7.0 REVIEW OF RESOURCE MANAGEMENT AND MONITORING APPROACHES

A mitigation and monitoring program (MMRP) is required for CEQA/NEPA 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 and permit monitoring requirements vary among sediment management projects. MMRPs may range from construction monitoring to meet 401 Water Quality Certification and/or WDR requirements to comprehensive, pre- and post-construction monitoring to verify impact significance. Differences in monitoring requirements among projects generally relate to project- and site-specific impact concerns. However, there also appear to be some differences in monitoring requirements that reflect inconsistencies in permit requirements (Section 5.5.2). Monitoring requirements also may vary from ecosystem-based to species-based. The CSMW desires better understanding of these differences in monitoring and resource management approaches. This report section addresses the following questions of interest to the CSMW:

- *What are the pros and cons associated with ecosystem versus single-species approach for regulating the environment and sediment management activities in general?*
- *What recommendations can be made concerning the most appropriate approach and what steps and information are needed to pursue and implement such an approach, if appropriate?*
- *What is the appropriate level of and type of pre- and post-project sampling needed to evaluate the project for significant changes?*

Section 7.1 provides an overview of differences between ecosystem- and species-based approaches to resource management. Section 7.2 gives an overview of monitoring approaches and considerations. Types of monitoring are reviewed by project phase in Sections 7.3 (Pre-construction), 7.4 (Construction), and 7.5 (Post-Construction).

Section Topics

Photo: SANDAG

7.1 Overview of Ecosystem- and Species-Based Resource Management Approaches

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."*

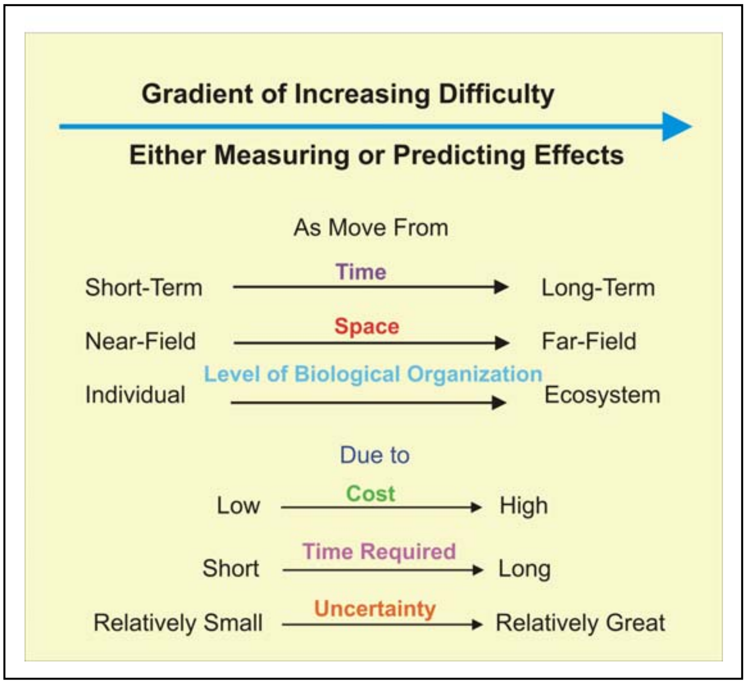
The primary advantage of the ecosystem management approach is the focus on protection of functions and values for all native resources, not just those of special interest due to endangerment status and/or commercial interest. In that sense, the ecosystem-based approach is more proactive in protection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

Examples of environmental regulations and policies 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 Management and Conservation 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 (MLPA), 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.

The ecosystem-based management approach is implicit in regional Multiple Species Conservation Plans that aim to preserve large blocks of healthy natural habitat for multiple species rather than to focus on saving individual species in a vacuum (Atkinson et al. 2004). Similarly, the ecosystem-based management approach is the basis for models such as HGM (hydrogeomorphic analysis) that focus on wetland function rather than on preserving habitat for specific species (Brinson 1993).

The advantage of the ecosystem-based management approach is that it simplifies management decisions by focusing on protection of native habitats and associated functions and qualities. By maintaining a healthy ecosystem, all species in the ecosystem, not just special interest species, will benefit. An advantage of ecosystem-based monitoring is that physical habitat boundaries are relatively easy to document. However, evaluation of impacts beyond 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. Generally, it is easier to inventory habitats than to measure and/or predict impacts to ecosystem functions (Atkinson 1985).



Source: Modified after Christensen et al. 1976 as cited in Atkinson 1985

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 (Section 7.2.2). 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, and/or laboratory analyses of collected samples. Therefore, a primary disadvantage of ecosystem-based monitoring is that it will likely be more costly than single-species monitoring. One strategy to minimize monitoring costs is to assess indicators and/or indicator species (Section 7.2.2.4).

Ecosystem-based management may be insufficient to ensure avoidance of direct impacts to federal- and/or state-listed sensitive species. The species-based management approach generally is focused on protection of sensitive, commercially important, and/or other special interest species. Examples of environmental regulations and policies 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) also are examples of the species-based management approach. The CDFG states that research will move marine management from a species-based focus to ecosystem-based, and will move the fishery management from a precautionary estimate of allowable catch to a scientific understanding of fishery facilitation (http://www.dfg.ca.gov/mrd/nfmp/index.html).

Management examples using a species-based approach include incidental take permits, time area closures, gear restrictions and/or other species-based limitations. Monitoring under the species-based management approach consists of direct assessment of individuals of a particular species.

This may be necessary to verify that impacts do not affect ESA species and/or managed species populations. Another example of species-based management is the use of indicator species as a metric of environmental heath. 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. A concern is that individual species may fail to detect relevant impacts until threshold levels are exceeded, thereby, precluding potential early management intervention to protect broader ecosystem values. The primary issue with a species-based management approach is appropriate selection of species to meet management objectives.

Both ecosystem-based and species-based monitoring programs have been applied to sediment management projects. The ecosystem-based monitoring approach is habitat-based and focuses on verification that habitat quality and/or boundaries are not significantly altered by project implementation.

Water quality monitoring is routinely conducted to ensure compliance with regional Basin Plan water quality objectives. Compliance with these objectives is designed to protect beneficial uses of waters, including ecosystem functions for fish and wildlife habitat.

Analysis of benthic invertebrate community recovery rates has been routinely used as an indicator of ecosystem recovery after beach nourishment and/or dredging (Sections 4.2.6 and 4.2.7). Sometimes dominant invertebrates are used as indicators of recovery (e.g., Peterson et al. 2000a). Because invertebrates provide trophic support to fish and birds, they are a useful indicator of broader ecosystem support. Peterson and Bishop (2005) noted that of the 46 studies they assessed, 78% were of macroinvertebrates, 33% included fish, and only 4% were of shorebirds.

Habitat boundaries have been used to assess whether sediment management activities remove, bury, or damage sensitive coastal strand, eelgrass, or surfgrass habitats (Sections 3.3.1, 3.3.7, and 3.3.8). Habitat boundaries and use of indicators generally are used to assess impacts on sensitive reef and/or kelp forest habitats (Sections 3.3.4, 3.3.5, and 3.3.6).

The species-based monitoring approach has primarily focused on sensitive species protection issues. This may include pre-construction habitat suitability surveys to determine potential for species occurrence and need for additional protective measures during construction. Construction monitoring is conducted to ensure activities do not directly harm or indirectly harass sensitive species or damage critical habitat.

The selection of an ecosystem-based or species-based monitoring approach or a combination of the two approaches may best be determined on a project-specific basis depending on a number of considerations, including the nature of the sediment management activity, project size, schedule, and proximity to sensitive species. These and other considerations important to selection of appropriate types of monitoring are reviewed in the following Section 7.2.

7.2 Overview of Monitoring Considerations

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., maintenance, repairs, renourishment). In addition, monitoring conducted during construction to support decisions of whether remedial actions are necessary to comply with permit conditions may be considered operational.
- *Performance* – to develop information and procedures for design verification and to document lessons learned that may be applied to future projects.

The following subsections address monitoring considerations for environmental monitoring relevant to biological resources.

7.2.1 Monitoring Program Elements

Monitoring is needed to answer a variety of management questions throughout all phases of project planning, implementation, and post-project evaluation. The analysis of data from an effective monitoring program should provide feedback to the design process (NRC 1995). In addition, monitoring should address management questions and support performance evaluations that may be applied to future projects.

Several types of management questions are relevant to biological resource protection and monitoring (Table 7.2-1). 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.

Table 7.2-1. Example management questions relevant to biological resource protection and monitoring.

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?
- 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 receiver site to inlet.
- Did unacceptable environmental impacts occur? How can they be avoided in the future?
    - Did sensitive habitat loss and/or degradation occur?
    - Did any sensitive species and/or critical habitat experience unacceptable environmental impacts?
- 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 will renourishment be necessary to maintain shoreline protection and persistent sandy beach habitat?
- 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?
- Is dune restoration effective for reducing renourishment schedules?
- Have commercial fishing activities and/or catches in the project vicinity substantially changed?
- How frequent should the same borrow site be used? When should alternate borrow sites be sought?
- When should structures be included as part of a project to increase the time between periodic renourishments?

Source: Inspired by NRC 1995.

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.

Each of the components is briefly reviewed below in the context of monitoring questions relevant to biological resource protection.

<u>Why</u> – The questions to be answered by the monitoring should be clearly stated. Questions may span a range of information requirements specific to the project and/or to provide information to support regional management decisions. The goal and/or objectives of the monitoring should be explicitly stated. Peterson and Bishop (2005) state that monitoring of beach nourishment should have two goals: first, to answer questions regarding environmental impacts, and second to quantify injury to allow compensatory mitigation.

<u>What</u> – What will be monitored may vary with project phase and biological issues of concern. Generally, pre-construction monitoring answers questions with respect to sediment characteristics and disposal options (including beach nourishment), biological resource constraints, and/or collection of data to support post-construction evaluations of impact significance. Construction monitoring usually is focused on documentation of water quality and/or other permit compliance, answering questions regarding need for additional operational controls to achieve compliance, and/or sensitive species protection. Post-construction monitoring generally addresses project performance and/or significance of impacts.

<u>Who</u> – Monitoring may be conducted by a variety of professionals, municipal staff, and volunteers (Ewing 1997). The monitoring technical requirements are the primary consideration with respect to who performs biological monitoring.

<u>Where</u> – Monitoring locations will depend on the questions being addressed. The primary consideration is the area of potential effect. Specific questions may examine near- and far-field differences, spatial extent of effect, and sensitive resource areas of concern.

<u>How</u> – Methods of monitoring will vary depending on how the information will be used; e.g., support decisions made with respect to operational controls during construction, verify compliance with permit requirements, and/or support environmental evaluations and impact assessments. Generally, visual observations and/or simple measurements are taken to address operational issues and/or compliance. Impact assessments require more rigorous sampling designs that permit comparison of pre- and post-construction monitoring at

appropriate temporal and/or spatial scales with respect to project-specific factors and resource of concern.

The most important consideration with respect to how monitoring will be conducted relates to the questions of concern. For example, if turbidity impacts are of concern, the method of monitoring may vary depending on the type of biological resources at risk; e.g., water clarity is relevant to visual foragers; light transmission is relevant to SAV habitats; and suspended solids is relevant to all aquatic life, particularly filter-feeders, suspension-feeders, and planktivores.

When – Monitoring may occur during all three project phases; e.g., before, during, and after construction. In addition, monitoring elements may vary depending on when a project is scheduled. For example, grunion monitoring is only necessary if the project is scheduled during the spawning season and habitat is suitable for spawning, but would be unnecessary if scheduled outside the spawning season (e.g., USACE 2006).

7.2.2 Scale and Duration of Monitoring

The scope of monitoring for beach nourishment projects generally relates to project size and potential for significant impacts (NRC 1995). Generally, the level of monitoring should reflect, to an extent, the expected effects and the uncertainty in the significance of these effects, fitting somewhere between the following extremes identified by the Ewing (1997):

> *If the effects will be slight, there may be no justification for monitoring, regardless of the uncertainty about whether an effect will occur. Likewise if there is high uncertainty about an effect, monitoring may not provide any gain and it may be preferable to consider mitigation or project denial.*

The NRC (1995) concluded that a more comprehensive monitoring program is warranted for large projects and projects conducted in areas with sensitive resources. In project areas with sandy substrates, small projects may only require receiving water quality and/or turbidity monitoring to comply with 401 water quality certification requirements if the project is implemented at a location or time period without sensitive species concerns (Table 7.2-2, Appendix D.). This also has been the case for mid- to large size projects (USACE 1995a, USACE 2000a, Merkel and Associates 2005).

Additional monitoring of mid- to large-sized projects in sandy substrate project areas generally have addressed specific impact concerns, such as benthic recovery rates (e.g., Parr et al. 1978, Reish 1982, Chambers Group 1992, SAIC and MEC 1996), fish community differences (e.g., Chambers Group 1994, SAIC and MEC 1996), and/or disturbance of sensitive species (see below).

This also is true for monitoring conducted elsewhere in the United States, where the focus has primarily been benthic recovery rates (e.g., Soloman et al. 1982, Reilly and Bellis 1983, Van Dolah et al. 1984, 1994, Johnson and Nelson 1985, Gorzelany and Nelson 1987, Peterson et al. 2000a, Posey and Alphin 2001, Rakocinski et al. 2001, Jutte et al. 2002) and occasionally benthic recovery and fish response (e.g., Burlas et al. 2001, Versar 2004), bird behavior and resting (CZR 2003), or other species concerns (e.g., turtle nesting, horseshoe crabs) (Greene 2002).

Table 7.2-2. Example monitoring elements for representative sediment management projects.

