline plans, as applicable, should be scheduled within 30-60 days prior to construction.

If adequate buffer distances are used, monitoring of kelp habitat would not be required during construction. Water quality monitoring guidelines include considerations for additional data collection if vegetated HAPCs have the potential to be influenced by turbidity (and sedimentation) during dredging or discharges.

Monitoring may be a permit requirement if there is uncertainty regarding potential impacts to the habitat from post-construction sand transport. If long-term monitoring is required, assessment of habitat changes, degradation, or sedimentation would require systematic and repeatable survey methods. Pre-construction and Post-construction surveys would be required to enable before-after impact documentation. A combination of diver transects and remote sensing (aerial photographs) may be most effective. Aerial photographs facilitate evaluations of large-scale changes in canopy cover, and should include consideration of reference areas to ensure adequate evaluation of the influence of natural variability over the course of the entire the monitoring period. Diver transects, when located at different distances from disturbance, provide a more exact data set for evaluating changes at specific locations over time, which then may be compared to the larger-scale assessment.

Volume 1 References: SAIC 2011 - Section 3 (3.3.6), Section 4 (4.2.9, 4.3.6), Section 5 (5.2.3.4, 5.3.3.3, 5.3.3.4, 5.4.3.3, 5.4.3.4, 5.5.4.2, 5.5.4.4), Section 6 (6.3.2, 6.3.5, 6.3.8, 6.4.1.1, 6.4.4.2, 6.4.5.2, 6.5, 6.6.2), and Section 7 (7.5.1).

Surfgrass HAPC Guideline
Phylospadix spp.

Surfgrass bed on reef
Photo credit: Karen Green

***Definition**:* Surfgrass is a type of seagrass that grows on rocky substrate.

***Status**:* EFH-HAPC.

***Functions**:* Surfgrass is primary producer and habitat for a variety of invertebrates and fish, nursery habitat for fishery species (e.g., lobster), and foraging habitat for birds.

Sediment Management Issues: Surfgrass is morphologically adapted to withstand shifting sand movement with its long, fibrous leaf blades (1 to 3 ft intertidal, 2 to 6.5 ft subtidal) that are adapted to sand abrasion; however, substantial or prolonged sand burial has the potential to affect growth, health, and survival. Sand burial in this context refers to sand accumulation above the hard substrate (i.e., along the blade length) not burial of the entire plant. Experimental studies have demonstrated reduced seedling survival with persistent sand burial of 2 to 10 in (5 to 25 cm) (Reed and Holbrook 2003), reduced carbohydrate storage with burial by 5 in (12 cm) (Plechner 1996), and a reduction in density when burial was at least 10 in (25 cm) (Craig et al. 2008). The timing of sand cover also appears to important. Plechner (1996) found that the amount of carbohydrates stored in summer months from photosynthesis was important to the survival of plants over winter and early spring.

Critical thresholds before habitat loss are poorly understood. It is considered unlikely that a single numerical value would be applicable. Surfgrass blade lengths naturally vary depending on species and environmental conditions (e.g., exposure, depth). In addition, the time of year, duration, or persistent depth of sand burial may be important considerations. Notwithstanding the concern for surfgrass survival, there also are ecological functions of the habitat relevant to consider from a resource protection standpoint (e.g., lobster nursery habitat, shelter and foraging habitat for invertebrates, fish, and foraging habitat for birds in the intertidal).

Persistent and substantial burial of surfgrass blades may degrade ecological functions as EFH-HAPC or result in habitat loss. Surfgrass may naturally recover from density reduction if the rhizome mat is not substantially disturbed, but recovery may take years if there is substantial loss of rhizome mat (Dethier 1984, Stewart 1989, Turner 1985, Turner and Lucas 1985). If sediment management activities resulted in substantial degradation or loss of surfgrass habitat, remedial or compensatory mitigation would be required to avoid a significant impact to a HAPC.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment • Pipelines, Vessels	• Equipment damage • Indirect sedimentation, turbidity
Other Activities or Issues of Concern	**Resources of Concern**
	• Surfgrass • California spiny lobster

Guideline Objectives:

- Avoid damage or loss of surfgrass habitat.
- Avoid degradation of ecological functions of surfgrass habitat.
- Minimize turbidity and sedimentation disturbance of surfgrass and associated resources.

Resource Protection Considerations

- Identify and delineate surfgrass HAPC if within area of potential project influence.
- Locate project site downcurrent (prevailing current direction) of surfgrass beds to minimize the potential for turbidity and sedimentation effects.
- Use buffer distance (≥ 1,000 ft, 305 m) to minimize turbidity or sedimentation impacts or determine alternate buffer distance based on project-specific grain size characteristics and site-specific hydrodynamics.
- Prepare anchor, dredge, discharge, and pipeline plans to avoid surfgrass habitat.
- Avoid direct sand placement on surfgrass.
- Avoid driving vehicles on exposed surfgrass during low tides.
- Minimize turbidity with constructed or operational controls (e.g., sand dikes, upper beach discharge, adjustments to operations), as appropriate.*
- Monitor and map turbidity plumes during construction, and determine extent of incursions into surfgrass habitat, as applicable.*
- If project duration will span > 1 week and turbidity plume incursions into surfgrass HAPC are documented over at least three consecutive days during the first week of monitoring, additional water quality monitoring may be warranted.*
- Modify discharge if water quality guideline thresholds for vegetated HAPC are exceeded.*
- Long-Term Monitoring. If surfgrass HAPC is within area of potential project influence, pre- and post-construction monitoring by a qualified biologist may be a permit requirement to ensure no significant impacts. This would be determined by resource and regulatory agencies during the permitting phase on a case-by-case basis.
- If substantial habitat degradation or loss is documented, coordinate with resource agencies and conduct remedial or compensatory mitigation, as applicable.

* Refer to Beach Water Quality or Nearshore Water Quality Guidelines, as appropriate

Effectiveness Considerations: Preparation of dredge, discharge, anchor, and pipeline plans are effective for avoidance of direct impacts to sensitive habitat. Use of distance buffers between sediment management activities and surfgrass habitat may be effective for avoiding or minimizing the potential for turbidity or sedimentation impacts when project size and site-specific environmental conditions are adequately assessed. A distance buffer of > 1,000 ft (> 305 m) may be protective for projects involving dredging or nearshore placement based on review of monitoring data and relevant reports (Sections 2.7.4.2, 2.7.4.3). Smaller distance buffers also may be protective depending on project- and site-specific considerations (e.g., project size, proximity to the sensitive habitat, water depth, sand source characteristics, and environmental conditions).

Determining a suitable buffer distance between sensitive habitats and a beach sand placement project is more complex because of higher current speeds and the need to consider both

turbidity/sedimentation during construction and post-construction sand transport effects. The appropriate distance for beach sand placement projects would depend on project volume and site-specific environmental conditions (e.g., reef heights and relative occurrence of surfgrass, surfgrass blade lengths, reef orientation and sand movement patterns, distance from receiver site, etc.). Modeling may be necessary to support assessment of potential impacts.

Monitoring of surface turbidity plumes during construction could be useful for identifying the potential to impact surfgrass habitat resources. Surfgrass has a relatively high light saturation irradiance level (≥ 40% surface irradiance) (Williams and McRoy 1982), therefore, light limitation from sediment management projects is of limited concern. However, surfgrass is an important nursery area for other marine species, including lobster, and turbidity and sedimentation represent issues of potential concern relative to this important habitat function. The Beach, Nearshore, and Embayment Water Quality Guidelines suggest additional monitoring of light transmission and/or TSS may be relevant if plumes persist in areas with vegetated HAPC habitat.

Long-term monitoring may be required to verify project impacts, if any. If impacts were to result in loss or substantial degradation of surfgrass habitat, remedial or compensatory mitigation may be required to avoid long-term significant impacts. This would need to be determined in coordination with the resource and regulatory permitting agencies for the project. Although surfgrass restoration is technically feasible, it has not yet been demonstrated beyond an experimental scale.

Seasonal Considerations: Intertidal surfgrass may experience increased sedimentation during summer, and subtidal surfgrass may experience increased sedimentation during winter associated with normal on- and offshore movement of sand. Seasonal changes in sand level should be taken into consideration when assessing the potential to impact surfgrass HAPC.

Monitoring Considerations: A rocky substrate habitat assessment survey may be necessary to identify boundaries, characteristics, and types of HAPCs (including surfgrass) in the vicinity of proposed sediment management projects. Prior to construction, pipeline and vessel anchor plans should be verified to ensure avoidance of surfgrass habitat. During construction, the primary objective would be to verify permit conditions (e.g., avoidance of surfgrass habitat, turbidity plume monitoring).

If long-term monitoring is a permit requirement, assessment of habitat changes, degradation, or sedimentation would require systematic and repeatable survey methods. Long-term data of seasonal sand level changes in the on- and offshore direction of the beach profile to the depth of closure is important to enable integration of biological observations with site-specific sand transport dynamics.

Volume 1 References: SAIC 2011 - Section 3 (3.3.7), Section 4 (4.2.2, 4.2.8, 4.3.7), Section 5 (5.2.3.4, 5.3.3.4, 5.4.3.3, 5.4.3.4, 5.5.4.2, 5.5.4.4), Section 6 (6.3.2, 6.3.5, 6.3.8, 6.4.1.1, 6.4.4.2, 6.4.5.2, 6.5, 6.6.2), and Section 7 (7.5.1).

3.4.3 Eelgrass Meadow

Photo credit: Keith Merkel

Status: Eelgrass is a special aquatic site (SAS) (i.e., vegetated shallows) under Section 404(b)(1) of the federal Clean Water Act of 1972, as amended (*www.usace.army.mil/inet/functions/cw/cecwo/reg/40cfr230.html*). Eelgrass meadows are EFH for managed fishery species. California's fishing regulations prohibit cutting or disturbing of eelgrass.

Habitat Definition: Eelgrass may be referred to as a type of submerged aquatic vegetation (SAV). Eelgrass forms submerged beds, also termed meadows. This habitat is found throughout California in bays, estuaries, and coastal lagoons and along some protected coastlines of the mainland and Channel Islands (Phillips and Wyllie-Esheverria 1990, Ware 1993, CINMS 2000).

The most widely distributed species is *Zostera marina*, which ranges from low intertidal to subtidal depths up to 66 ft (20 m). Both *Z. marina* and *Z. pacifica* (previously described as *Z. asiatica* by Phillips and Echeverria 1990) are found offshore the Channel Islands and along the coast of Santa Barbara County (Coyer et al. 2008). A third species, commonly known as dwarf eelgrass (*Z. japonica*) is non-native and a management concern California, its presence was first discovered in Humboldt Bay in 2002 (Foss et al. 2007).

Sediment Management Issues: Eelgrass supports trophic transfer across nearshore ecosystems, contributing primary production, detritus (decaying pWlant matter) that supports a variety of invertebrates, which are in turn eaten by fish and birds. Other important functions include water quality enhancement, sediment stabilization, and dampening of waves and current velocities (Fonseca and Kenworthy 1987, Phillips 1984, Fonseca and Cahalan 1992).

Sediment management activities involving dredging have been identified as a contributing factor to the loss of seagrass in the United States and elsewhere in the world (Phillips 1984, Giesen et al. 1990, Short and Wyllie-Echeverria 1996 cited in Sabol et al. 2005, NOAA 2001b). Concerns include eelgrass removal, sedimentation of adjacent plants, turbidity, light limitation, alteration of velocity or direction of currents, increased erosion or turbidity due to loss of the sediment-stabilizing function of eelgrass, or altered nutrient flow mechanics of the ecosystem (Phillips 1984, NOAA 2001b).

Resources of Concern

- Eelgrass
- Endangered least tern
- Endangered salmonids
- California spiny lobster
- Dungeness crab
- Pacific herring
- Fish nursery habitat
- Brandt goose
- Beach water quality
- Embayment water quality
- Nearshore water quality

Overview of Relevant Background Consideration:

Ecological Functions and Resources of Concern

Eelgrass is considered one of the most productive of coastal habitats supporting nearly twice the number of species than adjacent soft substrate sediments. More than 20 fish species and more than 200 invertebrate species have been collected from eelgrass meadows in southern California (Hoffman 1986, Ware 1993).

Eelgrass meadows support a variety of ecological functions

for invertebrates and fish, including structural refuge, shelter, foraging habitat, and reproductive habitat. Eelgrass meadows are used as spawning or nursery areas for many commercially and recreational important finfish and shellfish species, including California halibut, California spiny lobster, Dungeness crab, Pacific herring, rockfish, juvenile salmon, sand bass (barred, spotted), shiner surfperch, and steelhead (Hoffman 1986, Ware 1993, LFR 2004). Eelgrass meadows also are used as nursery areas for small forage fish (anchovies, silversides), which are favored prey of the endangered California least tern. The Brant goose (*Branta bernicla*) grazes primarily on eelgrass and associated invertebrates.

Sediment Management Activities and Impact Considerations

Types of sediment management activities and potential impact factors to eelgrass habitat include:

- Beach nourishment
    - Nearshore placement – equipment, burial, sedimentation, turbidity.
    - Profile placement – equipment, burial, sedimentation, turbidity.
    - Beach placement – sedimentation, turbidity.
    - Dune placement – sedimentation.
- Dredging
    - Maintenance dredging of embayments – equipment, sedimentation, turbidity.
    - Offshore borrow site dredging – equipment, sedimentation, turbidity.

Eelgrass habitat and associated functions have the potential to be affected, if present near areas of sediment management activities involving beach nourishment or dredging. Impact concerns during construction include damage or removal of eelgrass by equipment (dredges, anchors, chains, pipelines, vessel propellers), burial during nearshore or profile placement, and turbidity during dredging or sediment placement. Potential post-construction concerns include sand transport sedimentation or erosion of eelgrass habitat.

Eelgrass distribution and growth are largely controlled by light availability. A light level of approximately 10% of surface irradiance (roughly the Secchi disk depth) is considered a general indicator of the lower limit (compensation depth) of eelgrass (Dennison 1987). Light levels below 20% surface irradiance may reduce growth and survival (Backman and Barilotti 1976, Burke et al. 1996). However, eelgrass has different minimum light thresholds depending on the environmental conditions where it occurs, ranging from 3 to 12 hours of photosynthetic-saturating irradiance (H_{sat}) per day (Dennison and Alberte 1986, Zimmerman et al. 1990, Orth et al. 2006). Therefore, critical light thresholds may vary with location. A H_{sat} threshold of 5 hours per day has been established as a light monitoring guideline for entities conducting activities in San Francisco Bay (*http://swr.nmfs.noaa.gov/efh.htm*).

Eelgrass tolerance to light limitation also may vary depending on time of year and water depth. The accumulation and mobilization of carbon reserves appear to play a key role in the dynamics of eelgrass survival of variable environmental conditions (Burke et al. 1996, Cabello-Pasini et al. 2002). Eelgrass may draw upon reserves during times of light limitation. However, the amount of reserves may vary across the growing season, with generally lower reserves early in the season than later in the season. Plants located near the deeper range of depths where established beds occur in a water body generally would be expected to have less reserves than plants at shallower depths that experience less light limitation.

Turbidity associated with navigation-channel dredging resulted in loss of eelgrass in an adjacent boat basin with reduced circulation in a bay in Massachusetts (Sabol et al. 2005). Direct loss of eelgrass from dredging has occurred in California and elsewhere in the United States (Hoffman 1990, Nitsos 1990, Moore and Orth 1997). Partial burial of eelgrass leaves also can result in habitat loss. Available studies suggest that critical thresholds may differ depending on sediment characteristics (e.g., lower for silty sediments, higher for sands) and method of sedimentation (lower for deposition, higher for change in bottom elevation) (Onuf and Quammen 1983, Harrison 1990, Wilber et al. 2005).

Other Activities or Issues

Eelgrass distribution is highly influenced by duration of light exposure on a daily basis. Activities that increase turbidity or light attenuation (reduce light transmission through water) have the potential to modify eelgrass density, depth range, or occurrence, if persistent. This may be of particular concern in areas where tidal circulation is reduced or there is high ambient turbidity (e.g., from discharges, ship traffic, plankton blooms, etc.).

Recovery Considerations

Eelgrass meadows are slow to recover from physical impacts that results in disruption of sediment, removal of rhizomes, and removal of seed bank. Colonization by vegetative reproduction is very slow, and limited seed dispersal can affect natural recovery rates when there is substantial habitat loss (Orth et al. 1994, Orth et al. 2006). Eelgrass removed during dredging an anchorage area in Morro Bay, California did not recover after 3 years, and required transplant mitigation (Nitsos 1990). Eelgrass recovery after dredging in Mission Bay, California took 2 to 7 years depending on site conditions (Hoffman 1990). Eelgrass recovery ranged from 3 to 5 years for propeller damage to > 5 years for hydraulic dredging (Moore and Orth 1997).

Recovery appears to be faster if plant loss affects above ground leaves, but does not affect rhizomes or the seed bank. Experimental studies indicate eelgrass and other seagrasses may tolerate partial burial; however recovery from indirect sedimentation is not well understood. A coastal eelgrass population that lost all shoots due to storm-related turbidity reestablished from seedlings, which appeared within two months of loss of shoots; eelgrass achieved pre-disturbance densities within seven months (Cabello-Pasini et al. 2002). Recovery also occurred primarily from seedlings the following season after anoxia resulted in widespread loss of shoots in a Danish estuary; the relatively rapid recovery was attributed to stabilizing effect of remaining rhizomes, presence of large seed bank, and surviving shoots (4% survivorship) (Greve et al. 2005). Similarly, recovery occurred within 9 months following anoxia in a lagoon in France (Plus et al. 2003). Recovery was noted within one growing season of substantial red tides in southern California embayments (K. Merkel and N. Davis, 2006 personal communications). Substantial recovery of eelgrass indirectly impacted from dredge-related turbidity occurred within 17 months, although recovery was not complete within that time (Sabol et al. 2005).

Mitigation Considerations

No work zones and vessel restrictions may be used to avoid direct impacts. Buffer distances may be used to minimize effects of sedimentation or turbidity. BMPs and operational controls also may be used to minimize turbidity during construction. Environmental work windows do not apply (unless fully restricted); eelgrass habitat areas are protected year round.

Loss of eelgrass habitat would require restoration to avoid significant impact to EFH-HAPC. Mitigation requirements are specified in the Southern California eelgrass mitigation policy. Eelgrass has been mitigated or restored using transplants comprised of shoots/rhizome sprigs harvested from existing beds (donor site) (Fonseca 1989; Merkel 1990, Short et al. 2002), broadcast seeding (Pickerell et al. 2005, Orth et al. 2006), and with "seed buoys" (Hughes 2005, Pickerell et al. 2006).

Cross-Reference Table to Relevant Sections of the Volume 1 BIA Document

Topic	Volume 1	
	Section	**Subsection**
Resource Description and Sediment Management Issues		
Eelgrass	3	3.3.8
Dungeness Crab	4	4.2.3
Pacific Herring	4	4.3.2
Salmonids	4	4.3.3
Least Tern	4	4.4.2
Waterfowl and Seabirds (Brant)	4	4.4.7
Impacts		
Equipment – Eelgrass	5	5.3.3.4
Sedimentation Impacts – Eelgrass	5	5.4.3.4
Turbidity Impacts - Eelgrass	5	5.5.4.2
Mitigation Measures		
Avoid direct impacts to sensitive habitats	6	6.3.2.1, 6.4.1.1, 6.4.1.2
Buffers - Habitat	6	6.3.5
Schedule or seasonal restrictions – Eelgrass	6	6.4.2.1
Dredging operational controls – Turbidity	6	6.4.3.3
Dredging construction methods and BMPs – Silt curtains	6	64.4.1
Monitor water quality and modify activities if necessary	6	6.4.5.2
Compensatory mitigation – if sensitive habitat loss	6	6.5.2
Monitoring Considerations		
Physical/Chemical		
Turbidity	7	7.4.3
Biological		
Sensitive aquatic resource survey	7	7.3.2.1
Sensitive habitat boundaries	7	7.3.2.2
Impact verification	7	7.5.1

Guideline Considerations:

List of Relevant Resource Protection Guidelines

The following guidelines may be relevant to protection of Eelgrass habitat and supported resources:

Resource Protection Guideline	User's Guide	
	This Section	Other Sections
Physical-Chemical		
Beach Water Quality		3.3.1
Nearshore Water Quality		3.3.2
Embayment Water Quality		3.3.3
Biological		
Eelgrass	X	
Dungeness Crab		3.3.3
Pacific Herring		3.3.3
Salmonids		3.3.3
Least Tern		3.3.1
Migratory Birds		3.3.3

Other Potential Relevant Guidelines

Guidelines for the protection of eelgrass also would generally apply to associated wildlife.

Eelgrass HAPC Guideline
Zostera spp.

Eelgrass and black surfperch
Photo credit: Rick Ware, CRM

Status: EFH-HAPC

Definition: Eelgrass is a type of seagrass, and obtains nutrients from both the sediment and water column. Eelgrass forms submerged beds, also termed meadows. This habitat is found in bays, estuaries, coastal lagoons, and along some protected coastlines of the mainland and Channel Islands. It may occur from low intertidal to depths of 100 ft (30 m).

Functions: Eelgrass has long leaves that provide primary habitat for a variety of invertebrates and fish, nursery habitat for resident and migratory species, forage and foraging habitat for birds, including the endangered least tern (USACE et al. 2001).

Sediment Management Issues: The potential to impact eelgrass during sediment management activities would vary depending on several project-specific factors as well as environmental conditions at the time of project implementation. Key factors include proximity to eelgrass habitat; condition of eelgrass; and potential for damage, turbidity, or sedimentation.

Eelgrass has the potential to be directly damaged by dredges, anchors, support vessels, or equipment (pipelines) during dredging or sediment discharges, if present. Eelgrass is sensitive to light limitation. Although it may tolerate light reduction for days to weeks by drawing upon carbon reserves, the availability of reserves varies seasonally and may vary among plants in the same water body depending on light conditions (e.g., water depth, shading, other discharges). Eelgrass may tolerate a certain amount of sedimentation (partial burial of leaves). However, substantial sedimentation has the potential to result in a reduction in blade density or loss of plants.

Eelgrass recovery from disturbance may be within a growing season if impacts are minor; however, recovery may be several years if damage results in loss of rhizome mat. Habitat loss would require compensatory mitigation.

Relevant Impact Activity and Issue Summary Table

Relevant Sediment Management Activities	Impacts of Concern
• Beach nourishment, Dredging	• Equipment damage, sedimentation, turbidity
Other Activities or Issues of Concern	**Resources of Concern**
• Ambient turbidity (e.g., other discharges, plankton blooms, storm activity)	• Endangered salmonids, managed fishery species (e.g., Dungeness crab, Pacific herring) • Brandt goose, least tern

Guideline Objectives:

- Avoid damage or loss of eelgrass habitat.
- Avoid degradation of ecological functions or supported resources of eelgrass habitat.
- Minimize turbidity or sedimentation impacts to eelgrass habitat or supported resources.

Resource Protection Considerations

- Identify and delineate eelgrass HAPC if within area of potential project influence.
- Locate project site downcurrent (prevailing current direction) of eelgrass meadow to minimize the potential for turbidity and sedimentation effects.
- Use buffer distance (≥ 1,000 ft, 305 m) to minimize turbidity or sedimentation impacts or determine alternate buffer distance based on project-specific grain size characteristics and site-specific hydrodynamics.
- Prepare anchor, dredge, discharge, and pipeline plans to avoid eelgrass habitat.
- Minimize turbidity with constructed, operational, or engineered BMPs or controls (e.g., sand dikes, silt curtains, adjustments to operations), as appropriate.*
- Monitor and map turbidity plumes during construction, and determine extent of incursions into eelgrass habitat, as applicable.*
- If project duration will span > 1 week and turbidity plume incursions into eelgrass HAPC are documented over at least three consecutive days during the first week of monitoring, additional water quality monitoring may be warranted.*
- Modify discharge if water quality measurements exceed water quality criteria.*
- Long-Term Monitoring. If eelgrass HAPC is within area of potential project influence, pre- and post-construction monitoring by a qualified biologist may be a permit requirement to ensure no significant impacts. This would be determined by resource and regulatory agencies during the permitting phase on a case-by-case basis.
- If substantial habitat degradation or loss is documented, coordinate with resource agencies and conduct remedial or compensatory mitigation consistent with the California Eelgrass Mitigation Policy.

*Refer to Beach or Nearshore Water Quality Guidelines, as appropriate.

Effectiveness Considerations: Locating receiver sites downcurrent (prevailing current direction) of eelgrass may help to minimize potential turbidity or sedimentation impacts. Use of distance buffers between sediment management activities and eelgrass habitat may be effective when project-and site-specific environmental conditions are adequately assessed. A distance buffer of > 1,000 ft (> 305 m) may be protective for projects involving dredging or nearshore placement based on review of monitoring data and relevant reports (Sections 2.7.4.2, 2.7.4.3). A buffer distance of >820 ft (250 m) is included in the turbidity BMP decision flowchart for San Francisco Bay suggested by NMFS (reviewed below). Smaller distance buffers also may be protective depending on project and site-specific considerations (e.g., project size, proximity to the sensitive habitat, water depth, sediment characteristics, and environmental conditions). For example, buffer distances of 75 ft (23 m) were deemed protective when dredging sands adjacent to eelgrass beds in certain areas within the USACE Los Angeles District (Smith, personal communication).

Determining a suitable buffer distance from a beach sand placement project is more complex because of higher current speeds and the need to consider both turbidity/sedimentation during construction and post-construction sand transport effects. Modeling may be necessary to support project design considerations when beach sand placement project volumes or proximity pose a risk to eelgrass HAPCs.

Preparation of dredge, discharge, anchor, and pipeline plans would be effective for avoidance of direct impacts to sensitive habitat. Use of operational controls or engineered BMPs to reduce

turbidity may be effective for minimizing the potential for adverse impacts. For example, use of a temporary sand dike may be effective for minimizing indirect turbidity impacts from beach nourishment to eelgrass habitat, if present nearby. The effectiveness of silt curtains in embayments depends on local hydrodynamics (see embayment water quality guideline).

A turbidity flowchart has been developed by the NMFS (*http://swr.nmfs.noaa.gov/efh.htm)* to assist decisions of when BMPs should be implemented in proximity to eelgrass in San Francisco Bay. Key elements of the decision process include: buffer distance, sediment type, site orientation to prevailing currents, possible use of silt curtains, or light monitoring, as follows:

- Distance between project activities and eelgrass meadows (>820 ft, 250 m – no BMP necessary);
- Sediment type (>80% sand, <20% silt/clay – no BMP necessary);
- Site orientation to prevailing currents/existing barriers (sediments not dispersive towards eelgrass – no BMP necessary);
- Possible to use silt curtains (yes – BMP satisfied; no – conduct light monitoring);
- Light monitoring (H_{sat} of $\geq$ 5 hours met for duration of dredging activities – BMP satisfied).

Similar elements are included in the resource protection considerations. However, more general guidance is presented herein because critical thresholds related to buffer distances, grain size characteristics, or use of silt curtains may differ based on local site-specific considerations (e.g., hydrodynamics). Light monitoring may be effective when light requirements of eelgrass in the local project area are understood. If specific light requirements are not known, a general rule of thumb is that eelgrass will be limited when light levels are reduced to < 20% surface irradiance (Backman and Barilotti 1976, Burke et al. 1996). Eelgrass apparently has different minimum light thresholds depending on the environmental conditions where it occurs, ranging from 3 to 12 hours of photosynthetic-saturating irradiance per day (Dennison and Alberte 1985, Zimmerman 1990, Orth et al. 2006). Therefore, critical thresholds may vary with location. Light monitoring considerations are further described under the monitoring heading below.

Monitoring of surface turbidity plumes during construction could be useful for identifying the potential to impact eelgrass habitat and resources. In addition to the above-described light limitation concerns for eelgrass, this habitat is an important nursery area for other marine and estuarine species, including endangered salmonids and fishery species such as Pacific herring and Dungeness crab. Turbidity and sedimentation have the potential to degrade this important habitat function. The Beach, Nearshore, and Embayment Water Quality Guidelines suggest additional monitoring of light transmission and/or TSS may be relevant if plumes persist in areas with vegetated HAPC habitat.

Long-term monitoring may be required to verify project impacts, if any. If impacts were to result in loss or substantial degradation of eelgrass habitat, remedial or compensatory mitigation may be required to avoid long-term significant impacts. This would need to be determined in coordination with the resource and regulatory permitting agencies for the project. Mitigation is guided by the Southern California Eelgrass Mitigation Policy. Eelgrass restoration is feasible and successful mitigation has been demonstrated.

Seasonal Considerations: In northern California, eelgrass displays seasonal regularity with new and active growth of long leaves in spring-summer, seed production and dispersal in

summer, and production of shorter winter leaves in November (Phillips 1984). In southern California, eelgrass may grow year round, although beds exhibit some die back (bed thinning) in winter with reduced leaf density, slowed growth, or constriction of depth range (Ware 1993, MEC 2000b). The potential for turbidity impacts may be greater after storms (if the impact contributed to prolonged turbidity) or during the normal high growth period (by reducing ability to accumulate carbon reserves).

Mitigation Considerations: Impact losses of eelgrass habitat require replacement mitigation, which is guided by the Southern California Eelgrass Mitigation Policy. Success rates of eelgrass mitigation projects have increased over time as techniques have improved, and restoration of eelgrass functions and values has been demonstrated.

Monitoring Considerations: Monitoring may be required for projects with the potential to impact eelgrass meadows. Prior to construction, pipeline and vessel anchor plans should be verified to ensure avoidance of eelgrass habitat. During construction, the primary objective would be to verify permit conditions (e.g., avoidance of eelgrass habitat, turbidity plume monitoring). Monitoring the surface turbidity plume during construction would provide documentation of plume incursions provided that habitat boundaries are known.

If long-term monitoring is required to verify impacts, systematic and repeatable survey methods will be required. The Southern California Eelgrass Mitigation Policy (revision 11) describes methods for surveying eelgrass meadows likely to be impacted by project construction activities. Recently, recommendations were documented for an integrated southern California eelgrass monitoring program (Bernstein 2011). Inclusion of control sites is recommended to ensure project activities are not held responsible for lowered light conditions caused by natural variation.

Volume 1 References: SAIC (2011) – Section 3 (3.3.8), Section 4 (4.2.3, 4.2.7, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.4.2, 4.4.8), Section 5 (5.2.3.4, 5.3.3.4, 5.4.3.3, 5.4.3.4, 5.5.4.2), Section 6 (6.3.2, 6.3.5, 6.3.8, 6.4.1.1, 6.4.1.2, 6.4.2.1, 6.4.5.2, 6.5, 6.6.2), and Section 7 (7.4.3, 7.5.1).

Other References

Bernstein et al. 2011.

Draft San Francisco Bay Light Monitoring Survey Protocol (revised January 2010). NMFS, Santa Rosa Office.

Southern California Eelgrass Mitigation Policy (revision 11). *http://swr.nmfs.noaa.gov /hcd/HCD_webContent/aboutus/policies.htm*

4.0 Preparers and Participants

Seven outreach workshops were held throughout the state to review the objectives of this user's guide and to obtain input relevant to guideline development. Several stakeholders participated in the workshops including staff of federal, state, and municipal agencies, as well as several academic or consulting biologists with stakeholder interest. The preparer of this document and participants of the workshop process are identified below. In addition, acknowledgements are given for use of the photographs in this document.

Prepared by:

Science Applications International Corporation

Karen Green, M.S., Program Manager, Author, Workshop Moderator

Prepared for:

California Coastal Sediment Management Workgroup

Clif Davenport, Project Manager

Monterey Bay National Marine Sanctuary

Brad Damitz, Project Manager

Under Contract to:

Beach Erosion Authority for Clean Oceans and Nourishment (BEACON)
Gerald Comati, Project Manager

In Coordination With:

U.S. Army Corps of Engineers, Los Angeles District
Susan Ming, CSMW Project Manager
Heather Schlosser, CSMW Project Manager
Nate West, Workshop and Meeting Note Assistance

Agency Workshop Participants

California Coastal Commission
Jonna Engle

California Coastal Conservancy
Karen Bane

California Department of Fish and Game
Loni Adams
Vicky Frey
Nancy Frost
George Isaac
John Mello
Bill Paznokus
Mark Wheetley

California Geological Survey
Clif Davenport

California Marine Affairs and Navigation Conference
Jim Haussener

City of Encinitas
Kathy Weldon

Crescent City Harbor District
Richard Young

Elkhorn Slough
Quinn Labadie

Humboldt Bay Resource Conservation District
Adam Wagschal

Monterey Bay National Marine Sanctuary
Brad Damitz

Monterey Bay Research Institute
Heather Kerkering

National Marine Fisheries Service
Eric Chavez
Bryant Chesney
Bob Hoffman
Korie Schaeffer

Regional Water Quality Control Board, Region 3
Peter von Langen
Dominic Roques

Regional Water Quality Control Board, Region 9
Chiara Clemente
Mike Porter

San Francisco Bay Conservation and Development Commission
Carolyn Box
Jessica Hamburger

Santa Barbara County Flood Control District
Maureen Spencer

Santa Monica Bay Restoration
Lia Protopapadakis

State Parks
Syd Brown
David Pryor
David Smith

State Water Resources Control Board
Eric Bernsten
Karen Larsen
Toni Marshall
George Nichol
Bill Orme

U.S. Army Corps of Engineers, Los Angeles District
Jack Hogan
Susan Ming
Heather Schlosser
Robert Smith
Nate West

U.S. Army Corps of Engineers, San Francisco District

Debra O'Leary

U.S. Environmental Protection Agency, Region IX
Jorine Campospiano
Alan Ota
Brian Ross

U.S. Fish and Wildlife Service
James Bond
Sandy Vissman

Other Stakeholder Participants

Pepperdine University
Karen Martin, Ph.D.

University of California, Santa Cruz
Jaren Figurski

University of California Sea Grant
Susan Schlosser

Chambers Group
Noel Davis, Ph.D.

HT Harvey
Peter Nelson

Merkel & Associates
Lawrence Honma

Moffatt & Nichol
Brian Leslie
Betsy Watson
Chris Webb

Nautilus Environmental
Nick Buhbe

Phil Williams & Associates
David Revell, Ph.D.

Science Applications International Corporation
Karen Green

Streamline Planning Consultants
Sarah Caldwell
Trevor Parker

Trinity Association
Aldaron Laird

Other Stakeholders
Peter Oringer

Reviewers

Guidelines benefited from reviews by the following individuals:

William Brostoff, Ph.D., USACE, San Francisco District

Eric Chavez, NMFS, Habitat Conservation District

Bryant Chesney, NMFS, Habitat Conservation District

Peter LaCivita, USACE, San Francisco District

Andrew Lissner, Ph.D., SAIC

Karen Martin, Ph.D., Pepperdine University

Charles Phillips, SAIC

Dennis Simmons, City of San Diego

Larry Smith, USACE, Los Angeles District

Robert Smith, USACE, Los Angeles District

David Woodbury, NMFS, Protected Resources Division

Photograph Acknowledgements

The following individuals and organizations are acknowledged and thanked for use of their photographs.*

Shane Anderson, Biologist
Ralph Appy, Ph.D., formerly of Port of Los Angeles
Peter Bryant, Ph.D., University of California, Irvine
Callie Bowdish, Photographer
John Evans, SAIC
Dan Gotschall, Marine Biologist, Author, formerly of CDFG
Karen Green, SAIC
Danny Heilprin, formerly of SAIC
Kathy Keane, Keane Biological Consultants
Andrew Lissner, Ph.D., SAIC
Matt Manuel
Doug Martin
Karen Martin, Ph.D., Pepperdine University
Justin Meager, Ph.D., University of the Sunshine Coast, Australia
Keith Merkel, Merkel & Associates
Stephen Montgomery, SJM Biological Consultants
Rob Rundle, San Diego Association of Governments
San Diego Nearshore Program
Warren Savary, California Academy of Sciences
Abigail Smigel, Southern California Edison
Luis Solórzano, CalBiota
Nick Steers, Los Angeles Lifeguard Captain (public domain noaa.gov)
Karen Straus, Photographer
Rick Ware, Coastal Resources Management, Inc.
Johnathan Warrick, Ph.D., USGS
Chris Webb, Moffatt & Nichol Engineers
Kathy Weldon, City of Encinitas
Holly Williams, Grunion Greeter volunteer
Rachael Woodfield, Merkel & Associates

**Several of the photographs have permissions for use that are limited to this document.*

5.0 Literature Cited

Airoldi, L., 2003. The effects of sedimentation on rocky coast assemblages. *Oceanography and Marine Biology: An Annual Review,* 41:161-236.

Aleem, A.A. 1973. Ecology of a kelp-bed in southern California. *Botanica Marina.* Vol. XVI, p. 38-95.

Allen, L.G., D.J. Pondella, and M.H. Horn, 2006. *Ecology of Marine Fishes: California and Adjacent Waters*. University of California Press, Los Angeles. 660 p.

Ambrose, R. F., 1986. Artificial Reefs, Volume 1: A Review and Analysis. Prepared for Marine Review Committee, Inc.