Project	Volume (cy)	Duration (Years)	Monitoring Elements
Projects Conducted Within and Near Sandy Substrate Habitats			
Moss Landing Harbor Maintenance Dredging, California (USACE 2002c)	20,227	Construction	Water (turbidity, receiving water limitations)
Santa Barbara Harbor Maintenance Dredging with Beach Discharge, California (USACE 1998a)	350,000 up to 600,000	Construction	Water (bacteria, turbidity, receiving water limitations), Biology (grunion, snowy plover)
Imperial Beach Nourishment Project, California (Parr et al. 1978)	1,000,620	15 months (up to 5 months after)	Physical (sediment grain size, total organic carbon, beach profiles, temperature), Biology (Intertidal and subtidal benthic invertebrates)
San Diego Harbor Deepening with nearshore discharge at Imperial Beach (Merkel & Associates 2005)	1,700,000	Construction	Water (Turbidity, receiving water limitations effluent Limitations)
Bogue Banks, North Carolina (Reilly and Bellis 1983)	1,180,000	20 months (2 months after)	Water (TSS), Physical (sediment grain size), Biology (intertidal and subtidal invertebrates)
Bald Head Island, Caswell, Oak Island, Holden Beach, North Carolina (Versar 2004)	5,600,000	14 months (1 year after)	Biology (intertidal and subtidal benthic invertebrates)*
Asbury Park to Manasquan Beach Erosion Control Project, New Jersey (Burlas et al. 2001)	8,083,440	6 years (7 & 13 months after)	Water (turbidity, TSS), Physical (sediment grain size, total organic carbon), Biology (sandy beach, nearshore, and borrow site invertebrates, surf-zone and borrow site fish, ichthyoplankton)
Perdido Key, Florida (Rakocinski et al. 1996)	9,260,000	3 years (1 year after)	Biology (intertidal and subtidal invertebrates)*
Projects Conducted Within Sandy Habitat and Hard Substrate and/or SAV Nearby			
Goleta Beach Nourishment Demonstration Project, California (Moffatt & Nichol 2003, 2005)	79,000 in 2003, 18,600 in 2004	2 years (before, during, and up to 2 years after)	Water (Turbidity), Physical (beach profiles, inlet status), Biology (rocky intertidal, eelgrass, kelp)
San Diego Regional Beach Sand Project, California (Coastal Frontiers 2004, AMEC 2005)	2,104,000 receiver sites 101,000 to 421,000	5 years (before, during, and 4 years after)	Water (turbidity, receiving limitations, bacteria), Physical (beach profiles), Biology (grunion, snowy plover, seabird foraging, rocky intertidal, nearshore reefs, kelp beds)
Anna Maria Island Beach Nourishment Project Manatee County, Florida (Coastal Planning & Engineering 2004)	2,320,000	3 years (before and 2 years after)	Physical (sedimentation) Biology (nearshore reefs)*

* Note: construction monitoring requirements were not reviewed.

In areas and/or seasonal periods when sensitive resources occur, additional monitoring has been conducted. For example, California projects with beach discharge during the grunion spawning season and/or in areas where snowy plovers nest have included monitoring prior to and during construction (e.g., Hutchinson et al. 1987, MEC 1997, USACE 1998a, Chambers Group 2001, AMEC 2002, Worden and Smith 2004). Dredging and/or beach nourishment projects permitted in areas near least tern nesting sites during the breeding season have been monitored (e.g., MEC 1997, USDN cited in USFWS 2000, AMEC 2002). Monitoring also has been required in project areas where sea otters occur (Bodkin and Rathbun 1988).

Pre- and post-project monitoring may be conducted to verify impact significance in areas of sensitive habitats. For example, sensitive rocky and SAV habitats were monitored to verify impact significance of the relatively small, 97,000 cy, Goleta Beach Nourishment Demonstration Project (Moffatt & Nichol 2003). Similarly, pre- and post-project monitoring of sensitive rocky and SAV habitats were required for the larger, 2001 San Diego Regional Beach Sand Project, which placed volumes ranged from 101,000 to 225,000 cy at receiver sites where sensitive rocky and SAV habitats were downcurrent and/or offshore (AMEC 2005). Pre- and post-project monitoring also has been conducted in areas with nearshore reefs in other areas of the United States (e.g., Courtenay et al. 1972, Lindeman and Snyder 1999, Coastal Planning & Engineering 2004a,b,c).

7.2.3 Monitoring Study Design and Impact Detection

Biological monitoring may be conducted to support a variety of information needs and/or environmental evaluations associated with project performance, such as:

- Observations of whether sensitive resources occur in the project area.
- Observations of whether sensitive species experience disturbance and/or harm during construction activities.
- Observations, measurements, and/or sampling to determine water quality (including turbidity) compliance with receiving water quality limitations.
- Sampling and evaluation of recovery rates of benthic invertebrates after beach nourishment and/or dredging.
- Sampling and evaluation of response of secondary consumers (fish, birds) to effects of beach nourishment and/or dredging.
- Measurements and/or sampling and evaluations to verify impact significance to sensitive resources from direct impacts during construction and/or indirect effects after construction.

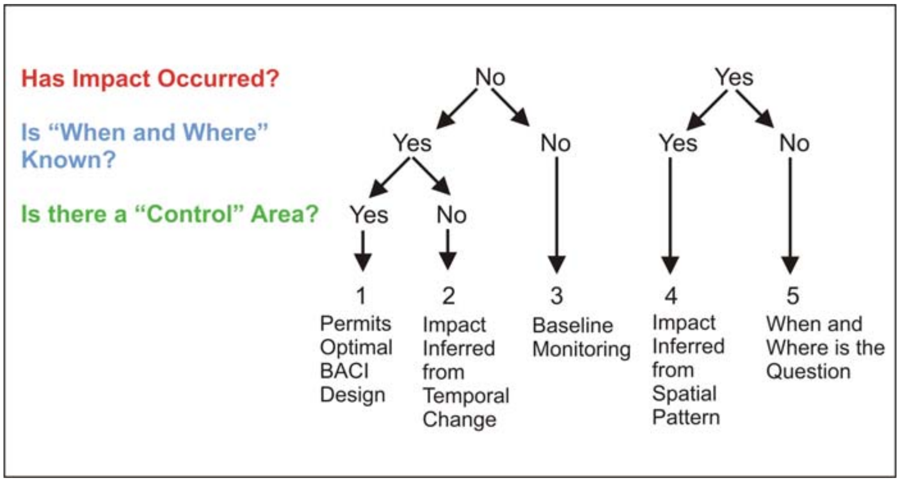
Generally, monitoring study design increases in scope as effort moves from observations, to measurements and sampling, to evaluation of impacts. For example, survey designs that address questions of sensitive resource occurrence in the area of potential effect may include reconnaissance or focused surveys involving presence/absence determinations and/or mapping of boundaries of sensitive habitats.

Survey designs during construction may include making systematic observations according to specific protocols to ensure activities do not directly or significantly impact sensitive resources.
Water quality compliance monitoring during construction may range from observations of turbidity plumes, taking *in situ* measurements, and/or taking samples for laboratory analysis to determine whether values are within or exceed established thresholds near and at specified distances away from the beach nourishment discharge or dredging source location.

In each of the above examples, the sampling designs are relatively simple, most of the effort is associated with the field work, and subsequent evaluations and reporting requirements are minimal.

In contrast, more rigorous sampling designs often are required to detect impacts to biological resources against the backdrop of natural environmental variability ("noise"). Before and after impact sampling must be conducted. A BACI (before-after-control-impact) sampling design generally is recommended to identify impacts when temporal and/or spatial scales of variability make detection of impact difficult (Green 1979, Stewart-Oaten et al. 1986, Peterson and Bishop 2005). For that sampling design, temporal replication before and after a disturbance is necessary to ensure that accurate estimates are made of average conditions, and spatial replication away from disturbance is essential for discriminating project-related impacts from those due to natural environmental variability (Underwood 2000).

Green (1979) reviewed that environmental studies generally fall within five categories with respect to an optimal BACI design. Determination of what category and type of impact analysis that can be conducted is shown in the following text box



Source: Redrawn and slightly modified from Green 1979

The level of sampling effort required to detect an impact will vary depending on how impact is defined. To allow precautionary decision-making, the type of predicted impact should be specified, along with the magnitude and duration considered significant (Underwood and Chapman 2003). It has been suggested that monitoring would be greatly improved if there was clearer upfront guidance from decision-makers with respect to what sorts, frequencies, and sizes of impacts they need to detect and manage (Underwood 2000).

For example, detection of a 10% decrease in population abundance and cover will require more sampling effort than detection of a 50% change. In addition, detection of habitat degradation will require more effort than habitat loss. The power of the BACI analysis to detect a certain level of change is an important consideration with respect to number of sampling locations and frequency of sampling.

A primary question addressed by many monitoring studies after sediment management projects is benthic invertebrate recovery rates (Sections 4.2.6, 4.2.7). Important considerations with respect to recovery relate to species composition, species-abundance relationships, and size distribution (or biomass) (Pearson and Rosenberg 1978, Reilly and Bellis 1983, Newell et al. 1998). Newell et al. (1998) reviewed that a practical approach to determination of "recovery" is that at least 80% of the species diversity and biomass is restored; abundance is not as informative since early succession may be characterized by high abundance of a few, opportunistic species. 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 and at control locations. This type of question has important implications with respect to hypothesis testing and sample size. Generally, fewer samples are required to test a one-tailed hypothesis (e.g., value is ≥ than before or control) than a two-tailed hypothesis (e.g., value is different, < or > than before or control) at the same level of power (Sokal and Rohlf 1969).

Sampling effort also may vary depending on the type of impact. Generally, more sampling locations are required to detect longer-term press disturbances while shorter-term pulse disturbances are best detected when the number of sampling periods is maximized (Underwood and Chapman 2003). Replication both at impact and "control" areas has been recommended to avoid confounding associated with natural variability that may occur between different locations (Lindegarth et al. 2000). This also may be an important consideration with respect to unbalanced temporal design. For example, the time period during which pre-construction data is collected often is limited, and more surveys may be conducted after impact to determine recovery rates or longer term press disturbance impacts. Differences between before and after periods may be greater than differences in the after period due solely to natural environmental conditions. Therefore, replication of reference sites will help overcome potential Type II errors (i.e., concluding an impact has occurred when it has not).

Peterson and Bishop (2005) reviewed 46 beach monitoring studies and identified a number of inadequacies in sampling designs. They concluded that only 11% controlled for both natural spatial and temporal variation, 56% reached conclusions that were not adequately supported by data, and 49% failed to meet publication standards for citation and synthesis of related work. Several specific short-comings of sampling designs were reviewed by the authors, including lack of independent controls, inadequate replication, insufficient pre-project baseline data to characterize natural differences between control and treatment sites, lack of formal statistical tests of significance, and insufficient study durations that terminated before recovery was demonstrated.

7.2.4 Use of Indicator Species and/or Indices

Use of indicator species sometimes is recommended to reduce the complexity of sampling designs and/or survey effort. The rationale is that the indicator is representative of broader habitat and/or ecosystem response.

An important consideration with respect to selection of indicator species is impact threshold. Sensitive indicator species may include those with a low tolerance of disturbance, water quality reduction, pollutant levels, and/or recovery from disturbance (Dayton et al. 1984, Foster and Schiel 1985, Moore and Orth 1997, Newell et al. 1998). Disturbance indicators often include early colonizing, opportunistic species (Daly and Mathieson 1977, Pearson and Rosenberg 1978, Littler et al. 1983, Stewart 1991, Newell et al. 1998). Many species fall between these extremes and generally are not used as indicators.

Another consideration is impact factor of concern. For example, different indicators may be relevant to questions regarding turbidity influence on SAV, interference with foraging of visual predators, and/or harm to early life stages. Examples of indicators are reviewed below.

<u>Turbidity – Light Limitation</u>

The literature review indicates that aquatic vegetation, herbivores, and suspension-feeders have substantially reduced diversity, abundance, and/or occurrence in areas with chronic turbidity and/or sedimentation (e.g., Bence et al. 1989, Pondella et al. 1996, CRM 1997). Large overstory algae such as giant kelp appear to be sensitive to prolonged turbidity. Eelgrass is recognized as a good indicator of environmental health because it is sensitive to poor water quality (eutrophication, turbidity). It has been selected as an indicator species for which improvements in water quality conditions in the Chesapeake Bay and coastal lagoon systems are assessed on the East Coast of the United States (Moore and Orth 1997).

Substantial eelgrass die-back has been documented from substantial turbidity and light-limitation over a period of two to three weeks associated with severe storm conditions (Cabello-Pasini et al. 2002). Eelgrass die-back also has been documented from prolonged turbidity exposure in a confined basin during dredging (Sabol et al. 2005).

Overstory kelp and eelgrass may be effective indicators because of their sensitivity to critical turbidity levels and boundaries are easily mapped. Furthermore, the species are ecologically important in structuring kelp forest and eelgrass habitats and, thus, are suitable ecosystem-based indicators. Eelgrass blades and kelp canopy vary seasonally associated with natural periods of annual die-back or thinning. Therefore, short-term response may only be detected during seasonal growth periods; however, longer-term response may be determined over multiple seasons.

Monitoring turbidity effects on eelgrass and kelp may be unnecessary for small projects with potential exposure durations < 2 weeks based on considerations such as carbohydrate reserves (North 1981, Gerard 1982, Dean and Jacobsen 1984, Zimmerman et al. 1991, Cabello-Pasini et al. 2002). However, they may be very useful as indicators for ecosystem impacts resulting from prolonged turbidity, sedimentation, and/or equipment damage.

<u>Turbidity – Foraging Interference</u>

Secchi disk depths < 3 ft (1 m) have been used to identify unsuitable water clarity for visual foragers such as California least tern and California brown pelican (USFWS 2000). The rationale is that reduced water clarity will interfere with feeding efficiency of these visual predators, if present during sediment management activities. Secchi disk readings require use of a boat; otherwise equipment is inexpensive and easy to use. Secchi disk measurements often are routinely collected during water quality monitoring to comply with WDRs or 401 Water Quality Certification.

Burial, Sand Scour, and/or Sedimentation

Several studies indicate reduced species diversity and dominance by sand, stress-tolerant species on hard-bottom habitat subject to seasonal sand accretion, erosion, and scour (Daly and Mathieson 1977, Ambrose et al. 1989, Litter et al. 1983, Stewart 1991, Pondella et al. 1996). Low-relief, hard substrate dominated by algal turf and having few to no associated invertebrate species was used as an indicator of sand, stressed reef (MEC 2000a).