Ambrose, R.F., D.C. Reed, J.M. Engle, and M.F. Caswell, 1989. California Comprehensive Offshore Resource Study. Submitted to: California State Lands Commission, Sacramento, California.

AMEC Earth & Environmental, Inc. (AMEC), 2002. Regional Beach Sand Project Preconstruction and Construction Monitoring Report. Prepared for San Diego Association of Governments.

AMEC, 2005. Regional Beach Sand Project, Year 4 (2004-2005) Post-construction Monitoring Report for Intertidal, Shallow Subtidal, and Kelp Forest Resources and Comprehensive Analysis Report (2001-2005). Prepared for San Diego Association of Governments. *http://www.sandag.org/uploads/publicationid/publicationid_1171_4641.pdf.*

Anchor Environmental CA, L.P. (Anchor Environmental), 2003. Literature Review of Effects of Resuspended Sediments Due to Dredging Operations. Prepared for Los Angeles Contaminated Sediments Task Force.

Archambault M.C., V.M. Bricelj, J. Grant, and D.M. Anderson, 2004. Effects of suspended and sedimented clays on juvenile hard clams, *Mercenaria mercenaria*, within the context of harmful algal bloom mitigation. *Marine Biology,* 144:553–565.

ASR Ltd., 2004. Oil Piers Reef – Phase II - Detailed Design of an Offshore Submerged Reef for Erosion Control at Oil Piers, Ventura County, California. Prepared for U.S Army Corp of Engineers (Vicksburg District) under Section 227 of the ERDC/WES Broad Agency Announcement (BAA): National Shoreline Erosion Control Development and Demonstration Program – Ventura County Demonstration Site.

Atwood, J.L. and D.E. Minsky, 1983. Least tern foraging ecology at three major California breeding *colonies*. *Western Birds*,14: 57-72.

Backman, T.W. and D.C. Barilotti, 1976. Irradiance reduction: effects on standing crops of the eelgrass *Zostera marina* in a coastal lagoon. *Marine Biology,* 34:33-40.

Baird, P. H., 1993. Birds, Pages 541-603 In: *Ecology of the Southern California Bight: A Synthesis and Interpretation.* M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.). University of California Press, Berkeley, California.

Barnard, W.D., 1978. Prediction and Control of Dredged Material Dispersion Around Dredging and Open-Water Pipeline Disposal Operations. Technical Report DS-78-13, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Barnard, P.L., L. H. Erikson, J.E. Hansen, and E. Elia, 2009. The Performance of Nearshore Dredge Disposal at Ocean Beach, San Francisco, California, 2005-2007. U.S. Geological Survey Open-File Report 2008-1347, 93 p. *http://pubs.usgs.gov/of/2008/1347/.*

Barnhart, R.A., 1988. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) - Pacific Herring. *U.S. Fish and Wildlife Service Biological Report,* 82(11.79). U.S. Army Corps of Engineers, TR EL-82-4.

Barry A. Vittor and Associates, Inc. Staff, 1999. Pre- and Post-dredging Monitoring, Macroinvertebrate Assemblages at a Borrow Area Located Offshore of Coney Island, New York: 1992–1998 Data Synthesis. New York, New York: U.S. Corps of Engineers, New York District.

Battelle, 2009. Final Summary Report: Plume Monitoring Boston Harbor Inner Harbor Maintenance Dredging Project. Prepared for U.S. Army Corps of Engineers, North Atlantic Division, New England District. Contract Number: DACW33-03-D-0004, Delivery Order 44. Prepared by Paul Dragos and Matt Fitzpatrick.

BCDC see San Francisco Bay Conservation and Development Commission

Beach Ecology Coalition, 2011. Protecting California Grunion on Sandy Beaches.

Beeler, H.E., 2009. Community Succession in Macroalgae Wrack: Implications for the Prey Resources of Breeding Western Snowy Plover (Charadrius alexandrinus nivosus) on Northern California Beaches. Thesis, Master's of Arts in Biology. Humboldt State University.

Bence, J.R., S.C. Schroeter, and R.O. Smith, 1989. Technical Report to the California Coastal Commission. F. Kelp Forest Invertebrates. Marine Review Committee.

Bennett, K.A. and E.F. Zuelke, 1999. The Effects of Recreation on Birds: A Literature Review. Delaware Natural Heritage Program, Division of Fish & Wildlife, Department of Natural Resources and Environmental Control.

Bernstein, B., K. Merkel, B. Chesney, and M. Sutula, 2011. Recommendations for a Southern California Regional Eelgrass Monitoring Program. Prepared for the National Marine Fisheries Service. Southern California Coastal Water Research Project, Technical Report 632.

Berry, W., N. Rubinstein, B. Melzian, and B. Hill, 2003. The Biological Effects of Suspended and Bedded Sediment (SABS) in Aquatic Systems: A Review. Internal Report. United States Environmental Protection Agency.

Bjork, M., F. Short, E. McLeod, and S. Beer, 2008. Managing Seagrasses for Resilience to Climate Change. IUCN, Gland, Switzerland. 56pp.

Blackmon, D., T. Wyllie-Echeverria, and D.J. Shafer, 2006. The role of seagrasses and kelps in marine fish support. *WRAP Technical Notes Collection,* ERDC TN-WRAP-06-1. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. *http://el.erdc.usace.army.mil/wrap*.

Blois, J.-C., J.-M. Francaz, M. Gaudichon, S. Gaudichon, and L. Le Bris, 1961. Observations sur les berbiers a *Zosteres* de la region de Roscoff. *Cahiers de Biologie Marine*, 2:223-262.

Bodkin, J.L. and G.B. Rathbun, 1988. Morro Bay Dredging Project, 1987. Morro Bay Sea Otter Study for U.S. Army Corps of Engineers.

Bohlen, W.F. and J.M. Tramontano, 1977. An Investigation of the Impact of Dredging Operations on Suspended Material Transport in the Lower Thames River Estuary. University of Connecticut, Groton, Connecticut.

Bowles, A.E. and B.S. Stewart. 1980. Disturbances to the Pinnipeds and Birds of San Miguel Island, 1979-1980. Technical Report submitted by Hubbs-Sea World Research Institute and San Diego State University to U.S. Air Force. 246 pgs.

Boyd, S.E., K.M. Cooper, D.S. Limpenny, R. Kilbride, H.L. Rees, M.P. Dearnaley, J. Stevenson, W.J. Meadows, and C.D. Morris, 2004. Assessment of the Re-habilitation of the Seabed Following Marine Aggregate Dredging. Science Series Technical Report, CEFAS Lowestoft, 121:154 pp.

Boyd, S.E., D.S. Limpenny, H.L. Rees, and K.M. Cooper, 2005. The effects of marine sand and gravel extraction on the macrobenthos at a commercial dredging site (results 6 years post-dredging). *ICES Journal of Marine Science*, 62:145-162.

Bridges, T.S., S. Ells, D. Hayes, D. Mount, S. Nadeau, M. Palermo, C. Patmont, and P. Schroeder, 2008. The Four R's of Environmental Dredging: Resuspension, Release, Residual, and Risk. Technical Report ERDC/EL TR-08-4. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Broenkow, W.W., 1996. Physical Oceanography. In: *Monterey Bay National Marine Sanctuaries Site Characterization*. *http://montereybay.noaa.gov/* sitechar/phys2.html.

Brooks, A. and E. Agate, 2001. *Sand Dunes: A Practical Handbook*. Published by BTCV Ltd., United Kingdom. ISBN 0 946752 32 X. *http://shop.btcv.org.uk/shop /level2/59/level*.

Brown, A.C. and A. McLachlan, 2002. Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. *Environmental Conservation,* 29(1):62-77.

Brownlee, D.C., K.G. Sellner, and K.R. Braun, 1988. Understanding the Estuary: Advances in Chesapeake Bay Research. Pages 79–90 *in* Chesapeake Research Consortium, Publication 129 (CBP/TRS 24/88), Johns Hopkins Press, Baltimore, Maryland.

Bruce, C., K. Miller, G. Page, L. Stenzel, and W. White, 1994. Western Snowy Plover. Pages 180-182 In *Life on the Edge: A Guide to California's Endangered Natural Resources*. C.G. Thelander (ed.). Biosystems Books:

Buell, J.W. 1992. Fish Entrainment Monitoring of the Western-Pacific Dredge *RW Lofgren* During Operations Outside the Preferred Work Period. Buell & Associates, Inc. Prepared for the Western-Pacific Dredging Company. 52 pp.

Burke, M.K., W.C. Dennison, and K.A. Moore, 1996. Non-structural carbohydrate reserves of eelgrass *Zostera marina*. *Marine Ecology Progress Series,* 137:195-201.

Burkett, E. E., R.J. Logsdon, and K. M. Fien, 2007. Report to the California Fish and Game Commission: Status Review of California Brown Pelican (*Pelicanus occidentalis californicus*) in California. Calif. Dept. of Fish and Game, Wildlife Branch, Nongame Wildlife Program Report 2007-04. 26pp.+ appendices.

Burlas, M., G. Ray, and D. Clarke, 2001. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Final Report. U.S. Army Engineer District, New York and U.S. Army Engineer Research and Development Center, Waterways Experiment Station. *http://www.nan.usace.army.mil/business/prjlinks/coastal/ asbury/index.htm*.

Bushing, B. 2000. Giant bladder kelp (Macrocystis pyrifera). *http://www.starthrower.org/ research/ kelpmisc/kelp_mp.htm*.

Byrnes, M.R., R.M. Hammer, T.D. Thibaut, and D.B. Snyder, 2004. Effects of sand mining on physical processes and biological communities offshore New Jersey, U.S.A. *Journal of Coastal Research,* 20(1):25-43.

Cabello-Pasini, A., C. Lara-Turrent, and R.C. Zimmerman, 2002. Effect of storms on photosynthesis, carbohydrate content and survival of eelgrass populations from a coastal lagoon and the adjacent open ocean. *Aquatic Botany,* 74:149-164.

Cacchione, D.A. and D.E. Drake, 1990. Shelf Sediment Transport. Pages 729-774 In: *The Sea. Volume 9, Ocean Engineering Science.* B. LeMehaute and D. M. Hanes (eds.). John Wiley, New York, New York.

California Coastal Commission (CCC), 1987. *California Coastal Resource Guide.* University of California Press, Berkeley, California.

_____ 1995. Procedural Guidance for Evaluating Wetland Mitigation Projects in California's Coastal Zone. *http://www.coastal.ca.gov/weteval/wetitle.html.*

_____ 2006a. Santa Barbara Harbor and Waterfront Area Sediment Management Program. Application 4-05-155. Staff Report of March 29, 2011.

_____ 2006b. Permit Amendment, City of Santa Cruz, Parks & Recreation Department, Beach Management Permit, 3-95-043-A2.

_____ 2008. A Summary of the Coastal Commission's Involvement in Climate Change and Global Warming Issues for a Briefing to the Coastal Commission.

California Department of Fish and Game (CDFG), 2001. *California's Living Marine Resources: A Status Report*. The Resources Agency, California Department of Fish and Game. W.S. Leet, C.M. Dewees, R. Klingbiel, and E.J. Larson (eds.). University of California, Berkeley, California. *http://www.dfg.ca.gov/marine/status/ status2001.asp.*

_____ 2003. Nearshore Fishery Management Plan (NFMP), Section 2 Environmental Documents. *http://www.dfg.ca.gov/mrd/nfmp/section2_chap3.html.*

_____ 2008. California Aquatic Invasive Species Management Plan. Funded in part by the Ocean Protection Council, State Coastal Conservancy, and U.S. Fish and Wildlife Service. January 2008.

_____ 2009. 09-10 Ocean Sport Fishing Regulations. State of California Department of Fish and Game.

California Environmental Resources Evaluation System (CERES), 2006. California's Coastal Plan Communities. *http://ceres.ca.gov/ceres/calweb/coastal/ plants.html.* Accessed September 2005 and February 2006.

CalFlora, 2005. Information on California Plants for Education, Research and Conservation. [web application]. 2005. Berkeley, California: The Calflora Database [a non-profit organization]. *http://www.calflora.org/.* Accessed September 2005 and February 2006.

California Native Plant Society (CNPS), 1996. Policy on Invasive Exotic Plants. *http://www.cnps.org/cnps/archive/exotics.php.* Accessed August 2005.

California Natural Resources Agency (CNRA), 2009. 2009 California Climate Adaptation Strategy. A Report to the Governor of the State of California in Response to Executive Order S-13-2008.

California Ocean Protection Council (OPC), 2011. Resolution of the California Ocean Protection Council on Sea-Level Rise. Adopted on March 11, 2011.

California Regional Water Quality Control Board, Central Coast (CCRWQCB) and State Water Resources Control Board (SWRCB), 1994. Water Quality Control Plan for the Central Coast Basin.

California Regional Water Quality Control Board, Los Angeles Region (LARWQCB), 1994. Water Quality Control Plan, Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties.

California Regional Water Quality Control Board, North Coast Region (NCRWQCB), 2005. Water Quality Control Plan for the North Coast Basin.

California Regional Water Quality Control Board, Santa Ana Region (SARWQCB), 1995. Water Quality Control Plan, Santa Ana River Basin (8).

California Regional Water Quality Control Board, San Diego Region (SDRWQCB), 1994. Water Quality Control Plan for the San Diego Basin (9).

California Regional Water Quality Control Board, San Francisco Bay (SFRWQCB), 2004. Water Quality Control Plan (Basin Plan) for the San Francisco Bay.

California Resources Agency and California Environmental Protection Agency, 2004. Protecting Our Ocean: California's Action Strategy.

California Sediment Management Workgroup (CSMW), 2010. California Beach Erosion Assessment Survey. Prepared October 2010.

Cardwell, R.D., D.G. Foreman, T.T. Payne, and D.J. Wilbur, 1976. Acute Toxicity of Selected Toxicants to Six Species of Fish. EPA 600/3-76-008, U.S. Envioronmenal Protection Agency, Duluth, Minnesota. 117 pp.

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker and M. Lowry, 2004. U.S. Pacific Marine Mammal Stock Assessments: 2003. NOAA Technical memorandum NOAA-TM-NMFS-SWFSC-358.

CCC see California Coastal Commission

CDFG see California Department of Fish and Game

CERES see California Environmental Resources Evaluation System

CEQ see Council of Environmental Quality

Chambers Group, Inc. 1992. Final Environmental Impact Report/Environmental Assessment for the BEACON Beach Nourishment Demonstration Project. Prepared for Beach Erosion Authority for Control Operations and Nourishment.

Chambers Group, Inc. 2004. Biological Monitoring of the BEACON Goleta Beach Nourishment Demonstration Project – 1 Year Report. Prepared for Moffatt & Nichol.

Channel Islands National Marine Sanctuary (CINMS), 2000. Draft Affected Environment Chapter. Draft Environmental Impact Statement for Channel Islands National Marine Sanctuary. April 29, 2000.

_____.Conservation Working Group. *Ocean Acidification and the Channel Islands National Marine Sanctuary: Cause, effect and response*. Adopted by the CINMS Advisory Council September 19, 2008. Prepared by S. Polefka and J. Forgie, Environmental Defense Center, Santa Barbara, California.

Chelton, D.B., Bernal, P.A. and J.A. McGowan, 1982. Large-scale interannual physical and biological interactions in the California Current. *Journal of Marine Research,* 40:1095-1125.

CINMS see Channel Islands National Marine Sanctuary

City of Encinitas, 2009. Pacific Station Turbidity Monitoring Maps, unpublished.

_____.2011. Encinitas Climate Action Plan. Prepared by CTG Energetics, Inc.

City of San Diego, 2007. California Environmental Quality Act Significance Determination Thresholds. City of San Diego Development Services Department. January 2007.

City of Solana Beach, 2009. Local Coastal Program Land Use Plan. September 2009.

Clark, D.B., F. Feddersen, M.M. Omand, and R.T. Guza, 2009. Measuring fluorescent dye in the bubbly and sediment-laden surfzone. *Water Air Soil Pollution* 204:103115. DOI 10.1007/s11270-009-0030-z.

Clarke, D.G., and D.H. Wilber, 2000. Assessment of Potential Impacts of Dredging Operations Due to Sediment Resuspension. *DOER Technical Notes Collection*, ERDC TN-DOER E9, May 2000. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. *http://el.erdc.usace.army.mil/elpubs/ pdf/doere9.pdf.*

Clarke, D. and J. Hoover, 2009. Potential Dredging Impacts on Green Sturgeon. Presented at the 2009 Green Sturgeon, Longfin Smelt, and Dredging Operations in the San Francisco Estuary Workshop Symposium.

Clarke, D.G., C. Dickerson, and K. Reine, 2003. Characterization of Underwater Sounds Produced by Dredges. (Proceedings Of The Third Specialty Conference On Dredging And Dredged Material Disposal, May 5-8, 2002, Orlando, Florida; Sponsored by Coasts, Oceans, Ports, and Rivers Institute (COPRI) of ASCE).

CNPS see California Native Plant Society

CNRA see California Natural Resources Agency

Coastal Planning & Engineering, Inc., 2004a. Anna Maria Island Beach Nourishment Project, Manatee County, Florida. Second Annual Post-Construction Biological Monitoring Report. Submitted to Florida Department of Environmental Protection.

Coastal Planning & Engineering, Inc., 2004b. City of Boca Raton, South Boca Raton Beach Nourishment Project, Two Years Post-Construction, Artificial Reef and Natural Hardbottom Biological Monitoring Results. Prepared for City of Boca Raton, Florida.

Coastal Planning & Engineering, Inc., 2004c. City of Boca Raton, Central Boca Raton Beach Nourishment Project, Pre-, Mid and Post-Construction Biological Monitoring. Prepared for City of Boca Raton, Florida.

Cohen, Andrew N. 2005 Guide to the Exotic Species of San Francisco Bay. San Francisco Estuary Institute, Oakland, CA, *www.exoticsguide.org*.

Collazo, J.; G. Hammerson, M. Koenen, and D. Mehlman, 1995. Species Management Abstract Brown Pelican *(Pelecanus occidentalis). The Nature Conservancy.* Accessed March 2007. *http://www.conserveonline.org/docs/2001/03/brpe.doc.*

Colby, D. and D. Hoss, 2004. Larval Fish Feeding Responses to Variable Suspended Sediment and Planktonic Prey Concentrations. *DOER Technical Notes Collection,* ERDC TN-DOER-E16, September 2004. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. *http://el.erdc.usace.army.mil/elpubs/pdf/ doere16.pdf.*

Collins, C.T., K.E. Bender, and D.D. Rypka, 1979. Report on the Feeding and Nesting Habits of the California Least Tern in the Santa Ana River Marsh Area, Orange County, California. Prepared for the U.S. Army Corps of Engineers, Los Angeles District.

Collins, M.S., 1995. Dredging-Induced Near-Field Resuspended Sediment Concentrations and Source Strengths. Miscellaneous Paper D-95-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Council of Environmental Quality (CEQ), 1997. Considering Cumulative Effects under the National Environmental Policy Act. January 1997. *http://ceq.hss.doe.gov/nepa/ccenepa/ exec.pdf.*

_____ 2011. Final Guidance for Federal Departments and Agencies on the Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact. *Federal Register* 76(14):3843-3853, January 21, 2011. *http://ceq.hss.doe.gov/current_developments/docs/FRN_Published_Mitigation_ Monitoring21Jan2011_76FR3843.pdf.*

County of Santa Barbara, 2006. Environmental Thresholds and Guidelines Manual. Planning and Development Department.

Courtenay, W.R. Jr., D.J. Herrema, M.J. Thompson, W.P. Azzinaro, and J. Van Montfrans, 1972. Ecological monitoring of two beach nourishment projects in Broward County, Florida. *Shore & Beach,* 9-13.

Coyer, J.A., K.A. Miller, J.M. Engle, J. Veldsink, A. Cabello-Pasini, W.T. Stam, and J.L. Olsen, 2008. Eelgrass meadows in the California Channel Islands and adjacent coast reveal a mosaic of two species, evidence for introgression and variable clonality. *Annals of Botany* 101: 73–87.

Craig, C., S. Wyllie-Echeverria, E. Carrington, and D. Shafer, 2008. Short-Term Sediment Burial Effects on the Seagrass *Phyllospadix scouleri.* EMRRP Technical Notes Collection (ERDC TN-EMRRP-EI-03). Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Crim, R.N., 2010. Effects of Ocean Acidification on Different Life History Stages of Northern Abalone (*Haliotis kamtschatkana*). A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, The University of British Columbia (Vancouver).

CSMW see California Sediment Management Workgroup

D'Antonio, C.M., 1986. Role of sand in the domination of hard substrata by the intertidal alga *Rhodornela larfx. Marine Ecology Progress Series*, 27:263-275.

Dahl, A.L., 1971. Development, form and environment in the brown alga *Zonaria farlowii* (Dictyotales). *Botanica Marina*, 14:76-112.

Dahm, J., G. Jinks, and D. Bergin, 2005. Community-based Dune Management for the Mitigation of Coastal Hazards and Climate Change Effects: A Guide for Local Authorities. April 2005. Prepared for Climate Change Office, New Zealand. *http://www.lgnz.co.nz/projects/EnvironmentalSustainability/ClimateChange/CommunityBasedDuneMangementpart1.pdf.* Accessed November 2005.

Dalfsen, J.A. van and K. Essink, 2001. Benthic community response to sand dredging and shoreface nourishment in Dutch coastal waters. *Senckenbergiana maritima*, 31 (2): 329-332.

Daly, M.A. and A.C. Mathieson, 1977. The effects of sand movement on intertidal seaweeds and selected invertebrates at Bound Rock, New Hampshire, USA. *Marine Biology,* 43:45-55.

Davies-Colley, R.J. and D.G. Smith, 2001. Turbidity, suspended sediment, and water clarity: A review. *Journal of the American Water Resources Association*, 37(5):1085-1101.

Davis, H.C., 1960. Effects of turbidity-producing materials ins sea water on eggs and larvae of the clam*(Venus (Mercenaria) mercenaria. Biological Bulletin*, 118(1):48-54.

Davis, N., Chambers Group, Inc., 2006. Personal communication to Karen Green.

DBW see Department of Boating and Waterways

Dean, T.A. and F.R. Jacobsen, 1986. Nutrient-limited growth of juvenile kelp, *Macrocystis pyrifera,* during the 1982-1984 "El Niño in southern California. *Marine Biology,* 90:597-601.

Defeo, O. and A. McLachlan, 2005. Patterns, processes and regulatory mechanisms in sandy beach macrofauna: a multi-scale analysis. *Marine Ecology Progress Series,* 295:1-20.

Dennison, W.C., 1987. Effects of light on seagrass photosynthesis, growth, and depth distribution. A*quatic Botany,* 27(1):15-26.

Dennison, W.C. and R.S. Alberte, 1986. Photoadaptation and growth of *Zostera marina* L. (eelgrass) transplants along a depth gradient. *Journal of Experimental Marine Biology and Ecology,* 98(3):265-282*.*

Department of Boating and Waterways (DBW) and State Coastal Conservancy (SCC), 2002. California Beach Restoration Study. Sacramento, California.

De Robertis, A., C.H. Ryer, A. Veloza and R.D. Brodeur, 2003. Differential effects of turbidity on prey consumption of piscivorous and planktivorous fish. *Canadian Journal of. Fisheries and Aquatic. Science.*, 60: 1517-1526.

Dethier, M.N., 1984. Disturbance and recovery in intertidal pools: maintenance of mosaic patterns. *Ecological Monographs,* 54(1):99-118.

Devinny, J.S. and L.A. Volse, 1978. Effects of sediment on the development of *Macrocystis pyrifera* gametophytes. *Marine Biology,* 48: 343-348.

Devlin, M.J., J. Barry, D.K. Mills, R.J. Gowen, J. Foden, D. Sivyer, and P. Tett, 2008. Relationships between suspended particulate material, light attenuation and Secchi depth in UK marine waters. *Estuarine, Coastal and Shelf Science,* 79 (2008) 429–439.

Diaz, R.J., G.R. Cutter, Jr., and C.H. Hobbs, III, 2004. Potential impacts of sand mining offshore of Maryland and Delaware: Part 2 – Biological Considerations. *Journal of Coastal Research,* 20(1):61-69.

Dickerson, C., K.J. Reine, and D.G. Clarke, 2001. Characterization of Underwater Sounds Produced by Bucket Dredging Operations. DOER *Technical Notes Collection (*ERDC TN-DOER-E14), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/dots/doer.*

Dugan, J.E., D.M. Hubbard, D.L. Martin, J.M. Engle, D.M. Richards, G.E. Davis, K.D. Lafferty, and R.F. Ambrose, 2000. Macrofauna communities of Exposed Sandy Beaches on the Southern California Mainland and Channel Islands. Pages 339-346 In: *Fifth California Islands Symposium*. OCS Study, MMS 99-0038.

Dugan, J.E., D.M. Hubbard, M.D. McCrary, and M.O. Pierson, 2003. The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. *Estuarine, Coastal and Shelf Science*, 585:25-40.

Dugan, J.E. and D.M. Hubbard, 2010. Loss of coastal strand habitat in southern California: The role of beach grooming. *Estuaries and Coasts,* 33:67–77.

EIC see Everest International Corporation

Engle, J.M., 1979. Ecology and Growth of Juvenile California Spiny Lobster, *Panulirus interruptus* (Randall). Ph.D. Dissertation, University of Southern California, Los Angeles, California. 273 p.

Erickson, D.L. and J.E. Hightower, 2007. Oceanic Distribution and Behavior of Green Sturgeon. *American Fisheries Society Symposium,* 56:197-211.

ESA, 2008. Redwood Landfill Final Environmental Impact Report. Second Amendment. SCH No. 199911033042. Prepared for the County of Marin, California.

Everts, C H. and C. Eldon, 2000. Beach Retention Structures and Wide Sandy Beaches in Southern California*. Shore & Beach*, Vol.68, No. 3, July 2000, pp. 11-22.

Everest International Corporation (EIC), 2006. California Coastal Sediment Management Plan: Policies, Procedures, and Regulations Analysis – Beach Restoration Regulatory Guide. Prepared for the Californian Coastal Conservancy and Coastal Sediment Management Workgroup.

_____ 2010. Fletcher Cove Reef Conceptual Design, Solana Beach, California, Final Report. Prepared for U.S. Army Corps of Engineers, Los Angeles District and City of Solana Beach, California.

Ewing, L., 1997. Procedural Guidance Document: Monitoring. California Coastal Commission. *http://www.coastal.ca.gov/pgd/pgd-mon.html.*

Fabry, V. J., B.A. Seibel, R.A. Feely, and J.C. Orr, 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES *Journal of Marine Science*, 65: 414–432.

Farnsworth K.L. and J.A. Warrick, 2007. Sources, Dispersal and Fate of Fine-Grained Sediment for Coastal California. U.S. Geological Survey Scientific Investigations Report: SIR 2007-5254.

Feder, H.M., C.H. Turner, and C. Limbaugh, 1974. Observations on fishes associated with kelp beds in southern California. California Department of Fish and Game, *Fish Bulletin*, 160:1-144. *http://ceo.ucsd.edu/fishbullandhttp://content.cdlib.org/ark:/13030/kt9t1nb3sh/.*

Federal Register 2005. Endangered Fish and Wildlife; Notice to Prepare an Environmental Impact Statement. Vol. 70(7):Tuesday, January 11, 2005.

_____ 2008. Compensatory Mitigation for Losses of Aquatic Resources; Final Rule. 73(70): 19594-19705, April 10, 2008.

Feely, R.A., C.L. Sabine, J. M. Hernandez-Ayon, D. Ianson, B. Hales, 2008. Evidence for upwelling of corrosive "acidified" water onto the Continental Shelf. *Sciencexpress/www.sciencexpress.org/ 22 May 2008/10.1126/science.1155676*.

Feely. R.A., S.R. Alin, J. Newton, C.L. Sabine, M. Warner, A. Devol, C. Krems, and C. Maloy, 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized wetland. *Estuarine, Coastal and Shelf Science* 88:442-449.

Fonseca, M.S., 1989. Regional Analysis of the Creation and Restoration of Seagrass Systems. Pages 175-198 In: *Wetland Creation and Restoration: The Status of the Science*. Kusler, J.A. and M.E. Kentula (eds.). EPA/600/3-89/038a. Environmental Research Laboratory, Corvallis, Oregon.

Fonseca, M.S. and J.A. Cahalan, 1992. A preliminary evaluation of wave attenuation by four species of seagrass. *Estuarine, Coastal and Shelf Science,* 35:565-576.

Fonseca, M.S. and W.J. Kenworthy, 1987. Effects of current on photosynthesis and distribution of seagrasses. *Aquatic Botany,* 27:59-78.

Foss, S.F., P. Ode, M. Sowby, and M. Ashe, 2007. Non-indigenous aquatic organisms in the coastal waters of California. *California Fish and Game* 93(3):111-129. Summer 2007.

Foster, M.S. and D.R. Schiel. 1985. The Ecology of Giant Kelp Forests in California: A Community Profile. U.S. Fish and Wildlife Service Biological Report, 85(7.2): 1-152.

Francingues, N. R., and M. R. Palermo. 2005. Silt Curtains as a Dredging Project Management Practice. DOER Technical Notes Collection, ERDC TN-DOER-E21. Vicksburg, MS: U.S. Army Engineer Research and Development Center. *http://el.erdc.usace.army.mil/ dots/doer/.*

Fulton, E.A., A.D.M. Smith, and C.R. Johnson, 2003. Effect of complexity on marine ecosystem models. *Marine Ecology Progress Series*, 253: 1-16.

Gartner, J.W., 2004. Estimating suspended solids concentrations from backscatter intensity measured by acoustic Doppler current profiler in San Francisco Bay, California. *Marine Geology,* 211:169–187.

Germano, J.D. and D. Cary, 2005. Rates and effects of sedimentation in the context of dredging and dredged material placement. *DOER Technical Notes Collection,* ERDC TN-DOER-E19, March 2005. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. *http://el.erdc.usace.army.mil/elpubs/pdf/doere19.pdf.*

Gibbs, R.E., 1902. *Phyllospadix* as a beach builder. *American Naturalist,* 36:101-109.

Giesen, W.B.J.T., M.M. van Katwijk, and C. den Hartog, 1990. Eelgrass condition and turbidity in the Dutch Wadden Sea. *Aquatic Botany,* 37(1):71-85.

Goreau, T.J., 2001. Reef Protection in Broward County, Florida. Report by Cry of the Water and the Global Coral Reef Alliance. *http://www.cryofthewater.org*.

Gray, J.R., G.D. Glysson, LM. Turcios, and G.E. Schwarz, 2000. Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data. U.S. Geological Survey Water-Resources Investigations Report 00-419. Reston, Virginia.

Gray, J.R. and J.W. Gartner, 2009. Technological advances in suspended-sediment surrogate monitoring. *Water Resources Research*, 45:1-20.

Green, K., Science Applications International Corporation, personal observation.

Greene, K. 2002. Beach Nourishment: A Review of the Biological and Physical Impacts. ASMFC Habitat Management Series #7. Atlantic States Marine Fisheries Commission.

Greve, T.M., D. Krause-Jensen, M.B. Rasmussen, and P.B. Christensen, 2005. Means of rapid eelgrass (*Zostera marina* L.) recolonization in former dieback areas. *Aquatic Botany,* 82(2): 143-156.

Griffin, F. J, E.H. Smith , C.A. Vines , and G.N. Cherr, 2009. Impacts of suspended sediments on fertilization, embryonic development, and early larval life stages of the pacific herring, *Clupea pallasi*. *Biological Bulletin*, 216(2):175-87.

Grimes, D. J. 1980. Bacteriological Water Quality Effects of Hydraulically Dredging Contaminated Upper Mississippi River Bottom Sediment. *Applied and Environmental Microbiology*, 39(4):782-789.

Habel, J.S. and Armstrong, G.A., 1977. Assessment and atlas of shoreline erosion along the California coast: California Department of Navigation and Ocean Development, 69 p. plus atlas (277 p.).

Hale, R. P. Calosi, L. McNeill, N. Meszkowska, and S. Widdicombe, 2011. Predicted levels of future ocean acidification and temperature rise could alter community structure and biodiversity in marine benthic communities. *Oikos*, 120:661-674.

Harrison, P.G., 1990. Experimental Eelgrass Transplants in Southwestern British Columbia, Canada. Pages 46-57 In: In: *Proceedings of the California Eelgrass Symposium, Chula Vista, California, May 27 and 28, 1988*. Sweetwater River Press, National City, California.

Harvey, J.T., 2004. Potential Impacts to Marine Mammals During Cable-placement Activities for the MARS Project (MBARI) off Monterey Bay, California. Appendix A: Marine Mammal Impacts MARS Cable Route Application of Lease of State Lands.

Hastings, M.C. and A.N. Popper, 2005. Effects of Sound on Fish. California Department of Transportation Contract No. 43A0139, Task Order 1. *http://www.dot.ca.gov/hq/env/bio/files/Effects_of_Sound_on_Fish23Aug05.pdf.*

Hayes, D. F., G.L. Raymond, and T.N. McLellan, 1984. Sediment Resuspension from Dredging Activities. *Proceedings of the Conference Dredging '84, American Society of Civil Engineers*, Clearwater Beach, Fla.

Hayes, D.F., 1986. Guide to Selecting a Dredge for Minimizing Resuspension of Sediment. Environmental Effects of Dredging Notes. EEDP-09-1. U.S. Army Corps of Engineers, Research and Development Center, Vicksburg, Mississippi.

Hayes, D.F. and C.H. Je, 2000. DREDGE Module User's Guide. U.S. Army Corps of Engineers, Research and Development Center, Vicksburg, Mississippi.

Havis, R.N., 1988. Sediment Resuspension by Selected Dredges. Environmental Effects of Dredging Technical Note EEDP-09-2. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Herbich, J.B. and S. B. Brahme, 1991. Literature Review and Technical Evaluation of Sediment Resuspension During Dredging. U.S. Army Corps of Engineers. Improvement of Operations and Maintenance Techniques Program.

Hesp, P., 2002. Foredunes and blowouts: initiation, geomorphology and dynamics. *Geomorphology*, 48:245–268.

Hickey, B., 1993. Chemical Oceanography and Geochemistry. Pages 19-70 In: *Ecology of the Southern California Bight: A Synthesis and Interpretation.* M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.). University of California Press, Berkeley, California.

Higgins, C.T., C.I. Downey, and J.P. Clinkenbeard, 2004. Literature Search and Review of Selected Topics Related to Coastal Processes, Features, and Issues in California.

Hill, S., M.T. Burrows, and S.J. Hawkins, 1998. Intertidal Reef Biotypes (Volume VI). An Overview of Dynamic and Sensitivity Characteristics for Conservation Management of Marine SACs. Scottish Association for marine Science (UK Marine SACs Project). 84 pp.

Hinchey, E. K., L.C. Schaffner, C. C. Hoar, B.W. Vogt, and L.P. Batte, 2006. Responses of estuarine benthic invertebrates to sediment burial: the importance of mobility and lifestyle. *Hydrobiologia,* 556, 85-98.

Hitchcock, D.R. and S. Bell, 2004. Physical impacts of marine aggregate dredging on seabed resources in coastal deposits. *Journal of Coastal Research*, 20(1):101-114.

Hitchcock, D.R. and B.R. Drucker, 1996. Investigation of Benthic and Surface Plumes Associated with Marine Aggregates Mining in the United Kingdom. In: *The Global Ocean-Towards Operational Oceanography. Proceedings of the Oceanology International Conference, 1996. Spearhead Exhibitions Ltd. Surrey KT3 3LZ.* ISBN 0 900254 12 2. Vol. 2. pp. 221 – 234.

Hodder, J. 2005. Marine Mammal Use of the Near Shore Waters Along Clatsop Spit: An Assessment of Distribution, Abundance, and Potential Effects from dredge Spoil Deposition Adjacent to the South Jetty of the Columbia River. Prepared for The Institute for Natural Resources Oregon State University.

Hoffman, R.S., 1986. Fishery Utilization of Eelgrass (*Zostera marina*) Beds and Non-Vegetated Shallow Water Areas in San Diego Bay. Southwest Region, National Marine Fisheries Service, NOAA, Administrative Report SWR-86-4.

Hoffman, R.S., 1990. Recovery of Eelgrass Beds in Mission Bay, San Diego, California Following Beach Restoration Work. Pages 21-27 In: *Proceedings of the California Eelgrass Symposium, Chula Vista, California, May 27 and 28, 1988*. Sweetwater River Press, National City, California.

Holbrook, S.J., D.C. Reed, K. Hansen, and C.A. Blanchette, 2000. Spatial and temporal patterns of predation on seeds of the surfgrass *Phyllospadix torreyi. Marine Biology,* 136:739-747.

Houston, L.J., M.W. LaSalle, and J.D. Lunz, 1989. Predicting and Monitoring Dredged-Induced Dissolved Oxygen Reduction. Environmental Effects of Dredging Technical Notes. EEDP-06-09. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

H.T. Harvey & Associates, 2012. Least Tern Literature Review and Study Plan Development, Final Report. Prepared for the U.S. Army Corps of Engineers, San Francisco District. Prepared by R.K. Burton and S.B. Terrill.

Hubbard, D.M. and J.E. Dugan, 2003. Shorebird use of an exposed sandy beach in southern California. Estuarine, *Coastal and Shelf Sciences,* 58S:169-182.