Sensitive habitats differ in vulnerability to burial and/or sedimentation. Giant kelp is very sensitive to sand scour and sedimentation (Dayton et al. 1984, Foster and Schiel 1985). Therefore, this species may represent an effective indicator of reef ecosystem impacts from sedimentation in areas where this impact is of concern. Seagrasses may display a greater tolerance to sedimentation before critical thresholds are reached (Littler et al. 1983, Stewart 1989, Harrison 1990), but are still effective indicators because a substantial portion of their habitat value to other species relates to structural aspects of plant occurrence and density.

Reef Quality

The richest species assemblages are associated with rocky habitats with higher relief, diverse substrate characteristics, and microhabitats (Ambrose et al. 1989). The microhabitat aspect of reef function may relate to surface texture (pitted, cracked), ledges, and rock formations of different size. Perennial vegetation and long-lived species are associated with higher relief reefs with hard substrate extending above the sand level throughout the year ("perennial reefs").

Reefs that experience substantial sand level change, including filling-in along the reef base to the same level or overtopping the reef support opportunistic, annual species and/or sand tolerant species. Some reefs may only be seasonally exposed above the sand level ("ephemeral reefs").

Monitoring of rocky intertidal, nearshore reef, and kelp bed habitats in proximity to beach nourishment projects in California have included use of indicator species. For example, several indicators were used during the 2001 San Diego Regional Beach Sand Project (Table 7.2-3). Species have been selected that have been well studied, based on ecological importance in structuring communities, occurrence at discrete tidal elevations, vulnerability to human impacts, practical considerations for long-term monitoring, and relatively common occurrence (AMEC 2005, Engle 2005). Therefore, indicators may include species that vary in tolerance to disturbance and sand inundation. Explicit selection of species that differ in sand tolerance (e.g., "sand-loving", sand tolerant, sand sensitive) and longevity (annuals, long-lived) is recommended to increase ability to distinguish different levels of sand inundation impacts.

Invertebrate Indicators

Emerita mole crabs, *Donax* clams, and/or *Ocypode* ghost crabs have been used as indicators of sandy beach forage and/or habitat quality. Peterson et al. (2000a) compared *Emerita, Donax,* and *Ocypode* abundance at bulldozed and unbulldozed beach site, and used *Emerita* and *Donax* to examine short-term impacts of beach nourishment. *Emerita* and

Donax are important prey items for shorebirds, fish, and *Ocypode* (DeLancey 1989, Peterson et al. 2000a, Hubbard and Dugan 2003).

Table 7.2-3. Example hard bottom indicator species.

Rocky Intertidal	Nearshore Reefs	Kelp Beds
Rockweed (*Silvetia compressa*)	Giant kelp (*Macrocystis pyrifera*)	Giant kelp
Feather boa kelp (*Egregia menziezii*)	Feather boa kelp	Leafy red complex (*Rhodymenia/ Gigartina*)
Red algal turf (*Corallina* spp.)	Sea palms (*Eisenia arborea*)	Red turf algae (*Corallina/Bossiella*)
Surfgrass (*Phyllospadix* spp.)	Sufgrass	Understory kelp (*Pterygophora californica*)
Sargassum weed *(Sargassum muticum)*	California spiny lobster (*Panuliris interruptus*)	Gorgonian (*Muricea californica*)
Acorn barnacle (*Chthamalus* spp.)	Sea fans (*Muricea* spp.)	Stalked tunicates (*Styela montereyensis*)
Pink thatched barnacle (*Tetraclita rubescens*)		Red urchins (*Strongylocentrotus franciscanus*)
Goose barnacle (*Pollicipes polymerus*)		Purple urchins (*S. purpuratus*)
California mussel (*Mytilus californianus*)		Kellet's whelk (*Kelletia kelletia*)
Owl limpet (*Lottia gigantea*)		Boring clams (*Parapholas californica*)
Black abalone (*Haliotis cracherodii*)		
Ochre seastar (*Pisaster ochraceus*)		
Aggregating anemone (*Anthopleura elegantissima/sola*)		
Sand castle worms (*Phragmatopoma californica*)		

Emerita is a useful indicator of successful recruitment, biomass development, and sand persistence. *Emerita* recruits to California beaches in spring-summer, and size structure of the population is a useful indicator of growth and biomass development after recruitment (Reilly and Bellis 1983). Presence of large, adult sand crabs early in the season indicates successful overwintering, which is generally associated with sand persistence (Dugan and Hubbard 1996). Because *Emerita* is a substrate generalist (Dugan and Hubbard 1996, Dugan et al. 2000b), it may not be a sensitive indicator of substrate change.

Donax species exhibit varying tolerance to change in grain size characteristics (Nel et al. 2001, Peterson et al. 2002), suggesting that they may represent useful indicators of substrate change. However, sensitivity varies among species. Information is limited on substrate relationships for California *Donax* species. Recruitment variability of California *Donax* may be substantial among years (Morris et al. 1980). These limitations should be adequately considered with respect to use of *Donax* as an indicator species.

Barros (2001) proposed counting ghost crab (*Ocypode sp.*) burrows as an indicator of environmental degradation of beaches. Ghost crabs occur on the backshore of beaches, particularly those backed by dunes. Although causal factors were acknowledged as being poorly understood, heavy recreational use and/or structural damage of dunes were suggested as being influential. Peterson et al. (2000a) reported ghost crabs were sensitive to beach bulldozing, with substantially fewer burrows observed after that activity.

Although ghost crabs do not occur on California beaches, other species indicative of the foreshore/backshore interface such as talitrid amphipods (beach hoppers) may be a useful indicator of sand persistence (when present) or erosional conditions (when absent). Prior to the 2001 San Diego Regional Beach Sand Project (2001), beach hoppers were not observed during spring but were seen at some beaches during summer (MEC 2000a). In contrast, beach hoppers were observed during spring and summer at some of the same sites after nourishment (SAIC 2006). Talitrid amphipods also are sensitive to beach grooming (Brown and McLachlan); therefore, they may be a useful indicator of human disturbance.

Based on consideration of the above relevant reports, invertebrate indicators such as *Emerita* can be used to answer basic questions with respect to presence of forage base, development of biomass after recruitment, and sand persistence. Occurrence of Talitrid amphipods may be useful as an indicator of habitat quality (e.g., beach width) or degradation (e.g., erosion, human disturbance). Talitrid amphipods feed on washed ashore wrack vegetation; therefore, food availability also would require consideration. Additional study is necessary to field-validate the usefulness of this species as a habitat quality indicator. The usefulness of *Donax* as an indicator may be limited by interannual recruitment variability. The utility of single species indicators is considered limited with respect to answering questions regarding habitat quality. Currently, assessment of species diversity and types of species (e.g., representing different feeding modes and life histories) are considered the most effective method for assessing effects of change in substrate and/or habitat quality.

<u>Mechanisms of Impact</u>

Wilber et al. (2003) reported that monitoring that focuses on mechanisms of impact may be more cost effective than monitoring of highly mobile populations such as surf zone fish that may result in inconclusive results. They suggested that examination of the physical condition of fish in the vicinity of the sediment plume may be more informative of potential impacts.

7.2.5 Monitoring Objectives

Ecological monitoring studies may include environmental and biological elements depending on the study objectives. The objectives vary depending on project phase. Monitoring during pre- and post-construction phases generally relate to answering questions with respect to sensitive resource constraints (Section 7.2.2). Monitoring during the construction phase focuses on compliance issues and sensitive resource protection.

Table 7.2-4 provides examples of different types of monitoring conducted during representative California sediment management projects (see Appendix D.2 for additional examples). Sediment testing during the pre-project phase to determine compatibility for placement on the beach or nearshore and water quality compliance monitoring during construction characterize many of the monitoring programs associated with dredging and beach nourishment in California. Exceptions include projects conducted during grunion spawning season, projects conducted near sensitive species nesting and/or roosting sites, and/or areas with sensitive habitats (reefs, SAV).

Table 7.2-4. Representative monitoring programs during beach nourishment projects.

Project (Habitat Types)	Volume (cy) and Habitat Types	Pre-construction	Construction	Post-Construction
Imperial Beach Nourishment Project:1977 (Parr et al. 1978)	1,000,620 Sandy beach, sandy subtidal	Sediment testing; faseline data for construction and post-construction monitoring	Intertidal and subtidal benthic invertebrates, grain size, total organic carbon, water temperature, beach profiles	Sediment grain size, total organic carbon, beach profiles, temperature, Intertidal and subtidal benthic invertebrates
Asbury Park to Manasquan Beach Erosion Control Project:1997-1999 (Burlas et al. 2001)	8,083,440 Sandy beach, sandy subtidal	Sediment testing; baseline data for post-construction monitoring	Turbidity	Sediment grain size, total organic carbon, sandy beach, nearshore, and borrow site invertebrates, surf-zone and borrow site fish, ichthyoplankton, recreational fishing
Santa Barbara Harbor Maintenance Dredging with Beach Discharge (USACE 1998a)	350,000 up to 600,000 Sandy beach, sandy subtidal	Sediment testing	Bacteria; if Mar and Apr schedule then grunion, snowy plover nesting	
San Diego Bay Channel Deepening Project with nearshore placement: 2004-2005 (Merkel & Associates 2005)	550,000 Sand-cobble	Sediment testing; *Caulerpa* at dredge location	Effluent limitations receiving water limitations, turbidity (light transmission)	
San Diego Regional Beach Sand Project: 2001 (SANDAG and USDN 2000, MEC 2000a, AMEC 2002, 2005, Coastal Frontiers 2004)	2,104,000 receiver sites 101,000 to 421,000 Sandy-cobble beach, sandy subtidal, rocky intertidal, rocky subtidal, kelp beds	Sediment testing; grunion habitat; baseline data for post-construction monitoring	Effluent and receiving water limitations, turbidity (water clarity, NTU), bacteria, seabird foraging, grunion, end of snowy plover nesting season	Rocky intertidal, Nearshore reefs, kelp beds, lobster, beach profiles
Goleta Beach Nourishment Demonstration Project:2003 (Chambers Group 2003, 2004, Coastal Frontiers 2003, 2004 cited in Moffatt & Nichol 2005)	79,000 in 2003, 18,600 in 2004 Sandy beach, rocky intertidal, eelgrass, kelp beds	Sediment testing; baseline data for post-construction monitoring	Turbidity plume	Rocky intertidal, eelgrass, kelp, beach profiles, inlet status

Monitoring objectives associated with the different project phases are reviewed below. Types of monitoring conducted during pre-construction, construction, and post-construction are reviewed in greater detail in Sections 7.3 through 7.5, respectively.

<u>Pre-construction Phase</u>

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 and/or after construction.
- *Establish baseline conditions* - to support post-project assessments of impact significance and/or project performance.

Types of monitoring questions that may be addressed during the pre-construction phase are listed in the box below.

Monitoring Questions That May Be Addressed During the Pre-Construction Phase

Determine Substrate Characteristics

- What are physical and chemical characteristics of source sands and/or dredged materials?

Characterize Existing Conditions

- What habitats occur in the project area?

Identify Constraints

- Are sensitive and/or managed species present and/or are habitat conditions suitable for their occurrence that may require implementation of protective mitigation measures?
- Does *Caulerpa* or other invasive species occur in project area?

Support Final Project Design

- What are the best routes for pipelines, vehicles, and/or vessels to avoid and minimize biological impacts?

Establish Baseline Conditions

- What habitat functions and values will be directly impacted?
- What are the boundaries and quality of sensitive habitats that may be indirectly impacted?

Generally, available existing information and/or reconnaissance level surveys are used to characterize biological existing conditions in support of CEQA/NEPA documents. In areas with greater environmental complexity and/or sensitive resource issues, a reconnaissance survey may be conducted to describe different habitat types and resources and environmental constraints in the project area. Constraints generally refer to sensitive resources that need to be avoided or otherwise protected during sediment management activities.

Information on shoreline habitats and sensitive resources may be obtained from a variety of sources. For example, the CDFG Office of Spill Prevention and Response has GIS shapefiles available online of shoreline habitats and sensitive biological resources (http://www.dfg.ca.gov/itbweb/gis/ospr.htm). Information on some constraints such as federal and state endangered, threatened, and/or species of concern may be obtained by contacting the USFWS for current information.

The field portion of the constraints analysis may vary depending on site-specific data gaps. The following examples illustrate a range of level of effort conducted during reconnaissance level surveys in support of environmental review:

- Several types of reconnaissance level surveys were conducted for the 2001 San Diego Regional Beach Sand Project (MEC 2000a). Surveys included characterization of benthic invertebrates within receiver site footprints, types of biota on intertidal hard substrates, side-scan sonar mapping of nearshore reefs and diver surveys to describe dominant biota and reef heights, and surveys of macroinvertebrates and fish at borrow sites. Other available information was used to supplement the characterization of marine resources in the project area.
- Benthic infauna communities were sampled at receiver and borrow sites and documented in a technical appendix to the ERIR/EA for the BEACON Beach Nourishment Demonstration Project EIR/EA (Chambers Group 1992). Other available information was used to supplement the characterization of marine resources in the project area.
- Intertidal and subtidal reconnaissance surveys were conducted to identify habitat types (i.e., sandy, reefs, surfgrass) and dominant biota on reefs in support of the marine biological impact assessment in support of the San Clemente Beach Replenishment Program Criteria and Concept Design (CRM 2000).

In contrast, more extensive monitoring protocols may be used to establish pre-construction baseline conditions to support post-construction impact verification assessments (Table 7.2-4, also see post-construction monitoring below).

Construction Phase

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 monitoring to ensure conformance with the California Ocean Plan. For example, small, opportunistic beach nourishment projects that qualify under RGP 67 (USACE 2006) may only require turbidity monitoring in sandy habitat areas if scheduled outside the grunion spawning season and no sensitive habitats or species are in the vicinity. Water quality monitoring requirements generally apply to any size or type of sediment management project with in-water activities and/or discharges. However, what parameters and how water quality is monitored has not been standard in California (Section 5.5.2.1). Protection of water quality represents the simplest form of ecosystem-based, operational compliance monitoring.

If sensitive habitats occur, monitoring may be used to ensure adequate buffers are maintained and turbidity is controlled to avoid excessive concentrations. If sensitive species occur in the project area, they may need to be monitored to ensure that project activities do not harm or disturb individuals.

Monitoring elements during the construction phase of California sediment management projects have addressed:

- Discharge effluent limitations.
- Receiving water limitations, often with additional specification for turbidity.
- Bacteria.
- Grunion spawning.
- Sensitive bird foraging, roosting, breeding, and/or nesting activities.
- Night-time light levels near nesting sites.
- Marine mammal behavior.

<u>Post-Construction Monitoring</u>

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 significance of effects (CCC 1997).

Primary considerations include project size and proximity to sensitive resources. For small to moderate sized projects in sandy habitat areas, additional monitoring beyond the construction period may not be required (Table 7.2-2, e.g., USACE 1998a). This also was the case for beach receiver sites during the 2001 San Diego Regional Beach Sand Project that were implemented in areas with sandy habitat in the nearshore.

A number of moderate to large-scale sediment management projects have been conducted to answer questions with respect to benthic recovery after beach nourishment, borrow site dredging, and/or embayment dredging (Sections 4.2.6, 4.2.7). Substantially fewer have examined secondary trophic effects on shorebirds and/or fish (e.g., Burlas et al. 2001, Peterson et al. 2002, CRZ 2003, SAIC 2006). Linkage of effects between benthic recovery and recreational fishing also has received limited attention (Burlas et al. 2001).

7.3 Pre-Construction Surveys and/or Monitoring

Different types of surveys that may be conducted prior to construction include:

- Sediment testing.
- Sensitive resource occurrence.
- Invasive species occurrence.

Pre-construction surveys also may be required to establish baseline conditions as part of a BACI survey design to verify significance of impacts for projects conducted in areas with sensitive habitat concerns. The methods used for monitoring will depend on type of resource and impact issue of concern. Baseline surveys in support of post-construction impact significance evaluations are discussed in Section 7.5.

7.3.1 Sediment Testing

Sediment testing of the physical and chemical properties of the substrate is required prior to dredging, ocean disposal, and/or beach nourishment programs. The primary national guidance document for embayment dredge material and upland sediment source testing is the Inland Testing Manual (ITM) (EPA and USACE 1998). The "Greenbook" is used to evaluate sediments for ocean disposal (EPA and USACE 1991). A Sampling and Analysis Plan (SAP) should prepared for approval by regulatory agencies (EPA, USACE) prior to sample collection and testing to ensure the testing results meet testing requirements and information needs of decision-makers. Sediments used for beach nourishment must test "clean" per testing requirements and satisfy grain size characteristics for beneficial use (also see Section 5.2.3.3).

Online Sources Information Regarding Sediment Testing

Inland Testing Manual
http://www.epa.gov/waterscience/itm/

Ocean Testing Manual
http://www.epa.gov/OWOW/oceans/gbook/index.html

Beneficial Use Guidance
http://www.spn.usace.army.mil/conops/beneficialreuse.pdf
http://el.erdc.usace.army.mil/dots/budm/budm.cfm

Monitoring Considerations:

Sediment testing results are used to support several types of biological impact assessments, including:

- Prediction of turbidity plumes based on grain size distribution, percent content of fines, overlying water depths, and hydrodynamics.
- Prediction of benthic recovery rates based on similarity of source sediments with receiver sites.
- Identification of substrate characteristics of potential concern to sandy beach habitat functions (e.g., high shell content, coarse sand, silt/clay).

Adequate characterizations of source and receiver sediment characteristics are needed to support the above types of environmental evaluations.

From a biological impact perspective, sediment characteristics should be free of substantial contamination and closely match those at the receiver site. Sampling requirements specified for the SCOUP program address testing of different types of sand sources (Moffatt and Nichol 2006a), which are briefly referenced below with a few annotated comments.

- Sampling guidance specifies that beach receiver site samples should be collected along transects perpendicular to shore, with at least two profiles sampled for each receiver site 1 mi (1.6 km) in length or less and at least one additional profile for every additional ¼ mi (0.4 km) Along the profile samples would be collected every 6-ft change in elevation from the backshore to depth of closure; e.g., +12, +6, 0, -6, -12, -18, -24, and -30 ft MLLW. Sample collection is specified for summer when sand volume typically is greatest on the beach. All samples would be analyzed separately using standard sieve analysis and a grain size gradation "envelope" is prepared for the beach. *Comment*: it may be useful to prepare grain size distribution summaries for backshore, foreshore, and nearshore samples to facilitate definition of existing conditions for those areas that will provide baseline for comparison of conditions over time if the site is used for renourishment.
- Sediment guidance for source material specifies that sampling should be representative of material, reflecting volume, homogeneity, potential for pollutants, etc., and will be approved on a case-by-case basis. The sample locations should reflect the maximum volume of material to be removed, do not need to be evenly spaced, but located relative to thickness of deposit to be removed. Samples from individual boring locations should be collected from near-surface, mid-depth, and at the bottom of potential source. These samples can be homogenized into one bulk sample for individual analyses, assuming USACE compositing requirements have been met. *Comment:* Compositing requirements generally are based on geotechnical appearance of core; e.g., whether obviously different layers are present. Separate bulk composite samples should be prepared if obvious layers are present.

Vibracore sampling
Photo credit: Danny Heilprin, SAIC

- Sediment guidance for source material acceptability also addresses surface characteristics such as color (must be reasonable match of existing beach after natural color changes occur), particle shape (must not be substantially angular or jagged shaped), debris (must be free of trash, debris, and organic matter), and compactability/moldability (must not form hardpan crust if placed subaerially on beach). *Comment:* No criteria are given with respect to how to identify when compactability/moldability may be an issue, but guidance is given that material with this trend should be placed in nearshore. Speybroeck et al. (2006) note that compaction is a short-term problem that can be remedied by "tilling" the beach after construction; wave action will naturally soften the beach, especially during storms.

7.3.2 Sensitive Resource Surveys

Existing conditions in project areas must be described to support CEQA/NEPA environmental evaluation and review and/or permit applications. Reconnaissance surveys conducted to support existing condition assessments generally are documented in a project Biology Report that accompanies the CEQA/NEPA document. Those surveys are conducted to satisfy environmental review requirements.

Additional surveys may be conducted prior to construction to provide updated information on sensitive habitat boundaries and/or species occurrence to support logistic decisions with respect to final construction plans. These surveys also may represent mitigation measures to ensure impacts are avoided and/or minimized during project implementation (Section 6.3.8). Pre-construction surveys may be appropriate in areas where sensitive resource occurrence varies within and/or between years. They also may be appropriate in areas where sensitive habitats have patchy occurrence and detailed boundary information is not needed until construction and/or access plans are finalized. Results of the surveys may support decisions as to whether additional protective measures and/or monitoring may be warranted during construction.

The following types of sensitive resource surveys have been conducted prior to construction for California sediment management projects (Appendix D.2):

- Sensitive habitat boundaries.
- Pismo clam bed occurrence.
- Grunion habitat suitability.
- Snowy plover occurrence.

Sensitive resource surveys should be conducted by qualified biologists. A variety of surveys methods may be used depending on the resource and location of occurrence.

7.3.2.1 <u>Sensitive Aquatic Resource Survey</u>

Relevant Reports

- RGP 67 (USACE 2006) specifies that a Sensitive Aquatic Resource (SAR) survey be conducted and submitted as part of the permit application requirements. The MMRP for the SAR must address turbidity plumes near any Areas of Special Biological Significance (ASBS), Pismo clam, and grunion habitat suitability and protection measures (as necessary depending on results of habitat suitability survey) (USACE 2006).

- Pre-construction surveys have been recommended to avoid direct impacts to coral reefs during borrow site dredging (Courtenay et al. 1972).
- Pre-construction surveys were recommended and used to finalize construction pipeline routes, monobuoy location, anchorages, and vessel routes prior to the 2001 San Diego Regional Beach Sand Project (MEC 2000a, AMEC 2002).
- Pre-construction surveys were recommended and used to refine pipeline routes and barge mooring locations for the Goleta Beach Nourishment Project (Chambers Group 1992, 2003, Moffatt & Nichol 2003).
- A pre-construction survey to determine occurrence of Pismo clam beds and/or sensitive hard bottom or SAV habitats was specified for the SCOUP program prior to implementation of a nearshore placement alternative (Moffatt & Nichol 2005b, 2006). Depending of survey results, receiver site boundaries may be adjusted and/or a different placement method used to avoid direct impacts.

Monitoring Considerations

Locations of ASBSs may be determined by reference to online sources (http://www.swrcb.ca.gov/plnpols/oplans/asbs_info.html). Methods for monitoring turbidity plumes, including additional measures if plumes exceed spatial criteria are included in RGP 67 (USACE 2006). The potential for turbidity to be an issue for an ASBS may be determined based on considerations of receiver site distance and orientation (up- or downcurrent) to an ASBS, placement location and method, and grain size distribution of source material. If it is likely that turbidity plumes will affect an ASBS, additional turbidity monitoring should be included in MMRP to satisfy RWQCB compliance requirements to address significance of plumes. Monitoring considerations for turbidity during construction are reviewed in Section 7.4.3. Monitoring considerations for sensitive habitat boundaries, grunion habitat suitability, and Pismo clam surveys are provided below.

7.3.2.2 Sensitive Habitat Boundaries Survey

This measure involves conducting a focused sensitive habitat survey to support logistic decisions for final construction plans. This measure may be appropriate in areas with coastal strand, reefs, and/or SAV habitats.

Monitoring Considerations:

Pre-construction surveys should be effective for finalizing equipment placement and/or access routes to avoid direct impacts to sensitive habitat resources (e.g., reefs, SAV, coastal strand). This measure should be used in areas where there is uncertainty and/or natural variability in boundaries of sensitive habitats. If there are potential impact concerns to sensitive habitats, pre- and post-construction monitoring will be necessary to verify significance of impacts. Sampling design considerations differ in complexity depending on resource of concern (Section 7.5.1).

7.3.2.3 Pismo Clam Bed Survey

This measure involves conducting a survey to determine occurrence of Pismo clam beds.

Relevant Reports:

- RGP 67 (USACE 2006) specifies that a Sensitive Aquatic Resource (SAR) survey be conducted and submitted as part of the permit application requirements. Pismo clam is one of the marine resources to be addressed in the SAR survey.
- A pre-construction survey to determine occurrence of Pismo clam beds and/or sensitive hard bottom or SAV habitats was specified for the SCOUP program prior to implementation of a nearshore placement alternative (Moffatt & Nichol 2005b, 2006). Depending of survey results, receiver site boundaries may be adjusted and/or a different placement method used to avoid direct impacts.
- A pre-construction surveys from +3 to -10 ft MLLW to determine occurrence of Pismo clams, and if found a collection and relocation effort in coordination with resource agencies (DFG, NMFS, USFWS) were specified prior to discharge of maintenance dredge materials on the beach or in the nearshore at Hueneme Beach, Ventura County (USACE 1994a). This measure was not a requirement in the subsequent EA (USACE 2000).

Monitoring Considerations:

Pre-construction surveys should be effective for finalizing equipment placement and/or access routes to avoid direct impacts to important fishery grounds (e.g., Pismo clam beds, sensitive reproduction areas of Dungeness crabs, and/or other substantial fishery spawning ground identified by CDFG and/or NMFS as being of local concern). If an important fishery ground is identified, project boundaries may require adjustment to avoid direct impacts and an appropriate buffer distance may be required to minimize impacts (Section 6.3.8.3).

Pismo clam beds may be persistent areas due to limited larval dispersal and individuals being long-lived (Section 4.2.4); therefore, there is no need for a seasonal limitation with respect to timing of surveys. RGP 67 (USACE 2003) specifies that CDFG shall be contacted prior to the SAR survey to request current information on local populations of Pismo clam populations and review survey methods. It may be most effective for surveys to be conducted by certified diver biologists along band transects, the number of which should provide representative characterization with project footprints. The presence or absence of Pismo clams should be recorded for each transect. Pismo clams may have sparse occurrence, particularly juveniles due to opportunistic settlement. Therefore, estimating relative density within an area of known dimensions (e.g., count clam siphons in $1m^2$ quadrats) along band transects should be effective for determination of sparse occurrence versus presence of a clam bed.

Survey results may be used to determine the need for adjustment of construction boundaries. Therefore, if a Pismo clam bed is detected, the boundaries of the bed should be determined. Although it may be technically feasible to relocate Pismo Clams, this is not recommended due to data gaps with respect to environmental requirements that promote formation of aggregated Pismo clam beds. Surveys results should be submitted to resource agencies according to requirements specified in the MMRP.

7.3.2.4 Locally Important Fishery Grounds

This measure involves conducting a survey to verify occurrence of important fishery grounds within borrow site and/or nearshore receiver site prior to construction activities and adjusting site boundaries to avoid significant impacts, if necessary. This measure may be applicable in areas where there may be concern for impacts to sensitive reproduction areas of Dungeness crabs, and/or other substantial fishery spawning ground identified as a concern by resource agencies (CDFG, NMFS) or local fishing organizations.

Relevant Reports:

- Commercial fishermen have expressed concern regarding the potential for impacts to Dungeness crabs with nearshore placement of dredged materials (K. Berresford, USACE, San Francisco District, personal communication 2005).

Monitoring Considerations:

Dungeness crab populations may be more vulnerable during the mating season when adult crabs concentrate in shallows (peak between March and June), females are in berried condition (between September and December, may vary geographically), and males are soft-shelled (summer-fall) (Section 4.2.3). During these periods, female and male crabs are less mobile and/or may be buried nearly completely in sediment. Therefore, in areas where impacts to the Dungeness crab fishery are of local concern, surveys should be scheduled with consideration of project schedule and seasonal periods of concern in consultation with CDFG. Other mitigation measures to avoid and/or minimize impacts may include use of environmental windows or dredging operational controls (Section 6.4.2 or 6.4.3.2).