Hughes, H., 2005. Encore for eelgrass. *Coast & Ocean*, 21(1&2).

Huntington, K.M., and D.C. Miller. 1989. Effects of suspended sediment, hypoxia, and hyperoxia on larval *Mercenaria mercenaria* (Linnaeus, 1758). *Journal of Shellfish Research*, 8:37–42.

Hurme, A.K. and E. Pullen, 1988. Biological effects of marine sand mining and fill placement for beach replenishment: Lessons for other uses. *Marine Mining,* 7:123-136.

Huston, J.W. and W.C. Huston, 1976. Techniques for Reducing Turbidity Associated with Present Dredging Procedures and Operations. Contract Report D-76-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

ICF Jones & Stokes and Illingworth and Rodkin, Inc, 2009. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Prepared for the California Department of Transportation.

Inman, D.L. and P. M. Masters (eds), 2003. *Living with Coastal Change*. Scripps Institution of Oceanography, University of California San Diego. *http://coastalchange.ucsd.edu.*

Jaques, D.L., C.S. Strong, and T.W. Keeney, 1996. Brown Pelican Roosting Patterns and Responses to Disturbance at Mugu Lagoon and Other Nonbreeding Sites in the Southern California Bight. National Biological Service, Cooperative National Park Resources Studies Unit Technical Report No. 54.

Jaques, D. and C. Strong, 2000. Post-breeding Brown Pelican Distribution and Roost Habitat Use in California, 1999. Appendix A. in American Trader Trustee Council, 2001. Restoration Plan and Environmental Assessment for Seabirds Injured by the American Trader Oil Spill.

Jones, R.A., and G.F. Lee, 1981. The Significance of Dredging and Dredged Material Disposal as a Source of Nitrogen and Phosphorus for Estuarine Waters. Pages 517-530 in: *Estuaries and Nutrients*. Humana Press, New Jersey.

Juhnke, L., T. Mitchell, and M.J. Pizker, 1990. Construction and Monitoring of Nearshore Placement of Dredged Material at Silver Strand State Park, San Diego, California. Dredging Research Technical Notes DRP-1-01. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Jutte, P.C., R.F. Van Dolah and M. V. Levisen. 1999. An Environmental Monitoring Study of the Myrtle Beach Renourishment Project: Intertidal Benthic Community Assessment of Phase II - Myrtle Beach. Supplemental Report. Prepared by the Marine Resources Division, South Carolina Department of Natural Resources for U.S. Army Corps of Engineers, Charleston, South Carolina.

KBC see Keane Biological Consulting

Keane, K., 2001. Final Report. Breeding Biology of the California Least Tern in Los Angeles Harbor 2000 Season. Prepared for Los Angeles Harbor Department, Environmental Management Division.

Keane Biological Consulting (KBC), 2011. California Least Tern Foraging Study with Respect to Proposed Dredging Locations. Prepared for U.S. Army Corps of Engineers, Los Angeles District.

Keitt, B. S., B.R. Tershy, and D.A. Croll, 2004. Nocturnal behavior effect reduces predation pressure on black-vented shearwaters *Puffinus opistomelas. Marine Ornithology*, 32: 173–178.

Kennedy, V.S., R.R. Twilley, J.A. Kleypas, J.H. Cowan Jr., S.R. Hare, 2002. Coastal and Marine Ecosystems & Global Climate Change: Potential Effects on U.S. Resources. Prepared for the Pew Center on Global Climate Change.

Kirk, J.T.O., 2011. *Light and Photosynthesis in Aquatic Ecosystems*. Third Edition. Cambridge University Press, New York. 662 pp.

Klimley, A.P., M.J. Thomas, M.G. Nafus and A.R. Hearn. 2009. Past, Present and Future Studies of Green Sturgeon Movements in the San Francisco Estuary Germane to Dredge Removal and Disposal. Presented at the 2009 Green Sturgeon, Longfin Smelt, and Dredging Operations in the San Francisco Estuary Workshop Symposium.

Komar, P.D., 1996, The budget of littoral sediments - concepts and applications. *Shore & Beach*, 64:18–26.

Komar, P.D., 1998. *Beach Processes and Sedimentation.* Prentice-Hall, Inc.

Konar, B. and C. Roberts, 1996. Large scale landslide effects on two exposed rocky subtidal areas in California. *Botanica Marina,* 39:517-524.

Kranz, P.M., 1972. The Anastrophic Burial of Bivalves and its Paleoecological Significance. Ph.D. dissertation, University of Chicago, pp. 1–177.

Lafferty, K.D., 2000. Status, Trends and Conservation of the Western Snowy Plover with a Focus on the Devereux Slough Population at Coal Oil Point Reserve, Santa Barbara County, CA. Museum of Systematics and Ecology Environmental Report No. 15, University of California, Santa Barbara.

Lafferty, K.D., 2001a. Birds at a Southern California beach: seasonality, habitat use and disturbance by human activity. *Biodiversity and Conservation*, 101:1949-1962.

Lafferty, K.D., 2001b. Disturbance to wintering western Snowy Plovers. *Biodiversity and Conservation*, 101:315-325.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta, 2001. Collisions between ships and whales. *Marine Mammal Science*, 17(1):35–75.

Landing, D., 1984. Food habits of wintering Brandt's Cormorants. *Wilson Bulletin*, 96(l):130-134

LARWQCB see Californian Regional Water Quality Control Board, Los Angeles Region

LaSalle, M., D.G. Clarke, J. Homziak, J.D. Lunz, and T.J. Fredette, 1991. A Framework for Assessing the Need for Seasonal Restrictions on Dredging and disposal Operations. Technical Report D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Lassuy, D.R., 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest) - Pacific Herring. U.S. Fish and Wildlife Service Biological Report 82 (11.126). TR EL-82-4.

Lassuy, D.R., and D. Simons, 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest) - Pacific Razor Clam. U.S. Fish and Wildlife Service Biological Report, 82 (11.89). TR EL-82-4.

Lee, G.F. and R. A. Jones, 1999. Oxygen Demand of US Waterway Sediments. Report G. Fred Lee & Associates, El Macero, CA.

Levin, P.S. and M.E. Hay, 2002. Fish-seaweed association on temperate reefs: do small-scale experiments predict large-scale patterns? *Marine Ecology Progress Series,* 232:239-246.

Lewis, R.D. and K.K. McKee, 1989. *A Guide to the Artificial Reefs of Southern California.* Department of Fish and Game. 73 pp.

LFR Levine-Fricke (LFR), 2004. Framework for Assessment of Potential Effects of Dredging on Sensitive Fish Species in San Francisco Bay. Prepared for U.S. Army Corps of Engineers, San Francisco District.

Lindeman, K.C. and D.B. Snyder, 1999. Nearshore hardbottom fishes of southeast Florida and effects of habitat burial caused by dredging. *Fishery Bulletin,* 97: 508-525.

Littler, M.M., D.R. Martz, and D.S. Littler, 1983. Effects of recurrent sand deposition on rocky intertidal organisms: Importance of substrate heterogeneity in a fluctuating environment. *Marine Ecology Progress Series*, 11: 129-139.

Love, M., 1996. *Probably More Than You Want to Know About the Fishes of the Pacific Coast*. Really Big Press, Santa Barbara, California.

_____ 1997. Effects of Water Movement and Other Parameters on Fishes and Fisheries. Prepared for California Seafood Council.

Magoon, O.T. and L.K. Lent, 2005. The costs of sand mining. *California Coast & Ocean*, 21(3). *http://coastandocean.org/coast_autumn2005/index.htm.*

Main, M. B. and W. G. Nelson, 1988. Tolerance of the Sabellariid polychaete *Phragmatopoma lapidosa* Kinberg to burial, turbidity, and hydrogen sulfide. *Marine Environmental Research*, 26:39-55.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis, 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society*, 78, pp. 1069-1079.

Marschalek, D.A., 2010. California Least Tern Breeding Survey, 2009 Season. California Department of Fish and Game Nongame Wildlife Program, 2010-03.

Martin, K., 2010 and 2011. Professor of Biology, Pepperdine University, personal communications with Karen Green.

Martin, K., M. Schaadt, and S. Lorenz-Miller, 2001. The Walker Scale for Assessment of Grunion Runs.

Massey, B.W. and J.L. Atwood, 1980. Application of Ecological Information to Habitat Management for the California Least Tern. Progress. Rep. 2. U.S. Fish and Wildlife Service Laguna Niguel, CA.

Masters, P.M., 2006. Holocene sand beaches of southern California: ENSO forcing and coastal processes on millennial scales. *Paleogeography, Paleoclimatology, and Paleoecology,* 232:73–95.

Maurer, D., R.T. Keck, J.C. Tinsman, W.A. Leathem, C. Wethe, C. Lord, and T.M. Church, 1986. Vertical migration and mortality of marine benthos in dredged material: A synthesis. *Internationale Revue gesamten Hydrobiologie*, 71:49-63.

McCauley, J.E., R.A. Parr, and D.R. Hancock, 1977. Benthic infauna and maintenance dredging: A case study. *Water Research,* 11:233-242.

McDonald, N.J., M.H. Davies, A.K. Zundel, J.D. Howlett, Z. Demirbilek, J.Z. Gailani, T.C. Lackey, and J. Smith, 2006. PTM: Particle Tracking Model, Report 1: Model Theory, Implementation, and Example Applications. Technical Report ERDC/CHL TR-06-20. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

McFarland, V.A. and R.K. Peddicord. 1980. Lethality of a suspended clay to a diverse selection of marine and estuarine macrofauna. *Archives of Environmental Contamination and Toxicology,* 9:733-741.

McLachlan, A., 1996. Physical factors in benthic ecology: effects of changing sand particle size on beach fauna. *Marine Ecology Progress Series,* 121:205-217.

McLachlan, A., A.C. Cockcroft, and D.E. Malan, 1984. Benthic faunal response to a high energy gradient. *Marine Ecology Progress Series*, 16:51-63.

MEC Analytical Systems, Inc. (MEC), 2000a. Appendix D to the San Diego Regional Beach Sand Project, Final Environmental Impact Report/Environmental Assessment. Evaluation of Impacts to Marine Resources and Water Quality from Dredging of Sands from Offshore Borrow Sites and Beach Replenishment at Oceanside, Carlsbad, Leucadia, Encinitas, Cardiff, Solana Beach, Del Mar, Torrey Pines, Mission Beach, and Imperial Beach. Prepared for KEA Environmental, Inc.

MEC, 2000b. Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay. Prepared for The Port of Long Beach, Long Beach, California.

MEC and U.S. Army Engineer Research and Development Center (U.S. Army-ERDC), 2004. Port of Oakland Outer Harbor Maintenance Dredging Operations, Spatial Characterization of Suspended Sediment Plumes During Dredging Operations Through Acoustic Monitoring, Final Report. Submitted to U.S. Army Corps of Engineers, San Francisco District.

Merkel, K., 2006. Merkel & Associates, Inc. personal communication with Karen Green.

Merkel, K.W., 1990. Growth & survival of transplanted eelgrass: The importance of planting unit size and spacing. Pages 70-78 In: *Proceedings of the California Eelgrass Symposium, Chula Vista, California, May 27 and 28, 1988.* Sweetwater River Press, National City, California.

Merkel & Associates, Inc., 2006. Final report on Eradication of the Invasive Seaweed *Caulerpa taxifolia* from Agua Hedionda Lagoon and Huntington Harbour, California. Prepared for the Steering Committee of the Southern California Caulerpa Action Team.

_____2010. Demersal Fisheries Response to the 2004 Channel Deepening Project in San Diego Bay. Prepared for the Port of San Diego, Port of Los Angeles, Port of Long Beach, NOAA Fisheries, and Naval Facilities Engineering Command Southwest.

Mertes, L.A.K., M. Hickman, B. Waltenberger, A.L. Bortman, E. Inlander, C. McKenzie, and J. Dvorsky, 1998. Synoptic views of sediment plumes and coastal geography of the Santa Barbara Basin, California. *Hydrological Processes*, 12:967-979.

Miller, D.J., J. E. Hardwick, and W. A. Dahlstrom, 1975. Pismo Clams and Sea Otters. California Department of Fish and Game Marine Resources Technical Report No. 31.

Minerals Management Service (MMS), 2004. Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies. Prepared by W.F. Baird & Associates, Ltd. and Research Planning, Inc. OCS Report MMS 2004-076.

Moffatt & Nichol Engineers (Moffatt & Nichol), 2002. Technical Report San Clemente Beach Replenishment Program Criteria and Concept Design. Prepared for the City of San Clemente, California.

_____ 2006. Final Sand Compatibility and Opportunistic Use Program Plan. Prepared for SANDAG. *http://dbw.ca.gov/CSMW//PDF.Final_SCOUP_ Master_Plan.pdf.*

Mok, C. R. A. Sniatowski, J. Van Tran, and K. Wheatley, 2006. An Analysis of Prey Selection in Brandt's Cormorants: A three year study of foraging on Alcatraz Island. Bio 141L Ecological Field Methods, University of California, Santa Cruz (UCSC), unpublished.

Moore, K.A. and R.J. Orth, 1997. Evidence of Widespread Destruction of Submersed Aquatic Vegetation (SAV) from Clam Dredging in Chincoteague Bay, Virginia. Report to the Virginia Marine Resources Commission.

Morris, R.H., D. P. Abbott, and E.C. Haderlie (eds.), 1980. *Intertidal Invertebrates of California.* Stanford University Press, California. 690 p.

Mulder, T., J.P.M. Syvitski, S. Migeon, J-C. Faugères, and B. Savoye, 2003. Marine hyperpycnal flows: initiation, behavior and related deposits. A review. *Marine and Petroleum Geology,* 20:861–882.

Murray, S.N. and R.N. Bray, 1993. Benthic Macrophtytes. Pages 304-368 in: *Ecology of the Southern California Bight: A Synthesis and Interpretation.* M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.). University of California Press, Berkeley, California.

NABCI see North American Bird Conservation Initiative, U.S. Committee

Naqvi, S.M. and E.J. Pullen, 1982. Effects of Beach Nourishment and Borrowing on Marine Organisms. Prepared for U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Virginia.

National Institute of Water & Atmospheric Research, Ltd. (NIWA), 2001. Effects of Suspended Sediment Levels on Suspension-feeding Shellfish in the Whitford Embayment. Prepared for Auckland Regional Council, New Zealand.

_____ 2004. Effects of Sedimentation on Macrofaunal Communities: A Synthesis of Research Studies for ARC. Prepared for Auckland Regional Council, New Zealand.

_____ 2008. Effects of Suspended Sediment Levels on Suspension-feeding Shellfish in the Whitford Embayment. Prepared for Auckland Regional Council, New Zealand.

National Marine Fisheries Service (NMFS), 2004. Essential Fish Habitat Consultation Guidance, Version 1.1. Office of Habitat Conservation, Silver Spring, Maryland.

_____ 2009. Magnuson-Stevens Fishery Conservation and Management Act (MSA) Essential Fish Habitat (EFH), Multi-Agency Training Workshop. Southwest Regional Office – Habitat Conservation Division. Sacramento, California, January 7, 2009.

_____ 2010. Federal Recovery Outline: North American Green Sturgeon Southern Distinct Population Segment. Prepared by the National Marine Fisheries Service Southwest Region.

_____ 2011a. Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Pile Replacement Project. Federal Register, 76(24): 6406-6430.

_____ 2011b. Personal communication, review comments on draft grunion spawning resource protection guideline.

National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NMFS-NOAA), 2008. Endangered and Threatened Wildlife and Plants: Proposed Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon; Proposed Rule. *Federal Register* 50 CFR Part 226 Vol. 73, No. 174 [Docket No. 080730953–81003–01, RIN 0648–AX04].

_____ 2009. Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon, Final Rule. *Federal Register* 50 CFR Part 226 [Docket No. 080730953–91263–02; RIN 0648–AX04].

_____ 2010. Endangered and Threatened Wildlife and Plants: Final Rulemaking To Establish Take Prohibitions for the Threatened Southern Distinct Population Segment of North American Green Sturgeon, Final Rule *Federal Register* 50 CFR Part 223 [Docket No. 070910507–0037–02; RIN 0648–AV94].

National Oceanic and Atmospheric Administration (NOAA), 1992. Final Environmental Impact Statement and Management Plan for the Proposed Monterey Bay National Marine Sanctuary. Prepared By: Sanctuaries and Reserves Division Office of Ocean and Coastal Resource Management National Ocean Service National Oceanic and Atmospheric Administration, Washington, D.C.

_____ 2001a. Glossary of Coastal Terminology. Washington State Department of Ecology, Coastal Monitoring & Analysis Program, Publication No. 98-105. Updated on April 09, 2001. NOAA Coastal Services Center. *http://www.csc.noaa.gov/text/glossary.html.*

_____ 2001b. Guide to the Seagrasses of the United States of America (Including U.S. Territories in the Caribbean). Available on U.S. National Oceanic and Atmospheric Administration. Coastal Services Center. Submerged Aquatic Vegetation: Data Development and Applied Uses. (CD-ROM). (NOAA/CSC/20116-CD). Charleston, SC.

_____2005a. Rip Currents. *http://www.ripcurrents.noaa.gov/overview.shtml.*

_____2005b. Upwelling. *http://oceanexplorer.noaa.gov/explorations/02quest/background/upwelling/upwelling.html.*

_____2008. Beach Grooming: Raking Through the Issues in California. *www.csc.noaa.gov/magazine/2008/06/article2.html.*

National Research Council (NRC), 1985. *Dredging Coastal Ports: An Assessment of the Issues.* National Academy Press, Washington, D.C. pp. 117-139.

_____1995. *Beach Nourishment and Protection*. National Academy Press, Washington, D.C. 334 pp.

Natural Resources Defense Council (NRDC), 2010. Testing the Waters: A Guide to Water Quality at Vacation Beaches. Twentieth Annual Report. *http://www.nrdc.org/water/oceans/ttw/sumcal.pdf.*

Nelson, W.G. 1993. Beach restoration in the southeastern U.S.: Environmental effects and biological monitoring. *Ocean and Coastal Management*, 19:157-182.

Newcombe, C.P. and D.D. MacDonald, 1991. Effects of suspended sediments on aquatic ecosystems. *North American Journal of Fisheries Management*, 11:72-82.

Newcombe, C.P. and J.O.T. Jensen, 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management,* 16:693-719.

Newell, R.C., L.J. Seiderer, and D.R. Hitchcock, 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanography and Marine Biology: An Annual Review*, 36:127-178.

Newell, R.C., L.J. Seiderer, N.M. Simpson, and J.E. Robinson, 2004. Impacts of marine aggregate dredging on benthic macrofauna off the south coast of the United Kingdom. *Journal of Coastal Research,* 20(1):115-125.