RGP 67 (USACE 2003) specifies that CDFG shall be contacted prior to the SAR survey to request current information on local populations of Pismo clam populations. It is recommended that the request also seek current information on other substantial fishery grounds of local concern (e.g., Dungeness crab sensitive reproduction areas, other local fishery spawning grounds of concern). That step may increase the broader effectiveness of this measure over time in response to changes in commercial fishing activities.

7.3.2.5 California Grunion Habitat Suitability

This measure involves conducting a survey to determine if beach habitat is suitable for spawning, if scheduled between March 1 and August 31. Survey results may be used determine the need for additional monitoring and/or protective measures during construction. This measure would not be necessary for projects scheduled outside the grunion spawning season (Section 6.4.3).

Relevant Reports:

- RGP 67 (USACE 2006) specifies that a Sensitive Aquatic Resource (SAR) survey be conducted and submitted as part of the permit application requirements. Grunion spawning habitat is one of the marine resources to be addressed in the SAR survey.
- Grunion habitat suitability surveys were conducted prior to construction for the 2001 San Diego Regional Beach Sand Project (AMEC 2002). Beaches that were erosive and lacked suitable habitat did not require further measures during construction. Beaches with potentially suitable habitat were monitored during construction and additional protective measures implemented, as necessary.
- Grunion habitat suitability surveys were conducted prior to construction for the Goleta Beach Nourishment Demonstration Project (Moffatt & Nichol 2003).
- Grunion habitat suitability surveys are recommended as part of the SCOUP project (Moffatt & Nichol 2006).

Monitoring Considerations:

Beach site visits to determine grunion habitat suitability should be conducted during high tide conditions to examine available width to support spawning (i.e., upper intertidal sand habitat not inundated during neap high tides). Sand depth measurements and substrate characteristics should be assessed in the upper intertidal zone at spring high tide level. Factors indicative of unsuitable habitat include wave inundation of neap high tide zone, sand depths < 5 in (13 cm), and extensive cobble cover on substrate surface.

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. Habitat suitability surveys should be effective if conducted prior to each predicted grunion run spanned by the construction period. It is recommended that monitoring and protective measures to be used during construction, if applicable, be included in the MMRP.

7.3.2.6 Snowy Plover Occurrence Surveys

This measure involves conducting a survey to determine occurrence of breeding/nesting snowy plovers prior to construction, if scheduled between March 1 and September 15, and the project location is within critical habitat. A survey also may be necessary if construction is scheduled in fall-winter (September through February) and the site supports a substantial overwintering population. Survey results may be used determine the need for additional monitoring and/or protective measures during construction.

Relevant Reports:

- Pre-construction surveys to determine snowy plover nesting activity and need for additional protective measures (including coordination with resource agencies) were specified if construction extended beyond March 15 for beach placement associated with maintenance dredging of Channel Islands/Port Hueneme Harbors (USACE 1994a), Ventura Harbor (USACE 1998b), and Marina del Rey (USACE 1999b).

Consideration of Potential Effectiveness:

The mitigation measure recommended in Section 6.3.8 specifies conducting a snowy plover survey within 30 days of a project if the site is within critical habitat and/or is known to support a substantial wintering population. The need for the survey should be determined well in advance of construction based on site location with respect to critical habitat and proximity to known nesting locations. In addition, prior coordination with the USFWS should be conducted to obtain recent information on local snowy plover occurrence in the project vicinity. If a survey is determined to be warranted, the focus should be identification of locations of nesting activity, site use patterns by adults and chicks, and/or site characteristics that limit suitability for occurrence. A MMRP should be prepared and approved by USFWS prior to the survey

Coordination with USFWS is necessary to satisfy ESA requirements for any project that may affect a federal listed species. Informal coordination with these agencies may be effective to review survey results and to identify reasonable measures that may be implemented during construction to avoid and minimize impacts to the species if it has the potential to occur during construction (Section 6.3.8). Informal coordination is recommended because avoidance and minimization measures may vary depending on site-specific conditions. Incorporation of appropriate minimization measures into the project description and/or MMRP should be effective at streamlining formal consultation and permitting processes.

7.3.3 Caulerpa Surveys

Prior to dredging, a survey to determine presence/absence of *Caulerpa* may be required. *Caulerpa* is an invasive, exotic plant species that is regulated in California. *Caulerpa* surveys must be conducted according to approved protocols (http://swr.nmfs.noaa.gov/hcd/caulerad.htm) by certified surveyors. *Caulerpa* surveys are required for any sediment disturbing activity (e.g., dredging) for California nearshore coastal and enclosed bays, estuaries, and harbors from Morro Bay to the U.S./Mexican border. Survey effort varies depending on whether the project location is within a designated *Caulerpa*-free or *Caulerpa*-infected waterbody.

Surveillance level surveys in *Caulerpa*-Free *area* are conducted not earlier than 90 days prior to the disturbing activity and not later than 30 days prior to the disturbing activity and are to be completed, to the extent feasible, during the high growth period of March 1 to October 31 (http://swr.nmfs.noaa.gov/hcd/caulerad.htm). Results are reported on standard survey forms and submitted to CDFG and NOAA according to protocol requirements. If *Caulerpa* is found, CDFG/NOAA must be notified within 24 hours of discovery, and no work is authorized until the area is treated and *Caulerpa* is eradicated.

7.4 Construction Monitoring

Several types of monitoring surveys may be conducted during construction to comply with water quality and/or sensitive species protection permit conditions with respect to:

- Sediment Compatibility Compliance
- Water quality com. pliance.
- Open inlet status
- Grunion.
- Sensitive bird occurrence.
- Marine mammal occurrence.

Two types of monitoring may be conducted during construction: verification of permit compliance, and to ensure no significant impacts to sensitive resources in vicinity. Different types of construction monitoring that have been conducted during California sediment management projects are briefly reviewed below. More detailed description of monitoring is given in Section 7.

7.4.1 Sediment Compatibility Compliance

Relevant Reports:

- Inspection of the beach at the end of construction to determine if undesirable sediment size differences and shell fragment content occur and whether a sand sweeper (or alternative mechanical separation device) should be used to alleviate problem was specified as a mitigation measure in the EIS/EIR for the Imperial Beach Shoreline Protection Project (USACE 2002). This measure also included follow up monitoring at one month intervals, as warranted, until potential impacts are considered less than significant.
- Periodic visual observations and sampling to verify proper quality of source sands is specified in the implementation guidelines for the BEACON South Central Coast Beach Enhancement Program (Moffatt & Nichol 2005a).
- Peterson et al. (2000b) recommended that substrate characteristics be inspected during construction to ensure no substantial change in characteristics than planned. Rehabilitation of substrate after placement was considered impracticable

Monitoring Considerations:

Regular inspection of substrate quality during sand placement should be conducted to ensure substrate characteristics match expectation based on permit requirements. Samples may be collected to verify sand characteristics based on results of visual inspection. Particular attention should be given to shell content, coarse sand, and/or silt/clay.

Final inspection of surface substrate conditions should be conducted to determine potential short-term compaction. Mechanical grading or "tilling" of the surface has been conducted to remedy compaction (NRC 1995, Speybroeck et al. 2006).

7.4.2 Water Quality Compliance

Monitoring of water quality may be conducted to satisfy requirements of the 401 Water Quality Certification and/or WDR for projects involving dredging and/or discharge of sediment into state and federal waters. Generally, compliance is determined by not exceeding Effluent Limitations, Receiving Water Limitations, and/or not exceeding specified thresholds relative to ambient conditions. Monitoring requirements may include visual observations, field measurements using *in situ* instruments, and/or sample collection for laboratory analyses (more detailed review in Section 5.5.1.1, Appendix C).

7.4.3 Turbidity Monitoring

The following questions of interest to the CSMW are addressed in this report section:

- *What level and type of turbidity monitoring before, during, and after sediment management activities is appropriate in order to more directly relate turbidity levels to biological effects?*
- *Can kelp or other species sensitivity to turbidity plumes be used as an indicator species defining limitations on sediment management activities?*

Turbidity will be generated during any sediment management activity that includes dredging and/or discharge in the aquatic environment. However, the magnitude and extent of turbidity will vary depending on project-specific factors such as substrate characteristics, project volume, construction equipment, and construction methods (Section 5.5). The effects of turbidity require consideration of the above project-specific factors, schedule, and site-specific conditions such as hydrodynamics and existing biological resources.

The following types of biological effects related to different aspects of turbidity are of potential concern:

- Light reduction that adversely affects photosynthesis and growth of aquatic vegetation.
- Reduction in water clarity that interferes with foraging success of sensitive, terrestrial species (e.g., California brown pelican, California least tern) that forage in near surface waters aquatic environments. Foraging success requires consideration of both the acquisition of prey as well as the travel distance to obtain food.
- Elevated suspended sediment concentrations that adversely affect foraging, respiration, development, and/or migratory behavior of aquatic invertebrates, fish, and marine mammals.

Turbidity impact concerns generally increase as project volume and duration increase (Clarke and Wilber 2000.). Therefore, it seems reasonable that monitoring requirements should reflect level of impact concern. Important questions with respect to identification of impact concerns include:

- How large an area will be affected by turbidity?
- What concentrations may be expected?
- How long will elevated turbidity last?
- Will turbidity plumes occur in areas where sensitive habitats and/or resources occur?

Level and type of monitoring relevant to biological impacts of concern are further discussed below followed by a review of considerations with respect to use of indicator species to define sediment management limitations. Several mitigation measures may be employed to reduce turbidity (Section 6.4) and should be considered when answering the above questions. This should help ensure that monitoring data is useful for evaluation of impact of concern as well as effectiveness of mitigation measure.

7.4.3.1 Level of Monitoring

Water quality and turbidity monitoring requirements for sediment management projects in California have varied with respect to constituents, sampling designs (number and distance of sampling locations, frequency of sampling), and compliance criteria (Section 5.5.1.1). These inconsistencies limit the usefulness of resulting data to support science-based evaluations of plume characteristics and ecological consequences of plumes.

It is recommended that level of monitoring should address both spatial and temporal scales of impact. Spatial scale considerations include turbidity plume dimensions, differences in plume characteristics along the near- to far-field gradient from the source, and ambient water characteristics outside the plume. Spatial considerations also include characterization of the plume in the vertical dimension of the water column relevant to the impact issue of concern.

Temporal considerations include differences in plume characteristics associated with environmental conditions during project implementation and verification of plume dissipation after construction is completed. Generally, 401 Water Quality Certification and/or WDR compliance monitoring specifies daily monitoring (Appendix C.1). Daily monitoring is justified as a control strategy to ensure compliance. It also makes sense from an environmental standpoint based on changeable weather conditions.

Depending on receiving environment, it may be appropriate to take measurements more than once a day or at alternate times of day when measurements are taken on consecutive days, if there are substantial changes in plume characteristics due to time-of-day differences in environmental conditions (e.g., winds, currents, tidal stage). Characterizing plume characteristics under different environmental conditions is considered preferable to only obtaining information on maximum plumes. For example, eelgrass response to light limitation depends on the number of hours per day of irradiance-saturated photosynthesis (Zimmerman et al. 1991). Therefore, understanding whether turbidity plumes occur over an eelgrass bed only under maximum plume versus all plume conditions associated with a project is an important distinction with respect to impact evaluation.

7.4.3.2 Types of Monitoring

Different methods of monitoring turbidity plumes and biological relevance of different methodologies have been reviewed by Puckette (1998), Thackston and Palermo (2001), and Davies-Colley and Smith (2001). Puckette (1998) summarized that an effective suspended-sediment plume monitoring program will first identify the locations and dimensions of the plume and then measure the appropriate parameters dependent on the goals of the monitoring.

Plume Dimensions

Information on plume dimensions is needed to address three types of objectives: (1) spatial scale questions relative to permit compliance, (2) spatial scale questions with respect to biological impact concerns, and (3) spatial scale questions with respect to effectiveness of mitigation measures.

Plume dimensions from the source (upcurrent, downcurrent, and offshore if applicable) should be determined. Time of day and environmental conditions at the time plume dimensions are determined should be recorded, such as weather (temperature, wind speed, cloud cover, rain) and surf conditions (wave height, swell). In addition, any operational and/or construction method strategies used to control turbidity should be recorded.

It is recommended that if sensitive habitats are in the vicinity, a determination of whether the plume occurs over SAV or reef habitat should be made. If turbidity plumes occur over sensitive habitats, additional monitoring of plume characteristics may be warranted.

Different methods may be associated with measurement of turbidity plumes. For example, RGP 67 (USACE) specifies that turbidity plumes will be visually estimated by a qualified observer from a high vantage point (e.g., lifeguard tower), and that the daily maximum plume area shall be mapped and documented with digitial photographs. Visual observation and determination of the extent of turbidity plumes is a common monitoring requirement of WDRs and/or 401 Water Quality Certifications (Appendix C.1).

More accurate determination of turbidity plume dimensions outside the surf zone and/or in embayments may be accomplished with a vessel equipped with a standard fathometer that has been adjusted to optimize display of backscatter combined with *in situ* measurements of turbidity and Secchi disk depth (Puckette 1998). Acoustic Doppler sensors (e.g., ADCP, PLUMES) sensors provide detailed information on the structure of the plume (see Figure 5.5-11) and on currents affecting the plume. ADCP may be warranted in areas near sensitive habitats where more detailed plume tracking is desired.

Plume Characteristics

It is well understood that suspended sediment concentrations decrease with increasing distance from the turbidity source (LaSalle et al. 1991, Newell et al. 1998). Most water quality monitoring programs associated with WDRs or 401 Water Quality Certifications specify taking measurements at certain distances from the turbidity source (Appendix C.1). Some monitoring compliance requirements focus on determination of whether turbidity at a certain distance from the source is within 20% of ambient (Appendix C.1). Other requirements may specify obtaining measurements at several locations at increasing distance from the source with criteria also based on whether turbidity at a specified distance from the source is within 20% of ambient.

Review of collected data from several monitoring programs indicate that near- and far-field differences in plume characteristics often are not adequately described by the sampling designs that have been used to-date, usually because of an insufficient number of sampling locations (Section 5.5.3). In addition, the spatial scale of the plume has not been demonstrated with sampling designs that do not include measurements beyond 500 ft (150 m) downcurrent (Section 6.3.5.1).