Nezlin, N.P. and P.M. DiGiacomo, 2005. Satellite ocean color observations of stormwater runoff plumes along the San Pedro Shelf (southern California) during 1997 to 2003. *Continental Shelf Research* 25:1692-1711.

Nichols, M., R.J. Diaz, and L.C. Schaffner, 1990. Effects of hopper dredging and sediment dispersion, Chesapeake Bay. *Environmental Geology and Water Sciences, 15(1):31-43.*

Nightengale, B. and C.A. Simenstad, 2001. Dredging Activities: Marine Issues. Submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington Department of Transportation.

Nightengale, B. and C.A. Simenstad, 2002. Artificial Night-Lighting Effects on Salmon and Other Fishes in the Northwest. Ecological Consequences of Artificial Night Lighting conference on February 23-24, 2002, sponsored by The Urban Wildlands Group and the UCLA Institute of the Environment.

Nimmo, D. R., T. L. Hamaker, E. Matthews, and W. T. Young, 1982. The Long-term Effects of Suspended Particulates on Survival and Reproduction of the Mysid Shrimp, *Mysidopsis bahia*, in the Laboratory. Pages 413–422 *in: Ecological stress and the New York Bight*. (G. F. Mayer, editor). Estuarine Research Federation, Columbia, South Carolina.

Nitsos, R., 1990. Morro Bay Eelgrass Transplant. Pages 43-45 In: *Proceedings of the California Eelgrass Symposium, Chula Vista, California, May 27 and 28, 1988.* Sweetwater River Press, National City, California.

Nittrouer, C.A. and L. D. Wright, 1994. Transport of particles across continental shelves. *Reviews of Geophysics*, 32 (1):85-113.

NIWA see National Institute of Water & Atmospheric Research

NMFS see National Marine Fisheries Service

NOAA see National Oceanic and Atmospheric Administration

Noggle, C. C., 1978. Behavioral, Physiological, and Lethal Effects of Suspended Sediment on Juvenile Salmonids. Master's thesis, University of Washington, Seattle, Washington, USA.

North, W.J., 1986. Biology of the Macrocystis resource in North America. In: *Case studies of Seven Commercial Seaweed Resources*. Doty, M.S., J.F. Caddy, and B. Santelices (eds.). FAO Fish. Tech. Pap., (281): 311 p. *http://www.fao.org/docrep/X5819E/x5819e0a.htm#TopOfPage.*

North American Bird Conservation Initiative (NABCI), U.S. Committee, 2010. The State of the Birds 2010 Report on Climate Change, United States of America. U.S. Department of the Interior: Washington, DC.

North Pacific Fishery Management Council and National Marine Fisheries Service (NPFMC and NMFS), 2010. Habitat Areas of Particular Concern (HAPC) with Essential Fish Habitat (EFH) HAPC Process Document. Prepared by North Pacific Fishery Management Council and National Marine Fisheries Service (NPFMC and NMFS, Alaska Region. September 2010.

NRC see National Research Council

NRDC see National Research Defense Council

Ocean and Coastal Policy Center, Santa Barbara, 2009. Developing Adaptive Policy to Climate Disturbance in Santa Barbara County.

O'Connor, J., 1991. Evaluation of Turbidity and Turbidity-Related Effects on the Biota of the San Francisco Bay-Delta Estuary. Submitted to U.S. Army Corps of Engineers, San Francisco District.

Ogle, S., 2005. A Review of Scientific Information on the Effects of Suspended Sediments on Pacific Herring (Clupea *pallasi*) Reproductive Success. Pacific EcoRisk. Prepared for U.S. Army Corps of Engineers and Long-Term Management Strategy Science Assessment & Data Gaps Workgroup Herring Sub-Committee.

Ogston, A.S. and R.W. Sternberg, 1995. On the importance of nearbed sediment flux measurements for estimating sediment transport in the surf zone. *Continental Shelf Research,* (13):1515-1524.

Ogston, A.S. and R.W. Sternberg, 1999. Sediment-transport events on the northern California continental shelf. *Marine Geology*, 154, 69-82.

Ogston, A.S., D.A. Cacchione, R.W. Sternberg, and G.C. Kineke, 2000. Observations of storm and river flood-driven sediment transport on the northern California continental shelf. *Continental Shelf Research*, 20(16):2141-2162.

Oliver, J.S., P.N. Slattery, L.W. Hulberg, and J.W. Nybakken, 1977. Patterns of Succession in Benthic Infaunal Communities Following Dredging and Dredged Material Disposal in Monterey Bay. Technical Report D-77-27, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Ontario Ministry of the Environment and Energy (OMOE), 1994. Evaluating Construction Activities Impacting on Water Resources Part III B: Handbook for Dredging and Dredged Material Disposal in Ontario – Dredging Transport and Monitoring. Report prepared by the Standards Development Branch, Ontario Ministry of the Environment and Energy. ISBN 0-7778-3292-5.

Onuf, C.P. and M.L. Quammen, 1983. Fishes in a California coastal lagoon: effects of major storms on distribution and abundance. *Marine Ecology Progress Series*, 12:1-14.

OPC see California Ocean Protection Council

Orr, R.T. and R.C. Helm, 1989. *Marine Mammals of California.* University of California Press.

Orth, R.J., M. Luchenback, and K.A. Moore, 1994. Seed dispersal in a marine macrophyte: Implications for colonization and restoration. *Ecology,* 75(7):1927-1939.

Orth, R.J., M.L. Luchenback, S.R. Marion, K.A. Moore, and D.J. Wilcox, 2006. Seagrass recovery in the Delmarva Coastal Bays, USA. *Aquatic Botany,* 84(1):26-36.

OSPAR Commission, 2009. Overview of the Impacts of Anthropogenic Underwater Sound in the Marine Environment. The Intersessional Correspondence Group on Underwater Noise (2007-2009).

Overton, C.T., 2007. Data Summary: A Review of Literature Regarding California Clapper Rail (*Rallus longirostris obsoletus*) Demographics, Habitat Use, Home Range, Movements, and Effects of Disturbance. Prepared for the State Coastal Conservancy, San Francisco Estuary Invasive Spartina Project.

Pacific Affiliates, Inc., 2006. City of Eureka and Humboldt Bay Harbor, Recreation, and Conservation District Cooperative Eureka Waterfront Facilities Maintenance Dredging Project, Eureka Channel, Humboldt Bay, CA. Samoa Beach Surf Zone Disposal Pre Project Monitoring Report.

_____ 2007. City of Eureka and Humboldt Bay Harbor, Recreation, and Conservation District Cooperative Eureka Waterfront Facilities Maintenance Dredging Project, Eureka Channel, Humboldt Bay, CA. Samoa Beach Surf Zone Disposal Post Project Monitoring Report.

Palermo, M.R. and R. E. Randall, 1990. Practices and Problems Associated with Economic Loading Overflow of Dredge Hoppers and Scows. Dredging Research Program Technical Report DRP-90-1. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Palermo, M.R., P.R. Schroeder, T.J. Estes, and N.R. Francinques, 2008. Technical Guidelines for Environmental Dredging of Contaminated Sediments. Prepared for U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, D.C.

Parnell, P.E., E.F. Miller, C.E. Lennert-Cody, P.K. Dayton, M.L. Carter, and T.D. Stebbins, 2010. The response of giant kelp (*Macrocystis pyrifera*) in southern California to low-frequency climate forcing. *Limnology and Oceanography*, 55(6): 2686–2702.

Parr, T., D. Diener, and S. Lacy, 1978. Effects of Beach Replenishment on the Nearshore Sand Fauna at Imperial Beach, California. Prepared for U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Virginia.

Parsley, M.J., 2009. Response of White Sturgeon to Dredging Operations in the Lower Columbia River. Presented at the 2009 Green Sturgeon, Longfin Smelt, and Dredging Operations in the San Francisco Estuary Workshop Symposium.

Parsons, J. D., J. Bush, and J.P.M. Syvitski, 2001. Hyperpycnal flow formation with small sediment concentrations. *Sedimentology*, 48:465–478.

Pearson, T.H. and R. Rosenberg, 1978. Macrobenthic succession in relation to organic enrichment and pollution of the environment. *Oceanography and Marine Biology: An Annual Review*, 16:229-311.

Peddicord, R.K. and V.A. McFarland, 1978. Effects of Suspended Dredged Material on Aquatic Animals. Technical Report D-78-29, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Peterson, C.H., 1985. Patterns of lagoonal bivalve mortality after heavy sedimentation and their paleoecological significance. *Paleobiology*, 11:139–153.

Peterson, C.H. and M.J. Bishop, 2005. Assessing the environmental impacts of beach nourishment. *BioScience*, 55(10):857-896.

Peterson, C.H., L.M. Manning, J.S. Taylor, G.A. Johnson, 2002. How Beach Nourishment Affects the Habitat Value of Intertidal Beach Prey for Surf Fish and Shorebirds and Why Uncertainty Still Exists. PowerPoint Presentation. *http://dcm2.enr.state.nc.us/ sitemap.htm. A*ccessed March 2006.

Phillips, R.C., 1979. Ecological notes on *Phyllospadix* (Potamogetonaceae) in the northeast Pacific. *Aquatic Botany,* 6:159-170.

Phillips, R.C., 1984. The Ecology of Eelgrass Meadows in the Pacific Northwest: A Community Profile. U.S. Fish and Wildlife Service, FWS/OBS-84/24. 85 pp.

Phillips, R.C. and S. Wyllie-Echeverria, 1990. *Zostera asiatica* Miki on the Pacific Coast of North America. *Pacific Science*, 44:130-134.

Pickerell, C.H., S. Schott, and S. Wyllie-Echeverria, 2005. Buoy-deployed seeding: Demonstration of a new eelgrass (*Zostera marina* L.) planting method. *Ecological Engineering*, 25(2):127-136.

Pickerell, C., S. Schott, and S. Wyllie-Echeverria, 2006. Buoy-deployed seeding: A new low-cost technique for restoration of submerged aquatic vegetation from seed. ERDC/TN SAV-06-2. U.S. Army Corps of Engineers, Vicksburg, MS. *http://el.erdc.usace.army.mil/elpubs/pdf/sav06-2.pdf*

Plechner, B. 1996. Effects of Sediment Depth and Season on growth and Carbohydrate Allocation in *P. Torreyi*. Thesis in partial fulfillment of requirements for the degree of Master of Science.

Plus, M., J-M. Deslous-Paoli, and F. Dagault, 2003. Seagrass (*Zostera marina* L.) bed recolonization after anoxia-induced full mortality. *Aquatic Botany*, 77(2):121-134.

Pondella, D. II, P. Morris, J. Stephens, Jr., and N. Davis, 1996. Marine Biological Surveys of the Coastal Zone off the City of Rancho Palos Verdes, Final Report. Prepared for the U.S. Army Corps of Engineers.

Powell, A., 2005. Up, Down, or Stable: Populations of Endangered Birds in Beach and Estuarine Areas in Southern California. USDA Forest Service Gen. Tech. Rep. PSW-GTR-195. 2005.

Public Policy Institute of California (PPIC), 2008. California Coastal Management with a Changing Climate. *www.ppic.org/main/publicatin.asp?i=755/*

Puckette, T.Pl, 1998. Evaluation of dredged material plumes: Physical monitoring techniques. *DOER Technical Notes Collection* (TN DOER-E5). U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/dots/doer*

Rahmstorf, S., 2007. A semi-empirical approach to projecting future sea-level rise. *Science*, 315:368-370.

Rakocinski, C.F., R.W. Heard, S.E. LeCroy, J.A. McLelland, and T. Simons, 1996. Responses of macrobenthos assemblages to extensive beach restoration at Perdido Key, Florida. *Journal of Coastal Research*, 12(1):326-353.

Redding, J.M. and C.B. Schreck. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. *Transactions of the American Fisheries Society*, 116:737-744.

Reed, D.C. and S.J. Holbrook, 2003. An Experimental Evaluation of Methods of Surfgrass (*Phyllospadix torreyi*) Restoration Using Early Life History Stages. Final Technical Summary, Final Study Report. Prepared for U.S. Department of the Interior Minerals Management Service Pacific OCS Region under MMS Cooperative Agreement No. 14-35-0001-30758.

Reine, K.J. and D.G. Clarke, 1998. Entrainment by Hydraulic Dredges: A Review of Potential Impacts. *DOER Technical Notes Collection,* DOER-E1, December 1998. US Army Engineer Research and Development Center, Vicksburg, Mississippi. *http://el.erdc.usace.army.mil/elpubs/pdf/doere1.pdf.*

Reilly, F.J, Jr. and V.J. Bellis, 1983. The Ecological Impact of Beach Nourishment with Dredged Materials on the Intertidal Zone at Bogue Banks, North Carolina. Prepared for U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Virginia.

Rice, T.M. and C.H. Peterson, 2005. The effects of Beach Nourishment Projects on Coastal Ecosystems. Presented at the Second Regional Workshop on Dredging, Beach Nourishment, and Bird Conservation: Atlantic Coast for Maine to Virginia. *http://el.erdc.usace.army.mil/training.cfm?Topic=Workshop&List=05oct-dots.* Accessed June 2006.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson, 1995. *Marine Mammals and Noise*. Academic Press.

Robinson, W.E., W.E. Wehling, and M.P. Morse, 1984. The effect of suspended clay on feeding and digestive efficiency of the surf clam, *Spisula solidissima* (Dillwyn). *Journal of Experimental Marine Biology and Ecology,* 74(1):1-12.

Sabol, B., D. Shafer, and E. Lord, 2005. Dredging Effects on Eelgrass (*Zostera marina*) Distribution in a New England Small Boat Harbor. U.S. Army Corps of Engineers Dredging Operations and Environmental Research Program, ERDC/EL TR-05-8. *http://el.erdc.usace.army.mil/dots/doer/pdf/trel05-8.pdf.*

SAIC see Science Applications International Corporation

San Diego Association of Governments (SANDAG) and U.S. Department of the Navy (USDN), 2000. San Diego Regional Beach Sand Project, Environmental Impact Report/Environmental Assessment. State Clearinghouse Number 1999041104.

SANDAG and U.S. Army Corps of Engineers (USACE), 2011. Environmental Assessment/ Final Environmental Impact Report, San Diego Regional Beach Sand Project II. State Clearinghouse Number 2010051063. Prepared by AECOM; Moffatt & Nichol; SAIC; Coastal Frontiers Corporation; Merkel & Associates, Inc.; and Everest International Consultants.

San Francisco Bay Bird Observatory (SFBBO), 2011. Western Snowy Plover Studies Agreement No. A3479F. Prepared by C. Robinson-Nilsen and J. B. Demers. Prepared for Santa Clara Valley Water District.

San Francisco Bay Conservation and Development Commission (BCDC), 2009. Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline April 7, 2009.

SARWQCB see California Regional Water Quality Control Board, Santa Ana River Basin

Schiff, K.C., B. Luk, D. Gregorio and S. Gruber. 2011. Southern California Bight 2008 Regional Monitoring Program: II. Areas of Special Biological Significance. Southern California Coastal Water Research Project. Costa Mesa, CA.

Schoeman, D.S., A. McLachlan, and J.E. Dugan, 2000. Lessons from a disturbance experiment in the intertidal zone of an exposed sandy beach. *Estuarine Coastal and Shelf Science*, 50:869-884.

Schoellhamer, D. H. 1996. Factors affecting suspended-solids concentrations in south San Francisco Bay, California. *Journal of Geophysical Research,* 101:12087–12095.

Schlosser, S. and A. Eicher, 2007. Humboldt Bay Cooperative Eelgrass Project. National Fish and Wildlife Foundation Report. UC Sea Grant Extension Program, Humboldt and Del Norte Counties. *http://escholarship.org/uc/item/9g98z1z1.*

Science Applications International Corporation (SAIC), 2006. Coastal Habitat Study, 2003-2005: Influence of Beach Nourishment on Biological Resources at Beaches in the City of Encinitas, California. Prepared for City of Encinitas, California.

_____ 2007. Coastal Reef Habitat Survey, Encinitas and Solana Beach, California. Prepared for City of Encinitas.

_____ 2011. Review of Sediment Management Impacts and Issues Relevant to Protection of California Coastal Biota, Volume 1: Biological Impacts Analysis. Prepared for the Coastal Sediment Management Workgroup (CSMW) under contract with Beach Erosion Authority for Clean Oceans and Nourishment and U.S. Army Corps of Engineers.

SDRWQCB see California Regional Water Quality Control Board, San Diego Region

Sea Engineering, Inc., 2006. Fall 2005 Inner Santa Cruz Harbor Dredge Disposal Monitoring Program. Prepared for Santa Cruz Port District.

Sebens, K. P., 1980. The regulation of asexual reproduction and indeterinate body size in the sea anemone *Anthopleura elegantissima* and *A. xanthogrammica* (Brandt). *Biological Bulletin* (Woods Hole), 158:370-3382.

Seymour, R.J., M.J. Tegner, P.K. Dayton, and P.E. Parnell, 1989. Storm wave induced mortality of giant kelp, *Macrocystis pyrifera,* in southern California. *Estuarine, Coastal and Shelf Science,* 28:277-292.

SFBBO see San Francisco Bay Bird Observatory

SFRWQCB see California Regional Water Quality Control Board, San Francisco Bay

Shaffer, K., 2002. Preliminary Revision to Marine and Estuarine Habitats of the California Wildlife Habitat Relationship System. California Department of Fish and Game. *http://www.humboldtbay.org/harbordistrict/documents/hbmp2007/Appendix_H_Marine_Estuarine.pdf.*

Shaw, W.N. and T.J. Hassler, 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest), California Pismo Clam. U.S. Fish Wildlife Service Biology Report 82(11.95). U.S. Army Corps of Engineers, TR EL-82-4. 12 pp.

Shepard, F. P., 1963. *Submarine Geology*, 2nd Edition. Harper and Row Publishers. 557 p.

Shepard, F.P. and L.L. Inman, 1951. Sand Movement on the Shallow Inter-Canyon Shelf at La Jolla, California. Technical Memorandum No. 26, Beach Erosion Board, U.S. Army Corps of Engineers.

Sherk, J. A., O'Connor, J. M., Neumann, D. A., Prince, R. D., Wood, K. V., 1974. Effects of Suspended and Deposited Sediments on Estuarine Organisms, Phase II, Reference No. 74-20. Natural Resources Institute, College Park: University of Maryland.

Sherk, J.A., J.M. O'Connor, and D.A. Newman, 1975. Effects of suspended and deposited sediment on estuarine environments. *Estuarine Research*, 2: 541-558.

Sherman, D.J., B.H. Jones, E.J. Farrrell, J. Wang, and Z. Zheng, 1998. The Fate of Fine Sediments in a Suspension Plume: Ponto Beach, California. Geomorphology Research Report No. 4. Prepared for the California Department of Boating and Waterways.

Sherwood, C.R., B. Butman, D.A. Cacchione, D.E. Drake, T.F. Cross, R.W. Sternberg, P.L. Wiberg, and A.J. Williams III, 1994. Sediment transport events on the northern California continental shelf during the 1990-1991 STRESS experiment. *Continental Shelf Research*, Vol. 14(10/11):1063-1099.

Short, A.D. and P.A. Hesp, 1982. Wave, beach and dune interactions in southeastern Australia. *Marine Geology*, 48:259-284.

Short, F. and S. Wyllie-Echeverria, 1996. Natural and human-induced disturbance of seagrasses. *Environmental Conservation,* 23(1):17-27.

Short, F.T., R.C. Davis, B.S. Kopp, C.A. Short, and D.M. Burdick, 2002. Site-selection model for optimal transplantation of eelgrass *Zostera marina* in the northeastern US. *Marine Ecology Progress Series,* 227:253-267.

Shuman, C.S., 2007. Reef Check California Monitoring Protocol 2007. *http://www.reefcheck.org/PDFs/2007_RC_CA_Protocol.pdf.*

Simmons, D., 2011. Beach Manager, City of San Diego, President, Beach Ecology Coalition, personal communication with Karen Green.

Smith, E. R., and J.Z. Gailani, 2005. Nearshore Placed Mound Physical Model Experiment," *DOER Technical Notes Collection* (ERDC TN-DOER-D3), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *http://el.erdc.usace.army.mil/dots/doer/.*

Smith, J.A. and J.L. Largier, 1995. Observations of nearshore circulation: Rip currents. *Journal of Geophysical Research*, 100(C6): 10,967-10,975.

Smith, L., 2011. USACE Los Angeles District, personal communication.

Sofonia, J.J. and R. K.F. Unsworth, 2009. Development of water quality thresholds during dredging for the protection of benthic primary producer habitats. *Journal of Environmental Monitoring*, xx:1-6.

Sousa, W.P., 1979. Disturbance in marine intertidal boulder fields: the nonequilibrium maintenance of species diversity. *Ecology*, 60(6):1225-1239.

Speybroeck, J., D. Bonte, W. Courtens, T. Gheskiere, P. Grootaert, J-P. Maelfait, M.. Mathys, S. Provoost, K. Sabbe, E.W.M. Stienen, V. Van Lancker, M. Vincx, and S. Degraer, 2006. Beach nourishment: an ecologically sound coastal defense alternative? A review. *Aquatic Conservation Marine and Freshwater Ecosystems,* 16:19-435.

Spratt, J.D., 1981. Status of the Pacific herring, *Clupea harengus pallasi,* resource in California 1972 to 1980. California Department of Fish and Game. *Fish Bulletin,* 171. 107 p.

Stanford, B., K. Ridolfi, and B. Greenfield, 2009. Summary Report: Green Sturgeon, Longfin Smelt, and Dredging in the San Francisco Estuary. Prepared for the U.S. Army Corps of Engineers. SFEI Contribution # 598. San Francisco Estuary Institute, Oakland, CA.

State Parks, 2002. Rules & Guidelines for Protecting the Snowy Plover. Prepared by the California Department of Parks & Recreation.

State Water Resources Control Board (SWRCB), 2009. Water Quality Control Plan, Ocean Waters of California, California Ocean Plan. State Water Resources Control Board and California Environmental Protection Agency.

Stauble, R.K. 2005. A Review of the Role of Grain Size in Beach Nourishment Projects. 2005 Proceedings National Conference on Beach Preservation Technology. Florida Shore and Beach Association.

Steevens, J.A. 2008. Dredged Material Evaluation and Testing Overview. Dredged Material Assessment and Management Seminar 15-17 April 2008, Sacramento, CA.

Stephenson, G., 1999. Vehicle impacts on the biota of sandy beaches and coastal dunes: A review from a New Zealand perspective. *Science for Conservation,* 121:5-48.

Stewart, J., 1989. Maintenance of a balanced, shifting boundary between the seagrass *Phyllospadix* and algal turf. *Aquatic Botany,* 33:223-241.

Stewart, J.G., 1991. *Marine Algae and Seagrass of San Diego County. A Handbook of Benthic Marine Plants from Intertidal and Subtidal Sites Between the U.S.-Mexican Border and Orange County, California.* A Publication of the California Sea Grant College, University of California, San Diego.

Stewart, J.G. and B. Myers, 1980. Assemblages of algae and invertebrates in Southern California *Phyllospadix*-dominated intertidal habitats. *Aquatic Botany*, 9:73-94.

Stober, Q.L, B.D. Ross, C.L. Melby, P.A. Dinnel, T.H. Jagielo, and E.O. Salo, 1981. Effects of Suspended Volcanic Sediment on Coho and Chinook Salmon in the Toutle and Cowlitz Rivers. University of Washington, Fisheries Research Institute, Technical Completion Report FRI-UW-8124.

Storlazzi, C.D. and B.E. Jaffe, 2002. Flow and sediment suspension events on the inner shelf of central California. *Marine Geology*, 181:195-213.

Straughan, D., 1982. Inventory of the Natural Resources of Sandy Beaches in Southern California. Technical Reports of the Allan Hancock Foundation, No. 6.

Swartz, M., 2005. *Encyclopedia of Coastal Science*. Springer, the Netherlands. 1211 pp.

SWRCB see State Water Resources Control Board

Tarr, N.M., T.R. Simons, and K.H. Pollock, 2010. An experimental assessment of vehicle disturbance effects on migratory shorebirds. *Wildlife Management,* 74(8):1776–1783.

Taylor, P.R. and M.M. Littler, 1982. The roles of compensatory mortality physical disturbance, and substrate retention in the development and organization of a sand-influenced, rocky-intertidal community. *Ecology*, 63(1):135-146.

Tegner, M.J. and P.K. Dayton, 1987. El Niño effects on southern California kelp forest communities. In: A. MacFadyen and E.D. Ford (eds.) *Advances in Ecological Research,* 17:243-289.

Thackston, E.L. and M.R. Palermo, 2000. Improved Methods for Correlating Turbidity and Suspended Solids for Monitoring. *DOER Technical Notes Collection* (ERDC TN-DOER-E8). U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil.el/dots/doer*.

Thieler, E.R., O.H. Pilkey, R.S. Young, D.M. Bush, and F. Chai, 2000. The use of the mathematical models to predict beach behavior for U.S. coastal engineering: a critical review. *Journal of Coastal Research*, 16(1), 48-70.

Thompson, B., J. Dixon, S. Schroeter, and D.J. Reish, 1993. Benthic Invertebrates. Pages 369-458 In: *Ecology of the Southern California Bight: A Synthesis and Interpretation.* M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.). University of California Press, Berkeley, California.

Thompson, B., S. Lowe, and M. Kellogg, 2000. Results of Benthic Pilot Study, 1994-1997, Part 1 – Macrobenthic Assemblages of the San Francisco Bay-Delta, and their Responses to Abiotic Factos. Technical Report 39. San Francisco Estuary Regional Monitoring Program for Trace Substances.

Thomsen, M.S. and K. McGlathery, 2005. Effects of accumulations of sediments and drift algae on recruitment of sessile organisms associated with oyster reefs. *Journal of Experimental Marine Biology and Ecology,* 328(1):22-34.

Trowbridge, C.C., 1996. Demography and phenology of the intertidal green alga *Codium setchellii*: the enigma of local scarcity on sand-influenced rocky shores. *Marine Biology,* 127:341-351.

Trulio, L. C. Robinson-Nilsen, J. Sokale, and K. Lafferty, 2011. Report on Nesting Snowy Plover Response to New Trail Use in the South Bay Salt Pond Restoration Project. Unpublished Report.

Turk, T.R. and M.J. Risk, 1981. Effect of sedimentation on infaunal invertebrate populations of Cobequid Bay, Bay of Fundy. *Canadian. Journal of Fisheries and Aquatic Sciences, 38:642-648.*

Turner, T., 1985. Stability of rocky intertidal surfgrass beds: persistence, preemption, and recovery. *Ecology*, 66(1):83-92.

Turner, T. and J. Lucas, 1985. Differences and similarities in the community-roles of three rocky intertidal surfgrasses. *Journal of Experimental Marine Biology and Ecology,* 89:175-189.

Turner, E.J. and D.C. Miller, 1991. Behavior and growth of *Mercenaria mercenaria* during simulated storm events. *Marine Biology*, 111: 55-64.

U.S. Army Corps of Engineers (USACE), 1976. Dredge Disposal Study, San Francisco Bay and Estuary. U.S. Army Corps of Engineers, San Francisco District, San Francisco, California.

_____ 1983. Dredging and Dredged Material Disposal. EM 1110-2-5025. Washington, DC: USACE Office, Chief of Engineers. *http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-5025/toc.htm.*

_____ 1988. Environmental Quality Procedures for Implementing NEPA. Department of the Army ER 200-2-2. U.S. Army Corps of Engineers 33 CFR 230, Washington D.C.

_____ 1991. Coast of California Storm and Tidal Waves Study (CCSTWS), Final State of the Coast Report, San Diego Region.

_____ 1993. Final Environmental Assessment Santa Barbara Harbor Maintenance Dredging (FY 94, 95, 96), Santa Barbara County, California.

_____ 1995. Environmental Assessment Surfside-Sunset/West Newport Beach Nourishment Project. Prepared by USACE, Los Angeles District. USACE, 2003. Morro Bay Estuary City of Morro Bay, San Luis Obispo County, CA Ecosystem Restoration Feasibility Study, F3 Conference Report Without-Project Conditions Analysis. Prepared July 2003.

_____ 1998. Final Environmental Assessment for Ventura Harbor Six-Year Maintenance Dredging Program, Ventura County, Ventura. Prepared by USACE, Los Angeles District.

_____ 1999. Final Environmental Assessment for Marina Del Rey Harbor Maintenance. Prepared by USACE, Los Angeles District.

_____ 2001. Final Environmental Assessment for Morro Bay Harbor Six-Year Maintenance Dredging Program, San Luis Obispo County, California.

_____ 2002. Coastal Engineering Manual. Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C. (in 6 volumes).

_____ 2006. Regional General Permit Number 67, Discharges of Dredged or Upland Derived Fill Materials for Beach Nourishment. USACE Los Angeles District, September 25, 2006.

U.S. Army Corps of Engineers and U.S. Environmental Protection Agency (USACE and EPA), 2004. Evaluating Environmental Effects Of Dredged Material Management Alternatives -- A Technical Framework. Prepared 1992 and revised 2004.

U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA), San Francisco Bay Conservation and Development Commission (BCDC), and San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), 2001. Long Term Management Strategy (LTMS) For the Placement of Dredged Material in San Francisco Bay Region, Management Plan 2001.

U.S. Department of Interior/Minerals Management Service (USDOI/MMS), 1999. Environmental Report: Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia. Office of International Activities and Marine Minerals. OCS Study. MMS 99-0036.

U.S. Environmental Protection Agency (USEPA), 1971. Noise from Construction Equipment and Operations, Building Equipment and Home Appliances. (Prepared under contract by Bolt, et al., Bolt, Beranek & Newman, Boston, Massachusetts.) Washington, D.C.

_____2006. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. Prepared by the Office of Water (OW) and Office of Research and Development (ORD), EPA-822-R-06-001.

U.S. Environmental Protection Agency and U.S. Army Corps of Engineers (USEPA and USACE), 1991. Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).

_____1998. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual (Inland Testing Manual).

_____2004. Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework. United States Environmental Protection Agency Office of Water (4504F), Department of The Army U.S. Army Corps of Engineers EPA842-B-92-008. November 1992, Revised May 2004. *http://el.erdc.usace.army.mil/dots/pdfs/epa/ tech-frame-rev04.pdf.*

_____ 2007. Identifying, Planning, and Financing Beneficial Use Projects Using Dredge Material: Beneficial Use Planning Manual. EPA842-B-07-001. U.S. Environmental Protection Agency, Washington, DC. and U.S. Army Corps of Engineers, Washington, DC.

U.S. Fish and Wildlife Service (USFWS), 2001. Amendment to Biological Opinion on San Diego Beaches Sand Replenishment Project, Coastal Zone of San Diego County, California; FWS Log. No. 1-6-01-F-1046.1; Corps Public Notice No. 1999-15076-RLK.

_____ 2003. Final Revised Recovery Plan for the Southern Sea Otter (*Enhydra lutris nereis*). Portland, Oregon. Xi + 165 pp. *http://www.fws.gov/ventura/speciesinfo/so_sea_otter/ ssorecplan.pdf*.

_____ 2005. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Pacific Coast Population of the Western Snowy Plover; Final Rule. *Federal Register* 70:56969-57119.

_____2006a. Estimating the Effects of Auditory and Visual Disturbance of Northern Spotted Owls and Marbled Murrelets in Northwestern California. Prepared by the Arcata Fish and Wildlife Office.

_____ 2006b. California Least Tern (*Sterna antillarum browni):* 5 Year Review Summary and Evaluation. Prepared by the U.S. Fish and Wildlife Service, Carlsbad Office.

_____ 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). In two volumes. Sacramento, California. xiv + 751 pages.

_____ 2010. Species Account: California Clapper Rail *Rallus longirostris obsoletus*. Prepared by the U.S. Fish and Wildlife Service, Sacramento Office.

_____ 2012. Endangered and Threatened Wildlife and Plants; Revised Critical Habitat for the Pacific Coast Population of the Western Snowy Plover; Final Rule. *Federal Register* 77:36727-36869.

U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS and NMFS), 1998. Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. *http://www.fws.gov/endangered/esa-library/pdf/sec7_bk.pdf.*

U.S. Department of the Navy, Southwest Division (US Navy), 1997. Environmental Assessment for Beach Replenishment at South Oceanside and Cardiff/Solana Beach, California.

University of California, San Diego (UCSD), 2003. Living with Coastal Change - Coastal Basics - Beaches. Scripps Institution of Oceanography, Coastal Morphology Group. *http://coastalchange.ucsd.edu/st3_basics/waves.html.* Accessed September 2005.

Vagle, S. 2003. On the impact of underwater pile-driving noise on marine life. Report prepared for the Canadian Coast Guard, Department of Fisheries and Oceans, Canada (unpublished). 41pp. [Available from *www.dfo-mpo.gc.ca*].

Valente, J.J. and R.A. Fischer, 2011. Reducing Human Disturbance to Waterbird Communities Near Corps of Engineers Projects. DOER Technical Notes Collection. ERDC TN-DOER-E29. Vicksburg, MS: U.S. Army Engineer Research and Development Center. *http://el.erdc.usace.army.mil/dots/doer/doer.html.*

Varanus Biological Services (Varanus), 1999. California Brown Pelican Night Roost Monitoring During Maintenance Dredging of Marina del Rey Harbor, Los Angeles, California, October 14-28 and November 10-14, 1999. Prepared for Hart Crowser.

Vavrinec, J., W.H. Pearson, N.P. Kohn, J.R. Skalski, C. Lee, K.D. Hall, B.A. Romano, M.C. Miller, and T.P. Khangaonkar, 2007. Laboratory Assessment of Potential Impacts to Dungeness Crabs from Disposal of Dredged Material from the Columbia River. PNNL-16482. Prepared for the U.S. Army Corps of Engineers, Portland District, by Pacific Northwest National Laboratory, Marine Sciences Laboratory, Sequim, Washington.

Vermeer, M. and S. Rahmstorf, 2009. Global sea level linked to global temperature, *Proceedings of the National Academy of Sciences*, published online before print December 7, 2009; doi: 10.1073/pnas.0907765106.

Versar, Inc., 2004. Year 2 Recovery from Impacts of Beach Nourishment of Surfzone and Nearshore Fish and Benthic Resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina. Final Study Findings. For the U.S. Army Corps of Engineers, Wilmington District.

Voigt, B., 1998. Glossary of Coastal Terminology. Washington State Department of Ecology Publication No. 98-105. Modified 26 April 2006. NOAA Coastal Services Center. Maintained by Coastal Monitoring & Analysis Program, Washington Department of Ecology. *http://www.ecy.wa.gov/programs/sea/swces/products/ glossary.htm.*

Wang, J.C.S., 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. A cooperative study by the California Department of Water Resources, California Department of Fish and Game, U. S. Bureau of Reclamation and U. S. Fish and Wildlife Service. Technical Report 9 (FS/B10-4ATR 86-9). *http://www.getcited.org/pub/102678553.*

Ware, R., 1993. Eelgrass (*Zostera marina*) in southern California bays and wetlands with emphasis on Orange County, California. *Shore & Beach*, 20-30.

Warrick, J.A., 2010. Fine Sediment in California Coastal Waters: Insights from the Tijuana Fate and Transport Project. Presented at the 2010 California and World Oceans Conference, San Francisco, California.

Warrick, J.A. and J.D. Milliman, 2003. Hyperpycnal sediment discharge from semiarid southern California rivers: implications for coastal sediment budgets. *Geology*, 31(9):781-784.

Warrick, J.A., L.A.K. Mertes, L. Washburn, and D.A. Siegel, 2004a. Dispersal forcing of southern California river plumes, based on field and remote sensing observations. *Geo-Marine Letters*, 24: 46-52.

Warrick, J.A., L.A.K. Mertes, D.A. Siegel, and C. MacKenzie, 2004b. Estimating suspended sediment concentrations in turbid coastal waters of the Santa Barbara Channel with SeaWiFS. *International Journal of Remote Sensing*, 25(10):1995-2002.

Warrick J.A., P.M. DiGiacomo, S.B. Weisberg, N.P. Nezlin, M. Mengel, B.H. Jones, J.C. Ohlmann, L. Washburn, E.J. Terrill and K.L. Farnsworth. 2007. River plume patterns and dynamics within the Southern California Bight. *Continental Shelf Research*, 27:2427-2448.

Washington State Department of Transportation (WSDOT), 2006. Advanced Training Manual: Biological Assessment Preparation for Transportation Projects. Part 2, Guidance on Specific BA Topics. *www.wsdot.wa.gov/Environment/Biology/B/default.htm#BAManual.*

Watt, S.G. and H.G. Greene, 2001. Monitoring of Dredged Upper Santa Cruz Harbor Mixed Sand and Mud Sediment Released into the Nearshore Area of Santa Cruz, California. Center for Habitat Studies, Moss Landing Marine Laboratories. Prepared for the Santa Cruz Harbor Port District and the California Department of Boating and Waterways.

Watters, D.L., K.T. Oda and J. Mello, 2001. Pacific Herring in California Department of Fish and Game California's Living Marine Resources: A Status Report:456-459.