Better understanding of near- and far-field differences in plume characteristics is needed to improve evaluations of adequacy of buffer distances and biological impact assessments. Standardizing monitoring requirements with respect to distance upcurrent and downcurrent of the dredge or discharge would facilitate comparisons among projects. This is desired to increase understanding of plume characteristics under different project-specific and environmental conditions.

RGP 67 (USACE 2006) requires mapping of the maximum extent of the plume with compliance criteria based on whether plume dimensions > one-half mile downcoast and offshore persist for more than two days and up to five days. If turbidity plumes exceed that criterion for more than two days, turbidity monitoring is to be conducted at a minimum of four locations: as close to the discharge site as practicable and one-half mile upcoast, downcoast, and offshore. RGP 67 specifies that light transmission is to be measured at mid-depth in the water column.

Monitoring Considerations:

Based on review of monitoring data from several beach nourishment projects, it appears that suspended sediment concentrations may be elevated in the surf zone over distances ranging from < 1,000 ft to 6 mi (10 km) long and 50 to 1,000 ft (15 to 300 m) wide depending on environmental conditions and operational controls (Sections 5.5.3, 6.3.5.1). Therefore the offshore component of the plume criterion for RGP 67 would not be expected to be within the plume. The length component of the monitoring criterion would be expected to be within the plume at least in the downcurrent direction based on persistent mapping of the plume beyond that distance. Limiting the monitoring to a minimum of the four stations specified in RGP 67 will not permit distinction of near-field and far-field plume characteristics associated with beach nourishment projects.

Review of monitoring data collected at several offshore borrow sites and during many harbor dredging projects indicates data gaps with respect to turbidity plume extent and near- and far-field characteristics with many of the WDRs that have been used to-date.

Based on the above considerations, the following monitoring considerations would improve characterization of turbidity plume characteristics.

- Beach nourishment – Two locations within plume: outside breaker zone within main part of plume and near but inside the offshore edge of the plume. Two locations at least 300 ft (150 m) outside the visible plume to serve as references for ambient conditions. Additional measurements at the following distances, if within visible plume (i.e., only would sample distances within visible plume): downcurrent at 100 ft, 300 ft, 500 ft, 1,000 ft, 1,640 ft, 2,500 ft, 3,281 ft, and upcurrent at 100 ft, 300 ft, 500 ft, and 1,000 ft (downcurrent at 30 m, 91 m, 150 m, 300 m, 500 m, and 1000 m; upcurrent at 30 m, 91 m, 150 m, and 300 m). Monitoring would not be necessary at distances that are outside the visible plume.

- Nearshore placement – Within visible plume at the following distances: downcurrent and upcurrent at 100 ft, 300 ft, 500 ft, 1,000 ft, 1,640 ft, and 1,640 ft (30 m, 91 m, 150 m, 300 m, and 500 m). Two locations at least 300 ft (150 m) outside the visible plume to serve as references for ambient conditions.
- Dredging - – Within visible plume at the following distances: downcurrent and upcurrent at 100 ft, 300 ft, 500 ft, 1,000 ft, and 1,640 ft (30 m, 91 m, 150 m, 300 m, and 500 m). Two locations at least 300 ft (150 m) outside the visible plume to serve as references for ambient conditions.

7.4.3.3 Compliance Criteria

Water quality compliance criteria generally specify that turbidity measurements at specified distances from the source to be within 20% of ambient conditions (Appendix C.1). Review of available data suggests that this criterion is protective of biological resources. However, values may exceed that criterion and still be within levels of relatively low turbidity (Section 5.5.3.6). In addition, out of compliance values may be below levels associated with biological effects.

Standard Measurements

Turbidity (NTU) - Measurements by a nephelometer are not directly relevant to biological impact concerns (Section 5.5.2.2). This is because turbidity is an optical property of water caused by the molecules of water, dissolved substances, and organic and inorganic suspended matter. However, there are no standard relationships between turbidity measurements and aspects of turbidity that may result in biological effects, such as light reduction, water clarity reduction, and/or increase in concentration of suspended sediment (Davies-Colley and Smith 2001). However, turbidity measurements are useful for providing useful, real-time data during construction for use as a control strategy (Thackston and Palermo 2000). For example, *in situ* measurements are used to support field assessments of whether water quality compliance requirements are being met and field decisions with respect to need to implement additional turbidity control measures.

Secchi disk – This method provides a relatively reliable measure of water clarity, rough estimate of light extinction, and may be useful under highly turbid conditions that may affect performance of *in situ* instruments (Davies-Colley and Smith 2001). Because of the widespread and historic use of the Secchi disk during water quality compliance monitoring in California, it is recommended that it always be included as part of any water quality monitoring program that includes *in situ* measurements. Secchi disk readings may be affected by lighting conditions; therefore, weather conditions should be reported. Relationships between Secchi disk, light transmission, and TSS must be empirically established during each project and/or when there is a substantial change in substrate characteristics (Davies-Colley and Smith 2001).

Light Reduction

Increased light attenuation due to turbidity may adversely impact photosynthesis, growth, and/or recruitment of kelp and seagrasses (Section 5.5.3.1). Light transmission and/or measurements of PAR provide relevant measures of light attenuation from turbidity effects. Transmissometers are reliable for measuring light transmission when particle concentrations are relatively low, but may become saturated at TSS levels above approximately 150 mg/L (Puckette 1988). PAR may be measured using a variety of sensors (e.g., LI-COR cosine-corrected sensors) (Dean 1985, Moore et al. 1996, Cabello-Pasini et al.. 2002). The Secchi disk provides a rough estimate of light extinction that may be useful under highly turbid conditions (Davies-Colley and Smith 2001).

If light reduction impacts are of concern, it is recommended that relevant measures of light transmission be monitored. Generally, projects spanning ≥ two weeks may be considered as being prolonged with respect to potential light limitation. Light transmission and Secchi disk depth measurements are recommended at several locations within the visible plume at different distances from the turbidity source to document the gradient of light limitation and also outside the visible plume to obtain ambient measurements (see plume characteristics).

Relevant Reports:

- A light level of approximately 1% of surface irradiance (PAR of approximately 0.2 E $m^{-2}d^{-1}$) limits the distribution of giant kelp (Foster and Schiel 1985). Recruitment is limited at 0.4 E $m^{-2}d^{-1}$ and juvenile growth is limited at 0.4 to 0.9 E $m^{-2}d^{-1}$ (Neushul and Haxo 1963, Dean and Dyscher 1983, Dean and Jacobsen 1984, Deysher and Dean 1984, Dean 1985). Saturation levels are 0.8 E $m^{-2}d^{-1}$ for recruitment and 1.8 to 3 E $m^{-2}d^{-1}$ for juvenile growth. Therefore, prolonged light levels < 5% of surface irradiance may reduce recruitment and levels < 10% may adversely affect growth.
- A light level of approximately 10% of surface irradiance is considered a general indicator of eelgrass compensation depth (Dennison 1987, Fonseca 1989). Light levels below 20% surface irradiance may reduce growth and survival (Backman and Barilotti 1976, Burke et al. 1996). Minimum light thresholds vary with environmental conditions, ranging from 3 to 12 hours of photosynthetic-saturating irradiance per day (Dennison and Alberte 1985, Zimmerman 1990, Dennison et al. 1993, Orth et al. 2006). Therefore, critical thresholds may vary depending on site conditions.
- Light levels < 40% surface irradiance limit surfgrass distribution (Williams and McRoy 1982).

Water Clarity for Visual Foragers

Impacts to sensitive, visual foragers that target fish prey in the upper water column (e.g., California least tern, California brown pelican) may be of concern during sediment management projects. Water clarity measurements using a Secchi disk provide a fairly reliable measure of the optical quality of waters (Davies-Colley and Smith 2001).

Relevant Reports

- Davies-Colley and Smith (2001) recommend measuring visual water clarity (measured as Secchi or black disk visibility) instead of turbidity to provide a more accurate optical quantity with relevance to fish habitat, aesthetics, and contact recreation.

- Secchi disk was specified as the method for measuring reduction in water clarity with relevance to California least tern foraging during the 2001 San Diego Regional Beach Sand Project (USFWS 2000). A Secchi depth of < 3 ft (1 m) was the water depth threshold and 1 hectare (2.47 acres) was spatial threshold for turbidity plumes for that project.

Monitoring Considerations:

A Secchi disk depth of < 3 ft (1 m) was recommended by the USFWS (2000) as a threshold for delineating plume characteristics with the potential to affect least terns and brown pelicans.

Water clarity measurements may be appropriate for sediment management projects conducted within one mile of active nesting sites of least terns. Need for monitoring should consider seasonal breeding period of the species (April 1 to September 15). Monitoring may not be necessary if only for California brown pelican because their breeding sites are located on offshore islands and they have wide foraging range along the mainland.

<u>Total Suspended Solids</u>

TSS is the measure most commonly used during laboratory studies of the effects of suspended sediment on invertebrates and fish (Sections 5.5.3.2, 5.5.3.3). TSS is relevant to effects associated with physical abrasion, respiration, physiological stress, and foraging interference for planktivores, filter-feeders, and suspension-feeders. Therefore, TSS is the most directly comparable measure to the available biological effects data concerning turbidity effects to aquatic animals.

Relevant Reports:

- Thackston and Palermo (2000) reviewed that there is no standard conversion between TSS and turbidity. They recommended measurement of both TSS and turbidity early in the project to develop a project-specific TSS-turbidity correlation, which will enable accurate conversion of subsequent *in situ* turbidity measurements to TSS. Additional water samples for TSS analysis are recommended if substrate conditions change within the project area during construction so that the accuracy of the TSS-turbidity relationship can be updated, as necessary.
- Clarke and Wilber (2000) reviewed that many of the past investigations of suspended sediment effects focused on detrimental effects, but the dosages required to induce them often were well above those likely to occur during dredging. In addition, appropriately designed studies to address dredging impacts associated with sediment resuspension are very limited. They concluded that extrapolations from inappropriate concentrations or exposure durations is a widespread practice and may lead to false conclusions. They strongly recommended that any impact assessment consider not only the concentration aspect of the dosage issue, but also realistic estimates of the likelihood and duration of exposure above that threshold.

Monitoring Considerations:

TSS concentrations in turbidity plumes should be monitored in areas near sensitive spawning grounds and/or nursery areas if the sediment management activity is conducted during peak recruitment and/or productivity periods. Acoustic monitoring is recommended to provide accurate mapping of the plume. Field collected turbidity measurements using a nephelometer and water samples for TSS are recommended to establish site-specific turbidity-TSS-backscatter correlations. The number of TSS samples necessary to adequately establish empirical relationships will vary depending on project- and site-specific conditions (Section 5.5.1.2).

7.4.3.4 Turbidity Indicator Species

Overstory kelp and eelgrass may be effective indicators because of their sensitivity to critical turbidity levels and boundaries are easily mapped However, their suitability may vary seasonally associated with natural periods of annual die-back or thinning.

The USFWS (2000) specified that turbidity plumes with Secchi disk depths < 3 ft (1 m) be used to identify unsuitable water clarity for visual foragers such as California least tern and California brown pelican.

7.4.4 Open Inlet Status

Relevant Reports

- Monitoring to determine if inlet closure occurs due to sedimentation and opening of the lagoon inlets as necessary until the inlet area has stabilized was specified for the BEACON South Central Coast Beach Enhancement Program (Moffatt & Nichol 2005b).
- Monitoring and establishing a fund for increased dredge volume and/or inlet opening of coastal lagoons was specified as a mitigation measure for the 2001 San Diego Regional Beach Sand Project (SANDAG and USDN 2000).
- Monitoring and opening inlet if closure occurs was specified as a mitigation measure for the Goleta Beach Nourishment Demonstration Project (Chambers Group 1992).
- No inlet closure was observed at Goleta Slough during or after beach nourishment at Goleta Beach (Moffatt & Nichol 2005c).

Monitoring Considerations:

Monitoring should be effective for documenting inlet status during and after beach nourishment (Section 6.4.5.3). Because sand level changes may exhibit substantial annual variation, two or more stations along a gradient between the discharge location and inlet should be surveyed before and after project. If other sand sources are of concern with respect to mitigation responsibility, there should be an adequate number of stations along the downcurrent gradient to follow sand movement. Particle tracking also may be used to measure sand transport (e.g., Black et al. 2004, National Institute of Coastal and Marine Management of the Netherlands 2004).

The overall effectiveness of this measure may depend on the communication and response protocols established during the pre-project phase. Therefore, documentation of responsible party commitment to remove and/or provide funding to remove excess sedimentation should be specified prior to the project. Preparation of an Inlet Monitoring and Response Plan that specifies communication, response protocol, and responsible parties should contribute to the effectiveness of the measure.

7.4.5 Sensitive Species Occurrence

7.4.5.1 <u>California Grunion</u>


Photo credit: Julianne Steers

This measure involves monitoring grunion to determine spawning activity and if observed to implement measures to avoid impacts to spawned eggs, if appropriate. Measures may include a diked buffer (Section 6.4.2.2), redirection of construction activities, and/or halt to construction for 14 days to allow eggs to hatch.

Relevant Reports.

- Sand placement on the beach during March and April has been conducted with grunion monitoring during maintenance dredging projects in southern California; e.g., Oceanside, Point Hueneme, Santa Barbara, and Ventura (USACE 1993, 1994a, 1998a, b, 2000b).
- Monitoring during construction and implementation of protection measures, as necessary, was specified for the 2001 San Diego Regional Beach Sand Project for those beach sites scheduled to be constructed during the spawning season
- Monitoring during construction is specified for the SCOUP project if construction is scheduled during the spawning season and a pre-construction survey determines habitat is potentially suitable for spawning (Moffatt & Nichol 2006).
- RGP 67 specifies monitoring during construction if the project is scheduled between March 1 and August 31 and a pre-construction survey determines habitat is suitable for spawning (USACE 2006).