Watts, G.M., 1954. Field Investigation of Suspended Sediment in the Surf Zone. Pages 181-199 In: Proceedings of Fourth Conference of Coastal Engineering. (J.W. Johnson, ed.), Chicago, Illinois, October 1953.

Weiser, E.L., and A.N. Powell, 2010. Does garbage in the diet improve reproductive output of Glaucous gulls? *The Condor,* 112(3):530–538.

Wilber, D.H. and D.G. Clarke, 2001. Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. *North American Journal of Fisheries Management*, 21:855-875.

Wilber, D.H., W. Brostoff, D.G. Clarke, and G.L. Ray, 2005. Sedimentation: Potential Biological Effects from Dredging Operations in Estuarine and Marine Environments. *DOER Technical Notes Collection,* ERDC TN-DOER-E20, May 2005. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. *http://el.erdc.usace. army.mil/elpubs/pdf/doere20.pdf*.

Wilber, D.H., D.G. Clarke, and M.H. Burlas, 2006. Suspended sediment concentrations associated with a beach nourishment project on the northern coast of New Jersey. *Journal of Coastal Research,* 22:1035-1042.

Wild, P.W. and R.N. Tasto, 1983. Life history, environment, and mariculture studies of the Dungeness crab, *Cancer Magister,* with emphasis on the Central California fishery resource. California Department of Fish and Game*., Fish Bulletin,* 172:1-339. *http://ceo.ucsd.edu/fishbull/.*

Williams, S., 1995. Surfgrass (*Phyllospadix torreyi*) reproduction: reproductive phenology, resource allocation, and male rarity. *Ecology*, 76(6):1953-1970.

Williams, G.L., 1998. Planning Considerations for Nearshore Placement of Mixed Dredged Sediments. Technical Note DOER-N3. U.S. Army Engineer Waterways Experiment Station. Vicksburg, Mississippi.

Williams, S.L. and C.P. McRoy, 1982. Seagrass productivity: The effect of light on carbon uptake. *Aquatic Botany,* 12:321-344.

Worden, J.B.., R.V. Smith, and A. Cope, 2002. Ventura Harbor California Least Tern and Western Snowy Plover 2001 Monitoring Report. Prepared for Ventura Port District.

Worden, J.B., and R.V. Smith, 2004. Ventura Harbor U.S. Army Corps of Engineers Dredging Western Snowy Plover Monitoring Report. Prepared for Ventura Port District.

Wright, L.D. and Nittrouer, C.A. 1995. Dispersal of river sediments in coastal seas. Six contrasting cases. *Estuaries,* 18:498-508.

Wright, L.D., S.-C. Kim, and C.T. Friedrichs, 1999. Across-shelf variations in bed roughness, bed stress and sediment suspension on the northern California shelf. *Marine Geology*, 154(1-4):99-115.

WSDOT see Washington State Department of Transportation

Zembal, R., S. Hoffman, J. Konecny, L. Conrad, C. Gailband, and M. Mace. 2009. Light-footed Clapper Rail Management, Study, and Propagation in California, 2009 Season. California Department of Fish and Game Nongame Wildlife Program, 2009-02.

Zimmerman, R.C., R.D. Smith, and R.S. Alberte, 1990. Seagrass Revegetation: Developing A Predictive Model Of Light Requirements. Pages 6-12 In: *Proceedings of the California Eelgrass Symposium, Chula Vista, California, May 27 and 28, 1988.* Sweetwater River Press, National City, California.

APPENDIX A
IMPACT AND MITIGATION SUMMARY TABLES

Introduction

Two types of summary tables are presented in this appendix. The first type, includes summaries of the types of potential impacts associated with equipment, burial, sedimentation, and turbidity for species and resource categories addressed in the Volume 1 BIA document.

A.1 Summary Tables by Type of Impact

Tables A.1.1 and A.1.2 summarize potential equipment impacts to habitats and associated species associated with beach nourishment (including sediment delivery pipeline routes) or dredging-related activities, respectively. At the end of each table is a list of issues considered relevant to potential impact occurrence or relative significance. These issues include considerations associated with habitat suitability, beach morphodynamics, sensitive species, fisheries, season, proximity to nesting sites or spawning grounds, and migration routes.

Table A.1.3 summarizes burial and sedimentation impact factors by habitat and species. Table A.1.4 summarizes turbidity impact factors by habitat and species. Similar to the above referenced tables, at the end of each table is a list of issues considered relevant to potential impact occurrence and/or its relative significance.

A.2 Summary Tables by Type of Mitigation Measure

Several mitigation measures may be applicable depending on type of activity (beach nourishment, dredging) and project phase (Tables A.2.1 and A.2.2). Similar mitigation measures may apply to habitats within or near where sediment management occurs during pre-construction and post-construction (Tables A.2.3 and A.2.4). The list of measures is not intended to be prescriptive. Appropriate measures would depend on project- and site-specific considerations. Primary considerations may include project location, project size, location, proximity to sensitive resources, and schedule.

Table A.1.1. Potential equipment impacts to habitats and species from beach nourishment activities.

	Vehicles	Beach Scraping	Sand Delivery Pipelines	Noise	Beach Lights	Reduce Forage
Habitats						
Coastal Dune or Strand	X		X			
Sandy Beaches	X	X	X			
Sandy Subtidal			X			
Rocky Intertidal			X			
Rocky Subtidal			X			
Kelp Beds			X			
Eelgrass Beds			X			
Surfgrass Beds			X			
Shallow Inlet Embayments			X			
Deepwater Inlet Embayments			X			
Species						
Abalone			X			
California Lobster			X			
Dungeness Crab			X			
Pismo Clam		X	X			
Soft substrate Invertebrates	X	X	X			X
Hard bottom Invertebrates			X			
California Grunion	Eggs	Eggs	Eggs		?	
Green sturgeon						
Pacific Herring						
Salmonids						
Demersal Fish		X	X	X		X
Pelagic Fish			X	X		
Reef Fish			X	X		
Tidepool Fish			X			
California Brown Pelican	X		X	X	X	
California Least Tern	X	X		X	X	
Western Snowy Plover	X	X	X	X	X	X
Shorebirds	X	X	X	X	X	X
Gulls, Terns	X	Gulls	X	X	X	Gulls
Wading Birds	X		X	X		
Waterfowl	X		X	X		
Cetaceans						
Pinnipeds	X		X	X	X	
Sea Otters						
Potential impact issues of Concern						
Habitat Suitability		X				X
Beach Morphodynamics		X				
T&E Species	X	X	X	X	X	X
Fisheries	X	X	X			
Season	X	X	X	X	X	X
Proximity to Nesting Site	X	X	X	X	X	
Proximity to Spawning Ground	X	X			?	
Migration Route						

Note: Blank entries indicate no equipment use impact concerns. T& E = threatened or endangered species

Table A.1.2. Potential equipment impacts to habitats and species from dredging and sand delivery activities.

	Dredge	Entrain	Vessel/ Prop	Anchor	Noise	Dredge Vessel Lights	Reduce Forage
Habitats							
Coastal Dunes and/or Strand							
Sandy Beaches							
Sandy Subtidal	X			X			
Rocky Intertidal							
Rocky Subtidal				X			
Kelp Beds	X		X	X			
Eelgrass Beds	X		X	X			
Surfgrass Beds				X			
Shallow Inlet Embayments	X			X			
Deepwater Inlet Embayments	X			X			
Species							
Abalone				X			
California Lobster				X	X		
Dungeness Crab	X	X		X	X		
Pismo Clam	X			X			
Soft substrate Invertebrates	X			X	X		X
Hard bottom Invertebrates				X	X		
California Grunion				X	X	X	
Green sturgeon	X	X	X	X	?	?	X
Pacific Herring	Eggs	X		Eggs	X	X	
Salmonids		X			X	X	
Demersal Fish	X	X		X	X		X
Pelagic Fish		X			X	X	
Reef Fish				X	X		
Tidepool Fish							
California Brown Pelican					X	X	
California Least Tern					X	X	
Western Snowy Plover					X	X	
Shorebirds							
Gulls, Terns					X	X	
Wading Birds					X	X	
Waterfowl	X		X		X		X
Cetaceans	X		X		X		
Pinnipeds	X		X		X	X	X
Sea Otters	X		X		X		X
Potential impact Issues of Concern							
Habitat Suitability							
Beach Morphodynamics							
T&E Species	X		X		X	X	X
Fisheries	X	X		X	X		X
Season	X	X		X	X	X	
Proximity to Nesting Site	X		X		X	X	
Proximity to Spawning Ground	X	X		X	X		X
Migration Route	X		X		X	X	

Note: Blank entries indicate no equipment use impact concerns.

Table A.1.3. Potential burial and sedimentation impacts to habitats and species from sediment management activities.

	Burial	Sand Transport	Turbidity Deposition	Reduce Forage	Displace
Habitats					
Coastal Dune and/or Strand	X				
Sandy Beach	X				
Sandy Subtidal	X				
Rocky Intertidal	X	X	X		
Rocky Subtidal	X	X	X		
Kelp Forest and/or Bed	X	X	X		
Surfgrass Bed	X	X	X		
Eelgrass Meadow	X	X	X		
Shallow Inlet Embayment		X			
Deepwater Inlet Embayment		X			
Species					
Abalone		X			X
California Lobster		X		X	X
Dungeness Crab					X
Pismo Clam	X				
Soft substrate Invertebrates	X				
Hard bottom Invertebrates	X	X		X	X
California Grunion	Eggs				
Green Sturgeon				X	X
Pacific Herring			Eggs		
Salmonids				X	X
Demersal Fish			Eggs	X	
Pelagic Fish			Eggs		
Reef Fish			Eggs		X
Tidepool Fish					X
California Brown Pelican					
California Least Tern					
Western Snowy Plover				X	
Shorebirds				X	
Gulls and Terns				Gulls	
Wading Birds, Waterfowl				X	
Cetaceans					
Pinnipeds					
Sea Otters				X	X
Potential impact Issues of Concern					
Habitat Suitability	X	X	X	X	X
Beach Morphodynamics	X	X	X	X	
T&E Species	X			X	X
Fisheries	X	X	X	X	X
Season	X	X	X	X	X
Proximity to Nesting Site				X	
Proximity to Spawning Ground	X	X	X		
Migration Route			X	X	

Note: Blank entries indicate no burial and/or sedimentation impact concerns.

Table A.1.4. Potential turbidity impacts to habitats and species from sediment management activities.

	Mortality	Reduce Recruitment	Feeding Interference	Reduce Growth	Displace Attract
Habitats					
Coastal Dune and/or Strand					
Sandy Beach		X			
Sandy Subtidal		X			
Rocky Intertidal		X			
Rocky Subtidal		X			
Kelp Forest and/or Bed	X	X		X	
Surfgrass Bed		X		X	
Eelgrass Meadow	X	X		X	
Shallow Inlet Embayment		X			
Deepwater Inlet Embayment		X			
Species					
Abalone					
California Lobster					X
Dungeness Crab		X			
Pismo Clam		X	X	X	
Soft substrate Invertebrates	X	X	X	X	X
Hard bottom Invertebrates	X	X	X		X
California Grunion		X	X		X
Green Sturgeon	X	X	X		X
Pacific Herring		X	X		X
Salmonids	X	X			X
Demersal Fish		X			X
Pelagic Fish		X	X		X
Reef Fish	X	X			X
Tidepool Fish	X				X
California Brown Pelican			X		
California Least Tern			X		X
Western Snowy Plover					
Shorebirds					
Gulls and Terns			X		
Wading Birds, Waterfowl					
Cetaceans					X
Pinnipeds			X		X
Sea Otters			X		X
Potential impact Factors of Concern					
Habitat Suitability			X		
Beach Morphodynamics					
T&E Species			X	X	X
Fisheries	X	X	X		
Season			X	X	X
Proximity to Nesting Site			X		X
Proximity to Spawning Ground		X			X
Migration Route			X		X

Note: Blank entries indicate no turbidty impact concerns

Table A.2.1. Types of pre-construction phase mitigation measures to avoid and minimize impacts by type of sediment management project.

Pre-Construction Mitigation Measures	Beach Nourishment Sand Discharge			Dredge Sand Removal	
	Dune	Beach	Nearshore	Off-shore	Bay
Maintain Sediment Compatibility and Quality					
Test compatibility for beneficial use	X	X	X	X	X
Minimize difference in sediment characteristics	X	X	X		
Minimize change in surface substrate	X	X	X	X	X
Environmental Design					
Assess habitats and identify sensitive species with potential to occur in area of potential effect	X	X	X	X	X
Avoid direct impacts to sensitive habitats	X	X	X	X	X
Match project volume to biological constraints		X	X	X	
Maintain hydrodynamics unless enhancement or restoration is conducted			X	X	X
Avoid steep scarps and slopes		X			X
Environmental Implementation Strategy					
Avoid repetitive disturbance in same year		X	X	X	X
Use multiple small sites instead of one large site		X	X		
Incorporate refuge areas				X	
Reduce Maintenance Frequency Over Time					
Incorporate dune restoration	X				
Use sedimentation basins and source control					X
Habitat Buffers					
Minimize turbidity impacts		X	X	X	X
Minimize sedimentation impacts		X	X		
Sensitive Species Buffers					
Fishery spawning grounds		X	X	X	X
Sensitive birds	X	X			X
Marine mammals		X			X
Environmental Coordination and Notifications					
Conduct EFH, ESA, or other sensitive species coordination, as appropriate	X	X	X	X	X
Hazardous materials plan	X	X	X	X	X
Inlet monitoring/response plan		X			
U.S. Coast Guard notification		X	X	X	X
Environmental training program	X	X	X		
Mitigation and Monitoring Program					
Finalize MMRP	X	X	X	X	X
Conduct pre-construction surveys, as appropriate	X	X	X	X	X

Table A.2.2. Types of construction phase mitigation measures to avoid and minimize impacts by type of sediment management project.

Construction Mitigation Measures	Beach Nourishment Sand Discharge			Dredge Sand Removal	
	Dune	Beach	Nearshore	OffShore	Bay
Location Controls					
Avoid use of equipment, pipelines, and construction materials in sensitive habitats	X	X	X	X	X
Avoid anchoring or operation of dredges, drill rigs, or barges in or above vegetated habitats			X	X	X
Surf-zone discharge location		X			
Upper beach discharge location		X			
Limit intentional approaches within 300 ft (91 m) and use slow vessel speed around sensitive marine mammals			X	X	X
Schedule and/or Seasonal Restrictions					
Environmental windows	X	X	X	X	X
Avoid repetitive disturbance in same year	X	X	X	X	X
Avoid peak recruitment and productive period		X			X
Dredge Equipment and Operational Controls					
Minimize entrainment – equipment or operation				X	X
Minimize turbidity – equipment selection				X	X
Minimize turbidity – operational controls				X	X
Construction Equipment, Methods, and Best Management Practices (BMPs)					
Use silt curtains or gunderbooms to minimize turbidity					X
Use dikes to minimize turbidity		X			
Use dikes protect sensitive resources		X			
Minimize potential hazardous materials leaks or spills	X	X	X	X	X
Reduce noise below injury or harassment	X	X			X
Shield artificial lighting	X	X	X		X
Minimize barriers to wildlife movement		X			X
Construction Monitoring					
Sediment compliance	X	X	X	X	X
Water quality compliance		X	X	X	X
Inspect inlet status		X	X		
Monitor sensitive species, as necessary	X	X	X	X	X
Post Construction Monitoring					
Verify impact significance, as appropriate	X	X	X	X	X

Table A.2.3. Types of pre-construction phase mitigation measures to avoid and minimize impacts during sediment management projects.

Pre-Construction Mitigation Measures	Sandy Beach	Sandy Nearshore	Bay, Lagoon, River	Dune or Strand	Rocky	Kelp Forest	Seagrass Bed
Maintain Sediment Compatibility and Quality							
Test compatibility for beneficial use	X	X	X	X			
Minimize difference in sediment characteristics	X	X					
Minimize change in substrate	X	X	X				
Environmental Design							
Assess habitats and sensitive species - area of potential effect	X	X	X	X	X	X	X
Avoid direct impacts to sensitive habitats			X	X	X	X	X
Match project volume to biological constraints	X	X					
Maintain hydrodynamics		X	X				
Avoid steep scarps and slopes	X						
Environmental Implementation Strategy							
Avoid repetitive disturbance in same year	X	X					
Use multiple small sites instead of one large site	X						
Incorporate refuge areas[1]	X	X					
Reduce Maintenance Frequency Over Time							
Incorporate dune restoration	X			X			
Use sedimentation basins and source control			X				
Habitat Buffers							
Minimize turbidity impacts	X	X	X		X	X	X
Minimize sedimentation impacts			X		X	X	X
Sensitive Species Buffers							
Fishery spawning grounds	X	X	X				X
Sensitive birds	X		X	X			
Marine mammals		X	X			X	
Environmental Coordination and Notifications							
Conduct EFH, ESA, or other sensitive species coordination	X	X	X	X	X	X	X
Hazardous materials plan	X	X	X				
Inlet monitoring/response plan			X				
U.S. Coast Guard notification		X					
Environmental training program	X						
Mitigation and Monitoring Program							
Finalize MMRP	X	X	X				
Pre-construction surveys	X			X	X	X	X

Table A.2.4. Types of construction phase mitigation measures to reduce direct and indirect impacts during sediment management projects.

Construction Mitigation Measures	Sandy Beach	Sandy Nearshore	Bay, Lagoon, River	Dune or Strand	Rocky	Kelp Forest	Seagrass Bed
Location Controls							
Avoid use of equipment in sensitive habitats			X	X	X	X	X
Avoid anchoring or vessels in or above vegetated habitats					X	X	X
Surf-zone discharge location	X						
Upper beach discharge location	X						
Limit intentional approaches of marine mammal (300 ft) or slow vessel speed	X	X	X			X	
Schedule and/or Seasonal Restrictions							
Environmental windows	X	X	X				
Avoid repetitive disturbance in same year	X	X	X				
Avoid peak recruitment and productive period	X						
Dredge Equipment and Operational Controls							
Minimize entrainment – equipment or operation		X	X				
Minimize turbidity – equipment selection		X	X				
Minimize turbidity – operational controls	X	X	X		X	X	X
Construction Equipment, Methods, and Best Management Practices (BMPs)							
Minimize turbidity - silt curtains, gunderbooms			X				
Minimize turbidity - dikes	X						
Minimize leaks or spills - BMPs	X	X	X				
Reduce noise below injury or harassment		X	X				
Shield artificial lighting	X		X				
Minimize barriers to wildlife movement			X				
Monitoring							
Sediment compliance	X	X	X				
Water quality compliance	X	X	X				
Inspect inlet status			X				
Monitor sensitive species, as necessary	X	X	X	X			
Post Construction Monitoring							
Verify impact significance, as appropriate	X	X	X	X	X	X	X