Monitoring Considerations:

Monitoring for grunion spawning to avoid areas where eggs are laid may be effective for avoiding and/or minimizing physical disturbance of spawning. For the monitoring to be effective, most days of the predicted run must be monitored (K. Martin, 2005 and 2007 personal communications).

The following monitoring recommendation was developed by the senior author in consultation with K. Martin for the SCOUP program (Moffatt & Nichol 2006) and RGP 67.

Monitoring should occur at night from 1 hour before the peak high tide to 2 hours after the peak high tide (i.e., at least 3 hour duration monitoring period) commencing on the second night after a new or full moon and continue for the next two nights (i.e., three nights). If no grunion are observed, no further action would be necessary. If grunion occur within the project area, their location should be mapped and number present estimated (e.g. by Walker Scale). An appropriate protective measure should be implemented and actions communicated to resource agencies in accordance with pre-coordination decisions specified in the MMRP.

7.4.5.2 California Least Tern

*Photo credit:
Kathy Keane, Keane Biological Consultants*

Monitoring of least tern foraging during sediment management projects may be conducted when sediment management projects are scheduled during the breeding season. Monitoring questions of interest, include: Do terns avoid foraging in turbidity plumes or forage less in turbid compared to clear waters, 2) Is the prey capture efficiency impaired in turbidity plumes compared to clear waters, 3) To what extent, if any, do turbidity plumes near tern breeding areas result in reduced reproductive success?

Relevant Reports:

- Permit requirements that water clarity not be < 3 ft (1 m) over an area > 2.47 acre (> 1 hectare) to protect potential least tern foraging were met with few exceedances (and remedied) during the 2001 San Diego Regional Beach Sand Project (AMEC 2002).
- Least terns were observed foraging in turbidity plumes during beach nourishment with diked discharge at Surfside-Sunset Beach (MEC 1997).
- Least terns, Forster's terns, royal terns, and brown pelicans were observed foraging in turbid and non-turbid areas during dredging operations for the NIMITZ Homeporting Project in San Diego Bay (U.S. Navy 1996 cited in USFWS 2000).
- Collins et al. (1979) reported that least terns foraged less consistently in a turbid flood control channel than in clearer waters in the vicinity.

Consideration of Effectiveness

Few studies of least tern foraging during sediment management activities have been conducted. Generally, an environmental window restricted period has been applied to dredging and beach nourishment projects in the vicinity of nesting sites during the breeding season). Available monitoring studies suggest that least terns avoid foraging in turbid waters when given a choice (Collins et al. 1979). However, a turbidity threshold that results in avoidance response has not been established.

Least terns have been observed to forage in the vicinity of beach nourishment (MEC 1997) and dredging (U.S. Navy 1996 cited in USFWS 2000) suggesting that water clarity in turbidity plumes generated by such activities were not depressed beyond visual thresholds of terns. Monitoring also indicates that water clarity reductions during offshore borrow site dredging and beach nourishment may be sufficiently localized to satisfy the USFWS Biological Opinion conservation measure that surface turbidity (water clarity not < 3 ft) be limited to ≤ 2.47 acre (1 hectare) to avoid potential effects to foraging when least tern nest sites are within two miles of these sediment management activities (USFWS 1-6-01-F-1046). Limited available monitoring studies suggest that impacts may minimized when turbidity is controlled.

Additional monitoring with respect to least tern foraging behavior, water clarity, and turbidity plumes would enable a more rigorous evaluation of potential impacts under different project conditions. That type of information could be useful for establishing science-based guidance thresholds to better regulate turbidity levels during sediment management projects so that breeding season constraints can be applied at the appropriate spatial scale.

7.4.5.3 <u>Western Snowy Plover</u>

Photo credit: Callie Bowdish

Snowy plover monitoring may be conducted if the project location is within critical habitat and project activities are scheduled during the breeding season. Monitoring also may be necessary if the site supports substantial overwintering populations and project activities are scheduled between September through February. Monitoring of snowy plovers during sediment management projects may be conducted if sediment management project schedules extend into the breeding season. Surveys may be used to determine species occurrence and whether additional protective measures may be required during construction.

Relevant Reports:

- Surveys to detect nesting and/or snowy plover behavior have been specified if construction schedules extend into the breeding season for maintenance dredging projects involving beach discharge near Channel Islands/Port Hueneme Harbors, Marina del Rey Harbor, Morro Bay, Oceanside Harbor, Santa Barbara Harbor, and Ventura Harbor (USACE 1994a, 1998a, 1998b, 1999a, 1999b, 2000b).

Monitoring Considerations:

Surveys to determine species occurrence prior to construction appear to be effective for determining need of additional protective measures during construction. Although no reports of injuries or nest damages during beach nourishment activities were identified in reviewed documents, considerable vigilance and contractor coordination may be required to avoid impacts if nesting occurs near the sand delivery pipeline (Hutchinson 1987). The use of qualified biological monitors with authority to halt and/or redirect activities is a primary consideration with the effectiveness of monitoring as an impact avoidance measure. Monitoring methods, protective measures, communication, and reporting should be determined in coordination with and approved by the USFWS as part of required ESA Section 7 coordination. Use of single-point discharge within a restricted corridor has been used to minimize impacts to foraging snowy plovers (Section 6.4.1.3).

7.4.5.4 Marine Mammal Occurrence

Use of environmental monitors on hopper dredges and/or support vessels to determine marine mammal occurrence, behavioral response to sediment management activities, and/or to document adverse impacts (e.g., collisions) have been recommended for some geographic regions.

Relevant Reports:

- The USACE, Los Angeles District specifies monitors are to be used during dredging when sea otters are present (http://el.erdc.usace.army.mil/tessp/info.cfm).
- Protocols developed monitoring borrow sites on the east and Gulf Coasts of the United States recommend use of marine mammal monitors on dredges and/or support vessels during offshore borrow site dredging activities (RPI et al. 2001).
- Monitoring of sea otters has been conducted during dredging at Morro Bay (Bodkin and Rathbun 1988).

Monitoring Considerations:

Sea otters appear to be sensitive to dredging activities (Bodkin and Rathbun 1998), which may be a concern for sediment management activities if conducted in the vicinity of kelp beds used as breeding areas and/or at wintering areas in embayments.

Pinnipeds are more sensitive to disturbance while on land; therefore, sediment management activities may be a concern if conducted near haul-out areas.

Whales appear to be tolerant of vessels when direct approach is avoided, movement is parallel to the animal, and speed is maintained at or slower than the animal.

Available information indicates that risk for collision is higher with fast moving vessels for any of these marine mammals (Laist et al. 2001).

Based on these considerations, monitoring may not be necessary if other mitigation measures are implemented that limit direct approach and control of vessel speed in areas where marine mammals are observed (Section 6.4.1.5).

The need for monitoring should be evaluated on a case-by-case basis for projects that include dredging and/or beach nourishment near sea otter breeding or wintering areas or pinniped haul outs.

7.5 Post-Construction Monitoring and/or Impact Evaluations

7.5.1 Impact Significance Verification and/or Habitat Recovery Rates

Several methods may be used to assess impacts depending on habitat type. Several sources of information with respect to methods commonly employed for assessments of California coastal habitats are listed in the following text box.

Useful Online Sources of Information of Field Sampling Methods

- Rocky Intertidal Habitats and Resources

  http://www.marine.gov/sampling-methods.htm, http://www.piscoweb.org/data/
- Rocky Subtidal Habitats and Resources

  http://www.piscoweb.org/data/
- Offshore borrow sites
  http://www.mms.gov/itd/pubs/2001/2001-089.pdf
  http://www.mms.gov/sandandgravel/MMS2000-054.htm
  http://www.mms.gov/sandandgravel/JCRVolume20MMSstudies.htm
-

Sandy Beach Recovery

Invertebrates

Invertebrates have been sampled using hand-held cores, box samples, and/or standard shovel samples (Parr et al. 1978, Straughan 1981, McLachlan et al. 1984, Nelson 1993, Dugan et al. 2000a, Schoeman et al. 2000, Dugan et al. 2003, SAIC 2006). Cores dimensions often vary among studies; e.g., ranging in diameter from 2 to 8 in (5 to 20.2 cm) and to depths of 4 to 12 in (10 to 30 cm). Collected samples are sieved to separate animals from sediment; sieve sizes of 0.5, 1.0, or 1.5 mm have been used.

Sampling design and method considerations associated with sampling sandy beach invertebrates are reviewed by Straughan (1981) and Nelson (1993). Both indicate that a core size diameter of at least 3-in (7.6 to 7.7 cm) accommodates all sandy beach species and enables efficient collection and processing of multiple samples during a low tide. Straughan (1981) recommends sampling to a minimum depth of 8 in (20 cm). Nelson (1993) recommended sieving with a 0.5 mm screen, although a slower sample processing time was acknowledged than with screens with larger, aperture openings. Straughan (1981) noted that use of a 0.5 mm screen often is difficult under field conditions due to clogging. Most sandy beach sample data collected in California has used 1.0 to 1.5 mm sieves (Straughan 1981, Dugan et al. 2000a, Dugan et al. 2003).

Sandy beach invertebrates exhibit tidal zonation and sampling designs often include collection of samples across the beach from low to high tide. This may be accomplished by sampling at uniform intervals and/or within upper, middle, and lower intertidal stratum (Parr et al. 1978, Straughan 1981, Dugan et al. 2000a, 2003).

Nelson (1983) reviewed that ten, 3-in (7.6 cm) replicate cores from each location and time may provide a sufficient level of replication for sandy beach studies, but recommended carrying out a power analysis to verify sampling design. Parr et al. (1978) determined that a total of 90 samples consisting of 10 samples per 3 intertidal strata times 3 transects enabled estimation of abundance with a precision level of ± 30% at a 95% confidence interval; approximately half that number of samples was required to estimate species number at the same precision level. A total of 49 and 17 samples were required to estimate abundance and species number with a ± 50% precision level.

Invertebrates in the shallow nearshore within the depth of beach closure may be collected by divers using hand-cores and/or a diver-operated suction sampler (Parr et al. 1978, Oliver et al. 1980, McLachlan et al. 1984). Similar to the above discussion, core dimensions have varied from 3- to 6-in diameter by 4- to 6.7-in deep (7.6 to 15-cm diameter by 10- to 17-cm deep). Screen size may vary from 0.5 to 1.0 mm. Apparently, fewer replicate cores are required to estimate abundance and species number than in the intertidal. Parr et al. (1978) determined that the number of replicate cores (3-in diameter by 4-in deep, 8-cm diameter by 10-cm deep) required to estimate invertebrate abundance and species number ranged from 11 to 15 at a ± 30% precision level and from 6 to 7 at a ± 50% precision level at depths of 12 and 20 ft (3.7 and 6.1 m).

Sampling design considerations (number of stations, replicates) for sandy beach and subtidal should be determined based on site conditions and monitoring objective. Simple characterizations of what types of sandy beach invertebrates occur on a beach require less rigorous designs than those addressing recovery of more stable communities.

Fishes

Beach seine sampling has been used to assess beach nourishment effects on surf zone fish. Burlas et al. (2001) used a 50 x 6 ft seine with a 6 by 6 ft bag and ¼ in mesh (15.2 by 1.8 m seine with 1.8 by 1.8 m bag with 6 mm mesh), which was deployed during daylight and hauled perpendicular to shore starting at a depth of approximately 4.1 ft (1.25 m) (also cited in Wilber et al. 2003). Sampling included three samples per station. Sampling was curtailed for safety reasons when wave heights exceeded 4.9 ft (1.5 m). Wilber et al. (2003) reported that although there sample size over a five-year period was 2,190 seines, the sample size was only sufficient to detect a 3-fold difference in abundance. The authors stated that this result suggests that interpretation of meaningful effect size is not simply detection of a 10, 50% or greater change, but realization that reductions in fish abundance (if any are detected) might have no other meaning than the fact that mobile fishes moved beyond the sampling bounds.

Beach seine sampling Batiquitos Lagoon
Photo: SAIC

Versar (2004) used a 150 ft X 6 ft seine with a 6 ft X 6 ft bag and ½ inch square mesh (46 by 1.8 m seine with 1.8 by 1.8 m bag and 13 mm mesh), which was deployed in a semicircle and pulled to shore by hand during daylight hours at or near low tide. Versar (2004) stated that they switched from a ¼ to ½ in (6 to 13 mm) mesh in order to target larger fish and also to reduce haul-back pressure and make sampling more feasible. Fish outside the breaker zone were sampled with a 25 ft (7.6 m) semiballoon, otter trawl equipped with two 3 ft X 1½ ft (1 x 0.45 m) wooden doors, net with a 2-in (50-mm) mesh body and 1½- in (38-mm) stretched mesh cod-end fitted with a 1/8-in (3-mm) cod liner. Replicate tows parallel to shore were conducted for 10 minutes, and trawl collections were standardized to numbers per 1,640 ft (500 m) of tow length.

Birds

Bird observations may be conducted within a standard length of shoreline (e.g., Hubbard and Dugan 2003), standardized transects (CZR 2003), and/or coastline sectors of known length (e.g., Lafferty 2001, SAIC 2006). Generally, birds associated with habitat (e.g., beach) are counted and over-flights by birds either are not counted or noted as such. Counts of birds by species and behavior (foraging, resting) may be conducted.

<u>Sandy Subtidal Recovery</u>

Biological and physical monitoring protocols for evaluating impacts of offshore dredging along the U.S. East and Gulf of Mexico coasts were developed by MMS (RPI et al. 2001, Nairn et al. 2004). The monitoring protocols address the following issues:

<u>Physical</u>

- Bathymetric and substrate surveys.
- Sediment sampling and analysis.
- Wave monitoring and modeling.
- Shoreline monitoring and modeling.

<u>Biological</u>

- Benthic communities and trophic relationships to fish.
- Marine mammals.

The RPI et al. (2001) recommended benthic monitoring involves collection of 0.10 m^2 cores to identify benthic invertebrate species composition, abundance, and biomass. In addition, otter trawls are recommended for collection of demersal fish and macroinvertebrates. The focus of the invertebrate sampling is analysis of recovery processes and rates of the benthic community. Analysis of trawl contents involves identification of species; measurement of length, sexual maturity, and weight of fish; and analysis of stomach contents of commercially and/or recreationally important fish species to assess diets and prey relationships with collected benthic invertebrates. Additional sampling of sediment grain size, total organic carbon, and stable isotope analyses (carbon, nitrogen) to compliment benthic recovery and trophic energy transfer analyses also are recommended. The RPI et al. (2001) biological monitoring protocols recommend surveys prior to dredging and in years 1, 3, 5, and 6 following dredging to assess long-term impacts.

Physical sampling is not addressed in this document. Descriptions of relevant sampling methods are available from several sources (RPI et al. 2001, Hitchcock et al. 2002, Boyd et al. 2004, Cooper 2005).

Invertebrates

RPI et al. (2001) review sampling equipment, sampling design, replication, and sampling processing recommendations for monitoring borrow sites on the East and Gulf Coasts of the United States. Generally, a sampler with a surface area of 0.1 m^2 is used. Other method descriptions for borrow site sampling are available in recent studies conducted off the East Coast (Brynes et al. 2004a,b). Similar methods are described for surveying aggregate mining sites in the United Kingdom (Boyd et al. 2005, Cooper 2005). Similar sampling has been conducted off California during regional, nearshore monitoring, and offshore studies in southern California (e.g., Fauchald and Jones 1983, Thompson et al. 1985). Generally, a box core sampler or Van Veen sampler with a surface area of 0.1 m^2 has been used off California.

Box core sampler
Photo: SAIC

RPI et al. (2001) recommend that the number of replicate samples be determined as part of a baseline or pre-impact survey using a power analysis. Additional recommendations include processing samples with a 0.5 mm, identifying animals to taxonomic categories, and weighing each taxonomic category (e.g., family). That method of analysis focuses on providing information that may be more easily linked to fish gut analyses, which is recommended to provide information on trophic response and recovery of secondary consumers. Off California, offshore samples have been processed with 0.5 and 1.0 mm sieves and animals typically have been identified to the lowest practicable taxon and weighed according to taxonomic categories (e.g., crustaceans, echinoderms, mollusks, polychaetes, other minor phyla). Specific sampling methods should consider comparability with other available data in the vicinity that may be useful as reference information.

The primary question addressed by most monitoring studies after sediment management activities is benthic invertebrate recovery rates (Sections 4.2.6, 4.2.7). Important considerations with respect to recovery relate to species composition, species-abundance relationships, and size distribution (or biomass) (Pearson and Rosenberg 1978, Reilly and Bellis 1983, Newell et al. 1998).

Newell et al. (1998) reviewed that a practical approach to determination of “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 and at control locations. This type of question has important implications with respect to hypothesis testing and sample size. Generally, fewer samples are required to test a one-tailed hypothesis (e.g., value is ≥ than before or control) than a two-tailed hypothesis (e.g., value is different, < or > than before or control) at the same level of power (Sokal and Rohlf 1969).

Fishes

Methods for trawl sampling are described in several of the above sources referenced under invertebrates (SCCWRP 1985, RPI et al. 2001). Generally, a 25- ft (7.6-m) otter trawl is used, and has been commonly employed for fish sampling off California. RPI et al. (2001) recommend a minimum of three day and three night trawls at each location. Sample analysis typically involves county by species, measurements of standard length, determination of sex, and weight; generally, length and weight is determined on a subsample of collected fish by species.

Marine Mammals

RPI et al. (2001) recommended shipboard monitoring during dredging (on dredge vessel or ancillary craft) and review of marine mammal stranding records. The shipboard monitoring would be conducted by qualified marine wildlife biologists and include observations for presence of marine mammals in the dredge area, documentation of behavior of marine wildlife to dredging activities, and documentation of any collisions or other negative interactions between the dredge vessels and/or support craft with marine wildlife. In addition, review of marine mammal and wildlife stranding data during and for 60 days following dredging events was recommended to check for possible correlation with dredging operation (e.g., body markings).

Rocky Habitats

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, http://www.marine.gov/sampling-methods.htm, http://www.piscoweb.org/data/ catalog/intertidal_community). 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 (http://www.piscoweb.org/data/ catalog/intertidal_community).

Monitoring of rocky habitats to verify impact significance with respect to beach nourishment projects in California has involved transect- and quadrat-based techniques with assessment of key species (e.g., Chambers Group 2003, AMEC 2005, Engle 2005). Key indicators used during a recent California sediment management project are listed in Table 7.2-3.

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/intertidal_community).

SAV Habitats

Techniques employed to map habitat boundaries of vegetated habitats may include aerial photography and/or underwater swims with surface vessel GPS tracking. Time of year is an important consideration with respect to aerial photography due to natural, seasonal die-back of vegetation. The CDFG posts online GIS shapefiles of kelp canopy along the California coastline based on use of a Digital Multi-Spectral Video system; historical data from 1989, 1999, and annual cover since 2002 are available at http://www.dfg.ca.gov/itbweb/gis/mr_nat_res.htm.


Reef monitoring surveys
Photo credit: Danny Heilprin, SAIC

Assessment of habitat changes and/or degradation requires a systematic method such as transects and/or quadrats. For multiple survey sampling, semi-permanent sampling locations should be established with a BACI survey design both in the area of potential impact and at nearby reference areas. Monitoring of SAV habitats to verify impact significance with respect to beach nourishment projects has involved transect--based techniques to assess percent cover of key species such as surfgrass, eelgrass, and kelp and/or quadrat-based techniques to determine densities of indicators within a standardize area (e.g., Chambers Group 2004, AMEC 2005, Engle 2005). Percent sand cover also is measured to examine changes in sand level and relationship with potential sedimentation impacts.

7.5.2 Burial and Sedimentation

Burial and/or sedimentation of sensitive habitats (reefs, SAV, fishery spawning grounds) may be a site-specific concern with sediment management projects. Several techniques may be employed to examine sand level changes and transport, including:

- Beach profiles.
- Sand level.
- Sediment traps.
- Remote Sensing.

Several of the above methods have developed with recent advances in technology and application may not be widespread. Information from these various methods may be very useful to sediment management planning. Resulting information may be very useful in providing empirical data to support biological impact evaluations that address the following types of questions:

Brief descriptions of the above methods are provided below with references for obtaining additional information.

<u>Sediment profiles</u>

Monitoring of beach profiles provides information useful for model verification; however, profile monitoring in California has been primarily used to document sediment movement, erosion, and/or persistence of beach nourishment projects (e.g., USACE 1991, Coastal Frontiers 2004). It is recommended that data from profile measurements and actual environmental data (wave climate) from the monitoring periods be used to examine model performance and/or to identify appropriate analytical adjustments that would improve model performance.

Cross-shore beach profile surveys give an indication of trends in beach sand loss or gain for each profile over time. The beach shape also may plotted on a graph to show which section of the beach the sand moves in over the years of survey (e.g., Figure 5.4-2, Coastal Frontiers 2004).

A network of beach profiles is a useful management tool for indicating trends in sand movements at specific locations. Such information is relevant to biological impact evaluations of sedimentation associated with sand transport from beach nourishment locations.

Monitoring of beach profiles provides information useful for model verification; however, profile monitoring in California has been primarily used to document sediment movement, erosion, and/or persistence of beach nourishment projects (e.g., USACE 1991, Coastal Frontiers 2004). Sediment profiles also may be useful for examining cross-shore elevation change between survey periods to evaluate sedimentation. This is of particular interest for beach nourishment projects in areas with hard-bottom substrates downcurrent and/or offshore.

It is recommended that data from profile measurements and actual environmental data (wave climate) from the monitoring periods be used to examine model performance and/or to identify appropriate analytical adjustments that would improve model performance.

Sand Level

Although sand level trends are apparent from beach profile data, direct sand level measurements provide a more precise measure of seabed depth changes. Semi-permanent rods or poles may be used and/or a measuring rod may be used during field surveys depending on question of interest. The following two examples illustrate use of sand level measurements.

SACPB (2000) uses brass sand level rods were installed in 1987 to monitor seabed changes in nearshore areas. The top of the rod is used as a datum to measure seabed height changes. Rods were installed along cross-shore profiles, spaced 82 ft (25 m) apart, for the first 3,281 ft (1000 m), then 164ft (50 m) apart further offshore. The rods have a known position and are located using a GPS by boat, then divers locate the rods underwater by compass and measure the rod heights. The rod lines are measured annually and compared with data from other survey methods to provide precise measures of sand level. This method may be useful in areas where mixed bottom type (e.g., and, hard bottom) occur adjacent to beach nourishment sites.

Measuring rods were used to determine sand depth (to refusal or 4 ft) during surveys examining habitat quality for sandy beach fauna before and after beach nourishment in the City of Encinitas, California (MEC 2000a, SAIC 2006). The primary author found the information useful for examining available sand habitat depth, degree of sediment reworking, sand level change, and sand depth persistence in the context of habitat suitability for invertebrates and grunion spawning.

Remote Sensing

Useful References for Seafloor Mapping

The CSUMB Seafloor Mapping Lab: http://seafloor.csumb.edu

USGS Pacific Seafloor Mapping Images: http://walrus.wr.usgs.gov/pacmaps/site.html

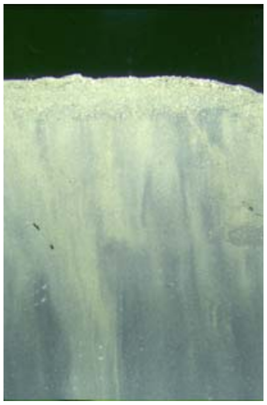
Several technologies involving high-resolution, acoustic remote sensing are being used to provide accurate and highly detailed seafloor maps in California. Technologies include bathymetric LIDAR, hydrographic techniques (multibeam and side-scan sonar), digital elevation models (DEM), and GIS based integration. Statewide seafloor maps with bathymetry, seabed geomorphology (via DEM), and texture (substrate type via acoustic backscatter and reflectance mosaics) are planned for California state waters (http://seafloor.csumb.edu).

Maps provide valuable information on habitat types (rocky versus sandy substrate), relief height, enable quantification of habitat types, and when created at different times can be subtracted from each other to precisely quantify environmental change (e.g. sediment transport, erosion and burial) (Canright 2005).

Acoustic surveys, videos, and underwater still photography have been successfully used to provide high resolution images of the seabed after trailer hopper dredging (e.g., Hitchcock et al. 2002, Boyd et al. 2004, Cooper 2005).

Underwater Photography

Benthic photography using a sediment profile camera may be used to provide images of the sediment profile and sediment-water interface. This methodology has been noted as being useful for examining thin layer, sedimentation (Germano and Cary 2005, Wilber et al. 2005).



Sediment Profile Camera **Sediment profile image**

Photos: SAIC

Modeling

A method of beach surface modeling has been applied in some coastal areas to more closely monitor beach erosion areas and major beach replenishment projects (SACPB 2000). Hydrographic, terrestrial and photogrammetry techniques are combined over the study area to create a dense grid of surface points, each with geographical position and elevation details, which are input into GIS to create the surface model (Fotheringham and Goodwins 1990 cited in SACPB 2000). When the model area is resurveyed, one surface model is subtracted from the other to produce a beach surface difference contour map with gradational shading corresponding to different levels of change.

The map is considered useful for identification of areas of sand loss or gain, supports improved calculations of volume changes, and also has been used to monitor effects of offshore dredging on sites where sand has been removed to replenish other areas of coastline (SACPB 2000).

Integrated GIS

Use of Geographic Information Systems (GIS) can greatly assist integration of different types of monitoring data to increase understanding of coastal change and assist shoreline management. For example, .beach profile data can be overlayed on beach surface difference maps and cross-referenced with sand level measurements for mapping sand movement, checking the accuracy of sand gain and loss volume calculations, examining trends over time, and supporting shoreline management decisions (SACPB 2000).

7.6 Summary and Recommendations

Nelson (1993) summarized that while evidence is beginning to accumulate that there can be minimum biological effects of beach nourishment where projects are properly designed, he considered it premature to decide that biological monitoring is unnecessary. Based on the current document review, his statement is still valid.

Many of the potential impacts associated with sediment management activities may be avoided and minimized when projects are properly designed and implemented (Section 6). However, data gaps and limitations indicate a need for additional information to assist environmental planning and protective design of sediment management projects in areas with sensitive biological resources in the vicinity.

There also is evidence that potential for impact varies depending on project size, proximity to sensitive resources, and natural disturbance regimes of receiving environment. Those factors should be taken into consideration with respect to development of appropriate scale monitoring programs.

Monitoring requirements will differ depending on project- and site-specific conditions. The following monitoring considerations are recommended:

- The objectives of the mitigation and monitoring program, methods, coordination and/or communication protocols, compliance criteria, analysis methods, and schedule should be specified. Monitoring conducted to verify impact significance should specify criteria that will be used to conclude that an impact is significant.
- Standardized monitoring should be conducted to the extent practical to support regional assessments of cumulative impacts.
- Sediment compatibility – Beach nourishment projects that use sediments that substantially differ in physical characteristics from the native beach sediments should require more extensive monitoring unless the change represents an enhancement (e.g., cobble to sand). Testing should verify that sediment characteristics do not become unsuitable for native fauna over time.
- Proximity to sensitive resources – Projects with sensitive resource in the vicinity at potential risk from equipment removal and/or sedimentation impacts should include impact verification monitoring.
- Project size – Larger projects should require more monitoring than small to mid-sized projects. Monitoring should be ecosystem-based.
- Less disturbed habitats – Monitoring of benthic recovery rates is recommended for sediment management projects conducted in less disturbed, nearshore habitats (e.g., borrow sites, nearshore placement). Although projects are unlikely to occur at beaches with persistent sand from a need standpoint, if a project was to occur (e.g., site used as feeder beach), monitoring is recommended to determine recovery rate. Monitoring should be ecosystem-based.
- Frequency of nourishment – Projects that require periodic renourishment should include monitoring that supports an adaptive management approach; i.e., adjustment in procedures and/or volumes to maintain project benefits in balance with environmental impacts.
- A BACI sampling design should be used for monitoring programs that address verification of impact significance or recovery rates so that impact can be detected from natural variability.